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Failure Analysis of Heat Exchanger Tubes at Different Operational Conditions

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Abstract— Heat exchanger tubes generally deteriorate or corrode as a result of their susceptibility to a wide range of tube and shell mediums under varying working conditions. The current study aimed to conduct a failure analysis of heat exchangers in the Petrochemical Industries under various operating conditions. According to kinetic and thermal analysis, heat exchanger tubes corroded primarily as a result of the carbon dioxide (CO2) solute in crude oil passing through the tubes, causing electrochemical corrosion. Polarized tests were carried out to analyze the outer surface cavities produced on the tubes. Tests revealed that CO2 had no substantial association with cavities on the surface of the tube. Additionally, microstructural analysis of corroded heat exchanger's tubes demonstrated that solid suspended particles of high hardness present in crude oil or methanol detached from previous phase catalysis causing electrochemical as well as the erosion-corrosion mechanism inside and outside heat exchanger tubes. Appropriate methods for prevention or mitigation of tubes corrosion were proposed based on the corrosion cause.

Keywords— Heat Exchangers, Errosion, Corrosion, XRF Petrochemical Industries.

I. Introduction

Corrosion is regarded as the common issue contributing to annually billion dollars losses [1]. Most industries' apparatus and amenities maintenance and repairs losses are instigated by corrosion. Heat exchangers are susceptible to consequent failure and corrosion [2]. The applications of heat exchangers vary from condensers, boilers to gas industries and petrochemical [3]. Heat exchangers are used in a variety of applications, including condensers, boilers, gas industries, and petrochemicals [3]. In general, heat exchanger is mainly utilized for cooling or heating of the process fluids, and the proper maneuver of this equipment is critical to the operation of a processing unit [4]. Many heat exchangers are designed for such applications where slot embedment, sedimentation, dissimilar metals connection, high fluid speed, stagnant fluid presence, and thermal ascents at the surface of metal and fluid are unavoidable [5]. In heat exchanger, the corrosive fluid accelerates corrosion, causes equipment failure, accelerates destruction, and ultimately phases out the production cycle. In chemical plants, reboilers are critical equipment used for the distillation of effective substances by heating the medium. Heat exchanger tubes is the reboiler critical components. Still, because they operate under complex conditions like two-phase flow [6], the high-temperature difference [7], and high pressure [8], and reboiler's heat exchanger tubes are susceptible to failures [9]. As a result, the failure of reboiler's heat exchanger tubes should be closely monitored to make sure that reboilers operate safely.

One of the most common causes of system shutdown in petrochemical refineries is the corrosion of heat exchangers [10]. In petrochemical plant, Heat exchanger tube corrosion can have severe consequences such as tubes perforation causes the leakage of coolant fluid into the process fluid. Significant product damage and loss caused by pollution of the processing fluid. There have been numerous expositions of heat exchanger failure caused by various corrosion contrivances, including stress cracking, even pitting, erosion, selective, intergranular, crevice, galvanic, and microbiologically induced corrosion [11-15]. The heat exchanger failure due to crude methanol contact constitute solute CO2 gas, water, and other side products is investigated in this paper. As per the refinery reports, corrosion is occurring in the tube. All of the doling out entities were investigated, and potential causes of heat exchanger corrosion and failures, such as ineffective inspection, inapt processing conditions, and repairs activities', or inadequate material assortment, were investigated. Besides sampling and tubes analysis, corrosion causes and mechanisms were examined through laboratory tests designed for desired heat exchanger. Lastly, appropriate solutions for corrosion prevention and mitigation are proposed within the research context..

II. METHODOLOGY

The Heat exchanger tubes made of carbon-steel sample was tested in a Pakistan-based oil refinery. The carbon-steel composition and transported medium crude methanol inlet and outlet temperature of 39.2 ◦C and 68.6◦C respectively are shown in Table-1. Figure 1 illustrate the failed or corroded heat exchanger tubes and Figure 2 shows immersion tests for corrosion. Two different sites i.e. Site I and II corroded heat exchanger tubes were collected along with corrosion product deposited on tubes. Microstructural analysis and surface morphology of site I and II samples taken were investigated with Scanning electron microscopy (SEM). X-rays Fluorescence (XRF) was performed to characterize elements, verify the composition of sample, and ionic chromatography was utilized for better examination. The heat exchanger tubes samples were immersed in simulated crude methanol of 300 mL inside electrochemical experiments. Similar to tubes, the cell was composed of steel samples and worked as an electrode. Silver and Silver chloride (Ag/AgCl) electrode was used as a reference electrode whereas the counter electrode was made of platinum plates. The forward scan voltage of the polarized sample was -0.2V to +1V against reversed scan open circuit potential -0.2V.

III. RESULTS

A. *Microstructural Analysis:*

Define Scanning electron microscopy images demonstrate the sample tube corrosion in Figures 2a, 2b, and 2c. The tube out surface looks like a regular pattern gear wheel and reduced thickness can be clearly seen in specified regions. The curved cavities formation on tube surface (2b) attributed to erosion-corrosion phenomenon. Additionally, accelerated under-deposited corrosion is caused by corrosion of the tube's outer surface. The spherical morphology of shell deposited corrosion is clear. It might be either caused by solid pollutant particles in crude methanol or products of detached corrosion. Also, sharp edges elimination on SEM image demonstrated the erosion phenomenon. X-rays fluorescence spectroscopy (XRF) and Energy dispersive spectroscopy (EDS) were performed for composition and deposited elements determination respectively. The deposited layer on the heat exchanger tubes was Fe, C, and O as shown in Figure 3. The composition of heat exchanger tubes before and after corrosion are shown in Table 2. The carbon contents increased from the original sample 0.06 wt% to 6 wt% on the corroded sample whereas oxygen was absenting the original sample but appeared in the corroded sample. The percentage loss of C, O, and Fe is actually the carbon steel sample corrosion. In short, iron oxide sand carbonate are the possible combinations that cause heat exchanger tube corrosion. Moreover, the iron carbonate was present in higher quantity compared to iron oxide which may conclude that iron oxide at the beginning was converted into carbonate due to crude methanol passage with CO2 through tubes.

IV. DISCUSSION

The perforation appearance on the inner wall expanded to the outer wall indicates that corrosion progress from inside to the outer side of the tube. Microstructural analysis of corroded heat exchanger tube deposited layer revealed that elements like iron, oxygen, and carbon weightage increased from original content. The percentage loss of iron is actually the carbon steel corrosion. The possible causes of heat exchanger tubes are iron oxide and carbonate which initiate the corrosion with iron oxide and transforms into iron carbonate by close contact with CO2 present in crude methanol. The presence of elements like Zn, Al, Si, Cu, and K on the shell deposited layer confirms that crude methanol had abrasive and hard particles as reported in Energy dispersive spectroscopy. Additionally, high content of Fe, C, and O was present which implies that FeCO3 might be the reason for accelerated corrosion in heat exchanger tubes.

The heat exchanger tubes deposited layer was analyzed using EDS-XRD where spectrum of various compound such as SiO2, ZnCO3, CuO, Fe2O, Cu2O, and Al2O3 were seen on the corroded sample. Abrasive particles include silica, alumina, and carbonate. These particles, depending on fluid motion types and flow intensity, can cause a significant surge in mechanical degradation influencing erosion-corrosion [16]. Moreover, with spontaneous reaction electrochemical corrosion rate enhanced with crude methanol substituted cupper particles [17, 18].

When the sediment of medium accumulated on the tube's surface, formic acid spot corrosion occurred easily beneath the sediment. S30408 was susceptible to stress concentration in pits [19, 20]. According to the results of the energy spectrum analysis, the corrosion position of the leakage fracture contained a high concentration of chloride ions. When chloride ion is present in the medium and the tubes are in the dry-wet, water-vapor alternated environment, the chloride is locally concentrated, and the sensitivity of stress corrosion cracking is significantly increased, according to GB/T 30579-2014 "Damage modes identification for pressure equipment." [21] The stress corrosion cracking of the tubes is indicated by the microstructure pattern of the river and a small amount of fan in the leakage fracture [22].

Overall, evidence from the macroscopic and microscopic examination of tube surface inveterate that the cavities are caused by solid particles such as ZnCO3, Al2O3, FeO, SiO2, and others corrosive particles. The relative hardness of particles silica, alumina, and carbonate are 2200 HV, 2600 HV, and 420 HV which is substantially higher than tube carbon steel 129 H. These particles can create corrosion cavities on the substrate. Additionally, according to the literature [23, 24], the iron carbonate layer had low adhesion substrate at temperature<70 C, confirmed by EDS results. Given that the heat exchanger's working temperature is around 53 C, the carbonate layer easily eroded and cannot protect corrosion [25]. These findings validated that erosion-corrosion is the primary cause of exchanger failure. Other corrosion possibilities are pitting, under-deposit corrosion, galvanic, and cavitation. For pitting corrosion, cyclic polarization testing revealed that without solid particles, pitting is unlikely [26].

SEM outcomes revealed that the cavities formed depth are almost equal or about to the mouth size, ruling out the pitting corrosion possibility [27]. Cavitation due to CO2 low vapor pressure at crude methanol average temperature of, i.e. 53 C, might be another possibilities. Producing holes seen on the tube is incapable [28]. The third possibility is Fe and Cu galvanic coupling. As per XRD analysis, Cu exists in the form of oxide and carbonate, not as a metal form capable of electrical contact. Furthermore, the Cu formation in corrosion deposits caused by galvanic coupling.

Furthermore, galvanic coupling reduces the thickness and increases the brightness of the active metal, in this case steel tube. Visual inspection, on the other hand, revealed a coarse and nonglossy surface. Moreover, the cathode to anode area ratio, which is an important factor in galvanic coupling, is substantially lower [29]. The galvanic coupling possibilities rule out in the system. Lastly, pits are deeper than the mouth under-deposit corrosion results. Furthermore, crude methanol high speed (66.5 Kg/s) protected the deposits beneath, implying that it might not be the corrosion primary mechanism [30].

A. Figures and Tables

TABLE I. CARBON STEEL COMPOSITION AS PER ASTM A179

Element	Composition (%wt)
C	0.06-0.08
Si	–
Mn	0.27-0.63
P	<0.035
S	<0.035
Compound	**Molar Percentage**
CH3OH	80.61
H2O	18.49
CO2	0.73
CH4	0.05
H2	0.02
CO	0.01
N2	0.01

TABLE II. COMPARISON OF BEFORE AND AFTER COMPOSITION OF CORRODED SAMPLE

Element	Composition Before (%wt)	Composition after Corrosion wt%
C	0.06-0.08	6.00
Si	-	-
Mn	0.27-0.63	0.27-0.63
P	<0.035	<0.035
S	<0.035	<0.035
O	Not present	Present
FeO	Not present	Present
FeCO3	NP	Present

TABLE III. XRF ANALYSIS OF TUBE MATERIAL COMPOSITION

Element	Composition Before (%wt)
Cu	43.092
Zn	9.82
Al2O3	15.92
SiO2	15.32
Na2O	4.32
Fe2O3	3.25
K2O	0.841
MgO	1.004

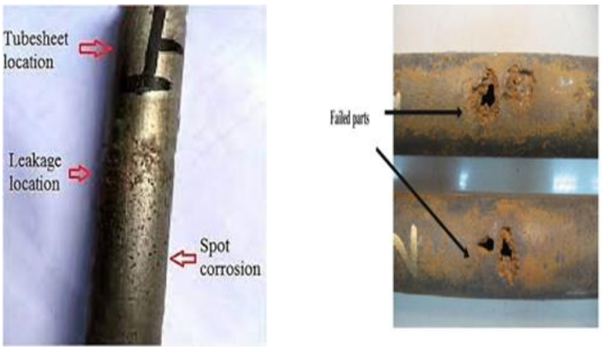

Figure 1. Heat Exchanger corroded tubes

Figure 2. Immersion test for corroded tubes sample with methanol

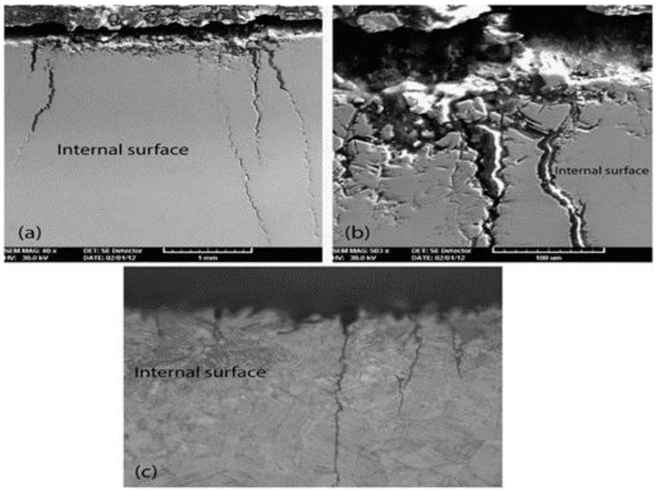

Figure 3. Scanning Electron Microscopy of Corroded heat exchanger tubes a) internal surface cracks, b) internal stress cracks, and c) erosion-corrosion

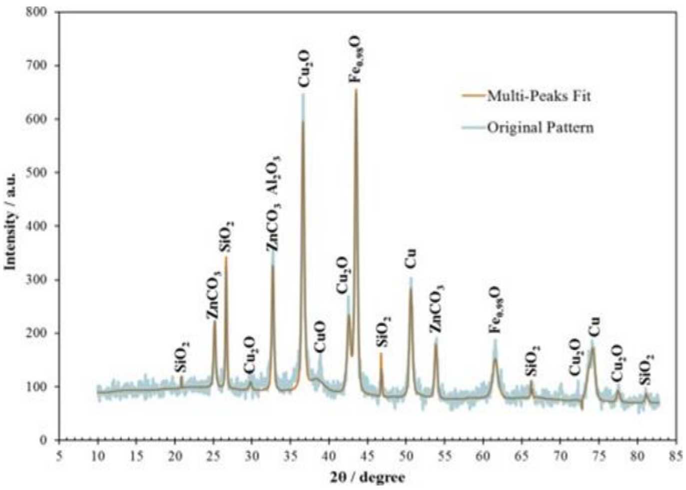

Figure 4. EDS-XRD of Corroded sample

CONFLICT OF INTEREST

The Author claims no conflict of interest.

CONCUSLION

Our study found that heat exchanger tubes corroded and failed due to the manifestation of solid abrasive particles in crude methanol. These abrasive particles lead to the erosion-corrosion phenomenon. Additionally, it was found that the formation of iron oxides and iron carbonate causes heat exchanger tubes failure due to corrosion in petrochemical industries. As a result, appropriate corrosion preclusion approaches were suggested, such as: using alloy steels A213; heat exchanger tubes to be made of higher carbon content carbon steel, tube surface hardening like carburizing; and filtration of crude methanol with suspended abrasive particles prior to entering heat exchanger.

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Comparison of Community based Projects and Community Owned Projects

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***Abstract*—** Community development projects (community projects) are established in the communities to enhance the lifestyle and living situation of the communities. In the area under observation, some of these community projects that were established for the welfare of the communities get failed or were not sustainable, despite having heavily foreign funding, state of the art construction and astonishing infrastructure. But, some of these projects which are locally funded, have some vague structures that are well operated and give effective outcomes for the community. This research is investigating the reasons for the failure or success of these community projects.

The objective of this study is to examine the failure of community-based and highlight the success of community-owned micro hydro power projects in the northern areas of the Khyber Pakhtunkhwa Province of Pakistan. This research is based on both qualitative and quantitative approaches. A survey has been conducted based on questionnaires and interviews. The outcome of this research will help the development authorities and other funding donor agencies to provide guidelines and strategies for better improvement of their future community project development.

***Keywords*—** Community projects, Project failure, community based and community owned projects, community involvement, Micro Hydro Projects in KP.

I. Introduction

Billions of dollars have been spent in rural areas around the globe to upgrade the living situations of the communities [1]. A number of projects are working to facilitate the communities with health, power, food, education, water and other essentials of life. These projects are normally driven by public sector organizations or by Non- government organizations (NGOs) as a strategy to fulfil the needs of the community and create more opportunities for the locals to better identify their problems and challenges and creates opportunities to better respond to their future needs [3]. Despite, these approaches of wellbeing to the communities, the dilemma with some of these projects are that most of these projects are experiencing major hurdles to sustain their life cycle, besides having effective construction and state of the art infrastructure. In most cases, these projects are terminated after a few years of operations. According to the study, almost 40 % of the community projects did not continue after their first few years of operations [5]. It is due to the fact that most of these projects are built with the focus on technical aspects of the projects without paying sufficient attention to its social and long term sustainability factor, thus causing failure of the project [5]. For the sustainability of any project, it is necessary to give enough importance to the social aspects and community acceptance of the project [5].

This research is focused on the MHP's Projects in North-West region of Pakistan, Khyber Pakhtunkhwa Province. The purpose of this research is to identify and analyze the factors influencing the community projects, to highlight those issues and manners which causes the failure and success of the projects. The outcome of this research will help the Pakhtunkhwa energy development organization (PEDO), Asian Development Bank (ADB) and other funding donor agencies, who are working on different community projects across the northern region of the province to better understand the root causes of the project success and failure.

II. Literature Review

This chapter reviews the literature on the community based and community-owned projects, community involvement and participation in the community projects, social impact of the project on the community, its management, causes of success and failure of different community projects, and interpersonal skills and monitoring as a contribution to the success and failure of the projects.

A. *Need of Rural Community Projects*

The majority of the communities of rural areas in different parts of the world are living without having access to clean and green electricity. Around 1.6 Billion People in the world, living in rural areas doesn't have access to electricity [9]. The reason is, it is too costly to provide electricity to the rural areas due to the remote locations and low populations. Moreover, due to the poverty in rural areas, and low income of rural inhabitants, it seems too expensive for them to get access to the main grid. Conventional sources of energy (wood, oil, natural gas, coal etc.) are used for decades for the provision of electricity in these rural areas. [10].

B. Success and Failure of community Projects (MHP's)

With this scenario, MHPP's are well adopted in the rural areas across the world, where there is no access to the grid connection or it has been considered expensive to afford the conventional source of energy. The funding and donor agencies always find it a better option for the communities to uplift the social and economic condition of the rural communities with the help of investment in the energy sector as MHPP's community mini-projects. Thus globally billion dollars have been spending by the donors' agencies to build MHPP's for the local communities and these investment is increasing day by day [1].

With the case of Kenya, where there is huge potential for micro hydropower projects in the rural areas, the sustainability of these projects are big challenge for the donor agencies. A lot of money has been invested on the community projects in rural areas where such MHPP's are the only hope for energy, yet majority of these projects have generally failed or struggling to bring sustainable benefits to the community. It has been observed that although some projects add the element of sustainability in their proposal stage, but the actual implementation of those elements seems to lack emphasis on sustainability.

C. Community Involvement in Community Projects

Community involvement is also an essential factor for a sustainable community project as it is the genuine involvement of the community people as active participants and partners in the project, whose concerns and local experience are important for the project's sustainability. It is the sociological process by which residents of the targeted community gather themselves and get involved in a community project at a different level of the project to improve the condition of daily life. It consists of various degrees of the individual or collective community involvement (Physical or financial contribution, political or social will) at different stages of a project [20].

N2 Gateway Housing pilot project, which is a massive housebuilding project in Cape Town, South Africa was affected due to noninvolvement of the community, because the housing department and local government were not willing to involve the community in the project and the community was also not interested to take participation in the departmental project meeting. Which ends up delaying in the project progress and success ratio [22].

D. Management in Implementation of the Commuunity Projects

Management of the project is considered as most dominant factor for any project, which contributes to project success and failure [26]. it is the set of tools, knowledge and techniques that when applied, will help you to get better outcomes for the project. Managing projects without management are the same as playing soccer without any gameplay, which results in nothing but failure [27]. The Project manager does planning from the top level, and then forward tasks to the other project members, and then follows it up to make sure the team members are doing their duties and completing their tasks on time. When the Management of a project is not well managed and well planned it leads to mismanagement in the projects, which results in failure of the project either it is during an implementation stage or operational stage.

E. Access and Management of Funds

Funding is the factor that could actively contribute to the failure and success of the community project [29]. While calculating the success and failure of the project, the availability of the funds should be importantly considered especially focusing on comparing an amount that has been proposed and the amount that has been received [30]. The fund's availability, the faithfulness of the members of the management of the project are also considered as important factors in the project sustainability. Lack of funding, ill-transparency and mismanagement could impact badly on project success. The success ratio in this regard for the community-owned project is a bit better than that of community-based projects. As there is some limited funding for the community-owned projects, but the ratio of transparency and faithfulness in community-owned projects are higher than community-based.

F. Monitoring and Evaluation

When the project is approved, the management and planning become the base for the project implementation stage, which captures the implementation process and monitoring and evaluation process [32]. It has been observed that many community projects failed to sustain their activities because they are not well monitored. In many such cases, when some abnormalities occur in the project activity, and if it has not been monitored, it creates major hurdles in the project sustainability. And if it has been monitored properly, the project will successfully deliver its objectives

G. Interpersonal Skills

Human resources should be treated in a professional manner and strictly in terms of labour prescription and the manager needs interpersonal skills of high level with his employee during the communal project implementation. They should be able to face problems, can analyze and solve the problems faced during the community project implementation [34]. One of the important factor of the management of the community project is to build understanding between manager and employees and manager should be able to maintain good human behaviour with other employees, been humble, flexible, friendly, accessible and can be able to give guidance and make decisions on personal problems faced by the employees can also affect the project.

H. Selection of Beneficiary Areas for Community Projects

A North West region of Pakistan, particularly Khyber Pakhtunkhwa (KP) and Gilgit Baltistan (GB) provinces are blessed with abundant hydropower potentials, which is yet to be materialized. According to the Feasibility Study report, 2015 of Pakhtunkhwa energy development organization (PEDO), the total identified hydropower potentials in Pakistan is estimated to be more than 60,000 MW [20]. But unfortunately, only 6900 MW hydropower potential has been exploited throughout the country, which is just 11.5% of the total available potential, while the rest of the potential remains unharnessed [20]. To explore and develop the hydropower potential at the provincial level, PEDO with the help of the Asian Development Bank (ADB) and other donor agencies, are implementing hundreds of Micro Hydropower Projects at the community level for the electrification of rural areas of this province, where local community has no access to the main national grid, and are dependent on these community projects. However, the construction of these projects cannot help these communities, if they fail after a short span of time. In order to make these projects sustainable and more effective for the communities, project failure rates of these systems should be reduced.

TABLE I. AREA WISE MHPP'S POTENTIAL IN PAKISTAN

S. No	Area Wise MHPP's Potential in Pakistan				
	Area	**No.of Potential Sites**	**Potential Range**	**Total Potential**	**Remarks**
1	Khyber Pakhtunkhwa	125	0.2 to 32 MW	750	Small / Micro Based on Natural fall / flow
2	Punjab	300	0.2 to 40 MW	560	Canals
3	Gilgit Baltistan	200	0.1 to 38 MW	1300	Natural Falls
4	Sindh	150	5 to 40 MW	120	Canal falls
5	Azad Kashmir	40	0.2 to 40 MW	280	Natural Falls

In northern areas, installation of MHPP's are supported by the GoP with the help of different non-government organizations such as Agha Khan Rural Support Program (AKRSP), Sarhad Rural Support Program (SRSP), National Rural Support Program (NRSP) funded by Pakistan Poverty Alleviation Fund (PPAF), Malakand Rural Development Project (MRDP), Welt Hunger Hilfe (WHH) funded by Germany and European Union (EU) etc [36]. Northern areas of Pakistan has an estimated potential of 3000 MW for Micro Hydro Projects [37].

III. RESEARCH METHODOLOGY

This Chapter is focusing on the methods of research to be followed in the research study. It contains aspects such as research methodology, research design, target population, sampling, data collection and data analysis.

A. Research Design

A descriptive survey was used in this research study to explore factors that causes the successful implementation of the community-owned projects and explore factors that causes failure of the community-based projects. A descriptive survey is the kind of survey that uses a method of gathering information by interviewing and administering a questionnaire to an individual sample [40]. Data has been collected through designed questionnaires about the impact of community-based and community-owned project from the individual interviews. Hence our research was about two different types of community projects, so two questionnaires were designed. One for community-based MHP's and other one for community-owned MHP's project. The questionnaire was designed to collect data regarding both the projects, which will then be analyzed and concluded to better identify the problem.

B. Sampling Design

Hence the research study has been taken for the northern areas of KP, for which four locations has been chosen for the sampling to be taken. For this purpose, Upper Dir, Chitral , Charsadda and Kalam have been selected, where a number of community-based and community projects have been selected for the research study. The following criteria were followed for sampling from community projects:

- Each type of project must be represented.
- Preference has been given to the literate people i.e. Degree holder, diploma holder etc.
- Technical persons and community leaders will be intervene regarding projects progress.

C. Target Communities

The target communities for this research are the northern areas of Pakistan, where the MHPP's projects have been implemented either community based or community-owned. Target communities include the northern areas are. i.e. Chitral, Swat, Upper Dir, and Charsadda where there is a huge potential for the MHPP's projects and a number of Communities Projects are implemented there. The study was composed of data collection and surveys of projects in these areas.

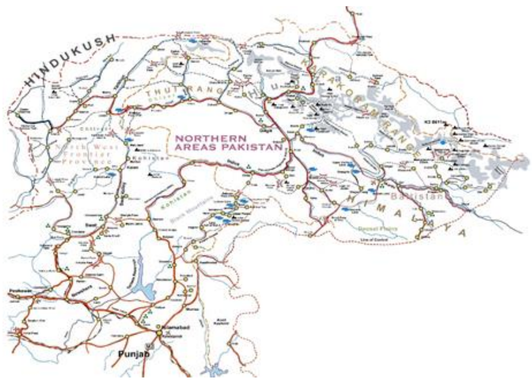

Figure 1. Detailed Map of Northern areas of Pakistan

D. Research Instrument

This research used questionnaires and interviews from individuals as a research instrument for collecting data. Questionnaire was structured and a number of copies have been distributed among the participant's and it has been ensured that each participant is asked the same, precise and simple clear questions that are understood by the participant. Interviews have also been taken from the local people of the target communities regarding project capabilities, its economic, environmental, and social impacts on community. Departmental officials have also been interviewed to get their views and opinions on the community project, people's opinions and involvement in the projects. Community leaders and elders are also interviewed regarding this matter, and their opinion, perceptions and suggestions for improvement have been recorded. Sufficient data were collected from the questionnaire and interview, which were recorded in the files.

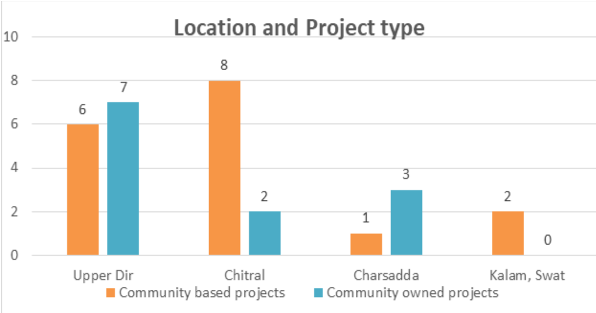

Figure 2. Location and project type of Mhp community projects considered for research study

E. Data Analysis and Interpretation

Data analysis is the searching and arranging the data extract from questionnaires and interviews, field notes and other helping material in some order to increase better understanding of the data, which will enable the researcher to better present, what has been discovered [43].

Figure 3. Jungle Inn MHP

Kalam (Swat)

Figure 4. Gharibabad MHP

Upper Dir

Figure 5. Jungle Inn MHP Project Site view

The collected was analyzed by using statistical methods. Data was first to be cleaned at the point of collection by ensuring the completeness of the information. As we have taken two samples, one for the community-based projects and other for community-owned projects, both type of Data is then be organized into different categories. SPSS V.20 (Statistical package for social sciences) tool is used to analyze the arranged data for both the samples separately by using descriptive statistical measures in order to answer the research questions and objectives.

IV. RESULTS & ANALYSIS

Two types of questionnaire have been distributed among the community members, technical persons, operators, project owners and community leaders. A number of questionnaires issued to the respondents were 100, In which 50 has been distributed to respondents regarding community-owned projects and 50 was about community-based projects, from which 91 questionnaires have been returned back and selected as reliable data information, and 54 interviews have been conducted. The collection of data was both qualitative and quantitative, which will be presented in this chapter using tables.

Two types of community projects have been selected for the research study, and a comparative analysis has been made to better identify the success and failure of these projects. A total of 4 Places has been visited, and 29 community projects have been identified and examined. Among the 29 community projects, 13 Projects were located in Upper Dir (7 Community Owned Project, 6 Community Based Projects), 4 in Charsadda (3 Community-owned projects, 1 Community-based project), 10 in Chitral (2 community-owned projects, 8 community-based projects), and 2 in Kalam (2 Community-based projects). The distribution of all these community projects are shown in the Table II below:

TABLE II. LOCATION AND PROJECT TYPE IN NORTHERN AREAS.

S.No.	Location	No. of Projects	Community Owned Projects	Community Based Projects
1.	Upper Dir	13	7	6
2.	Chitral	10	2	8
3.	Charsadda	4	3	1
4.	Kalam, Swat	2	0	2
Total		29	12	17

All of the 17 Community-based projects were funded by the Funding donor agency. e.g. SRSP, Hashaar, DADO, DOST, AKRSP and PEDO and the 12 Community-owned projects were funded and implemented by the local People, or by funding organization which is then handover to the community. The questionnaire has been distributed among the operators, managers, technical persons, community leaders and other respondents. Project Implementers, project owners, technical persons and local people were also interviewed for the challenges they have faced during the implementation, management and operation of the project.

A. Descriptive Analysis

The collected data was, first of all, entered into a statistical package for social scientists (SPSS) tool. As we have collected data from two types of projects, community-based projects and community-owned projects from which a total of 50 questionnaires each has been collected from both types. The data has been analyzed separately for each project type through SPSS tool. The information of project management, community involvement, Technical issues, billing mechanisms, interpersonal skills, people satisfaction on the project, and maintenance etc. was analyzed. This was done to capture the comparison of both the community based and community-owned projects. Moreover, the Causes of success and failure have been figured out. The analyzed data has then be presented with the help of tables for better understanding, which will be discussed in the sections ahead.

TABLE III. STATUS OF THE COMMUNITY PROJECTS

S. No	Type of Project	No. of Projects	Operational	Non-Operational	In %
1	Community Owned Project	12	11	1	9
2	Community Based Projects	17	14	3	19

B. Comparative Analysis of Community Projects

1) Upper Dir:

According to the report from SRSP, there are total of 37 micro-hydropower projects in district Dir, in which 32 were installed in Upper Dir, and 5 in Lower Dir [44]. These 32 micro power plants in upper Dir are jointly implemented by SRSP and EU are community-based projects for the welfare of the community. Among these projects, six projects have been taken into a research study and seven are community-owned projects, which has been owned by the local residents.

Figure 6. Detailed Map of Upper District

TABLE IV. COMMUNITY PROECTS IN UPPER DIR

S.No.	MHPP	Implemented by	Installed Capacity (KW)
1.	Yarkhun	AKRSP	800
2.	Laspur	AKRSP	500
3.	Jingiret Gol	Local	7.5
4.	Jingiret Gol 2	Local	50
5.	Garamchashma	AKRSP	100
6.	Shaghore	AKRSP	50
7.	Shishi	AKRSP	100
8.	Torkhow	AKRSP	25
9.	Lotkoh	AKRSP	25
10.	Golin Paye	AKRSP	50

Table IV shows the details of the selected community projects of both Community based and community owned projects in Upper Dir.

C. Comparison of the Projects:

It can be observed from above-listed projects in table X, the projects that are implemented by the community itself are low capacity power projects in comparison with those projects that are implemented by the donor agencies. Community-owned projects are not properly designed and were not in good condition, while that of community-based projects are well structured, having proper mechanisms for voltage and frequency control. Community owned projects have no powerhouse building, but that of community-based projects have well-structured civil work made for the project, including powerhouse building, channel designing etc. All the projects were installed on the irrigation canals, except Patrak bazar project which was installed on the natural flow.

2) Chitral

Located among Hindukush Mountains in the northwest, Chitral is the north-most district of Pakistan. AKRSP with the help of Swiss agency of development cooperation and Pakhtunkhwa energy development organization implemented more than 55 micro hydro power projects in the Chitral district.

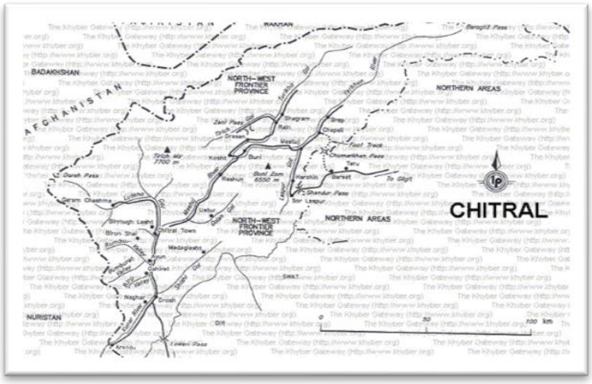

Figure 7. Detailed map of Chitral District

These 55 MHPP's are community-based projects, which has been built for the welfare of the community. Among these 55 MHPP's, 8 projects has been selected for the research study, which are located in different areas of the district Chitral. While that of 2 Community owned projects have been considered for the study. Community owned project that has been considered for the study are; Jingiret Gol, and Jingiret Gol 2. These projects has been implemented by the local people, to fulfill their needs and run their business machinery.

TABLE V. DETAIL OF MHPP'S PROJECT IN DISTRICT CHITRAL.

S.No	MHPP	Implemented by	Capacity (KW)
1.	Sangar	SRSP	100 (Not Operational Yet)
2.	Shahi Bagh	Local	24
3.	Kachalo	SRSP	25
4.	Dobando	Local	24
5.	Jungle Inn	Local	24

6.	Garibabad	SRSP	100
7.	Amrait	DADO	15
8.	Panakot	Local	24
9.	Jabber	DADO	30
10.	Patrak Bazar	Local	15
11.	Sananbal	SRSP	30
12.	Khas Kali Patrak	Local	24
13.	Khas Kali 2, Patrak	Local	24

D. Comparison of the Projects:

The number of Community owned projects is less in comparison with the projects that have been implemented by the donor agencies. Jingiret Gol project has been owned by the local resident who was trained to install and operate the MHPP's by Chinese and Korean Personnel during his Job with FC (Frontier Corps). Another community-owned project, Jingiret Gol 2 has been owned by the local resident named Asad Ullah Qureshi. These Community project has been managed and operated by their owners. Which provides electricity to the surrounding households. The Technical work has been done with the Local mechanic. The projects has some vague structure and not well designed infrastructure, but yet works fine since 1997 of Jingiret Gol 2 Project and 2001 of Jingiret Gol Project.

On other hand community based projects are well designed and implemented by AKRSP with the help of Swiss agency of development cooperation. The generation capacity of the CBP projects are comparatively higher than that of COP project. It is due to the fact that CBP are well designed with the art of civil engineering while that of community owned projects has not properly designed civil works. Community owned project are low generating capacity projects, which tends to provide electricity to the limited number of households, which doesn't require a bigger management mechanism to manage it, while that of community-based project requires proper managing protocols to manage the project as it provides electricity to the higher number of households in comparison with community-owned as currently no Proper billing mechanism has been made.

3) Charsadda

Charsadda is located 17 miles from the Provincial capital Peshawar in the west of KP . There are three rivers flowing in the district: the River Jindi, the Kabul River, and the Swat River. The river Jindi and River Swat form as distributed water canals in the district and then merged with the Kabul river. The Canals in Charsadda district is used for the irrigation purpose which provides feasible spot for the Mini and micro hydro power plants.

Number of MHPP's has been installed on this canals, in which some of the projects are community based, which has been implemented with the help of PEDO, and some are Community owned projects, which are owned and operated by the community or local resident by self. Four sites has been selected for the research study in Charsadda, in which three projects are owned by the locals, and one is implemented by PEDO, which is handed over to the community for commissioning.

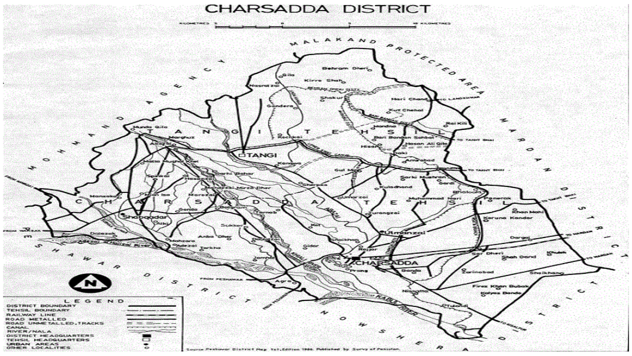

Figure 8. Detail Map of Charsadda District

TABLE VI. DETAILS OF COMMUNITY PROJECTS IN CHARSADDA

S. No.	MHPP	Implemented by	Installed Capacity (KW)
1.	Zyam	Local	20
2.	Hafeez G Killi	PEDO	15
3.	Utmanzai Palay	Local	15
4	Sarki	Local	2

Table VI. Shows the Details of the project selected for the research study. Three of the projects are community owned and one is community based project.

E. Comparison of the Projects:

Except Sarki MHPP, which is owned by the local, all other MHPPs were not operational. The reason behind the instability of the projects is to not undertaking communities in the project feasibility study. Which is certainly the flaws in management of the project. Local Community people use the canal water for the irrigation of their fertile land, and their first priority is to water their irrigated land. Due to which water flow rate available for the MHPP's are not enough to run the turbine at its designed RPM. The water flow issue has been reported at Hafeez G Killi MHPP also, which is community based project. The water flow issue created a rift between the operators and community, as when the MHPP's is operated the water level is decreased. That's why communities avoids being involved in project activity or utilize the power generated by the plant. No business model has been made to generate revenue from the facility for the community-based project, due to which rift occurs often between community and operator. While that of Community owned projects are implemented for the beneficiary own needs, which doesn't require any business model. Local available technical person is approached in case of technical problem in a project. All the operators were unaware of the technical knowledge regarding micro hydropower generation.

4) Kalam – SWAT

Different MHPP's has been implemented by PEDO and SRSP by working together in this region, in which most of them are in good condition and delivering power to its consumers. The residents of the valley are mostly poor and uneducated, that's why community owned projects are in very few numbers that has been installed by owners itself. This part of the country is mostly cold and the people does not need electrification for fans and refrigeration purpose. For the Lightening purpose they use conventional source e.g. Kerosene oil, woods, generators etc. That is why trends of community-owned projects was not been very welcomed by the community until the community based projects has been implemented, which changes people mindset and social life, as they gain the importance of MHPP's for the community. Meanwhile, two such projects have been selected for the survey, which was implemented by PEDO with the Help of SRSP. Both the projects are community-based projects that were installed for the welfare benefits of the communities.

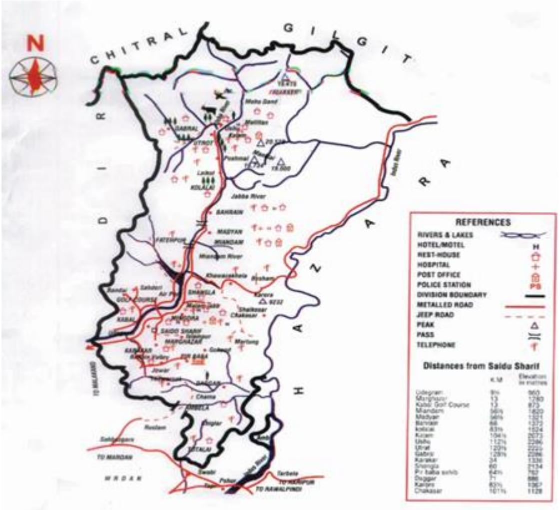

Figure 9. Detailed Map of Swat Valley (Sub-Valley Kalam)

TABLE VII. DETAILS OF THE TARGET PROECTS IN KALAM (SWAT)

S. No	MHPPS	Implemented by	Installed Capacity (MW)
1.	Jungle Inn	PEDO + SRSP	0.4
2.	Ashuran	PEDO + SRSP	1.2

Analysis:

A. Comparison of the Projects:

Both the Projects are implemented four years ago with the zest to fulfill the need of people of Kalam, which are operating in a good condition till date. There is no such issue in the project, except the Billing mechanisms and minor technical issues. There is no business plan for revenue generation from the consumers. Due to the maintenance, the projects get down for few days, then the consumers refuse to pay the bills. Which creates a rift between community people and operators. Floods are reported at the location, but yet no damage has been reported.

B. Degree of Satisfaction

This analysis deals with the people's perceptions about the project success and failure of CBP projects and COP projects in the selected places mentioned above in the northern areas of Pakistan. This analysis is based on the collected data through questionnaires, Group discussions, and interviews from the project beneficiaries. Total Number of Participants that responds to the research study are 145, with 91 questionnaires return and 54 interviews that have been conducted from over all 29 mhp projects of northern areas. The results pertaining to the hypothesis made are presented in the fig 10 below:

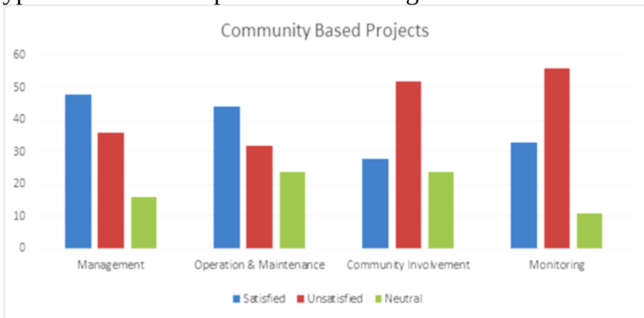

Figure 10. Degree of satisfaction for community based projects

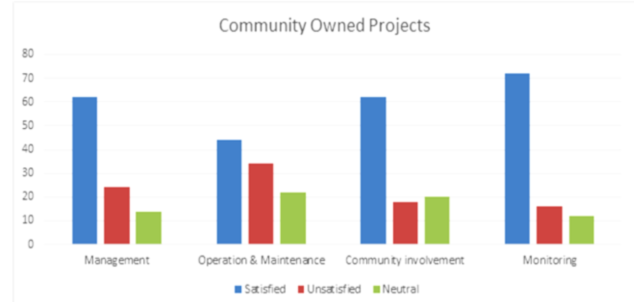

Figure 11. Degree of Satisfaction for community owned projects

C. Main Issues

1. Management Flaws:

It has been observed that most of the project that are non-operational are due to the flaws in project management. During the discussions with the communities, people point out some mis-management in projects implementation. e.g.

- Community participation has not been considered in project activities, due to which mostly people lost interest in projects.
- No Awareness campaigns, Incentives and motivation for the Community for the Social implications of the project.
- In some CBP projects, No such business model were made for revenue generation, due to which sometimes a conflict occurs between beneficiaries and operators Lack of skill training for the operational and maintenance staff in project. Mostly technical staff are uneducated with some adequate skill for the specific activity.
- In some of the projects, there are no data record for the project activities. No manuals are available for the project maintenance and operations.

2. Unskilled Operators:

Most of the project operators have no prior skills and experience in operating and maintaining the project. Among the survey of 29 projects, only 6 operators have little experience in operating the power plant equipment.

3. Low Education Level:

Most of the operators are illiterate or have low education. They don't have any technical skills.

4. Risk of Floods:

Most severe problem that occurs with most of the projects are the risk of floods. As the study has been taken in northern areas, which is the mountainous region. So in the summer season, most of the plants become damaged with the flood. As there is no protection walls or stone crates for the projects, the projects become badly affected by the flood.

5. Community Involvement:

If a Project is not well understood, appreciated or adopted by the community, the sustainability of the project could be challenging. The worst scenario is that some of the hardware, which is implemented by the external donor agencies, are designed and have some technical features, which is new to the beneficiaries and then don't know how to use it. Study shows that in some of the projects, the hardware is left to deteriorate after project implementation, because the community is not interested or committed to the project, or doesn't have financial or technical capability to maintain it. Due to this, a well-designed, and well-structured project can be unsuccessful in reaching its overall objectives because the community was not involved from the beginning of the project.

6. Low Flow Rate:

In the winter season, when the temperature goes down, and the snow freezes on hills, the water flow rate reduces, which affects the power generation from MHPP's. In Charsadda where people use canal water for irrigation purposes, this low flow rate of water only usable for their irrigation and daily life purpose causes the shutdown of the project for a whole season.

7. Financial constraints:

The owners or operators, whose plants are affected by disasters or if any other technical issue appears, they are mostly poor and cannot afford the cost of civil and technical problems. They mainly rely on the locally available technical person who has not that much technical knowledge of power plants. While that of community-based organization have the manpower with technical expertise and have protection protocols that they follow to prevent any disasters.

8. Institutional Arrangement:

There is no such mechanism for the institutional arrangement to address the repairing and maintenance after the disasters or when needed. The community people with their own efforts deal with these issues.

D. Key Findings

- All the participants after a detailed discussion agreed on the point that community-owned projects are successful than community-based due to their management and monitoring factor. But lack of funds and maintenance and operational cost makes it difficult for the owners to sustain the project. An incentive or motivational scheme from the government will allow the COP projects owner a better approach for their project, which will eventually help its sustainability.
- Respondents after a long discussion concluded that community involvement is key factor for the success of any project. As it was clear from the research study also that many projects were failed due to not involving communities in their project decision making decisions. All the respondents agreed on the point that members of the community should be included in decision making regarding collection bills, operation and maintenance of the projects.
- Regarding the issue of collecting bills issue, the community members said that there should be some rules and regulation for collecting bills from household and giving power connection to the bills for inducing transparency in the system. They said they will talk to the concern authorities regarding this matter.

Conclusion & Recommendations

A. Conslusion

This Paper identified and analyze various factors that influence the community projects, with the comparative analysis between community based and community owned projects. For this purpose total of 29 projects has been selected for the research study in which 12 were community-owned projects and 17 were community based projects. Survey has been conducted for each project and people associated with the project and its beneficiaries are interviewed. Questionnaires has been distributed among the local communities. The Collected data has then analyzed with the help of SPSS tool and then be presented with the help of Tables. From the research study it has been concluded that the community based projects are more efficient than that of community owned projects, only if the projects are well managed.

While that of community owned projects are implemented by the community itself for their own needs and has been mostly managed and operated by themselves. During the study, it is observed that the community owned MHPP projects are not well designed but it has been well monitored and well managed by their owners, that's why community thought the COP project as more efficient than the CBP. But lack of funds and lack of education and skills, these community projects doesn't operational for long term. The maintenance from the local mechanic which are mostly unskilled and uneducated causes permanent damages to the structures. Flood and natural disaster also damages the project infrastructure, which sometimes causes the permanent shutdown of the project. Low flow rate is another issue which badly effects the project efficiency. Some of the project which are designed for the high flow rate of water, doesn't work on low flow rate, which causes to create a rift between community and project operators and people lose interest in the project and finding alternate for their needs.

The study also uses informal survey techniques. From the analysis it has also been concluded that there are some disputes happens on land proposed, low capacity generation to meet the demand of the community and lack of awareness among the community members are issues which effects the project activities. However, for the project sustainability and success, the cooperation of the community is a key element. If the above-mentioned problems are solved for both the community-owned and community-based projects, then these projects will be the success in future to come.

B. Recommendations

Following are the recommendations and guidelines that derived from the research study, and should be considered for the successful implementation of both types of community projects:

- Government should support communities in implementing MHP community projects, until the community became independent in a way that they can maintain and operate the project themselves.
- Community involvement should be escalated by giving project related reports to the communities as project beneficiaries.
- Local people who have necessary skills in project activities should be recruited with priority to serve the project.
- MHP Projects are financially and environmentally feasible and have high return rate, therefore the government should motivate people by providing an incentive to the private investors.
- An arrangement of proper institution is needed to tackle the issue of flood, low flow rate, maintenance of projects hardware.
- Government should provide technical trainings to the operator for operating and maintaining the project activities.
- Funds management is key element for the successful implementation of any community project. Project leaders and implementers should emphasize and undertake training on funds management.
- Awareness workshops, seminars and training should be provided to the community inhabitants to raise social awareness regarding need of MHP Projects in the communities, and the use of energy in a sustainable manner.
- Enough funds should be provided to the community-based projects, so that operating and maintenance of the project could not be a challenge for the community.
- Monitoring must be intensified by government officials and community leaders.

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Rooftop PV Systems Development in Khyber Pakhtunkhwa: Barriers and Smart Policy Recommendations

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Abstract— The world is faced with the global challenge of climate change and there are two approaches to mitigate the conditions. Decrease the usage of fossil-fuels and increase the contribution of renewable sources to the energy mix, to decrease the Green House Gases (GHG) and carbon footprints. Large solar PV system utilizes a lot of ground space and it poses a challenge to the congested urban centers. This study offers a solution by optimizing the rooftop space for solar PV system through geo-spatial analysis by using multiple modelling approaches satellite image digitization and Arc-GIS. Khyber Pakhtunkhwa is the target of study, where the energy demand-supply comparison and socio-economic analysis have been observed to find the technical barriers and policy barries in the light of existant renewable energy policy with recommendations for future planning.

Keywords— Solar Energy, Photovoltaic Powe System, Renewable Energy Technology, Geo-Spatial Analysis and Energy Management.

I. INTRODUCTION

The energy situations of Pakistan have seen the worst dip in the previous decade where the electricity had been not available to the domestic users for more than 12 hours. The statistics show that Pakistan had a total power generation capacity of 15kMW in the year 2010, whereas the requirement was more than 20kMW. For the time being, Government of Pakistan added many non-renewable energy sources that were dependent on fossil fuels and had an uncertain future of sustainability. Resultantly energy prices went up and it pushed Pakistan into the trap of circular debt in energy sector. Poor planning and no consideration for environment and sustainable approaches led to the catastrophe of worst smog condition. Poor policyshift and technical barriers have been the offshoot of an incosistenct energy market.

In all of the renewable energy sources, solar-PV is more suitable for the conditions of Pakistan. Geographically, Pakistan is located on the equator line with a daily average of 4.5kW/m² [1]. According to the Alternate Energy Development Board (AEDB), the total contribution of solar PV into the energy mix of Pakistan is less than 3% [2]. It is far lesser than other developing countries. Primary reason for this low usage is poor quality of solar PV systems and no data for optimization, modelling to derive a suitable policy for renewable energy. The modelling approaches used in this research are novel and proves to be a corner stone for larger optimization of solar PV system in Khyber Pakhtunkhwa. A satellite survey has been conducted using Google Earth Pro, the selected sites high resolution images were digitized using ArcGIS for rooftop space availability. A novel approach of using hill-shade analysis is used in combination with the the available rooftop space for solar PV after digitization. A total rooftop space model has been developed that is further utilized for economic analysis and a comparative policy recommendations.

A. Solar Irradiance

Solar Irradiance is the unit for calculating the power per square meter (W/m²) coming down as electromagnetic radiation to earth from the sun [3]. Irradiance is measured in space or may be at earth surface after absorption in atmosphere and scattering. Irradiance is a function of distance in space from the sun, known as the solar cycle. Irradiance depends on the tilt of the measuring tool on the earth's surface, the sun height above the horizon and the atmospheric conditions.

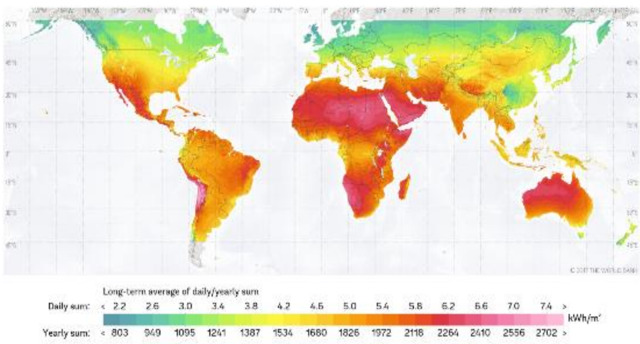

Figure 1. Global Horizontal Irradiance

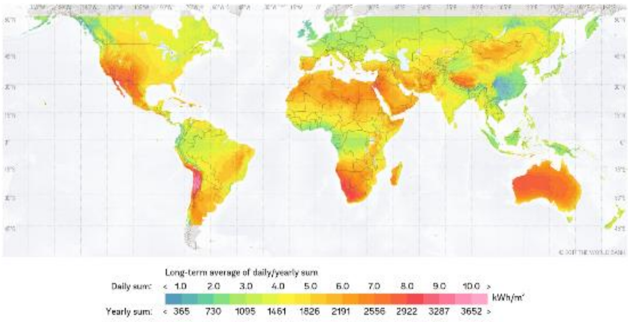

Figure 2. Global Direct Irradiance

Total Solar Irradiance is the sum of solar power at all wavelengths on the upper atmosphere of earth and is perpendicular to the sunlight. One Astronomical Unit (AU) is measure of solar constant.

B. Solar PV System

A Photovoltaic System is a combination of solar panels, in small and large scales, with inverters and other electrical and mechanical hardware, using solar energy to produce power. Solar PV System can be as small as a few panels array on a house rooftop and as large as giant power plants like Solar Parks i-e Quaid e Azam Solar Park in Bahawalpur, Pakistan [4], [5]. PV systems can operate as standalone systems in off grid locations or remote regions and also as grid-tied systems.

Solar energy is a kind of energy that is radiated in the sun light. It gets changed into electrical energy from light energy using the semiconductors, known as energy converters [6]. The converter in general terminology is called a solar cell. The solar photovoltaic are basically two types, light-heat generation and direct light generation.

Solar PV system use the solar cell module to generate electrical energy from solar irradiance. The solar module with the help of a power controller transfer the DC current to the inverter system, the inverter system converts the Direct Current (DC) to an Alternative Current (AC) which is then transmitted for the purpose required [7].

C. Solar Cell

These days there are different types of solar cells. There are different generation solar cells with variation in their structure, shape, durability and efficiency. Silicon based solar cells are widely used in solar modules because of their durability and comparatively mediocre efficiency [8]. The third-generation solar cells have higher efficiency but their durability is questionable. The principle of solar cell is, since it is a composition of semiconductor, the electron-hole nexus forms the potential difference in charge which allows the current to pass through, the current is collected and passed to the controller. The solar module is composed of many solar cells, in series and parallel combination which makes it stronger and effective [9].

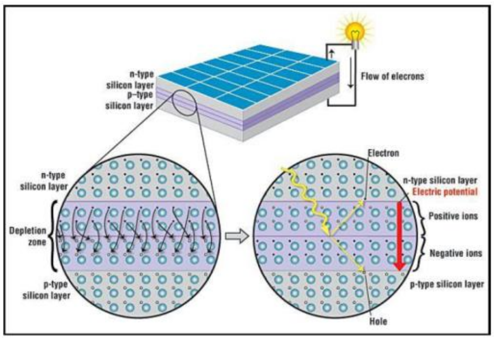

Figure 3. Solar PV Cell

These are various types of solar cells:

- Amorphous Silicon solar cell (a-Si)
- Biohybrid solar cell.
- Cadmium telluride solar cell (CdTe)
- Concentrated PV cell (CVP and HCVP)
- Copper indium gallium selenide solar cells (CI(G)S)
- Crystalline silicon solar cell (c-Si)
- Float-zone silicon.
- Dye-sensitized solar cell (DSSC)

Crystalline Silicon Solar Cell has dominated the world market share of solar cells. C-Si are the most used in commercially available solar panels, having about 85% of the market share with efficiency conversion of about 20% for polycrystalline cells [10]. There are mono-crystalline and poly-crystalline silicon solar cell. Solar Cells made of crystalline silicon are also called traditional, conventional or first-generation solar cells. The crystalline silicon (c-Si) solar cells are single junction cells and more efficient than their rivals second generation thin-film solar cells.

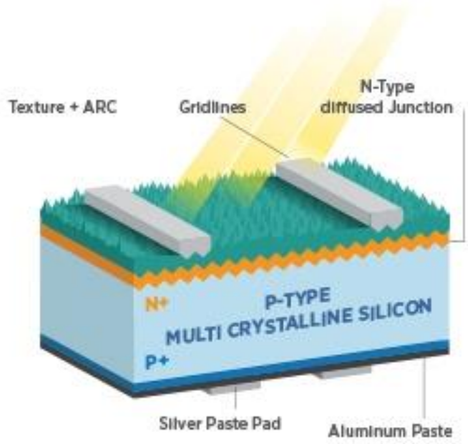

Figure 4. P-Type Crystalline Silicon

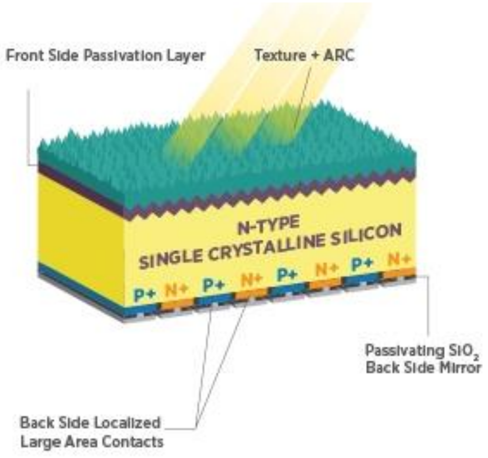

Figure 5. N Type Single Crystalline Silicon

D. Types of Solar PV Systems

a. On-Grid Solar PV System

Over the times, advancements have been in solar energy technology, that its use has become inevitable. One of the major and widely chosen type of solar system is the on-grid solar system. The on-grid solar power system is a generation plant which is connected to the main grid. The power generated from the system is directly transferred to the grid which is then used by the consumers at distribution end. At any time, the power that is exceeding the requirement is transferred back to the grid. Usually the on-grid solar system is preferred more than off-grid due to the grid connection and easy operation.

The on-grid solar system works in two directions, the power generated by the plant is transmitted to the consumer's home through the grid, and also in back direction from the consumer's solar system to the grid. It makes the on-grid solar system highly useful with the net-metering to measure the net-cost of the electricity. The operation at the consumer end is the same as that of a solar power plant, the solar panels transfers DC power to the inverter which is then feed to the grid in AC power.

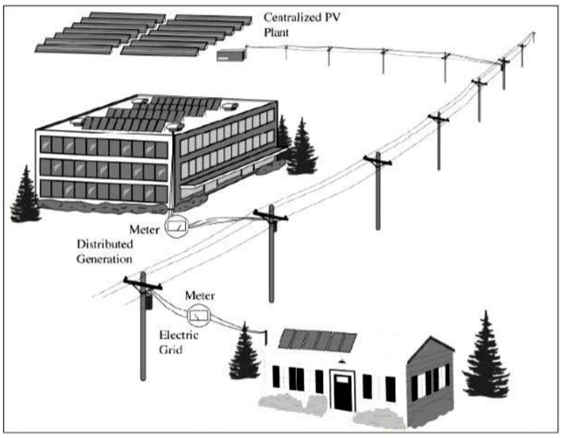

Figure 6. On-Grid Solar PV System

b. Off-Grid Solar PV System

Off-Grid solar system is another type of the solar power systems, it is also called stand-alone power system (SAPS) due to its independent operation. The off-grid solar system generates power from solar panels, and charge the batteries through controller. Inverter system is used for converting the Direct Current (DC) to Alternating Current (AC) for the usage purpose at home. Batteries are used so that there is non stop power supply even at night time, when the solar panels stop working or at times where the solar irradiance is less.

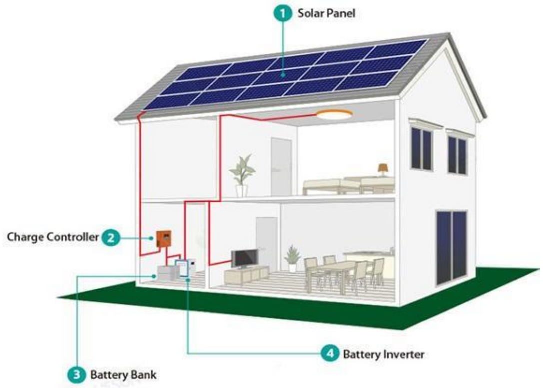

Figure 7. Off-Grid Solar PV System

c. Hybrid Solar Power System

As the name suggests, hybrid solar power system is a combination of different generation sources and produce power in same fashion as that of an on-grid solar system but the difference is mainly in inverters, instead of the normal inverters, hybrid inverters are used and the battery bank store energy for later use, also operate as the backup supply in case of blackout, similar to the uninterrupted power supply system (UPS).

Conventionally, the hybrid refers to two generation sources like solar or wind, however it is observed that in the solar world, the hybrid refers to a combination of solar and many other energy sources, that are also connected to the grid.

Figure 8. Hybrid Solar PV System

E. Energy Policy

The energy policy of Pakistan is planned and formulated by the federal, provincial, and local institutional elements in Pakistan, which address the issues of energy production, distribution, and utilization of energy, for example, gas mileage and oil guidelines. Energy policy requires the best possible enactment, universal bargains, appropriations and motivators to venture, rules for energy conservation, tax collection and other open policy procedures.

II. Methodology

The trickiest part of the research was the assessment of locations to be picked for detail solar irradiance estimation. Khyber Pakhtunkhwa's energy demands and relationship of Socio-Economic structure and the cost of energy. Since Khyber Pakhtunkhwa lies in the North West of Pakistan, and is a longitudinal province with variance in elevation and solar irradiance, it was deemed feasible to pick multiple locations for detailed analysis. Ideally the entire province estimation is possible but not practically due to lack of resources and accessibility.

A. Peshawar

Peshawar is the capital city of Pakhtunkhwa; it is very large and getting a high-resolution satellite image of the entire city for digitization is nearly impossible, therefore, Hayatabad was selected for a detailed and specific location.

B. Mardan

Mardan is one of the major cities of the province and contributes about second largest share to the revenue of the province, it is ideal for being a home to second biggest division in the Peshawar Valley, having a diverse population and a symmetrical housing society.

After selection of these locations, a geographic survey was conducted on Google Earth Pro software, to target the particular location, that has all the specifications required for this study. After a detailed survey of the geographic high resolution and update maps of these locations, a target location was selected in all regions.

The target location had the following specifications:

- Symmetrical buildings, having similar image patterns and shapes of the rooftops.
- Close knitted houses, for an accurate measurement and estimation.
- Widely known housing societies or townships, being home to a mixture of socio-economic classes.
- Standardized buildings and proper gaps for less shadow effect.
- Areas connected to National Grid for Net Metering.
- Off Grid for Remote Areas as an alternative solution.

C. Solar Irradiance

After extracting the total rooftop area of the targeted regions, it was deemed fit to further estimate for the available solar irradiance in these regions. For this purpose, SolarGIS was used to extract data of these regions, the data included the following main specifications.

- Avg PVout with Annual Irradiance details
- Temperature Charts
- Population Density
- Elevation

The SolarGIS maps intercorporate into the already available ArcGIS data for a detailed analysis of the region, in the light of solar PV-out estimation, in kW per day. Now after extracting the rooftop solar PV out data of the targeted locations, the software PVsyst was used for proposing a solar PV system that suits the conditions of the location. For this purpose, the coordinates of these locations were used as target locations and the software analyzed an ideal 2kW system for all the rooftops, given the average area available.

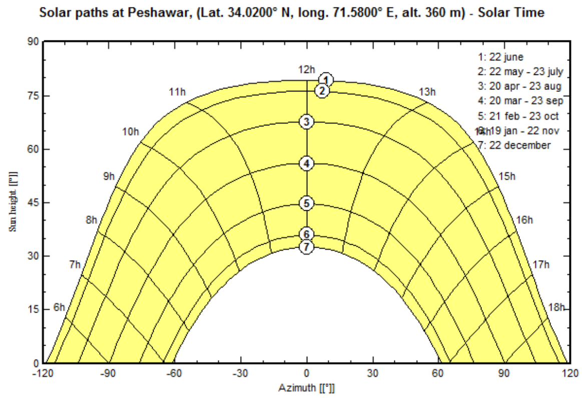

Figure 9. Solar Path in Peshawar using PVSyst

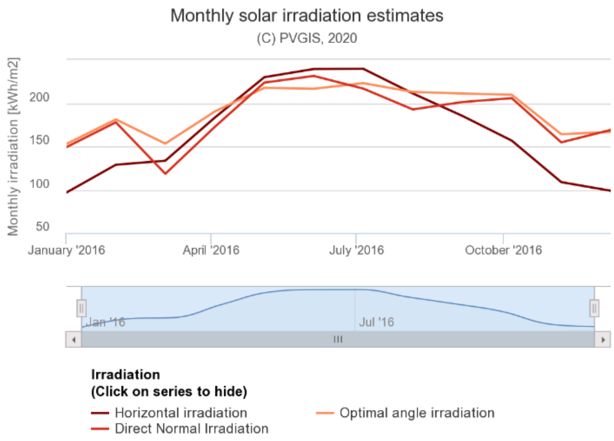

Figure 10. Monthly solar Irradiance estimation

III. Results

The simulation results show the irradiance in the targeted locations with technical specifications that there is a profound rooftop solar PV potential available in Khyber Pakhtunkhwa, as shown in the results of figures and estimates. The government of Khyber Pakhtunkhwa should show serious attitude in the drafting of a smart policy in the light of given technical specifications and empirical approach to meet the energy market.

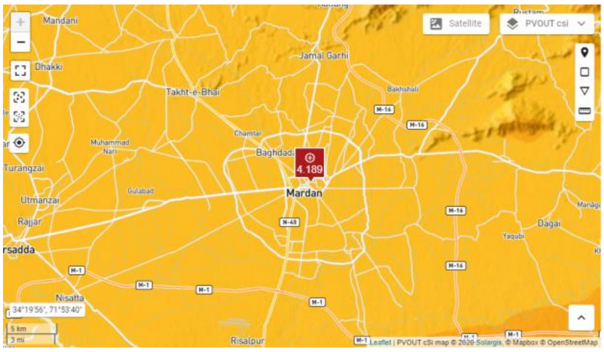

Figure 11. Solar Irradiance Map of Mardan

The above figure is an image of Solar GIS projecting the PV potential of the District Mardan and the surrounding regions, that is about the same 4.1 kWh per day. The city of Mardan lies on the bank of a river named Kalpani, however there is less to none hydroelectric infrastructure. Mardan has developed a lot in the recent past and it contributes the second highest revenue to the provincial exchequer, but still the average family income is pretty low, out of many factors, expensive energy is one. If the cost of energy is decreased by any mean, Mardan has the potential of rising the socio-economic graphs. To project these, a sample location of Sheikh Maltoon Town is selected for digitization.

TABLE 1. SPECIFICATION OF TARGETED LOCATION IN MARDAN

Area	Size (m^2)
1 Kanal	504
10 Marla	252
7 Marla	180
5 Marla	126

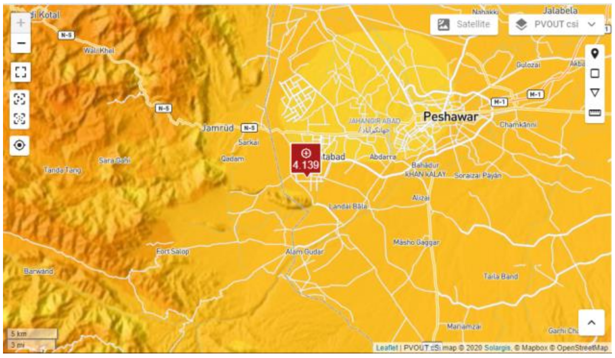

Figure 12. Solar Irradiance Map of Peshawar

The above fig. 12 is a SolarGIS image of Peshawar and the surrounding region, showing solar PV-out potential per sq-meter area, that is about 4.139 kWh/m^2. This location is further simulated for digitization of available rooftop PV potential.

It is the only sector in the entire Hayatabad city that is vastly populated and has fewer empty plots. Empty plots in our case is a waste of area because they are not feasible for installation of a PV system due to shadow effect from the side buildings. A survey visit was conducted to the selected location, the physical investigations found that most of the homes built in this location are fully covered, that indicates that the area of rooftops are mostly equivalent to that of the entire plot but still delicate estimations are made in this study to further increase the accuracy of the study.

Figure 13. Sample digitized rooftop space in Peshawar

The yellow line in Fig. 13 indicates the total area of single roof while the red line indicates the area required for PV system. I have digitized few roofs as sample to be applied over the entire sector. ARC-GIS software is used to digitize the rooftops to figure out the topography of the area.

TABLE 2. SPECIFICATION OF TARGETED LOCATION IN PESHAWAR

Features	Scale
No of Plots (5 Marla)	880
No of Rooftops	748
Avg Rooftop Area (m^2)	74
Total Rooftop Area (m^2)	55,352

In the above given tab. 1 and tab. 2 the specification of targeted locations in terms of rooftop places available has been specified. It shows that both the major urban centers of Khyber Pakhtunkhwa have good enough potential available. Only the targeted urban centers have shown a great solar PV potential available with the technical features and feasibility.

The tab. 3 suggests the technical specification of the targeted location in terms of the slope angle for titlted PV array and the azimuth and angle for maximum efficiency. The yearly PV average has also been indicated.

TABLE 3. TECHNICAL SPECIFICATION OF LOCATION

Features	Scale
Slope Angle	34 (opt)
Azimuth Angle	-7 (opt)
Yearly PV Energy	1490 kWh
Yearly In-plane irradiation	2110 kWh/m^2

In the tab. 4 the cost of a solar PV system with current marker prices have been indicated for the full scale optimization, and the payback periof of upto 5 years have been calculated with the current price of electricity ratio to the cost of solar PV system.

TABLE 4. COST OF SOLAR PV SYSTEM

Sr. No	Component	Cost ($) / watt
1	Solar PV Module	0.5
2	Inverter	0.25
3	Installation Cost	0.3

CONFLICT OF INTEREST

The authors have claimed no conflict of interest in this research article by the authors.

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Afraz Ahmad and Owais Ahmad dedicate this research study to the great Mardan Association, that has been part of all the hurdles we faced while going through this novel and enlightened journey of research. We specifically appreciate the role of Engr. Sheraz Khan, Engr. Kamran Khan and Engr. Rashid Mahmood and the prestigious institution of Center for Advance Studies in Energy (CAS-E), UET Peshawar.

CONCLUSION

After simulation and estimation, it has been concluded that a small part of the rooftop is selected, and a great amount of energy can be produced through these small portions. Each rooftop average area is 75 sq. meter and a system of 2kW covers up to 30 sq. meter area, producing on average 8.8 kilo watt-hour energy daily for the proposed system.PV potential from Hayatabad Phase-6 F-6 sector house's rooftops is sought out in this study. Also, it provides a detailed insight of PV energy potential. The main outputs from this study, estimation of solar irradiance through simulation in study area, and the total energy potential available on the rooftops of the study area. In this study, we found that there is a great amount of photovoltaic potential available for electricity production on the rooftops of Hayatabad F-6 sector, that is 2,453,450 kWh annually. In comparison to the energy consumption of this sector, it is approximately 60% of total energy consumption of this sector. And there is still good enough space for further upgradation of system on the rooftop.

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Design, Performance and Feasibility Assessment of Solar PV System for Irrigation

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Abstract— The energy crisis in Pakistan is a very major problem. The energy sector play a vital role in prospering the country. In Pakistan, the 10% of the total power and more is only consumed by Agriculture. The shortage of power greatly effects the food production. It was reported in "Pakistan Social and Living Standard Measurement" that almost seventeen out of every hundred households face food insecurity (moderate to severe). With the increasement in population, the problem may get worse and the country needs to take proper measure to make the food-sector self-supporting in terms of power. It is inevitable to use Solar PV system for agriculture sector in a country where the solar irradiance is in high number. In this study, the Solar PV system is used for irrigation of wheat field, the system Performance Ratio (PR), and the system loss diagram which showed all the major and minor loss throughout the process and in the end, the Life Cycle Cost Analysis (LCCA) has been done. So that the proper incite is given the reader by comparing both the Diesel Operated Irrigation System (DOIS) and Solar PV Irrigation System (SPIS). By adopting the method discussed in the research, the Power Sector which consume more than 10% will bring down the percentage with significant point and this 10% can be then used for other productivity. The food shortage and high food prices may also be reduced.

Keywords— Solar PV Irrigation System (SPIS), Renewable Energy, Energy, Agriculture.

I. Introduction

Pakistan is an agriculture country and the contribution of agriculture in economy is wide. In other words, the country can speedily prosper her economic position if the agriculture sector get develop but unfortunately, the farmers use regular watering methods to water their plant, which consume more power and are less efficient. Consequently, it will be inevitable to change from regular watering method to the renewable energy watering methods.

Pakistan is blessed with lot of solar irradiation. And the use of solar power in watering method is the need of time: for example, population [1]. Pakistan is the fastest growing population in South Asia and the world's 5th populace country. To mitigate the food and power shortage in near future, Pakistan needs to take serious steps to overcome this problem [2]. It is pertinent to mention that Agriculture sector in Pakistan consume 10% of whole power and contribute 19% to GDP of the country [3].

Pakistan has installed solar PV system in irrigation in some areas of Punjab province. But due to poor feasibility assessment, untrained farmers, the system was not efficient and sustainable. And the farmers were not able to get full benefits out of it. In this paper, an example of Solar Power System in irrigation installed at Punjab Province of Pakistan will be elaborated. The purpose of this study is to research the problem faced to the farmers and non-efficient use of Solar PV System in irrigation.

II. Literature Review

In Pakistan, Solar PV system in irrigation should be used and Government of Punjab has also given subsidy to farmer at some time, for up to 80% to be used as an alternative of diesel operated irrigation because of the reasons: non-reliability of fossil fuels, longer life, and cost effectiveness.

In remote areas of Pakistan, which is manly off-grid. Solar PV system in irrigation is appropriate choice. As Pakistan is blessed with high solar irradiation. Solar powered water pumping systems have the ability to distribute drinking water without any type of additional power or the complicated upkeep. solar PV system for irrigation could be regarded as being large-scale. However, Photovoltaic solar panels are frequently utilized to perform various agricultural operations. In distant regions or in areas in which the utilization of an alternative energy sources is better. In short, the solar powered water pumping systems have been established in the course of the some past few years. And to consistently generate an adequate amount of electricity straight from solar irradiation in order to deliver water for animals. As it is true that Solar PV system for Large irrigation area require huge sum of money but that initial cost can be repay back in short time. It can be concluded that, solar PV system is best alternative of diesel operated water pumps for irrigation [4].

Particularly in drip irrigation system, where the water has to reach at other corner of the large farm, say 22 acres. The length of pipes, diameter of pipes, curves and restraints, like for instance, valves in the pipes they all have a very significant effect on the pressure. And that should be thoroughly calculated before installation, in order to maintain a constant flow for the crops. The loss of pressure or pressure-loss, can be minimized by considering the proper length of pipes, proper diameter of pipes, minimize curves and reduce the number of restraints as possible.

In system curve vs pump curve graph, we can see the operating point can be shifted by introducing constraints like valves etc. to the flow of water.

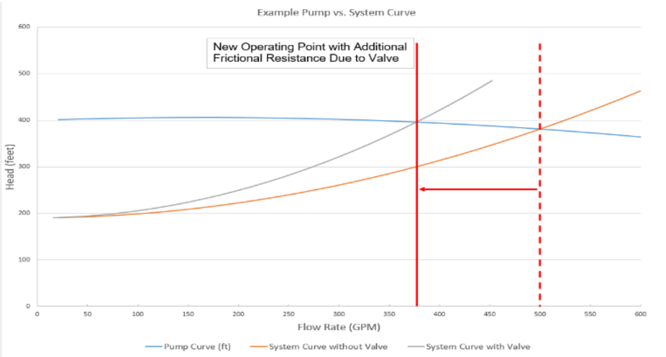

Figure 1 Pump vs System Curve

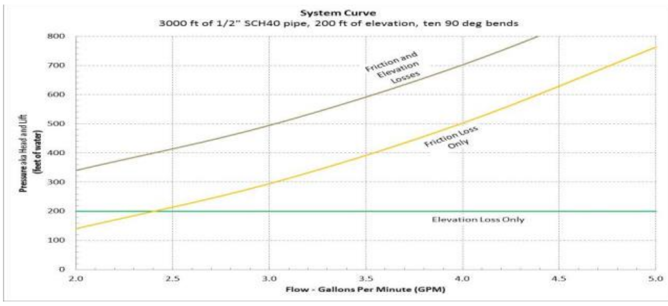

Figure 2 system curve

A. Flow

We use the word flow not only for liquid, but for gas and electricity too. Flow is the moving of liquid or gas in regular manner. Here in this research, flow is use for the flow of water in a solar PV system for irrigation. It usually denoted in Gallons per minute (GPM) of gallons per hour (GPH). The relation of pressure with flow is inverse, an increase of pressure will decreases the flow and vice versa [5].

The relation of pressure and flow can be adjusted and tuned depending on the need of reach. If we increase the pressure in order to the reach the other end of the farm, the flow will be reduces and diameter of pipe will also be reduced at that end.

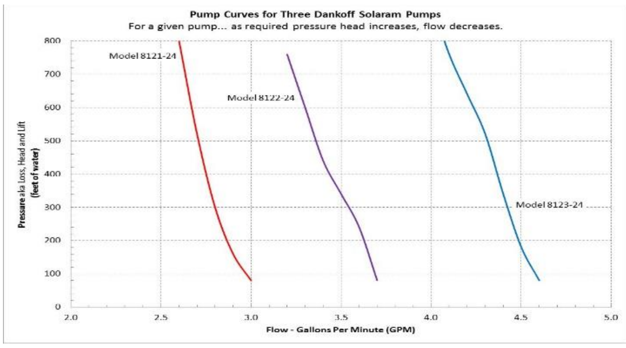

Figure 3 Flow variable in the solar powered water pumping system.

By Joining the pump and system curves help us in forecasting that whether the pump will do its function properly as desired or not. If we have the data of curves and all the plumbing system, by changing the flow rate we will get our operated point. The three pumps will deliver 2.75, 3.3, and 4.1 GPM correspondingly [6].

III. METHODOLOGY

A. Data Collection

Data was collected mainly through internet from verified and official national and international websites, for example:

- Alternate Energy Devolvement Board Pakistan (AEDB)
- Pakistan Agriculture Research Council (PARC)
- World Bank, Asian Development Bank (ADB)
- Different Punjab Government websites for renewable energy data
- Water Aid Globally
- Pakistan Council of Research in Water Resources (PCRWR).

B. Statistical data

Which are comprised of quantifiable data and are mainly associated with:

Climate of the subject area: 1, rain data. 2, temperature data. 3, humidity in the concerned area

- Global horizontal irradiation in Pakistan,
- Sunset and sunrise time, in other words. Length of day,
- peak solar hours
- population of the area
- Current food ratio in Pakistan, and future predicted food crisis data.

Past papers were studied based on solar PV system for irrigation. Data was collected from

- Ministry of National Food Security and Research (MNFSR)
- Pakistan Agricultural & Research Council (PARC)

- Read different research papers and websites on solar PV

Furthermore, parallel with data collection from internet a field visit was also conducted at Punjab where the solar PV system was already installed at some fields by Punjab Government, Pakistan, giving 80% subsidy.

C. Process and Refinement of Data

The data that was collected from different sources were gathered and analyze. Some of the data which was useful were further refined to the desirable statistical data. The solar Panels that were installed in different fields in remote areas of Punjab was get to known i.e. Yingli solar. This is a company solar manufacturing Chinese company. In our PVsyst simulation, same Yingli solar has been used to get the practical inclined results.

Figure 4 Solar Power Nameplate

As different place have different water depth and different water need. Based on the crops, season (time of year), altitude, temperature, and humidity in the air [6]. The average Water depth was selected and the area was selected Punjab.

Tilt for summer and winter was also calculated based on the latitude of Punjab –Pakistan.

D. Analysis of Computer Simulated Results

Its detailed analysis based on its performance and economic investigation that will help the country in agriculture, alternative energy and food sector.

E. Visit data

A wheat field in Punjab was selected. Where the drip irrigation was installed for wheat field. It was single time investment. The payback was calculated, which was 6 years.

The field was 22 acres. Two motors were installed one was 4 kW and another was 7.5 kW.

For 4 kw, the PV system which was installed has output power of 5.4 kw. The margin which was left was 1.4 kW for cloudy days and undesired situation

I. for Pump 1:

There were two foundation. Foundation 1 has 8 solar PV Panels each of 320 watts. And on foundation 2 has 10 solar PV Panels each of the 320 same voltage. Combine, they were giving the output power of 5760 watts. The motor pump which was installed for irrigation was of 4 kW.

Figure 5 Pump 1 specification

The first foundation was giving a total output power of 5760 watts. The pump Siemens 1le10021ba234aa4 can easily be run by the installed 1st foundation. The extra 1760 were left for the situations like cloud and dust, in which the output power reduce.

For Pump 2:

There were four foundations as the pump needed relatively more power than the first one. Foundation 1 and 3 has 6 solar PV Panels each of 320 watts.

And on foundation 2 and 4 has 10 solar PV Panels each of the 320 same voltage.

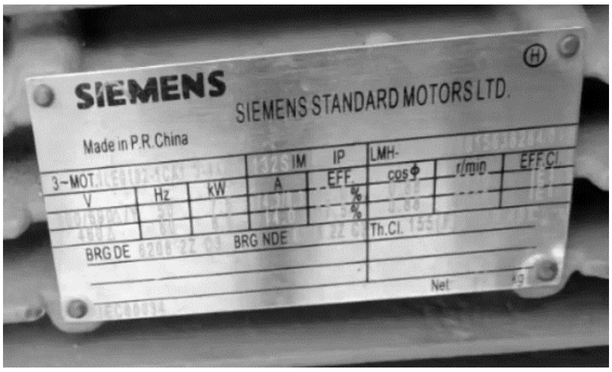

Figure 6 Pump 2 specification

Combine they were giving the output power of 10240 watts. The motor pump which was installed for irrigation was of 8.6 kW.

The first foundation was giving a total output power of 10240 watts. The pump Siemens 1LE0102-1CA1-8.6kw can be easily be run by the installed 2nd foundation. The extra 1640 were left for the situations like cloud and dust, in which the output power reduce so that the pump does not lag behind.

The polycrystlaine solar panels from yingli solar were installed. The characteristic and quantity is given below Table.1 in tabular form.

All the wiring was done underground. The total cost of the installed setup was approcimately 1.5 Million Pakistani Rupees. From the visit the researcher got the data that later used in computer simulation through PVSyst.

Table 1 Characteristic of Yingli Solar Panel 360 Watt

Characteristic	quantity
TC Power Rating	320W
PTC Power Rating	298.3W 1
STC Power per unit of area	15.3W/ft2 (164.9W/m2)
Peak Efficiency	16.49%
Power Tolerances	0%/+5%
Number of Cells	72
Nominal Voltage not applicable in this type	
I MP	8.64A
V mp	37V
I sc	9.18A
V oc	46V
NOCT	46°C
Series Fuse Rating	15A
Maximum System Voltage	1000V

For simulation in computer, there were some data obtained from different sources as discussed already in portion of data collection. Peshawar Valley was selected for simulation [7].

CONCLUSION

The data obtained from the farm where the Solar PV system for irrigation installed at farm was compared to the results of the simulation results obtained from PVsyst software by running the system of the same specifications. The problem identified (i.e increase in the volume of storage tank, shaded effect) above was rectified by following the recommendation of the software which consequently resulted in increment of the efficiency. It was identified that if following the recommendation the per unit cost of solar power is way cheaper than the diesel operated irrigation system and can further be reduced. The pay back period was calculated as 14 years.

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Measuring Access to Energy in Rural Areas of Pakistan: A Multi-Tier Framework Approach

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Abstract— The prosperity and living standard of any nation depends on the amount and quality of energy services they are using. The introduction of new technologies and high performance appliances have very much improved the life style as well the economic conditions of people. But still there are many remote areas which are lacking access to clean energy, and most of those are rural areas. This work is focused on northern areas of Pakistan being electrified by off grid systems, mostly Micro Hydro-Projects (MHPs). We have evaluated the World Bank's Multi-Tier Framework (MTF) for measuring the household electricity access because the traditional binary indicators are not accurate and might be misleading in some cases. Data from surveys and interviews is used for the targeted areas where Micro Hydro Projects (MHPs) are installed by government as well as national and foreign funding agencies. This study has shown the energy access conditions in Shangla, Kalam and Chitral areas of Pakistan by using a Multi-Tier Framework approach. It has also tried to explain that MTF addresses multiple objectives and it declares that access to energy measurement is highly sensitive to any changes in data availability and parameter values. We have also discussed some of the observations and limitations of this framework that needs some improvement for its application in future.

Keywords— Access to energy, Household Electricity Access, Micro Hydro Projects (MHPs), Multi-Tier Framework (MTF).

I. Introduction

About 1.2 billion people in the world do not have access to modern electricity according to a report shared by International Energy Agency in 2015. Also it is expected that about 1 billion people will not be able to access to energy modern energy services by 2030 particularly in rural regions due to growth and underdevelopment in energy infrastructure [1]. According to the statistics available, around 95% of the population living without electricity access are located in Sub-Saharan Africa/Asia and majority of them are located in rural areas [2]. Beside the fact that electricity can create conditions for economic development, it is also required for basic human needs and economic activities [3]. A majority of studies taken place all around the world suggest a strong relation between access to energy and rural poverty, also this relation is due to the fact that electricity is required for all productive activities [4]. Due to no access to modern, safe and reliable energy services, people in rural areas usually suffer considereing education, health and economic issues [5]. This means eradicating energy poverty is closely related to eradicating poverty as a whole.

II. Pakistan Energy Scenario

Power sector of Pakistan is a developing market, the gap between demand and supply has been an unresolved issue from years [6]. The demand for electrical energy is increasing day by day. The installed electrical power generation capacity in 2015 was 23.8 GW, but the actual generation was always less than this number which was about 106,966 GWh, where as the demand was ominously high than this number [7]. The growth rate of electrical power demand in Pakistan is close to 8% each [20]. At present, the generation of electricity comprises of indigenous natural gas (26.5%), oil (36.8%), hydel (30.4%) and 6.2% others including coal, renewable and nuclear [7]. If we scrutinize this mix, it shows that it has a huge burden on Pakistan's economy due to hydrocarbon imports, also some serious threats to this mix are due to rapidly shrinking domestic gas reserves, which contributes a major portion to electricity generation [8]. The exhaustion of these natural resources and the growing demand of energy have forced national planners as well as policy makers to opt for renewable energy sources and off-grid energy solutions [9]. The lack of access to energy is mostly in the rural and remote areas because there are many challenges involved in connecting those areas with grid. The purpose of this study to indicate those challenges and show how effective off-grid solutions can be, in those areas by measuring access of electricity through applying a Multi-Tier Framework approach.

III. WHY MULTI-TIER FRAMEWORK (MTF)

Access to electricity is usually measured through binary indicator, which shows whether a community have a grid connection or not, but this information is not enough to measure the exact level of energy access and we need some specialized tool or framework that answer questions like

1. What does it mean to have access to electricity?

2. Is this access sufficient for that area?
3. Is this provided services are of desired quality and quantity?
4. Is it reliable and affordable for the people living in those communities?
5. What are the gaps in energy access?
6. How to design the right metrics to measure it?

Many international agencies and organization have been working to design a tool that answer these questions. One the framework is developed by Energy Sector Management Assistance Program (ESMAP) working under World Bank, known as Multi-Tier Framework (MTF). This framework uses different dimensions known as attributes and those are:

1. Capacity
2. Availablility
3. Reliability
4. Quality
5. Affordability
6. Legality/Formality
7. Health and Safety

These attributes can be categorize into different tiers ranging from Tier 0 to Tier 5 with Tier 0 being the lowest, as shown in Figure 1. MTF is designed to transition from simple surveys that focus on binary measurements and outcomes to more comprehensive data collection methods. The assignment of tier and these attributes are aggregated by some rules and decisions in order to determine the overall assignment of the tier which further defines the level of access of electricity getting by a household. The framework scores participants across tiers and tells us about the situation of access to energy in applied areas.

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3[b]	TIER 4	TIER 5
Capacity	Power capacity ratings	Less than 3 W	At least 3 W	At least 50 W	At least 200 W	At least 800 W	At least 2 kW
	(W or daily Wh)	Less than 12 Wh	At least 12 Wh	At least 200 Wh	At least 1 kWh	At least 3.4 kWh	At least 8.2 kWh
	Services		Lighting of 1,000 lmhr per day	Electrical lighting, air circulation, television, and phone charging are possible			
Availability[a]	Daily Availability	Less than 4 hours	At least 4 hours		At least 8 hours	At least 16 hours	At least 23 hours
	Evening Availability	Less than 1 hour	At least 1 hour	At least 2 hours	At least 3 hours	At least 4 hours	
Reliability		More than 14 disruptions per week			At most 14 disruptions per week or At most 3 disruptions per week with total duration of more than 2 hours"	(> 3 to 14 disruptions / week) or ≤ 3 disruptions / week with > 2 hours of outage	At most 3 disruptions per week with total duration of less than 2 hours
Quality		Household experiences voltage problems that damage appliances				Voltage problems do not affect the use of desired appliances	
Affordability		Cost of a standard consumption package of 365 kWh per year is more than 5% of household income			Cost of a standard consumption package of 365 kWh per year is less than 5% of household income		
Formality		No bill payments made for the use of electricity				Bill is paid to the utility, prepaid card seller, or authorized representative	
Health and Safety		Serious or fatal accidents due to electricity connection				Absence of past accidents	

Figure 1: Multi-Tier Framework (MTF)

Figure 2 and 3 shows two studies carried out in Kinshasa, Congo and Ahmara Region, Ethiopia respectively [10]. These figures show measurement of access to electricity both by binary indicators as well as using MTF. The binary definition shows that Kinshasa area is 91% electrified, that means 91% of the population have access to electricity services. Out of this 91% population, 88% are connected to grid whereas 3% are connected to other electricity services. The rest 9% population are living without the access to any grid or off grid electricity supply. Now if we look at the MTF measurement, we can see that 46% of the population having access to electricity according to binary definition are placed in Tier 1, which means either they are not getting electricity in their connection line or the supply is for insufficient hours, 50% of the electrified population are in Tier 2, this also shows either the supply is for insufficient hours or they are facing some quality issues. Only 4% of population are in higher tiers which is tier 3 or above. The study in Ahmara Region, Ethiopia shows that according to binary definition, 94% of the population have access to electricity while only 6% of population are lacking access whereas MTF results show that 49% out of the total electrified population are in Tier 0. 1% of the electrified population is in Tier 1, 22% is in Tier 2 and the rest are in Tier 3 or above.

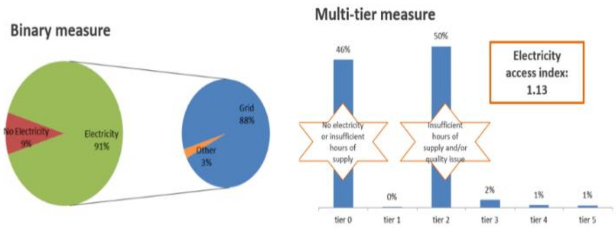

Figure 2: MTF at Kinshasa, Congo

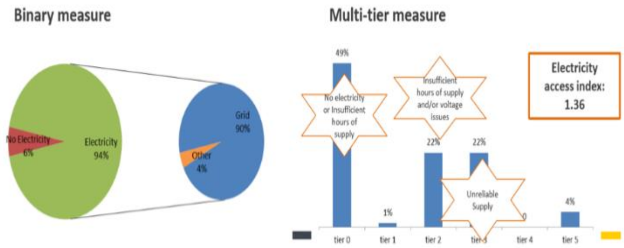

Figure 3: MTF at Ahmara Region, Ethiopia

IV. Applying MTF in Northerner Areas of Pakistan

Energy now a days is the basic need of life and is required both by urban as well as rural population. Two Third of the population in Pakistan is electrified or have access to electrical energy services and only 20 percent population have access to gas [11]. The remaining one third population with no electricity are mostly living in rural areas where either there is no national grid connection or people cannot afford it [11]. These statistics show that one third of population in Pakistan is living difficult and below standard life because this is the age of modern technologies and electricity is required for almost everything. Northern areas of Pakistan are the challenging part of country when we talk about access to reliable energy sources. Most of these areas are not connected to national grid and hence provincial government of Khyber Pakhtunkhwa initiated off-grid energy projects with the help of different national and international funding agencies. Most of them include Micro Hydro Projects (MHPs) because of a huge potential of such projects in those areas. For this study we have gathered data from Shangla District, Kalam Valley, and Chitral district of Khyber Pakhtunkhwa to measure the level of access to electricity provided by off-grid projects with the help of MTF. The selected districts cover a very large area and getting data from whole areas is very difficult, so rather a sampling technique was used in getting data. The technique was designed in such a way to gather maximum possible data for which we divided each village in different neighbourhoods and data was collected in some neighborhoods of every village. The same data was assumed for other neighborhoods with same (or nearly the same) population and conditions of access to electricity. In this way we were able to get maximum data required for applying MTF.

A. SHANGLA

Shangla is a district located in Malakand Division Khyber Pakhtunkhwa (KPK) province of Pakistan. A total of 120 households were surveyed in different union councils of Alpuri. 87% of the households were electrified whereas 13% lack an electricity connection (figure 4). The electrified households include electricity connections from national grid (33.4%), MHPS (60.67%) and MHPS as well as national grid (6%) as shown in figure 5

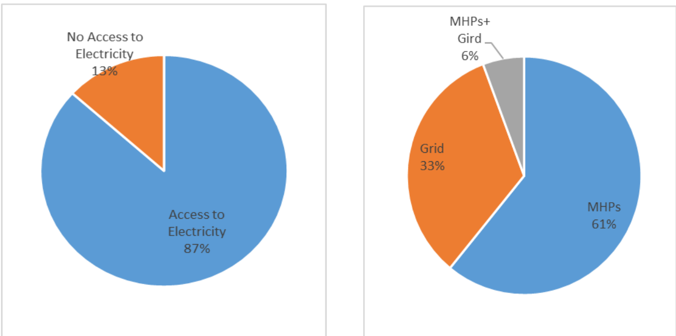

Figure 4: Access to Electricity at SHANGLA

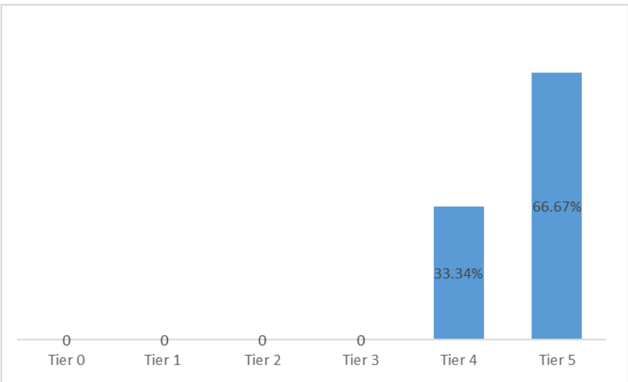

Figure 5: MTF at SHANGLA

The supply of electricity by off-grid sources was constant and there was no scheduled load shedding. The areas connected to MHPs were receiving electricity for almost 24 hours. However, the households connected to national grid were facing load shedding of 6-8 hours (including 2-3 hours in evening) in 24 hours. Based on these numbers the households connected to MHPs or both national grid and MHPs which are 66.67% of the total electrified households, can be placed in tier 5 whereas the rest 33.34% of the electrified households connected to national grid can be placed in tier 4 as shown in the figure 5. All the remaining attributes were fulfilling the minimum requirements to be placed in Tier 5.

B. KALAM

Kalam is a famous and beautiful place located in the northern side of Swat valley of KPK province, Pakistan. Its mountainous territory has many water streams which has the potential to generate electricity using hydro turbines. The whole Kalam valley is electrified by MHPs. Before the implementation of MHPs in Kalam, WAPDA which a government body responsible for water and power services in Pakistan, was responsible to supply electricity to the whole area. Electricity supply by WAPDA was not satisfactory and electricity services were provided only for few hours. Two major parts of Kalam including Ashuran and Jungle Inn were targeted for data collection and data for about 100 households was collected and used to apply in the MTF. As the area of Kalam have extreme winter conditions due to snow fall, most of the population migrate to plain areas in winters whereas in summers the population density becomes high and hence increases overall electrical load of the area. In winters, short-circuit problems occur quiet often while in summers 4-5 disruptions per month occur. The availability of electricity is almost for 22 hours including more than 4 hours in evening.

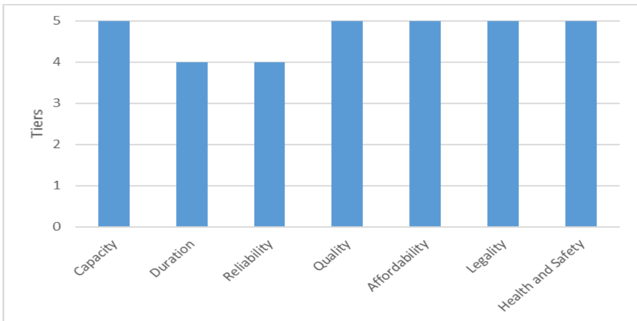

Figure 6: MTF at KALAM

There are no quality problems like voltage spikes, tariffs are highly affordable, no electricity theft found, people can run the appliances they own and also, no accident or health problems happened because of the services provided by off-grid projects. Based on analysis of data only duration and reliability attributes can be placed in Tier 4 while the remaining can be referred as Tier 5 attributes as shown in figure 6.

C. CHITRAL

Chitral is area wise, the largest district of Khyber Pakhtunkhwa Province in Pakistan covering an area of about 14,850 Sq. kilometers. As it is a large district with a high population rate, only few sites and villages were selected for conducting survey according to the sampling criteria. A total of 100 household's data was collected out of which only 18% households were not able of having electricity connection as shown in figure 7. Different sites like Ayun, Jingiret (Nagar Gol), Golin Payeen, Kuji Bala, Moroi Payeen and also 1 MW WAPDA hydro plant were encountered while conducting the survey.

In Chitral, the electricity is supplied both by national grid as well as different MHPs, although there are some parts where electricity is only provided by MHPs. While surveying, it was found that households connected to one of the off-grid projects, faces the problem of restriction on use of certain appliances and were allowed to use only lights and very small power appliances but this population only accounts to 10% of the total electrified area. This 10% area can be placed in Tier 1 for capacity attribute whereas the rest of population in Tier 5 as they never face such problem. The availability of electricity is almost constant without any scheduled interruptions in the whole area and fulfill the requirement for highest tier. The electrified areas do not experience any frequent disruptions and power outages. MHPs need some maintenance work once or maybe twice in a month which accounts for 10-12 hours in 6 months' season and the duration of each disruption is usually less than 2 hours, this data place the reliability attribute of MTF in Tier 5. About 30% of the population faces the issues of voltage fluctuations and changing frequency problems that sometimes cause damage to few appliances, the quality attribute for this population can be placed in Tier 3 while remaining 70 % households experiences no such problem. The tariffs for electricity services provided are affordable in Chitral.

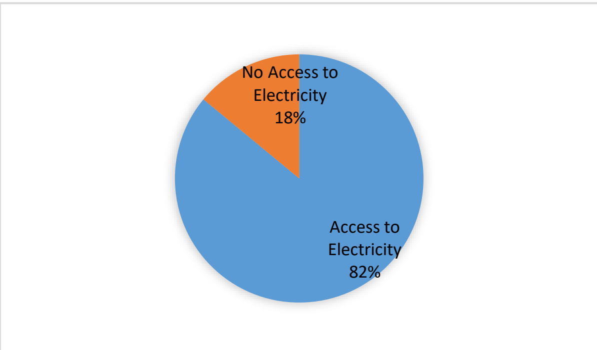

Figure 7: Access to Electricity at CHITRAL

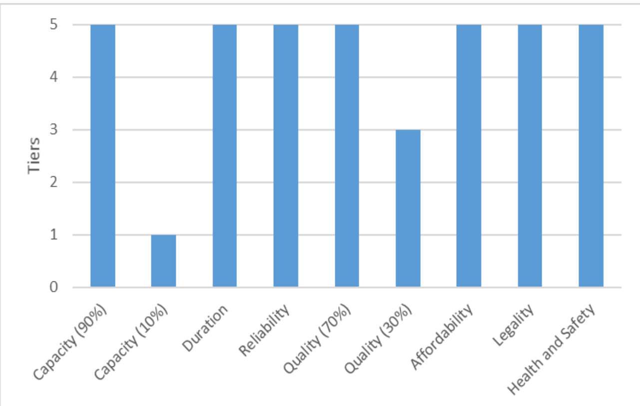

Figure 8: MTF at CHITRAL

The average household income varies from 20,000-25,000 PKR whereas the average monthly electricity expanses are about 800-1000 PKR which is less than 5% of the income. Moreover, the whole area is getting electricity legally and no health problems or accident found in the area. The summary of the MTF is shown in the figure 8.

CONCLUSION

The main objective of measuring access to energy is to know whether the supply of energy services is able to run some vital appliances and services, and not just measuring the level supply of energy or electricity. The traditional binary metrics for measuring access to energy are not able to achieve this objective and the ultimate SE4All goal. From the results of this study, it strongly advocates frameworks like MTF to be used for knowing the actual level of access to energy. We have seen that MTF is able to provide a very accurate data for the services that households actually receive which makes it a power full tool in making investment decisions and policy making.

We have also seen the impact of off grid energy projects like MHPs in the rural population. In most parts of the northern areas of Pakistan, either there is no national grid connected or in bas condition due to poor infrastructure which resulted in the poor living lifestyle of the local communities residing in those areas. From past two decades, the government and different national as well as international funding agencies have shown interest in electrification of these areas and installed micro hydro projects in different sites. The presence of those power projects have improved the level of access to electricity. As we have seen in this study, most of these areas being electrified by MHPs are in higher tiers which has impacted and improved the standard of lives including health, education, economic activities and reduced work load on females.

OBSERVATIONS AND RECOMMENDATIONS

Although Multi-Tier Framework (MTF) is currently the best available criteria for measuring the actual level of access to energy services but still some of the lackings were identified during this study which are mentioned below along with some recommendations:

1. Different attributes are independent of each other, and cannot be assumed to improve simultaneously across tiers.
2. The complex multi-tier framework requires extensive collection of data, which may not always be affordable.
3. MTF is still a supply side analysis rather than demand side.
4. It should include about requirements of the community which should cover demand side analysis as well.
5. Also it doesn't identify the gaps in energy access.

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Design, Fabrication and Energy Potential Assessment Of Small Scale Anaerobic Digester For Biogas Production

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***Abstract*—** Anaerobic digestion is a green and sustainable technology in which organic material is converted into burnable gas. This technology is used in many countries to fulfill mainly the energy needs of agricultural and domestic sector. The process is called anaerobic digestion because it is performed in the absence of oxygen. Different researches showed that biogas can also be generated from food waste. In this project, a small scale anaerobic digester is designed and fabricated to convert the kitchen waste into biogas. An experiment was performed to check biogas production potential of different samples. It was observed that the sample containing carbohydrates produced the most amount of biogas. This sample was selected for further testing and data collection.

***Keywords*—** Anaerobic Digestion, Municipal Solid Waste, Scrubbing, Retention Time.

I. Introduction

Anaerobic digestion relates back to one of the earliest technologies of the history. Biogas was used for heating bath water during the 10th century BC in Syria and in Persia during the 16th century, (http://www.biogasworks.com). This technique got advanced with scientific research and, Jan Baptista Van Helmont, Robert Boyle and Stephen Hale in the 17th century, proved that flammable gases can be evolved from decaying organic matter. In 1776 Count Alessandro Volta also performed an experiment and proved that there was a relationship between the amount of flammable gas produced and the amount of decaying organic matter (Lusk, 1997; Fergusen and Mah, 2006). Methane gas production from cattle manure by the anaerobic digestion process was demonstrated by Sir Humphry Davy in 1808 (Cruazon, 2007). The industrialization of this technology began in Bombay, India in 1859, with the installation of the first anaerobic digestion plant. This technique made its way to England in 1895, where methane gas generated in a well-designed sewage treatment facility and where this gas was used as a fuel for the street lamps. With the advancement in the field of microbiology, the anaerobic digestion further advanced. In 1930 the bacteria involved in this process were identified in a research led by Buswell and others (Lusk, 1997). Before 1920 this process was done in anaerobic ponds but as the technology advanced, this process was done in a more controlled environment which finally led to the use of closed tanks, heating and mixing equipments to maximize the biogas production. This technique and design was spread to the whole world and was booming but suddenly slowed down due to the use of low-cost coal and petroleum. This technology made a comeback in World War II due to the shortage of fuel and at the end of the war this technology was forgotten once again. In India and China, this technology is still embraced (Humanik, 2007). In developing countries, this technology is used for fulfilling the energy needs but in the developed countries, this technique is used for waste treatment.

II. Anaerobic Digestion

This is a step by step biological reaction in which large size organic wastes are converted into small and simple organic compounds by bacteria which results in the formation of a gas mixture called biogas, and some other solid remaining called digestate which can be used as compost in agricultural. [1]. This process involves the stabilization and degradation of organic materials in anaerobic conditions with the help of microbial organisms, which results in biogas production [2]. The main products of this process is the biogas including methane (50-75%), carbon dioxide (25-50%), hydrogen (5-10%), and nitrogen (1-2%) [3]. This process does not requires any external energy (in some conditions) but to enhance the biogas production we modify the process by adding the temperature control system and stirring mechanism. These two are the power consuming processes in the AD plant which maintains the design temperature, and the stirring mechanism. These processes are optional and can be avoided but if used, will result in increased biogas production.

There are different types of bacteria which survive at different temperature ranges. The bacteria which lives in the temperature range of 30 – 40 oC are called mesophilic bacteria and the bacteria which can survive in hotter conditions are called thermophilic bacteria which range from 55 – 60 oC. The mesophilic condition is easy to achieve however the thermophilic process has an advantage of quick starting time and higher loading bearing capacity [4].

TABLE 1: COMPOSITION OF BIOGAS

Name of the gas	Chemical Formula	Composition in biogas (%)
Methane	CH4	50-70
Carbon dioxide	CO2	30-40
Hydrogen	H2	5-10
Nitrogen	N2	1-2
Water vapors	H2O	0.3
Hydrogen sulphide	H2S	Traces

A. *Stages Involved In Biogas Production Process*

The biological decay of the organic compounds is done in four different stages. Each of which is discussed below:

1) *Hydrolysis*

The raw material is composed of longs chains of organic polymers. So in the first step these long chains of complex matter are broken down into small pieces and dissolving the smaller molecules into the solution is called hydrolysis. In this step the carbohydrates and proteins are broken down into single molecules of sugars and amino acids. (Sleat & Mah, 2006).

2) *Acidogenesis*

In this step the single molecules of sugar and amino acid produced in the first stage is further broken down into fatty acid and ethanol and also producing hydrogen sulfide and carbon dioxide as by-product. This process is very similar to the process in which milk become sour. (Boone & Mah, 2006).

3) *Acetogenesis*

This is the third stage of the anaerobic digestion process. In this stage the molecules produced in the second stage are further digested by the acetogens which largely produce acetic acid, hydrogen and carbon dioxide. (http://www.biotank.co.uk).

4) *Methanogenesis*

This is the fourth and final stage of the whole process in which the methanogens consumes the intermediate products of the third stage and convert it into methane gas (Ch4), carbon dioxide (CO2) and water (H2O). These are the major products of the anaerobic digestion process with small percentage of hydrogen sulfide (H2S) and some traces of other gases (less than 1%). This process is very sensitive to the pH level. Both the high and low pH level negatively affects the production rate of biogas. The perfect pH level range is between 6.5 and 8. (Martin, 2007). The remaining material which is not converted into biogas can be used as fertilizer of compost for the agriculture purposes.

The complete process of the biogas plant is shown in figure 1 below.

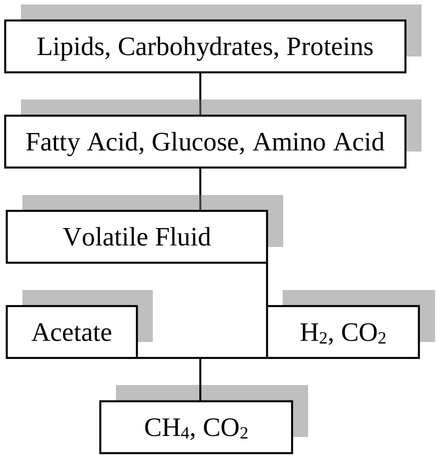

Figure 1: Process breakdown of Anaerobic Digestion

Major reactions occurring in this stage is given below:

$$CH_3\ COOH \longrightarrow CH_4 + CO_2$$
$$2\ CH_3CH_2\ OH + CO_2 \longrightarrow CH_4 + 2\ CH_3COOH$$
$$CO_2 + 4\ H_2 \longrightarrow CH_4 + 2\ H_2O$$

B. *Processing the Raw Biogas*

Raw biogas can be used for cooking and other activities but it contains other gases which decreases its calorific value and also makes it harmful for using in generators or vehicles, so it is very important to process the raw biogas and make it useful and safe. The technique of processing the raw biogas and removing the impurities is called scrubbing. This process improves the calorific value and the safety of the biogas.

C. *Scrubbing Of Biogas*

Scrubbing of biogas is mainly done for the removal of carbon dioxide and hydrogen sulfide. To upgrade the quality of biogas, first we have to remove all the sulfur from the biogas. This step should be done before the removal of CO2 because the CO2 removal process from biogas react antagonistically to the hydrogen sulfide; which means if the concentration of hydrogen sulfide is smaller, then there is a better effect of elimination of carbon dioxide from biogas. The hydrogen sulfide and carbon dioxide removal can be done in the same process line, but the process of H2S removal should be performed first [5]. This process can also be done in two separate steps. These steps are discussed below.

1) *Removal Of Hydrogen Sulfide*

H2S removal can be done by either of the two different easy ways. The first way is to add small amount of air (about 3-6% by volume) into the biogas reactor. Air can be supplied using pump but this is very critical because adding more air will minimize the effect of anaerobic digestion and hence decrease the biogas production.

Another technique for the removal of Hydrogen sulfide is to pass the gas mixture through a catalyst iron oxide. This is done by passing the gas through oxidized steel wool. When the raw biogas comes into contact with steel wool, the iron oxide converts into elemental sulfur.

2) *Removal Of Carbondioxide*

For this process, a 40:60 ratio solution by weight of NaOH and water can be used. The mixing of NaOH and water is exothermic process and releases enormous amount of heat. After the dissipation of heat, the raw biogas is passed through the solution, which minimizes the CO2 contents. A solution of limestone and water can also be used for the same purpose.

3) Removal Of Moisture

Moisture should also be removed from the raw biogas in order to get the full energy content of the biogas. This process is very simple. Silica gel which is easily available can be used for the removal of moisture content.

D. Factors Affecting Anaerobic Digestion

Anaerobic digestion is a delicate process which is done under very controlled environment. It is affected by various parameters which are discussed below.

1) Temperature

The process of anaerobic digestion is very much dependent upon temperature. This process works under specific temperature ranges as discussed below. Changing the temperature form the design temperature and the bacteria that is responsible for the biogas production dies and the process stops. Temperature also influences the methane yield and digestate (effluent) quality. Generally, the bacteria which can grow in temperature range of 10-30 oC is called psychrophilic. The bacteria working in the temperature range of 30-40 oC are mesophilic. Most of the biogas plants work on mesophilic conditions. The third temperature range is from 50-60 oC and is called thermophilic conditions. This condition has some advantages, metabolic rates are much higher, the growth rates are higher, and also the rates of the destruction of pathogens are very high, which results in higher biogas production [6].

2) pH

The value of pH is very important for the anaerobic digestion process. The life of the bacteria depends on the pH value. It has been observed that the pH value ranging from 6.5 to 8 is the best condition for the AD process. [7]. The value of pH depends on the amount of carbohydrates. The high the carbohydrate, the higher the production rate of methane gas, but when certain limit is reached, the value of pH increases so much which results in negatively affecting the bacteria and hence the biogas production decreases [8]. Increasing the pH value more than 7.5 and towards 8 can lead to proliferation of methanogens which inhibits acetogenesis process [9].

3) Loading Rate

This is also known as organic loading rate (OLR). It is the amount of organic raw material being fed into the biogas plant per unit time (daily, hourly etc.). Loading rate is another very important factor in the anaerobic digestion process. The loading rate of the system should not be very high as it may result in slowing down the biological fermentation process which in turn will result in an average or very low biogas production. The system is usually overloaded due to the presence of degrading substances in the system such as insoluble fatty acids which can cause hindrances in the path of biogas production [10]. Due to high loading rate, the amount of acidogenic bacteria increases which results in pH fall and hence results in the elimination of methanogenic bacteria or methane producing micro-organisms hence the system crashes [11].

4) Retention Time

This is the duration of the feedstock in the anaerobic digester. It is measured in no. of days (n) which is calculated as:

n (No. Of days) = Operating volume V / Flow rate Q

It is the average time required for the organic material residing in a digester to decompose considering the COD or chemical oxygen demand of the influent or the particles residing in and also the BOD or biological oxygen demand of the liquid waste materials. The organic matter decomposes better in longer retention time [11]. Retention time also depends on other factors such as content of the solid waste material and the operating temperature of the AD plant. The dry digestion and the wet digestion have different retention times and generally the dry systems or highly solid wastes have usually high retention time than that of wet system or liquid type waste. The retention time for a biogas digester is designed keeping in mind the composition of the waste [12].

5) Composition Of The Food Waste

The composition of the waste material has also a big impact on the biogas production rate and different raw material may affect the anaerobic digestion in a different way. The composition of the food waste generally depends on the many factors such as culture, habitat, time of the year, biotic and abiotic factors and also the environment of the region [12]. To predict the production rate of the biogas, it is very important to know the composition of the raw material. The biogas production rate depends upon four major components which are proteins, lipids, cellulose, and carbohydrates. The presence of high lipids content usually has high bio-methanization efficiency but it requires high retention time due to its complex structure. On the other hand carbohydrates and protein has less retention time as compared to lipids [13].

6) Carbon, Nitrogen C/N Ratio

This is the ratio of carbon to nitrogen in the slurry mixture also denoted as CN ratio. 25-30:1 is the optimum value of C:N for the maximum biogas output [14]. Nitrogen makes the cell structure while carbon provides the required energy. At the above discussed C:N, carbon is used about 20 to 30 times faster than the nitrogen. When there is excess quantity of carbon in the waste, then the nitrogen will be consumed first and carbon will be left behind, which will result in slowing down the digestion and which will eventually stop the process. If there is too much nitrogen in the raw material, then carbon is exhausted and the digestion stops. The remaining nitrogen will combine with the available hydrogen forming ammonia. This will result in killing the bacteria [15].

7) Toxicity

The growth of bacteria is stimulated by small quantities of mineral like potassium and sodium. There is a negative impact of the high concentration of detergents and heavy metals. They impact the rate of gas production. Antibiotics, soaps and organic solvents appears to be toxic for the growth of the bacteria in the digester. These types of substances should be kept away from the digester [16].

8) Depth To Diameter Ratio

According to studies done on the biogas technologies, it is revealed that if the diameter to depth ratio is kept in the range of 0.66 to 1.00, then the biogas. The reason might be that the temperature varies in different depths of the container and most of the activities happen at the lower half of the material [17].

9) Degree Of Mixing

Mixing the material results in improvement in biogas production. This mixing should be gentle because violent mixing results in killing the bacteria.

TABLE 2: PROPERTIES OF BIOGAS

Properties	**Range**
Net calorific value (MJ/m^3)	20
Air required for combustion (m^3/m^3)	5.7
Ignition temperature (^{0}C)	700
Density (kg/m^3)	0.94

III. METHODOLODY

A. Raw Material Source

In this project, food waste or kitchen waste was used as raw material for the production of biogas which was collected from the waste bin of the kitchen and cafeteria of the department.

B. Composition Of Kitchen Waste Of USPCAS-E Kitchen

The food waste collected from the kitchen and cafeteria of the department mainly consisted of bread pieces, cooked pulses, cooked rice, cooked meat (chicken and beef) and others. The waste also contained tissue papers, disposable plastic containers, cups and disposable cutlery. A survey was done for the composition of the kitchen waste. An Average composition of kitchen waste was analyzed on various occasions.

Compositions of Kitchen Wastages are:

- Cooked Rice and pulses
- Cooked Vegetables
- Cooked meat
- Bread

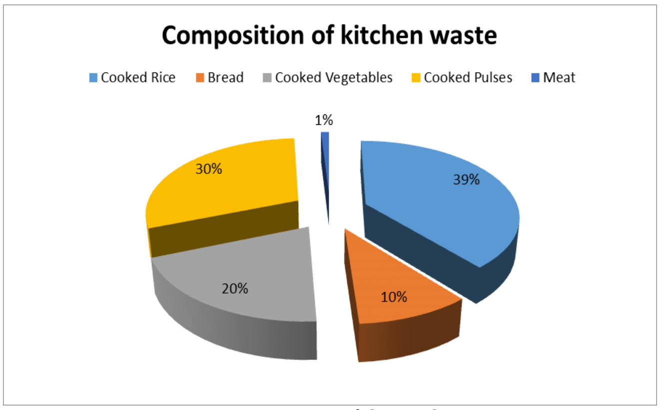

Figure 2: Composition of the Kitchen waste

C. Design Of The Reactor

This design contains two sections. In one section, raw biogas is generated and in the second section the raw biogas is processed and purified. In this project, a container of 160 liters volume was used. The container is a PVC container.. The top portion of the container consists of two pipes, one was used for intake of the organic waste or loading the raw material into the plant and the second pipe was used to collect the gases and to transfer it for the next treatment. The top lead also contains a mount for motor, which will be used to give circular movement to the raw material.

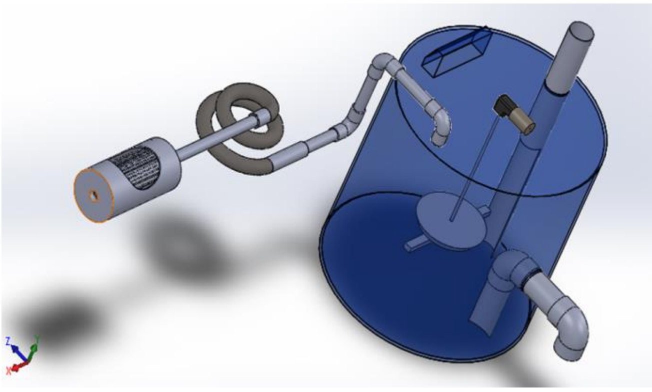

Figure 3: CAD Model of the Anaerobic Digester

D. Design Of The AD Plant

All the components of this plant were designed in Solid Works. The assembled design, the exploded view of the assembly as well as the CAD design of each individual component is shown below.

1) Feeding Funnel (Optional)

This is used to feed the raw material (Waste food) easily into the AD. This is an optional part which can be omitted. In this experiment, it is not used because an end cap is attached after feeding he raw material into the digester, so that the gases do not escape the digester.

2) DC Motor

This motor is attached to the stirring mechanism of the AD. It is programmed in such a way that it rotates for one complete revolution after every one hour. This mechanism is used in one digester plant only to check if adding the agitation mechanism increase the gas production rate or not.

3) AD Container

This is the main compartment of the AD in which the anaerobic digestion process happens. In this project, 160 liters of PVC tank is used. The container has four holes which are used for feeding of raw material, removal of extra materials, gas extractions and for the motor shaft. The top lid also contains the sensors and gauges to check the internal conditions of the AD plant.

4) Stirrer Blade

This is a mechanical stirrer, which is used for the stirring of the raw material. By this process the raw material inside the AD plant is constantly.

5) Control Panel

This is the monitoring system of the AD. Here the real time data of the AD such as temperature, pressure, methane content, CO2 content, H2S content, humidity, PH and the oxygen content is monitored, and then adjusted accordingly.

6) Scrubber

This part removes the unwanted gases from the methane gas, mainly the carbon dioxide and hydrogen sulfide. The scrubber contains two portions. An involute portion and a mesh structure. The involute portion is used to remove the carbon dioxide and the mesh portion removes the H2S. As the bubbles of gases will enter the scrubber, the gas will tend to move upwards, that's why the scrubber is designed to make the flow of the gases easy.

7) Piping

Piping PVP piping will be used to transfer the gases from AD to scrubber, and then from scrubber to the storage tank.

E. Material/Parts

TABLE 3: LIST OF PARTS USED IN THE PROJECT

S.No	Parts Names	Quantity
1	160 liters containers	2
2	1.5 liters bottles	2
3	2.25 liter bottles	2
4	Dc Motor	1
5	Battery	1
6	Stirrer Blade	1
7	3 inch pipe	4
8	1.5 inch pipe	2
9	Steel Wool	2
10	1 inch Rubber Pipe	2
11	¼ inch Rubber Pipe	2
12	3 inch Elbow joint	4
13	1.5 inch Elbow joint	8
14	Pressure Gauges	4

IV. EXPERIMENT

In this experiment, first the composition of the kitchen waste of the university campus was studied. The waste mainly consists of bread pieces, a portion of cooked vegetables and rice. For the experiment, four samples were made and were tested at temperature ranges of (30 – 34 oC). The experiment contains a total of four combinations of material as shown in Table-5

First different types of food waste samples were made and fed into 1.5 liters bottles and 2.25 liters bottles. Pressures gauges were fixed in the lids of the bottles. Digital temperatures sensors were installed to record the instantaneous temperature of the samples. pH sensor was also installed. In one bottle, u-tube monometer was installed to check the pressure. The experiment was performed and all the data was recorded.

A. Manufacturing Procedure Of large Scale Digester

In this experiment, a 160 liters PVC water tank is used. A total of four holes were drilled into the tank. Three of the holes were drilled on the top lid of the tank and one on the vertical wall near to the base. One of the holes on the top lid is three inches and the remaining two are one inch and 1.5 inch respectively. The fourth hole is also three inches, which is drilled on the vertical wall. Then pipes were installed in these holes in their respective sizes. A 3 inch pipe is inserted into the 3 inch hole on the top. The 3 inch diameter pipe is designated as the feeding pipe for the raw material. The lower portion of the pipe is cut to avoid chocking. This gives the pipe an easy path. The edges are sanded to have smooth surface. The pipe is pushed through the hole and twisted as it moves downward until it touches the lower surface of the tank. Due to the 450 cut, the raw material can be fed into the reservoir tank without clogging the pipe. A valve is installed on the upper end of this pipe and above the valve; a funnel is attached so that the raw material can be fed easily into the tank.

The second pipe which has 1 inch diameter is designated as the gas outlet pipe. A horizontal hole is drilled into the pipe at a height just below the top led of the tank. This pipe is also pushed into the tank. A valve is also installed on the upper end of this pipe and then connected into another pipe for further processing the gas. The feeding pipe and the gas outlet pipe are installed at the same side because at this configuration most of the food waste settles and most of the gas arises and collects.

The third pipe is installed at middle of the vertical wall of the tank. This pipe is used for the removal of extra material (fertilizer/composed) from the tank when new material is added.

V. Results & Discussion

The experiment was performed to find the maximum pressure generated by different samples and also to find the volume of gas generated by a unit mass of sample.

Three different masses of bread, manure were taken in different containers. The combinations of each sample are shown in the Table 4 below:

Table 4: Mixture ratios of raw materials with manure

Sample 1
260 grams bread + 260 grams manure + 1/10 part water of the total volume
Sample 2
520 grams bread + 520 grams manure + 1/10 part water of the total volume

A. Results

First three samples were selected for the experiment. In one sample, mixed vegetables were added to the manure in 50:50 ratio and 1/10 part water of the total volume. In second sample, only manure was taken and added with 1/10 part of water. In third sample bread was added with manure in 50:50 ratio and 1/10 part water. From literature it is observed that biogas generation starts at about 7th or 8th day. But in this experiment it was observed that the third sample having mixture of bread and manure started gas generation after 6 hours, which is very surprising. So for this experiment, the third sample was selected for further investigation.

Selecting the third sample (bread + manure), a total of 4 containers were taken, 2 containers of 1.5 liters volume, 2 containers of 2.25 liters volume. Two samples of different weights were made. For the 260 grams bread sample, this experiment was performed in a 1.5 liter bottle. A pressure gauge was attached on the top lid of the bottle to find the pressure curve and the maximum pressure that can be generated by sample. The pressure curve was obtained by measuring the pressure against time. To find the volume of the gas generated, a balloon was attached at the top of the second 1.5 liters bottle to find the volume of gas generated from the sample. The same mechanism was also applied to the remaining two samples. Using this method the pressure generation curve, the maximum pressure and the volume of gas generated per unit mass of the sample were recorded.

B. Data Gathered

The following data was gathered for all the samples.

1) *Sample 1 (260 Gram Bread + 260 Gram Manure + 1/10 Part Water)*

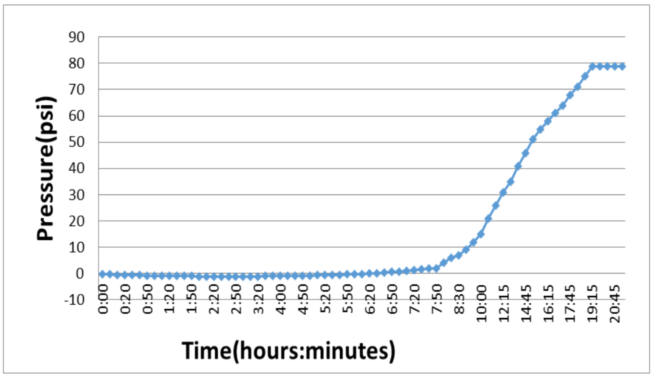

Figure 4: Graph of the Biogas generation pattern

The above graph shows that when the reaction starts, immediately the pressure drops and goes to negative value. We can divide this graph into three sections. In the first section we observe that the pressure decreases for about three hours. In second section the graph is a straight line with almost no changes. This negative pressure stays for about three hours. Then in the third section of the graph, we can see that the pressure starts rising. In about two hours the pressure comes back to zero psi. Then the positive pressure starts rising. From the graph we can see that once the positive pressure starts rising, then it increases exponentially for about two and half hour. Then after that the pressure increases linearly with time. The graph is split into two portions, which are shown below:

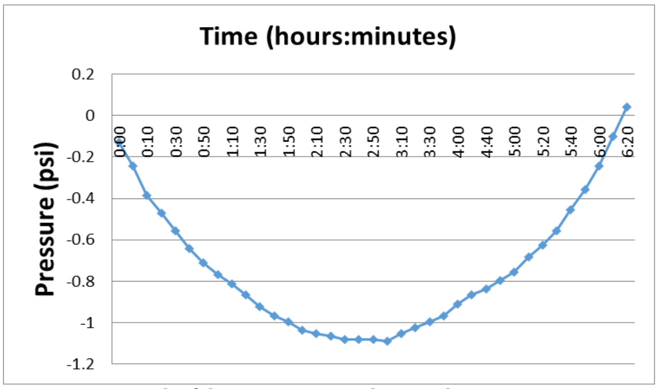

Figure 5: Graph of the gas generation showing the negative pressure

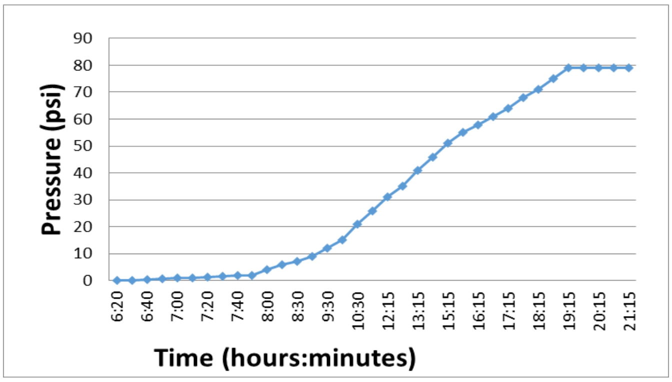

Figure 6: Second half of the graph showing positive pressure generation

Looking at this portion of graph, we can see that when the reaction starts, a negative pressure is generated. The pressure gradually decreases until it reaches a pressure of -1.08 psi, where this pressure stays for about six hours.

C. Volume Of Gas Generated From Sample 1

For the measurement of gas generated from sample 1, a balloon was attached to the opening of the 1.5 liters bottle. As the gas generation started, the balloon started swelling. The experiment was performed for 23 hours because after 21 hours the gas generation stopped and the pressure reached the equilibrium position. The volume of the balloon was 2.1 liters. This means that 260 grams of bread mixed with 260 grams of manure and 1/10 part water results in the generation of 2.1 liters of biogas.

D. Sample 2 (520 Grams Bread + 520 Grams Manure + 1/10 Parts Water)

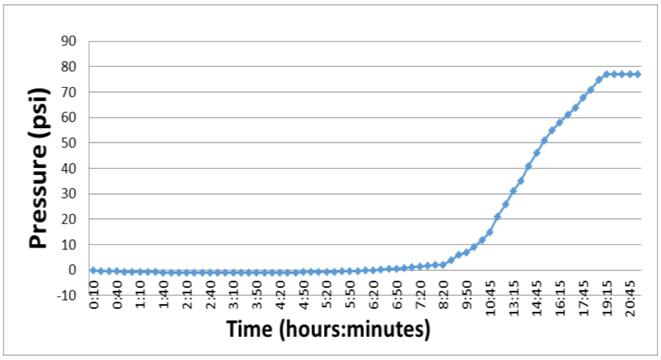

Figure 7: Pressure generation curve of sample 2

It can be observed from that in the initial stages, the reaction initially creates a negative pressure of -1.08 psi for about 1 hour. Then positive pressure starts to develop. From the graph we can see that the relation between the gas generation and time is almost linear until the maximum pressure of 79 psi reaches, where it stays unchanged until the environment is altered.

E. Volume Of Gas Generated From Sample 2

From the balloon major and minor axis diameter, I found out that the volume of gas generated from 520 grams of bread mixed with 520 grams of manure and 1/10 part water generated 3.1 liters of biogas.

The total mass of sample 1 (without water) was 520 grams (.52 kg) which generated 2.1 liters of biogas. From extrapolation I found out that 1 kg of mixture can generate biogas of 4.04 liters. From the sample 2, we got 3.1 liters of biogas from a mass of 1040 grams (1.04 kg). From interpolation, it was calculated that per 1 kg of material we can get 3 liters of biogas. Taking the average of both the readings, it is concluded that 1 kg of material can generate an average of 3.52 liters of gas. Plotting this of a graph we can see the potential of biogas generation from different capacity plants.

TABLE 5: GAS GENERATION POTENTIAL

S No	Material (KG)	Gas potential (Liters)
1	1	3.52
2	10	35.2
3	100	352
4	1000	3520

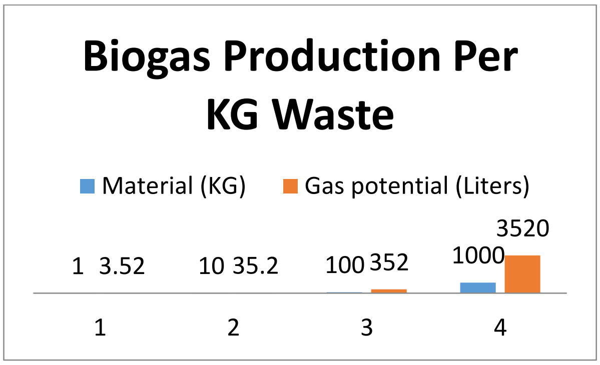

Figure 8: Biogas production (liters) per KG of waste

VI. CONCLUSION

From this experiment we can conclude that biogas technology can also work on small scale even on standard atmospheric conditions. Different organic materials have different time to decompose and to produce biogas. The material which took the least time to produce biogas is the mixture of bread, manure and water in the ratio of 10:10:1 respectively. It can also be concluded from the experiment the aforesaid sample has very high biogas production potential and can be very successful on different scales. As observed from the pressure generation graph that the pressures obtained in this process were very high, almost twice the pressure of a car tire, so it is of the most importance that the system should be so strong and leak proof to avoid possible danger. The gas generated in this process is highly flammable so extra precautions and care should be taken while working on this experiment. This experiment involves different materials which possess strong smell, so leaks should be properly blocked.

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Frequency Control of a Micro-Grid Using Demand Response and Ant Colony Method

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***Abstract*—** Frequency is the most important parameter in the power system. For satisfactory operation of power system, the frequency should remain constant to its desired value. Almost all components used in the power system itself and electrical appliances are designed for a specific frequency. Some reasons of frequency deviation include: sudden load change (mismatch between supply and demand), faults and renewable energy integration in the grid system. To maintain the frequency in their desired value, traditionally generation side controllers are used. Due to their high operational cost, generation side controllers are not desirable by the power system operators. This research proposes a Demand Response (DR) technique as a promising alternate for the conventional generation controllers. It regulates the frequency by switching the responsive load ON or OFF. The proposed research operates in three different operational modes depending upon generation and load demand. Mode 1: When generation is greater than demand side load, the proposed system will switch ON the dummy load to regulate frequency, while in mode 2: Generation is less than demand side load, then the system will regulate frequency by switching OFF the non-critical load using ant colony method. In mode 3: Generation is considered to be equal to demand, in this mode there is no need to switch OFF or ON any load because frequency is already in a desired limit. By using DR program, the amount of reserved required can be reduced and hence it is more cost effective. In addition it provides a wide range of operating time frame, from a few seconds to few minutes.

***Keywords*—** Demand Response, Frequency Control, Generation Side Controllers, Power Systems.

I. Introduction

The traditional power sector has moved towards the introduction of smart grid with the aim of developing more efficient, more reliable and cleaner electric grid. Commonly smart grid refers to electricity delivery network which improves the sustainability, efficiency, and economics of the production and distribution of electricity using the two way communication network and computer technology.

Micro grid (MG), within a smart grid network is defined as a distribution network that consists of distributed energy sources (DER) units, like solar panels, wind turbine (WT) and diesel generator (DZ). An MG can operate in both cases, either in an islanded mode or connected to main grid using common coupling point (CCP). In an islanded mode it is totally disconnected from the main grid, while in CCP it is connected to the main grid. In islanded mode, the frequency stability is the most critical issue because there is no such connection to the main grid and inertia of this system becomes lower than that of the grid connected mode. This also effects the system frequency. For keeping the system frequency in a desired range whatever the conditions are, the supply and demand equilibrium must be followed as shown in Figure 1.

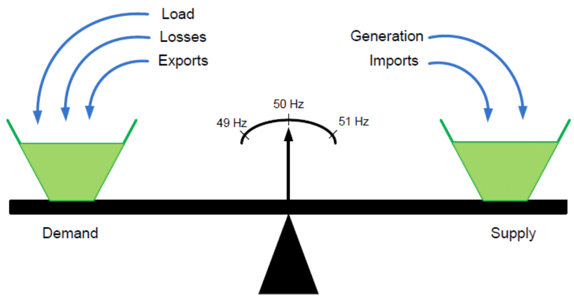

Figure 1. Supply and Demand Equilibrium

However a small disturbance happened in demand side or supply side can deviate power system frequency from its desired limit that needs to be compensated within a few seconds to maintain the power system stability. Some reasons of frequency deviation include: sudden load change (mismatch between supply and demand), faults (due to faults mismatch occurs), and renewable integration in the grid system (due to their stochastic nature, they are unpredictable) [1]. To maintain frequency stability, traditionally generation side controllers (as a spinning reserve) are used to maintain balance between energy supplied and load demand gap. These traditional generation side controllers have two main level controllers named as primary and secondary frequency controller. Primary frequency control restores the balance between generation and load within seconds, it is also called a local automatic controller. Here it is important to mention that primary controller is not much capable to return back the frequency to its desired limit, however it restricts the frequency from further drop and help in stabilizing it. Secondary frequency control is used to bring the frequency back to its desired value. The response time of both controllers should be taken into account. The secondary control action time is 30 seconds up to few minutes while the response time of primary frequency control is much shorter as compared to secondary, so the devices used in primary control must act very fast. These traditional generation side controllers add very high operation cost in the power system that is not desirable by the power system operator. High operation cost of traditional controllers and introduction of smart grid technology made researchers to start looking for new alternative methods. DR program within smart grid technology is considered as a promising alternate for these conventional controllers, to effectively regulate frequency by switching the responsive load ON and OFF. By using DR program, the number of reserved required can be reduced and thus it is more cost effective. Furthermore, it can act very fast and contribute in providing a wide operating range of time from a few seconds to a few minutes and also reduce CO_2 emission. In addition, DR has recently got considerable attention for its use in different purposes i.e. DR can be used in power market for economic benefit, it is also used for day-ahead scheduling and off-line planning as reported in [2]-[8]. In ancillary service market, availability of load as DR resources has been investigated in [9-11]. Although the references discussed above did not analyze DR's effect on system frequency neither any model nor strategy was discussed for transmission or distribution grid. This research presents a primary frequency control using DR strategy at the distribution side in a MG.

A. Research Problem

Frequency has much importance in the stability of power system, unstable power system increases the risk of black outs or power system outages. Frequency is mainly effected by integration of renewable energy sources (due to their stochastic nature), faults, and mismatch between supply and demand. Traditional methods for frequency control are on generation side and are very costly.

B. Objectives of Research

This research paper is aimed to achieve frequency stability based on demand response techniques. The objectives of this research paper are:

- To control and regulate the system frequency using primary frequency regulator based on DR technique.
- To make the system stable by controlling the gap between load demand and generation response.
- To achieve frequency control by making equilibrium between generation and demand.
- To suggest the technique in future which can be used for controlling the frequency practically.

II. LITERATURE REVIEW

The literature review of this research paper is divided into different parts which are explained individually.

A. Related Work to Demand Response

Y. Qing et al. [12] controlled the multi-area power system frequency using DR. They proposed a system that, control both tie-line swing and area frequency of different areas. Here two steps strategy was applied, firstly a DR strategy is proposed that adds the tie-line swing signal as a feedback in the controller which can stabilize the frequency of each area. They considered a three area power system for investigating DR strategy's effect on multi-area power system. Secondly, for enhancing the power system stability, DR is manipulated for each area. In order to control the frequency, the DR will change the switch ON/OFF. Each appliance used for DR strategy consists of two parts, an electric load and its controller. Electrical load may consists of air conditioner, a refrigerator and water cooler or heater etc. The controller can automatically switch ON and OFF the electrical load in order to control the frequency. Instead of proportional integrator (PI) controller, this DR control strategy only adopts proportional controller because it will permanently change the available DR for frequency control. In other words, we can say that if the frequency is stabilized the PI controller will not decrease power of its DR integrator to zero.

S. Ali et al. [13] performed primary frequency regulation of a micro-grid using real time central DR. They designed a demand response strategy using adaptive hill climbing (AHC) method. The AHC controller measures the frequency at the common coupling point (CCP) and used it as the input variable for the controller. If the frequency change is greater than 0.05 Hz than a percent of responsive load will turn OFF. While if the change in frequency is less than 0.05 Hz than a percent of load that is OFF will be switched ON, as shown in Figure 2. The rapid nature of AHC controller, makes it faster as compared to the speed governor of diesel generator. Since controllable load's power can be instantaneously changed from ON to OFF state depending upon the control signal they receive. Which can cause the manipulation of the responsive load at the start of disturbance (to bring the frequency within the permissible range). In order to decrease the number of manipulated load a step by step (SBS) controller is used up to where frequency is controlled. When the AHC controller control the frequency after that, SBS controller starts minimization of manipulated load up to a limit where frequency is stabilized.

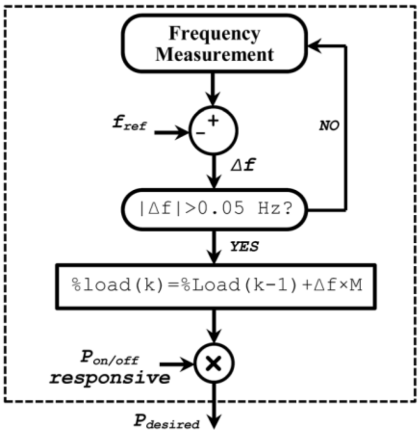

Figure 2. AHC Flow Chart

B. Related Work to Demand Side Management

P. Palensky et.al [14] gave a general overview and information about categories of Demand Side Management (DSM). According to them DSM is categorized into following categories as shown in Figure 3. In which Energy Efficiency (EE) means improving efficiency of an industrial site or building by solving hidden problems like misconfigured controls, compressed air leakage, broken equipment, dirty filters etc. Time of Use (TOU) tariff means to penalize a specified time period (i.e. 6:00-8:00 pm) for a price higher than normal hours. The customer rearrange its processes to minimize total cost of its electricity. Further DR is divided into two types. (i) Market DR which means all DR things related to market i.e. price signals, incentives, real-time pricing furthermore it depends on certain markets where prices and products are formed and traded. (ii) Physical DR is responsible for emergency signals and grid management. Spinning reserves (SR), represents the upper most (i.e. quick) category of the DSM spectrum and is implemented by loads. SR is seen as primary (active power) while secondary Control is used to restore the frequency with additional active power and grid state.

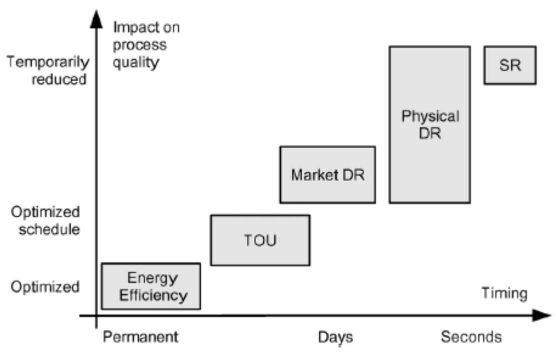

Figure 3. Categories of DSM

C. Related Work to Ant Colony Method

L. Slimani et.al [15] used ant colony optimization (ACO) method to solve the optimal power flow (OPF) problem of a medium power system. The fuel cost of thermal generating units is minimized by using ACO, for this purpose they simulate the network of 25-bus electrical network by using technique they can quickly converge to global optima. They also focused on conservation of acceptable range of generator reactive and real power outputs, transformer tapping's, bus voltage, shunt capacitances, and power flow of transmission lines.

III. METHODOLOGY

This research presents a primary frequency control at the distribution side of a MG using DR. A comprehensive DR strategy is designed in this research work which continuously tries to balance the gap between generation and demand using sliding mode control incorporated with ant colony function to regulate frequency, whether the frequency is greater or smaller than its desired limit. DR strategy used in this research is ancillary type DR in which DR events can be executed by utility company using DLC. In this way frequency is regulated by creating active power balance between generation and controllable devices. This strategy will work for electric loads such as electric water cooler or heater, air conditioning load, in short heating and cooling load physically work as a battery, because they store the energy in the form of heating and cooling. On average, residential cooling or heating loads consumption of electricity is 11% of total energy consumed which extends up to 30% during peak time [16]. The DR strategy used in this research consists of five main participants. 1. The balancing authority, which consists of frequency regulator. 2. Aggregator, which integrates or separates individual consumers. 3. Generation, is the total generated power in the MG. 4. Consumers, energy users who took part in DR program and 5. Dummy load (used to increase demand load). DR program starts by considering total generated power and total demand required for the system. Than balancing authority determines the volume of DR required accordingly. The scheduling procedure of DR is shown in Figure 4.

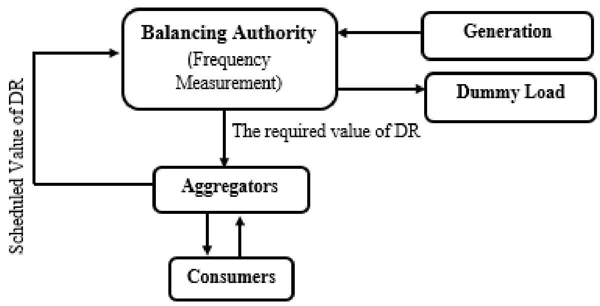

Figure 4. Scheduling Procedure of DR

A. Modes of Operation

The DR strategy used in this research paper, operates in three different operational modes, depending upon the generation and load demand.

i. Mode 1:

In this mode, frequency increases from its desired limit and sliding mode control uses its maximum effort to bring frequency back to its desired limit.

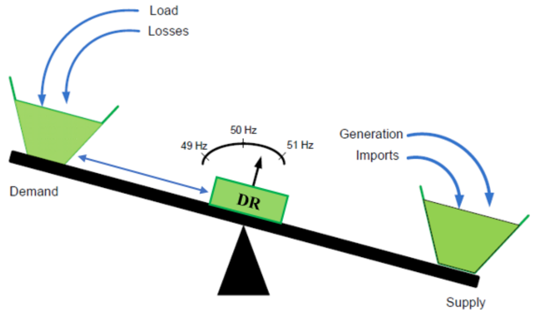

Figure 5. When Generation is greater than demand

ii. Mode 2:

In this mode, frequency decreases from its desired limit and ant colony function tries to bring back the frequency to its desired limit.

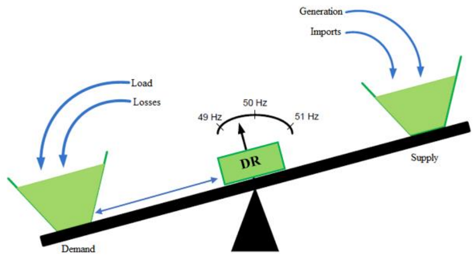

Figure 6. When Genration is less than demand

iii. Mode 3:

In this mode, no operation is done, because in this mode frequency is neither increased nor decreased from its limit.

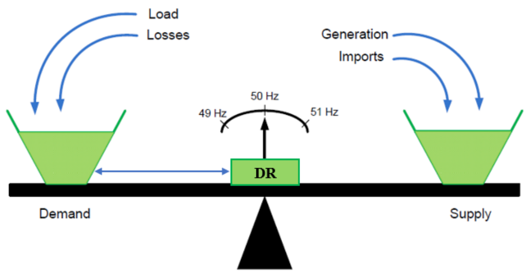

Figure 7. When Generation is equal to demand

IV. SOFTWARE MODELLING

In order to keep the frequency in its desired limit and verification of results for the sack of this, a MG model is designed in a Simulink-MATLAB software with two different controllers i.e. SMC (Sliding Mode Controller) with ant colony function and PID (Proportional Integeral and Derivative) with ant colony function. It consists of different blocks i.e. Grid, three phase circuit breakers, three phase loads, three phase secondary load also known as dummy load, frequency regulator (consists of frequency measuring and controlling devices) and scopes for displaying results etc.

These blocks are connected with each other in a proper manner for getting desired results, as shown in the Figure 8. The loads are further categorized as main load, non-critical and critical load. In the Simulink model the grid consists of generating plant and is connected to the different loads i.e. Main load, non-critical load and critical load. The main load is connected to the system for the whole time while non-critical and critical load can be disconnected or connected to the system through circuit breaker on the command of frequency regulator. Beside this, a dummy load also known as secondary load is also connected to the grid.

The frequency controller will act when the imbalances occur between the power generated by the synchronous generator and different consumer load i.e. when the consumer load is greater than the generated power the frequency controller will remove the non-critical load using circuit breaker. While, the frequency controller adds the dummy load when the consumer load is less than the generation, as a result frequency will be regulated.

The DR scheduling unit is designed in Simulink-MATLAB which comprises of, frequency measuring device, aggregator, and a controller which takes decision on the basis of change in frequency. If the change in frequency is greater than $\pm$ 0.005 Hz, it will switch ON or OFF the peak load or connect the dump load to the system. The controller is deigned on the basis of Sliding mode control technique. Further another ant colony optimization (ACO) [17] function will also be incorporated with controller for optimization and switching of non-critical load. The controller will decide that which load should be switched on first preference and which is to be on second. The schematic diagram of software model is shown in Figure 8.

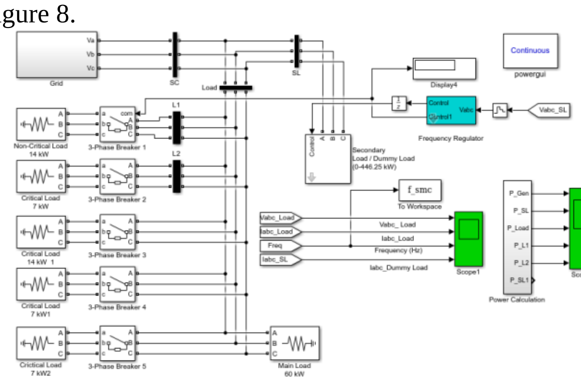

Figure 8. Software Model

A. *Frequency Regulator*

Frequency regulator with SMC and PID is used to control the frequency of the system and its model is shown in Figure 9. It consists of different blocks i.e. PLL (Phase log loop), dead band, discrete time integrator, Sliding mode control, pulse decoder, sampling system and Ant colony function. The frequency regulator starts with measuring frequency using PLL, after measuring the frequency, the frequency regulator compares it with reference frequency. Than the measured frequency signal is passed through dead band zone for upper and lower limit definition, after that discrete time integrator is used for filtering of the input error of signal. Than the purified signal is passed through SMC which decides for the switching of load on the basis of error or deviation in frequency. As the output of the SMC is in analog form, for converting it into digital pulse decoder is used and at last sampling system is used for switching 8 bit load. Furthermore Ant colony function is also incorporated for switching OFF of non-critical load when generation is less than demand.

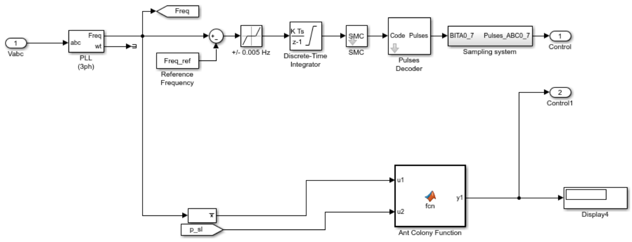

Figure 9. Frequency Regulator

V. RESULTS

In order to, keep the frequency constant (50Hz), the generation and demand must be equal. In this research work the demand side load is adjusted according to the given generation using SMC incorporated with ant colony function. For balancing the load at fixed generated power non-critical load is disconnected from the system when the generation is lower than the demand, however the dummy load is connected to the system whenever the generation is higher than demand side load.

In this research work the idea of frequency control using DR is implemented in a Simulink- MATLAB software. The results of this research work are also verified by comparing them with PID controller incorporated with ant colony function. The results achieved from the software model designed in Simulink-MATLAB software are satisfying the research idea and are explained below.

In order to fix the frequency at 50Hz, this research work is executed in three different modes. In mode 1, the generation is greater than demand side load while in mode 2, the generation is lower than the demand side load. In the last mode 3, the generation and demand side load are equal. The result of each mode are in detail discussed below.

A. Results of Mode 1

In mode 1, the generated power is considered too be greater than demand side load, due to which the frequency of the system is increased from its desired value. In order to bring back the frequency to its desired limit, the proposed system will add extra dummy load to the system. Due to the addition of dummy load the demand side load is increased and it becomes equal to the generated power. As a result a balance is occured between demand side load and generation. The result of this mode is also verified using PID controller. Figure 10 shows the result of frequency of both SMC and PID controller.

It is clearly seen in the Figure 10 that initially the generator frequency of both controllers is fluctuating for some time and both the controller tries to set the system frequency at their desired value within a few seconds. But the response time of SMC is far better than PID controller.

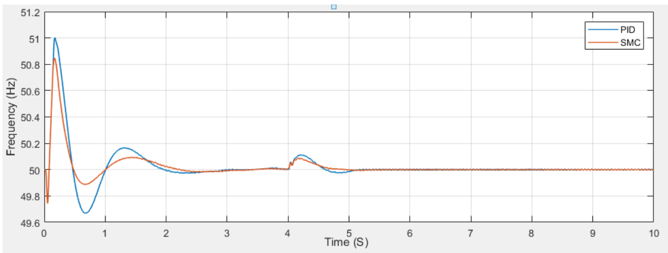

Figure 10. Generator Frequency

After 4 seconds a 7 KW load is disconnected from the system with the help of circuit breaker which can be seen in consumer load current graph in Figure 11 that it is decreased to some extent. The decrease in consumer load current means that the demand side load is now less than the generation, so the generator frequency also increases to some extent which can be seen in generator frequency graph in Figure 10.

So in order to bring back the generator frequency to its desired limit, system algorithm will add some dummy load, which can be seen in dummy load current graph in Figure 12.

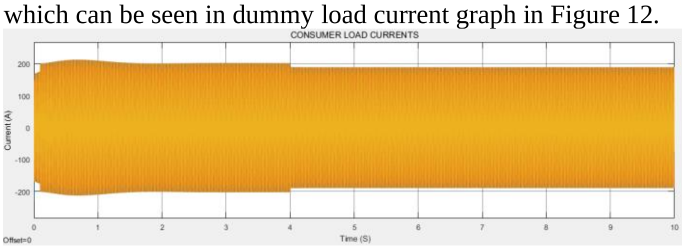

Figure 11. Consumer Load Current

That after 4 seconds dummy load current graph is increased to add some extra load in the system to create a balance between generated power and demand side load, as a result frequency becomes equal to the required limit i.e. 50Hz.

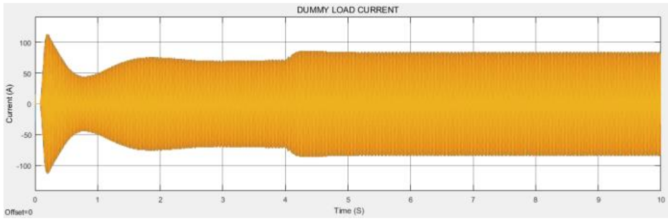

Figure 12. Dummy Load Current

Figure 13 Shows the graph value of total generated power for mode 1. In this figure a small transient can also be seen at 4 seconds because at that time a 7 KW load is switched ON.

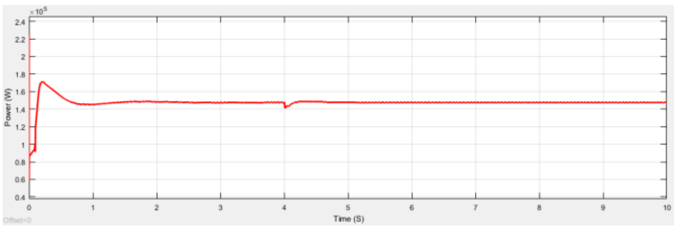

Figure 13. Total Generated Power

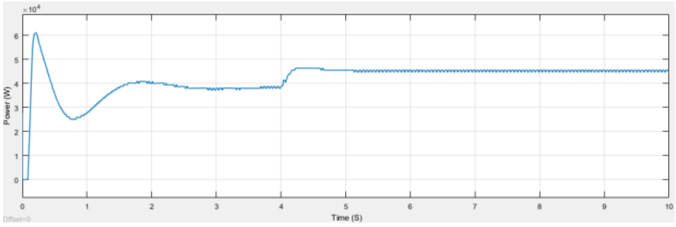

Figure 14. Dummy Load Power

In Figure 14 it is clearly seen that dummy load is initially fluctuating for a few seconds as frequency is also fluctuating, but at near to 2 seconds it became almost stable because frequency is also stable at that time. Then at 4 seconds a 7 KW load is disconnected from the system which increased the generated power as well frequency of the system, so in order to create a balance between generation and demand, dummy load is added to system in accordance to the generated power. It can also be seen in Figure 14 that the dummy load power is increased after 4 seconds.

As in mode 1 generation is greater than demand, so there is no need for switching OFF the non-critical load with the help of ant colony function, which can also be seen in Figure 15. In this figure it can be clearly observed that non-critical load is continuously connected to the system.

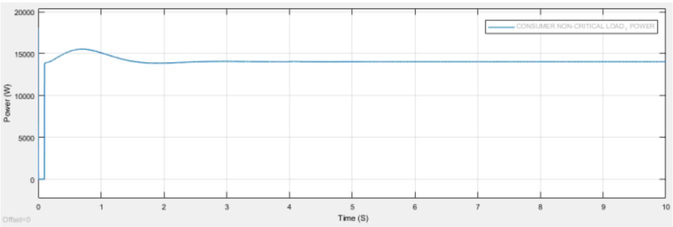

Figure 15. Non-Critical Load

TABLE I. SOFTWARE MODEL PARAMETERS FOR MODE 1

Generator Parameter	
Generator Power	150 KVA
L-L Voltage	440 V
Generator Frequency	50 Hz
Reactance of d-axis ($X_d, X_{d'}, X_{d''}$)	2.24,0.17,0.12 p.u.
Reactance of q-axis ($X_q, X_{q'}, X_{q''}$)	1.02,0.13,0.08 p.u.
Coefficient of Inertia	1 sec
Load Parameter	
Total Connected Load	109 KW
Main Load	60 KW
Critical Load	35 KW
Non-critical Load	14 KW
Controller Parameter	
Regulator gain [K_P, K_I, K_D]	255, 0.1, 70
Signum function gain (C)	0.3

B. *Result of Mode 2*

When the demand side load is greater than generation side, frequency will be decreased. In order to bring back the frequency to its specified limit i.e. 50Hz, the system will remove non-critical load using ant colony function. Due to removal of non-critical load the demand side load will be equal to the generation, as a result the desired value of frequency will be achieved as shown in Figure 16 from 3 to 5 seconds but in 5 – 7 seconds a 7 KW load is connected to the system which again decreased the frequency. This decreased in frequency is immediately overcome by SMC while PID controller did not attain the frequency stability.

Consumer load current graph is shown in Figure 17. In this graph it can be clearly seen that upon decrease in frequency ant colony function immediately switched OFF the non-critical load in order to balance generation and demand. Then in period between 5-7 seconds a 7 KW load is switched ON and again frequency decreases to some extent for few microseconds between 5-6 seconds. When this 7 KW load is switched OFF, frequency of systems increases for few microsecond and system tries to switch ON its non-critical load once again.

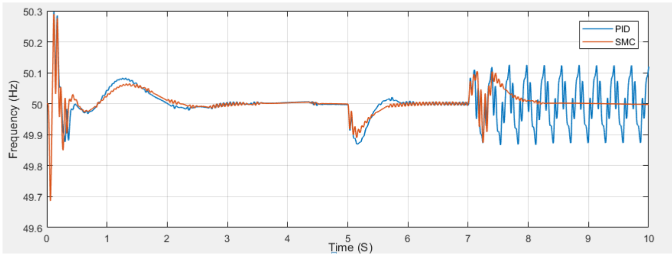

Figure 16. Generator Frequency

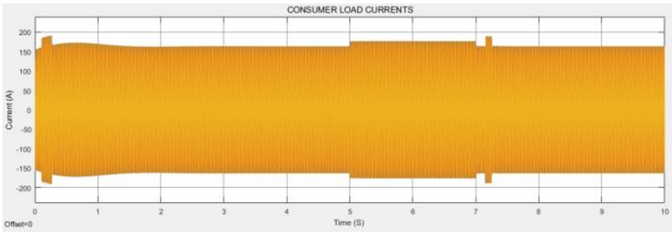

Figure 17. Consumer Load Current

Figure 18 shows the dummy load current graph. It clearly shows that before the closing of non-critical load, the dummy load approached to zero in between 0-1 second. After switching OFF non-critical load dummy load is switched ON to some extent for creating balance between generation and demand.

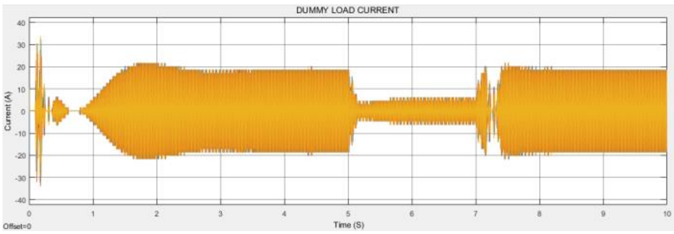

Figure 18. Dummy Load Current

Figure 19. Shows the graph value of total generated power for mode 2. In this figure a huge transient can be seen at starting few microseconds because of mismatch between generation and demand. By disconnecting the non-critical load a balance is created between generation and demand. After few seconds two more transients can be seen at 5 and 7 seconds because of switching OFF and ON a 7 KW load. In this mode generation is set at 100 KVA and demand load is 109 KW which creates an imbalance between generation and demand that's why frequency starts to decrease in starting few seconds.

To overcome this imbalance ant colony function switched OFF the non-critical load of 14 KW to regulate the frequency to its desired value. It can be clearly seen in Figure 20 that consumer non-critical load is switched off after 0.25 seconds. System tried to switch ON the non-critical load once again at 7 seconds but failed because generation is still less than demand. In Figure 21 dummy load power graph is shown. After disconnecting non-critical load generation remains the same of 100 KVA but demand load side load is decreased up to 95 KW. This difference between generation and demand is fulfilled by dummy load, which can also be seen in dummy load graph.

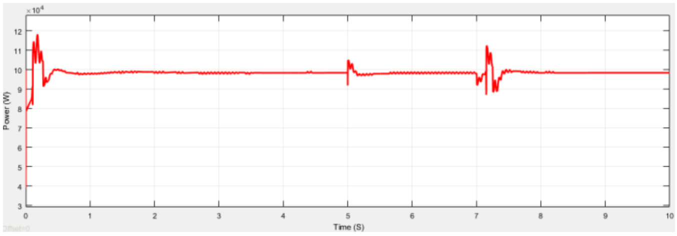

Figure 19. Total Generated Power

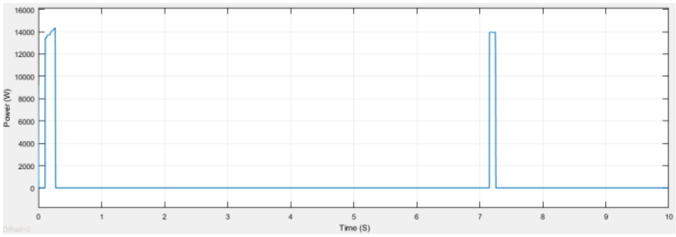

Figure 20. Non-Critical Load Power

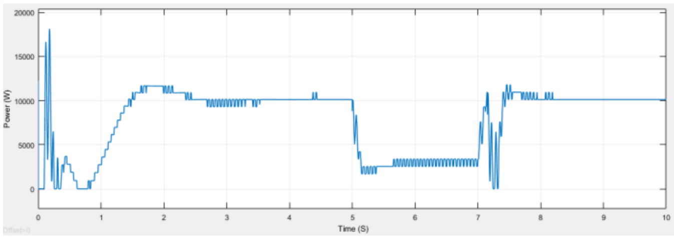

Figure 21. Dummy Load Power

TABLE II. SOFTWARE MODEL PARAMETERS FOR MODE 2

Generator Parameter	
Generator Power	100 KVA
L-L Voltage	440 V
Generator Frequency	50 Hz
Reactance of d-axis ($X_d, X_{d'}, X_{d''}$)	2.24,0.17,0.12 p.u.
Reactance of q-axis ($X_q, X_{q'}, X_{q''}$)	1.02,0.13,0.08 p.u.
Coefficient of Inertia	1 sec
Load Parameter	
Total Connected Load	109 KW
Main Load	60 KW
Critical Load	35 KW
Non-critical Load	14 KW
Controller Parameter	
Regulator gain [K_P, K_I, K_D]	255, 0.1, 70
Signum function gain (C)	0.3

C. Result of Mode 3

When the generation and demand side load are equal. It means that frequency of the system is in its desired limit, there is no need for switch ON or OFF of any load. The frequency comparison of mode 3 is shown in Figure 22.

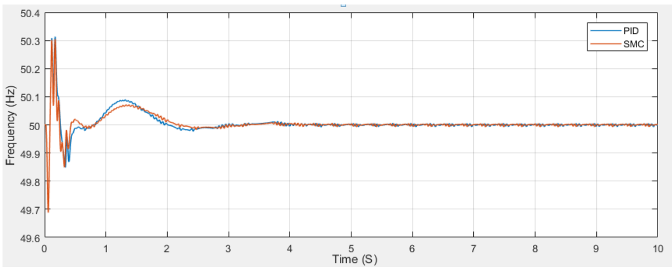

Figure 22. Generator Frequency

In this figure it is clearly seen that, results of both controllers are almost same. In this mode there will be no switching of load either critical or main load. Figure 23 shows the dummy load current graph. In this graph it is clearly seen that after few fluctuation in dummy load current graph, it has constant dummy load current.

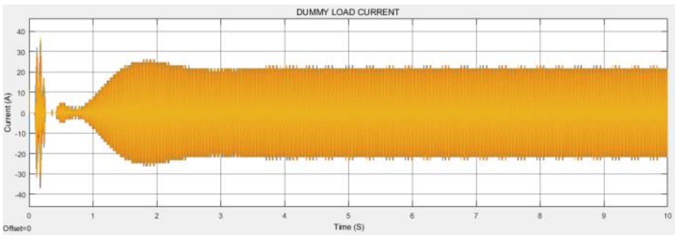

Figure 23. Dummy Load Current

In this mode generation is set at 109 KVA as shown in Figure 24 and demand load is 109 KW also increasing because of system losses as shown in Figure 25, which creates a small imbalance between generation and demand because of generation KVA rating as well as generator reactance and other losses.

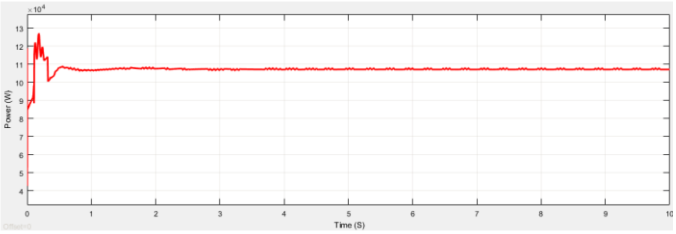

Figure 24. Generated Power

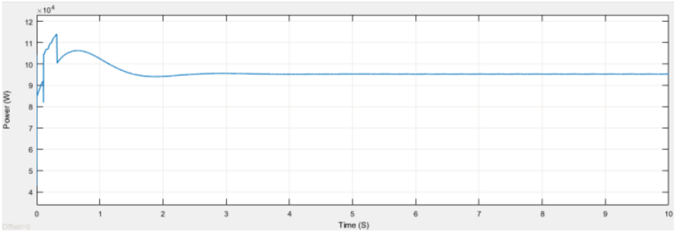

Figure 25. Total Demand Load

That's why frequency starts to decrease in starting few micro-seconds. To overcome this imbalance ant colony function switched OFF the non-critical load of 14 KW as shown in Figure 26 to regulate the frequency to its desired value. After switching the non-critical load there is approximately 12 KW extra generation in the system which is balanced by switching 12 KW dummy load ON to increase the system demand as shown in Figure 27.

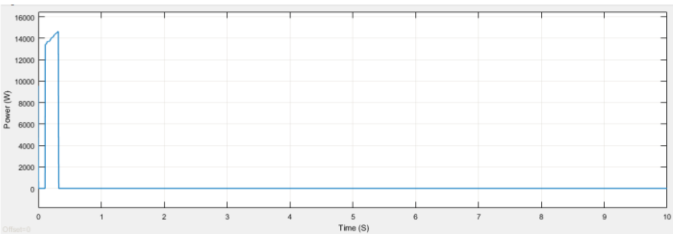

Figure 26. Non-Critical Load

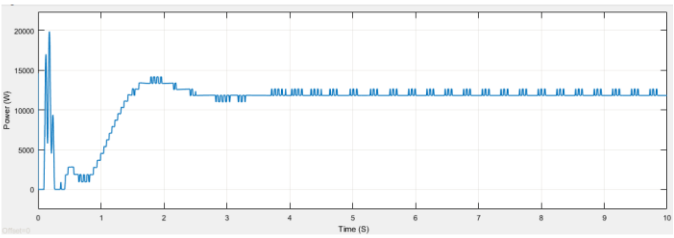

Figure 27. Dummy Load Power

TABLE III. SOFTWARE MODEL PARAMETERS FOR MODE 3

Generator Parameter	
Generator Power	109 KVA
L-L Voltage	440 V
Generator Frequency	50 Hz
Reactance of d-axis ($X_d, X_{d'}, X_{d''}$)	2.24,0.17,0.12 p.u.
Reactance of q-axis ($X_q, X_{q'}, X_{q''}$)	1.02,0.13,0.08 p.u.
Coefficient of Inertia	1 sec
Load Parameter	
Total Connected Load	109 KW
Main Load	60 KW
Critical Load	35 KW
Non-critical Load	14 KW
Controller Parameter	
Regulator gain [K_P, K_I, K_D]	255, 0.1, 70
Signum function gain (C)	0.3

CONCUSLION

It is concluded that, frequency is the most important parameter in the power system. Almost all components used in the power system itself and electrical appliances are designed for a specific frequency. A small variation in frequency can cause an electrical appliance to diverge from its desired output. Therefore, it is very important to keep the frequency within a specified limit. In order, to keep the frequency within, its desired limit the proposed system used demand response technique to regulate the frequency of the power system. With the help of this system frequency can be easily regulated using demand side, instead of traditional generation side methods.
The proposed system continuously measures the frequency of the system, if any abnormality in the system frequency is found, the proposed system will act accordingly. The proposed system will operate in three different modes. In mode 1: The generation is greater than demand side load, frequency is increased, so in order to stable the system frequency, the proposed system adds dummy load to the system. However, in mode 2: The generation is less than demand side load, frequency is decreased from its desired limit, and to bring back the frequency within the desired limit the proposed system disconnects the non-critical load using ant colony function. Moreover in mode 3: The generation is equal to the demand side load, frequency will be in desired limit and proposed system neither adds nor remove any load to and from the system.

FUTURE WORK

The purpose of this research is to regulate the power system frequency using demand response technique. In future this proposed system can be practically implemented for the controlling of frequency in the power system i.e. renewable energy systems, non-renewable energy systems and etc.

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Scheduling of Smart Home Appliances for Energy Management through various Optimization Algorithms

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***Abstract*—** Consumers regulate power use through two-way transmission between the source and the customer via Smart Meters, according to Advanced Metering Infrastructure (AMI) (SM). Smart Grid helps to reduce power consumption expenses by utilising DSM. User latency, on the other hand, increases as a result of home appliance planning. This problem with scheduling is characterised as an optimization problem. Meta-heuristic algorithms have garnered a lot of attention in recent years as a technique to solve optimization problems. As a result, using the Cuckoo Search Algorithm and the Multi-universe Algorithm, we provide an effective technique in HEMS to address the appliances optimization problem (MVO). One smart home and a smart building are part of the proposed concept, which includes thirty smart homes. Suggested solutions are exceptionally efficient in terms of power usage and Peak to Average Ratio reduction (PAR). Aside from that, the suggested solution strikes the right balance between power expenses and user comfort. The Real-Time Pricing (RTP) signal is used to compute the power cost of a single smart dwelling or a smart building.

***Keywords*—** Smart Meter, Advance Metering Infrastructure, Real-Time Pricing, Cuckoo Search and MVO.

I. Introduction

The Electricity Distribution System in Pakistan is plagued by technical, financial, and management issues. As the infrastructure ages and utilities are unable to satisfy demand, consumers are becoming increasingly irritated. The most up-to-date information technology can help to alleviate these problems. The Smart Grid is set up with an energy management system to assist in solving the problem of peak demand. The smart grid for power systems outlines the electrical networks, as well as the requirements and activities for consumers, in order to offer dependable, affordable, and safe electricity. Utilities throughout the world are working hard to satisfy smart grid demands. The combination of traditional grid systems with the most up-to-date information, communication, control, and digital technology is referred to as smart grid. [1]

Pakistan gets electricity from both renewable and non-renewable sources. Hydro, wind, tides, and solar are examples of renewable resources, whereas thermal and nuclear are examples of non-renewable sources. Due to construction, transmission, and long-distance electricity distribution, current-strength networks are experiencing electricity losses, according to ongoing study. Traditional transmission and distribution strains are responsible for about 90% of outages. However, the traditional energy infrastructure is incapable of meeting the energy customers' long-term needs. In addition, because of the heavy reliance on fossil fuels, current electrical systems emit excessive amounts of carbon dioxide. Globally, the electricity sector is responsible for 42 percent of greenhouse gas emissions. In contrast, fossil fuels are used in the transportation system. Thereby the transportation sector is responsible for 24 percent of worldwide greenhouse gas emissions [2-4].

II. Methodology

The energy sector is entering a new phase, dubbed "smart energy," in which it will efficiently use/store/produce/transmit/ energy, making it more sustainable, reliable, continuous, safe, ecological, and autonomous through the application of new information and communication technologies (ICT). The "smartest" method to tackle any future issue is to use modern technologies to change the energy components and the responsibilities of the participants.

A. Smart Energy

When it comes to smart energy systems, they're cost-effective and they make use of green renewable energy resources. Energy generation, storage, delivery, and consumption are all intelligently linked into a single system. An increasing trend in energy the world faces environmental, economic and sustainability issues. Finite resources are becoming more expensive, and the pollution created by fossil fuels is becoming unsustainable for the environment. Energy efficiency and sustainability can only be enhanced by supporting and growing the use of distributed and renewable energy generation (e.g., solar, wind, geothermal, biomass) close or at consumption sites, according to the World Energy Agency's (WEA) latest Global Energy Report.

B. Smart Grid

The Smart Grid is the combination of different renewable and non-renewable sources that has some salient trademarks for the market competitor. The decentralization of power generation (DPG) supports participation at the end of the node, not only for the consumer side but also for the generation. Smart Grid supremacy incorporates more efficient performance to reduce administrative expenses and cut energy bills for consumers. It also allows consumers to play a dynamic part in the operational system, ensuring efficiency and transparency while transferring or distributing electricity, as well as repairing itself and ensuring energy quality and harmony.

C. Micro Grid

Intelligent microgrids are miniature versions of future power systems that handle all of the functions of an energy system, including production, transmission, and control the flow of power to clients. Two modes of microgrid: grid and island mode connected. Consumers in a microgrid have control over consumption, timing, and amount. The electricity system changes from an external network to ESS-stored electricity when power generation is low in comparison to electricity. Power can be exported to neighbouring microgrids if there is excess power generation.

D. Smart Home

Contrary to previous eras, humanity has made technological advances in the last few decades. In the near future, units will be more intelligent, able to recognise our mental condition and our requirements, and even communicate with us directly. A new era will be ushered in by the Internet of Things and Artificial Intelligence (AI). On the other hand, smart lighting immediately responds to voice commands, or the TV automatically opens when your voice is heard, changing colours to match what's being shown on screen, etc. The home controller and automation system can access remote control devices from anywhere there is an internet connection. You can use it to organise and manage your activities if you want to start or stop your washing machine at a predetermined period dependent on the price of power. A device or event that, in a similar manner, triggers another device by specifying the activity according on the customer's choices. In an emergency, for example, the lighting system is turned on immediately, the power is placed in a critical position, all doors are opened/unlocked, and the emergency phone is activated.[8]

E. Home Energy Management System (HEMS)

The Home Energy Management System (HEMS) makes all of the choices in smart homes. In practise, the terms "smart home" and "household energy management system" are equivalent. The HEMS Interfacing allows the user to monitor, regulate, and manage the household's coherent power generation and consumption. From the perspective of public institutions, it reduces peak load and prevents the demand response system from collapsing. On the other hand, when combined with a decrease in energy consumption, the use of clean renewable energy supplies, and electric vehicles, lowering gas emissions per person is a tremendous success. It saves energy, lowers expenses, and improves user comfort. The displays and estimates power consumption based on the price of net-purchased energy, the amount the user sells to the net in real-time, the amount of energy generation from renewable energy sources, switched on / off devices, and the quantity of energy used by each device, among other factors. Furthermore, it visualises and tracks its energy "from generation through consumption, to the expenses and revenues of household energy" and offers energy-saving tips to users.

III. Results And Discussion

These results are simulated in Matlab and discussed in this chapter (2015). On the basis of performance, we determine which algorithm is the best. To demonstrate the correctness and efficiency of our suggested work. For single and numerous smart homes, we ran simulations to optimise the planning. It was therefore decided that in the heuristic techniques, it was necessary to include the average of 20 runs as a crucial variable. 12 smart gadgets with the same life, including 30 intelligent homes, are part of our design for separate households and structures (i.e., length of time, power rating). All units (appliances) used in our simulations are listed in the table below, along with their parametric parameters. Because they are unscheduled and operate at a specific time, non-deferrable devices are not included in the load management process. The operating schedule consists of 24 time slots per day, from 8 a.m. until 8 a.m. the next morning. On the basis of electricity costs, hourly consumption costs, PARs, and waiting times (described below), the suggested approach is compared to earlier meta-heuristic algorithms. [5-7]

A. Electricity Cost Simulation

A utility's peak demand can be maintained and controlled by implementing TOUs and other demand-side pricing strategies. Compare the cost of energy for scheduled and unscheduled (GA, Cuckoo, MVO) loads in figures 1 and 2, respectively. Using the meta-heuristic approach based on scheduled load, the simulation shows that the cost of the unscheduled load is substantially lower. While unscheduled and unscheduled algorithms have similar results, the MVO-based scheduling has better results in both circumstances.

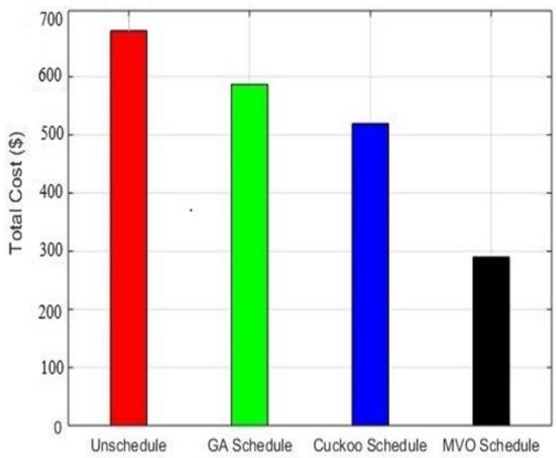

Figure 1: Cost for Single Home

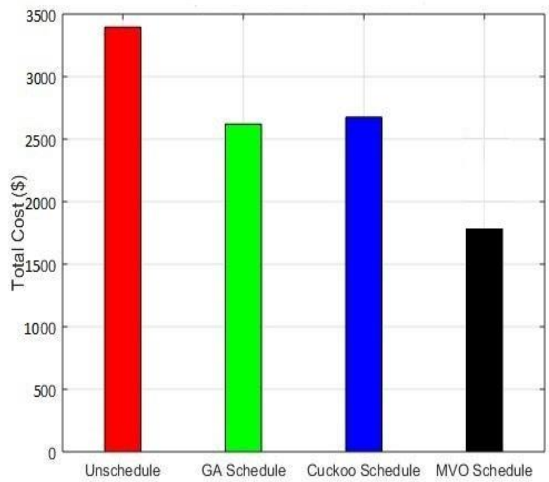

Figure 2: Cost for thirty homes

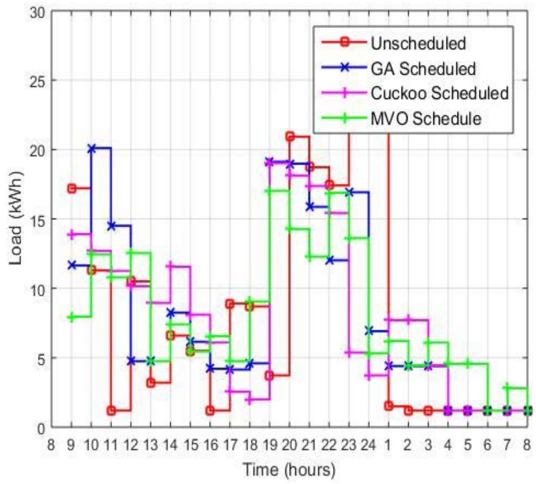

Figure 3:Hourly Consumption of Single Home

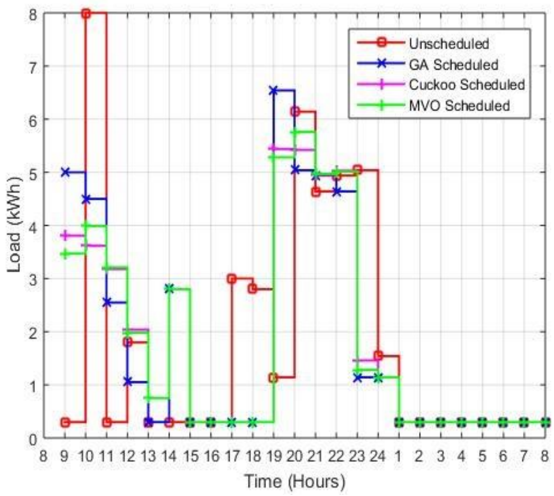

Figure 4: Hourly Consumption for 30 Smart Home

B. HourlyElectricity Consumption

Explain the graph of the consumer's hourly usage of different appliances in Figures 3 and 4. An unscheduled circumstance results in a spike in consumption due to the increasing demand for power. In order to switch the energy usage from Peak-Hour (PH) to OPH, the scheduling algorithms must be calculated first. This means that MVO's scheduled load patterns are reasonably stable and low during high-priced hours. In contrast, the scheduled load pattern for Cuckoo shows a more consistent response.

C. Peak to Average Ratio (PAR)

As the PAR increases or decreases, the grid's stability is impacted. The fall in prices has no effect on the PAR. PAR results employing RTP signals for a single smart home and 30 smart homes are shown in figures 5 and 6. Compared to other scheduling strategies, MVO-scheduled load PAR is less for single smart houses, and Cuckoo is somewhat less for 30 smart homes compared to other techniques. All scheduling strategies are considered in this paper, including MVO – Schedule load, which minimises the PAR. Another optimization method such as Cuckoo and GA are compared to the suggested algorithm PAR.

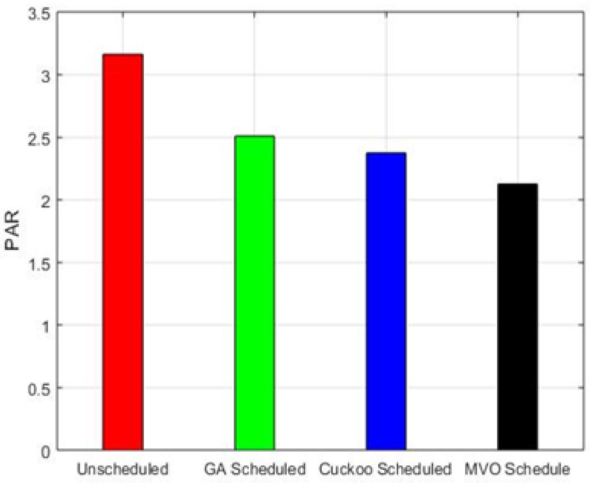

Figure 5: PAR for Single Home

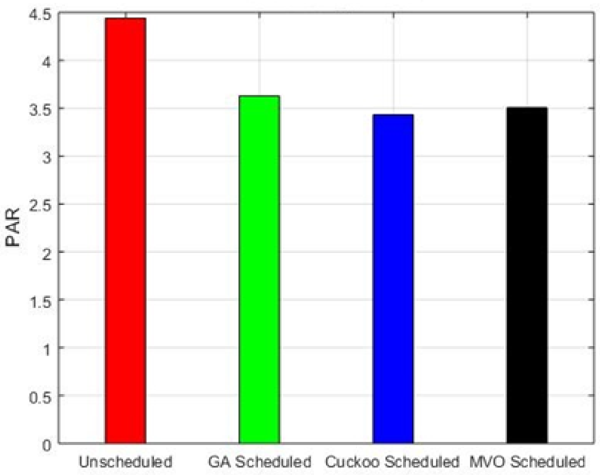

Figure 6: PAR for 30 Smart Homes

D. Appliances Waiting Time

Figures 7 and 8 of Single and 30 smart homes illustrate that as prices and PAR fall, the waiting time increases. Because of this, there is a trade-off between the cost of power and waiting time when energy costs are high (user comfort). In cases where a consumer turned on an appliance, but it did not work within the stated time interval, scheduling lowered electricity costs. A specific amount of time T is therefore required of the users in order for them to get their work done. As you can see, MVO's results are far superior to those of alternative scheduling algorithms in both circumstances.

CONCLUSION

These plans have been superimposed on the Demand Side Management Plan for Energy Expansion (DSMEP). MVO and CSA bio-metaheuristic algorithms are used in a real-world

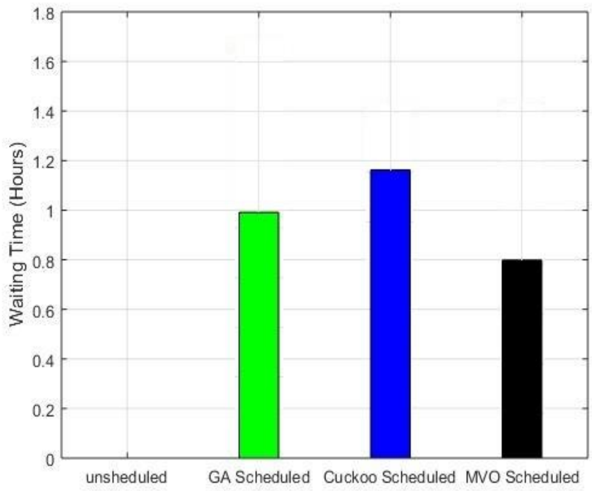

Figure 7: Waiting Time for Single Home

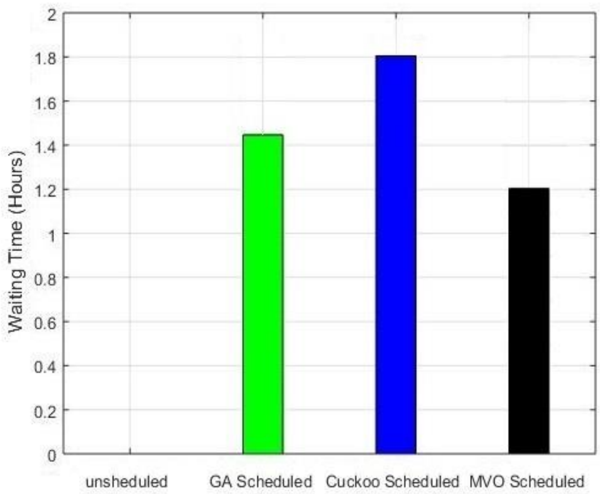

Figure 8: Waiting Time for 30 Smart Home

scenario to partition a household's power load into multiple units of load and determine the best way to use it. As soon as the cue is received from the providers, they are put in charge of arranging the portable contraptions in relation to their charges, which are escalating day-by-day. As a result, the proposed scheme's execution was compared to the unexpected load based on PAR, total energy consumption and billing data as well as a measure of the user's comfort in terms of time-savings gained. It was determined that the performance of our idea was superior to other well-known algorithms such as GA and Cuckoo Search since it reduced the cost of electricity and had nothing to do with operations by shifting some load to low-demand hours. Retaliation, it reduces utility loads by decreasing PAR and enhancing consumer comfort.

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Cogging-Torque Reduction Techniques in Axial Flux Permanent Magnet Machine

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Abstract: Axial flux Permanent magnet (AFPM) machines are popular due to their higher power density and reduced size. In recent years development of electrical drives and other direct drive applications, axial flux machines are gaining more attention. AFPM machines have a problem of cogging torque that needs to be tackled carefully. Cogging torque produces electrical noise and torque ripples. Power of an AFPM machine is directly proportional to its diameter, which makes cogging torque a sensitive design parameter. Cogging torque is proportional to the square flux and change in reluctance, with respect to its position to the stator. This paper paper explores various cogging torque reduction techniques.

Keywords: Cogging torque, axial flux permanent magnet machine, torque ripples reduction.

I. Introduction

Cogging torque is often called no-load torque. It is caused by the attraction between rotor magnets and stator teeth. Cogging torque is undesirable and an important parameter to be considered in machine designing. Although it has no net value but degrades the performance of machines [1].

There are numerous methods available and investigated for cogging torque reduction in axial flux machines. Broadly these techniques can be divided into two categories. Rotor side modification technique and stator side modification technique [2]. Stator side modification techniques are slot skewing, teeth notching [4], and slot opening variation. The rotor side cogging torque reduction techniques include pole skewing, magnet shaping [5], pole arc to pole pitch ratio, and pole arc offset [7]. The cogging torque can also be modified with changing airgap length.

II. Rotor Side Modification

In axial flux machines, it is convenient to modify rotor poles. It is possible to shape magnets for reducing cogging torque. In [2] different skewing techniques are used and investigated its effect on cogging torque. The rotor side modification is elaborated in the following sections.

A. Pole arc to pole pitch ratio

Pole arc to pole pitch ratio is an important design parameter, its effect on cogging torque is very prominent [7]. This research investigated different pole arc to pole pitch ratios and reached to the conclusion that at the ratio of 0.68 the cogging torque is minimum. At 0.55 and 0.77 the cogging torque has the maximum value the results can be summarized as in the table below.

Table 1 table below shows the change in cogging torque with the change in pole arc [2, 7].

Pole arc	0.444	0.555	0.666	0.68	0.778	0.88
Cogging torque (Nm)	7.9	8	3.1	0.8	8	7.5

Table 1 shows the effect of pole arc on cogging torque.Using a suitable pole arc to pole pitch ratio is an easy, simple, and effective way to reduce cogging torque. The equation used to find the optimum value of pole arc to pole pitch ratio is as below [2].

$$\alpha_{p=}\frac{N-k}{N} \qquad (1)$$

Where αp is pole arc to pole pitch ratio, N= Ns/2p, Ns is the number of slots and 2p is the number of poles. [7], [8]. k= 1, 2, 3 ….N-, however, due to the fringing effect pole arc value is slightly more than that calculated in (1). To represent this increase, another factor k2 is added to (1)

$$\alpha_{p=}\frac{N-k1}{N}+k2 \qquad (2)$$

In (2) k2 represents the effect of fringing, its value is from 0.01-0.03. [8]

B. Pole skewing

Pole skewing is another effective method to reduce cogging torque. The cogging torque is because of changing reluctance. The optimum value of skewing can be cited from [2][5].

$$\text{Maximum skew angle} = \frac{2\pi}{Nc} \qquad (3)$$

Where Nc is the least common multiple of stator slots and pole number. Different skewing techniques are possible [2][7]

[8]. However, skew angel is not the same as in (3) but slightly larger than that, in axial flux permanent machines. Magnet skewing is very easy to implement. M Aydin et al in [7] investigated different types of the skewing techniques, like triangular skew, double skew, parallel side skew, and trapezoidal skew that effectively reduced cogging torque. In [5] the research proposed the combination of short pitching and skewing of the magnetic poles, the result show that the combination of both short pitching and skewing is more effective than skewing alone.

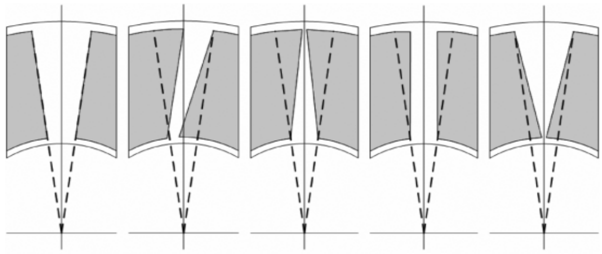

Figure 1: (a) Un skew (b) Conventional skew (c) Triangular skew (d) Parallel side magnet (e) Trapezoidal skew [9]
Figure 1 summary of the available skewing technique.

C. Magnetic Pole shaping

Magnetic pole shaping is used by [3], to reduce cogging torque. In axial flux machines usually trapezoidal shapes are used, in that case the whole edge of rotor pole interact with edge of rotor teeth and produce high cogging torque. The torque can be reduced with managing the shape of magnetic pole in such a way that both the edges (stator teeth edge and rotor pole edge) do not interact with each other as a whole at the same time. With magnetic pole shaping it became possible to reduce this interaction.

Three magnetic pole edge and face shaping techniques are investigated by [3].

- Rounded edges of magnetic poles figure 2.
- Magnetic pole with concave face figure 3.
- Magnetic pole convex face figure 4.

Rounded edges pole as in the figure one, machine was analyzed by [3] for different values of radius r for rounding the edge. The rounding of edge makes the interaction between stator and rotor gradually and hence reduces the cogging torque. The cogging torque reduction is 63% (maximum) when the rounding length r is equal to slot opening width wsw.

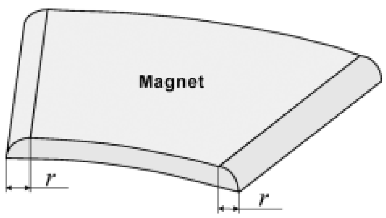

Figure 2: Magnetic pole with rounded edges.

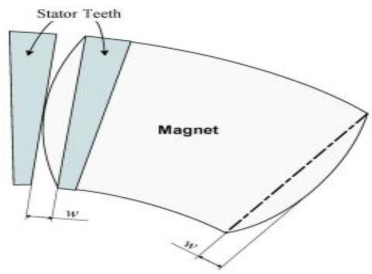

Figure 3: Magnetic pole with concave face.

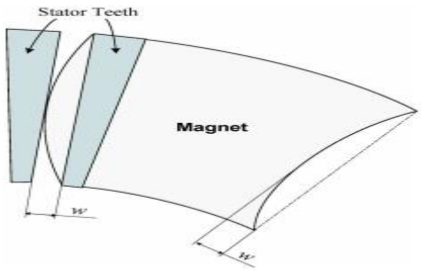

Figure 4: Magnetic pole with convex face.

The concave and convex face are shown in figure 2 and figure 3, both have similar effect on the cogging torque reduction, it makes the interaction between rotor and stator gradual, and hence reduces the cogging torque . The cogging torque is maximum when the rounded face length is equal to the slot opening width the reduction in cogging torque for concave face is 40%, and for convex face is 60%.

D. Double layer magnetic pole design for cogging torque reduction

Double layer magnetic pole is investigated by [10], the investigation used double rotor single stator machine. Every rotor has 8 pole total 16 poles, and 48 slots at stator. Ring type winding and NN type rotor facing were considered for the design. In the analyses volume of magnet is kept constant, first the reference model was investigated and then the double layer was simulated with finite element method software.

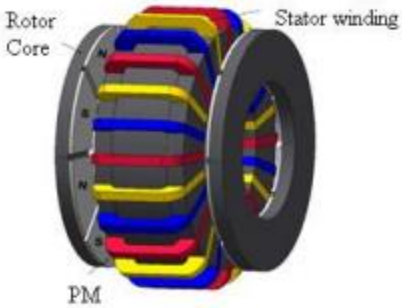

Figure 5: Double rotor single stator design of axial flux machine [10].

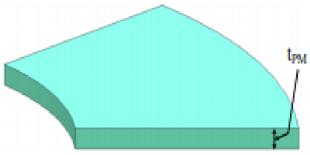

Figure 6: Conventional magnetic pole design with thickness tpm [10].

Figure 5 show axial flux machine design, while figure 6 show conventional model of magnetic pole.

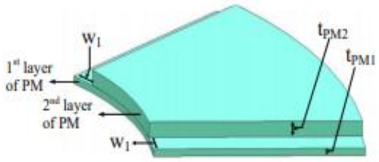

Figure 7: double layer magnetic pole [10].

Double layer pole shown in figure 7 the thickness and offset can be found with the following formula.

$$t_{pm2} = \frac{1 - x\, t_{sp}\left(t_{pm} - t_{pm_1}\right)}{1 - x\left(t_{sp} - 2w_1\right)} \tag{4}$$

$$x = \frac{P}{\pi\left(R_o + R_i\right)} \tag{5}$$

Where R_0 outer diameter of stator and rotor core while R_i is inner diameter. Thickness of layer 1 is t_{pm1} and layer 2 is t_{pm2}, W_1 is offset between two layers. The finite element method result show that the cogging torque is reduced from 10.6 Nm of conventional design to 2.2 Nm of modified design, with less performance degradation.

E. Segmented magnetic pole skewing

Segmented skewing is a low cost skewing technique investigated in [6]. Segmentation is techniques that also reduces eddy current losses in PM. The research used two segment magnetic pole and three segments magnetic pole and reached to result that regardless of pieces of magnet, this approach reduced the cogging torque significantly without effecting load ability of machine [6].

III. STATOR SIDE MODIFICATION

It is also possible to modify stator of machine to reduce cogging torque. However, this method is avoided by designers because of the manufacturing complication [2]. Stator modification techniques to reduce cogging torque is further elaborated in the following sections.

A. Stator teeth displacement

Stator displacement technique used by [1] for double rotor single stator axial flux machine to reduce cogging torque. The stator is sandwiched between two rotors, and stator have winding on both faces.

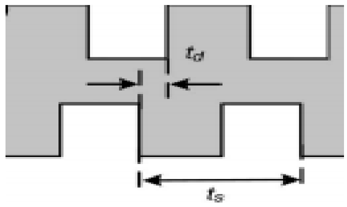

Figure 8: Stator slot displacement.

Figure 8 shows displacement of slots, ts is slot pitch td slot displacement. The author of [1] used a ratio kd = td / ts and investigated the stator for kd 0.13 0.46, and 0.86 the investigation concluded that cogging torque reduced 50% at kd 0.5.

B. Slot opening

P. Kumar and R. K. Srivastava in [4] used different type of slot opening and reduced the cogging torque effectively. The research used a reference machine with parallel opening slot machine and then modified the opening. The author of the paper used trapezoidal opening, parallel opening, and skewed opening (conventional skew, double skew, consecutive opposite skew) that reduced the cogging torque as compared to open slot machines as shown in figure 9 (a), (b) and figure 10.

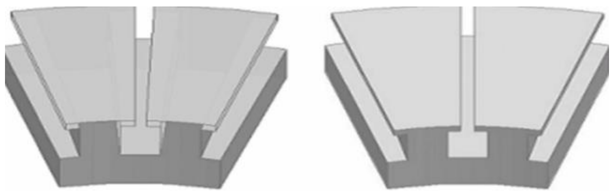

Figure 9: (a)Trapezoidal (b) Parallel l slot opening

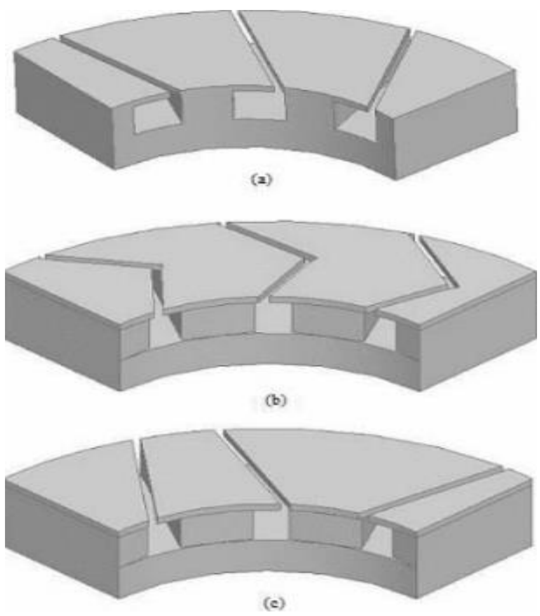

Figure 10: Slot opening modification (a) conventional skew (b) double skew (c) consecutive opposite skew

The paper also investigated 2mm, 3mm, and 5mm opening and compared the results, reached to the conclusion that the reduced slot opening also reduces cogging torque. . The results can be summarized as below.

- Parallel and trapezoidal shape opening have 90% and 91% reduction in torque.
- 2mm slot opening have 96.42 % reduction in cogging torque.
- Conventional skew has 97.75% reduction in cogging torque.
- Dual skew has 98.44% reduction in cogging torque.
- Consecutive opening opposite skew has 98.71 % reduction in cogging torque.

The consecutive opening opposite skew has maximum cogging torque reduction that is 98.71 % [4]. This is very significant reduction in the cogging torque.

C. Teeth notching

Impact of teeth notching in flux switching axial flux machine was investigated in [9] and reached to the conclusion, that in flux switching permanent magnet machines teeth notching is effective to reduce cogging torque. The author investigated there different notching techniques as in figure with finite element method. Slot one S1 and slot two S2 dimension are as give in the table 2.

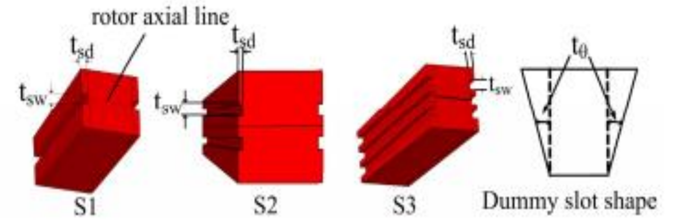

Figure 11: Show slot notch design slot 1 have one notch, slot 2 has two notches, slot 3 has three notches.[9]

Table 2: Result of optimum slot notches and comparison between slot 1 and slot 2 [9].

Slot notching	No dummy slot	Slot 1 (S1)	Slot 2 (S2)
slot width (tsw)	--	3.96^0	3^0
Slot depth (tsd)	--	1.01mm	1.79mm
Slot shape (t_0)	--	0.53^0	1.62^0
Cogging torque	1.06Nm	0.8264 Nm	0.6087Nm
Output torque	8.505	8.06Nm	8.263Nm

The finite element results for the dimensions given in the table 2 are, that cogging torque is reduced upto 22% by S1, and 43% by S2. The reduction in produced torque is 5.22% and 2.8% respectively [9] as shown in figure 11.

D. Slot opening displacement

Slot opening displacement is a simple method to reduce cogging torque. The research [4] investigated the slot displacement of 1.8750 and 3.750 with 3D finite element method (FEM) the resultant cogging torque was 96% less than that of conventional machine [4].

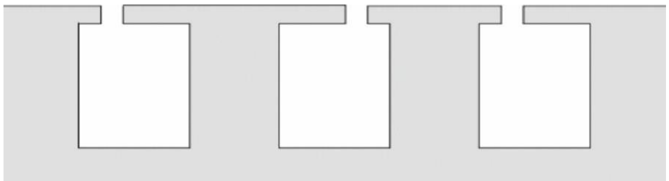

Figure 12: slot opening displacement of stator.

Figure 12 shows displacement of slot opening, slot opening can be away or toward each other, both will be having the same effect on cogging torque.

CONCLUSION

Rotor side modification is the preferred technique for cogging reduction in AFPM. The rotor side modification is simple and effective compared to stator side modification. Skewing of rotor pole is very effective. The same technique can be used on stator side but it increases manufacturing complexity. Axial and radial slicing of poles can also be implemented on rotor side of AFPM machines.

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Power Flow Control using Fact Devices in Power System with Simulkink Software

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Abstract— The demand for electricity is rising. speedily and installation of latest transmission lines is tough owing to factors relating to the environment and conjointly its not economical specially in full space wherever right of means is a problem as putting in new lines decrease the change of state of the world. In Asian nation the put in capability is bigger than the overall demand, the most reason is that the poor gear mechanism and therefore the power flow capability of the prevailing conductor to be exaggerated that is completed by victimization compensation devices. Recently, new advancement in versatile AC gear mechanism (FACTS) technology that is employed for reactive power compensation. Static synchronous series compensator belongs to FACTS family. It controls the flow of power in conductor and injects the voltage in construction with the conductor current. During this analysis, a 132 potential unit conductor returning from Kohat grid station to Gurguri grid station is chosen as a check system as a result of there's a voltage stability issue and high demand in summer months of June, July and august throughout now the losses will increase and cargo shedding phenomena become a typical issue. to realize voltage stability and enhance power flow within the network Static Syunchrouns Series Compensation (SSSC) technique has been during this analysis work. The check Simulink is used to simulate the model. for varied situations and therefore the results of active power ,voltage , current are examined while not victimization SSSC and with SSSC within the check system. The check system was conjointly simulated underneath a typical 3 section contact fault and therefore the result shows that by victimization SSSC the oscillations damped terribly compared to the circuit, fast while not victimization SSSC and therefore the Stability is preserved.

Keywords— Power Transmission, Power Flow Control, Voltage Stability,

I. Introduction

The electric energy grid is made up of components of electricity, parts that ar accustomed generate and provide, transfer, store wattage as shown within the fig 1. A grid that provides power to enlarged space is that the example of electrical installation Generators, storage, and delivery systems are common categories for electrical grid installation. Generators offer the ability. The transmission system that transports power from generators to loads. The distribution system offers the ability to homes or industries. In trade, hospital, business buildings and houses, smaller installation are found. consistent with the supply from that cause The following are some of the most common classifications for power plants that obtain steam:

A. Hydro Power plant

B. Plant of thermal energy

C. Plant of nuclear energy

D. Diesel Power Station.

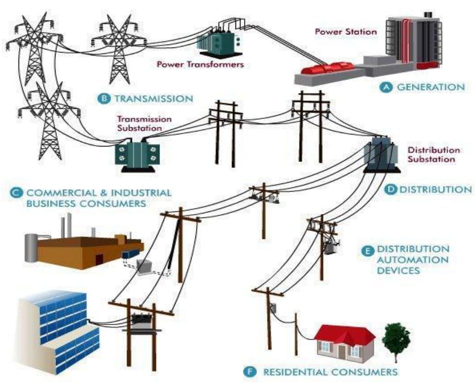


Figure 1. Power flow of transmission system

Modern wattage systems even have 3 parts i-e generation, transmission and distribution. At power generating centers, wattage is generated by synchronous alternators that area unit usually driven by either steam or hydro turbines. At generating stations, most of the facility generation takes place that will contain quite one such alternator-turbine combination. The generating stations area unit classified relying upon the sort of fuel used, like thermal, hydro, nuclear etc. These generating station area unit remotely settled. Power transmission is that the transmission of electrical power generated at any station over long distances to the load centers in cities or cities. In rural areas, power transmission towers and transmission lines are very typical [1]. Power transmission lines connect generating stations and cargo centres in modern power systems, which are advanced networks. Wattage is provided at either a 50Hz or 60Hz frequency.

Power demand has more than doubled in the last ten years, limiting the growth of power generation and transmission due to a shortage of energy and environmental constraints.Some transmission lines area unit powerfully loaded thanks to high load demand within the space. The system stability becomes an important issue for power transfer. For overcoming this example, installation become interlinked and sophisticated. therefore installation can't be analyzed simply. one amongst the important issues in wattage system is that the management of uncontrolled oscillation. Uncontrolled oscillation causes total or partial installation suspension. a lack of sufficient damping in the system is that the vital think about case of sustained or growing oscillation. installation stabilizer is that the initial live that has been wont to increase damping. FACTS devices are progressively used. To optimize each the steady state and dynamic performance of system,

FACTS devices ar used. For dynamic reactive compensation, the primary generation thyristor controlled FACTS device, like static power unit compensator (SVC) and thyristor controlled series electrical device (TCSC) are utilized in power grid. FACTS devices would like absolutely rated electrical device or reactor bank to provide or absorb reactive power. by using self-commutated voltage sourced shift converters to appreciate static synchronous voltage sources at harmonic The second generation FACTS instruments are the static synchronous sequence compensator (SSSC) and combined power flow controller (UPFC). These limitations have an effect on the quality of electricity generated. The case study of PESCO is the subject of this article. The PESCO Company has 132kV grid stations, all of which are interconnected.

A Research Problem

On the 132kV line between Kohat and Gurguri, increased power flow and transient stabilisation are needed because voltage at Gurguri bus and Tall bus fall to dangerously low levels during peak hundreds, causing current to rise and the system to become overloaded, causing not only power interruptions but also loss to PESCO. to beat overload, forced load shedding is allotted. so as to beat losses and compelled voltage profile, load shedding ought to be increased to boost the the flow of energy system. because it is known that improvement in power demand, useful corporations need to createTheir network is also expandable. As a result, power flow control is critical for the capacity system's stability. Any modern AC cable, even though it is inexpensive to instal and modify, necessitates the construction of a new line. it'll need heaps of value in thronged areas. it's lucky that power physics technology improvement, quick governable versatile AC gear (FACTS) devices to save lots of the required flexibility.

E. Objective of Research

The basic objectives of this research work are:

- To Increase the transmission potential of the power grid
- To Enhancement of the voltage profile
- Increasing the power system's transient reliability

F. Contribution of Results

Following square measure the most contributions of this analysis work:

a. to spotlight the angle applications of SSSC in Asian nation organization.

b. Insight issues of grid associated with voltage profile and power losses developed.

c. This analysis work also will be helpful for utility corporations.

The analysis result work are often used by PESCO, as Kohat,Gurguri and Tall Grid station squar measure their authority in terms of providing intellectual profit to the cable, transmission potential.

G. Paper Overview

This study is divided into five chapters, each of which is divided into five sections. is organized in the manner described below. The introduction to the analysis work is mentioned in the first chapter. In the second chapter, FACTS technology is mentioned. This chapter briefly mentions the power flow construction in transmission lines, power flow management methodology, and FACTS technology square measure. The SSSC is mentioned in the third chapter. The fourth chapter concludes the execution of the case study in MATLAB. Chapter 5 discusses the outcomes of possible scenarios. The sixth chapter contains the conclusion and future work.

II. LITERATURE REVIEW

Before we get into FACTS Technology, there are a few topics that will help us understand the FACTS concepts.

A. Principal of power transimission

To build a simulation of the procedure a conductor are often shown for point are shown in the diagram. The equivalent impedance (j X/2) of every Thevenin equivalent, as shown in Figure 2, represents the “short-circuit resistivity” on each side of the point.

Assume that the amplitude of the terminal voltages, Vs=Vr=Vm=V, remains constant and necessary. Two voltages at the terminals are often represented in rectangular coordinates using phasor notations, as shown below.

$$V_s = v\, e^{j\delta/2} = V(\cos \frac{\delta}{2} + j \sin \frac{\delta}{2}) \quad \ldots\ldots\ldots\ldots.(1)$$

$$V_r = V e^{-j\delta/2} = V(\cos \frac{\delta}{2} - j \sin \frac{\delta}{2}) \quad \ldots\ldots\ldots\ldots(2)$$

Where do Vs and Vr meet to shape an angle? As a result, the average value of Vs and Vr is equal to the middle phasor voltage Vm, as calculated by

$$Vm = \frac{Vs+Vr}{2},\ Vme^{j0} = V \cos\frac{\rho}{2} < 0° \ldots\ldots\ldots\ldots(3)$$

A line's current phasor is given by,

$$I = \frac{Vs - Vr}{X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4)$$

$$\frac{2V}{X} \sin\frac{\rho}{2} < 90° \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(5)$$

I = 2V/X sin/2 is a formula for calculating the magnitude of I. And if a line is lost, the power remains the same. As a result, the active real power P as given by is active at both ends and in the centre. The receiving end's reactive power Qr is equal to and opposite to the origins' reactive power Qs. The letter of the alphabet for the road is given below:

$$P_{max} = \frac{V^2}{X} \quad \text{and } Q_{max} = \frac{2V^2}{X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

If the line electrical phenomenon X is kept constant, the transmitted active power P may be varied, but any change in active power P changes the demand for reactive power on both the causing and receiving ends.

B. Related Work

FACTS controller ar wide employed in AC gear to scale back or dampen the system oscillations and to extend power transfer capability. The summarized results of various researchers ar mentioned intimately.

The main swing and resulting oscillation equilibrium limit of a system with SSSC and STATCOM one by one. were stated by the authors in [7], with the soundness of the system greatly accrued in each case. STATCOM significantly increased the first swing limit of stability, as shown by the results., but within the ulterior swings SSSC was a lot of emotive. In Transient State, this paper is deficient in device response.

SSSC is discovered by Authors in [8]; that belongs to FACTS devices. The voltage supply converter (VSC) touched through electrical device serial with the line in SSSC. It injects the voltage in construction with the road current. For the development of voltage stability and power flow, SSSC was used. This paper conjointly contains the negative feedback circuit of PWM controlled SSSC.It was clear from the resultant waveforms that increased most power flow at numerous buses once system is connected with SSSC as in comparison to the current system while not SSSC.

Authors in [9] mentioned that once disturbance occur the decrease within the rate of transient energy was used as AN index of facility damping. additional damping provided by SSSC or STATCOM decided by exploitation that index, and therefore the additional damping issued by each devices was compared.

The use of SSSC reduces the energy of transients at a faster rate than STATCOM, according to simulation data.

In paper [10] authors mentioned regarding some technical problems that Subsynchronous resonance is one of them., protecting equipment's and responsibleness of capacitors. historically used series electrical condenser couldn't get rid of these technological issues, therefore a brand new series compensation device known asIn transmissionsion, a synchronous series compensator that is static was used. The system consists of a synchronous voltage supply, a voltage supply convertor exploitation IGBT or a gate turn-off supported power needs to eliminate these issues. the premise for Voltage supply nature provided superior operation and efficiency of static synchronous series compensator.

Authors in [11] mentioned regarding active and reactive power so as to extend the number of The line's power output, authors conjointly mentioned regarding compensation ways. Performance of facility is formed higher by exploitation technique of sequence compensation which boosts the ability flow. In future some a lot of cooking pan may be worn. The aim of this paper is to model the SSSC in terms of how to manage the system's real and reactive power flow.

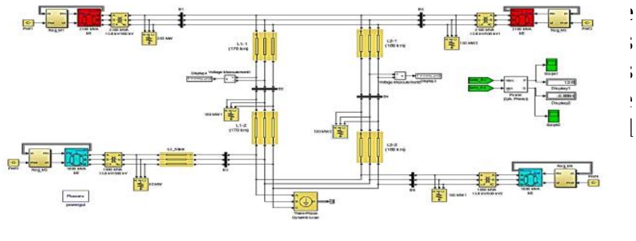
In paper [12] PTL (Power Transmission Line) enterprise SSSC were brought to bear with the road's electrical parameters. it absolutely was undemanding from the results that PI and PID

(The FACTS family (SSSC) has established a system for control to a large degree (fuzzy logic-controlled devices).

The necessity of true power and reactive power flow within the line was stated by the authors in [13] to explain Once the IPF Controller was used as a stand-alone SSSC, it was able to compensate and improve the power transfer capacity of a line. Over the course of this article, an action was bestowed, and the numerical results demonstrated that the efficiency and eligibility of the compensation device on cable were unquestionable.

The SSSC was modelled and sculpted. The SSSC injected voltage is curved and variable in magnitude in the review paper [14].SSSC is serial with the road. The inserted volts square measure in construction with the road amps. the road is serial with the electrical phenomenon electrical phenomenon and inductive electrical phenomenon. The operation and dealing of a completely unique management theme designed each for SSSC and the Authors described STATCOM in [15]. A type of 48-pulse GTO voltage supply electrical converter was used to support the theme. The authors investigated voltage stability and reactive power compensation in the electrical grid network. A full digital simulation of the planned theme containing SSSC and STATCOM within the power grid was performed..

In paper [16], the SSSC injected voltage is modulated using the lead-lag form. Gain block, washout block, and a two-stage lead-lag block are all examples of gain blocks. are the three main blocks in this style. Oscillations are dampened by a gain blockTwo stage blocks have phase-lead characteristics by compensating for output signals that are lagging behind the symbol. Block 3 is a high pass filter, also known as a wash out



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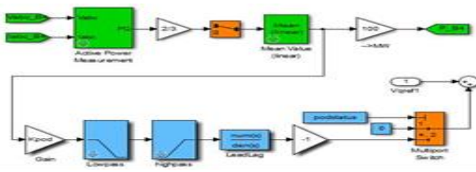

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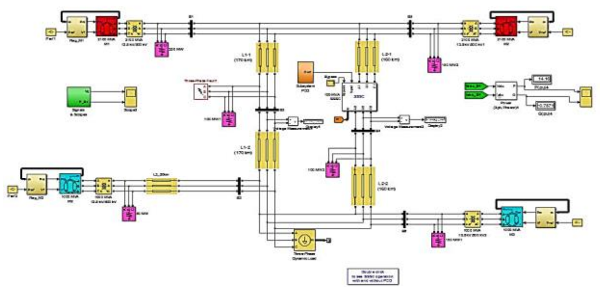

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Figure 1. (a) Without the SSSC, a four-machine device is possible. (Simulink model) [16], (b) Simulink model of a POD controller [16], and (c) SSSC is used in a four-machine configuration. (Simulink model) [16]

The author has depicted the four machine systems with and without the use of SSSC in this paper. It is obvious from simulation that using SSSC active power improves performance. oscillation is reduced, conjointly by victimization SSSC oscillation damps out quicker as compared to the mode while not victimization SSSC, and transient stability of the system becomes higher. any by putting in POD controller with SSSC it are often seen that voltage stability will increase and oscillations square measure utterly damped out compared with the system that isn't victimization POD. [16]

In paper [17], a two-space 11-bus check scheme As a result, we have two zones, Zones 1 and 2 are utilised to assess the sequence compensator's effectiveness. A static synchronous series compensator linked to buses 9 and 10., is the real family unit that is used for series compensation. Voltage sources of (13.8) kilovolts are wired to a (290) kilometre grid using a three-phase electrical system. This transformer has a 500KV output voltage and power in square measurea-1 and area-2 of 1000MVA and 4200MVA, respectively. In each square measurea-1 and square measurea-2, there are hundreds of people. measurea-2 are 30KW that are The truth flow of power on the route is from zone-1 and 2, with the associated load utilising both truth and reactive power may be a perform of the system volts. For all the calculations during this paper POD controller is often in ON state, It reduces device oscillations and produces the voltage (V reference) signal needed to regulate the SSSC. SSSC controls time from 0 to 10 seconds, and time from 2 to 6 seconds. From time t=6sec to 10sec, SSSC acts as an electrical unit, absorbing electricity, and from time t=6sec to 10sec, it acts as an electrical condenser, supplying power.

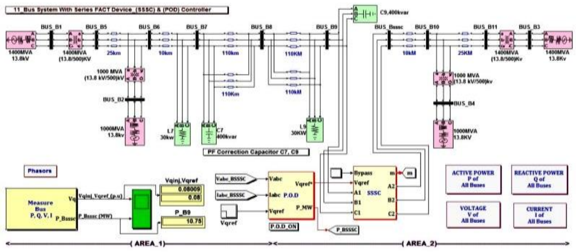


Figure 2. Bus 8 is equipped with a synchronous series compensator (Simulink model) [17]

This system has a Controlling the correct power flow in all buses, a FACTS family serial compensation unit (SSSC) was placed. SSSC boosted overall true power by 62.02MW, which is calculated through all buses. In capacitive mode, the total At all buses, the reactive power flow controlled by the static synchronous series compensator is 1723MVA.

The author mentioned SSSC in his paper [18], which is made composed of a transformer that couples or connects two wires the system to the transmission line in sequence, as well as an inverter (VSC) and a capacitor. With SSSC, the inserted series volts V are controlled in a way that changes the line's impedance. As a result, true power and reactive power of the line can be regulated.

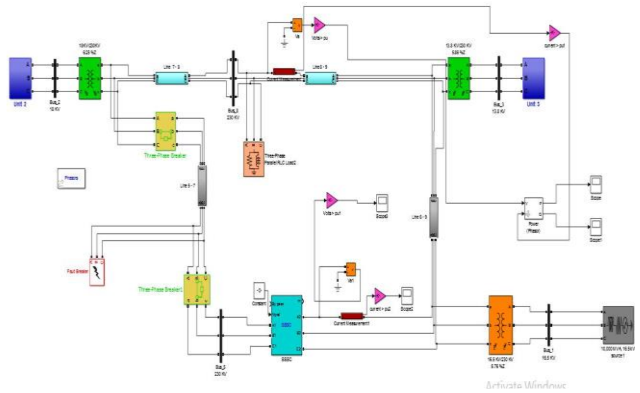


Figure 3. With a synchronous sequence compensator that is static (Simulink model) [18].

The author of paper [19] suggests that SSSC may be a voltage supply converter. By the the volts through the road's electric resistance, the road amps and transmitted power increase. For electrical phenomenon The output volts lag as a result of compensation. the road amps by ninety degree. The output volts ar reversed by voltage supply convertor by straightforward management action and create line current lead or lag by ninety degree. Energy device is put in and it helps in exchanging real power, while not energy device exchanging real power isn't economical. Superconductor

SMES is a magnetic energy storage system that injects or absorbs active or reactive fuel. Figure 1 shows a single line diagram of a multi-area test method..

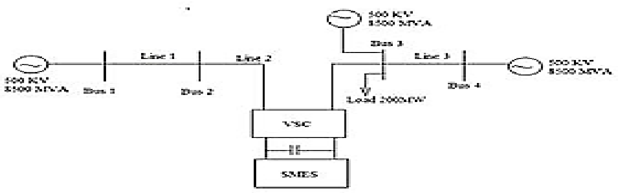


Figure 4. SSSC is used to test the device. [19]

III. FACT TECHNOLOGY

Traditional strategies for resolution issues, fastened and automatically switched series and shunt capacitors, reactors and synchronous generators ar used. because The derived response has not been successful because of the slow response, mechanical component injury. The invention of thyristor devices led to the creation of power electronic converters. It's a primarily based controller that provides wrinkle-free, continuous, at a good pace, and repeatable installation management efficiency.

FACTS is an electronic transmission system that integrates power electronic devices. FACTS are AC transmission systems that have an impact electronic controller as well as various static controls. FACTS devices ar wont to enhance the controllability yet as power transfer capability. for enhancing the power of electrical networks by managing active and reactive power these devices ar used. The definition of IEEE for FACTS controller is declared as, it's an influence electronic primarily based system and different static gears that keep the limit of 1 or a lot of AC transmission measurable factors for instance V, impedance, power cycle and Watt.

Power will be regulated to the required amount and transmitted through inscribed transmission routes and transmission line arrangements that are close to thermal, steady-state, and dynamic limits. Enhancing the ability to exchange data between interconnected transmission lines, expanding the range of services available to sensitive industries, and improving transmission efficiency and usability by restricting the impact of various flaws. The FACTS may be a set of power physics-based devices designed to improve AC system controllability, stability, and power transfer.

The model of various schemes and configuration of FACTS devices would dependant on combination of ancient grid elements specified electrical device, reactors, switches and capacitors, with power physics components like different types of junction transistor and thyristors. Current rating has increased to larger values for thyristor within the last years. It created powe physics capable of tens of thousands of megawatts in high-power systems .

FACTS devices, due to their speed and resiliency, may provide transmission with some advantages. Improved transient stability, power oscillation damping, voltage stability, and management are some examples. the device's type and rating, as well as the basic voltage

level, a transmission capability improvement of up to four-hundredth to five hundredth is also obtained by FACTS parts. currently days the elemental abstractions to the mixing of those promising innovations ar price, quality and responsibility problems.

FACTS technology will help with today's grid problems. It will improve the capacity to pass electricity. It also improves continuous voltage profile control, device damping, and loss minimization, among other things. With its real-time operative management, FACTS devices have high power physics-based instrumentality. 2 teams of FACTS controllers that relies on completely different technical approaches, leading to controllers capable to unravel transmission issues.

Reactive impedances or tap-charging transformers with thyristors switches as controlled parts is that the initial cluster. Self-commutated voltage sourced switch converters is that the second cluster. for each teams It is common to have good management and a swift response. Static volt-ampere compensator (SVC), Thyristor Controlled Series Electrical Condenser (TCSC), and segment shifter are the three main controller classes. Compensator for static synchronisation (STATCOM). Static synchronous series compensator (SSSC), unified power flow controller (UPFC), and interline power flow controllers make up the second cluster of controllers (IPFC)

A. *Types of FACT Controllers*

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

- **Shunt Controllers**

  The system shunt controllers inject current At the purpose of association. It causes a variable current flow once variable shunt electric resistance is connected to the road voltage and therefore shows current injection into the road Only reactive power is offered or consumed by the shunt controller. As long as the injected current is somewhat proportional to the road voltage. with the other part relationship between voltage and current can involve Handling of real power also. Shunt controllers embrace TSR, TSC, STATCOM, TCR and TCBR

- **Series Controllers**

  A series controller is nonparallel with the path to inject voltage. The voltage is proportional to the current on the lane. So long as the series controller is solely responsible for supplying or consuming reactive electricity. Real-power handling may also include a section Voltage and present have a friendship. It includes the TSSC, TCSC, TCSR, SSSC, IPFC, and TSSR.

- **Combined Series-Series Controllers**

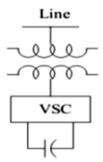
It is a controller in which series controllers have freelance series reactive compensation for each thread. It also moves actual power between the lines. The ability to transfer real power is transferred by series-series controls, brought up as IPFC, makes it to balance each real and reactive power flow within the lines. It enhances the use of the gear.

- **Combined Series-Shunt controllers**

For the shunt portion of the controller, combined shunt and series controllers inject current into the device and voltage serial inside the line with the series part of the controllers. The $64000 power will be exchanged between the series and shunt controllers until the shunt and series controllers are unified. A thyristor-controlled phase regulator is used in the combined series-shunt controllers. TCPAR is a non-profit organisation that promotes

- **Static Synchronous Compensator STATCOM**

STTATCOM may be a compensator for static power units. Electrical phenomena or inductive output current can be controlled. The AC machine voltage is individualistic. STATCOM is related to the AC system in terms of bus voltage magnitude or reactive capacity. The new that was added by STATCOM is either fits management the bus voltage magnitude or the reactive power injected at the bus.



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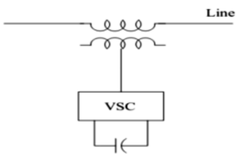

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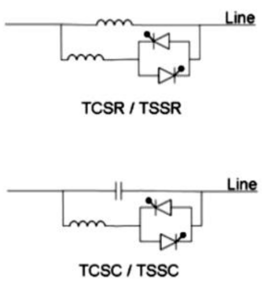

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Figure 5. (a) Shunt connected STATCOM [2], (b) SSSC linked in series [3], and (c) Schematic Diagram of TCSC&TCSR.

- **Static VAr compensator SVC**

A shunt-connected power unit generator or absorbent is what it is. Its output is changed to change electrical phenomena or inductive current in order to maintain the bus voltage. SVC is a thyristor-based FACTS controller from the first century. SVC addresses complex By providing high-performance, fast dynamic voltage control in both steady and dynamic environments, we can solve voltage problems. Due to its accuracy, availability, and rapid response, SVC has been used to improve conductor for many years. The most significant benefits of SVC are the ability to dampen power spikes. It also reduces device errors by optimising reactive power control. SVC is used to improve transient reliability.

- **Static synchronous series compensator (SSSC)**

The AC system and the SSSC are related in order. It's a synchronous generator that runs at a constant speed. The output voltage is in phase with the line current when regulating transferred electric power. The modified output current is used to monitor the magnitude of nodal or bus reactive force.. The schematic diagram of typical SSSC in show in Fig 2.3.

- **Thyristor controlled reactor TCR.**

TCR may also be a thyristor-controlled inductance with a shunt connection. The thyristor valve's partial-conduction management changes its successful physical phenomenon on a continuous basis..

- **Thyristor switched capacitor TSC.**

TSC may also be a thyristor-switched electrical unit with a shunt link. The thyristor valve's efficient physical phenomenon is modified in a stepwise manner by complete- or zero-conduction action.

- **Thyristor switched reactor TSR.**

TSR may also be a thyristor-switched inductance with a shunt link. The thyristor valve's efficient physical phenomenon is modified in an extremely stepwise fashion by absolute- or zero-conduction action.

- **Thyristor controlled braking resistor TCBR.**

TCBR may also be a thyristor-switched system with a shunt link. in the midst of disruptions The TCBR intends to feature associate effect device stabilisation or reduce generation unit power acceleration..

- **Thyristor Controlled series capacitor TCSC.**

TCSC is a physical phenomenon compensator in the most fundamental sense. It consists of a series condenser bank that is shifted by a thyristor-controlled reactor, resulting in the production of a smoothly variable series physical phenomenon.

- **Thyristor switched series capacitorTSSC.**

TSSC is also a physical phenomenon physical phenomenon compensator . It consists of a sequence capacitance bank that is switched by a thyristor..It is accustomed provide a stepwise management of series physical phenomenon physical phenomenon

- **Thyristor controlled series reactor TCSR.**

  The TCSR is primarily a compensator for inductive electrical phenomena. It comprises of a thyristor-powered series reactor. that produces a swimmingly variable series inductive electrical phenomenon.

- **Thyristor switched series reactor TSSR.**

  TSSR is an inductive reactance compensator. It consists of a series reactor shunted by a thyristor-controlled reactor.It is used to provide a stepwise control of series inductive reactance.

- **Thyristor controlled phase shifting transformer TCPST.**

  TCPST provides rapidly variable phase angle. It is a phase-shifting transformer adjusted by thyristor. This controller is also referred to as TCPAR.

- **Unified power flow controller UPFC.**

  planned UPFC is one among the FACTS devices which offer coincident management of The STATCOM and SSSC are related in such a way that they share a common dc condenser in the Unified Power Flow Controller. SSSC and STATCOM are regulated to produce simultaneous true and reactive series line compensation when there is no external electrical energy source. UPFC is the most robust FACTS voltage and power flow controller management in a single thread. Prior to dynamic compensation, all specific grid parameters (transmission voltage, line resistance, and segment angle) must be set. of grid. UPFC will fulfill the functions of STATCOM, SSSC and section shifter. A typical diagram of UPFC.

- **Generalized unified power flow controller GUPFC.**

  GUPFC can monitor device parameters such as bus voltage and actual and reactive power flows in the line. It can control five variables: a bus voltage, as well as freelance active and reactive power flows between the two tracks. A regular dc connection switches the $64000 power between shunt and series converters.

- **(S)Inter phase power controller IPC.**

  Any part of an IPC may be a series-connected controller with inductive and electrical phenomenon branches. to use dominant component changes and/or branch impedances to control reactive and active power Mechanical and electrical switches are used in IPC.

- **(T)Thyristor controlled voltage limiter TCVL**

  TCVL is a metal-oxide varistor with a thyristor switch. It is used to limit the voltage across its terminals under transient conditions.

- **(U)Thyristor controlled voltage regulator TCVR**

  TCVR is a thyristor-controlled transformer. It can provide variable in-phase voltage with continuous control.

- **(V)Interline power flow controller IPFC**

  IPFC may be a mixture of two or more SSSCs. IPFCs are connected to the SSSC's ac terminals through a normal dc connection, allowing for bi-directional real-time power flow. These are managed to generate freelance reactive compensation for the modification of actual power flow in each line and to ensure the necessary reactive power flow distribution among the lines.. If a STATCOM is connected to the IPFC common dc connection, it provides shunt reactive compensation. It compensates for or absorbs the conjucted SSSC's overall actual power deficit. The aim of installing this controller is to address the issue of transmission line range at a station. Two convertors are seen schematically in this diagram. IPFC is shown in fig 6.

Different transients occur in power systems, which can disrupt the overall system's output. The use of FACTS controls will improve the system's accuracy. The table below lists certain power system controls and their FACTS controller solutions.

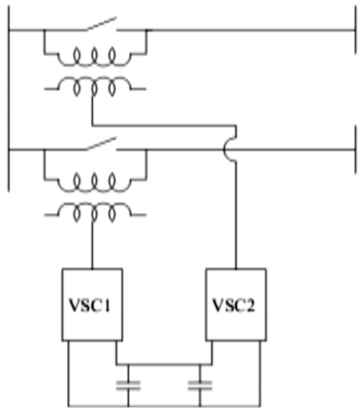


Figure 6. IPFC [6].

IV. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

This section covers the static synchronous sequence compensator (SSSC). We'll take a look at some series compensation techniques. to get a better understanding of how the SSSC works.

Historically, series capacitors were used in long cables to maximise power transfer and compensation. Capacitors are the most cost-effective solution for this. The disadvantage of using a condenser in a shunt is subsynchronous resonance (SSR). Using a synchronous resonance-free road area system to mount a condenser in a shunt. The positioning of the condenser in the shunt has a significant impact on its installation. Shunt capacitors are normally mounted at the cable's end. There are no such requirements for series capacitors. to achieve a degree of power parity improvement, shunt condenser can want higher rating. Qsh represents Shunt condenser is an example, and Qse is the series condenser ranking. Equation 3.1 illustrates the relationship between Qsh and Qse

$$\frac{Q_{se}}{Q_{sh}} = tan^2\left(\frac{\delta max}{\delta}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

The equation 3..1 describes the transmission of an equivalent a certain level of power a wire. exemplify the sharpest angular difference between the cable's ends. Series electrical condensers have a lower compensation benefit than shunt electrical condensers. As opposed to series electrical condensers, the price per unit volt-ampere of a shunt electrical condenser is 0.5. Series electrical condenser rating can nearly be 100% of shunt electrical condenser rating.

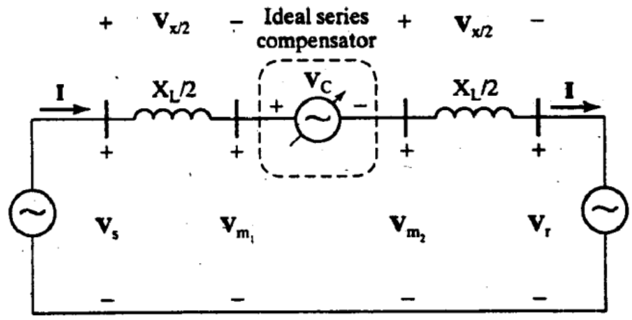


Figure 7. In the transmission line, there is an Series compensator that's ideal.

A. Principal Of Series Compensation

The movement of current would be controlled by introducing a voltage in parallel with the transmission. Between the causation and receiving finish of wire, the capacity will be regulated. The voltage supply VC is attached at the cable's intermediate point. as shown in Figure 3. A perfect series compensator is represented by 1. line current flowing in transmission line is given by 9

$$I = \frac{Vs-Vr-Vc}{jX}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(7)$$

In a transmission line, a Only reactive power may be supplied or absorbed by a voltage source. since a series compensator cannot supply or absorb actual power [4]. Capacitive or inductive impedance, as seen in equation 3.3, takes its place.

$$Xeff = X - Xcomp\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(8)$$

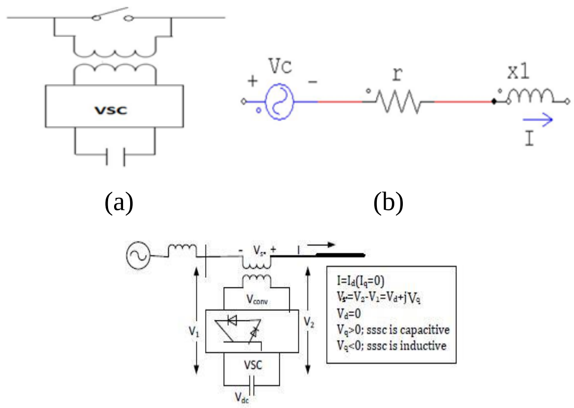
Inductive or electrical phenomena are represented by Xcamp, and absolute cable impudence is represented by X. The efficient electrical phenomenon is described by Xeff. By using a 90o inductive mode, current leads voltage.. once the need is to decrease the facility flow within the cable inductive compensation is finished. Power isn't absorbed/generated by the voltage supply (VC) put in in inductive and electrical phenomenon modes. electrical phenomenon mode of compensation is often used[4].

B. Applications of Series Compensation

As a result of voltage sags, or spikes, or some other form of interruption. Power grid disturbances and oscillations have a noticeable impact on machine-controlled manufacturing processes. a couple of unit of time disturbances will stop entire system. currently a days the standard of power is extremely a lot of necessary. top quality power is needed for industrial and industrial purposeBecause of a lack of supply or damage to goods, the trade suffers monetary damages. To protect critical masses from the effects of unsafe electricity quality, semiconductor technology and power physics technology have been used to accomplish similar goals to those accomplished by series capacitors [4]. For management of power flow, voltage stability and therefore the phase stability we are able to use SSSC. SSSC will induce series electrical phenomenon and inductive voltages on a line [5]. A SSSC has the potential to increase or decrease cable ability flow. Since the power supply is detrimental to the system's soundness, the SSSC has a chance to amortise mechanical unit oscillation in relation to the installed capacitors [5].

C. Static Synchronous Series Compensator (SSSC)

Static synchronous series compensator could be a third generation series compensation device. it's a voltage supply converter (VSC) device connected nonparallel with line through coupling electrical device as shown in figure. In power grid, third-dimensional management of power is given by VSC. usually condenser Reactors and banks There was a time when SSSC was used, but now it has been replaced by SSSC. It's a voltage supply change convertor with self-control that provides a voltage that's influenced by line current in part. SSSC is used to control reactive and active power in a line. SSSC is also used to dampen device oscillations. The image and equivalent circuit of SSSC are seen in the figures.



(a) (b)

(c)

Figure 8. (a) SSSC symbol(b) SSSC equivalent circuit, and (c) The transmission line is connected to the SSSC

Above figure shown as in 4.4 however SSSC is connected with the line within the installation, coupling electrical device is employed to attach SSSC serial with the line, electrica The condenser is attached to the circuit's DC side and is continuously charged by drawing tiny currents. A DC to AC transformer serves as the control block. l, which may be an insulated-gate bipolar transistor (IGBT). The power flow equation is given in its simplest form. as:

$$P = \frac{Vs\,Vr}{XL} \sin(\delta s - \delta r) = \frac{V2}{XL} \sin\delta \quad \text{..........................,(7)}$$

$$Q = \frac{Vs\,Vr}{XL}\left(1 - \cos(\delta s - \delta r)\right) \quad \text{...................................(8)}$$

$$= \frac{V2}{XL} * (1 - \cos\delta) \quad \text{..(9)}$$

Since SSSC will simulate a compensating reactance Xq (both inductive and capacitive) in series with the transmission line inductive reactance XL, the power flow expressions become:

$$P_q = \frac{v^2}{X_{eff}} \sin\delta = \frac{v^2}{XL(1-\frac{X_q}{X_L})} \sin\delta \quad \text{................................(10)}$$

$$Q_q = \frac{v^2}{X_{eff}}(1 - \cos\delta) = \frac{v^2}{XL(1-\frac{X_q}{X_L})}(1 - \cos\delta) \quad \text{.(11)}$$

Xeff is an electrical anomaly that occurs in the cable at the causation and receiving ends. It also has an emulated vector electrical anomaly Xq inserted by the injection voltage supply of the SSSC in equations three and four.

V. MODELLING OF CURCUIT IN MATLAB SIMULINK

This chapter's primary purpose is to add, explain, and set all of the SSSC parameters., with modelling done in the MATLAB/Simulink kit. In a grid network, SSSC is used for compensation. The circuit is implemented in MATLAB, a fourth-generation programming language for manipulating matrices, plotting functions and information, and implementing algorithms, among other things. Version R2016a of MATLAB is used to simulate expected function. employed during this analysis as shown in figure 5.1. To fill in the gaps in Simulink's surroundings, open the MATLAB tool strip and select the Simulink library option as shown. in fig5. 2. By way of the void library As seen, the simulation process is begun. in figure 5.3. There area unit range of libraries. in keeping with demand of model style correct library is chosen. Here 1st simscape library is chosen, by choosing simscape library, the below figure window opened. Sim power grid, sim fluid mechanics, sim natural philosophy etc. will be seen in simscape any in figure5.4.Simscape create offered Associate in Nursing atmosphere for modeling and simulating physical systems. It includes mechanical, electrical, hydraulic, and different physical domains. power grid is chosen because it is that the needed library. there are further different blocks as The window of power system shows that, namely application libraries, power electronics, electrical sources, power gui etc.The power guiblock is shown in figure 6.2. , which is needed for any Simulink model simulation. It includes advanced technology blocks for the Sim Power Grid.

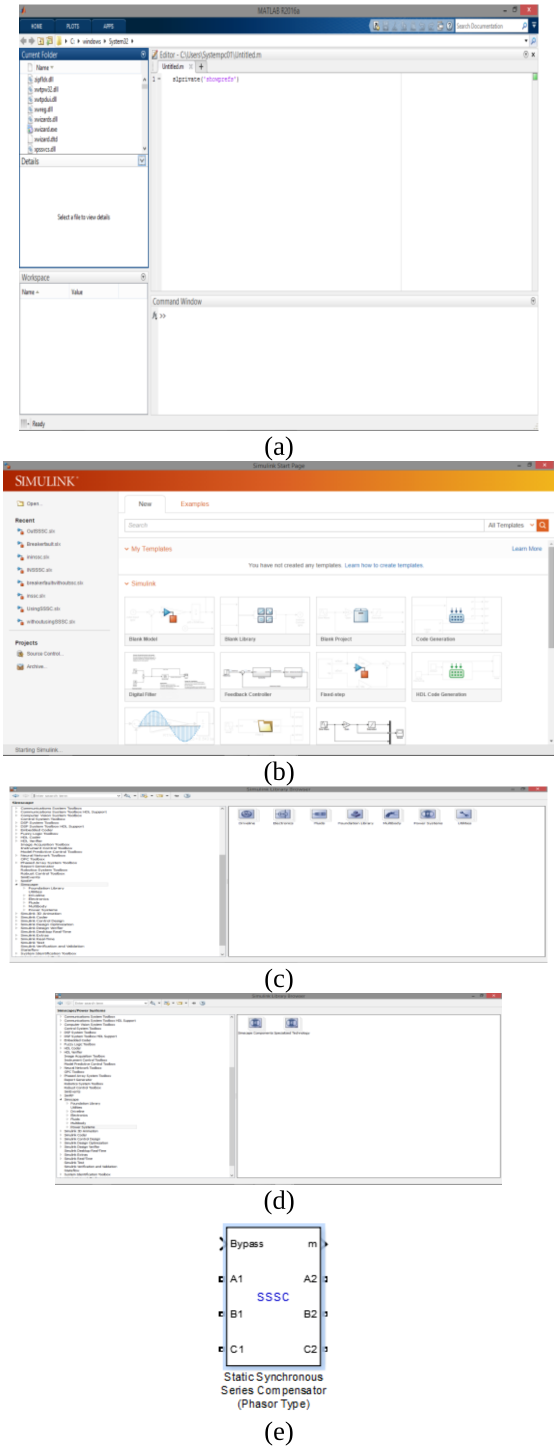


Figure 9. (a) MATLAB R2016a window, (b) Simulink start page, (c) Simulink library, (d) Grid of control in Simscape, and (e) . SSSC model in Matlab/Simulink

A. *Modelling Of SSSC In MATLAB/Simulink*

The two types of SSSC parameters are as follows: Awareness and control conditions of great power. to pick out the cluster of parameters that ar to envisioned show list box is employed. A1, B1 and C1 ar three input terminals and A2, B2 and C2 ar the 3 output terminals. By pass breaker ar set to external management. once parameters are Simulink signal is used when external management is selected. When the input is low or empty, bypass breakers open. and the other way around. There ar seventeen SSSC internal signals in Simulink output vectors. These ar either voltage or current phasors or management signal. they'll be approached by mistreatment the bus selector block, MATLAB/Simulink model of SSSC is shown. they'll be separately hand-picked by using the Bus Selector block.

1. Power Data

Figure 4 shows the Power tab. Nominal frequency and voltage , series convertor rating, series convertor starting line current, and the nominal voltage of DC Link are all examples of these values, and DC link gross equivalent capacitance, should be measured meticulously for SSSC modelling. Here is a detailed description of each one.

1.1. Nominal voltage and frequency

The nominal line-line voltage (Vres) is measured in hertz, and the frequency unit is hertz. The nominal line-line voltage in our test system is 123KV, and the frequency is fifty cycles per second.

1.2. Series Converter rating

The maximum price of the pumped T/F in PV of nominal component to ground voltage voltage Vconv on the voltage supply device axis in the series system nominal rating in (VA.). Default is [100e6, 0.1]

1.3. Series Converter impedance

The nominal convertor rating and nominal voltage were provided by the importance of positive-sequence resistance and inductance in per unit. The resistance and discharge inductance of the coupling electrical system located between the conductor and the voltage source converter, as well as the resistance and inductance of the series filtering inductors attached at the voltage source converter output, are represented by R and L.. Default is [0.16/30, 0.16].

1.4. Series Converter initial current

The magnitude and importance of the phasor current. of that is in per unit and introduce degrees is shown by this parameter. If the initial price of this in an exceedingly circuit is thought with reference to the SSSC in operation purpose could specify it so as to start out simulation in steady state. If initial price isn't identified, then mark them each zero [0 0]. once a brief transient the system can reach steady state. Default is [0, 0].

1.5. DC link nominal voltage

The DC link's nominal voltage in volts. Its default setting is 40000.

1.6. DC link total equivalent capacitance

The price|value of DC relation capacitance, as well as the value in farads, are shown in this parameter. This figure is based on the SSSC converter's ranking and the DC's nominal voltage. connector. A change in the nominal voltage of the DC connection or the converter rating may change the value of capacitance in a variety of ways. The DC link's entire capacitance is measured in faradsThe value of the capacitance is proportional to the SSSC converter rating and the nominal voltage of the DC connection.

2. Controller Tab

The figure depicts the Controller tab. For SSSC simulation, The injected voltage regulator Vqref ,bypass breaker, and DC voltage regulator gain levels should all be carefully considered. defined. Each one is explained in detail below.

2.1. Bypass Breaker

The bypass breaker'e their state is defined by this parameter. It's either transparent management, closed management, or external management. In external power, the by pass is controlled by an external signal.

2.2. Injected voltage reference Vqref

It is the atomic number that specifies the quadrature-axis portion of the voltage injected on the voltage device component of the coupling electrical device. 94.Default is 0.05.

2.3. Maximum rate of change for Vqref

It is the Vqref voltage's maximum rate of transition, its value is in pu/second. Default is 3.

2.4. Injected voltage regulator gains: [Kp Ki]

The price of injected transformer gains is the PI regulator gain that manages the injected voltage. The series unit resistivity parameters are used to calculate forward gain. The integral gain is ki, and the proportional gain is kp

2.5. Vdc regulator gains: [Kp Ki]

The PI regulator gain of DC voltage regulates the voltage around the DC side capacitor. Its values are calculated on a per-unit basis.

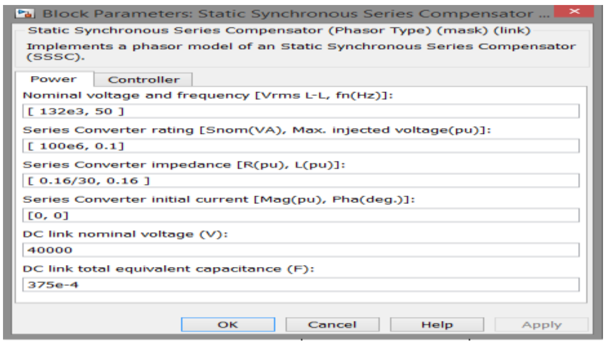


Figure 10. Control Screen/SSSC Parameter

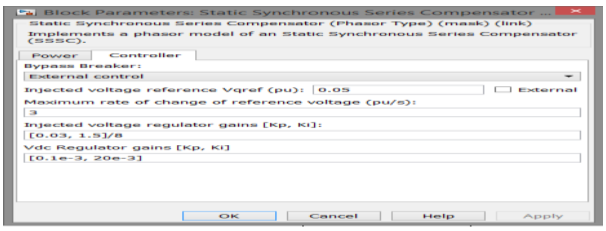


Figure 11. Control parameters/SSSC parameters

VI. Simulation and Case Study

The model is implemented in MATLAB/Simulink in this chapter. The method's results with and without SSSC are compared. The model was chosen from the swat space because low voltages are a problem in this region, particularly during peak load in the months of June, Gregorian calendar month, and August. We will increase the voltage profile, the power flow, and the system's transient stability by using SSSC..

In this paper we have a tendency to study the case study of city electrical provide company. PESCO has many range of 132 potential unit, sixty six potential unit and 132 potential unit grid stations and every one ar associated with one another. With relation to transmission and distribution facet the ability system has bound limitations in PESCO. The emphasis here is on a line case study. The current status of the case study is on line. Figure 5.1 depicts the current state of affairs for the case study, which includes Kohat, Gurguri, and Tall 132 future unit grid stations. Low voltage issues arise during peak load, especially in the months of Gregorian calendar month, Gregorian calendar month, and August, and the system becomes overloaded, as seen in tablea single Once there is a high prevalence of major faults in transmitting electricity, the problem of transient stability would become the limiting factor. SSSC is located near Gurguri grid station to improve capacity transfer capabilities and expand voltage reliability under overloaded and fault situations. The likelihood of blackouts can be reduced by increasing voltage stability at the patron finish. ar reduced during this space forced load shedding that is taken into account as an enormous loss for the utility firms is avoided.

In MATLAB/Simulink, the test device is simulated under overloaded conditions. As seen in figures 5.2 and 5.3, the outputs of the test device with and without SSSC in the circuit are evaluated..

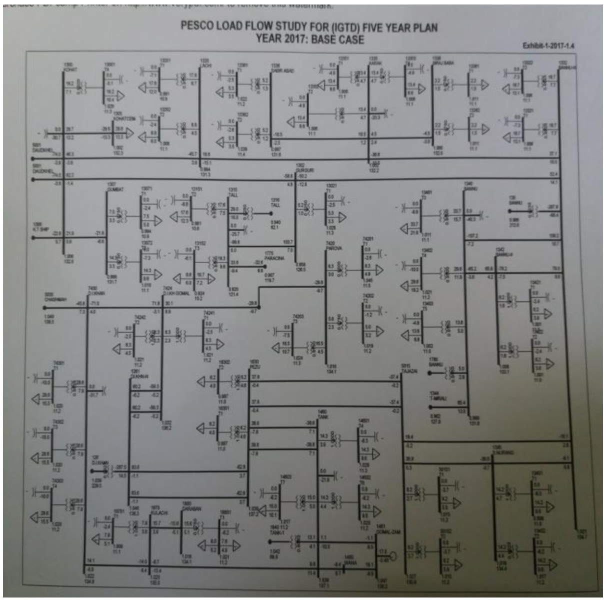


Figure 12. System for Testing

A. *System without Using SSSC*

In this device, a three-section programmable voltage supply is shaped like a 132 kilovolt Kohat grid station in MATLAB/simulink. This system makes use of three buses: the Kohat bus, the Gurguri bus, and the Tallbus. These are shaped like a three-section V-I activity. The cable between the grids is intended by the dispersed line parameter block gift in areas of the power grid.. In Simulink check system is shapely while not SSSC. Under overloaded conditions, the findings are analysed.

B. *System Using SSSC:*

From Kohat to Gurguri, there is a 132 kilovolt conductor. As seen in Figure 5.3, SSSC is placed near the Gurguri bus. Since the line length varies between medium conductors, SSSC can be used. The SSSC is used to meet the need for a check method. The check method is simulated with SSSC in Simulink, and the effects are also analysed..

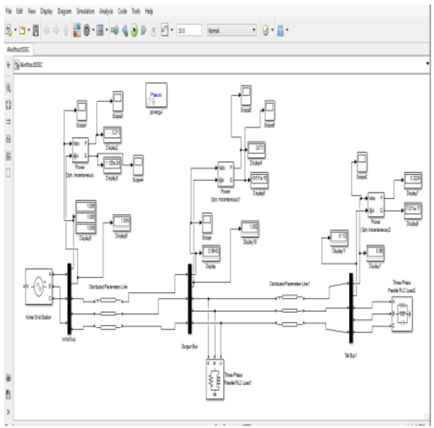


Figure 13. Without using SSSC, build a Simulink model of a test device

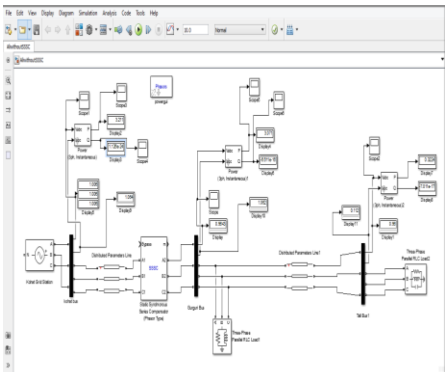


Figure 14. Simulink is a programming language that allows you to create SSSC model of a test device

C. *Discussion on Results*

Table three and Table four, respectively, demonstrate the outcomes of simulations with and without SSSC. The findings show that the voltage profile at Gurguri and Kohat buses has risen. The active and reactive power of the system are also compounded. The values are given in per unit, in accordance with PESCO zero. 95 Pu is beyond the safe voltage range; beyond this, the circuit becomes overloaded.

At peak hours, the voltage on the Gurguri and Kohat buses falls below the safe voltage cap, causing current to rise inside the circuit, increasing losses and causing the battery to become overloaded, resulting in load shedding, which is a loss to PESCO.

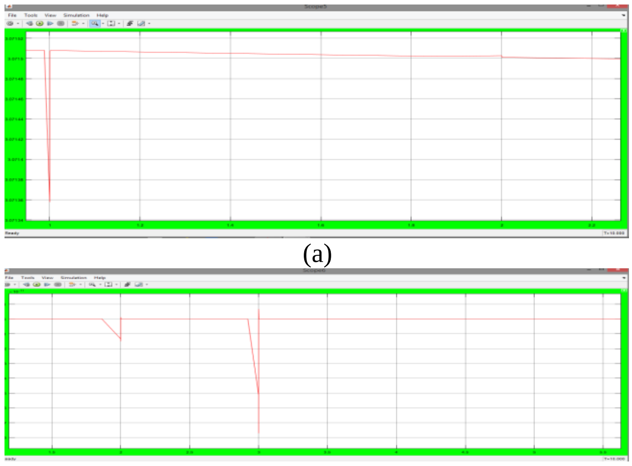
FACTS technology series compensator SSSC is installed inside the device to minimise losses and extend the flow of electricity. After simulation, it would be clear that the voltage profile has been changed and compounded on top of zero. Every Kohat and Gurguri bus costs 95 Pu. In addition, the flow of active and reactive power inside the device has increased. Figures 5.16 and 5.17show the consequences of reactive and active control for both the SSSC-free and SSSC-enabled test systems, and the simulation findings show that the system without SSSC oscillates rather than the system with SSSC. As seen in Figures 5.18 and 5.19, using SSSC in the system causes oscillations to be damped easily and the system to become stable.

TABLE I. TABLE TYPE STYLES

Bus	**Voltage per unit(pu)**	**Current per unit (pu)**	**Active Power per uni(pu)**	**Reactive power per unit (pu)**
Kohat bus	1.007	1.020	1.201	0.9596
Gurguri Bus	0.9424	1.031	1.207	0.8255
Tall Bus	0.9181	0.1871	0.2010	0.1922

TABLE II. TABLE TYPE STYLES

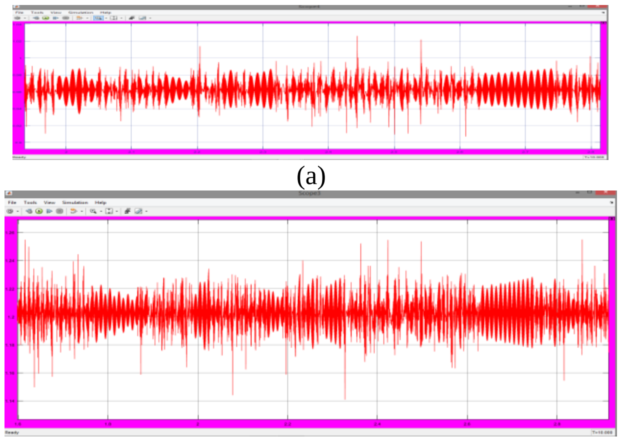
Bus	**Voltage per unit (pu)**	**Current per unit (pu)**	**Active Power per unit (pu)**	**Reactive Power per unit(pu)**
Kohat Bus	1.061	1.065	3.212	2.973
Gurguri Bus	0.9644	1.063	3.072	2.959
Tall Bus	0.961	0.113	0.3225	0.1989



(a)

(b)

Figure 15. (a) Under overloaded conditions, active power flow in a test device using SSSC (b) Figure 27. Under overloaded conditions, SSSC is used to simulate the flow of reactive control in a test environment.



(a)

(b)

Figure 16. (a) Under overloaded conditions, reactive control flow in the test system without the use of SSSC, and (b) Under overloaded conditions, active power flow in the test device without the use of SSSC is possible.

CONCUSLION

For grid reactive power compensation, SSSC has recently emerged as the most powerful and required system.. The cost of installing new transmission lines is usually low. It's also very time consuming, disrupts power supply, and costs a lot of money in maximum space. Because of the construction of the most recent transmission lines, the status of the realm has changed. is lost SSSC is used to increase voltage stability and expand the ability flow. It's the most cost-effective way to improve power transfer. The 132Kv conductor returning from Kohat to Gurguri is used as a case study in the PESCO room in Kohat. Voltage stability is not preserved in overloaded situations, especially during the months of Gregorian calendar month, Gregorian calendar month, and august. Losses will rise, forcing load shedding, which will result in a significant reduction in the capacity to deliver services. The grid network is in desperate need of compensation. SSSC is used in this research study to achieve voltage consistency and improve power transfer within the network. Simulink enforces the check model with two very separate scenarios. While being victimised even while not being victimised SSSC is an acronym for "Standardized The effects of current, voltage, active control, and reactive power are analysed in this method. The first section of the check method was simulated in its entirety. When comparing simulation results, it's obvious that using SSSC inside the circuit improves the voltage profile significantly. In addition, the victimisation of power flow capacity has grown. SSSC is an acronym for "Standardized Standardized The check mechanism was simulated under a typical three-section tangency fault in the second section, and the results indicate In contrast to the circuit without SSSC, the oscillation was damped remarkably quickly using SSSC, and stabilisation was achieved. was sustained.

In Pakistan, SSSC can be deployed on more complex networks, ensuring future stability. The voltage profile and power flow regulation in MATLAB/Simulink are investigated. Via further machine studies, the location of SSSC should be configured for network.

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Load Confinement for Implementation of Load Management on Consumer Side using Smart Grids

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Abstract— Earth is facing the issues of power crises despite of the fact that it contains unlimited resources in it. This is all due to mismanagement of resource usage or poor planning. Exploring and developing of new ventures takes time and budget, so for developing and under develop countries it is very tough to manage, so all they are left with is well management of resources. Problem the world, especially South Asian countries are facing with conventional load management is the loose control on consumer demand, peak shaving methods, efficient utilization of system and poor reliability. This paper is proposing an idea through which we can manage high power demand of consumers, utilize the power generated efficiently and promptly, take control of load on very root level, increase or decrease it, instead of cutting of whole feeders for peak shaving called as Load Confinement Method. The process is implemented using simulations, performing several experiments.

Keywords— Load Management (LM), Load Shedding (LS), Demand Side Energy Management (DSEM), Renewable Energy (RE), Solar Energy, Nuclear Energy, Wind Energy, Smart Grids (SG), Smart Meters (SM), Load Confinement (LC).

I. INTRODUCTION

For stability of grid operation, electricity supply must be equal to demand [1]. Major imbalance in supply and demand causes frequency fluctutaions, generation failure and blackouts [2]. In developed countries, the blackouts are avoided with contigency plans for continuity of supply. This plan consist of multiple levels on small and large scales [3]. In developing countries, the situation is opposite, as its very difficult to make any long term plan with insufficient power system data, demand and supply curves are always random, non predictive and extremely complicated to handle for grid operator [4].

In this time of modernization, still over a billion people don't have electricity [5]. Alone in India, there are 239 Million people without electricity and Pakistan and Bangladesh has over 25% of population without electricity [5]. The reliability of supply can be increased only by decreasing the system voltage,hence decreasing the overall load. These blackouts and supply cuts are seen as the source of cutting load and balancing the demand and supply electricity to every area for some time [4]. Sales of electricity in Pakistan have increased from 17.6TWh in 1985 to 100TWh in 2017 which is six times increase in sales [6].

These mismatch of demand and supply creates outages and electricity outages creates huge losses to economy of countries [7]. So small household tends to adopt some back system in the form of diesel generator or unintrupted power supply (UPS) [8]. In both choices of backup supply UPS gets an upper hand on generator due it small size, low noise, easy handling, low cost etc but its overall impact on system is still hidden, as the efficiency of domestic UPS system are quite [4] These UPS comprises mainly on Lead acid batteries as storage device [8] which on its own is very un-efficient. It is well documented by [8] that combine efficiency of charging, discharging and UPS circuitry drops well below 50% which shows a huge loss of energy and extra burden on system.

Discussing about energy conservation with better quality battery storage backup supply and desmand side management by usage of smart devices in coordination to smart meters will help us in load forecasting and load management [4]. Elaborating the load management, the paper emphasis on direct control of load from control center reducing the demand with usage of smart devices instead of classical equipments [4]. Showing the impact of battery dependent backup system, [4] perform an experiment that a transformer of 25KVA feeding a domestic area consisting of 15 houses, was rarely overloaded, but one third of same houses when installed with battery supported back up system, the same transformer was overloaded up to 170% of its capacity during summer season.

Billions of dollars of developing as well as developed countries are lost annually due to power outages and load management [9]. Strong power system infrastructure is the emphasis since last decade. Quality of power supply is decreased as the usage of electricity is increased [9]. In 1985, total energy generation of world was 10 PWH where as it improved to 20PWH in 2011 showing the increase is on double after lapse of 25 years, but on the other hand the energy demand is rising more than the production [10]. As the definition goes, load management is the procedure by which the supplier balances the demand of energy with the production of energy and keeps the rated frequency between its acceptable levels. This procedure enables the energy supplier to meet the demand in peak time economically [11]. Smart Grid (SG) is a thing of future which proposes different intelligent methods to solve this energy shortfall issue [10].

As a part of developing country, we hugely face the issue of Load Shedding/Management exceeding several hours per day. This load management is result of cutting off low recovery area in time of peak demand [12]. This is the method used conventionally as it has several advantages of its ease of implementation; economy and no infrastructure are needed. However, these direct cutting areas out of power supply impact hugely the repute and reliability of supplier [13].

This paper furthers the work of [14] regarding direct load management using smart meters and minimizing the use of battery storage back up supplies by proposing a method which is increases system reliability and efficiency by eliminating outages completely, minimizing the need of Backup supplies [15]. It is proposed that during high demand time, instead of cutting the low recovery areas, perform DSM by limiting each consumer to its Base/Backup load only by switching the smart devices [16], thus reducing/shaping the overall demand during peak hours and also saving the consumers from complete power failure, hence improving the consumer reliance on system and well as reliability [17].

II. Load Confinement Technique

This method suggests that the load of each and every consumer will be limited instead of complete outage, during peak hour, by using smart devices. For purpose of understanding, consider the load limits reduced to the same load which the backup supplies were going to provide during load management hours. By this way every consumer will be controlled directly by intelligent servers in control center with the help of smart meters.

Figure 1. Smart Meter

This different type of load is divided into different classes depending upon their nature and named as “Consumer Classes” as given in Table 1. Every consumer class has well calculated “Back-up load” limits which in case of usage of smart devices will be implemented automatically and in case of conventional devices, signal will be given regarding system to consumers which each consumer has to follow during peak hours. If the consumer violates the set limits by the supplier, the energy meter has the capability to sense, warn through SMS/messaging and then cut the connection till the end of peak hour. Also system data and set limits are shared time to time with consumer to keep them well informed. This technique will make sure that every consumer gets a fraction of power generated during peak hours instead of complete power cuts.

As it’s a common practice that whenever there is supply cut, all consumer have their back-up supply, first of all they turn off all the equipment of household/industry, then they shift slowly and gradually to back-up power supply, reducing their overall load and tends to maintain that load until the supply is restored from main power supplier. This is how a whole area which was running on routine load, abruptly switches to reduced/back-up load during supply cut. This paper follows the same concept but suggest that the back-up load which the consumers are getting from backup supply now should be fed by power supplier, called as “Back-up Supply”. The time/duration of peak hours and back up supply limit should be communicated to consumer prior to the peak hours, so every consumer manages/reduces his load. If any consumer violates/ignores the intimation by system of reducing load, then should be cut off completely for pre-decided time span or until the peak hours finishes, the option is left to the consumer. Consumer classes have been set for distinguishing different type of consumers and their set load limits during peak hours. The back-up load limits is worked through the following equation.

Total Generation Capacity (TC) = C1+C2+C3+C4...+Cn.

$$Cn = TC * Pn$$

Where, $$P1+P2+P3.....+Pn = 1$$

Also, $$Cn = Nn * V * BL$$

So, $$BL = Cn / (N * V)$$

Pn = Priority for Consumer Class
Cn = Power Allocation for Consumer Class n
Nn = No of Sub Consumers of Consumer Class n
V = Voltage Supplied
BL = Back-up Load

For Example, for generation capacity of 1000MW, following are the back-up load limits.

Table 1: Consumer load Classes and Back up Load

S #	Consumer Class	Priority (Pn)	No of Sub-Consumers of Consumer class n (Nn)	Voltage Supplied	Back-up Load (BL)
1	Domestic	0.2	100k	220V	9.09A
2	Commercial	0.24	200k	220V	4.95A
3	Industrial	0.26	100	440V	5909A
4	Medical	0.2	200	440V	2272A
5	Government	0.1	1k	440V	227A
	Total:	**1**			

An area fed through feeder have multiple of each consumer class. With the help of smart meter, the above loads limits will be conveyed and implemented on each consumer. The smart meter have the ability to SMS, communicate with smart devices/consumer/supplier, sensing load and cut off/restore power connection. To analyze the usefulness of this technique, it is implemented through software and the results are analyzed.

III. SIMULATION AND TEST CASES

This technique was implemented in MATLAB Simulink and response of the system was noted that how it impacts over all loading curves.

Three different types of simulation tests were performed and their results were analyzed and compared with conventional load management. The source used in the calculation/simulation is 200KVA transformer.

Test Case 1

Fig. 2 shows collective load of 15 consumers and the transformer can be seen almost 90-100% loaded before load management. After implementation of load confinement technique the load is reduced by 50%. It means 40 % load is reduced from conventional system and no supply failure is faced by the consumer during peak hour.

Test Case 2

In second experiment the consumers are increased to 30 and same scheme is implemented. First when the routine load is fed, the transformer got overloaded by 180%. Then back up limit is set to each consumer and the overall load on transformer is reduced to 40% as shown in fig. 3.

Test Case 3

In third experiment fig.4 shows that the transformer rating is improved and different nature of consumers are considered with different loads. The overall load limits was set on 1000A on transformer to keep it from overloading. Initially the overall load was within set limit, so no action is taken by smart meter and same load was being fed. But when the load crosses the 1000A limit, the smart meter start shaving the peak and 15-20% load confinement is performed to keep the system within levels.

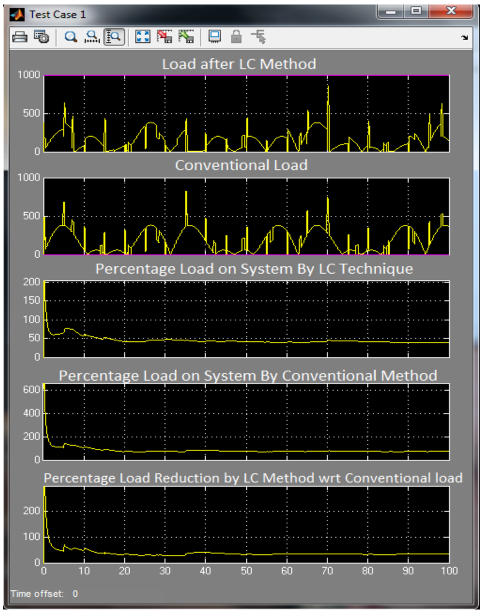

Fig 2. Experiment 1 Results

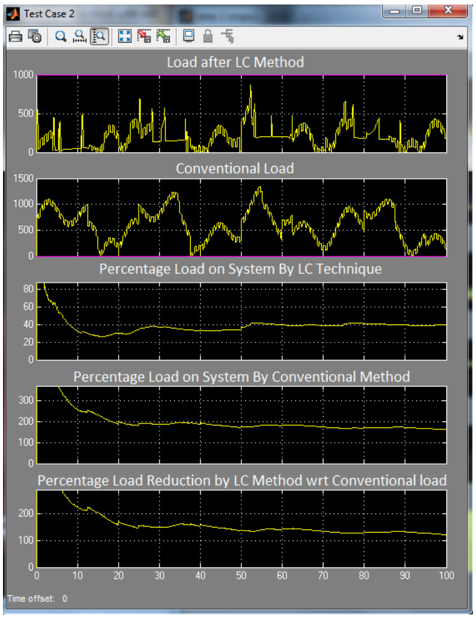

Fig 3. Experiment 2 Results

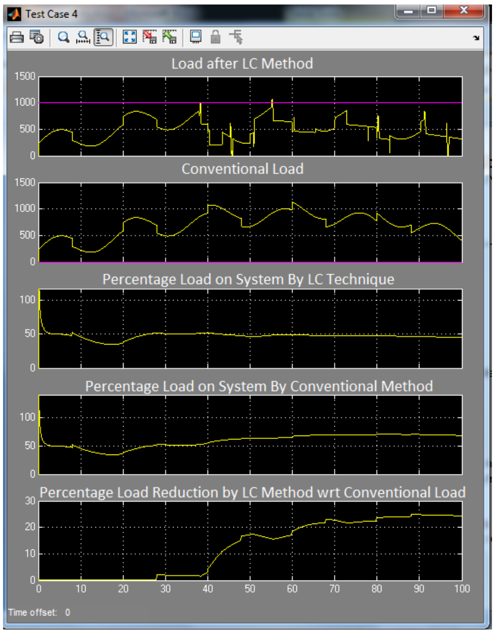

Fig 4. Experiment 3 Results

This experiment shows an interesting sequence that both the waveform before and after application of LC technique, are the same until the load exceeds the set backup limit.

IV. RESULTS AND COMPARISON

The results show that the load confinement technique reduces the overall load as per set backup limits and provide useful results.

- The results show that the conventional load curves were shaved/reduces after implementation of LC technique as shown in fig.5.

- This technique limits every consumer to backup load hence making the overall system very predictable and manageable. It provide ease to system operator to manage load easily and the cases of abrupt increase in load will decrease.
- In case of limit violation the connection is terminated by smart meter. The smart meter act as an intelligent switch, deciding and disconnecting in time.
- All experiments were successful in reducing overall load on system. The load is reduced
- It's a complete scheme addressing many issues of conventional LM technique. It can be implemented easily with installation of only smart meter and upgraded control centers. Also if user uses smart appliances than switching will be more user friendly in comparison to conventional passive loads.
- Smart meter can be programmed to manage load during peak hours on its own but if conventional loads are used then the consumer has to manually lessen the load during peak hour.

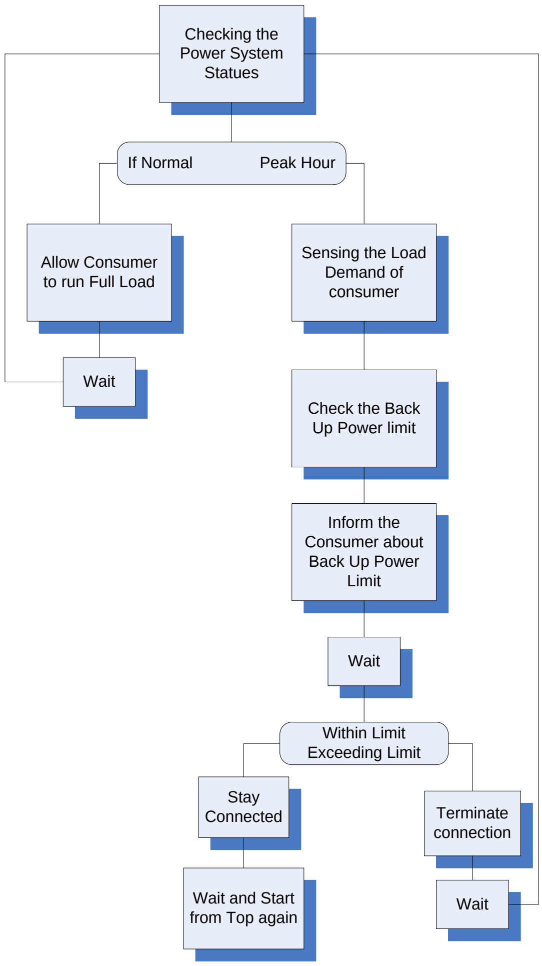

Fig 5. Step wise Flow Chart of Load Confinement Technique

V. Future Work

SG is only implemented on very basic level in even developed countries and a lot of work can be done to improve. The lot of future work can be performed on LC technique for betterment too, such as:

- Work can be done on improving data communication between consumer, control center and smart meter such that consumer manages their load remotely and plan a schedule to control their bills.
- Work can be done for studying the impact of transients made during switching of devices during peak hours.
- If the connection is cut off due to voltage violation then there should be an option through which a consumer can request for restoration of connection once he brought his load within limits.
- During peak hours if consumer requires full/normal load, then he can request control center but with higher tariff.
- As most of the consumer are using simple devices (with no smart option), the manual switching of equipment for consumer is hectic. So, further work can be done on design of control box which enables smart meter to switch all devices as required spontaneously.
- Work can be done on intelligent algorithm for setting back up load limits in real time. All experiments were performed with random values for analysis purpose only. In real time, the system will decide load limits and change it with requirement of system and feed it to each consumer.
- Mentioned advancement in the technology requires work complex networking and communication, which increases the overall cost of the system. It's always a trade-off between cost and technology. So we always choose the features which we require supremely at first.

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A Novel Design of a Circularly Polarized Micro Strip Patch Antenna with Narrowed Radiation Pattern

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***Abstract*—** In the recent era of technological advancements, it becomes the basic needs of the day that every person wants a better and faster means of communication. Antennas design is of the greater importance to achieve better communication. With the development advances of communication systems in different fields of study such as development in the field of IoTs (internet of things) antenna design becomes the talk of the day. Antenna design also has many complications in its design, structure and working. Researchers are trying to achieve such antenna design which should be simple, easy to use and no complexities in structure. This research study circulates around a design and investigation of a newly designing of circularly polarized (CP) micro-strip antenna with a conical pattern of radiations. Major distinctive feature of such design includes single feeding mode, simple design and low profile. The octagon shaped patch can be obtained by two superimposed square patches. Omnidirectional circularly polarized radiation from two superimposed square patches is acquired by generating two mutually perpendicular degenerated TM11 modes. This research study is carried out to understand the fabrication and operation technique of CP micro-strip Patch antenna and the results are obtained. The obtained results shown the linearity with the simulation as well as theoretical results. The antenna is capable to generate conically CP radiation samples with average axial ratio (AR) of value 1.8 dB in azimuthal plane (ϴ=45̊). 3-dB AR BW covers GPS L1 band.

***Keywords*—** circularly polarized micro-strip patch antenna, conically radiated pattern, omnidirectional pattern, octagon star shaped patches.

I. Introduction

Antenna is referred to as "a source of transmitting & receiving radio waves for communication purpose"[1]. Vital role of antenna happens to be wireless communications; indeed without antenna wireless communication is impossible [2]. The signal generated by transmitter is fed to the air by antenna in the form of electromagnetic wave. As shown in Figure 1.1. At receiver this signal is captured by receiver antenna and fed to the receiver [3][4]. The significant properties of antenna are described below. Pattern of radiation for an antenna gives us the information about the direction of minimum and maximum radiations. The power transmitted per unit solid angle by an antenna is referred as radiation intensity [5].Practical antenna does not radiate equal energy in all direction. So directivity termed as "the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions" [5]. Directivity related to an ideal antenna is one (1) while that of practical has directivity of more than 1.Gain is regarded as " antenna radiation intensity in a specific direction divided by the antenna radiation intensity could be achieved if the power acknowledged by the antenna were radiated symmetrically in all orientation" [5]. Gives the information about the volume of power echoed back to the transmission line from the antenna input terminals. If magnitude of the reflected power less than-10 dB the reflected energy is minimum and maximum power is fed to the transmission line [1].It can also be defined as the Frequency range within which maximum power fed and power reflection at its minimum value [6]. "It is the ratio of voltage and current at the antenna's input terminals" [5]. To avoid reflection at antenna we are required to comply with maximum power transfer theorem. It states that antenna's input terminals impedance and transmission line must be complex conjugate of one another [7]. In small devices like mobile phones, laptops, etc. requires portable antenna featuring low profile to radiate and receive the electromagnetic waves and micro strip antenna is very applicable in this regard. Its installation is simple and invisible to the end user[5][8][9][10][11][12]. Micro strip patch antenna comprises of 3 various components i.e. patch, ground plane, and substrate. The two components, ground plane and patch are designed from such material which is good conductor of electricity mostly of copper. The patch & ground are detached by a dielectric material called substrate. Equally shown in Figure 1.3. Feeding mechanism is used for energizing purpose for micro-strip antenna, there are several methods for micro-strip antenna feeding. [5]. Micro-strip line feed is allied to the patch and imprinted on the same substrate, its width, height of substrate, and εr decides Its impedance [13]. Coaxial line feeding coaxial cable is utilized en route for feeding the antenna. Coaxial cable consists of two conductors along with dielectric flanked by them [5]. Fabrication of patch is done on the upper substrate while the fabrication of micro strip link is done on the lower side of the other substrate. They are so combined that upper substrate gives patch whereas lower substrate gives microstrip line. [14]. Proximity coupled feeding structural geometry is correspondingly comprises of two substrates. The ground is on lower substrate and micro-strip line at the upper face. [15]. Patch is needed to be approximately $\frac{\lambda}{2}$ (i.e., half of the wavelength). Stipulation the voltage at one end is extreme in positive direction at that time there should be minimum negative voltage at the other end. It is obvious that horizontal element of fringing field close to the plane of patch takes the identical route. So, owing to identical phase they encapsulate and give growth to radiation from antenna [5-15].

II. Related Work

Most common design of CP antennas are obtained by the excitation of two orthogonal modes at different resonance frequency, mostly such antennas are unidirectional [16]. Omnidirectional radiation pattern for CP have been developed such as Introduction of Curved branches [17] and [18], asymmetric slits implemented [19] and parasitic stubs implanted [20].By rearranging the CP radiating antennas elements through a cylindrical surface [21] having high profile, fabrication issues and complex feeding network. Omnidirectional CP antenna through four bended dipoles [22]. While another technique is based on shorted monopole and 4-dipoles [23]. Both of these techniques are characterized by wide bandwidth, high profile structure and complex feeding circuit. Omnidirectional circular polarized antenna with two faced slot radiator and 2 planar inverted F antenna [24]. Characteristics of such model are low profile and compact structure but associated issue with such model are complex design with addition of extra feeding network.

Dual band omnidirectional CP antennas with planner structure and low profile [25] and [26] however its configuration complex. the design is made in such a way to have the axial ratio (AR) the L1 band i.e. GPS band but the applied limit of 3 dB has been exceeded [27]. Circularly polarized antenna is superior to that of linearly polarized antenna in many aspects including wireless communications [28]. Circular mushroom structure with curved branches using ZOR and ENG TL modes operated at vertical polarization to achieve omnidirectional radiations, while the horizontal polarization is attained by curved branches [29]. Circularly patches wideband. Omnidirectional CP antenna with various prolonged curvy branches works as a polarizer, [30].

Wideband omnidirectional CP antenna designed for broadband [31]. A low profile, wideband CP antenna with conical-beam centrally fed mono-polar patch designed to achieve the wideband CP radiations [32].

Omnidirectional circular polarized micro-strip antenna without the curvature effect for mounting cylinders with radius of each is greater than the guided wavelength [33]. A broadband CP omnidirectional antenna with 4 broadband CP rectangular prototype best suits for 2G/3G base stations [34]. Omnidirectional radiated CP using bended dipoles and integrated baluns is fabricated for a bandwidth of 220MHz with LHCP gain of greater than 0.15 dBic [35]. Omnidirectional CP antenna is designed by placing spiral elements above the conducting drums in horizontal plane, by increasing the numbers of spiral elements leads to the omnidirectional radiations [36]. Omnidirectional CP antenna having non-linearity in results been controlled at 1.5 dB in azimuthal plane [37]. Omnidirectional patch antenna having equilateral triangular patch and a number shorting vias with circular slot rings, triangular patch gives twofold uses, minimizing patch size as well as produces radiation null at upper band [3]. DPDB antenna with to achieve omnidirectional radiation pattern, with the horizontal polarization is achieved through eight asymmetrical open slots, in the upper band in order to get omnidirectional linear polarization the TM01 is excited [38]. Omnidirectional radiations at single plane for GPS system a differentially fed back-back patch antenna [39]. In order to generate the circularly polarized conical radiations a circular micro-strip antenna has been excited at higher order modes, at different higher order modes or substrate is loaded with different materials of changed dielectric constants the peak of the conical radiations has been changed, for this different feeding modes are needed [40]. For the purpose to achieve wide impedance, AR and gain bandwidths along with low profile and high gain a CP conical beam patch with featuring wideband is design [41]. Dual CP micro-strip with conically radiated pattern integrated with hybrid coupler to achieve better results through 2nd order exciting mode gives conical peak around 46 degrees can be applied on vehicle mounted satellite communication [42]. An omnidirectional azimuthal coverage is archived through TM21 mode circularly polarized ARMSA with a feeding line in ring shapes provides better impedance matching and annular ring provides the better CP with carefully designed feeding line inside the ring [43]. With the intention of lessen the frequency ratio of the slotted patch dual band antenna for the application of GPS system transmission or receiving an antenna design featuring low profile and cost using short circuited micro-strip stub for defining reactive loading, moreover the frequency ratio dual band can further be reduced by optimizing the antenna [44]. In order to minimize the multipath fading and to acquire CP with high gain a CP antenna designed for the GPS use with 12 elements antenna array, by increasing the elements gives CP with high gain and reduced multipath fading [45]. With the purpose of accomplishing wideband CP radiations a metasurface single feed, rectangular shaped with slotted patch implemented, the given results states that AR mainly depends on the metasurface configuration, patch radiator size and feeding point location [46]. Enhancement of Circular polarization achieved with feeding the L- shaped probe feed, CP is obtained via two perpendicular polarized fields from L-shaped probe, using 4 L- shaped feeding probes reduces more mutual coupling than 2 L- feeding probe [47]. L-shaped probe with single feeding patch with horizontal portion act as transmission line with ground plane designed to get impedance, gives limitations in bandwidth because of inductance associated with L-shaped probe [48]. Differentially fed patch with symmetrical arrangement for CP with L- shaped probes feeding is done through capacitive coupling gives linear pattern, serves in desired in mm-wave phase antenna [49]. CP performance with reduced size of the antenna by reducing annular ring patch size , using cross slots in ground plane is designed and implemented [50]. CP embedded with square micro-strip having singly fed tri-band features, parallel to the sides of upper square patch two pairs of narrow slots are capable of generating circularly polarized radiations with a better performance of the antenna design [51].

Rectangular patch embedded on the glass epoxy FR-4 with a singly fed stacked design to achieve better results of impedance and AR bandwidths and gain found applications like wireless satellite communication where high AR bandwidth are required which is in most cases desired [52].

Based on the mode analysis a new design is implemented where higher mode frequencies (TM20-TM50) reduced and combined with resonant mode dominating TM10, in order to get CP radiation pattern for a wide band [53]. Comparison of Yagi antenna tilted beam inclined on a wall is made with the patch antenna [54]. An asymmetrical feeding point is proposed for the CP UWB HRMSA for calculating impedance matching, AR, gain and radiation pattern found its applications in S, C, and X-band applications [55]. Four feed with TM21 mode right hand CP to cover L1 band for GNSS receiver application, gives the conical radiation pattern achieving null at boresight and peak at desired phase [56]. CP micro-strip feeding patch antenna operating at 5.8 GHz frequency design [57].CP-MPA with a conical grounded plane operating at an X-Band with a composite single-feeding operating mode found the application in the SMP connector based termination [58]. A pressure driven enabled antenna having reconfigurable polarization antenna design having micro channel developed to multiple contact points for low loss conducting pathways [59]. MSA antenna operating having linearly polarized designed for the application like Altimeter [60].

III. METHODOLOGY

In this section the stepwise approach for design is covered. The following steps are illustrated below for the anticipated antenna design.

Step 1 antenna parameters:

TABLE I. ANTENNA PARAMETERS DESCRIPTION AND VALUES.

Name	Description	value
Theta d	Feeding point phase angle	22.5
Theta	Phase angle	45
t	time	0.05
h	height	5
d_{out}	Outer distance	1.7
d_{in}	Inside distance	0.5
dL	Change in length	2
d	Distance from the patch center	32.2
R	Radius of substrate	80
L_{coax}	Coaxial cable length	15
L	Length	94.4
ε_r	Relative permeability	2.164

Step 2 design simulation:

Step 3: theoretical analysis:

- *TM_{11} – Mode Square Patch Antenna.*

The tangential electric field at the patch sides can be calculated in from equation 1 given below.

$$Ez(x',y') = -A/2h(\sin\frac{\pi}{L}x')(\left(\sin\frac{\pi}{L}y'\right), -h \leq x' \leq 0 \qquad (1)$$

The magnetic field can be premeditated via equations given below.

$$\begin{Bmatrix} Mx1 = A\left(\sin\frac{\pi}{L}x\right), y = \frac{L}{2} \\ Mx2 = A\left(\sin\frac{\pi}{L}x\right), y = -\frac{L}{2} \\ My1 = -A\left(\sin\frac{\pi}{L}y\right),\ \ x = \ \frac{L}{2} \\ My2 = -A\left(\sin\frac{\pi}{L}y\right),\ \ x = -\frac{L}{2} \end{Bmatrix} \qquad (2)$$

Source of magnetic lines producing the far-field is given by equation.

$$E = -\frac{1}{\varepsilon o}\nabla \times F \qquad (3)$$

Electric potential vector is represented by F.

$$F(r) = \frac{\varepsilon o}{4\pi r}e^{-jkor}\int Me^{jkor'.\hat{e}r}\,dl' \qquad (4)$$

$$\begin{Bmatrix} E_\theta^{TM11}(\theta,\varphi) = -jk_o\frac{e^{-jk_o r}}{4\pi r}\left(-f_{mx}\sin\varphi + f_{my}\cos\varphi\right) \\ E_\varphi^{TM11}(\theta,\varphi) = jk_o\frac{e^{-jk_o r}}{4\pi r}\left(f_{mx}\cos\theta\cos\varphi + f_{my}\cos\theta\sin\varphi\right) \end{Bmatrix} \qquad (5)$$

Whereas

$$\begin{Bmatrix} f_{mx} = \int_{-\frac{L}{2}}^{\frac{L}{2}}\left(M_{x1}e^{j\frac{k_oL}{2}\sin\theta\sin\varphi} + M_{x2}e^{-j\frac{k_oL}{2}\sin\theta\sin\varphi}\right) \times e^{jk_o x\sin\theta\cos\varphi}dx \\ f_{my} = \int_{-\frac{L}{2}}^{\frac{L}{2}}\left(M_{y1}e^{j\frac{k_oL}{2}\sin\theta\cos\varphi} + M_{y2}e^{-j\frac{k_oL}{2}\sin\theta\cos\varphi}\right) \times e^{jk_o y\sin\theta\sin\varphi}dy \end{Bmatrix} \qquad (6)$$

- *Octagon-Star Shaped Patch Antenna.*

Design of the desired antenna obtained by making two TM_{11} superimposed square patches at angle of 45^o having size of Δι. The far field of the proposed antenna can be calculated as.

$$\begin{Bmatrix} E_{\theta}^{star}(\theta,\varphi) = E_{\theta}^{TM11}(\theta,\varphi) + jE_{\theta}^{TM11}(\theta,\varphi+45^o) \\ E_{\varphi}^{star}(\theta,\varphi) = E_{\varphi}^{TM11}(\theta,\varphi) + jE_{\varphi}^{TM11}(\theta,\varphi+45^o) \end{Bmatrix} \quad (7)$$

- *Resonance Frequency*

$$f_1 = \frac{c}{L\sqrt{2\varepsilon_r}} \quad (8)$$

Resonance frequency of the patch having length (L+l) *(L+l) can be found

$$f_2 = \frac{c}{(L+\Delta\iota)\sqrt{2\varepsilon_r}} \quad (9)$$

Step 4: Effect of variations in variables on results.

Step 5: comparative analysis.

IV. Results

A. S_{11}-Parameters of the Proposed Antenna.

As already stated that the antenna is deliberated to function in the frequency of 1.55 GHz. The resonance frequency of the antenna is 1.575 GHz while the Bandwidth is 23.8 MHz that is1.54 %, the operative frequency range of the antenna in -10dB range is as of 1.545 to 1.569 GHz. As shown in figure.1

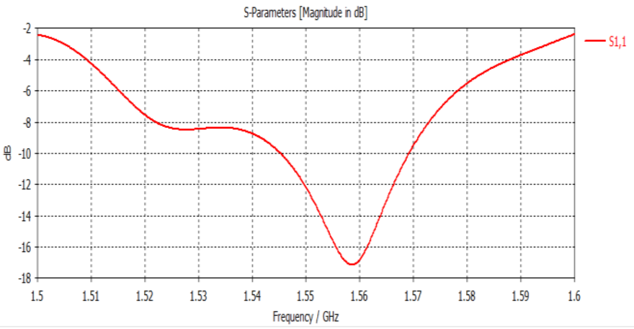

FIGURE .1 S11 PARAMETERS FOR THE PROPOSED ANTENNA.

B. 3-dB Axial Ratio Bandwidth and Directivity.

The figure 2 shows the simulated results for the axial ratios ARs of the presented antenna design. The bandwidth measured for the antenna at φ =0o and θ =45o is between the frequencies operating within the range of 3dB. The range of frequencies for presented antenna is measured in the range of (1.53-1.5415) GHz, having a Bandwidth of 11.5 MHz which is 0.74%.

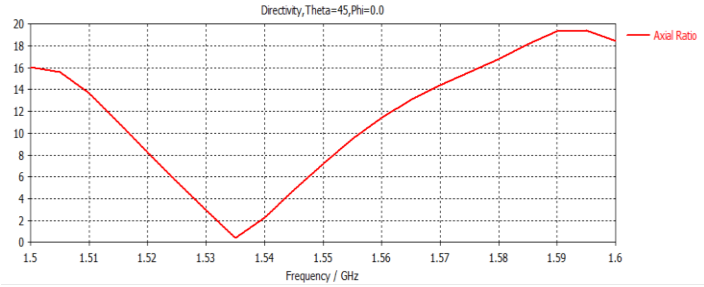

FIGURE 2. SIMULATED AXIAL RATIO BANDWIDTH

The effect of varying different variable parameters have significant impact on the 3dB AR Bandwidth. Some of them are explained as follows. First of all we have seen the effect of changing the length shown that AR is very sensitive to the change in length. Changing the length may deteriorates the AR, in order to operate in an optimum region the two TM11 modes should in separated in such a way that conditions for circularly polarized radiation must not be violated.

By changing the position of feeding point may not affect the AR parameters much but feeding point must be at a point where optimum impedance matching is achieved which will be sited at the center of the patch specified in the parameters description which is 22.5o. By varying the thickness of the substrate from 3-5mm results in an increased AR bandwidth from 0.5-0.8%, also by lowering the constant dielectric constant from 2.164 to 1 further enhance the AR bandwidth from 0.6 to 1.1 %.

Omnidirectional pattern of radiation is produced at an azimuthal plane. The proposed antenna is not capable of generating desired pattern in omnidirectional because of ground plane, thus due to this the sedated level of cross polarization is less than -18dB at theta=45o.

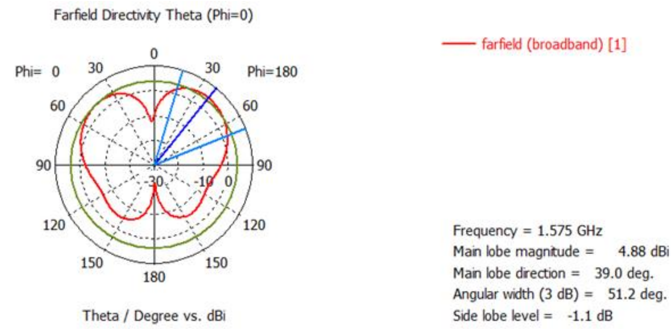

FIGURE 3. FARFIELD DIRECTIVITY THETA WITH (PHI=0O)

Figure below shows the graphical view of the Farfield Directivity phi

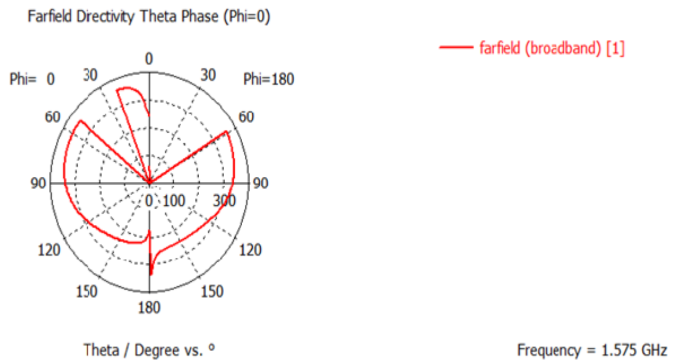

FIGURE IV. FARFIELD DIRECTIVITY PHI WITH (PHI=0O)

C. *Gain of the anticipated antenna.*

Figure 5 provides the insight into the gain of the offered antenna. The peak gain which shown in the results is 5.64 dBi at 1.575 GHz having gain variation over the period of 1.55-1.575 GHz is 0.59 dBic. The measured gain is less than that of the simulated gain because of the losses at different stages of the antenna design.

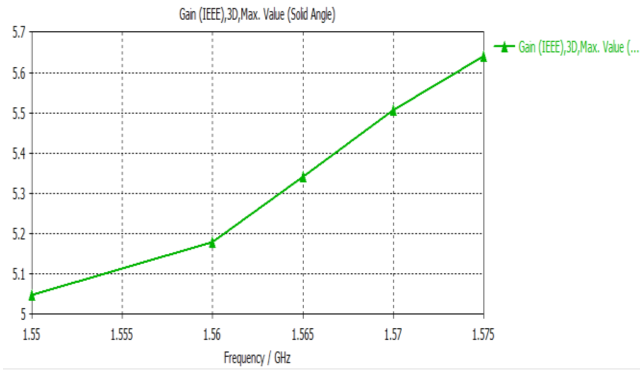

FIGURE 5. GAIN OF THE ANTICIPATED ANTENNA DESIGN

D. *Efficiency of the anticipated Antenna.*

Efficiency of the presented antenna design is given in the figure 6. The results shown comprises two types of efficiencies which are radiated efficiency and the total efficiency. Radiated efficiency over the period of 1.5-1.6 GHz ranges from -0.15-0.35 dBs. With a maximum value of 0.35dB. Total efficiency of the antenna design over the frequency range of 1.5 – 1.6 GHz is in the range of the -4dB to -0.1dB. The peak of the total efficiency is -0.1dB which is occurring at the frequency of 1.56 GHz, the point where the radiated and total efficiencies are almost equal. The graphical view of the efficiencies related to the antenna are given in the figure below.

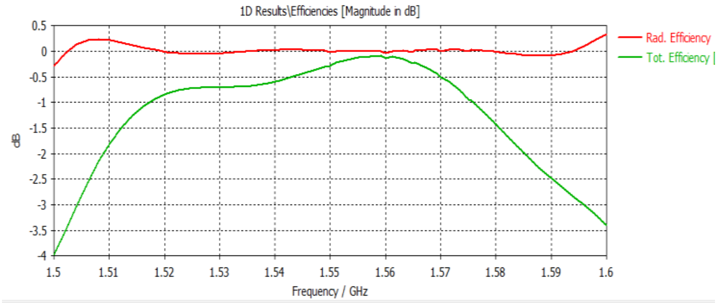

FIGURE 6. EFFICIENCY OF THE ANTICIPATED ANTENNA DESIGN

E. *Evaluation of the anticipated antenna design with literature study.*

In this a proposed antenna design comparison is made with the previous work illustrated in the literature review shown in the table 4.1 given below.

On comparison with the [2-4] the presented antenna shows the similarities in respect to low profile, single layer and single feeding mode and few design variables leads to easy design of the antenna. On comparison with [12-13] dual band antenna design gives good agreement of the AR bandwidth, same design and gives higher gain. The comparison with multilayered antenna design [9-11] presented antenna design features higher gain, low profile, simple design with no extra feeding point. Comparing the presented model with a TM21 mode based antenna design in [15, 16, and 18] gives easy design without any extra feeding point for the excitation of orthogonal mode thus giving less design complexities. While when compared with [21] shown that previous work suffered from the issues like poor radiation pattern and high profile design. On the other hand the proposed design has narrow AR bandwidth when compared with the previous work, thus results in such a way that the proposed antenna design suits for the application of GPS L1 band. The AR bandwidth can be improved by selecting thicker substrate and having permittivity of 1. While comparing with truncated antenna design our antenna design shows the same behavior such as simple design, single feed, easy design, and narrow AR bandwidth of less than 1%. The only mismatch between them is that the offered antenna gives conical radiation while the corner truncated antenna gives the unidirectional radiation pattern. At the end the comparison is made [paper] the results shown that the offered antenna has higher gain and AR bandwidth as compared to the previous work, while keeping antenna dimensions same.

CONCUSLION

This research work is carried out to design and simulate a circularly polarized octagon-star shaped micro-strip patch antenna having radiation pattern of conical shape. The features of this antenna design includes low profile, single feed, and simple and easy design without having any extra feeding connections. The two orthogonal degenerated TM_{11} having radiator forming an octagon-star shaped patch is responsible for the generation of an omnidirectional circularly polarized radiation pattern. The working techniques of the presented work is explained with an appropriate cavity model analysis. The simulated results of the design gives the conical radiation pattern with a peak positioned at $\theta = \pm 45^{\circ}$ while the 3dB AR bandwidth covers the GPS L1 band.

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Blockchain: A Workable Distributed Energy Exchange Framework for Prosumers in a Micro-Grid

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Abstract— The rampant increase in demand of electrical energy with raising life standards owing to technological advancement coupled with already stressed power system infrastructure, has exacerbated the energy regime. Chasing this demand gap, many countries are heavily investing in non-renewable generating plants. On one hand, it will worsen the global climatic condition, while on the other hand it will further tense the power transmission and distribution systems. A better alternative is to invest in renewable DG's along with the culture of energy sharing. Currently, net metering is widely used for energy sharing, yet the introduction of Blockchain will revolutionize this industry. A dedicated analysis based on payback, break-even point, levelized cost of energy, and rate of return has been carried out for both net metering and Blockchain system to find a workable distributed transactive energy exchange framework for con(pro)sumers in a micro-grid.

Keywords— Blockchain, Net-Metering, Payback period, Levelized Cost of Energy, Break-Even Point.

I. Introduction

In the twenty-first century, electricity is regarded as a critical socioeconomic engine. The use of electrical energy has expanded dramatically as people's living standards have materially elevated. The mushrooming load-demand can't be met by a solo component like a utility company, we've to come up with innovative strategies to meet it. Consequently, we decided to pool our energy resources aided with latest technologies. In this regards, many new concepts and approaches in the electrical market emerged for the sharing of energy. Initially, the mechanism of a Net Metering System (NMS) for sharing excess energy has been introduced in recent years. But now the Blockchain System (BCS) has been also introduced in addition to the NMS for a decentralized pooling, a concept borrowed from crypto currencies. Not only will this new technology modernize the energy industry, but it will also end utilities' monopolies. Conventionally, solar power system installers are rewarded for the kWh they contribute to the grid through net-metering [1]. The approach is to create maximum energy from the sun during the day and in favourable conditions and add it to the grid, while importing energy back when needed at night or in unfavourable conditions. This is one approach to relieve grid pressure, meet power deficits, and eliminate the costly backup system while saving money on utility bill. In contrast, blockchain is a relatively new internet that empowers con(pro)sumers to sell surplus solar energy to others on a secure platform in a very active viable exchange[2]. In terms of decreasing utility monopolies and boosting energy sharing among consumers and prosumers, it outperforms the net metering mechanism. In this research, we intend to assess the infrastructure and architectural aspects of a micro grid based on NMS and BCS. A range of economic measures are utilised to analyse each system for this investigation.

II. Literature Review

The power grid is rapidly evolving, current technology has improved the usage of advanced control methods, and next-generation grid technologies will require a focus on the integration of DERs with customers who can buy and sell electric energy in a seamless manner [4]. The growing load on power plants and transmission lines has cleared the way for distributed generation, utilising renewable energy sources (RES)[5]. Because renewable energy sources are inherently intermittent, harnessing them necessitates extensive technological and economic considerations[6]. As a result, exporting excess RES energy to the utility grid and receiving credit for it is more feasible[7]. It is advantageous to both the consumer and the utility [8]. The technical considerations for exporting electricity to the grid have been thoroughly examined in [9], which includes a comparison of traditional and advanced smart metres. Because renewable penetration in the national grid is limited, it is preferable to exchange electricity among peers in close proximity, according to the paper. Procedures and mechanisms for sharing and trading electricity between customers and prosumers have been put in place after a lot of work. Trading via NMS and BCS will be the subject of our research.

Net metering, according to [10], is a policy aimed at encouraging the adoption of modest renewable energy systems for power generation. When a system owner generates extra power than they require during a certain passé, they are given retail credit for the amount of electricity they subsidise[10]. Import/export tariffs are typically imposed by regulators usually favour utility corporations [11]. Furthermore, market competitiveness in the Net metre is unfavourable for all energy trading stakeholders except utility[12]. Despite the fact that prosumers profit more from net metres than consumers, the utility maintains its monopoly by dictating tariffs [11].

Blockchain for energy sharing is a recent field with little research. A detailed examination of the possibility of peer-to-peer communication may be found in [13]. In this study [14], Jianzhong described a comprehensive bidding mechanism for peer-to-peer systems, which featured the Elecbay energy exchange. While Ehmke [15] explains the scalability question in Blockchain lumps, he then suggested explicitly keeping the state of the system in the current block, but he goes even farther by including the relevant part of the existing system data in new transactions using Ethereum. Another credible paper [3] on the use of Blockchain in the financial sector, with a focus on supply chain management. Similarly, M. Condoluci says though data requirement for blockchain is enormous, yet the development of 5G can cater its demand [16]. In short, the literature review of Blockchain reflect that with all its complication the BCS is capable is bring revolution in energy market.

III. METHODOLOGY

The objective of creating a sustainable decentralised energy trading system using Blockchain or net metering has been set, recognising the huge benefits and importance of this technology in the future smart grid. Following an exhaustive literature review, we are now aiming to apply theoretical knowledge to build several scenarios that aid us in evaluating each system. For objectives of this study, we assumed a micro-grid with some pro(con)sumers who have specific solar generation and mentioned loads. For ease, we assume that the local micro-grid is connected to main grid; consequently, we consider the infrastructure that has to be changed or upgraded in the existing power structure for Net-metering system or Blockchain System are taken into account. Power, Control, Communication, and Business are the four layers that make up the infrastructure of NMS and BCS. After carefully assessing the cost per unit for both systems, a dynamic revenue generating model is created. The data supplied by the per unit cost and income model is thoroughly investigated using a variety of economic indicators. The results are correlated, culminating in a workable decentralised trading system for prosumers in a smart microgrid.

A. Payback Analysis

The time it takes to recoup the money invested is referred to as the payback period. It is best if the payback period is as short as possible. The payback for both NMS and Blockchain are investigated in this paper. We calculated payback by removing the salvage value from the capital cost of each system to arrive at net capital cost. The payback analysis is based on the capital investment and revenue generated by each system. Finally, by following a formula, we were able to obtain payback.

$$\text{Payback Period} = \frac{\frac{\alpha \sum_{i=1}^{n} G_i}{(1-r)^y} - SV}{\beta G_r}$$

Where,

α	Estimated system cost per unit watt
i	No. of Pro(Con)sumer 1, 2, 3 … n
Gi	Installed Generation Capacity of ith pro(con)sumer
r	Depreciation’s Rate
y	Expected Lifespan of the system in yrs
SV	Salvage Value of the system
β	Price per unit watt for sale
Gr	Yearly kWh Produced

B. Break-Even Analysis

The Break-Even Analysis (BEA) tells you when your investment will be repaid and when you'll start making money. In most cases, the power system's breakeven point is expressed in years. It differs from the payback time in that it is a little longer. We use Rs. 13/kWh in repayment as decided by national regulator, but we use nearly Rs.17/kWh here because this is a savings decided by market. Each system's net capital cost and annual savings were calculated for BEA. The payback calculation is identical to the net capital cost, while the savings, on the other hand, are determined by multiplying the kWh/year produced by Rs. 17/kWh.

The BE Point is calculated using the formula:

$$\text{BEA} = \frac{\frac{\alpha \sum_{i=1}^{20} G_i}{(1-r)^y} - SV}{\gamma G_r}$$

Where,

α	Estimated system cost per unit watt
i	No. of Pro(Con)sumer 1, 2, 3 …
Gi	Installed Generation Capacity of ith pro(con)sumer
r	Depreciation Rate
y	Expected Lifespan of the system in yrs
SV	Salvage Value of the system
β	Price per unit watt for sale
γ	Saved per unit watt
Gr	Yearly kWh Produced

C. Levelized Cost of Energy

The term "levelized cost of energy" (LCOE) refers to the cost of solar power produced over a period of time, usually the system's usable life. We calculated the capital costs of both systems for a period of 25 years for this analysis. This analysis also includes the cost of operation and maintenance. Following the discovery of capital investment, we computed the number of kWh generated over a 25-year period (Useful life of the system). The LCOE is determined using the formula below.

$$\text{LCOE} = \frac{\frac{p\sum_{i=1}^{n} G_i}{(1-r)^{y}} + \sum_{j=1}^{\zeta} O_m}{\zeta G_r}$$

Where,

p Estimated cost of the system per unit over a 25-year period

i Pro(Con)sumer 1, 2, 3 … n

Gi Generation installed Capacity of ith pro(con)sumer

r Depreciation Rate

y Expected Life of the system in yrs

Om Estimated cost of O&M

ζ The whole system's life span is 25 years.

Gr Yearly kWh Produced

IV. Results and Analysis

The results are obtained by rigorous computation, using the formulae discussed in section 3 and aided by a variety of data tables. Based on these results a comprehensive analysis has been carried out. Both systems are compared based on cost per unit watt analysis, payback analysis, break-even point analysis and LCOE analysis; which is discussed hereunder.

A. *Cost Based Comparative Analysis*

The cost of Net Metering and Blockchain systems is compared using a Radar chart based on the cost of four layers. The cost of the control layer and power layer for both systems is practically identical, as seen in the graph. This is owing to the fact that the architect of both at power level are identical, with the cost per watt of the power layer being Rs. 90.67 each. The control layer, on the other hand, differs just slightly, with NMS charging Rs. 19.75 and BCS charging Rs. 20.19.

The communication and business layers, on the other hand, are more expensive in Blockchain than in NMS. Due to its intricacies, the communication layer has a cost per watt of Rs. 8.59 in BCS and Rs. 5.49 in BCS. As a result, the findings of the cost comparison demonstrate that the initial investment in NMS is lower than that in BCS.

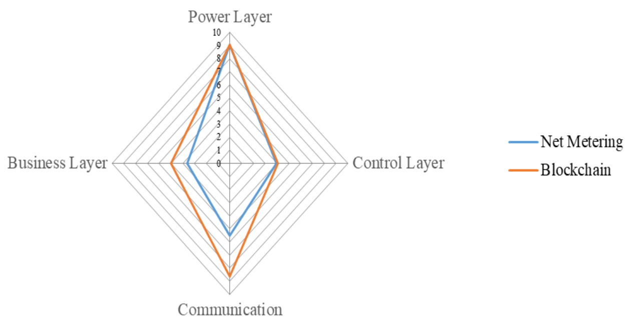

Figure 1. Comparative Analysis of NMS and BCS on Cost

However, because the difference is so small (i.e., only Rs. 3.66 per watt), the BCS should not be rejected outright at this stage. As a result, we conducted additional study using economics toolbox, which is explained in the following sections, and the results are really fascinating.

B. *Payback-Based Comparative Analysis*

For payback, the formula discussed in section 1.3.1 is used, where the yearly electricity cost is computed by multiplying the annual energy use in kWh with the annual electricity tariff. The annual profit of net metering is computed by multiplying the number of kWh generated by the selling price per unit (Rs. 13/kWh currently in Pakistan). The net outcome of the previous two values resulted in annual trade bill. The installed capacity and the cost per watt are used to compute the capital cost of NMS. The salvage value is computed using the cost per watt of the salvage value multiplied to the installed capacity of each prosumer. Finally, results are obtained using the said formula and graphically demonstrated as:

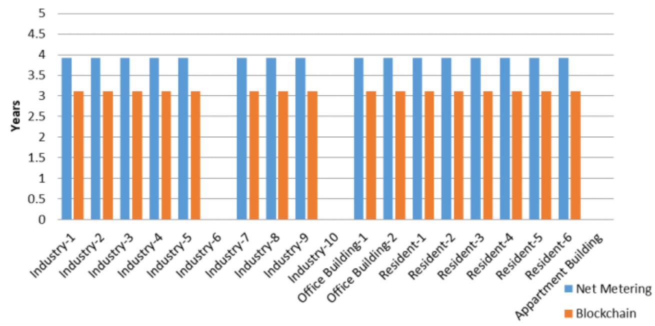

Figure 2. Comparative Analysis on the basis of Payback

The payback period for NMS is longer than that of Blockchain, as evidenced by the outcomes. NMS has a 4-year repayment time, while BCS has a 3-year payback period. The rationale for this is that the Blockchain income model appears to be more viable, profitable and market oriented. The NMS revenue model is fixed at Rs. 13 per unit, whereas the BCS unit cost varies with market conditions but is always higher than NMS, resulting in a shorter payback period.

C. *Breakeven Point Based Comparative Analysis*

The break-even analysis is discussed in detail in section 1.3.2, here we shall discuss the results. Net capital cost is obtained in the same way as that of payback. Using the annual savings and capital cost, we calculated the BEP. In the following bar chart, the results are compared.

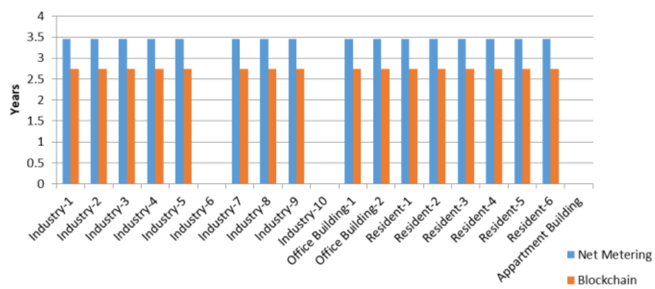

Figure 3. Breakeven point-based comparative analysis

The chart shows that Blockchain is better than NMS because in NMS the BEP reaches in more time than Blockchain. The BEP is 3.45 years for NMS, and 2.74 years for Blockchain. Therefore, in terms of BEP Analysis, BCS is better than NMS.

D. LCOE-based Comparative Analysis

The levelized cost of energy, discussed in section 1.3.3, tells how much each unit will cost us. For the LCOE the cost of entire system life is estimated for each system. Because the various elements in NMS and BCS have a different lifetime, a benchmark for 25 years is considered as the system life and the number of substitutions a component might need is accounted for; Like for a 5 years of the inverter life, we will need five substitutes throughout our lifetime. The generation of energy in useful life is estimated after the cost of the system is determined. The LCOE is calculated and the findings are presented below.

The chart shows that Blockchain's LCOE is Rs. 3.67/kWh, while Rs. 3.78/kWh for NMS. Therefore, in terms of LCOE, the BCS is also better than NMS.

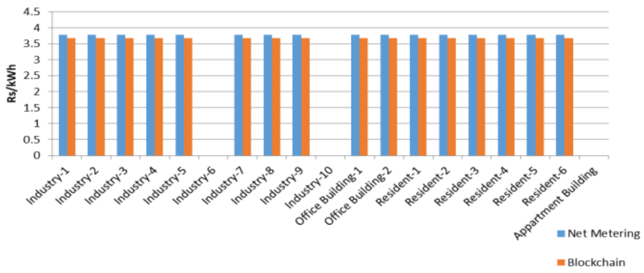

Figure 4. LCOE-based comparative analysis

CONCLUSION

It is concluded for the detailed analysis that the Blockchain-based energy sharing system outperforms the NMS. The following radar charts compares both system in regards of our findings. The payback analysis clearly shows that Blockchain outperforms NMS. BEP reaches BCA earlier than NMS implying a better performance in BEA for the Blockchain. The LCOE of Blockchain is lower than that of NMS, implying that BCS is less expensive per kWh than NMS. The Rate of Return of BCS is higher than that of NMS, indicating that BCS offers a better return than NMS. The only metric in which NMS outperforms BCS is cost per watt analysis, which is owing to the complexity of BCS being a little higher. Thus, an energy sharing mechanism based on Blockchain technology is recommended for modernising the grid.

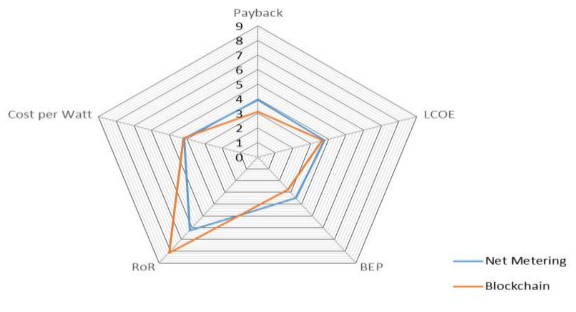

Figure 5 Net Metering Based Microgrid vs Blockchain Based Microgrid Comparison

Technological advancements have a broad scope in terms of experimental, analytical, field cases and numerical studies in complex petroleum engineering projects. These can be pertinent to transportation system and gathering and safety in oil and gas production. The current research was aimed at examining the challenges pertinent to safety prognostic technology as well as various ways in which it can be implemented for resolving issues in complex petroleum engineering projects. For the conduct of this research, qualitative methodology was used and primary data was assessed to present critical evaluation of the stated aim. The interviews were conducted from 10 petroleum engineers working in different public and private companies in Pakistan. The snowball technique followed by thematic analysis data analysis technique was applied for the generation of primary findings. The results of the research examined that safety prognostic technologies are significant in terms of enhancing safety, reliability and reducing the possible errors in maintenance. It has further examined that in complex engineering systems, there are multiple propagation paths to different consequences some of which might differ with respect to the most single faults.

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Assessing Safety Prognostic Technology for Complex Petroleum Engineering Projects

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***Abstract*—** Technological advancements have a broad scope in terms of experimental, analytical, field cases and numerical studies in complex petroleum engineering projects. These can be pertinent to transportation system and gathering and safety in oil and gas production. The current research was aimed at examining the challenges pertinent to safety prognostic technology as well as various ways in which it can be implemented for resolving issues in complex petroleum engineering projects. For the conduct of this research, qualitative methodology was used and primary data was assessed to present critical evaluation of the stated aim. The interviews were conducted from 10 petroleum engineers working in different public and private companies in Pakistan. The snowball technique followed by thematic analysis data analysis technique was applied for the generation of primary findings. The results of the research examined that safety prognostic technologies are significant in terms of enhancing safety, reliability and reducing the possible errors in maintenance. It has further examined that in complex engineering systems, there are multiple propagation paths to different consequences some of which might differ with respect to the most single faults.

***Keywords*—** Complex Petroleum Engineering Projects, Safety Prognostic Technology, Diagnostic Models.

I. Introduction

In complex petroleum engineering projects, a special focus has been placed on the advanced technologies for production, drilling and reservoir engineering (Zhang & Hu, 2013); (Tewari, Dandekar, & Ortiz, 2018). This has created a significant impact on today's petroleum sector from the exploitation to advanced non-conventional and non-conventional technologies from atypical hydrocarbon resources in the diverse applications of petroleum engineering (Ershaghi & Paul, 2017). According to (Tiddens, Braaksma, & Tinga, 2015), in most of the complex engineering projects, products and processes such as transportation system and gathering, compressors and pumps in the long-distance pipelines, close relationship to oil and gas production, and various chemical equipment, and technological advances are increasing at a rapid pace.

Moreover, as stated by (Zhang & Hu, 2013), one of the effective technological integration in the field of engineering has been identified named as safety prognostic technology which is useful for resolving the challenges pertinent to complex projects. This is considered suitable for posing substantial challenges in ensuring proper control, design, management and safety for continuous operations. In general, safety prognostic techniques are known for aiding the owner of the project in optimal decision making. Besides, this can also be utilised for the reduction of safety and business risks which can often be faced by the failure of critical systems to cater cycle costs (Tiddens, Braaksma, & Tinga, 2015).

In the research by (Tiddens, Braaksma, & Tinga, 2015), it has been analysed that progresses in the technologies of prognostic maintenance offer opportunities to aid the asset owner for life cycle decision making and optimal maintenance such as lifetime extension or replacement of physical assets. The research further elucidated that the literature related to specific technique on the usage and adoption of safety prognostic technology is limited as very few companies have integrated these for maintenance decision making. The results of this research presented that a range of organisational arrangements, maintenance technologies, products, industry and organisational arrangements are dealt with safety prognostic technologies. These are significant in terms of enhancing safety, reliability and reducing the possible errors in maintenance. Similarly, (Vogl, Weiss, & Helu, 2019) in their research presented that, recent progress by safety prognostic technologies has been observed to be promising in the engineering application of safety and risk assessment. In the complex projects of engineering, these technologies are expedient for inherently safer design, better quality of product, reliable process operations.

and abnormal events management (Zhang & Hu, 2013). However, as explained by (von Plate & M., 2016), prognostic and diagnostic components would be impossible without collection of data from sources such as programmable logic controllers (PLCs) and sensors. These are effective in complex petroleum projects related to lubrication and oil analysis, thermography, laser alignment, etc. For the enhanced safety provided by automobile, General Motors (GM) are serving their customers with a data-driven prognostics and diagnostics. Additionally, in the study by (Epelle & Gerogiorgis, 2020), the researcher depicted the analysis regarding the rise in prognostics analytics in the field of petroleum engineering. It has examined that there are a plethora of sensors, data collectors and transmissions devices that deal with the challenges of malfunction in complex projects. The use of safety prognostic technology is suitable for forecasting the safety issues via predictive diagnostics and monitoring such that forecasts provide assistance in the major challenges that are faced in petroleum projects. Consequently, the process data and condition of a cracked gas compressor is utilised by an application of prognostics to generate future malfunction risk profiles as well as useful life distributions.

As analysed in the study by (Zhang & Hu, 2013), safety prognostic technology is required to predict and model the emergent behaviour in complex engineering systems. It is also pertinent to the examination of future effects of various hazards which can be caused by an initial abnormal event. It is useful in the sense of providing an early warning that offers adequate actions or methods to control adverse incidents by the minimum possible losses. The same study further highlighted that safety prognostic technology includes two different aspects i.e. prognostic control and prognostic analysis. Moreover, results of the research identified that the reaction of prognostic analysis with respect to management activities such as prevention and control, correction and degrading trend which has been initially caused by some basic abnormal events is highly effective (Zhang & Hu, 2013).

The safety prognostic techniques are crucial for dealing with the accident consequences and causes of the complex engineering projects. In addition, the rationale of these safety prognostic techniques is that they are not only limited to the subjective cognitive ability but also assess the objective complexity of accidents. This research has elucidated the importance of safety prognostic technology which has recently integrated for the effective monitoring of petroleum engineering systems. However, there is still a gap observed in terms of assessing the various aspects such as complex petroleum engineering systems and failure propagation behaviour as well as challenges pertinent to safety prognostic technology. Therefore, the current study was conducted with an aim to cater the existing problem by examining the various challenges in complex engineering projects and how in different ways safety prognostic technology can resolve these challenges potentially in the field of petroleum engineering.

II. METHODOLOGY

There are two types of research methodologies that are utilised for the conduct of any study based on the nature of the study. Research methodology is adopted for data collection and analysis classified as quantitative and qualitative research design (Hameed, 2020). According to (Basias, & Pollalis, 2018), dealing with the statistics and numbers in any research is attempted by the adoption of quantitative method. On the contrary, qualitative methods are utilised for the interpretation of data in textual format which is pertinent to exploration of human ideas and experiences. In the current study, qualitative methodology was used to examine the ways in which safety prognostic technology can be utilised for complex petroleum projects. In addition, qualitative method will be beneficial for carrying out analysis of data for the identification of hidden patterns and presenting and in-depth assessment suitable for the study by analysing the multiple perspectives.

A. *Data Collection Method*

Moreover, methods of data collection are categorised as primary and secondary. As stated by (Beer & Faulkner , 2014), primary data is collected by the collection of first-hand data such as interviews or focus group discussion. On the contrary, secondary data is the information that has already been collected by other researchers such as newspaper articles, company records, and journal articles. This research was carried out by the collection of primary data by conducting interviews from 10 petroleum engineers working in different field having association with the public and private companies. The participants were accessed by means of snowball sampling technique.

B. *Data Analysis*

A research analysis tool which is suitable for the assessment of primary data is termed as thematic analysis that assists in the quantification and analysis of certain themes and concepts (Erlingsson & Brysiewicz, 2017). As mentioned by (Neuendorf & Kumar, 2015) , it allows the researcher to examine hidden patterns in a systematic and reliable manner by making valid inferences, interpreting and coding documents. Furthermore, the use of thematic analysis was appropriate for this research as it allowed the examination of different valuable insights regarding safety prognostic technology and their uses for dealing with the issues in complex petroleum engineering projects.

III. ANALYSIS

A. *Safety Prognostic and Diagnostic Models*

The field of petroleum engineering from the perspective of processing and safety is both complex and dynamic. This is because petroleum industries often produce a multitude of products from the extracted crude oil, and hence require various equipment, possessing a multitude of causal relations among the process variables and the components (Sanni , 2018). Furthermore, literature analysis indicates that with the introduction of external variables such as environmental sustainability issues, and also due to the requirement of improved quality of fuels, the petroleum industries have optimised their processes in order to achieve better efficiency (Hasheminasab, Gholipour, Kharrazi, & Streimikiene, 2018). It is also to be noted that such optimisations also incorporate the element of cost-effectiveness, which is often accomplished through design changes of components (Bigliani, 2013). However, changing equipment design is accompanied by changes in their operational and management practices. Therefore, their safety measures also need to update consistently (Knegtering & Pasman, 2009). In order to manage the ever-growing system, automated, intelligent, high speed, and non-linear relationships are established among the process variables and their equipment (Yagiz, Gokceoglu, Sezer, & Iplikci, 2009). This necessitates early detection of errors and failures to limit the damage. Furthermore, safety prognosis requires step-wise systematic processes built-in to the system, so that in times of emergency, the system could self-regulate before human intervention is done (Patel, Prajapati, Mahida, & Shah, 2020).

The decision-makers of modern manufacturing facilities are shifting towards using diagnostic and prognostic safety technologies to cement their service-led competitive strategies. Therefore, from the equipment point of view, the safety market is shifting from "sale of product" to "sale of use" (Grubic, Redding, Baines, & Julien, 2011). On inquiry regarding decision support system in refineries, one of the interview participants responded:

"Decision support systems are not the solution themselves. They are only mediator between the computer and the human aspect of petroleum industry. Therefore, decision support systems have to be developed in line with specifics of the refinery".

Since safety prognostics help in minimising the cost of maintenance by controlling the fault isolation and detection times. Therefore, companies are employing custom-based systems to detect equipment failure. The Equipment Health Management (EHM) system, as adopted by Rolls-Royce, is one such example (Rolls-Royce, 2009). However, survey data in the context of United Kingdom shows that only a small proportion of manufacturers are engaged in adoption of safety diagnostic technologies (Grubic, Redding, Baines, & Julien, 2011) . The findings could be further aggravated for petroleum refineries, since petroleum refineries produce a significantly large variation of products compared to manufacturing firms. Upon investigation of equipment health in petroleum refineries, one participant answered:

"The concept of proactive maintenance and servicing is not new. However, refineries differ in their financial and technical capability to comply with standardised maintenance practices. I think if practices are to be complied with diligently, significant amount of issues could be resolved without radical changes in the system".

Since protection, safety, and post- error prognostic is crucial for modern equipment to save costs, therefore, a technique which could monitor and device prognosis of the entire industrial system is needed, which includes digital systems, structures, and components (Kordestani, Saif, Orchard, Razavi-Far, & Khorasni, 2019).

For this purpose, "Prognostic Health Monitoring (PHM)" as propounded by (Pham, Agarwal, Lybeck, & Tawfik, , 2012) includes monitoring of structural, thermal, and chemical loading throughout the life span of the integrated equipment, as shown in Fig.1.

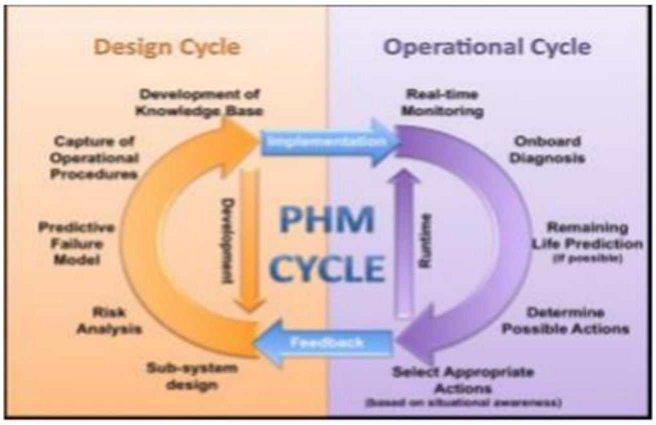

Figure 1. Cycle of PHM
Source: (Stecki, Cross, Stecki , & Lucas, 2012)

Although, installation of PHM in petroleum refineries would help in reducing operations and maintenance cost, and reduce plant outage time, however, it is also shown from literature that implementation poses an economic challenge from the perspective of nuclear industry (Pham, Agarwal, Lybeck, & Tawfik, , 2012). In order to minimise costs, selection of components to be monitored is important. Since equipment are classified into safety-related and non-safety related equipment, therefore, their integration within the PHM requires planning of prioritization (Moir, Niculita, & Milligan, 2018). Therefore, petroleum refineries undertaking PHM need to develop concomitant plan of operations, before adoption of PHM decision support system.

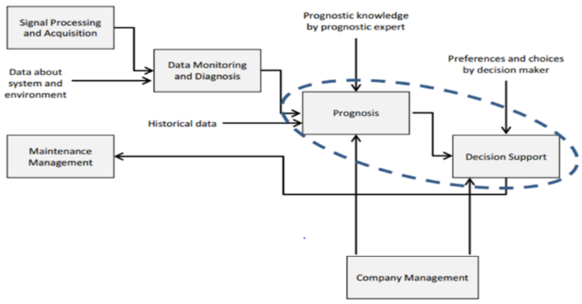

Figure 2. Planning and Equipment Selection for Integrated Decision Support

Planning and prioritisation could be accomplished through diagnostic models. Flow diagnostics, in this respect, are computational tools that are derived from controlled numerical flow experiments which obtain quantitative information regarding the flow behaviour of a reservoir model. In contrast to output from traditional reservoir simulators, flow-diagnostic measures can be obtained within seconds (Møyner, Krogstad , & Lie, 2015). This method could be utilised to evaluate the rank (the priority), and compared strategies of prognosis. In upstream oil extraction processes, the fault diagnosis comprises of monitoring of oil wells. For this, an automatic fault diagnostic system is equipped in the pressure cavity pump by (Horowitz, Faundez, Maestri, & Cassanello, 2014). The local model implemented by the system compares the pump variables at the time of fault with the previously generated library of faults signatures. In contrast, prognostic models, also known as RUL models (due to prediction of Remaining Useful Life) are intended to predict the time beyond which an equipment will no longer function efficiently. RUL models depend upon prior data acquisition which could be enhanced through aforementioned diagnostic methods (Horowitz, Faundez, Maestri, & Cassanello, 2014). Further, RULs are integrated with the decision support systems, to form the overarching Condition-Based Maintenance (CBM), as shown in Fig.1

Field engineer participants were inquired about their planning and equipment selection procedure. One interviewer responded:

"Planning and selection of equipment is done through our internal planning schedules. Usually there are no hard and fast guidelines for equipment selection. Thus, selection is done on the basis of qualitative assessment of engineers and their experience".

From the above response, it is clear that refineries adopt a subjective approach towards equipment selection. In petroleum industries, the CBM would include data on individual equipment such as the rotations per minute (RPM) of the drill, pressure differentials of pumps, temperatures and pressures within the process columns etc. (Bousdekis, , Magoutas , Apostolou, & Men, 2018). Because variety of equipment and processes involved is high, therefore, efficacious safety prognostic in petroleum industry requires techniques that could also monitor the evolution of equipment over time. (Hu, Zhang, Ma, & Liang, 2010) propose an integrated incorporating Hazard and Operability Study (HAZOP). Markov process, and dynamic Bayesian Network (DBN), which would foresee the evolution of system from the point of its degradation to predict the time at which it will lose all its functions. Another respondent was asked about planning and maintenance selection, to which they replied:

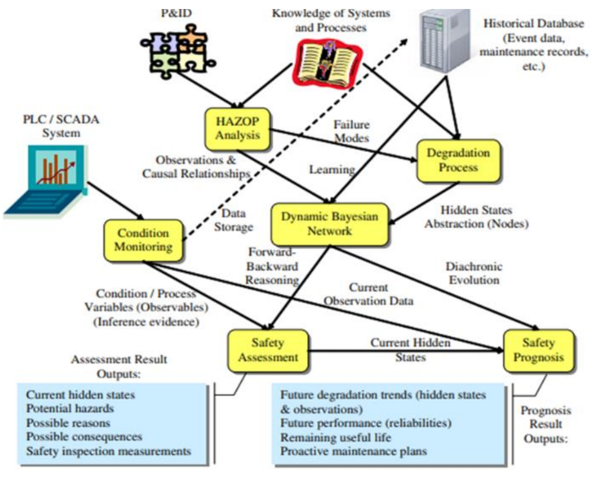

Figure 3. Challenges in Safety Prognostic Technology

"High end methods are usually not applied in petroleum industries, because industries have manpower working from different backgrounds who may not be able to comprehend the usage. Instead, we train them on standard HAZOP models".

This technique could be viable for large-scale equipment whose replacement is arduous. Following is a simplified diagram of the integrated system in Figure .3. From Figure 3. Process flow diagram for the proposed integrated method for safety pre-warning development Source (Hu, Zhang, Ma, & Liang, 2010)

Some prominent challenges petroleum industries experience in implementing suitable prognostic technique, are selection of correct parameters to be measured, understanding of systemic behaviour of equipment over time into a meaningful decision support system to minimise the role of human intervention (Sun, Zeng, Kang, & Pecht, 2012). In this respect, (Tiddens, Braaksma, & Tinga, 2015) highlight an ideal framework for the abovementioned system. In this respect, participants were asked about challenges they face and viability of future technologies in safety prognosis. A participant responded that:

"Although high-end technologies have started making their way in our industry. But big data and AI still have a long way to go before integrating with petroleum refineries".

In this respect, the biggest challenge faced is the precise comprehension of data and its response.

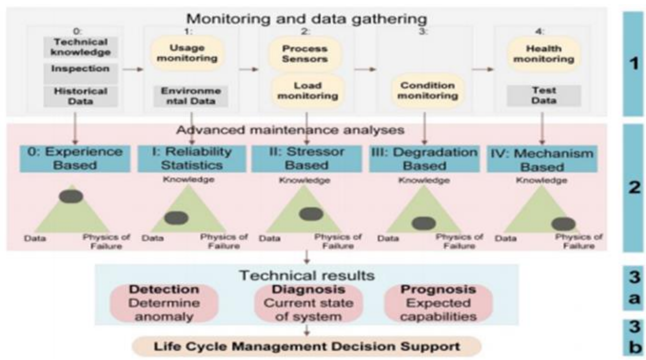

Figure 4. Integration model of data, statistics, and decisions
Source (Tiddens, Braaksma, & Tinga, 2015)

From the diagram and literature, it is apparent that petroleum industries lack integration of second and third tiers of decision support system i.e. the statistical results are not concomitantly utilised in equipment performance. Furthermore, in fault diagnosis systems, issue is faced in detection of early fault phenomenon, because field engineers in refineries are unable to separate the noise from characteristic weakness symptoms (Skaf, 2015). Additionally, samples of one fault detection are usually unique not only to the equipment but the case itself. Therefore, challenge is faced in accurate establishment of identification models. Although decision support tools (DSTs) minimise the unplanned downtime in operations maintenance, however, precise degradation analysis for every equipment is challenging, since it requires intelligent systems for diagnosis and forecasting (Skaf, 2015). When participants were asked about decision support tools in their refineries, it was revealed by one participant that:

"We do not deal with decision support tools as extrinsic elements. Instead they are built in in our machineries, and provide us guidance on how to proceed after a failure detection".

Intelligent systems require vast libraries of data regarding past behaviour of the refinery equipment. Currently, processing plants, specifically petroleum refineries are facing challenge of integration of data recorders into decision platform, because second-to-second monitoring of processes and equipment produce tremendous amount of data, whose processing negatively impacts computers' processing time, leading to delay in prognostics (Xu , et al., 2019). This challenge mandates to be solved through developing advanced automated data selection and analysis strategies to identify the right data for the execution of prognostics models. In furtherance, majority of implemented prognostic models focus on point-prognostic; targeting a single equipment or area. However, high level prognostic efficiency and precision requires analysis of the entire system (Skaf, 2015). This is a major challenge due to lack of exchanged information among different equipment, and limitation of equipment data bases to include prognostic data of other equipment.RESult and discussion

IV. Results and Discussion

According to (Müller & Oehm,, 2019), in most of the complex engineering projects, products and processes such as transportation system and gathering, compressors and pumps in the long-distance pipelines, close relationship to oil and gas production, and various chemical equipment, technological advances are increasing at a rapid pace. (Zhong, Han, & Han, , 2019) expound that, one of the effective technological integration in the field of engineering has been identified named as safety prognostic technology based on data integration methodology, as analysed in above section. This is useful for resolving the challenges pertinent to complex projects. However, aforementioned analysis shows that efficient diagnostics and prognostics systems require collection of tremendous amounts of data from each of the component of the processing plant. To promote data collection and transmission, techniques of machine learning and AI-based intelligent diagnostics are proposed, which would further need modifications to become implementable in petroleum industries.

conflict of Interest

No conflict of interest claim by author

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It can be concluded from this research that safety prognostic technology is playing a major role in many aspects for the good progress in further development of knowledge and technology. The safety status is usually determined by its current, future as well as historical states considering the various time-variant and dynamic states. These can be effective in tracking the dynamic states and predicting the probable danger in the future. In addition, in order to overcome the disadvantages of traditional approaches of safety, prognostic technology is prone to produce false alarms as well as provide an assessment of adaptive online safety consisting of dynamic weighting scheme. These consequences can be catered to by the self-control system of safety prognostic technology that reduces the chances of accidents by failure propagation behaviour. In order to integrate decision support system, it was revealed from literature review that refineries should develop their customised planning tools. Further, in order to expedite response system, organisations should plan and prioritise equipment for the prognosis procedure, which will significantly reduce time delays, and thus save equipment functionality.

In the future, the current study can be conducted by the application of quantitative methodology. This can be attempted by presenting an extensive analysis of monitoring the fault systems and identifying the root cause of faults. Additionally, further research can also be useful in pursuing the safety prognosis by the integration of abnormal event identification and online monitoring, data-driven or model-driven evaluation of degradation by predicting fault trends. Moreover, the study can be useful for future researchers who aim to examine the effects of safety prognostic technology for different petroleum projects.

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Determination of Mechanical Properties of Marble Cement Mortar using Pozzolanic Material

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***Abstract*—** In the marble production, huge quantity of marble is lost in the pattern of strange blocks of varying dimensions and dirt containing water and fine particles. When dry, the effluent turns into powder. Both mud and powder have negative impact on the surrounding. This experimentation focuses on the beneficial use of waste marble dust (WMD) to convert it into a valued binding material. To accomplish the objective, WMP and clay were gathered and tested to achieve their physical and chemical properties. A blend of WMP and clay was put together and burned at 1300oC. The burnt mixture was powdered to obtain marble cement (MC). The chemical formulation shows that MC contains 52.5% calcium silicate (C2S), 3.5% tri-calcium silicate (C3S) and 23% free lime. The marble cement was then incorporated in mortar with various proportions of blast furnace slag 20%, 30% and 40%. The compressive and flexural strengths of mortar cubes and prisms were examined. Aside from this, X-ray diffraction (XRD) analysis and thermo-gravimetric analysis (TGA) were also carried out. The compressive strength of MC mortar at 28 days is 156.12 psi is comparison to 885.27 psi of normal cement mortar, which is 82% less. Likewise, 91 and 182 days later, the compressive strength of MC mortar is 77% and 62% lesser than normal cement mortar. The addition of various proportions of blast furnace slag (20%, 30%, 40%) as marble cement replacement in MC mortar increased its compressive strength at all curing periods. The highest increment in compressive strength was observed in 40% blast furnace slag substituted mortar (B40) at 182 days curing. The similar strength development pattern was observed in case of flexural strength as well.

***Keywords*—** Marble Powder; Binding Material; Cement; Blast Furnace Slag; Mortar; Mechanical Properties.

I. INTRODUCTION

Water Marble has been utilized for construction and aesthetic reasons since ages [1]. Requisition for these characteristics have developed substantially due to the late corporate advancements. Pakistan is among the major producers of marble on the planet. It has about 400 thousand million tons of marble backlog, and the factual resources could be even higher [2]. Marble factories in Pakistan excavate and process about 10 lac tons of marble annually. During excavations, the exploding approach is frequently applied, resulting in the loss of about half of the entire production [3]. The debris originated in the excavations is in the form of strange blocks of different dimensions [4]. Nonetheless, there is no suitable course to discard the debris, and thus the debris continues to scatter around the excavations.

Large sized raw marble blocks are transported from the mines to marble refinement sections to generate marble slates and other precious blocks of various measurements and profiles [5]. There are many marble refinement sections in Pakistan which have different types of instruments and gear that work for the handling of these rocks. In the course of carving and shining of rough marble blocks, debris is also caused as an outgrowth. The debris is in the type of strange rocks of various sizing, shapes and dirt, containing fine particles of marble. About one-fifth of these rocks are lowered to microfine particles, which differs with refinement mechanism [6].

Debris is commonly discarded in open territories in the vicinity of plants. There is no organized pattern to get rid of dirt. Thus, it is the result of vast mounds of waste. As a result, the slush dries and turns into a fine dusting.

At the time high gusts, strong winds can readily convey delicate granules of marble and bring about numerous fettle problems [7]. In addition, piles of dirt are widespread throughout the manufacturing zone and spoil the whole region appearance [8]. In addition, when dissolved in water, sludge results in water contamination [9]. Moreover, it lessens the transmissivity of the surface soil, causing water to accumulate in the region [10]. Fine marble granules lessen the productivity by enhancing the basicity of the soil. In addition, there is damage to plants and animals. That is, pre-grown trees and shrubs dry up owing to the accumulation of minute-marble particles on plants and plant leaves [11].

To resolve the above challenges, various scholars have utilized waste marble sludge and powder in different building materials. Sutco et al. [12] and Sabaoya et al. [13] used WMD in the creation of clay blocks. The scholars determined that the weight of clay blocks is significantly reduced, although its shrinkage strength is slightly reduced. Gancel et al. [14] utilized WMD in the creation of concrete pavement blocks. He ascertained that the growth in the magnitude of marble mud was the result of a decrease in compressive strength. Despite that, this decline is inside the tolerable margins. In addition, the summation of WMD enhanced the toughness and freezing resilience of concrete blocks. Rahman etc. [5] utilized marble sludge in the masonry bricks. Additionally, dirt, OPC, plaster of Paris, sand, crushed stone and acrylic fibers were also utilized. They fulfilled that whilst useless marble sludge, sand and OPC are utilized in a proportion of 80, 5 and 15 correspondingly, with acrylic fibers. An utmost compressive strength of 7.98 MPa was attained, adequate for construction operations where eminent power is not needed. In addition, these bricks are cheaper than traditional bricks. Kabir and Vyas [15] substituted the sand with WMD in the mortar in different proportions up to a limit of 100 percent. He indicated a significant increase in the features of the mortar such as compressive strength, elastic strength and density modules. Sadat et al. [16] examined the substitution of dolomite with WMP in mortar for tiles and heat proof boards. Similarly, the 28-day elastic strength of 100% substitution by MP was 8.45 MPa, that is higher than the least needed value of 0.077 MPa of the European Standards Institute EN-1348. Furthermore, the researchers analyzed the expenses and stated that the binding material with MP containing dolomite was 25% low-cost.

Topco et al. [17] and Alemic & Anis [18] combined WMD as a filling agent to self-compacting concrete. He pointed out that waste WMD does not impact the working capacity of self-compacting concrete.

Khodebakhshian et al, [19] changed cement with MP which loses up to 20% in concrete. They saw a substantial rise in compressive and elastic strength with concrete flexibility modules, when cement was substituted with 6 % WMD. Despite that, with more than a 10% increase in the WMP conversion rate, the mechanical properties decreased. In addition, the cement was replaced at different proportions of silica foam (SF) and WMD combine. When 15% SF is utilized then the mechanical properties of concrete are improved by a maximum of 20% for any percentage of WMP powder. Singh etc. [20] cement was replaced by WMD in concrete blocks, up to utmost of 25% in different percentages. They also changed the ratio of water to binder for all blends. The scholars registered a 15% change in the mechanical and durability attributes of the concrete block.

Aliabdoet al. [21] emphasized on the utilization of WMD in the manufacture of cement together with concrete. WMD was blended with OPC in varying proportions up to an utmost of 20% by weight. Samples of blended cement paste and mortar were set up and examined. It was noticed that WMD blended in cement meets the provisions of Egyptian regulations. Likewise, sand was substituted by WMD in concrete in varying proportions up to a maximum of 15 percent. It was pointed out that the substitution of WMD with low W/C ratio has superior physical and mechanical attributes in concrete as compared to the ordinary concrete.

Argon [22] utilized WMD and diatomite as partly substitution of OPC in concrete. Concrete specimen were correctly corrected and tested. Test outcomes show that concrete having 10% WMD and 5% diatomite or 5% WMD and 10% diatomite because OPC has superior elasticity and compressive strength than ordinary concrete.

Ma et al. [23] cement was partly converted into mortar by WMD and nano-silica (NS). In accordance, the flow and setting time of mortar was extended when the OPC was substituted with WMD only. Nonetheless, the compressive strength of mortar was notably diminished when the substitution was greater than 15%.

Mechanical properties improved significantly when OPC was substituted with a blend of WMD and NS. Maximum conversion of OPC with 10% WMD and 3% N-S was proposed. Muneer et al. [24] with WMD, cement was partially converted to mortar by 0, 10, 20, 30 and 40 by mortar. Mortar was less capable of working with WMD than a controlled mix. Likewise, the compressive strength of mortar with 10% WMD was higher than that of the control mix, which lowered with furthermore rise in WMD content.

Kawas and Olgan [25] partially replaced the cement with these materials to mix marble dust and crushed bricks. Different properties such as timing, volume dilation, elastic and compressive strength of both mixed cement and mortar were established by different tests. Scanning electron microscopy (SEM) analysis was performed to identify the micro-pattern of the mortar. The setting time was retarded with WMD and OPC crushed bricks. Although, the summation of WMD and crushed bricks to the OPC remarkably enhanced the compressive strength of the mortar. It was pointed out that partly substitution of OPC by WMD and crushed bricks gave very optimistic outcomes. Arontas et al. [26] Prepared waste marble dust blended cement (WMDCs) using waste marble dust (WMD) in different percentages in cement. Cement clinkers were replaced with WMD with 10% weight. Specimen of cement mortar were set and fixed. The chemical, mechanical and physical attributes of the mortar were found out passed 7, 28 and 90 days, correspondingly. It was stated that WMDCs meet the EN-197-1 regulations, which explains the 10% changes of OPC clinker with WMD in the manufacture of blended cement.

Khan et al. [3] waste marble dust (WMD) was used in the manufacture of burnt clay bricks. In accordance with the scholar, the chemical formulation of WMD and soil is provided in the Table 1.

As reported by Neville and Brooks [27], OPC comprises of about 60 to 66% calcium oxide, 22 to 27% silica and 6 to 10% alumina. Moreover, as stated by the authors, $CaCO_3$ is used as the main origin of CaO in the manufacture of OPC. When CaO acts with SiO_2 at 1450 to 1650 ºC, it produces calcium silicates (CS), which reacts with water to form calcium silicate hydrate (CSH), which is highly bound. The chemical formulation of limestone and marble is almost the same, both contain huge amounts of CaO. Therefore, WMP / sludge and silica sufficient materials, for example, clay can be utilized in the preparation of binding material.

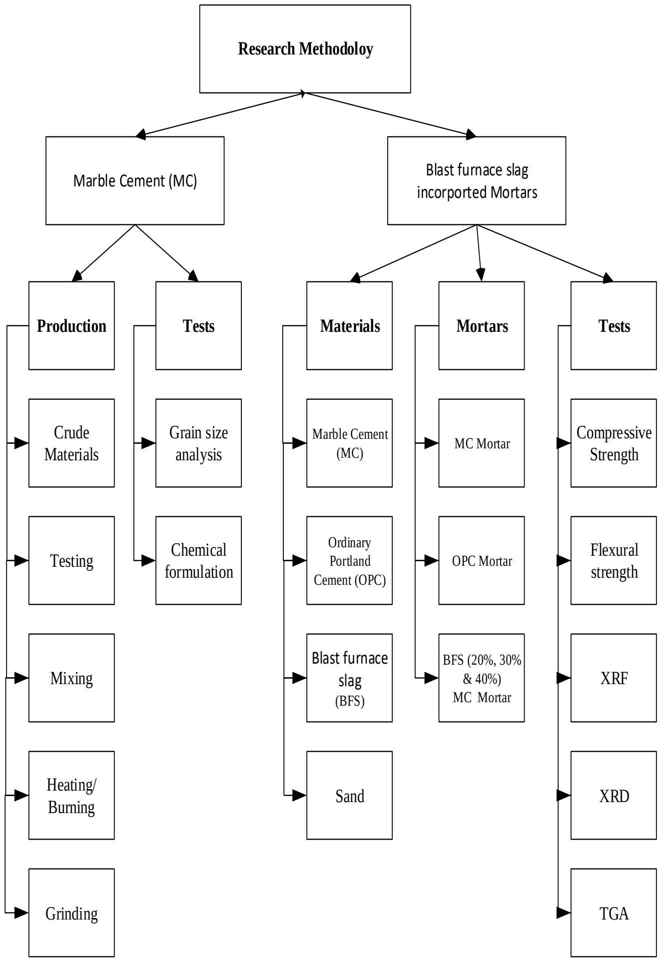
Limestone is the main crude material utilized in the manufacture of OPC. Though, extensive cement production needs huge amount of limestone. Consequently, the organic wealth of limestone is getting reduced. Making binding material from waste can lead to additional materials for OPC, and is hence a vital pace in the direction of longer-lasting of natural wealth. In addition, precarious waste materials can be transformed into useful materials. According to the best knowledge of the authors, there is no published research work on the transformation of minute marble powder into binding material. This study seeks to make the best use of WMP. Marble powder and clay has been addressed so that marble cement can be utilized in the building sector. Different procedures such as grain size analysis, X-ray diffraction (XRD) and thermogravimetric analysis (TGA) were employed to examine the various attributes of marble cement (MC) and paste. In addition, mechanical properties such as marble cement and blast furnace slag compressive and flexural strength of the mortar were also examined.

TABLE I. CHEMICAL FORMULATION OF WMD AND CLAY [3]

Major Elements	Clay (wt%)	Marble Dust		
		Buner	Muhmand Agency	Blend
SiO_2	57.55	0.77	0.42	0.31
TiO_2	0.3	0.01	0	0
Al_2O_3	15.84	0.24	0.07	0.04
Fe_2O_3	3.32	0.05	0	0.03
MnO	0.04	0	0	0
MgO	2.35	0.94	0.24	0.3
CaO	6.77	54.08	55.65	55.07
Na_2O	1.39	0.39	0.36	0.29
K_2O	1.59	0.02	0.01	0.01
P_2O_3	0.12	0.01	0.03	0.02
LOI	10.73	43.49	43.23	43.93

II. METHODOLOGY

Flow chart of the methodology is provided in Figure 1.



A. *Collection and Testing of Raw Materials*

In this phase, crude materials were gathered, consisting of WMP and clay. Waste was received from Marble refining industry at Marble Industrial zone, Hayatabad, Peshawar.

Meantime the clay was gathered from South Bypass Road Peshawar.

After the crude materials were gathered, X-ray fluorescence (XRF) review and grain size analysis were used to test their chemical and physical properties.

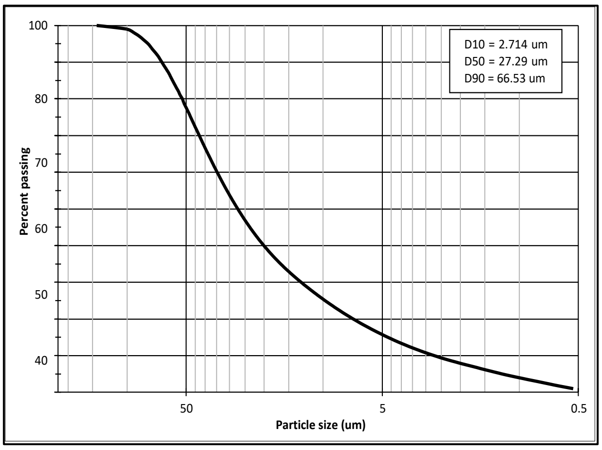


Figure 1. Grain size dispersion of WMP

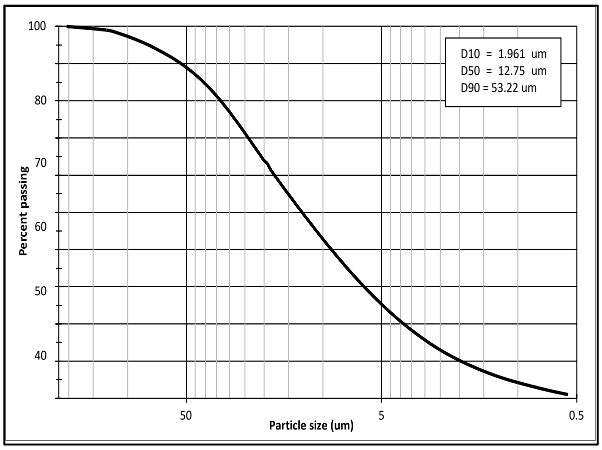


Figure 2. Grain size dispersion of clay

B. Chemical formulation of Crude Materials

I. Chemical formulation of WMP and clay were examined by X-ray fluorescence (XRF) analysis. The outcomes are shown in Table 2.

TABLE I. CHEMICAL FORMULATION OF CRUDE MATERIALS

Item	WMP Weight (%)	Clay Weight (%)
Na_2O	0.04	4.14
Al_2O_3	0.19	14.2
MgO	2.73	4.32
CaO	49	3.46
SiO_2	0.4	56.73
K_2O	0.01	1.01
MnO	0	0.05
P_2O_5	0.01	0.12
Fe_2O_3	0	3.23
TiO_2	0	0.55
Loss on ignition (LOI)	47.44	12.19

The amount of CaCO3 in WMP is 96.44%. Of which free lime is 49%, while LOI, i.e., CO2 content is 47.44%. The chemical formulation of WMP is comparable to that of limestone. Hence, it has been utilized as a vital crude material in the manufacture of new binding materials. In addition, the soil contains 56.73% SiO2, which combines with CaO at elevated temperatures to form tri-calcium silicate and di-calcium silicate. Therefore, the crude material is rich in CaO and SiO2, which makes it an appropriate basis of binding material.

C. Physical Properties of Crude Materials

II. Grain size analysis of WMP and clay were conducted by grain size analyzer. The outcomes are given in Figures 2 and 3.

D90 of WMP and clay is 66.53 µm and 53.22 µm correspondingly. Generally, the D90 of the crude blend in the manufacture of OPC is held less than 90 µm. As the D90 of materials is less than 90 µm. This is why, there is no need to grind.

D. Proportioning of Crude Materials

At this stage, the crude materials were blended in certain fractions, subject to their chemical formulations. The ratio was acquired depending on the saturation factor of the lime. In the manufacture operation of OPC, the saturation factor of lime is usually held between 0.91 and 0.99, so that the CaO formed by the ignition of calcium carbonate (CaCO3,) is completely converted to SiO2. The goal was to maintain the conclusive outcome CaO-free. The purpose was to acquire a lime saturation factor of 0.91 to 0.99. Derived from the chemical formulation, 25 kg of WMP and 7 kg of clay were blended to achieve a saturation of 0.97 lime.

E. Blending of Crude Materials

After the determination of blending ratio, the crude material was first blended well in a dried manner in a ball mill. Later, they were blended in moist form with the aid of sugar-cane husk and water. This wet blend was turned into pellets. In addition, the pellets were placed in sunlight for three days to completely remove the water.

TABLE II. MIXTURE PROPORTIONS FOR MORTAR

Mixture notation	OPC	Marble cement	sand	w/c ratio	W/(M.C) ratio
Controlled	1	0	2.75	0.5	0
MCM	0	1	2.75	0	0.72

* Specimen size:
(i) = 50 mm cube (Compressive strength);
(ii) = 40×40×160 mm (Flexural strength).

F. *Burning of Crude Materials and Grinding of Clinkers*

At this stage, the pellets were put into a rotary furnace. At first, the furnace temperature was low. Nevertheless, the temperature was slowly elevated to the utmost at hand capacity of 1300 OC. The pellets were burned in the furnace at about 1300 OC for 2.5 hours.

There was no set-up to cool the red-hot pellets swiftly. Hence, they were kept in the rotary furnace for a day and slowly cooled. When cooled, the burned pellets were brought out from the furnace and turned into a powder in a ball mill. The associated powder is a dedicated binding material called marble cement.

G. *Testing of Binding Material*

In this phase, the phase formulation of marble cement was examined by X-ray diffraction (XRD) test. The aim of this step was to validate whether the marble cement contained sufficient amounts of calcium silicates, which were necessary to develop the binding attributes. The grain sizes of both marble cement and OPC was examined using of grain size analyzer.

Mortar cement and OPC powder were utilized in the manufacture of mortar. Both mortars were made by blending one unit of cement in 2.75 units of sand as described in ASTMC 109 / C 109 M-02 and ASTMC 348-14. Has gone According to ASTM standard, the ratio of water to cement was kept at 0.5. However, the ratio of water to marble cement in marble cement mortar was not 0.5. Therefore, the ratio of mortar cement to water was held 0.72 to have a workable mortar as shown in Table 3. The mortar was readied manually as no automated blender was accessible. To ascertain the compressive strength of mortar, 50 mm cubes were made from both OPC and MC mortar according to ASTMC 109 / C 109 M-02. Similarly, 40 mm x 160 mm prisms were made from both OPC and MC mortar in accordance with 40 mm ASTMC 348-14 to determine the elastic strength of mortar.

After 24 hours, the specimen were taken out from the molds. Immediately after removing the OPC mortar specimen from the molds, they were submerged into the curing tank. Owing to the high content of CaO in marble cement, it dispersed if dipped in water. So, the samples of marble cement mortar were held in a moist cloth for fourteen days. Past fourteen days, the specimen were submerged in the water tank. All specimen were submerged in the water tank till the the time of the test.

To perform X-ray diffraction (XRD) analysis and thermodynamic analysis (TGA), samples were prepared from pastes containing marble cement, OPC and blast furnace slag. Samples of OPC paste were submerged in the water tank after 1 day, while specimen of paste containing marble cement and blast furnace slag were wrapped with a moist cloth for fourteen days. Later, the specimen were submerged in a water tank.

III. Result and Discussion

A. *Phase Formulation*

The phase formulation of marble cement and OPC powder was found out by X-ray diffraction analysis. The outcomes are shown in Table 4.

TABLE III. PHASE FORMULATION OF MARBLE CEMENT AND OPC

S.No.	**Items**	**Marble cement**	**OPC**
		Weight (%)	**Weight (%)**
1	Alite [C_3S]	3.73	59.51
2	Belite beta [C_2S]	52.50	17.14
3	Ferrite [C_4AF]	9.26	8.20
4	Aluminate cubic [C_3A]	2.48	2.81
	Aluminate ortho [C_3A]	3.38	5.59
5	Free lime [CaO]	23.09	0.00
6	Portlandite [$Ca(OH)_2$]	1.49	1.50
7	Periclase [MgO]	3.66	3.10
8	Acranite [K_2SO_4]	0.00	1.78
9	Aphthitalite [$K_3Na(SO_4)_2$]	0.41	0.37
10	Calciolangbeinite [$K_2Ca_2(SO_4)_3$]	0.00	0.00

The results show that marble cement has 3.73% C3S, 52.51% C2S and 23.09% CaO The lower content of C3S, the higher the percentage of C2S and CaO is due to the retarded cooling operation. The marble cement pellets were calmed very sluggishly. As a result, after C3S reached 1100 oC, it changed to C2S and CaO. In the production of OPC, cement clinkers are chilled very swiftly to maintain the high temperature C3S. Thus, OPC marble contains less percentage of C2S than cement and free lime, as shown in Table 4.

B. *Grain Size Analysis*

The grain size of marble cement and OPC was examined using grain size analyzer. The outcomes are given in Figures 4 and 5 reveal that the D90 of marble and OPC is 33.26 µm and 60.44 µm. Because marble cement is very fine, its surface area is large. Due to the high surface area, the ratio of marble cement to water is more than the ratio of OPC to water, as given in Table 3. In addition, owing to the high surface area of marble cement, hydration begins instantly. Thereby, extra water is needed to retain its viablilty.

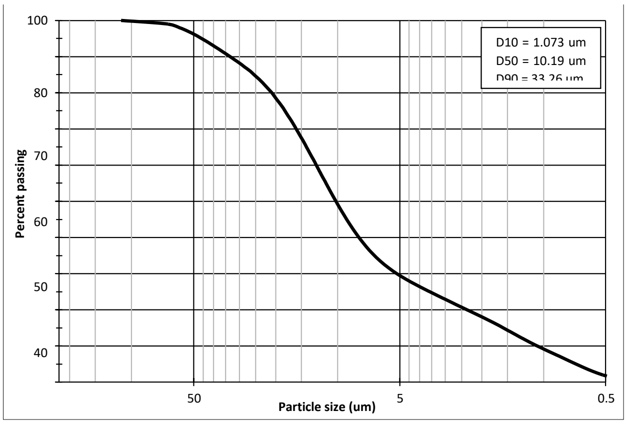


Figure 3. Grain size dispersion of marble cement

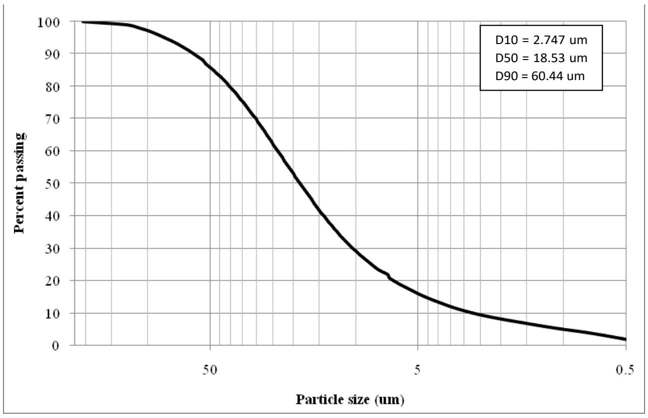


Figure 4. Grain size distribution of OPC

C. *Compressive Strength of Mortar*

Samples of marble cement, OPC mortar and mortar designed to detect the compressive strength of blast furnace slag were taken out from the water tank right before the testing. These tests were performed at 28, 91 and 182 days of age, correspondingly. The loading was employed at a gauge of 1.2 KN / sec according to ASTM C109-02 [28]. The outcomes are given in Table 5 and Figure 6.

TABLE IV. COMPRESSIVE STRENGTH OF MARBLE CEMENT, OPC AND BLAST FURNACE SLAG MORTARS (ALL UNITS IN PSI)

Age	MC	OPC	B20	B30	B40
28	156.1	885.27	232.15	235.0	303.0
91	302.3	1359.1	369.17	385.7	391.2
182	925.5	2501.5	1414.2	1589.6	1907.4

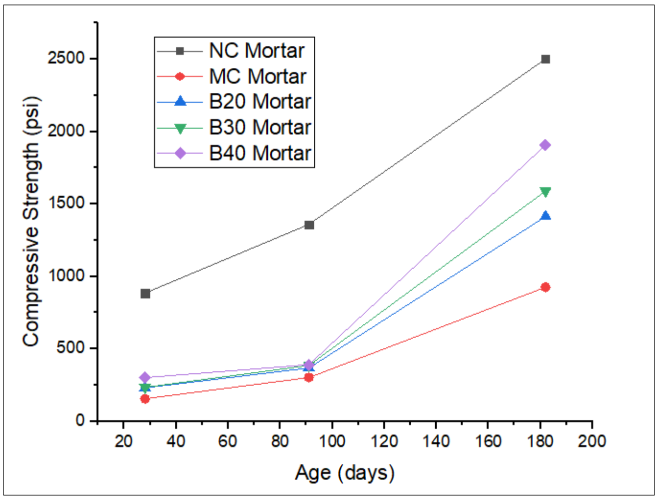


Figure 5. Compressive strength of Marble cement, OPC and blast furnace slag mortars

The compressive strength of MC mortar is 156.12 psi in 28 days as compared to 885.29 psi of NC mortar. Thus, after 28 days of treatment, the compressive strength of MC mortar is 82% low than the NC mortar strength. Likewise, 91 and 182 days later, the compressive strength of MC mortar is 77% and 62% lesser as of NC mortar.

From Figure 6, it is clear that mortar with conventional ingredients gave higher compressive strengths than all mortars and all blast furnace slag mortars gave higher compressive strength than the MC mortar at all ages of curing. The pattern of the strength establishment curve is almost same for all types of mortars. Generally, the strength with the addition of blast furnace slag content in MC mortar increased its compressive strength. For B20 mortar, the increase in MC mortar compressive strength is 48.69% past 28 days, for 91 days the increase in strength is 22.11% and for 182 days the increase is 52.77%.

By incorporating blast furnace slag as a marble cement substitution (30 % by weight of cement) the test outcomes showed an increment in compressive strength for all ages. For B30 mortar, the increase in MC mortar compressive strength is 50.58 past 28 days, for 91 days the increase in strength is 27.58% and for 182 days the increase is 71.73%.

By incorporating blast furnace slag as a marble cement substitution (40 % by weight of cement) the test outcomes showed an increment in compressive strength for all ages as well. For B40 mortar, the increase in MC mortar compressive strength is 94.11% past 28 days, for 91 days the increase in strength is 29.40% and for 182 days the increase is 106.08%.

It can finally be concluded that all MC mortars in which marble cement was substituted with different contents of blast furnace slag, increased the compressive strength and can also be decided that higher the blast furnace slag content, higher was the percentage increment in compressive strength especially at extended curing period i-e 182 days.

D. *Flexural Strength of Mortar*

To find out the flexural strength of marble cement, OPC mortar and blast furnace slag mortar (B20, B30 & B40), the samples were taken out from the water tank right before the testing. These tests were performed at 28, 91 and 182 days of age, correspondingly. The outcomes are given in Table 6 and Figure 7.

TABLE V. FLEXURAL STRENGTH OF MARBLE CEMENT, OPC AND BLAST FURNACE SLAG MORTARS (ALL UNITS IN PSI)

Age	MC	OPC	B20	B30	B40
28	99.5	570.8	119.4	132.7	132.7
91	172.5	663.7	185.8	199.1	220.3
182	318.6	796.5	278.7	345.1	371.7

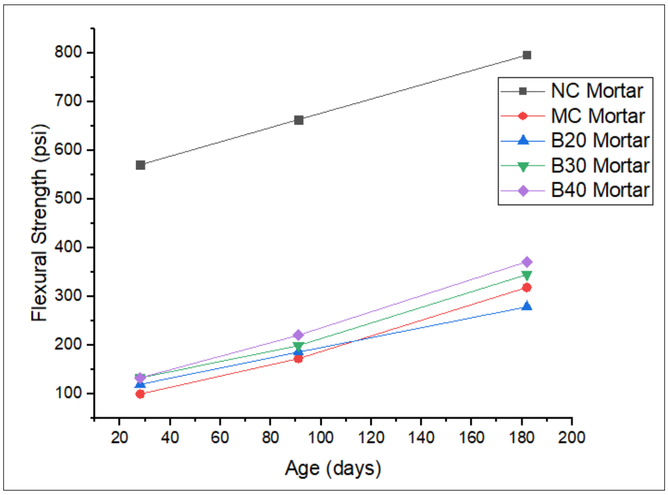


Figure 6. Flexural strength of marble cement, OPC and blast furnace slag mortars

The flexural strength of marble cement mortar is 99.56 psi in 28 days as compared to 570.83 psi of NC mortar. Thus, at 28 days of age, the flexural strength of MC mortar is 82.55% less than that of NC mortar. But this difference in strength decreases with time so after 91 and 182 days, the flexural strength of MC mortar is 72.98% and 60% less than NC mortar.

From Figure 7, it is found that mortar with conventional ingredients gave higher flexural strength than all mortars and blast furnace slag mortars gave higher flexural strength than the MC mortar except for B20 mortar at 182 days curing. The pattern of the strength establishment curve is almost same for all types of mortars. Generally, the strength with the addition of blast furnace slag content in MC mortar enhanced the flexural strength. For B20 mortar, the increase in MC mortar flexural strength is 20% at 28 days curing, for 91 days the increase in strength is 7.69% and for 182 days the flexural strength decreased by 12.5%.

By incorporating blast furnace slag as a marble cement substitution (30 % by weight of cement) the test outcomes showed an increment in flexural strength for all ages. For B30 mortar, the increase in flexural strength is 33.34% past 28 days, for 91 days the increase in strength is 15.38% and for 182 days the increase is 8.33%.

By incorporating blast furnace slag as a marble cement substitution (40 % by weight of cement) the test outcomes showed an increment in flexural strength for all ages as well. For B40 mortar, the increase in flexural strength is 33.34% at 28 days later, for 91 days the increase in strength is 27.69% and for 182 days the increase is 16.66%.

Ultimately, it can be concluded that all MC mortars in which marble cement was replaced with various blast furnace slag proportions, in addition to B20 mortar, increased flexural strength in 182 days of treatment. The 28 days flexural strength values of MC mortar, B20, B30 and B40 mortar were higher than the minimum requirement of 47 psi (0.33 MPa) of M1 mortar of BCP [29].

E. X-Ray Diffraction (XRD Analysis)

X-ray diffraction analysis of marble cement, OPC and blast furnace slag mortar (B20, B30 & B40) was performed. After 28 days of curing, the results are provided in Figure 8.

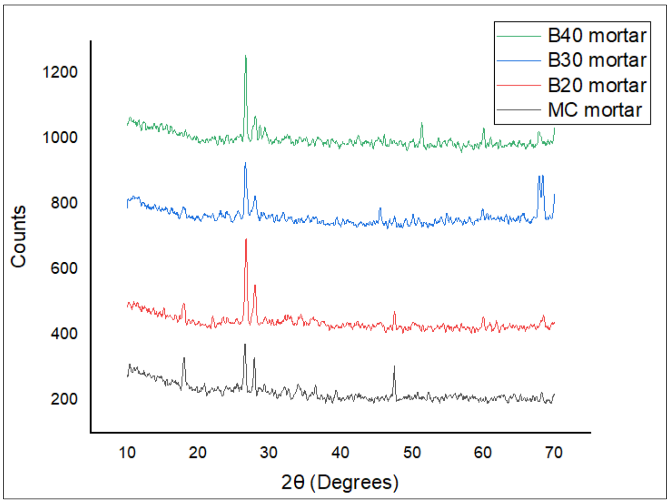


Figure 7. XRD analysis of marble cement, OPC and blast furnace slag mortars

The peaks of 18o and 47.5o in MC mortar in Figure 8 show Ca (OH)2 due to hydration of CaO and calcium silicates in marble cement. These peaks have been significantly reduced in the B20 mortar and have completely disappeared in the B30 and B40 mortars, due to the reaction between amorphous silica (present in blast furnace slag) and Ca (OH)2, which has resulted in CSH gel. Figure 8 shows the peaks of 27o in all graphs, the small peaks between the silica (quartz) in the sand and the 28o-32o, that C2S remains unaffected by the slow hydration reaction.

F. Thermo-Gravimetric Analysis (TGA)

Thermogravimetric analysis (TGA) of marble cement, OPC and blast furnace slag mortar (B20, B30 & B40) was performed. Results 28 days after curing are given in Figure 9.

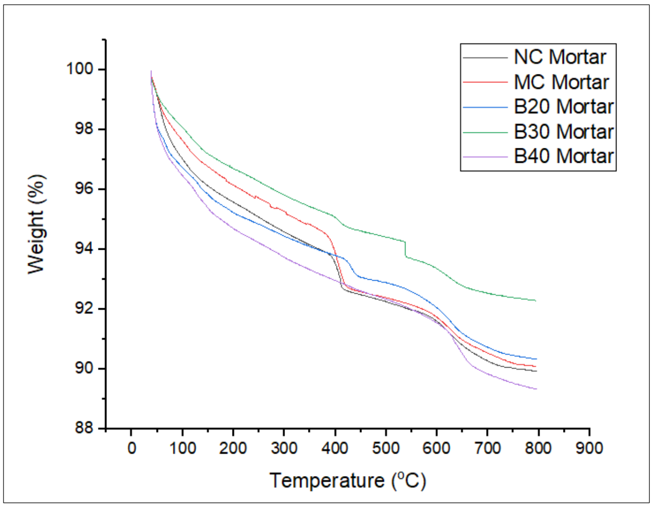


Figure 8. TGA analysis of marble cement, OPC and blast furnace slag mortars

As the temperature rises from 0oC to 100oC, the external water in all materials is pumped out. As materials were placed in water before the test, the amount of free water they have is almost the same and thus the weight loss is almost the same. As the temperature rises from 100oC to 400oC, the water in the C-S-H gel, ettringite and C-A-H gel is expelled. OPC mortar has higher levels of C-S-H and ettringite than marble cement paste, so OPC mortar has more weight loss in this range than marble cement mortar. Weight loss from 400-450oC is owing to dehydration of Ca (OH)2. Marble cement paste contains more Ca(OH)2 than OPC mortar. Therefore, in this extent, the weight deficit in marble cement mortar is higher than in OPC mortar. All in all, the weight deficit in OPC mortar is 2.03% higher than MC mortar, indicating that hydration of OPC mortar is swifter as compared to the MC mortar.

Also, in the case of blast furnace slag mortars B20, B30 and B40, as the temperature rises from 0oC to 100oC, the surface water present in all the material is expelled. As all the samples are placed in water before the test, the amount of free water in all of them is almost the same and thus the weight loss is almost the same. As the temperature rises from 100oC to 400oC, the water in the C-S-H gel, ettringite and C-A-H gel is expelled. Compared to B20 and B30 mortars, B40 mortars have more weight loss in this range, as there is more C-S-H owing to the availability of large amounts of silica for the silica portlandite (calcium hydroxide) reaction. Weight loss from 400 - 450oC is owing to dehydration of Ca(OH)2, so in case of B20, B30 and B40 mortars there is very little weight loss in this range like Ca (OH)2 Marble cement has been converted to CSH gel with the addition of blast furnace slag. Overall, the weight loss in B40 mortar is 0.76% higher than MC mortar and 1.24% lower than OPC mortar, which depicts that hydration of B40 mortar is swifter than MC mortar and slower than OPC mortar.

CONCLUSIONS

The objectives of this experimental study were to investigate the mechanical properties of marble cement mortar and blast furnace slag incorporated in marble cement mortar in different proportions (20%, 30%, 40%) by using standard procedures. The different phase identification analysis (XRF, XRD and TGA) on the mortars permitted us to assemble a clear concept at microstructure level and to feature the connection between the parameters seen by this investigation and the properties of mortars studied. On the basis of the experimental outcomes, the succeeding conclusions were outlined.

The total content of C2S and C3S in marble cement is 56.23%. Both are very important in establishing binding properties. Therefore, it can be utilized as a binding material.

The lately produced marble cement can be utilized in mortar with confidence, as the compressive strength of mortar is 925.68 psi 182 days later. However, the 28-day compressive strength of the mortar is 156.12 psi, which is higher than the M1 mortar of Pakistan Building Code. Also, blast furnace slag replacement has considerably enhanced the mechanical properties of the marble cement mortars.

- The highest increment in compressive strength was observed in B40 mortar at 182 days curing. After 182 days, the compressive strength of B40 mortar is 1907.38 psi which is 52% more than the MC mortar and 23% less than the NC mortar at the same curing period respectively.

- The maximum increase in flexural strength was observed at 182 days curing in B40 mortar which is 15% more than the MC mortar and 62% less than the NC mortar at the same curing period respectively.

- Due to the high content of C_2S, the hydration of marble cement is calmer than that of OPC and thus is highly suggested for hot weather and large-scale concreting.

- It is recommended to build a small marble cement production unit in marble processing plants which will not only give a beneficial construction material but will also consume the marble waste generated as a result of marble processing.

CONFLICT OF INTEREST

The authors proclaim no conflict of interest.

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Investigating PI & PID Controllers for DFIG Installed at Micro Hydro Turbine

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***Abstract*—**The power extracted from the water i-e hydropower is one of the clean and economical source for the generation of power. The flow of water does not remain constant throughout the year so we have to build large storage tanks i-e dams to store water for power generation. But building these large dams have limited this source of energy. Consequently, the trend is going to change by building small hydropower plants. There is no availability of storage of water for producing power then mostly small hydro power plants are built there which are also called as run off river plants. The flow of water vary throughout the year resulting in inconsistent generation of power.so there is a need of variable speed operation that can operate at different operating point to achieve maximum efficiency. So for varying speed operation the one of the famous operating system that is doubly fed induction generator can be used to achieve desired results. In this work the DFIG in a MHPP's is studied, there steady state and dynamic models are discussed. The 3 phase voltages and currents are transformed into 2 phase for ease in calculation by using Clark and park transformation. Then doubly fed induction generator has to operate at the required references which are reactive power, active power and also for speed. And eventually the model of vector control of doubly fed induction generator is achieved. The main objective of developing the model of doubly fed induction generator is to manage the two powers (i-e reactive and active power). The whole simulation should be carried out in MATLAB/Simulink. In this model of doubly fed induction generator we are using two different type of controllers, i-e Proportional integral and Proportional Integral Derivative controllers, to check the efficiency of the model. The results which are then obtained such as the torque, speed, rotor current, voltages on the rotor side as well as Bus voltage, reactive power on the grid side obtained from the two controllers are then compared with each other to see that which controller is giving good efficiency. Therefore, in this research, a predictive controller is proposed to manage the powers i-e active and reactive, of a hydropower plant using doubly fed induction generator.

***Keywords*—** PI, PID, Controllers, DFIG, MHPP, Micro Hydro, Turbine.

I. INTRODUCTION

Lack of energy is the main issue now days. Due to increase in environmental pollutions and power energy scarcity, the different companies relating to the power sectors are showing a great deal of interest on introducing the new technology of renewable energy which are making a good progress in energy sector. The sources of renewables are wind power, hydro power and solar power. The DFIG i-e dual fed induction generators have gained more popularity due to improved energy quality, improved controllability and its efficiency in micro hydro power plants.[1] Traditionally, hydropower plants used are mostly designed with synchronous generators having fixed frequency that of similar to the frequency of the power grid. Therefore, by using DFIG instead of synchronous generator increases the efficiency as in DFIG there is an option of changing the turbine speed while keeping the efficiency high. Whereas keeping in mind that the variation made in changing the speed should be up to 30% of the synchronization speed. There is certain equipment's such as electronic power transformer which is to be used along with DFIG for controlling the rotor voltages. But by introducing these converters which are to be connected to the DFIG makes the model more complex and there is an increase in power loss due to above equipment. Similarly, the power to be supplied to the rotor circuit needs slip rings along with carbon brushes and it then requires maintenance as there is a constant wear and tear in carbon brushes and slip rings.[2][3] As there is a lot of work done in the field of wind energy while using the very same technology i-e of DFIG so it will make easy for adopting the very same technology on the small scale hydro power plants.[4] Hydropower plant capacity depends on location; Water flow is not constant throughout the year, so the available energy and efficiency of water system generation also vary due to various factors such as head and flow, which need to adopt different methods to improve the efficiency and operation of the power system to make it to the optimum efficiency point. Many sites with moderate flow are available, but they cannot be exploited due to large deviations in flow and head that make them uneconomical to operate. A conventional power station controls the flow of water through the inlet gate slot that reacts slowly to changes in load variance and usually has a fixed time for seconds while controlling for power electronics and reaction times. Due to which variable speed hydroelectric control reacts relatively fast. The control of the generator is much less than that of a water turbine. Variable speed operation not only improves the efficiency of the generating system, but also increases the energy generation capacity and improves the use of the transmission network. Various methods have been proposed over the years to achieve efficient operation of hydroelectric systems. Some specifically focus on redesigning the generator for efficient operation of the hydropower system, while others focus on various control algorithms to achieve efficient operation.[5][6] DFIG is very popular in wind power applications and is an economical option for varying speed operation along with compact size of the transformer as compared to synchronous generators used by full-size transformers. This work performs a technical evaluation of DFIG for use in micro-hydropower systems, comparing the efficiency of operation of variable speeds using a variety of controllers. In these processes, separate units of high output reference speed were developed, then simulations were performed using DFIG to validate various parameters (such as power, torque, currents, voltage, etc.).[7]

II. Related work

In this work the problems relating to the frequency and voltages are resolved by using the new technology i-e DFIG instead of using the synchronous or induction type generators. The entire model is then validated in Mat lab/ Simulink software under different conditions such as discharge variations and reactive power. From the results obtained from the simulations of the DFIG model it is clearly observed that DFIG is able to control the various parameters effectively. And also that it is maintaining the referenced value of the voltage and frequency in between the power grid & DFIG. By doing so will give us small networks and distributed generation.[9] [10]

In This paper different control strategies have been proposed and implemented on a generator i-e DFIG producing 2 MW of power from wind energy by managing the rotor side converter variables. Generally, wind turbine run in Mppt mode for maximum efficiency. Generally, there are certain techniques for controlling the RSC to achieve the MPPT. These different techniques are then modeled and their simulation is done while keeping in mind the desired results of achieving the MPPT. All the simulation is done while keeping the range of speed of wind in between 3.2m/s and 25m/s. Also the voltage oriented control is used on the grid side of the DFIG while maintaining the DC bus voltage constant at the desired values. The different techniques used are then compared and analyzed .[11]

In this paper the main idea is by using two voltage source inverters that will supply to the DFIG. The feedback of the two voltage source inverters (VSI) are then electromechanically coupled so as to achieve the desired results. As a result of using two VSI method there produces a dual direct torque control. Stator and rotor vector control flux models are developed. the result shows a better performance and dynamic behavior in all the four quadrants. Moreover, it has shown a better performance in speed tracking performances. [12][13]

In this paper the new and advanced research is done in the area of control systems of the DFIG of the WECS. With this methodology of control, the simple techniques like the decoupling of torque and the reactive power is easy to achieve but there are certain techniques that provides better overall performance. While discussing the sensor less control scheme the MRAS and RCMO schemes provide good result in both cases that is in standalone and grid connected operations of DFIG. [14][15]

In this study the work is done in the area of control system of DFIG. The control system for various systems are discussed including standalone system, balanced and unbalanced grid with which the DFIG should be connected. Certain work is carried out in removing the oscillations in case of unbalanced loads. To achieve the above goals, the RSC or GSC control can be used. A greater degree of freedom is available using both cases simultaneously. They have also discussed the different parameters such as assistance services & support networks and their controls. Finally, it has been discussed for LVRT dfig' s control systems. The commonly used elements in compliance with LVRT were discussed and also analyzed.[16]

In this paper the work is carried out on finding the position of the wound rotor induction generator's rotor and this above operation is carried out without using sensors i-e it is sensor less operation. For achieving the above objectives, the MRAS technology is used .it is basically divided into two models. One model is the adaptive model which gives the rotor emfs and currents whereas the other model is the reference model which give the parameters that are directly available. A hysteresis or PI controller is used to control the operations. Stability analysis are also done on the model. The results shows that this method of finding the different parameters is an appropriate method for the vector control DFIG if the operation is carried out under the stability region.[17] [18]

In this research paper the sliding mode method while using the DFIG for controlling the active and reactive power is introduced in the wind energy system. In this paper certain control algorithm is applied in which the RSC is controlled. The MPPT is obtained by applying fixed flow oriented control technology on RSC. The main thing is to maintain the power factor of the DFIG and is to be kept near the unity for better results and this can be achieved by using fixed flow control technology. The result obtained clearly shows the regulation of speeds while maintaining the efficiency high and also maintained a balance in between the active power and reactive power.[19]

In this paper the strategy to control the DFIG id basically based on the sensor less control by controlling the direct voltage control. Basically it compensates the negative sequence in the rotor side converter by supporting the unbalanced load that are asymmetric. The main thing to obtain is the slip angle so that it become able to fully control the asymmetric loads. This paper is able to find the slip angle in the synchronous reference frame by measuring the value of the important parameter of the machine i-e the value of the stator inductance. This value of inductance can be measured by using real machine parameter. So after finding the said parameter and then integrating this parameter into the direct voltage control strategy which then results in negative compensation for long range of asymmetric loads.[20][21]

In this proposed work an advanced control technique is used making the operation of DFIG reliable. Basically an approach named general predictive control i-e GPC is used in this work. It is basically designed to make the torque of the generator smooth that is by removing the oscillation. The oscillation is due to the result of control signals. So when the current flows in the machine will contain low frequency harmonic contents which in result reduces the fluctuations and oscillations thereby making the electromagnetic torque of the machine smooth i-e free from oscillations. Simulations and results clearly shows that by applying this approach the oscillation in electromagnetic torque can be reduced up to much extent thereby making the machine more efficient.[22][23]

By the development of wind power generation, the Doubly Fed Induction Generator which is based on that wind power system may experience Sub Synchronous Resonance and High Frequency Resonance which are in the series and parallel compensated fragile network. Using Bode Diagram as an analysis tool, the principle and frequency of HFR have been demonstrated. Moreover, the HFR can be classified into two different types: The first one is Undamped HFR, which mostly exits in steady state. Other is Unstable HFR, which results in complete instability and divergence. The above mentioned types are not investigated before. Since Both the Undamped and unstable HFR are crucial to the quality of output wind power as well as the safety and reliability of operation of The DFIG system. It is good to investigate them by using The Nyquist Criterion from two perspectives. First is by determining either the Undamped or the unstable HFR happens, and the second is by estimating the amplitude of The Undamped HFR. The factors which influence, including the weak network shunt capacities. The current PI controller parameters are discussed while estimating the amplitude of the Undamped HFR, the experimental and simulation results of a 7.5 kw down-scaled DFIG setup are provided to validate the analysis on the Undamped HFR and unstable HFR.[24]

There is a comparison in the present paper mentioning the three different methods to control doubly fed induction generator (DFIG) in wind energy conversion systems (WECS). In an experimental setup which is based on a digital signal processor, namely Vector Control, direct torque control and last is direct power Control. These three are the most widespread and well-performing control approaches. The above mentioned methods are kneely reviewed and their performances is analyzed. After that their performances are compared on the basis of stimulation and experimental results. The obtained comparison's results whether it is qualitative or quantitative are likely to be more interesting for especially for the Engineers and Researchers working in the field of DFIG-based WECS.[25][26]

In this paper the work has been done regarding harnessing energy from the small rivers and streams which is the cleanest system of generating the power. As it doesn't require any storage of water so it can be installed easily. In this the water will pass directly through the turbine and will be directed again to the river or to any other stream for agricultural purposes. The design parameters are calculated by the help of Mat lab Simulink program. the turbine is selected on the basis of some important parameters which is flow rate and site head. There will be losses in the turbine because of variation of flow rate of water. There is also a loss of power in the penstock which ranges from 5 to 10 percent depending upon different factors. keeping in mind the efficiency of turbine and also generator the system is designed.in this proposed work it is proved that the construction of the micro hydro plant is feasible and that there is no major problems in the design.[27]

In this paper work is been carried out regarding the controls of the DFIG system as the conventional control system doesn't respond well to changes that comes in the frequency of the system. Actually in this paper the frequency response and the inertial response are studied by comparing the characteristics of DFIG and conventional power plan.in this work some auxiliary loop parameters and algorithms are introduced. As a result of which there comes improvement in different factors i-e frequency control, speed protection, rotational speed delay and also coordination control associated with the DFIG. The simulation results show that the proposed control system has a quick response to the errors relating to the frequency. Hence it is proved that it can also participate to the whole system's frequency up to much extent.[28][29]

As we know that everyone is looking for improving the efficiency of the system to get better results by giving less.so a good control system will give us a better efficiency and also reliability. In this paper different control strategy for doubly fed induction generator is proposed to achieve better performance. As DFIG works at different operating speed which means that there is a lot of variation in the speed and hence requires a complex control system. So in this paper a new approach is introduced i-e Field oriented control or in short we can say FOC .In this paper the proposed control is modeled in ma lab /Simulink and the control is simulated .The results obtained from simulating the above mentioned model shows that proposed control system is suitable for the DFIG operating at variable speed and also be able to control the other parameters such as active ,reactive power & Dc Bus voltage.[30]

III. MATHEMATICAL MODELLING

A. *Doubly Fed induction Generator*

DFIM (doubly fed induction machine) or WRIM (wound rotor induction machine) is a common terminology used to describe an electrical machine, which has been used for many decades in various applications, often in a megawatt range of energy and also less common in a group of a few kilowatts. This concept of the device is as an alternative to the most common and asynchronous & Synchronous machines. It can be useful in applications that have a limited speed range, which allows to reduce the size of the electronic transformer for power supply, for example, in variable speed generation, water pumping etc. The typical supply configuration for DFIM is shown in Figure III.1. The stator is supplied with a three-phase voltage directly from the network with a constant amplitude and frequency, which creates a magnetic field for the stator. The rotor is also provided with three-phase voltage efforts that take different amplitude and frequency in stable condition to reach different machine operating conditions (speed, torque, etc.). This is accomplished using a three-phase sequential transformer, as shown in the simple schematic figure of the figure. This transformer, along with the appropriate control strategy, is responsible for enforcing the rotating AC voltages required to control the overall operating point of DFIM management and to conduct energy exchange through the rotor to the grid. Although the voltage source transformer is displayed, different configurations or converter topology can be used.

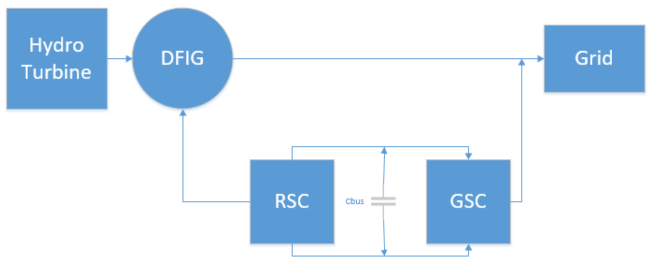

Figure III.1: General supply configuration of DFIM

As mentioned above, DFIM consists of two sets of three-phase windings. Each coil consists of three phases of three windings 120 turned from each other and can have pairs of electrodes, one in the stator and the other in the rotor. The stator can be connected to either delta or wye and the user can choose the connection based on the available voltages and specific DFIG ratings. It is common to use a connected Y-rotor, but usually there are only three slip rings, as no neutral point is needed. The flux produced by the stator rotates at a synchronous speed given by the number of poles and the frequency of currents in the stator and is given by

$$N_s = f_s * 60 / p$$

Where fs represents the stator frequency and p is the pole pairs. Similarly, the angular frequency of the currents and voltages of rotor is given by

$$\omega_r = \omega_s - \omega_m$$

Where ωs represents angular frequency of the stator current & voltages and ωm represents rotor mechanical angular frequency.

B. *Equivalent circuit of DFIG*

The DFIM equivalent circuit is similar to the induction machine induction circuit, but have an extra feature of voltage source in the rotating part of the circuit.

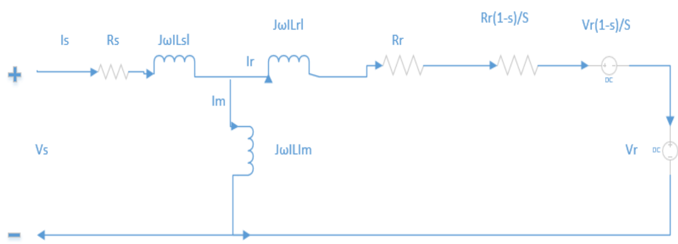

Figure III.2: Equivalent circuit of DFIG

It is common to divide the rotor resistance and voltage source into two parts to show the slip dependent part and the unreliable part. All quantities denote the stator side. The circuit appears in the figure III-2

Whereas in above figure L_{ls} is Stator leakage inductance, L_{lr} is Rotor leakage inductance, Lm is Magnetizing inductance, R_s is Stator resistance & R_r is the Rotor resistance.

Whereas the relation between the actual inductance and leakages inductances are given by the following equation

$$L_s = L_m + L_{ls}$$
$$L_r = L_m + L_{lr}$$

The static part that is the stator flux and rotor flux are given by below equations which are in phasor form:

$$\lambda_s = L_s * I_s + L_m * I_r$$
$$\lambda_s = L_m * I_s + L_r * I_r$$

The steady state voltages can be obtained from Kirchhoff's voltage law to be applied on the equivalent circuit of DFIG which are as under

$$V_s = R_s I_s + j\omega_s \lambda_s$$
$$V_r = R_r I_r + j\omega_r \lambda_r$$

C. *Active & Reactive power control*

As shown above, energy can be exchanged through the rotor and stator, depending on the operating mode. According to the agreement, the energy is positive when extracted from the machine and negative when extracted from the machine. DFIG's total energy balance is

$$P_s + P_r = P_{cu,\,r} + P_{cu,\,s} + P_{mech}$$

The equivalent circuit for the active power is shown in figure III.3

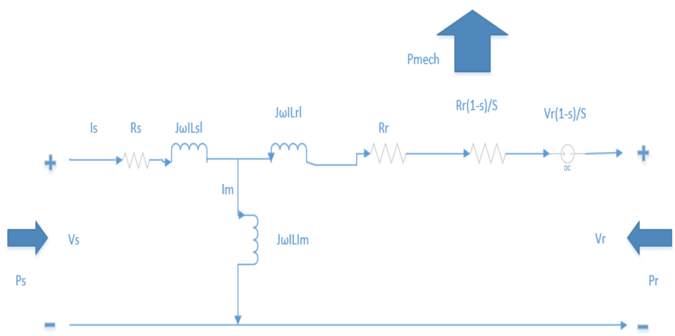

Figure III.3: Active Power Flow in equivalent circuit of DFIG

Whereas Ps is the stator power, Pr is the rotor power, Pcu, r is the copper loss in rotor, Pcu, s is the copper loss in the stator and Pmech is the mechanical power.

Reactive powers are important for magnetizing machines due to the production of electromagnetic torque inside machines due to magnetic flux reactions from stationary devices and rotors The reactive powers obtained by quadrature components use the energy fed by stators and rotors. Thus, the relationship of the interactive forces of the device is:

$$Qs = 3Im\{VsIs^*\}$$

$$Qs = 3lm\{VrIr^*\}$$
$$Q_{LIs} = 3|I_s|^2\omega L_{Is}$$
$$Q_{LIr} = 3|I_s + I_r|^2\omega L_m$$
$$Q_{VIr} = 3I_m(1-s)\, {V_r I_r}^* / _S$$
$$Q_{LIs} + Q_{LIr} + Q_{Lm} = Q_{VIr} + Q_s + Q_r$$

The equivalent circuit of reactive power is shown in figure III.4:

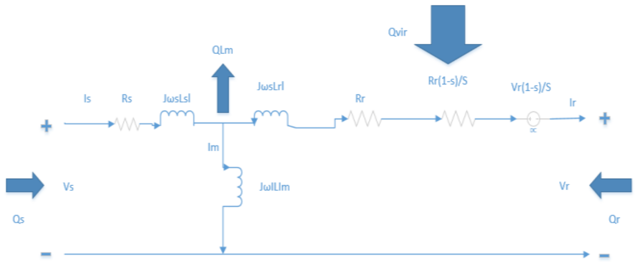

Figure III.4: Reactive Power Flow in equivalent circuit of DFIG

D. *Vectrol control of Grid connected DFIG*

The two converters connected from back to back are responsible for generating voltages of the same size, frequency, size and phase from the rotating circuit, and for ensuring that the power exchange between the rotating circuit and the grid is possible in both directions. The system is shown schematically in Fig III.5

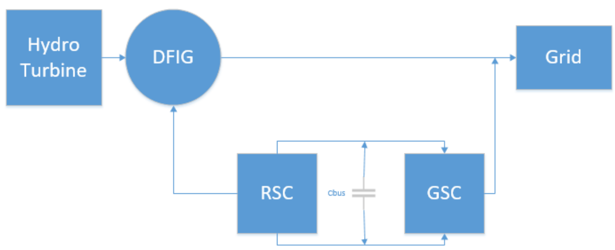

Figure III.5: Doubly Fed Induction Generator with MHPP

The basic idea behind DFIM's vector control is to control the d and q axis of converter currents. First of all, the transformer three phase currents are measured and converted into d and q components using Clarke and Park shifts. Park switching requires a variable frequency angle with same phase currents. The angle can be measured and matched with grid voltage or static flux. Secondly, the currents d and q have to be controlled to be of some desired value, which is defined by the user. The values are then compared with values which will be defined by the user. Different controllers are used to control these currents which are discussed in the controller section. Then the output current controllers, dq, are the components of d- and q-axis of the voltage to be produced by the transformer. The dq voltage values are converted to abc voltages, which are used as a reference to the sinusoidal PWM problem controlling the transformer. The angle of the Park conversions used is the same as the current transformation discussed above. In short the main idea is to control the currents by controlling the voltages.

E. *Vector Control of Rotor side converter:*

Rotor side control the power of the active and reactive stators by adjusting the dq current in the rotor circuit. Active Power Control is used to control the speed of DFIM.

1)Arrangement of dq coordinate system:

The alignment of the rotor currents is done through two ways one way is through stator flux orientation and the other is grid voltage orientation. In the stator flow orientation, the stator flux is calculated and the d-axis of the rotating frame synchronized with the stator space vector is aligned. This is the traditional way to control DFIG. However, for mains voltage differences, the rotation speed is not constant, which adds angular interference, which is best suited for rigid gratings. While in the case of mains voltage orientation, the d axis of the synchronous frame is aligned with the mains voltage. The grid angle is as rough as the grid frequency. It results in more toleration for voltage drops. It also makes an ease to find the grid voltage.

2)Equations for vector control of RSC (Rotor Side Converter)

The RSC i-e rotor side converter controls the d & q axis of the rotor circuit. The real and reactive power of rotor circuit is given by.

$$Ps = \frac{3}{2} R\,(\mathrm{Vs}\,.\,\mathrm{Is}\,) = \frac{3}{2}(VdsIds + VqsIqs)$$
$$Qs = \frac{3}{2} S\,(Vs\,.\,Is) = \frac{3}{2}(\,VqsIds - VdsIqs)$$

Q axis becomes equal to zero after aligning the d axis.so the equation becomes

$$Ps = \frac{3}{2} Vds.\,Ids$$
$$Qs = -\frac{3}{2} Vds\,.\,Iqs$$

This gives the effective power that depends only on the d-axis current and the reactive power that depends only on the stator current q. Stator expression is needed based on the rotor to understand how to control the system. The stator flow 90°is shifted and lag behind the stator voltage. As we know that stator voltage axis are aligned to d axis so the equation becomes.

$$LsIds + UdrLm = 0$$
$$LsIqs + UqrLm = \lambda$$

Finding values of Ids and Iqs from above equations we get

$$Ids = -\frac{Lm}{Ls} Idr$$
$$Iqs = \frac{\lambda s - LmIqr}{Ls}$$

By rearranging the above equations, the final values for active and reactive becomes

$$Ps = -\frac{3}{2}\frac{Lm}{Ls} * VdsIdr$$

$$Qs = \frac{3}{2}\left[\frac{Lm}{Ls}VdsIqr - \frac{Vds^2}{2 * \omega sLs}\right]$$

As the above equations show, the real power is proportional to the rotor of the d axis, while the reactive power can be controlled by the rotor of the q axis, but it has an additional duration depending on the voltage and frequency. The control of reactive energy is then determined by the current classifications of circulation and active energy. The voltage to current ratio should be used when designing the rotor transformer control system.The following relationships are found for the reference frame dq for dynamic modeling of the rotor

$$Vdr = RrIdr - \omega r\lambda qr + \frac{d}{dt}\lambda dr$$

$$Vqr = RrIqr - \omega r\lambda dr + \frac{d}{dt}\lambda qr$$

Whereas the flux equations for rotor circuits is given by

$$\lambda dr = \left(Lr - \frac{Lm^2}{Ls}\right)Idr$$

$$\lambda qr = \left(Lr - \frac{Lm^2}{Ls}\right)Iqr + \frac{Lm}{Ls}\lambda qs$$

As we know that the stator flux derivative contained in the q axis equation is zero during normal operation. However, this is not the case for voltage changes at the ends of the stator. The term stator flow for the axis equation d is constant and can be compensated for controllers. So The final equation for the plant becomes as

$$Vdr = RrIdr - \omega r\sigma LrIqr + \sigma Lr\frac{d}{dt}Idr$$

$$Vqr = RrIqr - \omega r\sigma LrIdr + \sigma Lr\frac{d}{dt}Iqr$$

3)Calculation of Angle for RSC

Park conversions used in stator lateral transformer require a rotor angle. The angle of the rotor can be estimated from the below equations

$$\omega r = \omega s - \omega m$$

Similarly, for angles the equations are

$$\theta r = \theta s - \theta m$$

4)Speed Control

As described above, the current d-axis controls the active part of the power. The turbine can be considered a torque control engine and does not control speed. This can be a fast turbine water greater than 1.5 to 2.5 times the nominal speed, which requires it. For speed control. Typically, hydropower plants are used simultaneously working at a fixed operating speed at which the regulator regulates the speed. The governor increases the flow of water to increase the production of mechanical energy when he increases the load generator. In this case, DFIM should control the active stator power by adjusting the rotor currents.

F. Internal module control

There is a need of internal controller to control the internal model of the process based on internal model control. The control is basically a cascaded type of control. It consists of two types of loops i-e inner control loop and outer control loop. Basically the outer control loop is used to control the speed of the DFIG whereas the inner control loop works on the reference values which they get from the outer loops. The outer loop gets its actual value from the turbine model whereas the reference value is given to the controller. The controller start comparing these two value and in case the values do not get matched an error is produce as an output. This output becomes an input to the inner control loop which actually is controlling the current of the machine. The inner loops correct the current error and send a signal to the machine to correct the error either by increasing or decreasing the speed, power etc. The inner loop has to work faster than the outer loop so the bandwidth of the inner controller is more than the outer loop.

1)PI Controller

In case of PI controller, the control will depend on the two gains i-e Proportional & Integral. The control diagram of the PI controller is shown in figure III.6.

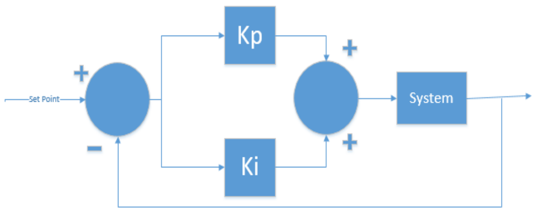

Figure III.6: Proportional Integral Controller

2)PID Controller

In case of PID controller, the control will depend on the three gains i-e Proportional, Integral & Derivative. The control diagram of the PID controller is shown in figure III.7.

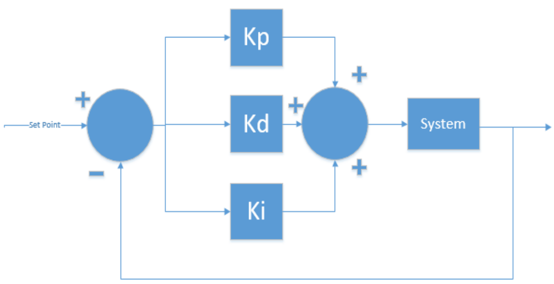

Figure III.7: Proportional Integral Derivative Controller

G. Grid side converter Vector Control (GSC)

The GSC is basically responsible for keeping the voltage across the capacitor. The power flows in between the Rotor side converter and Grid side converter. As there is a bidirectional flow of power across the rotor of the DFIG so if the power is coming from RSC to the capacitor then the grid side return the excess power to the main grid whereas if the power is flowing from the DC link capacitor towards RSC then Grid side supply the power to the rotor of the DFIG.

1) Equations for vector control of GSC (Grid Side Converter)

In order to find the equations for active and reactive power we should align the d-axis of the rotating frame with grid voltage space vector as a result of which the q-axis becomes equal to zero. The equations are given below as

$$V_{df} = R_f i_{dg}(t) + L_f \frac{di_{dg}(t)}{dt} + V_{dg} - \omega_a L_f i_{qg}$$

$$V_{qf} = R_f i_{qg}(t) + L_f \frac{di_{qg}(t)}{dt} + V_{qg} - \omega_a L_f i_{dg}$$

As we know that q component is equal to zero so the equation becomes;

$$V_{df} = R_f i_{dg}(t) + L_f \frac{di_{dg}(t)}{dt} + V_{dg} - \omega_a L_f i_{qg}$$

$$V_{qf} = R_f i_{qg}(t) + L_f \frac{di_{qg}(t)}{dt} + \omega_a L_f i_{dg}$$

Now by calculating the equation for active power and putting the above values the equation becomes;

$$P_g = \frac{3}{2} v_{dg} i_{dg} = \frac{3}{2} |v_g^{\to s}| i_{dg}$$

Similarly finding the equations for reactive power and putting the above values of voltage the equation becomes;

$$Q_g = -\frac{3}{2} v_{dg} i_{qg} = -\frac{3}{2} |v_g^{\to s}| i_{qg}$$

As it is clearly shown in the above equations that active power is depending on the d-axis current. Hence the active power can be controlled easily by controlling the d-axis current. Similarly, in case of reactive power, it is depending on the q-axis current so by controlling the q-axis current the reactive power can be controlled.

2)DC link Voltage controller

As we know that the DC link capacitor is of great concern in the model of DFIG. As it decides and allows the bidirectional flow of power across the rotor. There are two conditions that are going to occur over the DC link. First is when the DFIM is acting as a generator. In this case the supply is fed to the rotor. The supply came to the rotor by passing through grid side converter, DC Link then rotor side convert and then to the rotor. In this case the GSC act as a rectifier whereas the RSC act as an inverter. Secondly when the speed of the generator increases the it will start supplying power to the grid. In this case the RSC act as a rectifier whereas the GSC act as an inverter. While leaving the setting according to the 1st condition the power will not flow to the grid and as a result the DC link voltage will start increase. As a result, active power cannot be fed back to the grid. Whereas active power is controlled by the d-axis current. So this operation can be made to operate smoothly by using a controller which constantly compare the value of DC bus link with the reference value. As result of which changing of converter into rectifier and inverter works smoothly and the DC link remains in Equilibrium.

IV. RESULTS

This section discusses the implementation of design of the Doubly fed Induction Generator in the software MATLAB. The design is implemented in the Simulink/mat lab software and results are obtained which will be discussed later in detail. First of all, the whole Simulink model is discussed and after that the control block of the DFIG will be discussed. After that we will discuss the whole model using PI controller in the control block and its results will be discussed with respect to time and discharge of water. Same we will do Using PID controller in the control block and its results will be discussed with respect to time and discharge of water. After discussing the results of both controllers we will then compare the results of both controllers and see which one is better and which one is not in efficiency and working

A. Discharge of water

At start the discharge is 8m^3/sec. After 3sec the discharge is changed to 5m^3/sec. Similarly, the discharge is changed again to 12m^3/sec at 4.5 sec. The graph between time and discharge is shown below. In this graph the variation in the flow of water is shown with respect to time in figure IV.1 .

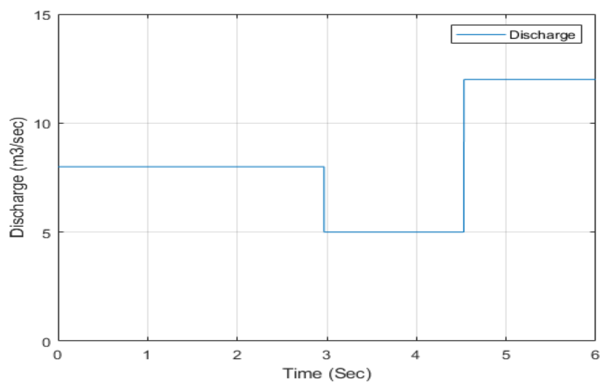

Figure IV.1: Discharge of water

B. Comparison of PI and PID Controllers

Now we will discuss the DFIG using both the controllers that is Proportional Integral Derivative controller (PID) and Proportional Integral controller (PI). We will discuss the different parameter of the model which is speed, torque, Id, Iq, Vs etc. of both controllers and will compare the results of both controllers with each other. We will see what changes comes in these parameters when the discharge of the water gets changes and which controller is performing better.

Figure IV.2 & IV.3 shows the speed of DFIG. It is clearly shown in the graph at 3 secs and at 4.5 sec that there is no change in the speed of machine due to the change in the flow of water which means that the dfig is maintaining the constant output. The PID controller starts tracking the reference line earlier than PID controller.

1)Speed of DFIG (Omega):

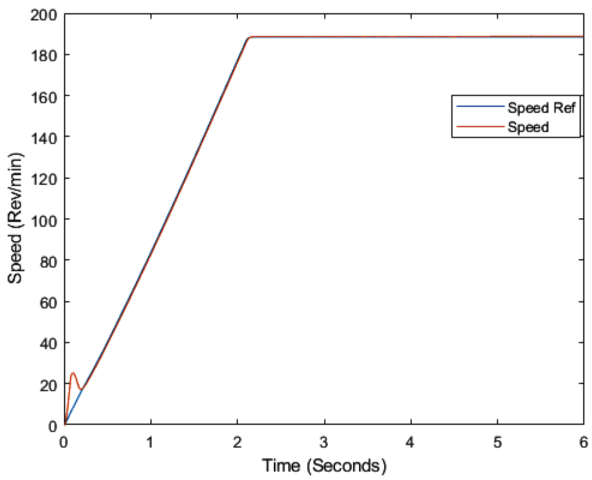

Figure IV.2: PID Controller

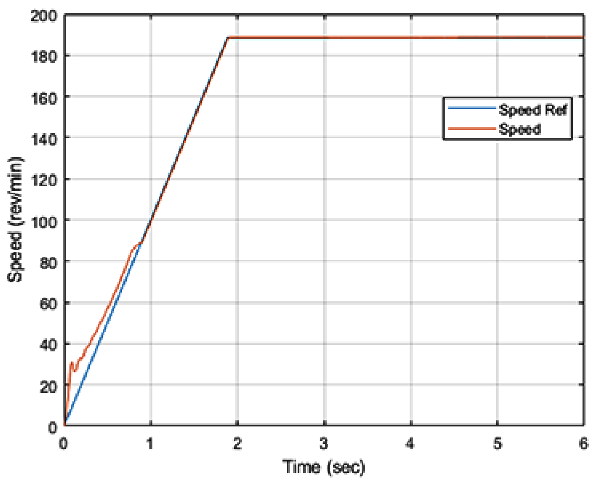

Figure IV.3: PI Controller

2) Torque in DFIG (Tem)

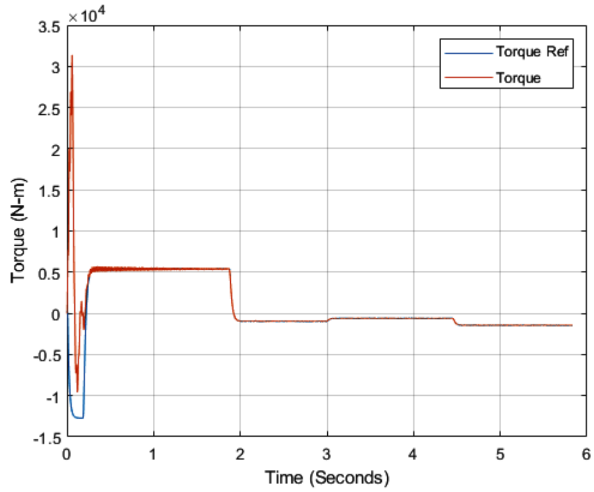

Figure IV.4: PID Controller

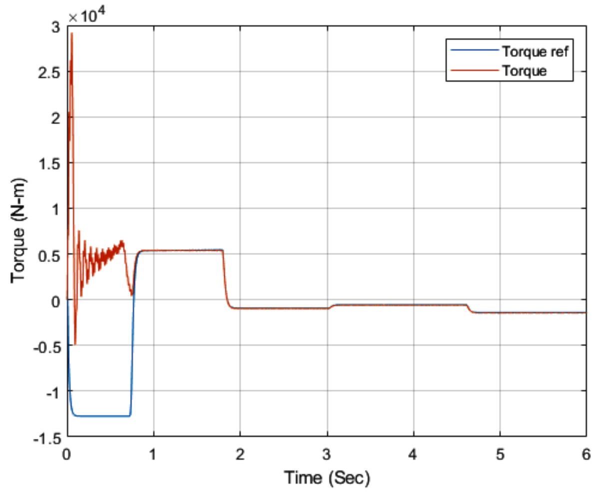

Figure IV.5: PI Controller

In figure IV.4 & IV.5 the torque of the machine is drawn with respect to time. At 3sec as we know that the discharge is decreased as a result the torque get decreased. Then at 4.5sec the discharge is increased as a result the torque also get increased. Note that the values of torque are in negative which means that the machine is operating as a generator. And If we compare the results of both controllers, the PID controller start tracking earlier than the PI controller with less oscillations.

3) *Rotor direct current (Idr)*

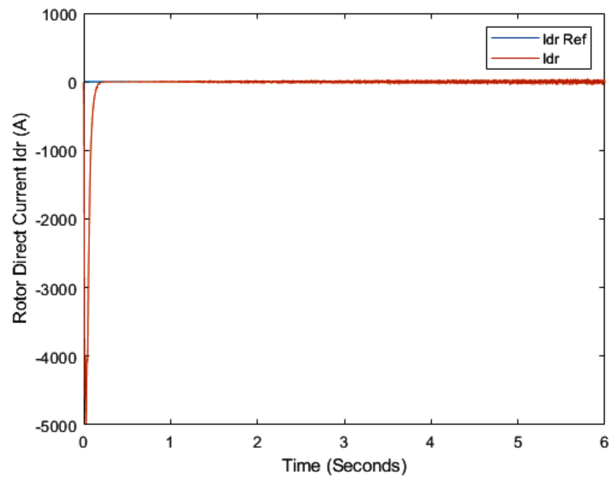

Figure IV.6: PID Controller

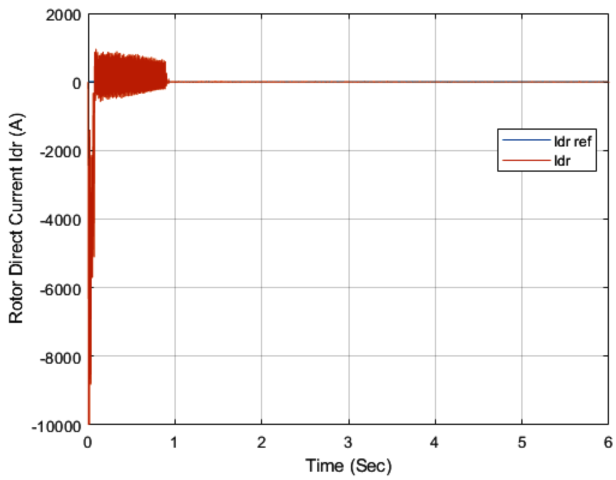

Figure IV.7: PI Controller

In figure IV.6 & IV.7 the graph of rotor direct current is plotted against the time. The reference rotor direct current is set equal to zero. The rotor direct current is following the reference value which is equal to zero. As it is clear from the graphs that PID controller is suppressing the harmonics in the start very well as compared to the PI controller. As it is clear from the graph the PID controller starts tracking earlier than the PI controller with less harmonics.

4) *Rotor Quadrature Current (Iqr)*

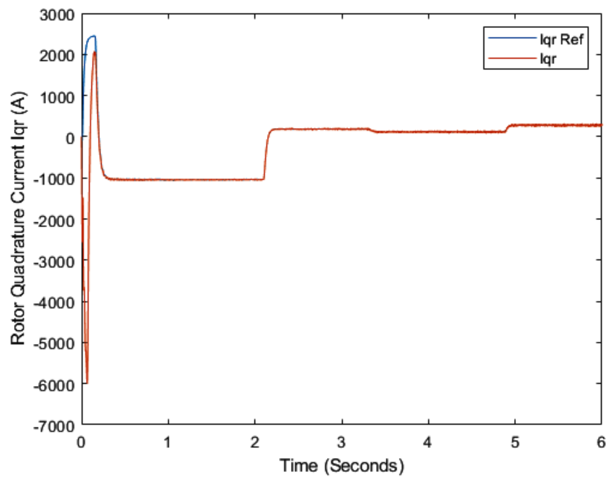

Figure IV.8: PID Controller

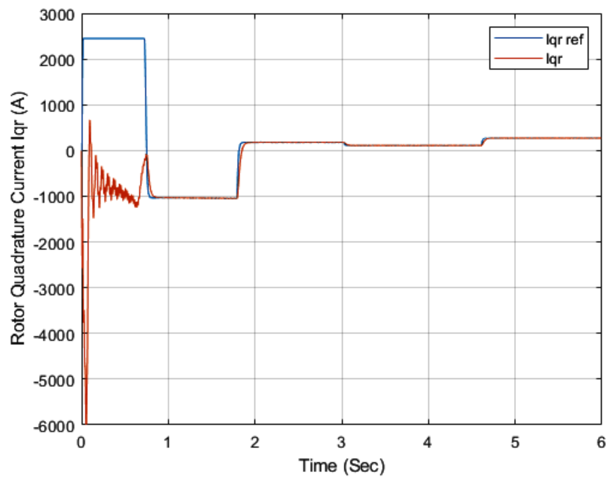

Figure IV.9: PI Controller

In figure IV.8 & IV.9 the graph is plotted in between rotor quadrature current and time. It is clear from the graph that Iqr changes accordingly to the change in the discharge of water in order to keep the output constant. At 3 secs when the discharge is decreased the Iqr also decreases similarly at 4.5sec when the discharge is increased the Iqr also get increased. The PID controllers starts tracking more earlier than the PI controller and with no harmonics.

5) *Three Phase Stator Voltages*

In figure IV.10 & IV.11 the graph is plotted in between Three phase stator voltage and time. It is clear from the above graph that regardless of the changes in discharge of the water it gives a constant three phase output voltages to the Grid.

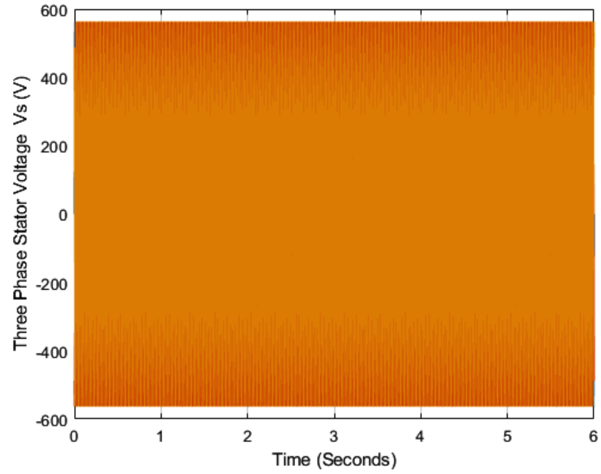

Figure IV.10: PID Controller

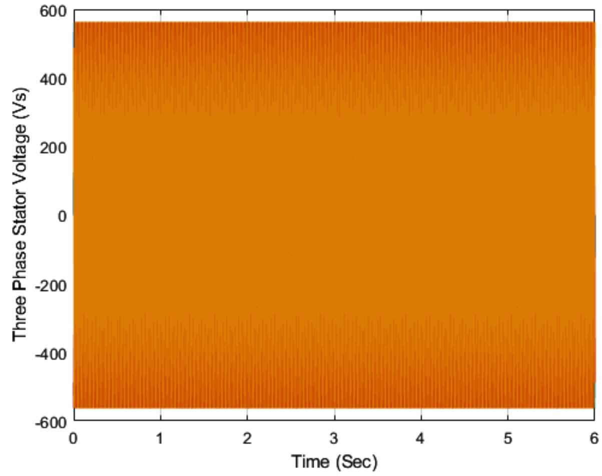

Figure IV.11: PI Controller

6) Three Phase Rotor Current (Ir)

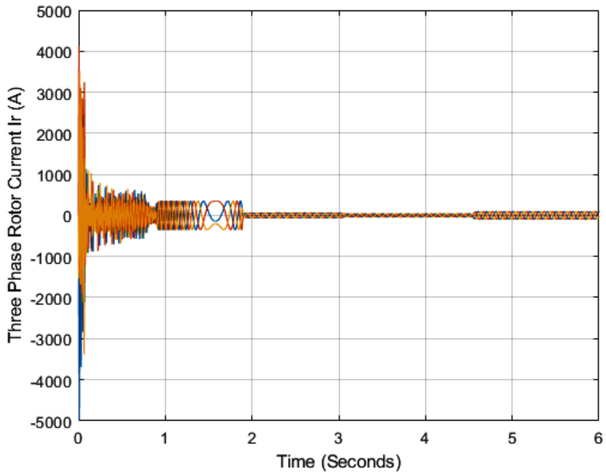

Figure IV.12: PID Controller

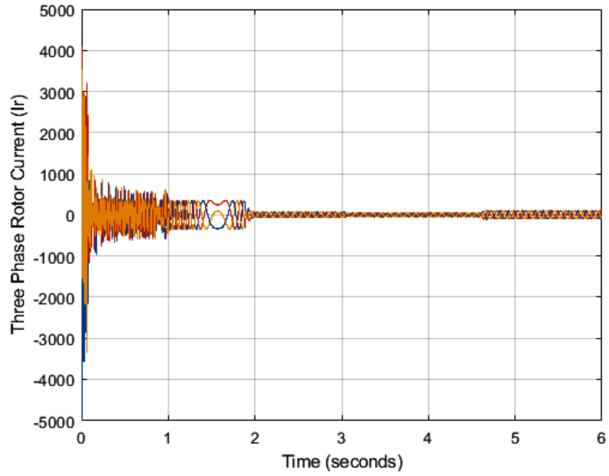

Figure IV.13: PI Controller

In figure IV.12 & IV.13 the graph is plotted in between Three phase rotor current and time. In the above figure it is clearly shown that as the discharge decreases the rotor current also decrease which is at 3sec.Similarly at 4.5sec the discharge is increased and as a result the rotor current also increases. As it is clear from the graph that the PID controller graph looks much smoother than PI's graph which means there is much less harmonics in PID as compared to PI controller

7) Bus Voltage (Vbus)

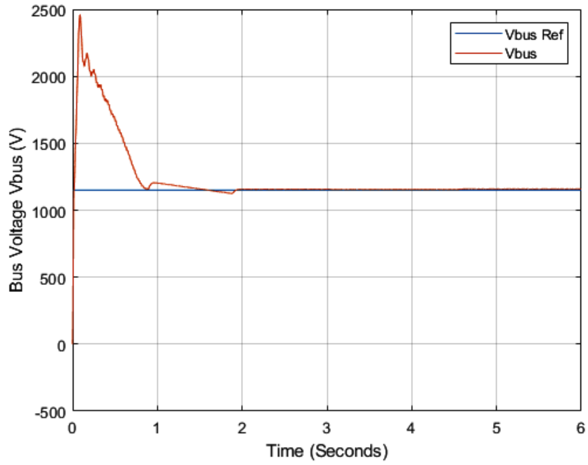

Figure IV.14: PID Controller

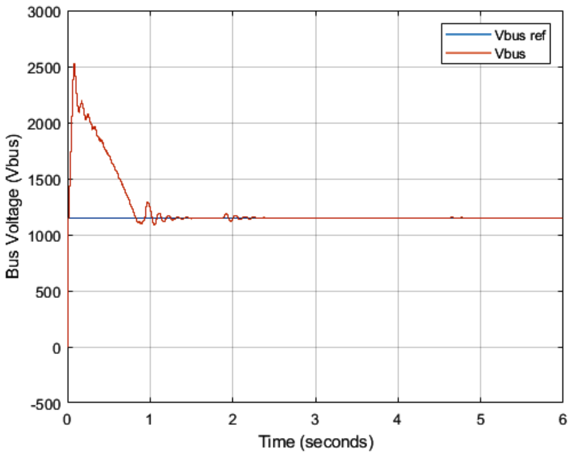

Figure IV.15: PI Controller

In figure IV.14 & IV.15 the graph is plotted in between Bus voltage and time. It is clearly shown from the above graph that reference value is set at 1150 V. The bus voltage is tracking the reference voltage. As it is clear from the graphs that PID controller is suppressing the harmonics in the start very well as compared to the PI controller

8) Quadrature Grid Voltage Reference (Vqg_ref)

In figure IV.16 & IV.17 the graph is plotted in between grid quadrature voltage reference and time. In the above graph it is shown that there comes a change in the value of voltages. The grid quadrature voltages changes with the change in the rotor current which ultimately changes with the change in the discharge of the water. So when the discharge of the water get changes the grid quadrature voltage also get changes. As it is clear from the graphs that PID controller is suppressing the harmonics in the start very well as compared to the PI controller

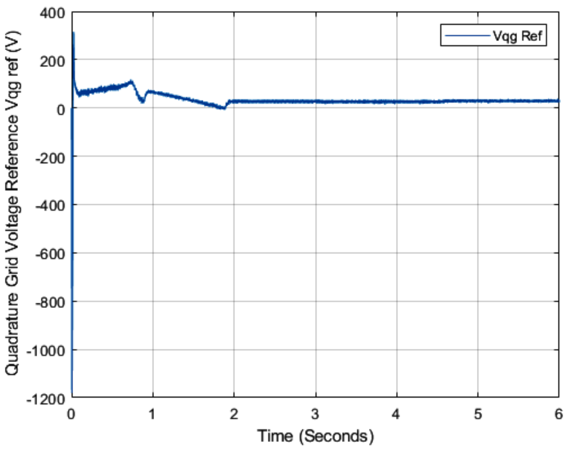

Figure IV.16: PID Controller

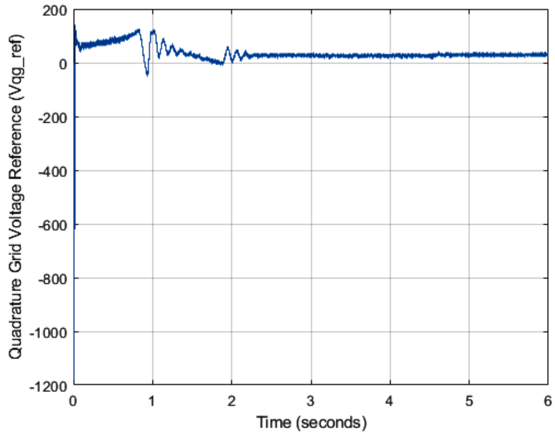

Figure IV.17: PI Controller

9) Grid Reactance Reference Power (Qg_Ref)

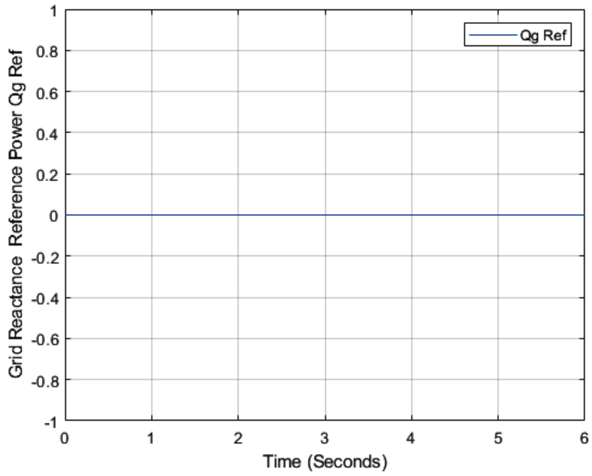

Figure IV.18: PID Controller

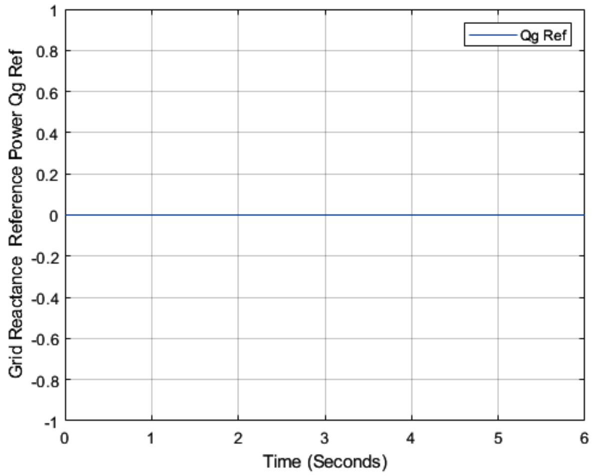

Figure IV.19: PI Controller

In figure IV.18 & IV.19 the graph is plotted in between grid reactance reference power and time. In the above figure the reactive power reference is set to zero. We can change it according to our requirements.

10) Direct Grid Voltage Reference (Vdg_ref)

In figure IV.20 & IV.21 the graph is plotted in between grid direct voltage reference and time. Above graph shows the of direct grid voltage reference which is very small equal to Zero almost. As it is clear from the graphs that PID controller is suppressing the harmonics in the start very well as compared to the PI controller.

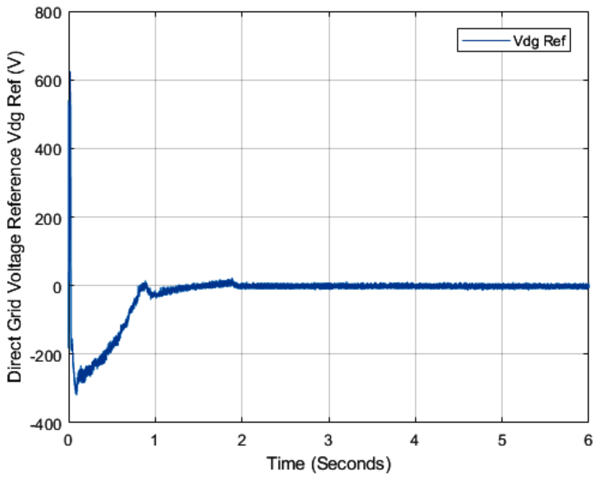

Figure IV.20: PID Controller

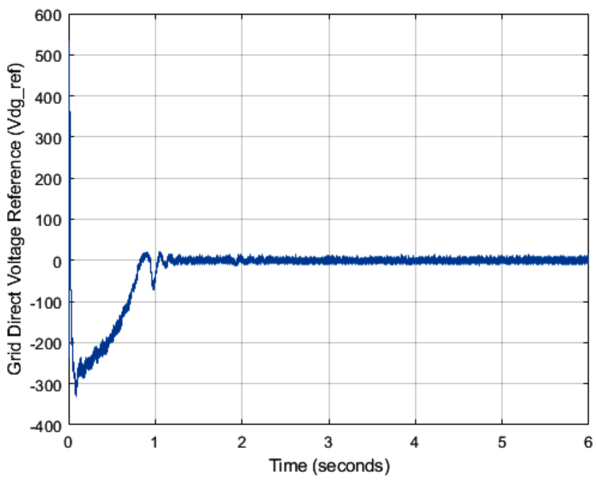

Figure IV.21: PI Conrtroller

CONCUSLION

The objective of this work was to improve the efficiency of doubly fed induction generator installed at the run off river plants/small scale hydro power plants. In this thesis work is based on the control strategies. Two types of control strategies are introduced in this work which are PI and PID controllers. Simulation of the whole DFIG model is carried out separately by both the controllers. After simulating the model by both controllers the results obtained are compared with each other. Results clearly show that the PID controller is working more efficiently than PI controller. The PID controller start tracking earlier than the PI controller. Similarly, the fluctuations in PID controller model results are seen less than the PI controller results.

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An Efficient Android-Based Application and Tool Development to Trace Smartphones

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***Abstract*—** Nowadays, smartphones are a crucial aspect of life for everyone involved in day-to-day activities. Sometimes mobile phone users need to keep their mobile phones quiet. This silence option is handy in many scenarios or locations such as meetings, lectures, libraries, museums or places of worship, and mobile phones might occasionally be lost. In this article, we have demonstrated that how to make it easier for Android phone users to discover their smartphone that has been lost due to quiet mode and how to monitor mobile phones by sending a single text message on the mobile phone, whether the mobile phone starts ringing, and users can simply search. There is no need to connect to the internet during mobile search if a user knows that the mobile phone is close to the location by listening to the emergency security alert beeping, which is also set up in this application to make it easier for users to find the mobile phone rather than searching through GPS Tracking System. It also tells users about the mobile phone's present position. If the mobile phone is far from the user, the user can only get location information if the mobile phone is linked to the internet or the mobile phone enables data packet. The Coral Draw graphics program is utilized to develop a beautiful interface for this project. Using SDK and JDK packages and libraries, Android Studio is utilized to code portion and performance features of this application.

***Keywords*—**Android, SDK, Security, GPS Tracker, SIM Detection.

I. Introduction

With the advancement of mobile technology, the world is becoming shorter. As the number of users rises daily, the Possibilities also expand. Starting with simple ordinary mobile phones used exclusively for calls, mobile phones have transformed and become part of our lives. Now, not only do they make calls, but they have countless purposes and may be used as a camera, music player, tablet, TV, online browser etc. In addition, new technologies also require new software and operating systems [1].In the previous 15 years; operating systems have progressed a lot. Mobile OS has gone a long way from black and white to the present smartphones or mini-computers. Mobile OS has progressed from Palm OS in 1996 to Windows Pocket PC in 2000 to Blackberry OS and Android. Especially with smartphones. One of the most popular mobile operating systems nowadays is Android. Andy Rubin, Rich Miner, Nick Sears and Chris White established Android Inc. in California, USA, in 2003 in Palo Alto [2] .Android Inc. was eventually acquired by Google in 2005. After the first release, a lot of upgrades were released in the original Android version. Android is a mobile operating system, including smartphones and tablet computers. It was developed under Google's guidance by the Open Handset Alliance. It's based on Linux. The Open Handset Alliance, a consortium of 83 hardware, software and telecoms businesses devoted to supporting open standards for mobile devices, was founded on 5 November 2007 with the launch of Android distribution [3].This alliance has a shared purpose of promoting mobile device innovation and offering customers with a significantly improved user experience than many on today's mobile platforms. By providing developers with a new degree of openness that enables them to cooperate better, Android will speed up the rate at which consumer's access to innovative and exciting mobile services [4].The green robot on the right commonly symbolizes Android. Since its introduction, Android has progressed significantly. Google called all their dessert projects. Below is a list of the main versions, which must not be memorized; it is just intended to show the fast progress and numerous improvements [5]. Android is developed "on the Internet," which is far faster than the conventional technique (e.g., Windows releases, which are typically several years apart). Several programs already on the market include tracking systems and anti-theft programs such as mGuard, which identify illegitimate SIM cards. In contrast to this use, AALTm [6] can identify illegitimate device cards by comparing the Integrated Circuit Chip Card Identification (ICC-ID). For each SIM card, the ICC ID number is unique. The market for mobile phones already has tracking apps such as Mobile Tracking Systems [7], AccuTracking [8], and Phone Back (also an anti-theft application [1]). Most of these systems give specialized solutions using mobile device tracking technologies, but simply enable ring and receiving the new SIM information would not be sufficient for monitoring smartphones. We may use some additional applications such as MSpy, Mobile Location tracker or Live Mobile Location tracker [9]. We've designed a basic Android app to monitor and find the position with an extra enhanced silent mode Finder function that differs from the disadvantages of Android apps before. It is an upgraded and amended application form. This application is installed in the background and does not display in the Task Manager. This will allows the user to follow a mobile device and get an SMS notice to a pre-defined number whenever the mobile phone is lost.

II. PROPOSED APPLICATION DESIGN&DEVELOPMENT

The V-model represents a software development process (also applicable to hardware development) as shown in Figure 1 below, which may be considered an extension of the waterfall model. Instead of moving down in a linear way, the process steps are bent upwards after the coding phase, to form the typical V shape. The V-Model demonstrates the relationships between each phase of the development life cycle and its associated phase of testing. The horizontal and vertical axes represents time or project completeness (left-to-right) and level of abstraction (coarsest-grain abstraction uppermost), respectively. We have used Android Studio in our application development environment. Jdk, sdk, all Android packages, and Coral Draw are all required. The android studio platform will be used to finish the building of a tracking mobile phone application. Although there is an earlier platform called "Eclipse," we choose to utilize Android Studio. Because Android Studio is built on IntelliJ IDEA, which combines all of the functionality of Eclipse's ADT plugin with a slew of new ones. The inspiration for this software arose after i misplaced my Android phone in my room, which was on silent mode, making it extremely difficult to locate. This application is only for An-droid phones. The developer has picked Java and Android Studio as their programming and design tools [10,11]. This application has three phases: the mobile phone recognizes that it must begin beeping right now, thus a condition is set that the phone will only beep when the precise message is received. Some graphic programs, such as Coral Draw and Photoshop, will be utilized to develop the app's logo and user interface. This project's implementation should take three months, after which testing will take place, with the application being installed on the phone and checked to see whether it works properly. Maintenance should be done on a regular basis after the installation and testing phases to keep the project useful for the users. These days, losing your phone may be a major hassle. findmyphone uses audio and video to trace the position of your missing phone in real time. Not only do you lose money, but every lost phone carries personal information about you and your family, such as text messages (SMS), photos, phone numbers, and other information. Lost phones and Droids may be found via findmyphone. When your phone is used, you might also receive a missing phone notification. "Breadcrumb location" allows you to keep track of your gadgets at all times. It may help track down your spouse's and/or children's phones, as well as mobile phones and Droids. This is a one-stop shop for all things relating to the security of your phone.

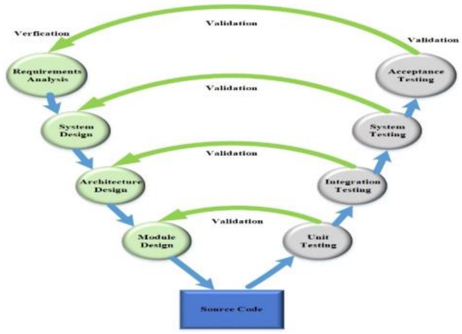


Figure 1. Components of Android structure

A. *Software development tools*

Software development [12-14] tools are mainly based on java and java virtual machine. Java is a computer language created by Sun Microsystems (Sun) in 1991 by James Gosling. The first Java release (Java 1.0) was released in 1995. In 2010, Oracle Corporation adopted Sun Microsystems. New enhanced Java versions have been published over time. The Java platform allows software developers to create program code in languages other than the language of programming for Java. The Java platform is frequently linked to Java and Java's core libraries.The Java virtual machine is especially designed for a certain operating system [15]. For example, Linux, just like Windows, has to be implemented. The Java Runtime Environment (JRE) and the Java Development Kit (JDK).The Java runtime environment (JRE) consists of the JVM and the Java class libraries and contains the necessary functionality to start Java programs. The JDK contains in addition the development tools necessary to create Java programs. The JDK consists therefore of a Java compiler, the Java virtual machine, and the Java class libraries.

III. ANDROID ARCHITECTURE

Android is a mobile device software platform and operating system. It is open source software. It enables developers to create managed Java programs and manage the device through Google-developed Java tools. The Open Handset Alliance announced the availability of the Android SDK in November 2007. Android is a mobile operating system built on top of the Linux kernel 2.6. The following features distinguish it. [12, 15, 16]:

- No fees for licensing, distribution and release
- GSM, 3G EDGE networks for telephony

- IPC messaging
- Background processes and applications
- Shared data storage
- Full multimedia hardware control
- API's for location based services like GPS.

The overall architecture of Android framework and its constituents is shown in the figure 2 below;

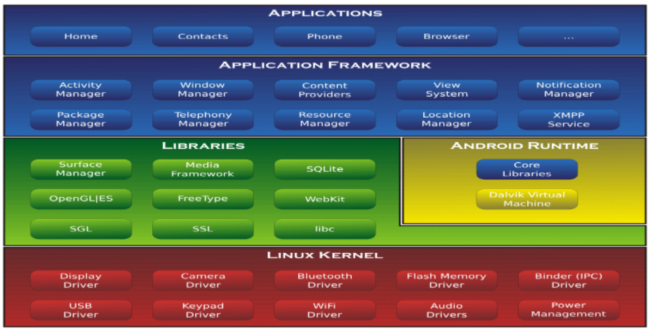
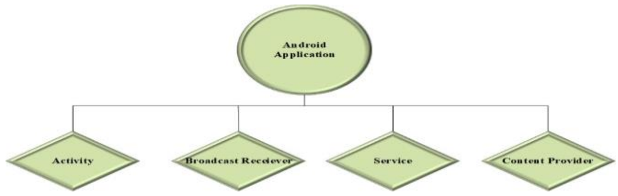


Figure 2. Architecture of Android OS

Android comes pre-installed with a set of essential programs, including an email client, an SMS programs, a calendar, maps, a browser, and contacts. All programs are developed in Java. Each application is designed to achieve a certain objective. All of the capabilities may run in the background of the mobile device and be accessed through a pop-up window. The application framework is the subsequent layer. This cate-gory comprises programs that control the phone's fundamental tasks, such as resource management, phone apps, switching between processes or programs, and monitoring the phone's actual location. Developers have complete access to the Android application framework. This enables users to take use of the processing power and support features of An-droid while developing an Android application. Consider the application framework to be a collection of fundamental tools that a developer may utilize to create far more complicated tools. Libraries Layer comprises the Android native libraries. All of these shared libraries are written in C or C++, are built for the phone's specific hardware architecture, and are pre-loaded by the phone maker. The Android Runtime layer is comprised of the Dalvik Virtual Ma-chine (DVM) and a collection of essential Java libraries. Each Android application receives a dedicated DVM instance. Dalvik was designed to allow the efficient operation of multiple virtual machines on a single device, and it executes files using the dex (Dalvik Executable Format) extension, which is memory-efficient [17-19].

IV. Components of Android

Android application's fundamental components are the Activity, the Broadcast Receiver, the Service, and the Content Provider as shown in figure 3 below. Each of them must be specified in the AndroidManifest.xml file when utilized in an application. The Views define the component's user interface. We employ Intents and Intent filters to communicate between



these fundamental components, which are critical throughout the app development process [12, 13].

Figure 3. Components of Android structure

Fundamentally, an activity is an object with a lifespan. An Activity is a section of code that performs some task; this task may involve showing a UI to the user if required. However, it is not required—some activities never show UIs. Typically, we will use one of our application's activities as the application's entry point. Another sort of component is the Broadcast Receiver, which is capable of receiving and responding to any broadcast announcements. A service is a collection of related pieces of code that operates in the background. Depending on its requirements, it can be executed in its own process or inside the context of another application's process. Other components "bind" to a service and make remote procedure calls to its methods. A service is an example of this; even if the user exits the media-selection UI, she likely wants her music to continue playing. Even after the UI has been closed, the service continues to play music. A Content Provider is a data repository that grants access to data on the device; a classic example is the Content Provider that grants access to the user's contact list. Our application may access data that has been provided by other apps via a Content Provider, as well as establish our own Content Providers to expose our own data.

V. Implementation

A. Activity diagram

The Activity Diagram depicts the phases that comprise a complicated process as shown in Figure 4 below. It depicts the control flow, similar to sequence, but with an emphasis on operations rather than objects. This module determines which action should be taken when the attention word "ringmydevice-vice" occurs. If it is matched, activity begins, allowing the device to ring. If the attention word matches the term "getlocation," it initiates an activity that obtains the device's location and transmits the data to the SMS sender. Simultaneously, it terminates message broadcasting, preventing messages from reaching the native messaging application's inbox.

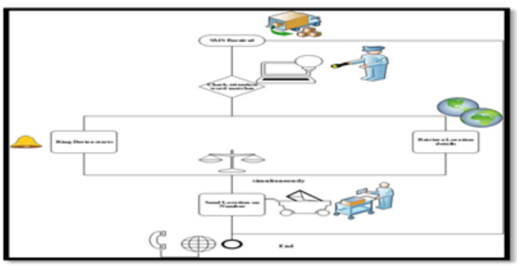


Figure 4. Demonstration of activity diagram

If the attention word does not match the designated key word, then broadcasting is enabled, allowing the message to reach the inbox of the native messaging application.

The components used in this are as follows:
- Rounded Rectangle: It indicates the process
- Arrow: It indicates transition line
- Rhombus : It indicates the decision
- Bars: It represents the start or end of concurrent activities
- Solid Circle: It represents the initial state of workflow
- Encircled Black Circle: It represents the final state of workflow.

B. Sequence diagram

A case diagram depicts the interaction of a collection of items in order to accomplish a complicated function as shown in Figure 5 below. This sort of diagram enables the other developer to validate the interaction. A sequence diagram depicts many processes or objects that exist concurrently as parallel vertical lines (lifelines) and the messages that are passed between them as horizontal arrows in the order in which they occur. This graphical interface enables the defining of straightforward runtime scenarios.

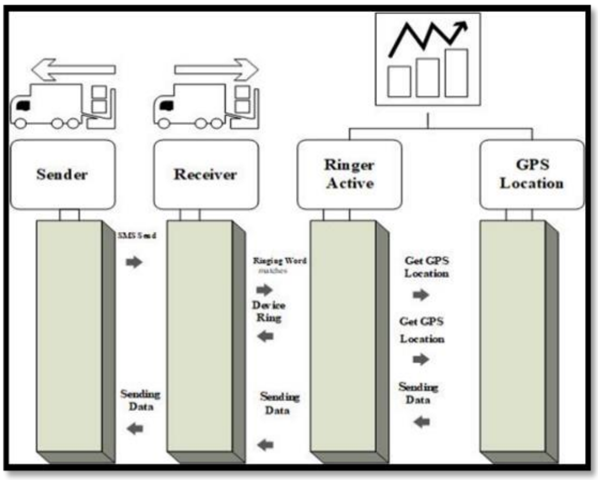


Figure 5.Demonstration of sequence diagram

In order to implement our proposed system modules, we have to meet the requirements for the hardware on the developer as well as software requirements on the client side as well as mentioned below in Table 1 and 2.

Table 1. Hardware requirements on the developer sider

Processor	Dual core or above	Processor
RAM	4GB	RAM
Hard disk	80GB or above	Hard disk
Monitor	15’’ LCD or CRT Monitor or above	Monitor
Keyboard	Standard windows keyboard	Keyboard

Table 2. Software requirements on the client sider

Development Kit	Android SDK 2.3, Java JDK 1.6
Languages	Java
IDE	Eclipse Helios, Android Emulator
Platform	Window 7/8

VI. PROPOSED ALGORITHM

Our proposed algorithm is shown in Figure 6 below. It determines which action must be carried out if the word attention matches the keyword "ringmydevice." Ifmatched,the activity commences, which allows the device to ring. When the term 'attention' matches the term 'get-location,' it starts to find the location of the device and transmit information to the SMS sender ,as shown in figure 5 below. At the same time, it aborts message broadcasting in order to prevent a message to the Native Messaging Application inbox. If the attention word does not match the defined key word simply, broadcast the message in the inbox of the native messaging application can be accessed.

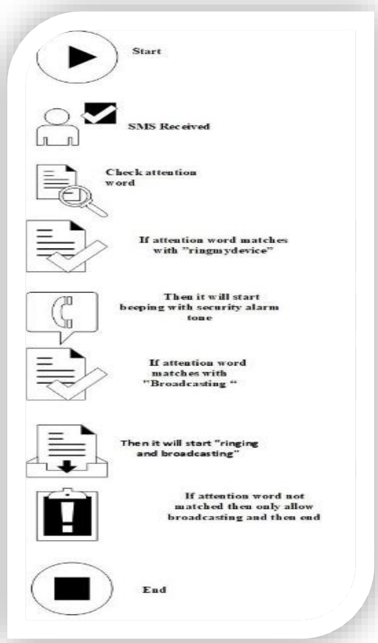


Figure 6. Description of proposed algorithm

VII. TESTING OF APPLICATION

With the various tests that have been made to the developed software to detect the failures it may have. Along this chapter there will be carried out two types of tests: unit tests and integration tests.

A. *Unit testing*

Table 3. Unit Testing

S/N	Scenario	Expected Results	Actual Results	Status
1	Install DroidLoactor.apk file on Android phone	Installation Successful	Installation Successful	Success
3	Send SMS From Application	SMS Sent	SMS Sent	Success
4	Receive SMS Inside Application	SMS Received	SMS Received	Success
5	Read Contents Of SMS	Contents Read	Contents Read	Success
6	Make Device Ring	Device Ringing	Device Ringing	Success
7	Retrieve Latitude And Longitude	Latitude And Longitude	Latitude And Longitude	Success

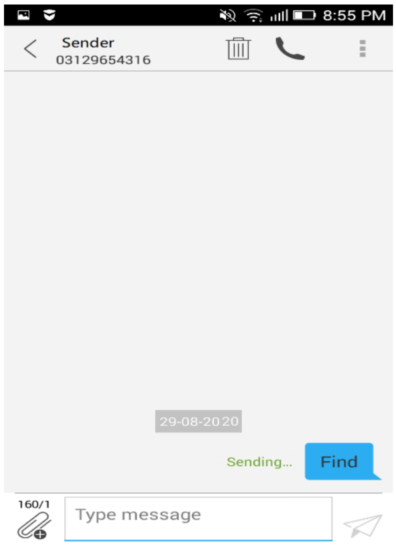
B. *Integration testing*

Ascertain that all of these features are available and correctly integrated into our application.

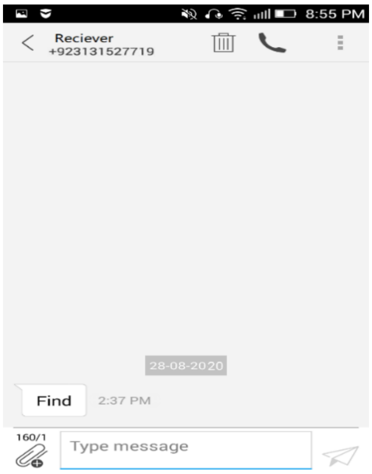
- Application starts receiving SMS
- SMS content reads and fits the word attentiveness
- If it's a ringer word, then the telephone ring is quiet or vibrating
- Recognizes the state of the telephone requested through SMS
- If the GPS attention word matches the current location, information will be retrieved and sent discreetly back to the phone
- Stop application

VIII. RESULTS OF PROPOSED APPLICATION

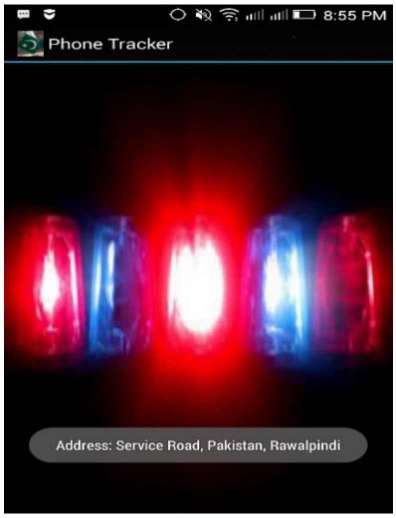
Each telephone has a unique international identification number for mobile devices, which may be used in case of loss or theft. This number may be obtained by calling * # 06 #, and it is essential to write it down immediately after your phone is purchased. When the telephone is stolen, submit a police first-information report and include the identifying number of the telephone. Give your service provider a copy of the First Information Report and the International Motive Equipment Identity Number, which may then trace your mobile phone. The ID number for international mobile equipment can be used for tracking a device even if it is used with another SIM or is even switched off. Once the device is discovered, ask your service provider to prevent its use until it is re-attainable. The results are being demonstrated in Figure Figures 7 (a), (b), (c), (d) and (e) below.



(a)

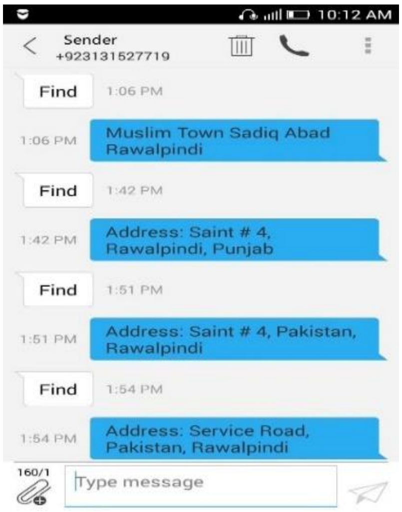


(b)



(c)

(d)



(e)

Figure 7. Demonstration of our application results **(a)** Send "find" message **(b)** Mobile number received message **(c)** Start beeping and retrieve location **(d)** Track current Location **(e)** Send location back to the sender or send to the original user of mobile phone.

CONCLUSION

Android Based Application to Trace Misplaced Cell Phone is a one-of-a-kind and very effective application that is used to trace lost/misplaced android phones. All of the functionalities operate via SMS. As a result, the SMS format of the receiving message is critical. Our Android application, which runs on mobile phones, keeps track of all incoming texts. If the SMS is intended for the application, it is read and performed as expected. We've developed features that complement the existing mobile tracking system. The application is distinct from previous systems in that it not only utilizes GPS data but also utilizes GSM/text messaging services, which makes it a simple and distinctive application. Some of the following functions may be enhanced in the future, including: Receive notification when a SIM card is changed to SMS/Call Filtering. Droid Locator enables you to remotely control your An-droid using a web-based interface.

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A Techno-Economic Analysis of Alternative Fuels in Cement Industry in Pakistan

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***Abstract*—**Alternative fuel use in cement industry has seen a rise in the recent years in lieu of the growing concerns about the growing share of the industry in global green house emissions which stand at 8% of overall carbon dioxide emissions worldwide. Prominent amongst the reasons for this high emission is the use of conventional coal in providing heat requisite for processing in the cement industry. The use of alternative fuel, however, has started a positive downward trend in the emissions of the industry. The use of alternative fuel, most prevalent among which is Refuse Derived Fuel (RDF), has a twofold advantage: economic fuel for cement production, and a venue for disposing off the solid waste in the landfills around big cities. This experiment of alternative fuels use in cement industry is largely without any impact assessment on the economy and ecology of the cement manufacturing. Obviously the technical assessment has been performed by the industries themselves in terms of energy contents, the larger impact of these fuels on economy and environment is still unknown or not published. This research undertook the technical analysis of these alternative fuels used in three cement industries in Pakistan comprised of characteristics like calorific value, Sulphur and chlorine contents, carbon emissions accruing from the use of the these fuels. In addition the economics associated with the use of these fuels were also investigated through comparison with economy of the conventional fuels.

***Keywords*—** Techno-Economic, RFD, Fuel, Cement, Industry.

I. INTRODUCTION

Fossil fuel supply is depleting fast and is slated to run out in the third quarter of the current century [1]. The current rate of fossil fuel exploitation has raised alarms for the sustainability of the energy resources of the world. There in an acute instability in the prices which is fast forcing the world to look for alternative means of energy. Global warming has been treated with accentuated seriousness for the past thirty years starting with Kyoto protocol, where the consensus on the negative repercussions of the increased dependency on fossil fuels was realized and a plan to barricade against it was formulated. In the ensuing years, the need to keep up with global economic growth has forced individual countries to leave out the promises of environmental upkeep and focus more on their individual economic growth. This had resulted in the increased utilization of fossil fuels post Kyoto protocol as shown in the Figure 1.

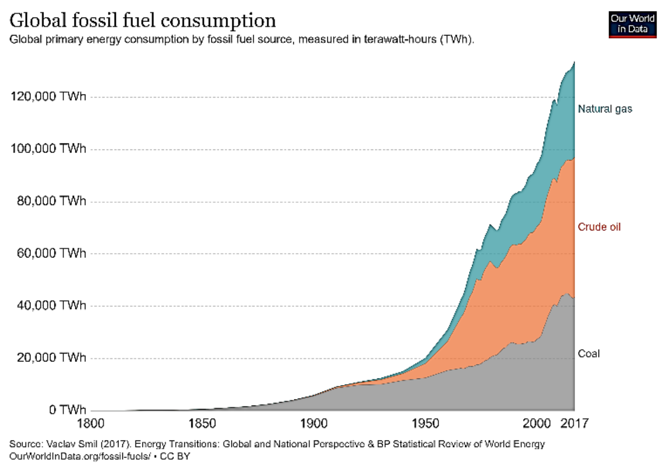

Figure 1. Fossil Fuel Consumption[2]

Refuse Derived Fuel is used in various cement industries in Pakistan. The fuels are made from the landfills and waste dumps in the vicinity of these industries. The RDF fuels, however, have not yet been analyzed through an independent research to form an all-encompassing view of the contents, economic impact, and emissions.

In addition to the differences in the chemical composition of the RDF fuels caused by the variation of landfill composition, the emissions resulting from the burning of these fuels also vary from site to site and day to day [3]. This research will also investigate the emissions level and composition of the emission in the product of combustion of the RDF fuels in various cement industries in Pakistan. The determination of the emissions, their impact on environment, and the comparison with the conventional fuels across the whole life cycle of these RDF fuel will establish convincing evidence for their large-scale acceptability in other industries across the country.

II. Literature Review

A. Cement Manufacturing Process

Cement manufacturing process is highly energy intensive consuming energy in the form of electrical and thermal energy at different stages of the process. Additionally, energy is also required for the transport of the raw material, mining of the raw materials, and the end product..

B. RDF Production Process

The steps involved in the RDF production are given one by one in the following and schematically illustrated in Figure 2

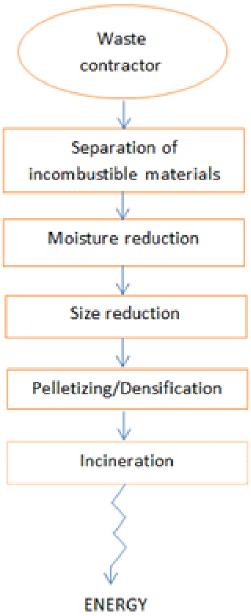

Figure 2. RDF pellet production process

C. Municipal Solid Waste for Energy Applications

MSW has been commonly used for electricity generation all over the world and has resulted in significant GHG mitigation [4]. In developed world particularly this technology has seen the greatest growth to the point where Sweden, for the first time, had to import MSW from neighboring countries in 2018 for electricity generation [5].

Current state of the MSW based electricity generation generally involves the conventional techniques such as direct incineration, pyrolysis, and biogas gasification [6]. Even in these conventional techniques there is a net positive impact on the environment for providing an avenue for disposal of non-disposable waste such as plastic waste [7].

Incineration, in the initial years, was solely used for reducing the solid waste volume, however in the recent years has found more and more use in electricity generation in co-processing with other conventional fuels [8]. The average energy contents in the various components of MSW is given in the Figure 3 below which would paint a clear picture for drawing the calorific value of MSW given the component percentage [9].

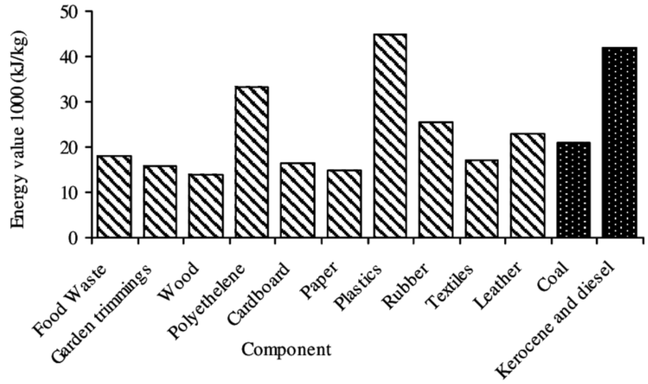

Figure 3. Energy Content of various components present in MSW

D. RDF in Pakistan

In Pakistan, as in most of the developing world the landfills are a big source of methane production, where extended stay leads to ever greater methane generation. Uncontrolled landfills contribute one third of global methane production, which can be significantly reduced by handling the MSW in a more productive way like converting them to RDF [10]. In Pakistan per capita waste generated ranks 135th amongst the world contributing 0.8% of global methane production [11]. The municipal waste in Pakistan consist of the common components in the proportions indicated in the Figure 4 below [12].

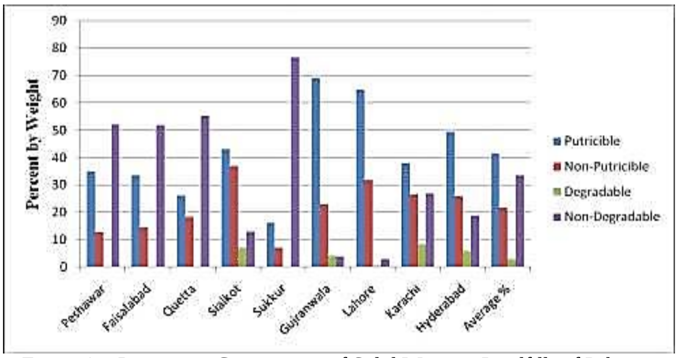

Figure 4. Percentage Composition of Solid Waste in Landfills of Pakistan

III. Methodology

A. Sample Collection

The Refuse Derived Fuel (RDF) samples from the three cement manufacturers were acquired along with a sample of the coal used in the respective facilities for cement manufacturing. The samples were coded as RDF 1, RDF 2 and RDF 3 for masking the names of the industry from where the sample were taken.

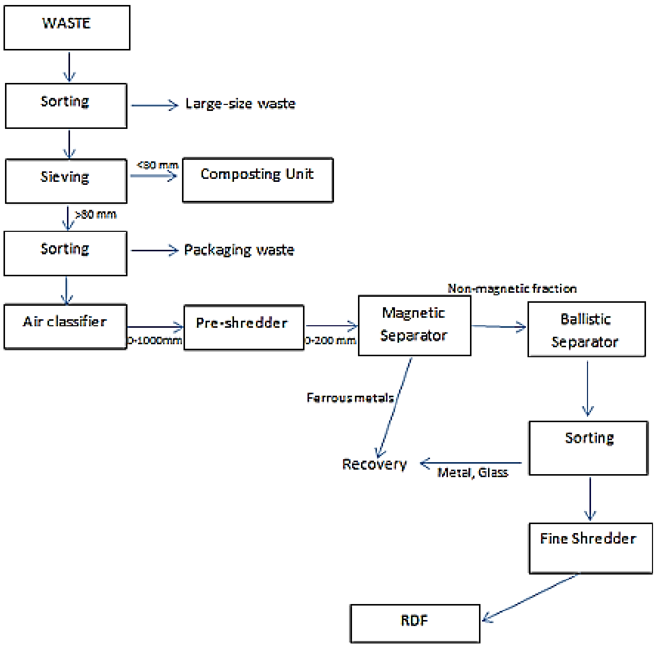

Figure 5. RDF Manufacture Process

B. Proximate and elemental analysis

The proximate and elemental analysis of the all the samples was conducted. The standard ASTM D5142 was followed for conducting this analysis. The standard is specially purposed for determination of coal, and coke quality parameters such as moisture content, ash, and volatile matter content. This standard will also be used for determination of these parameters for the RDF samples [13].For carrying out proximate analysis, the fuel was assumed to contain two kinds of portions: volatile matter and fixed carbon content. Accordingly, the moisture content of the samples were found out by placing the sample (1g each) at 105ºC for approximately 2 hrs. The weight loss accruing thus is a good indicator of the moisture content of the samples. For volatile matter and ash content the weight loss resulting from oxidation at temperatures of 550ºC and 750ºC respectively for 2 hrs. was measured. The fixed carbon contents are the difference of the volatile and ash content from the whole dry sample.

C. Calorific value determination

Calorific value of the RDF and coal samples from all the industries was conducted. For this purpose, bomb calorimeter was used [14]. A bomb calorimeter, as shown in the Figure 6, consists of a constant volume container, hence the process is isochoric. The heat contents of the sample are determined using the change in internal energy, obtained from temperature change inside the container and the heat capacity of the calorimeter. For finding calorific value of a sample a known weight was placed inside the steel ball and combusted. Subsequently pressurized oxygen is provided and the steel ball is kept in adiabatic water bath, connected to electric current. The spark from electrical energy combusts the sample, heating the water, and the change in the temperature is measured by electronic thermocouple. The change in mass vs the change in temperature gives an idea of the calorific value per kg of the sample.

Figure 6. Bomb Calorimeter for CV determination

D. Carbon dioxide emission analysis

The emissions, mainly Carbon Dioxide, determination in the samples will be carried out. For this purpose, The International Standards Organization's ISO 16948 standard was used. The standard presents the instrumental arrangement, calibrations, and precautions for determination of the carbon, hydrogen, and nitrogen contents of solid fuels [4].The equipment used for this purpose is called flue gas analyzer.

E. Flue Gas Analyzer

This analyzer consists of two separate units called conditioning and photon unit. Moisture in the flue gas is blocked in the conditioning unit, thus filtering out the solid particles in the flue gas. Consequently, what is reported is usually the emissions on dry basis. The conditioned flue gas is analyzed in photon unit. The flue gas analyzer gives out the percentage of CO_2, CO, NO, NO_2 and SO_2. Figure 7 shows a flue gas analyzer in the Laboratory of Department of Inorganic Chemistry at University of Peshawar.

Figure 7. Flue gas analyzer at UOP Laboratory

F. Comparison of Economy

For comparing the cost components of various RDF samples, the data from the sources to manufacture 1 Kg of RDF and the corresponding heating values in MJ was deduced from the CV and compared with the conventional fuel i.e. coal. The fuel cost per ton of cement manufacture for each of the alternative fuel samples and coal will be determined to give a Birdseye view of the economics of the RDF fuels in cement industry. The comparison of economy will also incorporate the long-term economic benefits and impact in terms of energy price, environmental impact, and the savings accruing thereof. The following formula was utilized to compute the net savings, both to environment and in direct benefits from Petcoke replacement.

Net Savings = ((Traditional Fuel Cost Savings + CO2 Emissions Cost Saving − RDF Production Cost) × (100 − Energy Loss))/100

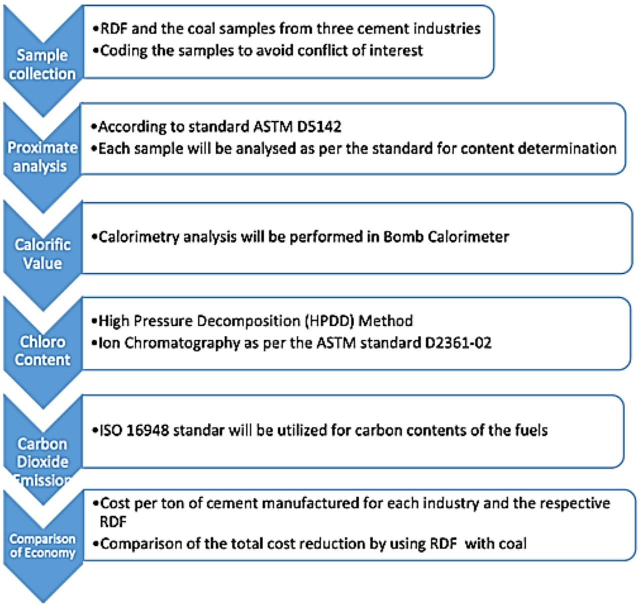

Figure 8. Overview of Methodology

IV. Results and Discussions

A. Proximate analysis of RDF

The combustion properties of any fuel largely depend on the moisture content, ash and volatile matter in the solid fuel. Unless these properties are known it is not possible to get an idea of the nature of combustion the fuel undergoes [15].

The proximate analysis of a solid fuel sample usually yields four results namely: moisture content of the sample, volatile matter contained in the sample, fixed carbon i.e. nonvolatile content of sample, and inorganic byproduct in combustion process.In the current research the proximate analysis of the three available samples of RDF obtained from three different cement manufacturing plants in Pakistan was carried out. The results are given in the Table-1 in the form of the abovementioned four parameters.

TABLE I. PROXIMATE ANALYSIS

Samples used	Percentage moisture (%)	Percent Volatile Matter (%)	Fixed carbon content (%)	Ash content (%)
Sample-A	1.6	80.3	5.2	12.9
Sample-B	4.8	68.5	11.8	14.9
Sample C	5.2	74	10.6	10.2
Coal*	4.3	29.3	51.2	15.2
Petroleum coke**	6	12.1	81.2	0.7

The main portion of RDF is usually volatile matter which is also the case n the curent research. It should be noted that the volatile fraction is greater in case of the sample A in comparison with the rest. Also noticeable is the fact that the volatile matter in Coal and petcoke is usually smaller at the expense of higher carbon content. The moisture content of sample A is significantly lower than the other samples and coal and petcoke. This is due to long drying periods in the facility where the samples were produced. Large drying time leads to lower moisture content which inevitably manifests in desirable calorific values. Another factor which is significant in the Table-1 is the low carbon contents of sample A in comparison to the other samples and conventional fuels. This will give the RDF greater desirability in environmental protection. To categorically establish the credibiity of the results obtained here, a comparison was made with literature survey data [16]

B. Ultimate analysis of the samples and Calorific Value

The chemical composition of the fuel samples is significant to determining the combustion behavior of fuels. The exact carbon, oxygen, and hydrogen contents are important to the current study as they form the crux of the waste. In addition, nitrogen contents are also important aspect of fuels as they give an idea of the NOx gases released as a result of the burning of the fuels. Furthermore, Sulphur contents, due to their impact on the kiln and chimney and the formation of SO2 and SO3 is also important parameter in the viability of a fuel. For these reasons the ultimate analysis of the RDF samples was carried out. The results of the ultimate analysis are given in the Table II. The composition is compared with coal and petcoke chemical composition to give a clear idea of the viability of RDF as an alternative to conventional fuels.

TABLE II. ULTIMATE ANALYSIS

Sample s	Carbo n (%)	Hydro gen (%)	Nitrog en (%)	Sulfur (%)	Oxygen (%)	Calorific Value (cal/g)
Sample –A	43.24	5.55	0.95	-	35.37	5262.63
Sample –B	56.76	8.67	1.65	0.47	17.45	4596.56
Sample -C	50.56	6.9	1.43	0.33	23.44	4958.34
Coal	63.76	3.65	1.75	0.55	12.94	6127.32
Petcoke	68.35	3.53	1.96	4.73	20.51	8217.53

The ultimate analysis of the samples under study suggest N, H composition under 9% albeit higher than the coal and petcoke samples suggesting presence of greater quantity of organic matter in the MSW. The samples are predominantly made up of carbon and oxygen. The higher CV of sample A than the others may be due to organic content in the samples. The coal under study is high cost and high CV so it may not come as a surprise that the CV of coal exceeds that of the RDF samples.

The CV values of the RDF samples are still closer to that of coal as compared with the other alternative fuels used in literature as shown in the Figure 9.

In terms of CV we can see that petcoke performs better than coal and RDF samples. This is largely due to the higher carbon contents, hence higher combustible material of the petcoke samples as indicated in the ultimate analysis. The petcoke sample has a higher C/H ratio when contrasted with that of the coal sample while lower C/O ratio than coal. The same ratios are in completely different range for the RDF samples providing a key distinction amongst the samples.

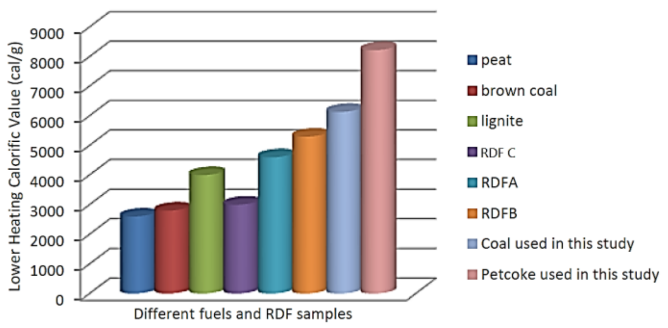

Figure 9. Comparison of RDF samples and coal and petcoke samples Calorific value with other fuels

C. Carbon Dioxide Emissions Determination

For the purpose of carbon dioxide emission determination flue gas analyzer was used on the RDF to give an idea of the percentage CO_2 emissions from the samples. The results are shown in form of the graph shown in the Figure 10 below.

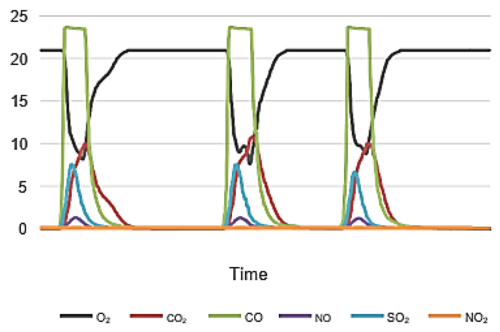

Figure 10. Flue gas analyzer results of RDF sample A

D. Economic comparison of RDF use with Coal

For assessment of the economic impact of using RDF instead of petcoke in the cement industry kiln an economic analysis was carried out. The analysis was based on the following assumptions:

- 4000 tons /day kiln production limit for 24 hours operation
- 24 hrs. operation implies 7200 hrs./year operation
- 381 tons/day petcoke consumption or 15.8 kg/hr.
- 715 kcal/kg.cl energy consumed in total
- Clinker production energy required 45.6 kWh/t
- Petcoke calorific value 8000 kcal/kg
- RDF calorific value 3500 -4000 kcal/kg (current research)
- Petcoke CO2 emissions: 70% of mass
- Cost of 1 kg emissions: 15 USD
- 1-ton RDF production cost 24 USD

Literature suggest the most optimum levels of RDF in cement production to be 15% in co-processing with petcoke or coal. Therefore, the current economic analysis takes this percentage in consideration for mathematical computation. Petcoke provides approximately 286x 107 kcal/kg.cl energy for producing 4000 tons of cement. Substituting 15% of this petcoke with RDF would suggest that 429 × 106 kcal/kg.cl of energy will be provide by RDF. Calculating the dollar cost of this mixture for energy generation results in total financial savings of 2,640,522 USD/year.This saving does not yet contain the savings accruing from CO2 mitigation. This saving is for scenario with adding 15% RDF with petcoke in co-processing for a plant with capacity of 4000 tons/day production.

CONCUSLION

The research endeavored to analyze the potential of Refuse Derived Fuel vis-à-vis the conventional fuels as an alternative. To this end RDF samples used in three Cement industries in Pakistan were collected and passed through a series of tests in laboratory and then economic comparison to figure out the most optimum performing RDF which could give us an insight in to the best practices regarding their production and use. The Calorific values of the three RDF samples, and a coal and petcoke samples from one of the industries were also carried out. The CV values of RDF samples, albeit lower than the coal and petcoke samples, showed a considerable disparity amongst themselves. This was also in agreement with literature data where the CV value ranged through a big margin. Upon deeper analysis through proximate and ultimate analysis it was found that the CV performance of the RDF samples was dependent on the dryness, C/H, and C/O ratios, however their exact correlation could not be determined. It was discovered that all the RDF samples possessed lower carbon and nitrogen and Sulphur contents as compared with the coal and coke samples. This is particularly desirable for alleviating the overarching impact of cement industry on environment and could mitigate the emissions.

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Effect of Local Seasonal Temperature Variation on Energy Efficiency of Water Evaporation using Peltier Module

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***Abstract*—** A residential surface water tank is normally exposed to ambient conditions. Evaporation of water from such a source, using a Peltier device is expected to results in variation of energy efficiency for a system due to variation of ambient temperature. In this research work local conditions of city of Peshawar in Khyber Pakhtunkhwa province of Pakistan are considered. A MATLAB Simulation was performed to find out the seasonal energy efficiency variation for Peltier based evaporation. The results show that there is significant variation of energy of evaporation process due to seasonal variation ambient conditions.

***Keywords*—** Ambient conditions, Peltier module, Simulation, MATLAB Simulink.

I. Introduction

Water is the most important component of human's life. It is used for different purposes ranging from drinking to agriculture and industrial use. Ground water is the water present beneath the earth. [1]. The problem with ground water it that it contains some unwanted impurities. The type and concentration of impurities found in ground water depends on geological material through which water flows. Some of the common impurities are magnesium, calcium, chloride, arsenate nitrate and iron [2]. Other industries and agriculture impurities are also found in water such as mercury, copper chromium lead etc.[3]. According to world health organization (WHO) standard, water containing impurities less than 1000mg/L is fit for drinking [4]. Due to global warming and excessive use , the scarcity of Water is increasing day by day, by the year 2025, 1800 million of people will not have access to clean water, and almost two-third of population could be under severe stress condition[4], [5]. The reasons behind the scarcity of water is overpopulation, industrial waste product and pollution [6]. Sometimes water is available but it is not fit for use, such water is called brackish water. Brackish water is water contains impurities [7]. Hazardous impurities are removed by different processes called desalination of water to make it fit for use. For this purpose, many different methods, one of the cheapest method is evaporation of water. In evaporation of water the brackish ground water is exposed to heat allowing molecules to form vapors and impurities are remained at the bottom of container. By evaporation of water, unwanted impurities are removed from brackish ground water.

II. Literature Review

Water scarcity threat is increasing in south Asia and especially in Pakistan. Pakistan is facing many serious challenges in near future, out of which one is water scarcity. It is estimated that Pakistan will run out of water till 2025[8]. To overcome this challenge, many solutions are reported, out of which one is Thermal distillation which involves evaporation of water[9], [10]. Distilled water is the purest form of water and distilled water has some good effects on human's health[11]. The evaporation of water is a function of pressure inside the chamber. Decreasing the pressure inside the chamber creates vacuum. Due to vacuum water evaporates at low temperature and hence low energy input is required[12]. Vacuum desalination is a viable method for distillation of brackish / sea water. The cost of decreasing pressure is lower than the cost of heating water at normal temperature [13]. The natural vacuum desalination system works at low pressure which is achieved by gravity. Evaporation at low energy input is required which means low temperature input is utilized. Waste heat or renewable energy is utilized [14]. The performance of natural vacuum desalination system is affected by evaporator temperature and ambient temperature. Impurity in brackish water also plays a vital role in evaporation [15]. The local Ambient plays an important role in evaporation and condensation. Local ambient temperature is a function of declination angle, day length, Latitude and day of year counted from January 1st, ambient temperature is not same throughout day and night, and it is changing[16]. Evaporation of water requires input heat (heating) and condensation of evaporated vapors require cooling. For this purpose a thermoelectric device called Peltier device is one of the best suited solution. Peltier module is a device when potential difference applies, it creates temperature difference. The Peltier module has two junction, when potential difference is applied, one junction becomes hot while the other becomes cold. The hot side evolves heat while the cold side absorbs heat. The hot side is used to heat water evaporator and cold side is used to extract heat from hot vapors in condensation chamber. It works as heat pump [17]–[19]. Peltier module works better at low hot side temperature and low temperature difference between hot and cold side [20]. Productivity of Peltier module is important. Madhhachi [21] reported that the productivity of Peltier module is 91%, out of total input electric power, 52% of electric energy is used for electric energy is used for evaporation and 39% of electric energy is used for condensation.

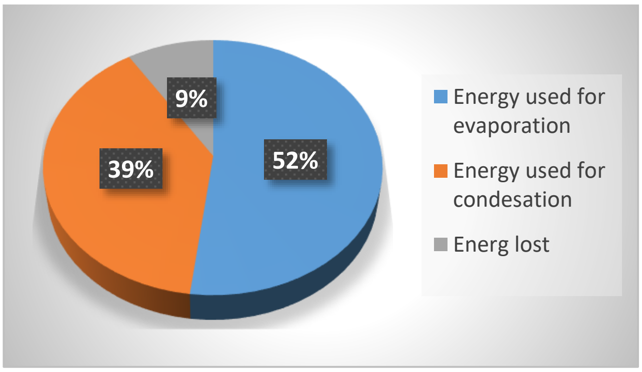

Figure 1. Productivity of Peltier module reported by Madhhachi [21].

III. Methodology

Peltier based evaporation is modeled and simulated in MATLAB Simulink taking into account the local ambient temperature. MATLAB Simulink is a simulation software consists of block which is used to solve dynamic equation. It is used to study the performance of different system using graphs. It is easy to use and user friendly. MATLAB Simulink has wide spread libraries. As Peltier module works like heat Pump. It creates temperature difference when voltage is applied across the Peltier module. One junction evolves heat and becomes hot while the other junction becomes cold and the other becomes cold. The hot junction of module evaporates water. The schematic diagram of working of Peltier module is given below in figure 2.

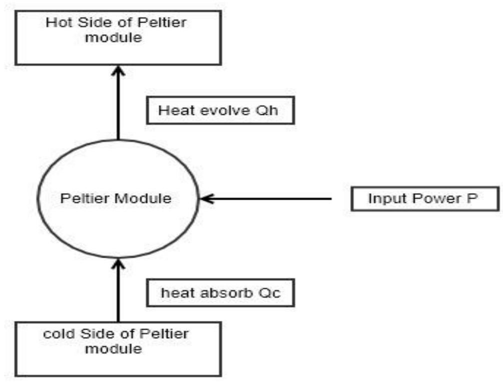

Figure 2 Schematic diagram of Peltier module.

The heat released by hot side and cold side of the Peltier module is given by equation [22].

$$Q_h = ST_hI + 0.5RI^2 - K\Delta T \quad (1)$$

$$Q_c = ST_cI - 0.5RI^2 - K\Delta T \quad (2)$$

$$COP_H = \frac{Q_h}{P_{in}} \quad (3)$$

Where S is seebeck coefficient, I is current through module, R is resistance of Peltier module, K is thermal conductivity of module, T_h is temperature of hot and T_c is temperature of cold side , and ΔT is temperature difference between hot and cold side.. The above equations are used to simulate the system in MATLAB Simulink. The hot side the Peltier module is used to heats up water in the evaporation chamber and the cold side of the Peltier module is used cools down hot vapors. Peltier module in the current system transfers heat from the cold side of the Peltier module to the hot side of the Peltier module. The modeled is developed in MATLAB Simulink and run few time. Blocks are created and each block represents each component of model.

TABLE I. Values of different parameters of Peltier module

Seebeck coefficient (S)	0.0196 V/K
Thermal Conductance (K)	0.96 W/K
Resistance (R)	0.152 Ω

The local ambient temperature also plays important role in evaporation of water. As when water evaporates, the temperature of water is greater than ambient temperature therefore some useful heat is loss to surrounding due to temperature difference between water and ambient. As reported in the literature that ambient temperature is changing hour by hour. Ambient temperature depends on declination angle, latitude of place, day length and day of year counted from January 1st. A plot of temperature variation of May 27 in Peshawar is given in figure 3 [23].

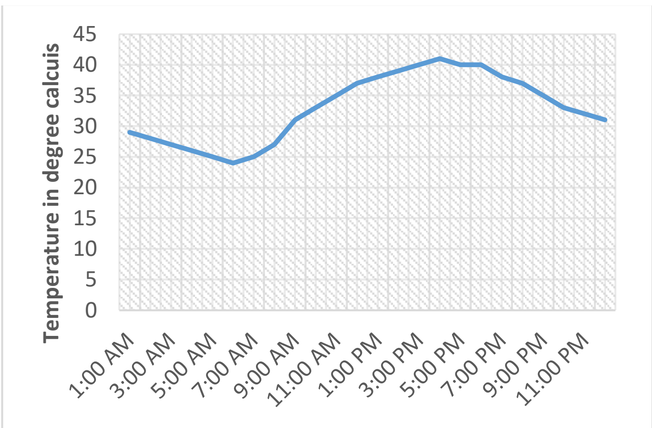

Figure 3. Temperature variation in Peshawar on May 27.

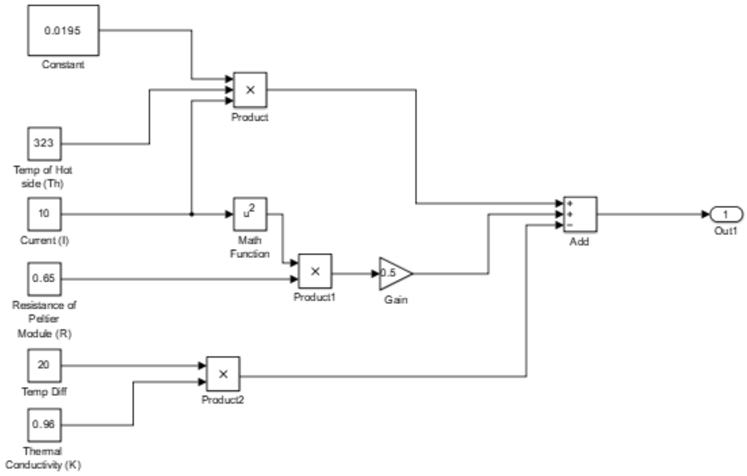

Figure 4. The MATLAB Simulink model of Peltier module.

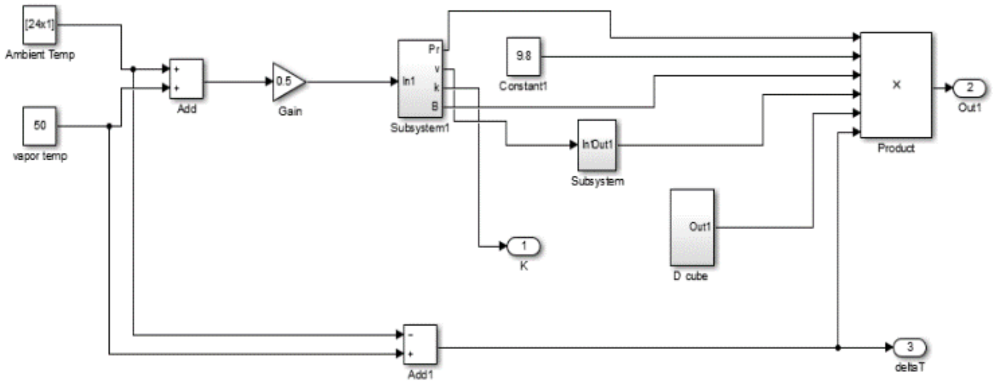

Figure 5. MATLAB Simulink model for Heat loss due to local ambient temperature.

IV. Results and Discussion

The simulation developed in MATLAB Simulink is receiving input electrical energy. The Peltier module creates temperature difference when electrical energy is applied. One junction of Peltier module becomes hot and the other side becomes cold.

In figure 6, Heat loss due to local ambient temperature from evaporated vapors is plotted for one day (27 May). The ambient temperature of Peshawar is selected as local ambient temperature. As in figure 3, local temperature of Peshawar is plotted for one day. As from 1 AM till sunrise the temperature decreases, the temperature difference between hot vapors and ambient temperature increases and due to which heat loss increases. From sunrise till 4 PM the ambient temperature increases, temperature difference between hot vapors and ambient decreases and therefore heat loss decreases. After sunset the ambient temperature decreases, temperature difference increases and convective heat loss from hot vapors to ambient increases.

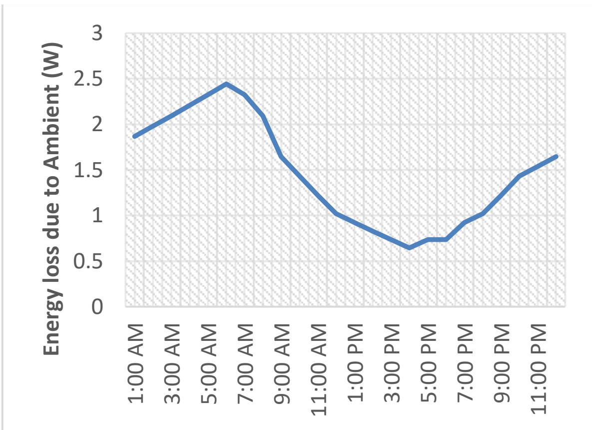

Figure 6. Simulation result of energy loss due to local ambient temperature

In figure 7, the COP of Peltier module is plotted for one day. As the ambient temperature increases, the COP of module increases. There are two reasons for increase in COP. The first reason is that as the ambient temperature increases, the heat loss due to ambient decreases and hence the COP of module increases. The second reason is that as the ambient temperature increases, the temperature of water also increases. As a result less heat is required to raise the temperature of water so the efficiency of Peltier module increases

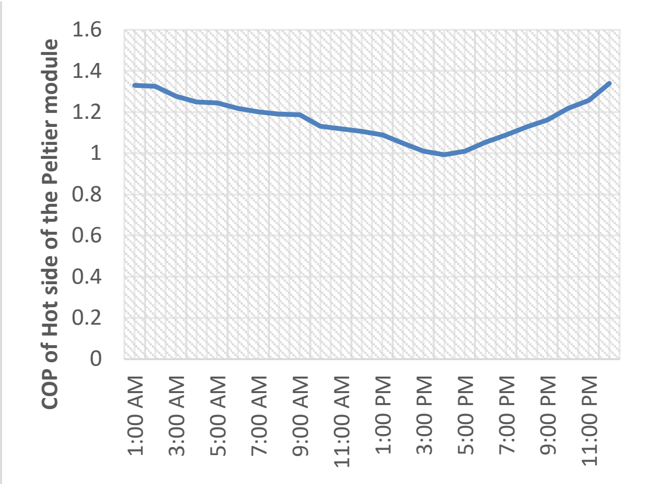

Figure 7. Co-efficient of Performance of Peltier module taking into account the ambient conditions.

In figure 8, COP of Peltier module is simulated for monthly average ambient temperature. It is found that as the average monthly temperature increases, the heat loss from the evaporator decrease and hence the COP of Peltier module is increased.

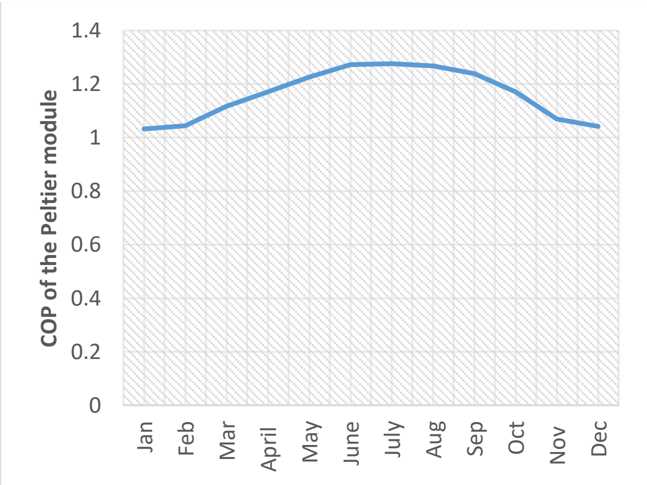

Figure 8. COP of Peltier module for monthly Average ambient temperature

CONFLICT OF INTEREST

The author has no conflict of interest.

CONCLUSION

Based on the above results the following conclusions are made.

1) Ambient also play an important role in evaporation. Some heat from chamber where water evaporates, is loss due to temperature difference between local ambient temperature and hot vapors. Heat loss is maximum when temperature difference is maximum and heat loss is minimum when temperature difference is minimum. At 6 AM the heat loss has a maximum value of 2.4 watt and at 4 PM heat loss has minimum value of 0.6 watt.
2) The daily COP of Peltier module is a function of temperature difference between vapors temperature and ambient temperature. As the ambient temperature increases the COP of Peltier module increases and vice versa. In figure 7, the relative percentage difference between maximum and minimum COP is 20%.
3) The relative percentage difference between maximum and minimum COP for year (Figure 8) is 22 %. Which is reasonable that seasonal ambient conditions affects the efficiency of Peltier based evaporation

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Compliance to the Environmental Law & Its Implications for the Oil & Gas Exploration & Production in Pakistan

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***Abstract*—** The current Climate change issues in Pakistan & Globally is not merely a coincidence rather this has developed and got worse with the passage of time through industrial revolution, more demand of energy and the race to further development among each country. To meet the energy demands, fossil fuels, one of the primary resources of energy are being explored with unprecedented rate worldwide. May it be Land or Sea, desserts or forests, if there is a potential suspected, the Oil exploration firms start their activities. On one side, if this helps to meet the growing energy demands, on the other, more and more effects of such activities are changing the environment. To avoid severe and immediate damages, environmental protection rules and laws are being passed Globally the purpose of which is to make sure such activities are carefully planned and all checks are in place prior to starting the operations to avoid any harmful impact on the eco-system. Various countries have customized these laws as per their environmental visions and established organizations which make sure these laws are implemented and followed. Pakistan, a developing nation, is one of the countries who are in the game of Oil exploration also has set forth such Acts & Laws but the assurance that the Companies are operating under the established Environmental law of the Country has never been completely done. International firms and National entities have their own set of checks in place which try to follow the Federal and Provisional rules. The goals and authority of Provisional environmental protection agencies are defined at policy level but the implementation and monitoring steps have various loop holes which need to be filled. The differences in the working methodology, related to environment, between Government owned firm vs International operators also shows the mindset of the local environmental agencies. The environmental policies need to be updated at Federal and Provisional levels with more implementation and monitoring structure in place.

***Keywords*—** Pakistan, Exploration and Production, Oil and Gas, Environment, Hazards, Mitigation

I. Introduction

Pakistan is under an acute energy shortfall since 2006 [3]. This predicament is assuming alarming proportions in its severity with each passing day. This shortfall in supply has given a negative impact, on society as well as economic development. This is also reflected in an estimated 4-7% loss to the country's GDP [5]. Pakistan's demand of energy has spiked at yearly consumption increment rate of 4.8 percent in the past few years. In the next few years, expectation are that it will grow at a rate of 8 to 10 percent yearly [6]. This is resulting in an urgent requirement to initiate a scenario where the supply of power and development capabilities with major infrastructure develops at the rate of 7 to 8 percent per annum so that steady growth can be supported in the Country's' GDP [6]. Despite having a major stock of such indigenous natural resources, inability to adhere the utilization of the existing energy mix and formulate an integrated energy policy has been one of the primary shortcomings in the lack of growth in this sector.

Following were the key aims of the study:

- To review legal guidelines governing the issues related to community welfare and environmental protection during exploration activities in Pakistan
- To identify key flaws in legal framework as well as the mechanisms of implementation and monitoring of those laws and rules
- To examine the implementation process and issues related to it on the legal framework specially in the oil and gas producing areas

Scientists and governments have now started to strongly believe on climate change issues and are acting rapidly to avoid the damaging impacts of these. Organizations have initiated to change their processes to make themselves ready for a carbon controlled scenario. Below data shows a few main potential environmental hazards of the fossil fuel industry;

- Ground water issues due to release of water effluents consisting of inorganic compounds such as salts which discharge without treatment
- Thermal contamination due to release of effluents with high temperatures as compare to recipient water reservoirs
- Water pollution caused by oil spill

- Particulate discharge in air due to activities at various industrial plants

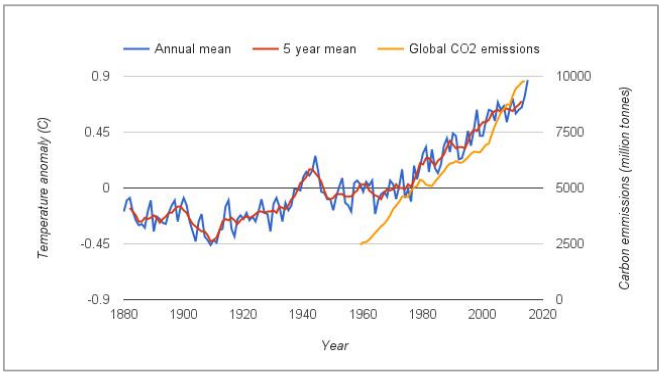

Figure 1. NASA Worldwide Land Ocean Temperature Chart

II. LITERATURE REVIEW

A. National Environment Policy - 2005

This policy provides a framework for addressing the environmental troubles Pakistan is facing, mainly pollution of the clean water bodies and coastal waters, air pollutants, lack of waste disposal, cutting down forests, extinction of biodiversity, natural devastations, and climate variations. It additionally offers directions for addressing various sectorial troubles in addition to the reasons of environmental affects and meeting global duties.

The national environmental policy, while aiming at the goals of the Pakistan conservation objective, National environmental plan and different current environmental associated national guidelines, techniques and action plans, highlights vast guidelines to the federal and provincial governments as well as local government for addressing the environmental issues and making sure controlled management in their environmental assets. [9]

B. Pakistan Conservation Strategy

The National Conservation Strategy (NCS) is the major policy record of the Pakistan Government on national environmental problems. The policy was accredited by the Cabinet in Q1 of 1992 [10]. The Strategy additionally gained popularity by international agencies providing aids, specifically the World Bank. This policy identifies 14 major sectors which include protection of biodiversity, pollution control, soil and water resource and preservation of old cultural history and advises priority attention to these core sectors in order to preserve Pakistan environment.

A review of the goals achieved of the policy was done in 2000 which concluded that achievements under this NCS have been majorly due to awareness spreading and institutional building rather than real development to the ecosystem. Similarly, the NCS was not made and is not properly centered for Pakistan sustainable development goal (GoP, November 2000) [8]. The requirement therefore rises for an extra focused National Action Plan on environment, which will bring about actual enhancements in the conditions of Pakistan's environment with deeper focus on reduced poverty issue and development in the economy other than environmental sustainability. [3]

The NEAP was recognized by the Pakistan Environmental Protection Council under the authority of leadership of Pakistan in February 2001. NEAP now consists of Pakistan's environmental plan and its primary objective is to start actions that ensure public health, enhance sustainable living and promote the quality of day to day activities.

Pakistan Government and United Nations Development Program (UNDP) have mutually started a support area, known as the National Environmental Action Plan - Support Program which was approved in October 2001 and the implementation began in 2002 [1].

C. Pakistan Environmental Protection Act 1997

This Act is the fundamental legal document to empower the Country's leadership to establish the rules and guideline for environmental protection.

The Act is generically relevant to air, marine, soil pollution, it also covers the management of hazardous waste. Penalties are kept for those who bypass the provisions under this Act. Au-thority of the Government Environmental Protection Agencies (EPAs) are extensively increased under this law and are been given authority to initiate investigations if the law is breached related to environmental issues. This can be started either on their own or upon receiving a complaint. [2]

According to section 12 of the Act, no task concerning to the construction projects or any variation in the physical environment is allowed to start unless the prerequisites are all met [7]. This includes conducting IEE or EIA and submitting a report to the relevant authorities.

D. National Environmental Quality Standards

The NEQS were formulated in 1993 and revised in 2000 for the last time [4]. They include the fundamental guidelines for liquid and gaseous substances emissions coming from municipal and/or industrial discharge. These requirements advise the maximum concentration for allowable liquid effluent before it's released into ocean, land water supplies & sewage systems, similarly gaseous emissions in air from commercial or industrial activities.

During the development and operation phase of the exploration & production activities, these standards will apply to all such emissions.

Table: 1 National emission requirements (NEQS)

Date	Number	Scope
1993	742(I)/1993	Liquid, gaseous emission, vehicle noise
1995	1023(I)/1995	Gaseous discharge - power plants
2010	1062(I)/2010	Air
2010	1063(I)/2010	Quality of water for drinking
2010	1062(I)/2010	Noise pollution

E. World Bank Envirnmental Guidelines

Publications of the World Bank that contain environment related guidelines are;

- Environmental evaluation focused on operational Policy 1999
- Environmental evaluation sourcebook, volume I, 1991
- Environmental evaluation sourcebook, Volume III, 1991
- Pollution control handbook, UN environment protection initiative, 1998

Initial two publications give the generic recommendations for the planning of an EIA and reviews the EIA participants along with project designers. Sourcebooks specifically have been formulated by keeping financial institutions projects in view and are greatly relevant to impact assessment evaluations of bigger scale infrastructure developments activities. It presents a huge amount of information which is beneficial to environmental research teams and project firms.

III. Methodology

A. Site Study

The IEE was done and developed in line to the guidelines of Pakistan Environmental Protection Act, Pakistan Environmental Protection Agency (Review of EIA/IEE) Regulations-2000, and the Environmental Assessment Procedures of Pakistan.

Various steps undertaken in the IEE preparation includes getting an idea of the planned activity, review of legal documents, policy and standards, IEE area of interest and techniques involving gathering of data pertaining to physical, socio-economic as well asl biological environment along with cultural aspects, hazard identification, mitigation controls with checks and audit process, management plan development and documentation.

The team conducting the IEE visited the activity area in 2018. During the visit, base line information on the conditions involving community, eco-system, cultural heritage of the activity area was gathered. Communities and their representatives living in and nearby the activity area were also taken into confidence and their concerns, opinions were also documented during the study.

Environmental impacts investigated for this IEE study are classified AS;

- Effects on physical environment
- Effects on biological environment
- Effects on socio-economic environment

For each impact, a brief evaluation of the issues related to environment is performed. To reduce or eliminate effects highlighted during the study, control measures, which may reduce the exposure or probability of happening of an impact are mentioned.

These mitigation measures are based on either;

- Changes in project planning and design
- Improved monitoring techniques
- Compensation or substitutes or rehabilitation of the habitat

B. Proposed Porject Area

Project owner was allocated Badin area, South of Pakistan for performing oil and gas exploration in the block. The firm planned to initiate seismic activities in Buzdar regions of the block. The vicinity in which the 3D survey is planned was designated as the "project area". As a requirement of the license issued by the Government, Project owner planned to gather data of 3D seismic information in approximately 398 Sq Km area. TGA region covers around 150 Sq Km whereas Buzdar region covers an area of about 248 Sq Km.

C. Proposed Project Overview

Planned survey will include the gathering of 3D seismic information. Seismic information will be gathered using deep hole method, which involves the detonation of dynamite in holes with a depth of 25 m. around ~7 kg of dynamite will be detonated in each hole. Seismic data will be recorded using geophones, which will be laid out along the shot holes.
The project activities require one base camp and at least two fly camps, which will have accommodation and messing facilities. Fly camps will facilitate logistics. For seismic activity strength of the crew is around 500 - 600 persons.
It is envisaged that the seismic survey activity may affect the natural and socio-economic conditions of the surroundings. Primary goal of implementing environmental strategy is to direct, review and manages options so that environmental effects and risks are continually reduced to as low as practicably possible and performance objectives and standards are met for the duration of the activity.

The 3D seismic activity is expected to affect the following:

- Geomorphology
- Soil & water
- Climate
- Natural vegetation
- Socio-economic impacts

D. Justification

The regulations of Pakistan Environmental Protection Agency explain the different lists of activities which require an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) in Schedules I & II.

As per the EIA/IEE Regulations: "An owner of an activity under any point listed in Schedule I is obligated to file an IEE with the Federal authority, moreover provisions covered in section 12 will be applied to this activity".

Similarly, "An owner of an activity under any point listed in Schedule II is obligated to file an EIA with the Federal authority, moreover provisions covered in section 12 will be applied to this activity".

As per Schedule I, Category B (Energy), the activities including oil and gas exploration & production require an IEE, keeping in view;

- Minor sensitivity of micro-environment
- Impact of activities such as construction and operations, confined to environment
- Meeting the cited rules

If any such activity is planned out in a sensitive zone then requirement of IEE would be changed to an EIA. The activity would come under Category B, Schedule I which requires an IEE assessment.

Similarly an IEE assessment is done and the documented findings is to be submitted to EPA of Sindh Province for review and approval. Both TGA and Buzdar regions of Badin block were carefully studied on SOP maps and found that project area does not include any protected area and may undergo an IEE study.

IV. Results and Discussions

A. Monitoring the Policy Implementation

Monitoring is also one of the weakest areas in the policy. The government as well as the exploration firms are assigned some major roles and responsibilities once agreement of exploration and production is reached between both. However, there are no proper monitoring mechanisms to make sure that these companies are really fulfilling their roles and responsibilities in the field especially with regard to the local environment and the communities. On the contrary, the government's key concern, according to the policy, is to provide maximum facilitation to the exploration companies to make sure that more and more firms invest in this sector. For that purpose, the section V of the policy titled "Implementation and Removal of Difficulties", suggests formation of "a committee to discuss the concerns of the execution of this guideline, excluding problems, focusing on abnormalities and authorizing framework for development of the institutions to further improve it effectiveness for policy making and regulations for upstream industry".

Committee will have the following;

- Minister, Petroleum and Natural Resources
- DC, Planning Commission
- Secretary, Finance
- Secretary, Petroleum
- DG Petroleum Concessions

The complete above process emphasizes on the facilitation to the exploration companies working in the Country. On the contrary, there are serious complaints about the multinational firms of violating their commitments and agreements with the government, regarding jobs for the local communities, making investments for social welfare and development of the local areas and communities and preventing the local environment from degradation during the phases of exploration and production. There are no proper mechanisms that should ensure monitoring the implementation on the sections of the policy, dealing with the prevention of the local environment, investment in community welfare projects etc

B. Gaps in Policy Framwork

Oil and Gas Policy 2007 can be termed as a positive document as many key aspects of exploration and production have been covered in the document. However, there is census among the local communities, civil society activists and experts that still there are many gaps in the policy. Some of gaps are as under:

- The key emphasis of the policy is on facilitating the exploration and production firms to invest in the fossil fuel sector, however, there are no proper monitoring mechanisms in place to monitor the implementation on respective environmental laws as well as the laws and rules dealing with local community welfare, trainings and jobs to the local communities etc.
- There are schedules for payment of royalty and production bonus and other payments to be made by the exploration firms.
- Policy in its bid to attract more and more investment in the sector tries to safeguard the rights and privileges of multinational oil and gas companies. However, there is little emphasis in the policy on safeguarding the rights of the local communities and the local environment of the oil and gas producing areas
- The policy also places little emphasis on the participatory approach specially the participation of the provincial and district governments , local communities and their resentatives in the process of issuing licenses for exploration and production sector, despite the fact that the locals are the key suffers of impacts from the activities on such exploration firms
- The environmental effects of the oil and gas exploration and production have also not been properly addressed in the policy despite the fact that globally there are serious concerns of the environmental impacts of oil and gas exploration and production. Little emphasis has been placed on the possible environmental risks of the oil and gas ex-ploration as well as the mitigation measures to prevent such risks.
- The policy also deprives the local communities and their representatives of their right to information by emphasizing on the confidentiality of the data. This is also violation of human rights as right to information is also one of the basic human rights. Pakistan has already enacted Freedom of Information (FOI) Ordinance 2002. However, the oil exploration and production policy sections with regard to access to information are in conflict with the Freedom of Information (FOI) Ordinance 2002

Figure 2. Key Gaps in Policy Framework

C. Penalties on Non-Compliance

Penalty for not following the provisions and the guidelines of discharges and emissions and similar environmental protection orders is a fine that can go to 1 million PKR, in case of first offence. Similarly, not conforming to rules regarding the handling of hazardous sub-stances, penalty may go to 100,000 PKR. Moreover, penalties for second or repeated offenders can be shut down or confiscation of site, machinery or items involved in the offence. Penalty can also be to bring back the environment to its original form at the violator's expense or to pay compensation for any damage caused by the violation, in addition to jail time for up to two years.

D. Poor Awareness

Generally there is lack of understanding among the local communities as well as the elected representatives, government officials and civil society at large about the severe possible environmental impacts of oil and gas exploration activities. There is little awareness as to how the different phases of oil and gas exploration and production affect the local environ-ment, biodiversity and natural livelihood resources. The local communities and even official know little about the global experiences of increased environmental degradation as a result of oil and gas exploration and have little knowledge of the different chemicals being used during the oil and gas exploration process and the impact of those chemicals on the local envi-ronment

CONCUSLION

The centralized system at the federal level of awarding petroleum and gas exploration licenses, taking no provincial and local governments into confidence, has emerged as one of the key problems associated with the policy, legal framework, and their implementation. The centralization in the process and systems has been observed at both the levels i.e. policy mak-ing as well as policy implementation specially awarding concession licenses to the Exploration and Production [E&P] firms. As for as the policy formulation is concerned mainly it has been the Ministry of Petroleum and Natural Resources shaping the policies with regard to awarding concession licenses to the oil and gas operating firms, with almost no participation of other stakeholders including the government, civil society and the local communities.

The whole process of agreements of awarding concession licenses to the oil and gas companies and monitoring the process of implementation need complete overhauling. There is greater need of decentralizing the process in a way that not only the Ministry of Petroleum and Natural Resources but also other key stakeholders including the concerned provincial de-partments, elected leadership, concerned district level departments / government and elected representatives should also be made part of the Petroleum concession agreement process to ensure greater participation and inclusion in the process. As a first steps all the policies and laws should be reviewed with the participation of all the key stakeholders at the federal, provincial and district level making the policies and laws more community and environment friendly. There is need of removing the abnormalities in the policy and laws, ensuring greater space and participation of different stakeholders in the decision making process. Besides, there is also a need is to bring changes in the monitoring mechanisms to make these mechanisms clear and participatory. In place of leaving each and every monitoring process on the Ministry of Petroleum and Natural Resources, there is a strong need to ensure participation of the concerned provincial and district level departments as well as the elected representatives and civil society representatives in the monitoring process.

The government policy and the legal framework should ensure that the provincial and district government as well as the local communities, their representatives and civil society organiza-tion regularly receive information / data on not only oil and gas exploration but also on the expenditures by the oil and gas companies on the community development, environment and other heads in the local areas.

The Environment Impact Assessment study preparation and dissemination processes should be localized with greater participation of the local communities as well as local governments and elected representatives in the processm

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Cost Optimization of Grid-Connected and Off-Grid Hybrid System for a Community in Rural Area of Pakistan

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Abstract— Remote and far off communities are usually not connected to grid owing to their location and are not economically feasible. Rural areas possess great abundance of renewable energy resources, utilizing these resources for energy production are environmentally friendly compared to thermal energy systems for power generation. Thermal power plants are costly and releases poisonous gases which causes many environmental menaces. Where the grid-connected rural communities also faces the issues like load shedding and power outages due to which rural community peoples suffered a lot. These aspects are the core driving forces to motivate the scientists, academics, technologists and investors to discover and finance in the field of renewable energy systems. But renewable energy sources are weather dependent and site specific. The main obstacle towards the deployment and investment in these systems is the intermittent and dynamic characteristic of renewable energy sources. The most appropriate option is hybrid renewable energy system to overcome the intermittent nature of the renewable energy sources. In our design model the hybrid renewable energy systems are based on photovoltaic, micro-hydro and biomass to provide reliable and cheaper electricity to remote areas of the Pakistan in case of off-grid and grid-connected mode. The one and only tenacity and purpose of this study is to design reliable and optimized hybrid energy system by using HOMER software with lowest possible Levelized Cost of Energy (LCOE) and Net Present Cost (NPC). The hybrid energy system comprised of solar PV, micro-hydro and biomass for grid-connected and off-grid models. HOMER software analyze different configurations of hybrid renewable energy system and according to the NPC and LCOE most optimized hybrid energy system is selected among the possible configurations. In our hybrid energy system models micro-hydro and solar PV has been used as a primary sources for delivering the base load demand while for meeting the peak demand and for backup biomass gasifier is used. This optimization tactics overpowers the uncontrolled behavior of the renewable energy sources. By well-organized and effective planning we can lessen use of biomass gasifier fuel for power generation along with the system Net Present Cost, LCOE and environmental dangers are abridged.

Keywords— Biomass Gasifier, Net Present Cost (NPC), Cost of Energy (COE), HRES, Microhydro.

I. INTRODUCTION

The major drive behind any country's economic development, industrialization and prosperity is reliable and continuous supply of electricity. Pakistan is developing country and population of Pakistan is increasing drastically, due to increase in population energy demand is going up day by day. To meet the demand of energy with growing demand rate the world is seeking for some alternative source of energy instead of conventional energy sources because conventional energy sources are limited and lessen with the passage of time [1]. According to [2] almost 70-75% population of Pakistan's is living in the far off scattered areas, where they have either very poor access to grid electricity or don't have grid electricity access. The only way they have to get energy is the traditional way of using wood, crops and animal waste for domestic purpose. These traditional ways of getting energy is very old and have very poor efficiency, which leads to wastage of most of the biomass potential.

According to [3], the economic survey held in 2017-2018 the transmission and distribution losses are 18.9% in 2013. With the improved infrastructure these losses decreased by 1% and fall down to 17.9% in 2018. The transmission losses can be reduced by two ways, either by further improving the transmission infrastructure or by adding renewable energy sources near to load centers. By adding renewable energy near to load center can reduce burden on the transmission lines along with reduced carbon footprints and providing energy to those areas where grid electricity is not available.

The renewable energies has proven to be a reliable, clean and green technology to overcome the energy crisis in Pakistan [4].

Cost-effective and reliable generation of energy can be made possible through proper use of renewable resources. In addition, stability and reliability of the renewable energy systems can be further enhanced through efficient management, optimization and proper scheduling of different generation units. Pakistan is entirely relying on fossil fuels for the generation of electrical energy. Escalating prices of fossil fuel in global market has a direct impact on local market, due to which per unit cost of energy is increasing day by day. Moreover, too much exploitation of the conventional power plants has destroyed the wildlife, greenery and polluted the environment to a great extent, which is alarming for the whole world. The generation of electrical energy from the renewable resources is too much cheaper and environmentally friendly compared to conventional power plants. As, conventional energy resources such as oil and gas are limited and their fear of depletion motivated and encouraged the world towards some alternative sources of energy for energy security. Alternative Energy Development Board (AEDB) was evolved in 2003 to motivate, support and encourage the researcher to find out feasible renewable energies technologies. The objective of AEDB is to attain 5% share of energy from renewable resources by the end of 2030 [5][6].

In [7][8] the role of different renewable technologies have been discussed specially stresses on the promotion and development of renewable projects in Pakistan. This paper enlighten the total energy usage along with the electricity related issues in the country. Each and every perspective of Pakistan power sector is analyzed such as demand and supply, generation capacity, installed capacity, energy risks and increasing electricity costs. This paper clearly proclaim that renewable energy resources are sustainable and economical then convention al energy resources. Geographical location of Pakistan is very indispensable in term of potential of renewable energy resources such as solar PV, wind, biomass and wind. The estimated renewable potential is around 168GW, which is extremely mammoth amount of energy.

In [9][10][11], the significance of the electrical energy in the economic and industrial development and the overview of renewable energy resources in Pakistan have been discussed. Pakistan is among those countries which are facing worst energy crises and contingent solely on imported fossil fuels to compensate for growing energy demand. As discussed, Pakistan has enormous amount of renewable energy resources which can be utilized to meet the growing demand of industrial, commercial and domestic sectors. The PV potential is around 2900GW, hydro is 60GW and biomass is 10GW, which is plenty amount of energy. Pakistan energy deficiency can be easily cover up by proper management and utilization of these resources.

Pakistan generation capacity is 25.2GW in 2017, 30GW in 2018 and in 2019 it is around 34.3GW. The increase in demand is 8% per year along with that the mean energy is 22GWand the energy shortfall is 5,000 to 6,000 MW. According to [12], the present generation installed capacity from different sources is shown in the diagram below. It shows that the share of hydro generation in term of installed capacity is 29%, thermal share is 61%, nuclear share is 4% and share from renewable sources is 6%.To properly solve the energy issues in different areas of Pakistan, specifically rural areas, either load shedding, power outages or unavailability of grid electricity, we will design a power system comprised of renewable energy sources. But renewable energy resources are site specific and intermittent in nature[13]. So, a micro grid relying on just single renewable source is very unreliable. To cater out intermittency and unreliability issues we will devised a hybrid system which will be composed of multiple renewable resources. This hybrid system or micro grid could be either in grid-connected or off-grid form and its range vary from few kilowatt to 100kW. The suggested Hybrid Renewable Energy System (HRES) is very advantageous in term of reducing transmission lines stresses and losses and it is also helpful in avoiding installing extra transmission line to the far off rural areas[14]. Rural areas are usually too far from the grid station so, extension of transmission lines to these areas are either too expensive or not feasible. So micro grid is the best solution for these rural areas to meet their energy demand. In this research work an integrated approached is used to design an optimize hybrid system comprised of solar PV, biomass and micro hydro as renewable resources to meet the load demand of a rural community cost-effectively, either in grid-connected or off-grid situation[15].

In all the above work the authors has employed HOMER for simulation of the hybrid model after inserting all the required data. The optimization results of the HOMER can be easily interpreted and the optimized system among different system can be obtained. In this system integration of these sources is done intelligently and effectively to minimize the greenhouse gases emission and cost of the system. The primary sources which feed the base load in both grid-connected and off-grid mode are solar PV and MHP. In order to enhance the stability and reliability in case of peak demand and low generation from primary sources, the biomass and grid electricity will be utilized. Generation from MHP is almost constant throughout the year except in the month of December and January, in which water flow is reduced almost to zero, so, in this case biomass is integrated with solar to meet the demand in off-grid situation. Also, during night times, generation from solar PV become zero and MHP cannot fulfill the load demand independently, so biomass will provide the required energy to serve the load, where, in case of grid-connected mode, grid will provide the required energy. This is the first system in this region of KPK to be exploited. On the other side, the intermittent nature of the renewable sources get diminished through idea if hybrid system. Optimization is done through HOMER software to lessen the NPC and COE of the system.

II. RESEARCH METHODOLOGY

The methodology of this research work comprised of several most important steps for the design of optimal and economically viable hybrid stand-alone system for the selected off-grid and on-grid site. The steps carried out for the completion of this research work are the following

i. Collection of load data site description

ii. Meteorological data collection i.e. solar/ Resource assessment or estimation

iii. Component assessment

iv. Making the objective and cost function for different equipment's and operations

v. Hybrid energy system design

vi. System optimization through HOMER

vii. Optimization results

As we know, the designing of hybrid system, for a community, includes the load data collection, so, it is important to collect the load data of the community properly. For this purpose, a survey has been conducted for the selected site. The survey include, a school, two mosques, minor industry and twenty five residential users. In this survey, questions were asked from the customers about number of lights, fans, television, Air condition, fridge, PCs and printers and water pump. Customers were asked about the usage pattern of different electrical appliances. Seasonal load profile is estimated for different seasons according to data gathered. In the second step, diverse resources potential was acknowledged to proposed and design an electrical hybrid system to accomplish load demand. A survey was conducted to discover the micro hydro potential at the selected site. The information about the discharge rate is being gotten from the viability report of Mardan irrigation department. Average solar Global Horizontal Insolation (GHI) and clearness index figures is taken from (NASA), which is available online. Biomass resource potential data for the community is gained from the World Bank site and due to an agriculture area waste of diverse crops is noted for simulation use. The renewables sources available at the selected site are micro hydro, biomass and solar PV, which were selected for the designing and modeling of hybrid energy system. Cost of each equipment is necessary for the designing and planning of optimal system. After getting different quotations from various dealers and discussion with specialists in the relevant field helped us to know the actual cost of each equipment. HOMER software is exploited for the designing of hybrid energy system. HOMER do simulations and modeling based on several inputs like resources potentials, cost of each equipment's, and load data. After simulation HOMER deliver the top optimized model and relates it with other possible systems.

III. SITE ELUCIDATION AND LOAD ESTIMATION

A. Site Elucidation

The selected site is located in Skardu one of the districts of Mardan, Pakistan. The selected area has both on-grid and off-grid sites but this research focuses on the prototype of a hybrid system for both the off-grid and on-grid sites. The geographical location of is 35oN 74oE with time zone (UTC + 05:00) Islamabad, Karachi.

B. Load Estimation

As the nominated site for the project installation is a small town in Mardan, where the load is divided into four different categories i.e. a School, two mosques, one small industry and residential load. The load requirement of each consumers is different and their load profiles are presented in detail in the subsequent section.

1. Residential Load

The The load data for thirty five house hold users is gathered by counting number of fans, lights, lights for security purposes, fridges, televisions, water pumps, AC and PCs. The collected data shows that, the peak demand of residential load occurs in months of June, July and august, on the other hand in winter off-peak occurs from November to December. The daily peak load demand in summer is from 18:00 to 23:00, while in winter season the peak load occurs from 16:00 to 21:00. The figure below depicts daily load profile for the summer season.

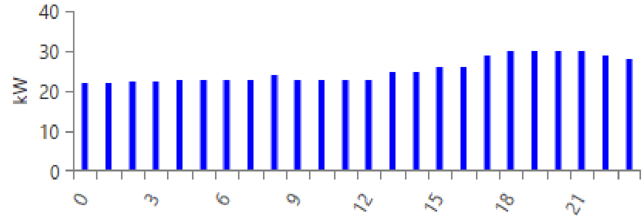

Figure 1. Daily Load Profile of Residential Load

2. School Load

The daily load profile of the school shows that the peak load of the school is around 2 kW. The load comprises of lighting load, fans, water pump heater etc. In winter season the school timing is from 08:00 am to 01:00 pm, while in summer school starts at 07:00 am and closes at 12:00 pm. There are four security lights which are ON during the night time. The diagram below depicts daily load profile of the school during summer.

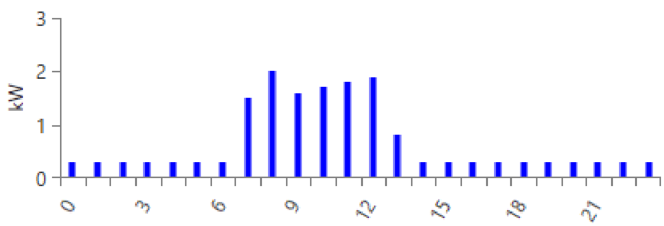

Figure 2. Daily Load Profile of School

3. Mosque Load

The load requirement of a mosques changes with the season conditions and occurs during prayer timings. In mosque, five times prayers are offered and their timing changes from on weather on another, for Fajar prayer the timing is 04:00 am to 07:00 am, time for Zuhar prayers is from 12:45 pm to 02:00 pm. Prayers timing for the other three prayers i.e. Asr, Maghrib and Isha is from 03:45 pm to 08:00 pm in winter season and from 05:00 pm to 10:30 pm in summer season. Water pump in mosque is usually operated during Fajar and Maghrib time. The figure below shows the variation in load demand of mosque.

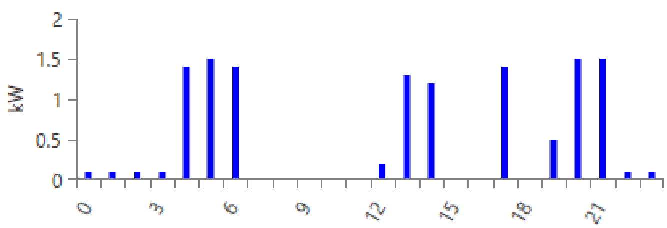

Figure 3. Daily Load Profile for Mosque Load

4. *Industrial Load*

There is a small industry in the community which has a peak load of 17kW. The operating time of the industry is from 9:00 am to 5:00 pm daily. The industry load is almost constant and appears for the whole year. There is only two fans and ten lights for security purpose when the industry working hours is off.

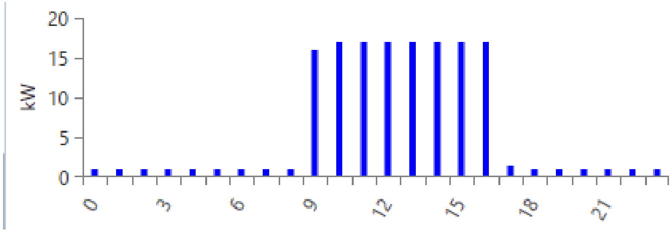

Figure 4. Daily Load Profile for Industrial Load

5. Combine Load Demand

The connected load of the community is 50kW and the peak demand is almost 46kW, as we know which are composed of industrial, school, residential and mosque load. The load demand change with the weather conditions. In summer the load demand is highest, while in winter the load demand is at their lowest value. The diagram below shows the daily average load profile for the combine load over 24 hours.

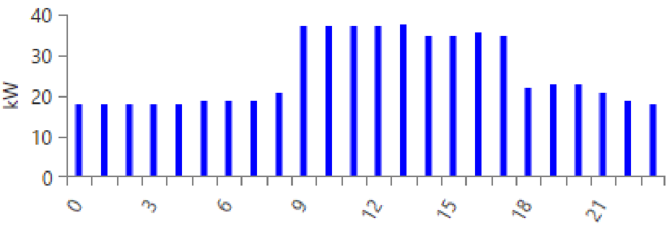

Figure 5. Combine Average Load Profile

IV. RESOURCES POTENTIAL

Detailed study and analysis of resource potential is compulsory before going to design and install the project. The available potential of various sources is studied and are nominated to integrate to supply uninterrupted power to the clients. Three renewables sources are selected for the optimization of the suggested system, the sources are micro hydro, photovoltaic and biomass which are discoursed in detail below.

A. *Biomass Potential*

Pakistan is a country having large fertile property and great portion of the population belongs to the agriculture sector. Pakistan has a huge biomass potential e.g. only sugar industry could contribute more than 10,000 MW potential. There is huge requirement for advance research and technology to transform waste into useful biomass fuel for power generation. The site chosen for the hybrid energy system is a rural area of KPK province, Pakistan, where main source of revenue of the individuals is agriculture crops. The World Bank report demonstrate that, biomass data for Mardan of KPK province of Pakistan is given in table below.

TABLE I. BIOMASS POTENTIAL OF MARDAN

Residue Name	Theoretical Potential 1000 ton/year	Current Technical Potential 1000 ton/year	Available Potential and Readiness to participate in supply Chain 1000 ton/year
Wheat, Straw	125	1	1
Cotton, Stalks	36	6	5
Rice, Straw	6	0	0
Rice, Husks	1	0	0
Maize, Stalks	110	3	3
Maize, Cobs	29	1	1
Maize, Husks	19	1	0
Sugarcane, Trash	33	1	1
Sugarcane, Bagasse	82	2	2

B. *Solar PV Potential*

Monthly average solar Global Horizontal Irradiance (GHI) data for the selected site has been collected from National Renewable Energy Laboratory (NREL) database. The table below shows the monthly average irradiance

TABLE II. MONTHLY AVERAGE IRRADIANCE

Month	Clearness Index	Daily Radiation ($kWh/m^2/day$)
January	0.581	3.031
February	0.580	3.804
March	0.561	4.697
April	0.572	5.748
May	0.610	6.787
June	0.612	7.056
July	0.575	6.475
August	0.541	5.598
September	0.616	5.429
October	0.643	4.490
November	0.612	3.343
December	0.517	2.485

C. *Micro-Hydro Potential*

Jalala canal of district Mardan, KPK has a microhydro potential, in Cusec is exposed in table. The available head is 10 meter and the two years e.g. 2013-14 discharge and the data about the average discharge each month is estimated based on on-site calculations.

TABLE III. MICRO-HYDRO POTENTIAL

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	50.5	61.1	76.2	118.1	132.25	130.1	119.1	92.3	103.4	98.1	80.2	78.3
2014	52.3	58.2	70.3	99.4	133.35	134.3	138.2	105.2	97.3	80.2	70.5	68.6
Mean Monthly Discharge	102.8	119.3	146.5	217.5	265.6	264.4	257.3	197.5	200.7	178.3	150.7	146.9

The power generated by the water potential is calculated through the formula below

$$Power = (Q)(g)(\rho)(h) \quad (1)$$

Where, Water density is denoted by ρ = 103 kg/m3, Q is flow rate of water, Qminimum =0.1275m3/s and Qmaximum =0.382m3/s, Earth gravity is denoted by g=10m/sec2 & head is denoted by h =15m

$$P_{minimum} = (\rho)(Q_{min})(g)(h) \quad (2)$$

P_{min}=19 KW

We have taken system efficiency of 80% for micro hydro. For simulation we have taken it 80% too. For maximum power generation from MHP at Qmax is

$$P_{Max} = (\rho)(Q_{max})(g)(h) \quad (3)$$

Considering 80% efficiency, so, the maximum power from MHP is,

P_{Max}= 57.3 KW

V. SYSTEM DESIGNING

A. Hybrid System Design for Off-Grid Community

The hybrid energy system is designed for the rural community where, there is no access of grid electricity. The sources utilized while designing of the hybrid system are solar PV, hydro and biomass. These resources are available in abundance at the selected site. The disgram is given below

The hybrid system shown above comprised of 30kW hydro, generator size of 10kW and PV size of 30kW. Generator and hydro power is AC in nature so, it is connected to the AC bus, whereas, PV output power is DC in nature so it is connected to the DC bus and converter transform this DC power into AC. The inverter size is 20kW. During night time when the solar PV output is zero than the biomass generator meet the remaining demand of electricity. Electronic Load Controller (ELC) is interfaced with micro hydro to make the system more stable by attaching or detaching ballistic load with rise or reduction of load/generation. The governor is installed to control the output of biomass generator according to the received data from the controller. In peak hours' biomass generator operate and generate electricity to meet the peak load demand.

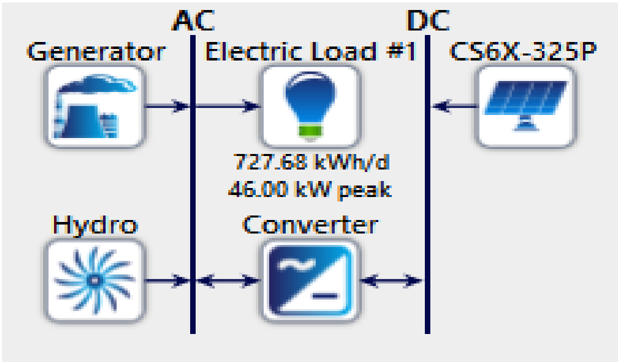

Figure 6. Hybrid system layout for off-grid community

B. Hybrid System Design for Grid-Connected Community

In this section, hybrid system is designed for a rural community, in Mardan district of KPK, connected to the grid. The system comprised of solar PV, biomass, micro hydro and having grid access too. The diagram below shows the whole schematic diagram of the grid-connected hybrid system for the rural community.

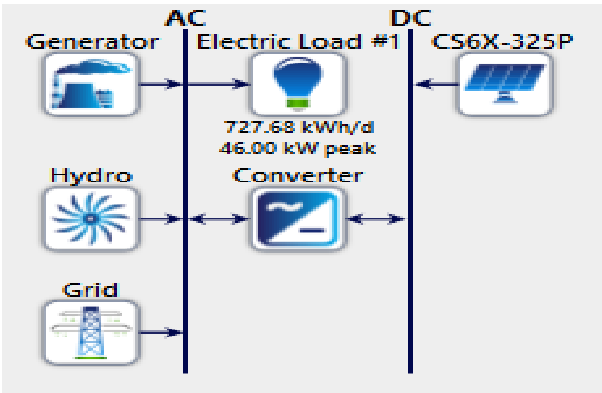

Figure 7. Hybrid system layout for grid-connected community

Here the hybrid system comprised of the sources as was there for off-grid site, but here this hybrid system is connected to the grid. The grid electricity price is taken 15Rs/kWh.

VI. OBJECTIVE FUNCTIONS

Cost of each and every element is very imperative for the economic analysis, optimization and modelling of the hybrid system. HOMER exploit these cost functions to determine the Net Present Cost and LCOE of the system. In the following segment cost functions of each system elements are discoursed.

A. Micro-hydro Cost Function

The economic analysis and optimization of the hydro power plant is done using equation below

$$NPC_{MH} = CC_{MH} + INS_{MH} + \sum_{1}^{K} O\&M_{MH} * T_{life\ time} + REP_{MH} * REP_{K} \tag{4}$$

Where NPCMH, CCMH, INSMH, O&MMH, REPMH designates Net Present Cost, Capital Investment, Installation and Commissioning Cost, System Operation and Maintenance Cost and Replacement expenditures. Initial capital comprised of synchronous alternator, protection devices, crossflow turbine, cables and other various costs. Installation cost consist of shipment, civil work, labor and installation cost. Power house life time in years is depicted by Tlifetime and the annual operating and maintenance cost of the micro hydro power plant is indicated by O&M. Replacement expenditures include the cost of any security or protective equipment's which needs replacement in case of failure. REPN indicates the total amount of components required to be replaced in project running time.

B. Solar PV Cost Function

Solar PV plant economic analysis and optimization is done using equation below

$$NPC_{PV} = CC_{PV} + INS_{PV} + \sum_{1}^{K} O\&M_{PV} * T_{life\ time} + REP_{PV} + REP_{K} \tag{5}$$

Initial capital investment cost comprises of solar panel and mounting structure cost, Cables and protective equipment's and other essential material cost. Installation cost consist of modules consignment cost, labor and installation cost. O&M is the cost of all necessary operation and maintenance cost.

C. Objective Function of Biomass Power Plant

Biomass power plant cost function is shown below

$$NPC_{BM} = CC_{BM} + INS_{BM} \sum_{1}^{K} O\&M_{BM} * T_{life\ time} + REP_{BM} * REP_{K} + \sum_{1}^{8760} Fuel * T_{life\ time} \tag{6}$$

Here the Initial investment consist of biomass generator and equipment's cost, and other essential material cost obligatory for the operation of biomass power plant. For the proper operation of biomass generator biomass fuel cost is prerequisite, which is contingent on the operation hours of the whole project life.

D. Inverter and Sync Panel Cost Function

Equation 7 is used for the economic analysis and optimization of invertor.

$$NPC_{inv\,\&\,sync} = CC_{inv\,\&\,sync} + INS_{inv\,\&\,sync} + \sum_{1}^{K} O\&M_{inv\,\&\,sync} * T_{life\ time} + REP_{inv\,\&\,sync} * T_{life\ time} \tag{7}$$

Where, all the terminologies are same as above. These all cost values are essential for calculating net present cost of the inverter.

VII. RESULTS AND DISCUSSION

For getting optimized results a well-known software HOMER is used. HOMER needs several input parameters for the designing, modelling and optimization of the system. Figure 5.1 put down a simple and lucid view of the general structure of the input and output.

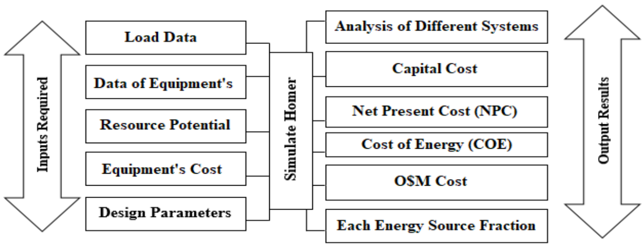

Figure 8. HOMER Modeling with Several Input Parameters

A. Optimization Results for Off-Grid Community

As we know peak load for the off-grid community is almost 45kW and the hybrid system consist of hydro, PV, biomass generator and converter. Hydro and PV act as a primary sources of electricity whereas the biomass gasifier acts when the demand reached to their peak value and when PV output is negligible, during the night time. The diagram below shows the simulation results for the off-grid community using HOMER. HOMER simulates all the possible configuration from the available sources.

Architecture					Cost				System	
CS6X-325P (kW)	Generator (kW)	Hydro (kW)	Converter (kW)	Dispatch	NPC (Rs)	COE (Rs)	Operating cost (Rs/yr)	Initial capital (Rs)	Ren Frac (%)	Total Fuel (tons/yr)
30.0	10.0	30.0	20.0	CC	Rs33.1M	Rs9.63	Rs2.00M	Rs7.26M	100	3.21
	20.0	30.0		CC	Rs67.2M	Rs19.57	Rs4.72M	Rs6.20M	100	9.02
	50.0			CC	Rs403M	Rs117.47	Rs30.7M	Rs7.00M	100	147
20.0	50.0		20.0	CC	Rs405M	Rs118.05	Rs30.7M	Rs8.76M	100	128

Figure 9. Simulation Results for Off-Grid Community

There are two possible configurations: the first one is composed of PV, hydro, biomass generator and converter and; the second configuration is composed of biomass generator and hydro. The first configuration is the most optimized one due to low Cost of Energy (COE) and Net Present Cost (NPC), which are 9.63Rs/kWh and 33.1M respectively. The first configuration consist of 30kW PV, 10kW biomass generator, 30kW hydro and 20kW converter. The initial capital cost of the system is 7.62M and operating cost is 2.00M. Now, the second configuration is comprised of 20kW biomass generator and 30kW hydro having COE and NPC of 19.57Rs/kWh and 67.2M, which is too much higher than the above case. So, the HOMER chosen the first configuration as the most optimized one on the basis of COE and NPC.

The monthly electric production from all the three sources is shown in the diagram below. Different color represents the production of electricity from the different sources. The hydro production is greater than from the PV and biomass. Production from the biomass generator is very less because is operates only in peak hours and when PV is not available.

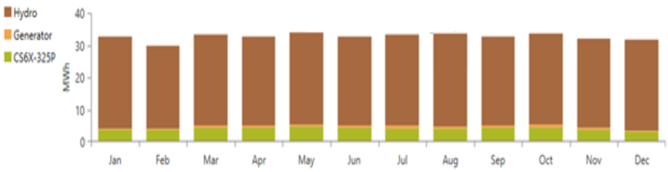

Figure 10. Monthly Electric Production

In the month of December and January production from the PV system get reduces due to reduction in day hours and irradiance. The diagram below shows the various cash flows, including capital cost, O&M cost, replacement cost and salvage value, for the hybrid system over a period of 25 years.

The table below shows different sources along with their generations for the first configuration means the most optimized one. Major portion of the electricity is generated from micro-hydro and then from solar PV. Almost 85.5% is contributed from hydro and 12.8% from solar PV. The amount of excess electricity is generated nearly 125,954, which is almost 32.1%.

TABLE IV. ELECTRICITY PRODUCTION AND CONSUMPTION SUMMARY

Production	kWh/yr	%	Consumption	kWh/yr	%
Canadian Solar Dymond (CS6K-285M-FG)	50,069	12.8	AC Primary Load	265,603	100
Generic 10kW Biomass genset	6,686	1.71	DC Primary Load	0	0
Micro-Hydro	335,064	85.5			
Total	391,819	100	Total	265,603	100

B. *Optimization Results for ON-Grid Community*

The peak load for the grid community is same as in the above case of off-grid community. The system comprised of PV, biomass gasifier, micro hydro and converter which is connected to the grid. This hybrid system is net-metering enabled, so, per kWh tariff of buying and selling are Rs17 and Rs8 respectively. The hybrid system consist of 30kW hydro, 10kW generator and 10kW of solar PV. The optimization results below shows different configuration along with their COE, NPC, capital and operating cost and other parameters.

Architecture						Cost				System	
CS6X-325P (kW)	Generator (kW)	Grid (kW)	Hydro (kW)	Converter (kW)	Dispatch	NPC (Rs)	COE (Rs)	Operating cost (Rs/yr)	Initial capital (Rs)	Ren Frac (%)	Total Fuel (tons/yr)
10.0	10.0	999,999	30.0	10.0	CC	-Rs10.9M	-Rs1.93	-Rs1.25M	Rs5.28M	100	13.1
	10.0	999,999	30.0		CC	-Rs10.3M	-Rs1.88	-Rs1.14M	Rs4.40M	100	13.1
10.0		999,999	30.0	10.0	CC	-Rs2.59M	-Rs0.566	-Rs531,074	Rs4.28M	99.3	0
		999,999	30.0		CC	-Rs1.13M	-Rs0.253	-Rs350,275	Rs3.40M	97.2	0

Figure 11. Optimization Results for Grid-Connected Community

As this hybrid system is net-metering enabled, so, the extra electricity from the renewable sources will be sold out to the grid. The NPC and COE for the first configuration is, which is comprised of PV, biomass, micro-hydro, converter and grid, -Rs10.9M and -Rs1.25. The negative sign is show that the revenues is greater than the expenses. The initial capital cost for the first configuration is 5.28M, which is higher than other but HOMER compare system on the basis of NPC and COE. In the first configuration the renewable fraction is 100%, its mean the community don't need to buy electricity from the grid. Other configurations are shown along with their NPC and COE. The system having less NPC and COE are the most optimized one among the configurations. So, the first one is the most optimized configuration having less COE and NPC. Different other important parameters are shown subsequently. The diagram below shows the monthly electric production from the different sources.

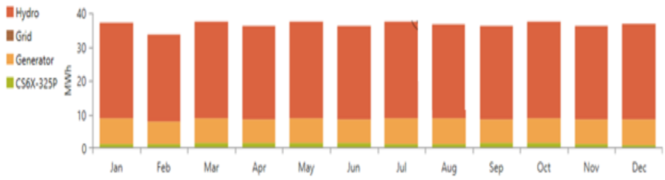

Figure 12. Monthly Electric Production

In the diagram 12, percentage of electricity generation from each source is shown by different colors. Maximum generation is done by hydro and minimum from the PV. The table following is shown energy generation and consumption scenario along with grid sales.

TABLE V. ELECTRICITY PRODUCTION CONSUMPTION AND GRID SLAES

Production	kWh/yr	%	Consumption	kWh/yr	%
Canadian Solar Dymond (CS6K-285M-FG)	16,690	3.80	AC Primary Load	265,603	60.6

Generic 10kW Biomass Genset	87,600	19.9	Grid Sales	172,916	39.4
Micro-Hydro	335,064	76.3			
Total	391,819	100	Total	438,519	100

The table depicts, almost 172,916 kWh/yr is sold out to the grid for getting revenues, and it is almost 39.4 percent of the total energy production.

CONCLUSION

To reduce the problem of power outages and load shedding in rural areas of Pakistan and to diminish the environmental hazards of the greenhouse gases, distributed generations and micro-grids are the most feasible solution both technically and economically. As we know, there is a huge potential of renewable energy resources in Pakistan, but the intermittent nature of the renewable sources and climate conditions make hurdles in the implementation of RES. This project is carried out to diminish the intermittent nature of the renewable sources through a hybrid system approach; combining several renewable sources. This project further explore the optimization approaches for getting the optimization of the hybrid system out of several different configurations. With this approach rural community in Mardan district got retrieve from the power outages and load shedding issues. The hybrid system for the community comprised of micro-hydro, solar PV and biomass; first in stand-alone mode and then in grid-connected mode.

HOMER Pro tool established by National Renewable Energy Laboratory (NREL), was used for designing, developing and optimization of hybrid renewable energy system for stand-alone and grid-connected mode. It is concluded from the simulation results that the first configuration for off-grid system, comprising of 30kW PV, 10kW biomass generator and 30kW hydro is the most optimized system among the different available configurations due to their less NPC and COE, which are 33.1M and 9.63RS/kWh. In this configuration the solar PV and micro-hydro are the main and primary sources for the generation of electricity, where biomass is employed during peak load hours and usually in night hours. In the other configuration such as biomass and hydro, biomass, PV and biomass the COE and NPC is got higher, so, these configuration are not the optimized one.

The second case is the grid-connected, where the community is connected is connected is to the grid too, so, a hybrid system has been designed to completely diminish the problem of load shedding and power failure and net-metering allowed the system to sell extra energy to the grid, which has further increased the revenues and reduced the NPC and COE. The simulation results has shown that the first configuration, comprising of 10kW PV, 10kw Biomass generator, 30kW hydro and having grid access, has the NPC and COE of –Rs10.9M and –Rs1.93 respectively, which are much less than the other configuration. So, HOMER software helped us for the designing and getting a most optimized hybrid system. By proper strategies and designing we have reduced the intermittent nature of the renewable sources.

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A Review of Traffic-Related Air Pollution

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***Abstract*—** Traffic-related air pollution in urban areas is of growing concern as it worsens air quality which ultimately causes health problems. The exponential growth in urban traffic vehicles seriously deteriorate air quality as a result of higher fuel combustion products which disperse in the air. This review investigate and compile prominent researches conducted about traffic-related air pollution. The review found that traffic related air pollution is measured usually with Air Qaulity Index (AQI), which determines how much the concentration of a traffic air pollutant surpasses the satisfactory AQI category. The higher the value of AQI or the pollutant concentration, the worse the air quality. Each AQI category have its own implication to health and wealth of the people.

***Keywords*—** Traffic-related air pollution, AQI, Particulate Matter, NO_2, SO_2

I. INTRODUCTION

The review paper summarizes some of the most significant researches conducted about traffic-related air pollution impact on public health, economy, air quality and climate change. Some of the major urban challenges includes congestion, lack of funds for basic services, a shortage of adequate housing, declining infrastructure and rising traffic air pollution. United Nations estimates that 3.5 billion people lives in cities currently and 5 billion projected to live in cities by 2030 and with only 3% of the Earth's land occupied by cities, but account for 60-80% of energy consumption and 75% of carbon emissions. Rapid growth in population, industrialization and urbanization have led to increases in the overall number of motor vehicles. Many local vehicles are aged and poorly maintained and contribute excessively to air emissions and pose adverse health risk to the residents in the city. One of the most prominent cause of urban air pollution in Pakistan is vehicular traffic emissions, as motor vehicles increased from 2 million to 10.6 million during period of 20 years from 1991 to 2012 [1]. Traffic emissions which includes but not limited to; PM_1, $PM_{2.5}$, PM_{10}, CO_2, SO_2, NO_2, O_3, which contribute to overall air pollution largely. Traffic Related Air Pollution (TRAP) is increasing day by day in Pakistan while policy makers have no KPIs.

Similarly, air pollution is the 6th leading risk factor for mortality in Pakistan, responsible for more than 9% of deaths (128,000) in 2017 alone as shown in Fig 1. Air pollution exposures, including exposure to outdoor particulate matter ($PM_{2.5}$) and household air pollution have been linked to increased hospitalizations, disability, and early death from respiratory diseases, heart disease, stroke, lung cancer, and diabetes. Exposure to ambient ozone is linked to Chronic Obstructive Pulmonary Diseases (COPD). Also, air pollution is associated with climatic changes, global warming, deteriorating telecommunication networks, economic and ecological losses. Pakistan currently has 5th largest numbers of deaths because of $PM_{2.5}$ exposure and is ranked 6th in the world for the greatest number of deaths from chronic destructive pulmonary diseases (COPD) SOGA 2019 [14]. A scientific research has found that long term exposure to ambient air pollution increases mortality and morbidity from cardiovascular Han [20], respiratory diseases Kim et. al. [7], effects Pulmonary function and inflammation Li [19] lung cancer and reducing life expectancy.

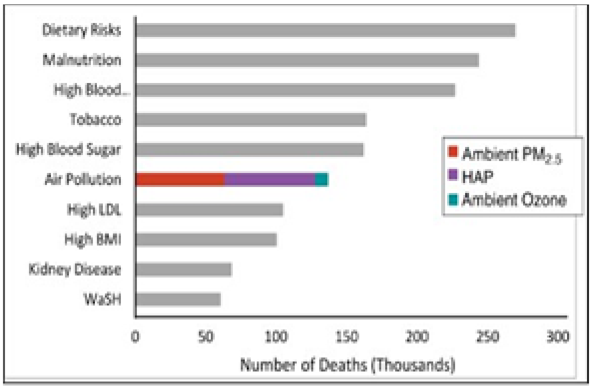

Fig. 1 Leading risk factors for death and disability in Pakistan in 2017 (SOGA, 2019)

A. *Measuring methods for TRAP*

Fig 2. shows the three distinct stages of TRAP measurements, each require different type of apparatus. Usually, measuring stage III emissions are useful and easy. Combustion of fossil fuel such as hydrogen (H_2), methane (CH_4), and octane (C_8H_{18}) produces product of combustion such as (1) shows its chemical process.

$$\underbrace{\mathbf{CH_4 + 2O_2}}_{\text{Reactants}} \rightarrow \underbrace{\mathbf{CO_2 + 2H_2O}}_{\text{(Product)}} \quad (1)$$

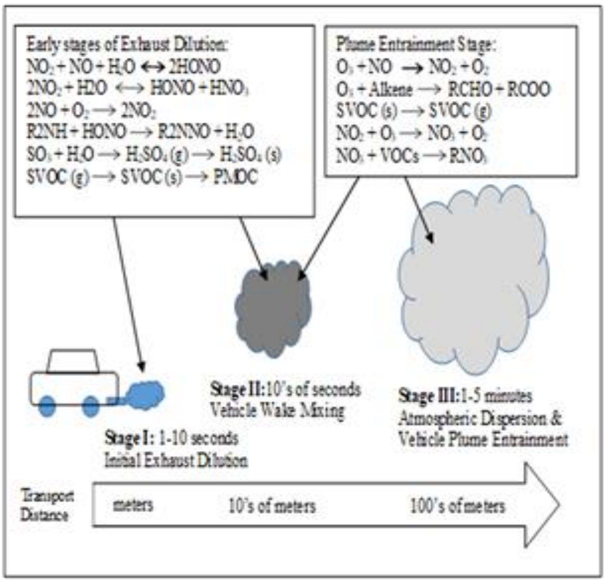

Fig. 1 Layout of possible chemical transformation of motor vehicle emissions [HEI, 2010]

The reactions described here is carried out in air, which can be approximated as $21\%\ O_2$ and $79\%\ N_2$. This composition is referred to as 'theoretical air.' With this definition, for each mole of O2, 3.76 (or 79⁄21) moles of N2 are involved Eastop [17]:

$$CH_4 + 2O_2 + 2(3.76)N_2 \rightarrow \mathbf{CO_2 + 2H_2O + 7.52N_2} \qquad (2)$$

Even if the nitrogen is not part of the combustion process, but due to high temperature in the combustion chamber, Nitrogen heats up, Oxides of Nitrogen forms because of the excess air and temperature. Other pollutants form light duty vehicles (LDVs) which uses gasoline and ethanol as fuel, are the cause of CO and volatile organic compounds (VOC) Pérez-Martínez [11]. Also, heavy duty vehicle (HDVs) generate Nox and Particle Matter (PM). The concentration of traffic-air pollutant once measured, converted to Air Quality Index (AQI) using US EPA breakeven point technique, using (3) [2] along with breakpoints Table I. AQI categorical representation by colour scale is in II, which helps in knowing the level of hazard or toxicity of a pollutants through color.

Daily average AQI was calculated from pollutant concentration based on US EPA procedures

$$\boldsymbol{I_p = \left(\frac{I_{high} - I_{low}}{BP_{high} - BP_{low}}(C_p - BP_{low}) + I_{low}\right)} \qquad (3)$$

I_p= the (Air Quality) index,
C_p = the pollutant concentration,
BP_{low}= the concentration breakpoint that is $\leq C_p$
BP_{high}= the concentration breakpoint that is $\geq C_p$
I_{low}= the index breakpoint corresponding to, BP_{low}
I_{high}= the index breakpoint corresponding to BP_{high}

TABLE I. BREAKPOINTS FOR CALCULATING AQI (SOURCE: US EPA, AIRNOW [2]

These Breakpoints...							**...equal this AQI**	**…and this category**
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour1	$PM_{2.5}$ (µg/m3) 24-hour	PM_{10} (µg/m3) 24-hour	CO (ppm) 8-hour	SO_2 (ppb) 1-hour	NO_2 (ppb) 1-hour	AQI	
0.000 - 0.054	-	0.0 – 12.0	0 - 54	0.0 - 4.4	0 - 35	0 - 53	0 - 50	Good
0.055 - 0.070	-	12.1 – 35.4	55 - 154	4.5 - 9.4	36 - 75	54 - 100	51 - 100	Moderate
0.071 - 0.085	0.125 - 0.164	35.5 – 55.4	155 - 254	9.5 - 12.4	76 - 185	101 - 360	101 - 150	Unhealthy for Sensitive Groups
0.086 - 0.105	0.165 - 0.204	(55.5 - 150.4)	255 - 354	12.5 - 15.4	(186 - 304)	361 - 649	151 - 200	Unhealthy
0.106 - 0.200	0.205 - 0.404	(150.5 - (250.4)	355 - 424	15.5 - 30.4	(305 - 604)	650 - 1249	201 - 300	Very unhealthy
	0.405 - 0.504	(250.5 - (350.4)	425 - 504	30.5 - 40.4	(605 - 804)	1250 - 1649	301 - 400	Hazardous
	0.505 - 0.604	(350.5 - 500.4)	505 - 604	40.5 - 50.4	(805 - 1004)	1650 - 2049	401 - 500	Hazardous

TABLE II. AQI SCALE OF CATEGORIZATION (US EPA)

AQI Class	AQI Category	Colour Representation
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151-200	Unhealthy	Red
200-300	Very Unhealthy	Purple
>300	Hazardous	Maroon

B. *Research review*

To the best of our knowledge, there is hardly any mechanism localy available to measure the concentration of these air traffic pollution systematically using IoT and implement appropriate strategies. Reviewing the extensive literature available can help to develop a compressive design of a measuring and monitoring system for traffic related air pollution. Based on the investigation, design for TRAP containment through research process can help government to implement strategies for its citizens. Data collected though measurment by IoT sensors, may be exploited to increase the transparency and promote the actions of the local government towards the citizens, enhance the awareness, of people about the status of city. By controlling those parameters originated from traffic related air pollution, it is possible to improve the level of comfort and health of residents in the city. Also, by publishing the findings of the compilation of extensive review investigation, thereby contributing meaningful and relevant data to the peer-reviewed literature. Various investigations conducted throughout are summarized the Table II explaining TRAP, its measurement and its impact.

II. REVIEW OF STUDIES

Various studies investigates traffic-related air pollution. Some prominent worked done in this regards is summarized in below Table III. Real-time traffic air measurement is not an unachievable task but certainly a complicated business. Numerous methods have been implemented to know air pollution. Berkowicz, et al. [3] used Danish Operational Street Pollution Model (OSPM) of estimation for traffic emission (NOx and CO) at the Copenhagen University building based on the COPERT model. Other studies adopted an indirect approach such as Zanella, et al. [4] have conducted a pilot study at Padova, Italy, about new IoT technology, for the street lighting system and measurement of environmental parameters. Mobile Crowd Sensing (MCS) was another IoT technique coined by Montori, et al. [5], which collected corporate, state, and end-user data for analysis. Another research by Ahmad, et al. [6] on determining the concentration of particulate matter PM10 and Pb at Upper Dir and Charsadda by using Reference Ambient Air Sampler and graphite furnace atomic spectroscopy. Similarly, an investigation discovered the level of temperature, humidity, and Carbon Dioxide using IoT, where data from the transmitter node has been sent to the receiver node and stored in a customized excel sheet [7]. For measurement of the concentration of CO2, NOx, and PM10, Non-Dispersive Infrared Photometry, Chemiluminescence, and an automatic sampling of Beta Radiation methods were employed respectively by Pérez-Martínez, et al. [8]. The correlation of exposure to TRAP and hospital readmission was analyzed by Newman, et al. [9] for a period of 12 months by means of logistic regression and the COX Proportional Hazard model and found that hospital TRAP has positive effect on readmission to hospital. Another method was applied by Pascal, et al. [10] where the concentration of ozone (O3) and Particle Matter (PM2.5) was collected with the UV Absorption method and Tapered Element Oscillating Microbalance (TEOM) respectively.

Not many studies assesses TRAP as most them worked on the interconnection of health with air pollution [10] and excessively focused on impact of TRAP on Asthma [9] and other health issues [1, 11-15]. There is hardly any research in the city for monitoring TRAP based on contemporary IoT system. However, this research tried to provide a long-term systematized approach for the understanding of this issue, by measuring and monitoring TRAP. Traffic air is being the primary concern in this research, and is being analyzed by measuring the concentration of parameters that are responsible for the degradation of air quality. Depending on the climate, including humidity, temperature, and rainfall, the concentration of traffic air pollutants changes region to region [16]. So, it was necessary to measure TRAP in Peshawar as well.

TABLE III. TRAFFIC-RELATED AIR POLLUTION STUDIES

Study	Location	Data acquisition	Parameter
Zanella, et al. [4]	Padova Italy	IoT for smart cities	Benzene, light, Temperature and Humidity
Montori, et al. [5]	Multiple locations	Mobile crowed sensing	Environmental parameters i.e. Temperature, Humidity
Wong, et al. [17]	Hong Kong	Outdoor and indoor infiltration data	PM2.5, CO, O3, BC etc
Wu, et al. [18]	Macao, China	DustTrack monitoring system	PM1, PM2.5, PM10
Fontes, et al. [19]	Beijing, China	4 hours a day	PM2.5
Kesavachandran, et al. [13]	India	Spirometer	Particulate matter
Kim, et al. [14]	Francisco	Logistic regression	BC, NOx, SOx, Particle matter
Berkowicz, et al. [3]	Denmark	OSPM and COPERT models	NOx and CO
Shah and Mishra [7]	Gujrat, India	IoT based system	Temperature, Humidity and CO_2
Nigam, et al. [20]	Nagpur, India	AQI based comparison	PM2.5, PM10, SO2 and NO2
Ahmad, et al. [6]	Khyber Pakhtunkhwa, Pakistan	Reference Ambient Air Sampler (RAAS)	PM10 and Lead concentration
Ahmad, et al. [1], [11]	Rome, Italy	Comparative assessment	PM10, NO2
Linares and Díaz [15]	Madrid, Spain	Data analysis from hospital	NO2, NOx, PM2.5, PM10, SO2
Pascal, et al. [10]	Europe	Aphekom Project	PM2.5
Pérez-Martínez, et al. [8]	São Paulo, Brazil	nondispersive infrared photometry	CO, NOx, O3, PM10
Abdullah S. Modaihsh [21]	Riyadh City, Saudi Arabia	aerosol spectrometer	PM2.5, PM10

CONCLUSION

After extensive review of the literature available on traffic-related air pollution, it can be concluded that traffic air pollutant has declined the air quality in large. Further, various methods for estimation of pollutant concentration have been applied. Real time concentration of traffic air pollution is monotonous job, however recommendation of sensor deployment for continues monitoring of traffic related air pollution can be found from the exploration of various investigations.

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Two-Step Skipping Techniques For Solution of Nonlinear Unconstrained Optimization Problems

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Abstract—The development of recent engineering systems has introduced increasing levels of complexity and uncertainty over time. Combined with the planning philosophy of engineering itself, this has given rise to several studies addressing the straightforward or multi-objective optimization problems present in these complex systems. Although conventional approaches are often applied to engineering optimization depends largely on the character of problem, but they suffered to supply some quick and reasonable feedback to designers and can't be challenging to further possible problems. However, researchers prefer quasi-Newton methodsto solve the unconstrained non-linear optimization problems, using updating the approximation to the inverse Hessian. This technique is a computationally expensive operation and, therefore, in this paper we investigate the possibility of skipping update of Hessian approximation on every second step. The experimental results show that the new methods (i.e. with skipping) give better performance in general than existing two-step methods, particularly as the dimension of the test problem increases.

Keywords—unconstrained non-linear optimization, quasi-Newton methods, approximation to the inverse Hessian, skipping updates, two-step methods.

I. INTRODUCTION

Optimization theory is one of the fundamental theory examined in various mathematical branches such as control theory, linear algebra, calculus of variation, linear programming and game theory etc. Optimization problems arises in various fields of science, engineering, economics, business management and space technology etc. Taking simple examples such as, reducing of cost and minimizing profit, finding elevated point of throw for known initial speed.

For the solution of such problems, different optimization techniques are available. To deal such problems, the iterative methods are best in solution. The improvement of efficiency and convergence of iterative method always motivated researchers to work on this method to get best result, further see [3]. Non Linear optimization problem can be solved using various techniques such as, Newton's method, Conjugate gradient method, Golden section method and many other. Among these methods Newton's method is of the most interest to get the desired optimal solution. In case of high dimmensions, the Hessian calculation becomes expensive. To overcome this difficulty, researchers introduced various techniques such as, Newon's method with sparse matrix estimation techniques, Quasi-Newton method and partitioned Quasi-Newton method, further we refer [4, 5, 6, 7, 8, 9].

The fact that optimization theory is now used in nearly all branches of life motivates researchers to either develop new improved methods or to further develop the performance of existing methods. This fact also motivated us to further explore the existing single/multi-step quasi-Newton methods for unconstrained non-linear optimization. As it is evident from literature that in many situations, one of the more expensive operations in the code for a quasi-Newton method is the updating of the inverse Hessian approximation H_i to produce H_{i+1}. Thus this issue is strongly needed to be addressed to reduce the computational expanse and time.

In order to address the said issue a new technique, of skipping the Hessian update in every second iteration, is introduced. In order to get the Current Hessian approximation, two-step methods, employ data from more than one previous step. BFGS formula is also utilised by the two-step method but replacing the vectors normally employed in the BFGS formula by the vectors determined by the two-step version of the quasi-Newton equation. Hence to explain, in-detail, the process of two-step methods, we consider the problem of the unconstrained minimization of a twice differentiable objective function $f(x)$ (where $x \in R^n$), using two-step quasi-Newton methods. The gradient and Hessian of f are denoted by g and G, respectively. In standard quasi-Newton methods the approximation B_{i+1} to the Hessian $G(x_{i+1})$ is required to satisfy the secant equation

$$B_{i+1}s_i = y_i \tag{1}$$

wheres_i is the step in the variable space and y_i is the corresponding step in the gradient space, defined by

$$s_i = x_{i+1} - x_i$$

And

$$y_i = g(x_{i+1}) - g(x_i)$$

Clearly, in performing the update of B_i to produce B_{i+1} these methods employ data from just one step, and so we refer to them as single-step methods. In the case of two-step quasi-Newton methods, the approximation B_{i+1} is required, instead, to satisfy a condition of the form

$$B_{i+1}(s_i - \gamma_i s_{i-1}) = y_i - \gamma_i y_{i-1} \quad (2)$$

Or

$$B_{i+1}(s_i - \gamma_i s_{i-1}) = y_i - \gamma_i y_{i-1} \text{ say} \quad (3)$$

Ford and Moghrabi noted that the derivation of this relation depends on the construction of interpolating quadratic curves $\{x(\tau)\}$ and $\{h(\tau)\}$ [9], where $\tau \in \mathcal{R}$:

$$x(\tau_j) = x_{i+j-1}, \qquad j = 0, 1, 2,$$
$$h(\tau_j) = g(x_{i+j-1}), \qquad j = 0, 1, 2.$$

Thus $G(x_{i+1})$ will satisfy the relation

$$G(x_{i+1})x'(\tau_2) = G(x(\tau_2))x'(\tau_2) = g'(x(\tau_2)), \quad (4)$$

where derivatives with respect to τ are denoted by primes. If we consider

$$r_i \stackrel{\text{def}}{=} x'(\tau_2)$$

and

$$w_i \stackrel{\text{def}}{=} h'(\tau_2) \approx g'(x(\tau_2))$$

and substitute these relations in equation (4), we obtain a relation of the form
(2)/(3). Then B_{i+1} can be obtained by use of the the *Broyden–Fletcher–Goldfarb–Shanno* (BFGS) formula

$$B_{i+1} = B_i - \frac{B_i r_i r_i^T B_i}{r_i^T B_i r_i} + \frac{w_i w_i^T}{w_i^T r_i}. \quad (5)$$

The value of the scalar i in equation (2) is given by

$$\gamma_i = \frac{\delta^2}{2\delta + 1},$$

Where

$$\delta = \frac{\tau_2 - \tau_1}{\tau_1 - \tau_0}.$$

Extensive numerical experiments have confirmed the need for care in choosing three values $\{\tau_k\}_{k=0}^2$. Ford and Moghrabi [2] described one successful method for choosing suitable values, involving distances computed by using a metric

$$\varphi_M(z_1, z_2) = \sqrt{(z_1 - z_2)^T M(z_1 - z_2)} \quad \forall \quad z_1, z_2 \in \mathcal{R}^n, \quad (6)$$

where M is a symmetric positive dfinite matrix in $R^{n\times n}$.
This leads to the adoption of the following two approaches for definition of the set $\{\tau\}_{k=0}^2$ [2],

A. Accumulative Approach

Taking $\tau_2 = 0$, the values τ_1 and τ_0 are computed by accumulating distances between consecutive pairs of points [2]. Hence

$$\tau_2 = 0; \tau_k = \tau_{k+1} - \varphi_M(x_{i+k}, x_{i+k-1}), \text{ for } k = 0, 1.$$

B. Fixed Point Approach

Again we take $\tau_2 = 0$, but this time find the values of τ_1 and τ_0 by measuring the distances from $x_{(i+1)}$ to x_i and $x_{(i-1)}$ directly [2]. It follows thatτ_2=0; τ_k=$-\varphi_M(x_{i+k}, x_{i+k-1})$, for k=0,1.

For both approaches, possible choices of the weighting matrix M are

- M = I;
- M = B_i;
- M = $B_{(i+1)}$.

Each choice gives rise to a corresponding algorithm, which we represent by A1, A2, A3 (accumulative methods) and F1, F2, F3 (fixed-point methods), respectively.

Numerical experiments with these methods showed significant improvements over the standard single-step BFGS method [2].

II. SKIPPING TECHNIQUE

In many situations, one of the more expensive operations in the code for a quasi-Newton method is the updating of the inverse Hessian approximation H_i $(= B^{-1})$ to produce H_{i+1}. This is an $O(n^2)$ operation. Following the idea of Kolda et al. [4] and Fukushima et al. [5], we propose to investigate `skipping' certain of these update operations in order to reduce the computational burden. We recognize that omitting to update $H_i$ on every iteration may lead to an increase in function evaluations and/or iterations (because we will be using an `older' approximation to generate some of the search directions), but any such increase will be offset (in computational terms) by the reduced number of update operations. In this paper, we intend to investigate the simplest implementation of this proposal: namely, that of skipping the update on every second iteration. This leads to the following general algorithmic form:

1. Choose x_0 and H_0; set $i = 1$.
2. Compute $p_{i-1} = H_{i-1}g_{i-1}$, perform a line search along $\{x_{i-1} + t_{i-1}p_{i-1}\}$,giving a value of t_i for t, and set $x_i = x_{i-1} + tp_{i-1}$.
3. Compute $p_i = -H_i g_i$, perform a line search along $\{x_i + tp_i$, giving a value of t_i for t, and set $x_{i+1} = x_i + t_i p_i$.
4. Update H_{i-1} to produce H_{i+1}.
5. Check for convergence; if unconverged, then $i := i + 2$, and go to step 2.

III. NUMERICAL RESULTS

The new two-step skipping methods were compared with the existing twostep methods and the standard one-step BFGS method (i-e both non-skipping and skipping modes) also. All the algorithms in these experiments employed the BFGS formula to update the inverse Hessian approximation

$H_i \stackrel{\text{def}}{=} B_i^{-1}$,

but(in case of multi-step methods) with the usual vectorss_i and y_i replaced by r_i and w_i in the case of multi-step methods

$$H_{i+1} = H_{i-1} + \left(1 + \frac{w_i^T H_{i-1} w_i}{r_i^T w_i}\right)\frac{r_i r_i^T}{r_i^T w_i} - \left(\frac{H_{i-1} w_i^T r_i^T + r_i w_i^T H_{i-1}}{r_i^T w_i}\right) \quad (7)$$

A total of 15 test functions were employed in the experiments with dimensions ranging from 2 to 200, raising the test function set to 93. These were chosen from standard problems described in the literature [10]. For each function, four different starting points were used, giving a total of 372 test problems.

TABLE I. TEST PROBLEMS AND DIMENSION

No	***Problem***	***Dimension***
1.	Extended Rosenbrock	2, 20, 26,40, 60, 80, 100, 120
2.	Extended Wood	4, 12, 24, 48, 68, 92, 112, 140
3.	Extended Powell Singular	4, 8, 60, 100, 140
4.	Penalty 1	10, 14, 20, 30
5.	Penalty 2	10, 16, 24, 30
6.	Modified Trigonometric Function	16, 32, 64, 95, 128, 150
7.	Broyden Tridiagonal	18, 36, 72, 90, 108, 144, 186
8.	Discrete Boundary Value	20, 38, 60, 90, 120, 136, 188
9.	Discrete Integral Equation	20, 84, 100, 150, 175, 200
10.	Freudenstein and Roth [11]	28, 52, 85, 118, 190
11.	Variably Dimensioned	30, 55, 75, 100, 130, 150
12.	Merged Quadratic [11]	30, 50, 70, 110, 136, 180
13.	Discrete ODE II [12]	33, 44, 66, 88, 110, 176
14.	Discrete ODE I [13]	42, 58, 78 96, 114, 160
15	Extended Engvall Function[11]	64, 76, 88, 104, 155, 196

These test functions were classified into the following subsets (where n is the dimension of the vector x):

1. Low: $(2 \leq n \leq 20)$,
2. Medium: $(20 \leq n \leq 60)$,
3. High: $(61 \leq n \leq 200)$,
4. Combined: $(2 \leq n \leq 200)$.

In total there were 15, 24 and 54 functions in the `low', `medium' and `high' subsets, respectively. These gave 60, 96 and 216 test problems in the three subsets. All functions are from J.J. Mor_e, B.S. Garbow and K.E. Hillstrom [10], unless otherwise indicated Summaries of the results from this set of experiments are presented in Table II, III, IV and V. For each method the total number of function/gradient evaluations, iterations and time to solve all problems in the given test set is stated. The best result, incase of function evaluation, for each set is highlighted with bold textand incase of execution tiom with bold & italic.

Focusing attention on the results given in Table II and III, we observe that nearly all the two-step skipping methods are compatible, and in some cases performing better, with Single-step BFGS skipping method. Following conclusions can can be drawn while evaluating the numerical performance of BFGS skipping method and two-step skipping methods in Table II and III [1]:

- It is proved that in low and medium dimension, in case of function evaluation, **F1 Skip** is outperforming the BFGS Skip method. On the other hand ***BFGS Skip*** is wining on execution time over all the two-step skipping methods.
- The results of single and two step skipping methods in high dimension illustrates that ***F1 Skip*** is outperforming the BFGS Skip method in, both, function evaluation and execution time. Though, it can be noted that in case of computational time A1 Skip is also compatible with BFGS Skip and F1 Skip.
- It is evident from the results, provided in Table III, that ***F1 Skip*** is outperforming BFGS Skip in, both, function evaluation and computational time.

TABLE II. RESULTS FOR SKIPPING CASE

Methods	Evaluations	Iterations	Time (sec)	Problem set
BFGS Skip	16142	10805	2.39	
A1 Skip	20276	1279	2.69	
F1 Skip	**15507**	**10199**	**2.46**	
A2 Skip	16206	10640	2.68	**Low**
F2 Skip	16307	10845	2.84	
A3 Skip	16321	10869	2.58	
F3 Skip	14753	9981	3.05	
BFGS Skip	17788	10722	**3.19**	
A1 Skip	17607	10649	3.20	
F1 Skip	**17419**	**10559**	3.21	

A2 Skip	17607	10728	3.54	**Medium**
F2 Skip	17679	10701	3.63	
A3 Skip	17700	10672	3.38	
F3 Skip	17715	10762	3.52	
BFGS Skip	42787	25422	18.95	
A1 Skip	42045	25141	**18.34**	
F1 Skip	**42044**	25326	18.63	
A2 Skip	42232	25903	19.91	**High**
F2 Skip	42672	25451	19.80	
A3 Skip	42108	**25120**	19.12	
F3 Skip	42452	25720	19.76	

TABLE III. TABLE 3: RESULTS FOR SKIPPING CASE

Methods	Evaluations	Iterations	Time (sec)	Problem set
BFGS Skip	76717	46949	24.63	
A1 Skip	79928	48069	**24.32**	
F1 Skip	**74970**	**46084**	**24.39**	
A2 Skip	76045	47271	26.24	**Combined**
F2 Skip	76656	46997	26.35	
A3 Skip	76129	46661	25.17	
F3 Skip	76622	47176	26.05	

TABLE IV. RESULTS FOR NON SKIPPING CASE

Methods	Evaluations	Iterations	Time (sec)	Problem set
BFGS	13095	10665	2.55	
A1	12098	9720	2.42	
F1	12123	9490	2.39	
A2	12468	9652	2.80	**Low**
F2	13099	10357	3.04	
A3	12115	9226	2.52	
F3	13551	9976	2.15	
BFGS	16664	15518	4.73	
A1	13848	12397	3.98	
F1	14098	12366	4.00	
A2	15130	13241	4.02	**Medium**
F2	13372	12405	4.56	
A3	13959	12535	4.28	
F3	15106	12873	4.70	
BFGS	44251	42320	40.64	
A1	34204	31915	29.64	
F1	34757	31806	29.87	
A2	35876	32145	31.17	
F2	33421	31342	30.14	**High**
A3	35856	33768	32.20	
F3	33425	33425	31.84	

TABLE V. RESULTS FOR NON SKIPPING CA

Methods	Evaluations	Iterations	Time (sec)	Problem set
BFGS	74010	68503	48.02	
A1	60150	54032	36.13	
F1	60978	53662	36.35	
A2	63474	55038	38.76	**Combined**
F2	60243	54104	37.83	
A3	61930	55529	39.08	
F3	66058	56279	39.68	

CONCLUSION

Therefore, by above discussion it can be conclude that two Step Skipping methods (specially F1 Skip) is performing better than the single step skipping method (BFGS).
On the other hand, following conclusion can be drawn by comparing the results of skipping methods (Table II, III) and non skipping methods (Table IV, V):

- It is evident that all the **skipping methods** (single and two step) are wining on iteration and computational time in comparison with corresponding non skipping method. Though, an increase in number of evaluationcan also be noted in both single and two step skipping methods.
- Over all **F1 Skip** is winning over skipping and non skipping versions of single and two step methods.

In future we intend to focus on a technique where decrease in number of evaluation in the case of skipping methods can be addressed without losing the property of reduction in computational time.

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Design and Performance Evaluation of Desktop Rod Electrode Discharge EDM Machine in Pure Water

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Abstract**—**Home EDM wire cutting technology has an irreplaceable position in special processing with continuous development and improvement [1]. The current EDM machine tools on the market are almost large and medium-sized. It is easy to cause waste of resources when cutting small parts. In the case of special processing courses offered by many colleges, vocational and technical schools. The laboratory is equipped with industrial-grade electric discharge wire machines. it requires a lot of floor space. The cost of cutting machine tools is very and it is not convenient for unprofessional to understand its processing principles and actual processes, if we are not very careful and system failure may happen such as wire breakage or other problem and so on. In recent years, the equipment is moving in the direction of miniaturization. Desktop-level 3D printers, milling machines have already appeared, and the field of small wire-cut EDM machine tools is in a blank paper. In this context, this article proposes to design desktop-level WEDM on the basis of industrial-grade machine tools based on the use of Small-diameter rod-shaped electrodes cutting. The mechanical structure of desktop-level EDM machine tool is designed so that it can be used for cutting small workpieces and teaching demonstrations. Compared with industrial-grade machine tools, it also greatly reduces the energy consumption of cutting small samples. It is more convenient for EDM machine equipment and transportation and popularization in the laboratory. Important parts such as ball screws were checked, various supporting parts were self-designed and the machine tool motion control system was designed.

Keywords: WEDM, desktop machine, rod electrode, dielectric as water.

I. INTRODUCTION

EDM (Electrical Discharge Machining) is a special processing method for etching the residual material of conductive workpiece by immersing the working fluid and connecting the two poles of the pulse power supply. EDM (WEDM) is an important part of EDM. Its machining principle is essentially the same as that of EDM: using moving wire (copper wire or molybdenum wire) as tool electrode to connect the negative electrode of pulse power supply. Conductive material or semi-conductive material to be processed parts connected to the positive electrode of pulse power supply, and add sufficient working fluid with good insulation between the poles. When the pulse power gives off a continuous high frequency pulse signal, a certain potential difference is formed between the tool electrode and the workpiece to be processed. If the distance between the two reaches the normal discharge gap, the electrolyte with insulation performance will be broken down. An instantaneous spark discharge is formed between the poles. Discharge produces a large amount of heat, instantaneous high temperature (up to more than 1000℃) makes the workpiece local metal material quickly melt to melting point, even to boiling point until a small amount of gasification, gasification of metal vapor and working fluid will instantly expand, accompanied by local micro-explosion, Under the force of thermal expansion and micro-explosion, the candle removal product will be thrown out of the cutting seem to realize the cutting of the workpiece[2, 3]. The electric motor drives the running of the wire storage tube during the machining of the industrial grade EDM machine, thus driving the operation of the electrode wire, while the workpiece to be machined is fixed on the coordinate table of the machine tool. According to the input NC program control processing to obtain a certain shape of the workpiece [4].

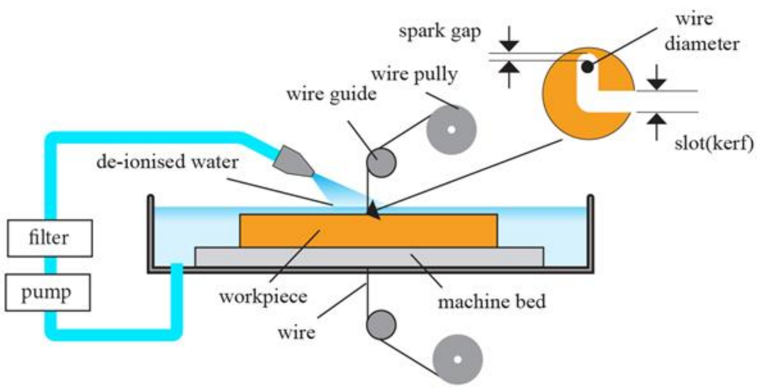


Figure 1: Basic principles of EDM

There are many researchers has been working on EDM since its birth in 1970, after decades of development, the machining performance of high-speed EDM wire cutting machine has been continuously improved, and it is in the leading position in the machining of large thickness and large taper workpiece. Before the 1980s, its machining accuracy and machining efficiency are equal to that of low-speed EDM machine. However, in recent years, the high-speed WEDM machine has been gradually surpassed by the low-speed WEDM machine in addition to maintaining certain advantages in the cutting of large thickness workpiece. The fundamental reason is that the theoretical research of high-speed WEDM machine is very slow [5,6].

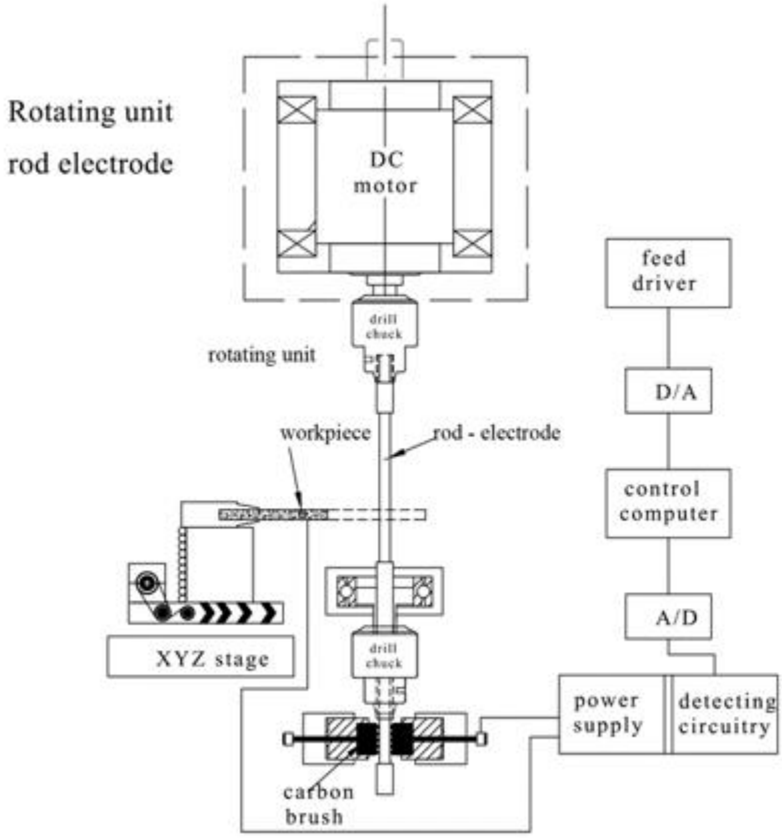


Figure 2: Design and configuration of rod electrode discharge EDM

At present, most of the WEDM machines in the market are large and medium, covering a large area, complex structure, high price, and difficult to maintain. This creates two contradictions: one is that a large proportion of the parts and products processed by WEDM are small, small in size and quality, and that the use of large and medium-sized machine tools is overused of large materials, which is actually a waste of resources and economy; the other is that many universities and vocational and technical schools with machining-related courses contain EDM-related contents and require various EDM teaching experiments, but they do not have specific production tasks, and generally do not need large and medium-sized expensive EDM machines[7, 8].

In recent years, the equipment is developing towards miniaturization, and miniaturization manufacturing is also a new field and new development in the future of mechanical manufacturing. It aims to optimize the allocation of resources and sites with the least amount of resources and reduce investment to improve the utilization rate of resources. As a result, the table-top lathe milling machine and so on have come out one after another, the table-top machine has the advantages of small volume, small inertia mass, small calorific value, low energy consumption, low cost and high efficiency, which can save energy, save manufacturing space and resources, and meet the requirements of contemporary energy saving and environmental protection [9]. Industrial WEDM machine tools are widely used and are standard equipment in large machining laboratories. There is no desktop-level wire-cutting machines, however, and processing equipment such as industrial-grade 3 D printers and milling machines have emerged, and for example 3D printers have been widely used [10, 11, 12].

In this context, this paper proposes to design desktop level EDM machine to consider the basic principle of EDM where the pulse spark generates between the tool and work piece (positive, negative electrode) and metal start to remove material and get in required in shape in Fig. 1. So, for. This desktop level EDM tools can be used for small sample cutting, mainly for small workpiece, so that everyone can understand their working principle. It is difficult for unprofessional to see the process of EDM in special machining laboratory. In this paper, the mechanical structure determined by the original function of WEDM machine is reduced and optimized, and the small diameter rod electrode is used to realize the cutting, so that the rod electrode EDM machine is modified to make it suitable for teaching demonstration and small sample cutting.

II. SYSTEMATIC DESIGN OF ROD ELECTRODE EDM

The systematic design of rod electrode discharge EDM is present in Fig. 2. The rotating unit is considered main part to rotate rod electrode and workpiece used to move forward and backward in the feed direction for the electrode feeding. The wire electro discharge function is similar as grinding phenomena which rotate together with workpiece and rod electrode and a computer-controlled system is established for this system.

The rotating unit is mounted on top an aluminum profile and connected with various supporting plates. The electrode is rotated together with the inner spindle of the rotating head supported by precision ball bearings and driven by a DC motor [13]. This led to bring the addition of an indexable rotation axis of the workpiece which tolerable the advance of effectively different WEDM grinding and turning procedures, but also to the machining positioning subsystem of the workpiece by its rotation round an axis [14]. As for the rode electrode discharge machine tool making, there are a few conventional strategies such as wire changing, capillary tube. Design configuration of rod electro discharge machine and reverse of WEDM. But compared with these, the wire electro discharge grinding is proficient of getting higher accuracy both in estimate size and shape [15]. Its distinct strongpoint is that the diameter of machined electrode is precisely kept by the wire movement along the wire guide, thus compensating the wire wear in its radial direction [16]. As shown in Fig. 1, a rode electrode is shaped by compound movements of wire moving, electrode feeding and rotating, based on the electro-discharge machining rule.

Theoretically, material volume remove by a single pulse in EDM process is proportional to its discharge energy. The discharge energy Wp of a single pulse can be expressed as in [Eq. (1)

$$Wp = \int_0^T u(t) \cdot i(t) \cdot dt \qquad (1)$$

where T, t are pulse width and discharge duration time, and u(t), i(t) are discharge voltage and current respectively. The minimization of discharge energy Wp of a single pulse, down to the order of 0.1–1 μJ, is needed for rod electro-discharge machining. From Eq. (1), there are some possibilities and ways to reach it, by decrementing either the value of voltage and current or the pulse width. But it is additionally kenned that only when the discharge voltage and current reach up to a certain range, though it varies with the different electrode and workpiece materials, electro discharge machining can be kept perpetually. Thus, the feasible method for the minimization of discharge energy of a single pulse is to decrement the pulse width. Then an RC circuitry is considered opportune for the rod-electrode discharge generation.

III. DESIGN OF HARDWARE SYSTEM

The desktop rod electrode wire cutting machine adopts small diameter rod electrode and pulse power supply as energy. Its non-contact machining form makes the machining process without macroscopic force and can almost process any conductive material. Because it is difficult for small machine tools to realize high speed wire walking, in order to ensure that small machine tools can be processed normally and reduce wire breakage rate as much as possible 0.8 mm small diameter rod copper rod is used as electrode material, that is, rod electrode. In order to make full use of the electrode material cutting, this paper starts with the synchronous rotation structure of the cutting electrode. Thus, the table level EDM machine will be composed of a mechanical structure frame, coaxial rotary motor, NC coordinate table, pulse power supply, working fluid circulation system, several modules and other detail designing procedure will be discussing below. In Fig. 3. 3D CAD model of present invention machine is illustrated.

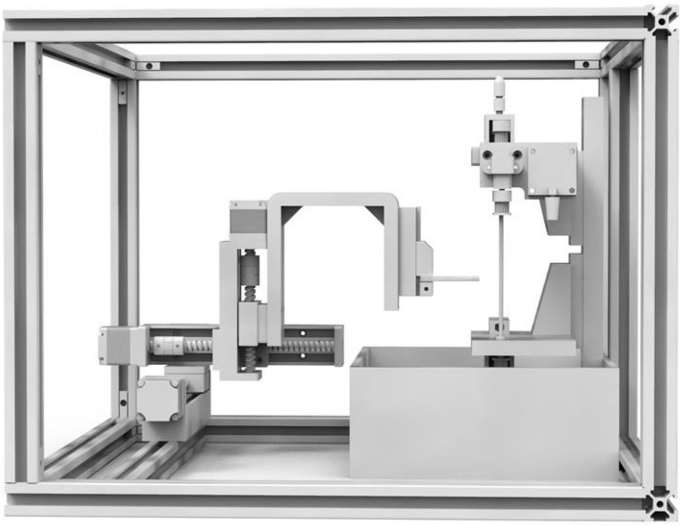


Figure 3: 3D CAD model of present invention rod electrode discharge EDM

A. External supporting frame

Taking into account all the mechanical structure and the overall size of the desktop EDM machine designed in this paper is 370 mm ×410 mm ×300 mm, in Figure 3-a. Select TDT industrial aluminum profile to form an outer frame, mainly to play a supporting role. Density of this material is only g/cm 2.73. Angle slot connectors are used to connect aluminum profiles with M5 inner hexagonal disc head screws and special trapezoidal nuts. The angle slot connectors are used for right-angle connections between the two profiles. The connectors are corrosion-resistant, reliable, waterproof and rust-resistant It has excellent corrosion resistance in most environments and aluminum profiles are not ferromagnetic. It is an important feature in the electrical and electronic industries. Arrange the Y shaft working slide table and coaxial rotary motor on the outer frame and give the center of gravity to working system and make system more stable. The connection mode structure is shown in Fig. 4(a).

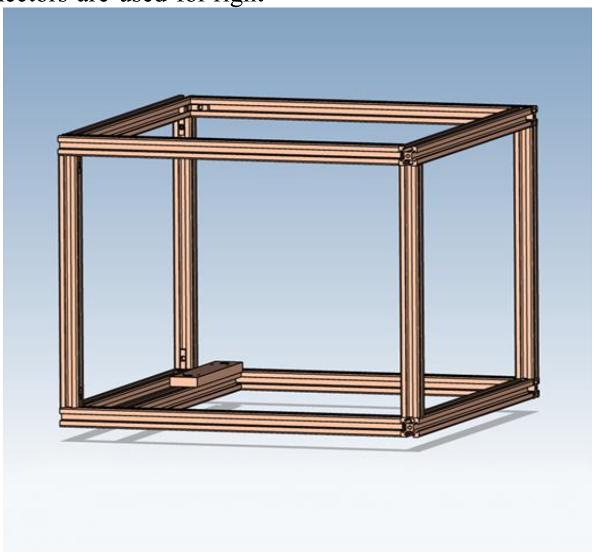


Figure 4(a): Mechanical structure of EDM

B. Alignment of rod electrode

The EDM depends on the electrode to discharge the workpiece. In order to ensure the machining quality and reduce the wear of the electrode in the machining process, the electrode needs to maintain a certain stability. That is, in the process of processing will not be pulled and compressed and other problems. In order to realize the rotation of rod electrode, the main effect of rotation of the rod electrode changes the unilateral wear of the rod electrode to circumferential wear, which can make the wear more uniform, reduce damage electrode, maintain sparking and improve the motion stability during the working process. It can achieve high precision by rotating motion under small tension.

The Alignment of rotating unit is similar to mini lath, which is composed of various parts in Fig. 4(b). A fixed motor on the right side of the upper support plate is connected to 12 V of power supply, and the motor shaft and the synchronous pulley installed on it are transitioned to drive the synchronous pulley to rotate at a certain speed. The shaft 1 and the upper and lower support plates are equipped with bearings to reduce friction. The electrode material is clamped on shaft 2, both ends are fixed with chuck, and the rod electrode can pass through from top to bottom in turn. This synchronous rotation can realize the rotation of different cutting electrode materials (copper wire or small diameter tungsten rod) with certain diameter.

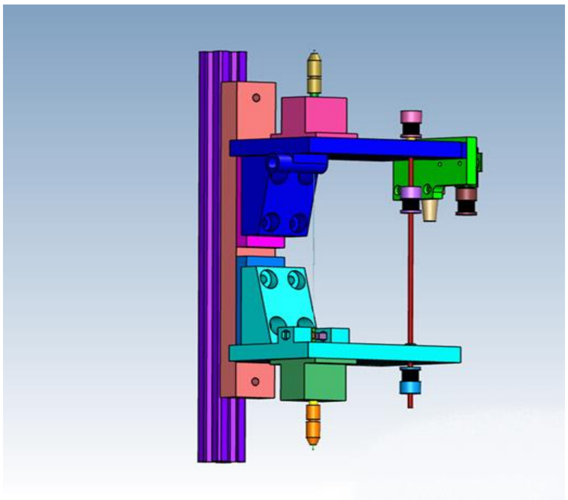


Figure 4(b): Rotating electrode clamp design

The coaxial rotary motor module should realize the adjustable rod electrode speed of 10~200 r/min, select the micro-DC motor with rated voltage of 12 V, no-load speed of 300 r/min, load speed of 240 r/min, model of N20, and with rated current of 5 mini PWM governor to achieve speed adjustment. The specific parameters micro-DC motor and PWN governor are shown in Table 1 and 2 respectively.

Table 1. N20 DC motor technical parameters

DC/V of rated voltage	r/min no-load speed	Load speed r/min	kg/cm of rated torque
12	300	240	0.50
m A rated current	kg/cm of blocking torque	m A of blocking current	Slower than 1:00
300	4.00	300	100

Table 2. PWM Governor technical specifications

DC/V of operating voltage	Control power W	Static current A	PWM duty cycle	PWM frequency KHz	Net kg
5~30	120	0.015	1%~100 %	12	0.01 5

C. NC coordinate table

The worktable on which the workpiece will be installed for the cutting track as known as NC coordinate table, which include fixture with supporting beam piler and three small micro precision linear actuators with stepper motors, which respectively control the X, Y and Z direction of the workpiece. The X direction is fixed at one on the aluminum profile, the other two stepper motors are connected by dual-purpose connectors. The cutting size range of workpiece is 100 mm×100 mm and X/Y linear actuators with travel range of 100 mm is selected. While the Z axis is mainly used for workpiece moving up and down with travel range of 50 mm. In Fig. 4(c) shows combination of workbench X, Y, Z – motion.

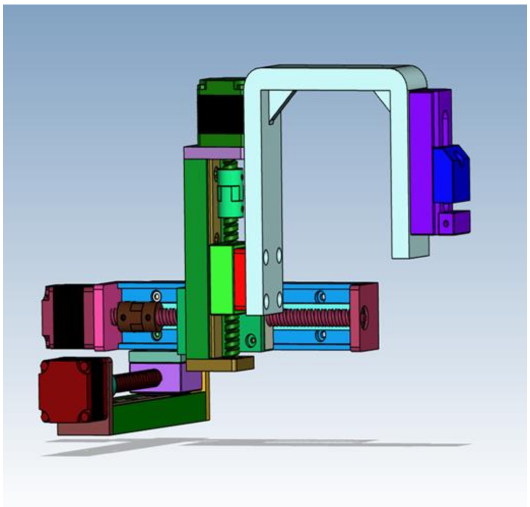


Figure 4(c): combination of workbench X, Y, Z – motion

The construction each linear actuator table is that a two-phase four-wire 28 step motor drives the ball screw rotation through a flexible coupling, and the screw rotation drives the slide table above the lead screw to move in a straight line. The tail end of the screw is equipped with deep groove ball bearings (Type 603) to ensure the coaxiality of the screw and reduce friction between the screw and the slide baffle.

Motor selection: Since the size of the motor should not be too large, thus, in this paper selects a two-phase four-wire motor with a step angle of 1.8°. The thickness of the fuselage is 30 mm and the model is 28 HB30-401A.The specific technical parameters of the stepping motor as shown in Table 3.

Stepper motor is controlled DM430 two-phase four-wire stepping motor driver, and 400 subdivision is adopted, that is, each 400 pulses are rotated once to overcome the low frequency vibration phenomenon.

Table 3. stepper motor parameter table

Step angle	Phase voltage	Phase current	Phase resistance	Phase Electrical
° step 1.8	2.4 V	0.6 A	4.0Ω	2.2 mH
Static moment	Positioning torque	moment of inertia	Number of leads	Weight
0.045 N ·m	0.003 N ·m	g ·cm 6^2	4	105 g

Ball screw selection: ball screw with small friction resistance, high transmission efficiency, high precision, high axial stiffness. To adapt to the size of the external frame and to maintain the portability of whole EDM machine, according to the required cutting workpiece size range 100 mm ×100 mm, select the X 、 Y direction slide table travel range 100,100 wire screw distance 1 mm, precision 7, Select ball screw model GB17587-6×1×100.

Fluid circulation system: In the bottom a water tank provides a place for water circulation, and a water pump is placed in the water tank, which is connected to a water spray plate also installed on the aluminum profile, through a water pipe to procced the function of water circulation. The water circulation function begins when the workpiece is processed. Water to achieve the effect of cooling the workpiece and the electrode.

IV. CONTROL SYSTEM

In this paper, the control system of desktop wire cutting machine tool is not only the speed control of coaxial stepper motors, but also the machining track control. The control system accuracy and stability are related to the overall machining effect of the machine This control system mainly the control of the X, Y, Z coordinate worktable and continuously generates vertical and horizontal motion by given instructions. To obtain the target shape and size of the workpiece the design precision of this paper is not high, the open loop servo system is chosen, the cost is low, the structure is simple, and it is convenient for maintenance [17]. From the SD card input to process the track coordinate information, then by the single chip microcomputer to process the track interpolation operation, and send motion instructions to the stepper motor driver to drive the stepper motor motion, to achieve cutting function. The control functions of the control system include:

i. System initialization;

ii. Table reset;

iii. Input machining trajectory coordinates;

iv. Emergency shutdown, keyboard scanning;

v. Worktable over-range display, installed on the machine limit switch, when the worktable displacement over the stroke, can immediately stop the worktable movement;

vi. Manual control of the worktable;

vii. Automatic control and linkage control of workbench.

In figure 5. the controls system consists of display panel (including keyboard and LED display screen), main STM32 controller, three stepper motor drivers, three stepper motors and pulse power supply.

(a) LED display screen (b) STM32 Single-chip (c) Progressive Motor Driver

Figure 5: Control system main component

A. process motion control process

Stm32 the single-chip microcomputer starts, the first step is to manually control the motor part. The function of the manual control part is to adjust the step motor by keyboard scanning before cutting to make the clamping part reach the best position and complete the cutter of EDM wire cutting so that the back can be cut smoothly. In Fig. 6 shows the motor drive diagram system

The automatic control part requires the input of coordinate information in the SD card first, and then stm32 will read the coordinates from the SD card and cut automatically according to the coordinates. The cutting algorithm is a interpolation algorithm, which is basically divided into two categories: straight line interpolation and arc interpolation. It can be modified according to the existing interpolation algorithm, and the code of Z axis motion can be changed to make the Z axis move up and down. In order to avoid cutting process, rod electrode consumption is too fast.

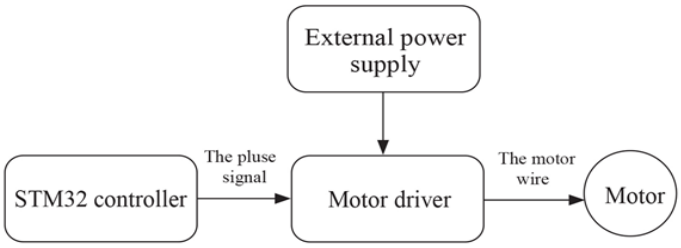


Figure 6: Motor drive diagram

B. *interpolation algorithm selection*

The interpolation refers to the process of calculating the moving path of the X, Y direction tool in the NC system of machine tool, in which the interpolation algorithms commonly used in the NC system are point by point comparison method and digital integral method (Digital Differential Analyzer, abbreviated as DDA method).

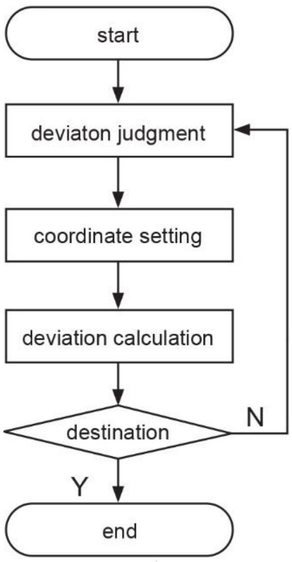


Figure 7: Principle of point-by-point comparison

The basic principle of the point-by-point comparison method is that the relative position between the tool and the machined part contour is continuously compared in the process of the tool moving according to the required trajectory, and the feed direction of the next step is determined according to the previous comparison results. The algorithm program diagram is as follows in Fig. 7.

V. EXPERIMENT SETUP

The experiments were conducted using the present invention prototype desktop-level machine tool based on a small diameter rod electrode in Fig. 8. The relaxation type pulse generator is selected which is able to generate a pulse at different levels of energy. Capacitance with five different levels (stray capacitance, 10pf, 100pf, 220pf, 3300pf) has been set for this machining process, and the open-circuit voltage range from 20V – 120V. The polarities of the tool electrode and workpiece can be reversed for testing. The dielectric fluid used for the experiment was pure water, a wide range of pulse energy level can be achieved by setting the machining parameters.

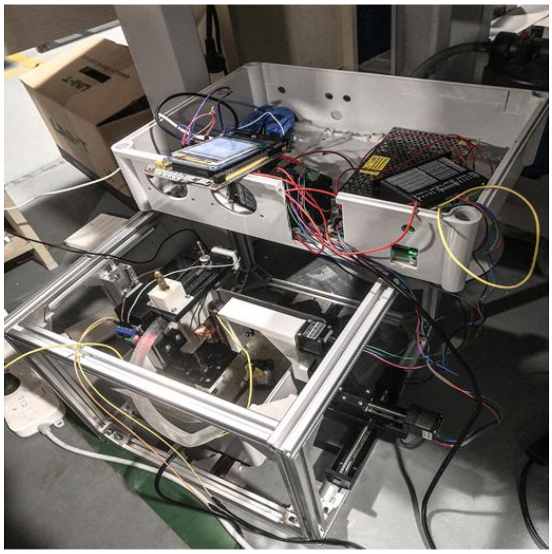


Figure 8: Prototype design desktop rod electrode discharge EMD

Silicon, Iron, and steel are used as a workpiece for this experiment. Iron and are steel are highly conductive materials, their superior hardness, toughness, and corrosion resistance make them ideal for structural components, building, automotive applications, chemical processing, power generating equipment, roads, railways, and other infrastructure. Most large modern structures, such as stadiums and skyscrapers, bridges, and airports, etc. while silicon is hard, dark grey, and lustrous semi-conductive metal that is used to manufacture steel, solar cells, and microchips.

As for tool electrode concern, a variety of tool metals can be used such as copper, brass, aluminum alloys, silver alloys, etc. therefore, the electrode used in this experiment was a rod copper with a 0.8mm diameter regarding the machining parameter settings up, three levels of voltage, two levels of capacitance, and positive and negative workpiece polarities were considered. Table 4, shows the details of the experimental parameters.

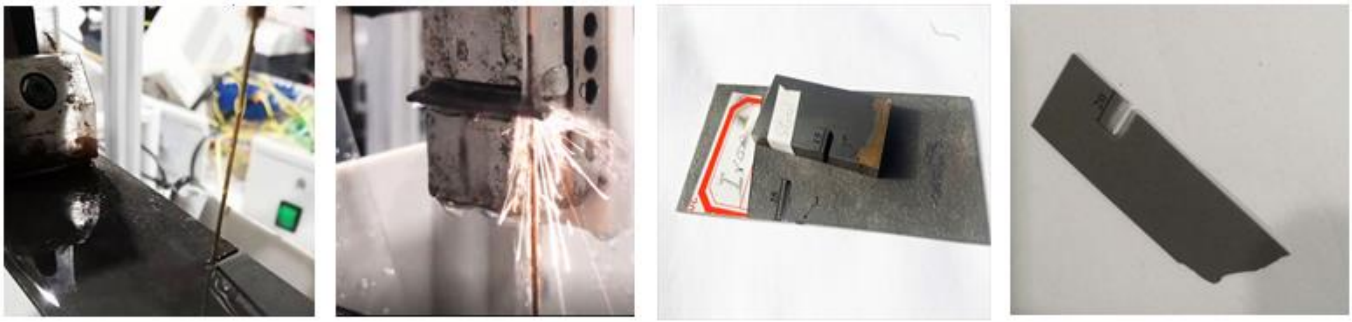
Table 4. Experimental parameters

Workpiece	: 304 stainless steel/ Irone/ Silicon
Tool electrode	: Copper rode with 0.8mm diameter
Dielectric	: pure water
Pulse generator	: RC circuit
Open circuit voltage	: 60V, 90V, 120V
Capacitance (pf)	: q3:220 pf, q4:3300 pf
Pulse duration	: 28-30 µs
Pulse interval	: 270 µs
Workpiece polarity	: Positive (+), Negative (-)

A. Experimental procedure

For a smaller scale base on rod electrode discharge EDM, the sensitive plan is requested for the development of this mechanical structure, but the machining strategies were complicated. In common, there are numerous factors affecting EDM procedure, such as cathode, setup alignment, electrode vibration, and workpiece materials, dielectric fluid, electro discharge energy release vitality each pulse and the pulse recurrence, in order to limit the variety of the trial's experiments, a standard experimental procedure was recognized

The first three samples were prepared; 1 mm thickness silicon sheet metal used to prepare the workpiece which was cut into 20 mm long. Second sample, 5 mm thickness 304 stainless steel sheet metal workpiece which was cut into 15 mm long, and the final sample, 1 mm thickness iron sheet metal which was cut into 25 mm long. In all of the following machining experiments, water is being used as the dielectric liquid, and the tool electrode was a copper rod with a 0.8mm diameter. The power supply output voltage is set up at 100V ant the resistance used in the RC circuit is 850Ohm. The electrode rod's rotation speed is set at 50 r/min.



(a) Workpiece installation (b) Spark generated during process (c) Iron and steel experimentally cut (d) Silicon experimentally cu

Figure 9: experiment samples

Figure 9 (a) and (b) show the workpiece installation and spark generating during the process of the experiment while figure c and d show the selected respectively workpieces Iron, steel, and silicon experimentally cut by the present invention rod electrode the discharge machine, by means of the rotation speed of rod electrode of 50 r/min. The feeding step is 25-27 µm. power supply with 05 amperes and the output voltage was set at 100V for each step. The feeding step is smaller, and the machining accuracy in shape will be better in such condition but one of the main drawbacks of this present invention machine was overcut increasing due to the unitability of tension in between two at endpoints of the electrode [18, 19] main reason behind was this because two chucks cannot tightly hold at the end point of the electrode and vibration gradually increase along with rotating speed.

Figure 10: Over cut

B. measuring current and voltage

According to this Eq. (2), the total energy of a single discharge can be determined

$$P = \sum_{0}^{t_{on}/\Delta t} V(t) \cdot I(t) \cdot \Delta t \qquad (2)$$

where $\boldsymbol{V(t)}$ is voltage and $\boldsymbol{I(t)}$ is current data over the discharge duration; ton is the pulse on time; $\Delta \boldsymbol{t}$ is the sampling interval. Tektronix TPS2024 oscilloscope was used to record the discharge voltage and current data. The schematic of the information securing framework appears in Figure 11. Tektronix CT-2 current probe was used to convert from voltage signal to current signal

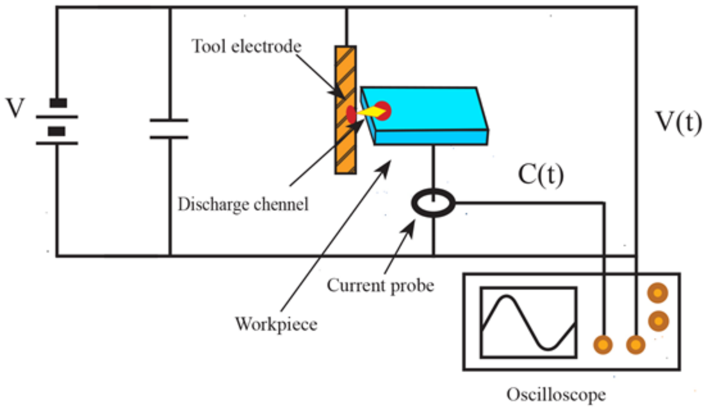


Figure 11: current and voltage signal acquisition schematic

Bight discharges are getting fire during the single discharge experiment. By representing the input factors for each experiment condition, the average current and voltage are analyzed. Before calculating the average, the data needs to be ranged. Figure 12, shows the data reconstruction process. At the spot where the current changes from 0 to positive value, it will be set as time 0. The nature of the discharge station is equivalent to the metal in EDM, then the average values for each sample time are considered based on the new 0 times. Figure 13 shows the condition discharge voltage and current waveforms, where the blue dash line is five measured current and voltage waveforms, which are loaded together. The red lines are their average. This shows high keep changing of the current and voltage signals. The various adjustment between each tool electrode workpiece V C(t) Current probe Oscilloscope V(t)42 is small. It shows the user the averages of the voltage and current to characterize separate voltage and current is practical.

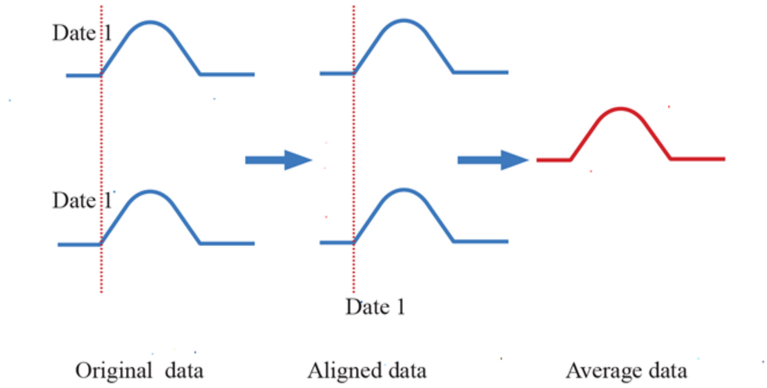


Figure 12: Data reconstruction process

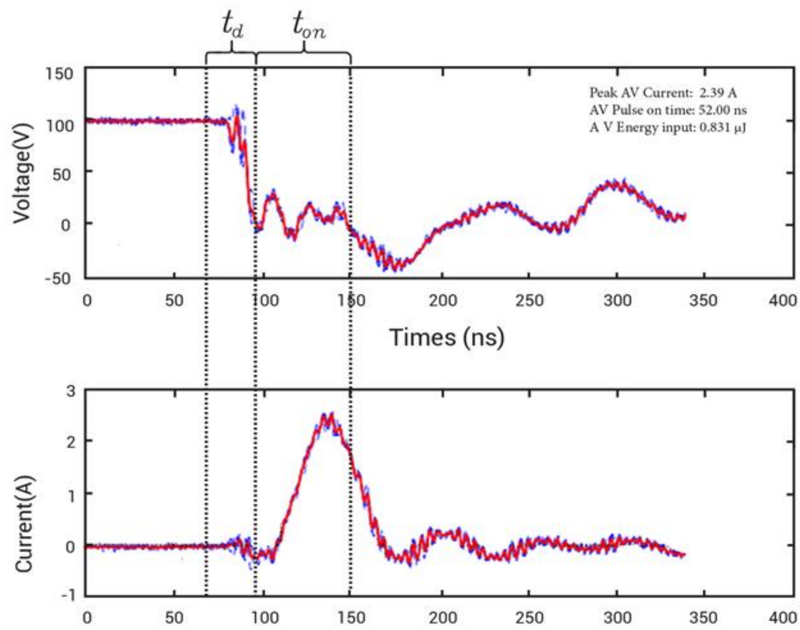


Figure 13: Average current and voltage waveforms

By estimating the release current and voltage waveforms. The pulse ignition delay and pulse on time can be determined by calculating the release current and voltage waveforms. Figure 13 shows the pulse injection timing and pulse on time as td and ton, respectively

VI. RESULTS

In this portion, the results and other factors during the experiments using prototype rod electrode discharge EDM, include flow discharge energy, peak current, pulse on time are discussed. Figures 14 to 16 show the discharge energy, peak current, and pulse on-time independently, they are Perform feature analysis which were introduced in the previous section

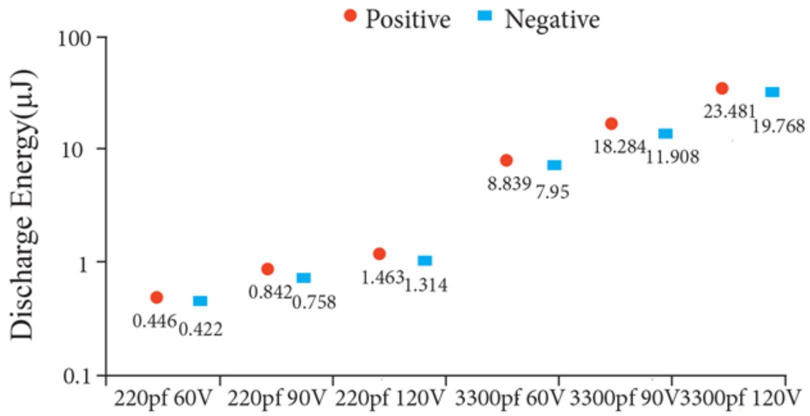


Figure 14: Average discharge energy

The average discharge energies under in various experimental conditions are shown in Figure 14. The discharge energy is just 0.42 J at the lowest point. Results of ANOVA show that the flow of discharge is greatly influenced by voltage, capacitance, and polarity, If the capacitance increases then discharge energy also increase. The estimated discharge power is 17.85 times that of the average discharge power using the 220 pf to 3300 pf respectively. In addition, by increasing the open circuit voltage range which will increase the discharge energy. Energy stored in the capacitor 1/2 CV2 where C is the capacitance and V is the open-circuit voltage. This equation Partly explains why the pulse energy is positively associated with voltage and capacitance level.

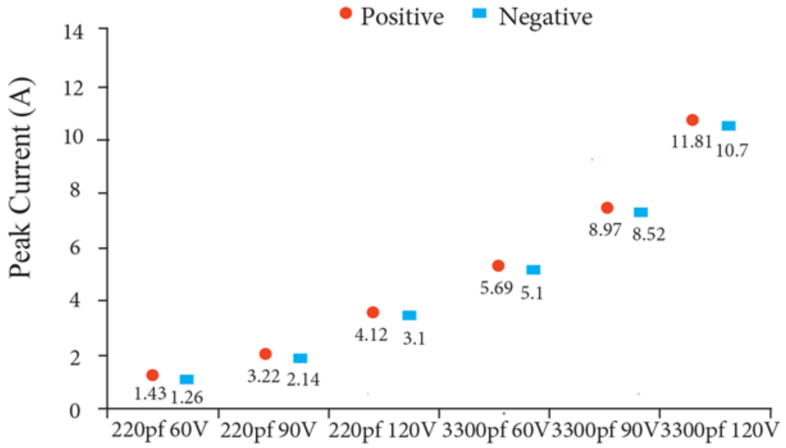


Figure 15: Peak current & average current waveform. [20]

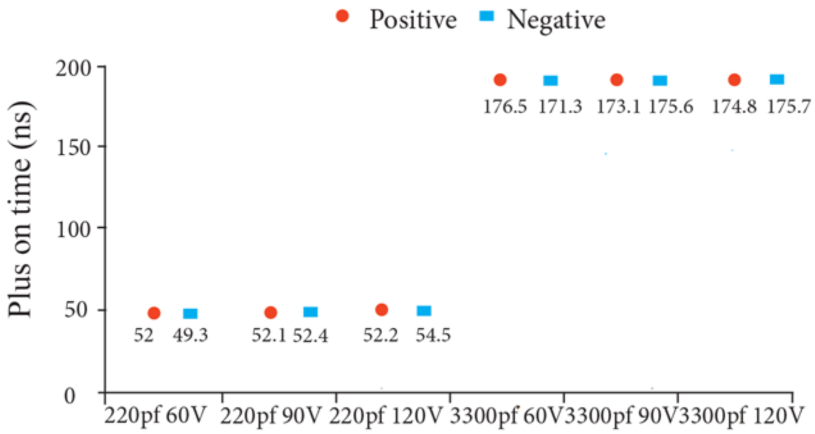


Figure 16: Pulse on tim

In any case, the released energy isn't equivalent to the energy put away in the capacitor. The average limit in the circuit is by one reason causing the distinction. Therefore, when a positive extremity is applied the released energy is higher than a negative extremity is applied. The figure 15 is showing the peak current of the corresponded to the usual average current waveform. The peak current flows are up to 12.4 A, which shows the release discharge process is exceptionally strong. Investigation shows that the peak current is expanding by utilizing the huge capacitor. The increasing of the open-circuit voltage likewise increasing the peak current altogether. Moreover, the change of polarization shows no impact on the peak current.

The Pulse on time appears in Figure 16. The pulse on-time is around 50 ns when utilizing the 220pf capacitor, and around 180 ns when utilizing the 3300pf capacitor. The beat on time is just essentially influenced by the capacitance. Since the releasing time consists of an unwinding type discharge generator is controlled by the hours of opposition and capacitance. The progressions of open-circuit voltage and extremity are not showing critical impact and also will increase because of extreme temperature in the discharge side [21 ,22]; therefore, the continuous discharge are in average limit. If the positive polarity discharge is adopted then the discharge current will increase and the process efficiency will improve

CONCLUSION

A method commonly used in the field of machining in EDM, in which EDM wire cutting uses EDM etching reaction to cut workpiece, which can theoretically process any conductive material and belongs to non-contact machining. Therefore, in this paper, the design of desktop rod electrode EDM machine tool is proposed and uses small-diameter rod-shaped electrodes with a diameter in the range of 0.3mm-3mm with pure water. The size of the workpiece cut by the present invention desktop level rod electrode EDM tool can be as small as the metal plate of 200×200×50mm. The overall frame size of the EDM desktop machine tool is 370 mm×410 mm×300 mm. Coaxial rotating unit, stepping table and the machine tool motion control system was designed which include DC switching power supply, M3S main board, LCD display and DM320, DM420 and other drivers.

The desktop machine tool of the present invention has the advantages of small quality, low cost, small size and simple operation, and can complete processing tasks anytime and anywhere. After appearance design, it can be used in mass production. In addition, there are some improvements in this design, such as improving the accuracy of motion control system, optimizing appearance, further reducing weight and volume, etc.

The machining experiments were conducted on selected workpieces were silicon, Iron and steel using the present invention of desktop level rod electrode EDM tool. The polarity of the electrode was set as positive while that of workpiece was negative. In all of the following experiments, water is being used as dielectric liquid and copper is the material of the electrode rod with 0.8mm diameter. The power supply output voltage is set up at 100V and the resistance used in the RC circuit is 850Ohm. The electrode rod's rotation speed is set at 50 r/min. And the various factors and issues were also discussed the experiment.

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Performance Analysis of Perturb & Observe and Open Circuit Voltage Algorithms for MPPT Tracking at Different Environmental Conditions

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***Abstract*—** Photovoltaic PV is eco-friendly source of energy. Due to increase in ecological pollution and decrease in usual means of power, the importance of non-conventional energy sources has grown up rapidly. The output of PV systems depend on atmospheric conditions like temperature and irradiance. Also efficiency of PV system is very much less which needs to be increased. Installation cost is another problem existed with photovoltaic modules. Different techniques are used to get high power. MPPT of PV system at any condition is necessary to transfer maximum available power. Therefore, to generate maximum power at output of PV, installation of MPPT is necessary. Using MPPT, high efficiency of PV is also ensured. Different algorithms are utilized to track down MPP of PV. Out of all algorithms used, two algorithms are discussed briefly over here i.e. Perturb & Observe (P&O) and Open Circuit Voltage algorithms for MPPT at different environmental conditions by changing irradiance and temperature. Variation in temperature and irradiance level results in different output of PV cell. By changing slight temperature and irradiance, voltage and current at the MPP changes. Results which are obtained as a result of changing external conditions are simulated in PSIM and LTSpice and are then compared with each other. Effect on MPP, maximum voltage and maximum current at MPP are observed by changing environmental and atmospheric conditions like irradiance level and temperature. After comparing both these algorithms. Two different software named PSIM and LTSpice IV are being used for implementation and modelling of PV cell and both algorithms.

***Keywords*—** MPPT, Maximum Power Point Voltage, Maximum Power Point Current, Perturb and Observe and Incremental Conductance.

I. Introduction

Photovoltaic (PV) provides green sustainable mean electric power, of which sun is the fuel, a renewable energy. Due to increase in ecological pollution and decrease in usual means of power, the importance of non-conventional energy sources has grown up rapidly. The main sources of pollution free power includes solar, wind turbine, geothermal, biomass and hydro. However, there are some drawbacks of renewable energy systems which have large cost of installation and small transformation efficiency of photovoltaic arrays. Photovoltaic also has nonlinear IV and PV characteristics curves and is greatly varied with change in irradiance and temperature.

Undeterred all the favorable factors put forwarded by photovoltaic cell energy generation, initial implementation cost is very large and efficiency of transformation of energy is very small. To achieve high efficiency in operation, some techniques are necessary to use for extracting maximum power available at PV panels output. It has been noticed that temperature greatly govern PV output voltage, and output PV voltage and irradiance has both a linear relation.

Normally, there is always a distinctive point on IV and PV curves and that point is known is Maximum power point (MPP) and efficiency of whole photovoltaic system (converters, PV cell, array, etc.) at MPP is maximum and generates its maximum power which is available at the output depending on environmental conditions. As MPP changes with seasons and insolation, it is very impossible to constantly keep track of MPP and get highest power at the output of PV system.

MPPT play vital role in a PV generation system. It has important role due to current and voltage characteristic which is nonlinear in nature of photovoltaic array or module. At changing temperature and solar irradiance, the nonlinear relation between power and voltage that PV becomes more complicated so the solving the problem of MPP analytically gets very difficult and as a result different algorithms have been proposed to track down MPP. All different MPPT are different from each other on the basis on different requirements like the number of required sensors, popularity, implementation hardware, complexity, cost, speed of convergence, efficiency range etc. Many algorithms are put forward to track the MPP that is MPPT of PV array. Those algorithms are Perturb & Observe, Incremental Conductance, short circuit, open circuit algorithm, fuzzy logic controller method etc.

The algorithm which sampled the operating voltage in the required direction to get maximum power, is called P&O algorithm. This iteration will continue unless it finally reaches the MPP.

II. PHOTOVOLTAIC CELL

For understanding the electronic behavior, it is necessary to design an electrical equivalent model of it. This model is based on well define behavior of discrete ideal components of electrical. Ideal PV cell might be electrically designed by current source connected in parallel with the diode. Practically, no ideal PV cell exist, due to which series and shunt resistances are connected.

Figure 1 shows that the total current generated by PV cell is equal to difference of current source and the current that flows through diode, minus the current which flows through shunt resistance

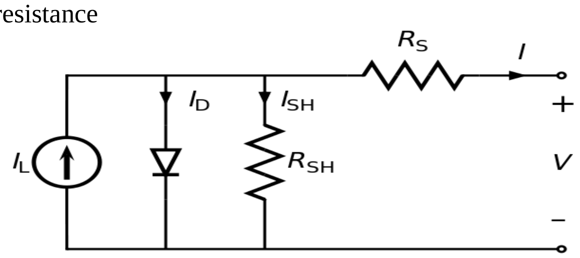

Figure 1. Single Diode PV Cell

Characteristic equation of PV cell is given in equation 1

$$I = I_L - I_O\left(e^{\frac{V+IR_S}{nV_T}} - 1\right) - \frac{V+IR_S}{R_S} \qquad (1)$$

A. *Modelling of PV cell in LTSpice IV*

F Solar cell or Photovoltaic cell is modeled in LTspice and curves between V and I, and V, P are observed at different Irradiance level, parallel and series resistances given in figure 2.

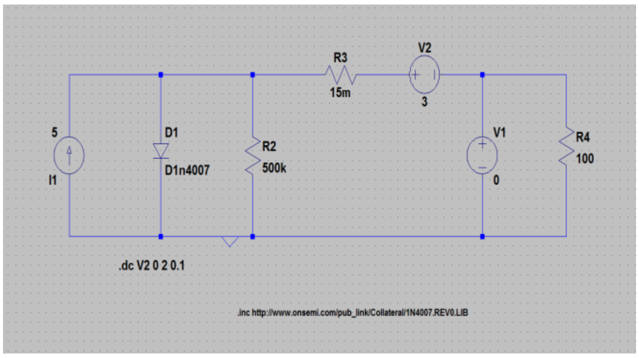

Figure 2. Basic Model of PV Cell

After simulating circuitry of PV cell in LTspice, the curve between I and V that is IV Curve is obtained at different irradiance level as shown in figure 3

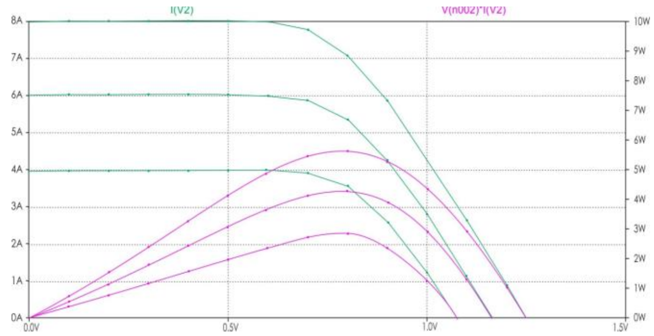

Figure 3. I-V at different Irradiance

B. *Power Loss*

The circuit diagram for calculating power losses in PV cell is given figure 4.

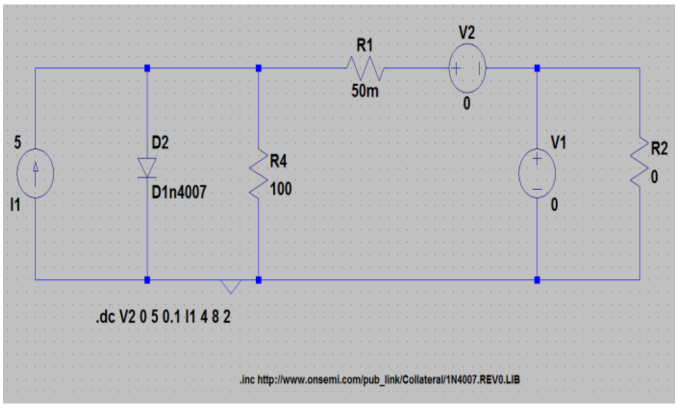

Figure 4. PV cell for Power loss

It has been observed that the current loss due to recombination is more than any other loss in photovoltaic cell. Graph of the power losses in PV cell is shown in figure 5.

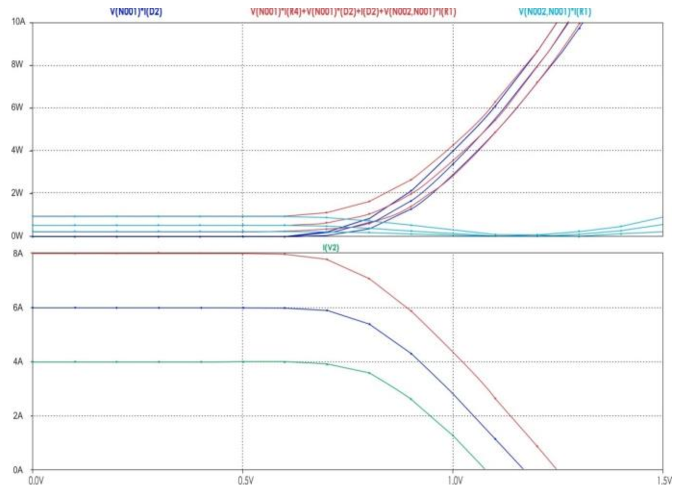

Figure 5. Power loss due to recombination

III. MPPT ALGORITHMS IN PHOTOVOLTAIC CELL

MPPT is the process in which higher and greater is extracted out of photovoltaic module and is done with MPPT controller. By using MPPT, solar system efficiency can be increased gradually. The solar photovoltaic source has been acknowledged the most important resource of energy with the advancements in Power electronic technology. It is environmental friendly energy and is present in a very huge amount which is free. The use of MPPT can enhance PV efficiency. For tracking MPP efficiently, many MPPT methods have been developed. Among all the mostly used algorithms are P&O and Incremental Conductance algorithms. All other algorithms have a lot of drawbacks of either being slow or wrong tracking.

Power versus voltage curve has just on maximum point in normal conditions which isn't problem. But when the array is shaded partially, the number of maximum points increased from one to multiple. So some algorithms are implemented in order to relieve this problem. These techniques differed from each other in many aspects like cost, complexity, sensors required etc. Depending on the objective of the circuit algorithms are suggested that which one should be used.

A. *Perturb and Observe (P&O)*

This is mostly used method on commercial level. In most of the practical PV systems P&O is used dominantly due to its high reliability, simple implementation and high efficiency.

This is actually a trial and error method. In this method, MPPT is usually based on calculating power of PV system and power change by sampling the PV array current and voltage. It is operating by incrementing or decrementing the PV array voltage after fixed time interval.

Suppose a certain perturbation resulting in an increment or decrement in the PV power, following perturbation should be produce in similar or reverse way. Unless the MPP has been reached, chopper duty cycle constantly changed and repeated. It tells that system is oscillating around the MPP. Reducing step size of perturbation can reduce oscillations. But much smaller step reduces speed of MPPT which is its main drawback. For varying values of temperature and irradiance levels, PV system will give different curves and each curve will have highest power. At that stage maximum voltage is being deliver to the converter.

The P&O can easily be implemented but has many disadvantages which include

i) The energy from PV system can't be utilized fully because PV array isn't operated often at MPP due to slow error process and trial.

ii) The PV array operates in the mode of oscillation even if the sunshine is at steady-state which results in inverter output fluctuation.

iii) Because of sudden changes in sunshine the PV system might be failed to track thee MPP in correct direction.

B. *Incremental Conductance*

It is the process in which incremental changes in PV module's current and voltage are measured by controller to forecast impact of voltage change. This algorithm is complex than P&O but track the varying conditions quickly than P&O. It also produces oscillations in power. Under rapidly varying irradiation conditions it track more quickly and accurately than P&O but is costlier circuit.

In this, incremental conductance, dI/dV,of PV array is used to calculate the sign of power changing with respect to voltage, dP/dV. It calculate MPP by comparing incremental conductance (I_Δ/ V_Δ) to array conductance (I / V). The output voltage is the voltage at MPP when both of above conductance becomes equal. Controller will maintain this voltage unless and until a change in irradiance or temperature occurs.

This algorithm works on principal of calculating slope of curves between power and voltage or power and current. If slope is zero of PV array it means that this system in at the MPP, positive slope means left of MPP and negative means right of MPP. Also Inc-Cond is based on the observation that $dP/dV = 0$, and that $P = IV$ at MPP. Current taken from PV is shown as function of voltage: $P = I(V)V$. Hence, $dP/dV = VdI/dV + I(V)$. Taking this to zero gives: $dI/dV = -I(V)/V$. So MPP is achieved if incremental conductance and negative of instantaneous conductance becomes equal.

Two main disadvantages of these techniques are in. Main drawback is that it easily loss track of MPP if irradiance changes quickly. It tracks the MPP very well in case of step change because curve doesn't keep on changing and the change is instantaneous. However, when change in irradiation follows a slope, the curve in which this method is based varies with irradiance, hence change in current and voltage is not just because of voltage perturbation. Hence, it is not possible to find whether power change is because of its own increase in voltage or change in irradiance.

C. *Open Circuit Current*

This uses the rough linear relation between V_{MPP} and V_{OC}, which continuously changes with change in temperature and irradiance level

$$V_{MPP} = K_1 V_{OC}$$

K_1 is constant number which is dependent on PV module properties and it should be calculated in advance by measuring V_{MPP} and V_{OC} for different temperatures and irradiation levels. The value of $K_1$is being reported among 0.70 ad 0.77.

As $K_1$is known, value of $V_{MPP}$is measured periodically by calculating the open circuit voltageV_{OC}. The converter needs to shut down momentarily for the measurement ofV_{OC} so in every measurement power loss occurs. Other problems in this technique are that this technique is not capable of tracking MPP under irradiance slopes, because the determination ofV_{MPP} is discontinuous and also because the relation is just supposition so the MPP reached is not the actual one.

Some techniques have been proposed for overcoming these problems. Like the use of pilot cell for obtaining open circuit voltage V_{OC}. Pilot cells are like PV cells but not used to generate current and are only used to get characteristics parameters like open circuit voltageV_{OC} without disturbing or interfering with converters. The pilot cells are carefully selected and placed so that it represents the characteristic of PV module and the conditions of irradiation. Using pilot cell has also a drawback which is that the system cost is increased. This technique is used in the systems where cost is not an issue as these are very precise and can be implemented easily. It is also cheap in a sense that it doesn't need any DSP and just a single voltage sensor is used. But as in under partial shading this method is not valid and accurate because the value of K1 changes. Instead of this, voltage sweep is proposed but this increases the complexity and cost of system. Power losses also increase during sweep.

IV. MPPT ALGORITHMS SIMULATION IN PSIM

A. Modelling of Perturb & Observe (P&O) Algorithm

To simulate Perturb and Observe algorithm in PSIM we can divide the whole circuitry in three parts

- Sensing part is to sense current and voltage of PV module
- Buck converter to track theV_{MPP}.
- Control unit to generate the required PWM after processing the P&O algorithm.

Simulation results are given below which are simulated at different environmental condition

✓ Temperature = 25°C, Radiation= 1000$\boldsymbol{W/m2}$

At standard condition the MPP of the panel is 60W and when the algorithm is run on PSIM it tracks the MPP in 2ms which is in figure 6.4. In figure red line shows MPP ofPV array at standard condition whereas blue line is the operating power of PV array which shows that the algorithm tracks the MPP as shown in figure 6

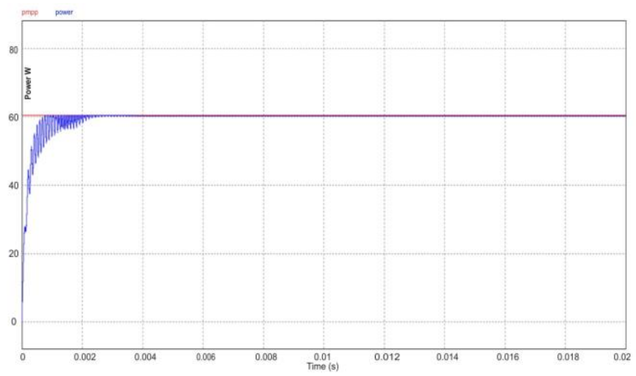

Figure 6. At Standard Condition

✓ *Temperature = 25°$\boldsymbol{C}$, Radiation = 1200$\boldsymbol{W/m2}$*

At this environmental condition the P_{MPP} is 77W as in figure 7. When P&O algorithm is simulated at this specific condition the P_{MPP} is tracked in 3ms.

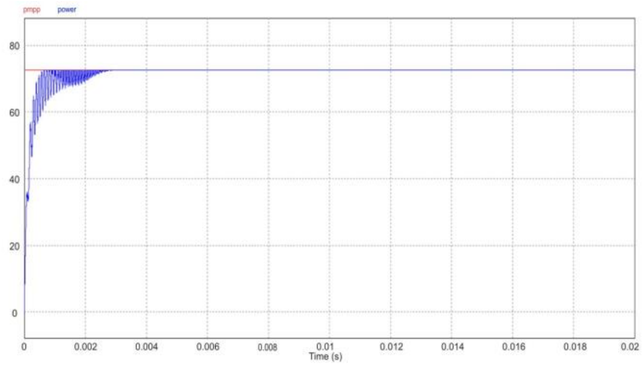

Figure 7. At Temperature= 25°C and Radiation = 1200W/m2

✓ *Temperature = 50°$\boldsymbol{C}$, Radiation = 1000$\boldsymbol{W/m2}$*

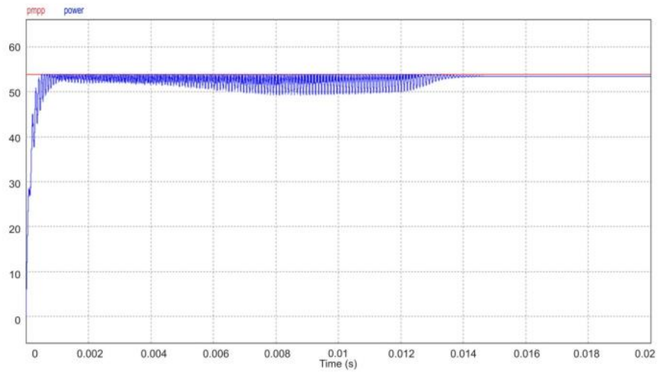

Figure 8. At temperature= 50°$\mathbf{C}$, Radiation = 1000$\mathbf{W/m2}$

The P&O algorithm is simulated with different environmental condition and it tracks the MPP very fast as compared to other algorithms. At low radiation level and low temperature, the exact MPP is not able to track using this algorithm whereas the Temperature and Radiation level close to standard value are tracked accurately and in less time. This algorithm is more suitable to places where environmental conditions do not vary much.

B. Modelling of Open Circuit Voltage Algorithm

The method which gives linear relation between V_{MPP} and V_{OC} of the photovoltaic module, during changing environmental conditions like change in irradiance and temperature levels and is known as Open circuit Voltage algorithm.

$$V_{MPP} = K_1 V_{OC} \quad (2)$$

K_1 is a constant number which depends on PV array characteristics which should be calculated in advance by measuring V_{MPP} andV_{OC} for wide range of temperatures and irradiation levels. The value of $K_1$is among 0.70 ad 0.77.

Simulation results are given below which are simulated at different environmental condition

✓ IV and PV Curve at standard condition

The curves between voltage and current, and Voltage and Power simulate in PSIM are given in Figure 9

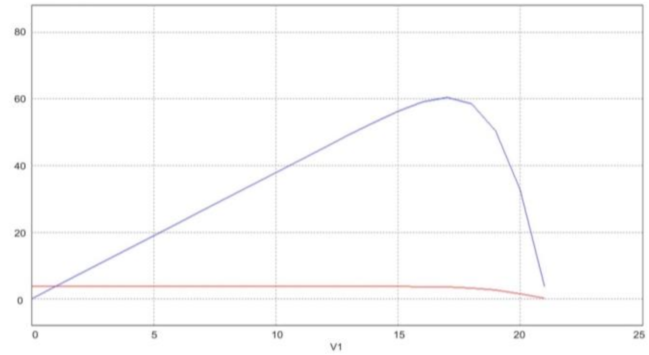

Figure 9.   IV & PV

V_{MPP}= 17.1V
I_{MPP}= 3.5A
P_{MPP}= 60.4W

✓ Tracking of MPP voltage at standard condition

The voltage at MPP is being tracked using this algorithm in PSIM which is shown in Figure 10

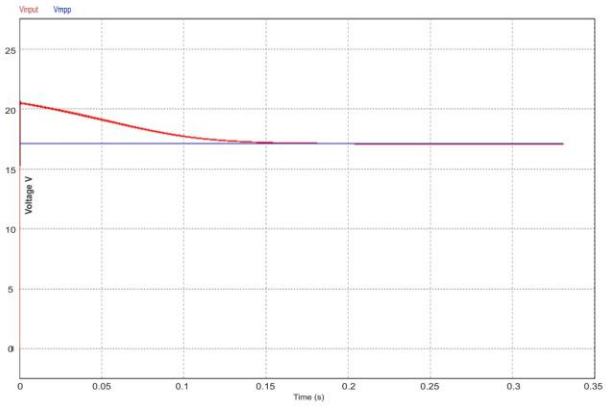

Figure 10. MPP tracking at standard condition

V_{Panel} = 17.09 V
P_{Panel} = 60.5 W

✓ *Tracking of MPP current at standard condition*

PV panel current is being tracked using open circuit voltage algorithm in PSIM which is shown in figure 11

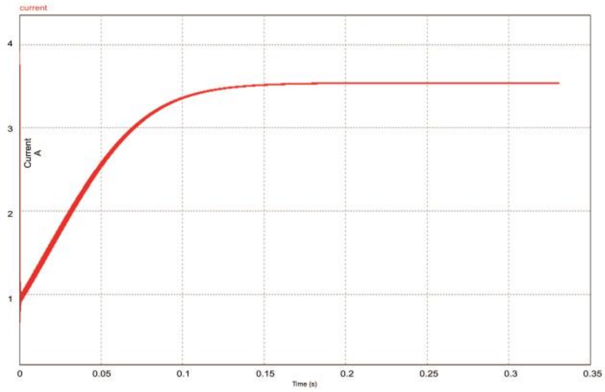

Figure 11 MPP Current Tracking

I_{Panel} = 3.54A
P_{Panel} = 60.5W

CONCUSLION

MPPT maximizes power extraction out of PV arrays which results in increasing the overall efficiency of PV system. Different MPPT algorithms can be used depends on environmental conditions and applications. Constant voltage algorithms suits when the solar irradiance is less while P&O method and Inc Conductance methods suit high solar irradiance level. If the environmental conditions are varying quickly the P&O method efficiency decreases due to which the amount of power to be extracted from PV system decreases. P&O method tracks true MPPT while Open Circuit Voltage does not track true MPPT. Both of the algorithms can be made digital as well as analog. Periodic tuning is very effective in case of Open circuit voltage algorithm. For Pakistan environmental conditions which on average are not varying quickly so P&O algorithm and Inc Conductance algorithms are suggested.

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TRNSYS Modeling and Simulation of a Solar-Fuel Hybrid Thermal Power Plant based on a Central Receiver System

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Abstract— Energy plays a key role in the socio-economic development of a country. Although the available potential of solar energy and other renewable sources is sufficient to encounter the energy needs of the world but unfortunately, fossil fuels are used to a large extent for the purpose and this adds a serious problem of unsustainability to the energy market. A solar thermal power plant hybridized with natural gas as fuel is developed and simulated using TRNSYS simulation software to study the parameters and output of the plant. The model was simulated for the 2nd January and for the whole year which gives 53.7 Mwh of energy throughout the day and 20717 MWh of energy per anum. Peshawar was considered as a reference location for the plant. A field of 250 heliostats having a total solar reflective area of 25000 m^2 provides the required input energy.

Keywords— TRNSYS, hybrid CSP, Brayton cycle, heliostats, Peshawar Pakistan

I. INTRODUCTION

Energy requirements of the modern world are increasing on daily basis at a rapid rate. Conventional sources of energy like fossil fuels have been under use for the last few decades to cover the energy demands which leads to problems like faster depletion of their limited volume and various environmental threats from their lethal emissions.

To overcome the associated problems with fossil fuels, the world is shifting towards the opportunities of renewable sources which are economical and sustainable. Energy from the sun emerges to be the most auspicious renewable source which could decrease the usage of fossil fuels and emissions of harmful gases like carbon dioxide[1]. Solar Photovoltaic and concentrated solar power are the major entrant technologies in the contest of solar power generation in which CSP has an edge of good efficiency, more life, and economical dispachability over solar PV [2].

Pakistan is facing an exceptional energy crisis for the past two decades. The gap between electrical power demand and supply has reached 5 GW countrywide, while the rate of electrification has been dropped to seventy-three percent [3]. According to the energy survey of Pakistan for the year 2018, the Energy mix of Pakistan includes sixty-five percent contribution of fossil fuel [4]. Since the country is not self-sufficient in fossil fuels, therefore it is imported from other countries to meet the demand which makes a burden on the state treasury and hence shortfall occurs which causes daily load shedding of more than 10 hours in main cities, while it is up to 18 hours in villages [5]. The geographic position of Pakistan receives direct normal irradiance of 1.9 to 2.2 Mwh/m2 annually with an average of 10 hours of daily sunshine which makes total solar potential up to 2900 GW [6]. The given statistics are perfect reasons to opt for concentrated solar energy as an alternate source for Pakistan.

The main principle of a CSP plant is based on the reflection of sunlight over an absorbing area with the help of reflecting surfaces to capture solar energy. Based on reflecting mirrors and collectors combinations, CSP has many technological configurations out of which solar power tower is a leading technology in the energy market. Solar power tower carries a receiver at the top of a tower in which a continuously circulating fluid receives the concentrated solar energy reflected by a field of reflecting mirrors around the tower called a heliostat field.

Solar power tower technology has the second-highest concentration ratio after parabolic dish and therefore a temperature of high level can be achieved by the working fluid in the receiver [7]. Power plants using this kind of technology are more economical for large-scale power production.

Solar energy shows transitory behavior and it needs either integration of an energy storage system or hybridization with a fuel source to supply a constant temperature and enthalpy at the inlet of the gas turbine. Moreover, hybridizing with fuel or integrating with an energy storage system increases the availability of energy and reduces the cost of a concentrated solar thermal power plant [8]. Therefore, the combustion chamber is added to a hypothetical Brayton cycle in the current research work and for this purpose, a central receiver-based model is developed using TRNSYS simulation software to simulate the variation of power and energy generated by the solar-fuel hybrid power plant.

1) Working principle of power tower technology

The tower is installed in a field of reflecting mirrors called heliostats which concentrates solar energy over a receiver mounted at the top of a tower. Fluid flowing through the receiver gain energy and as a result its temperature raises. The fluid of high temperature gives its energy to rotating machinery called turbine and the mechanical energy of rotating shaft of turbine converts into electrical energy in a magnetic field. Hence solar energy received at the heliostat field is delivered as electrical energy at the generator end of the plant.

2) Main Components of the plant

a) Heliostat: A large number of mirrors are configured around a central in such a way that they continuously track the sun to focus the sunlight over a small area of the absorber. Heliostat needs to have excellent reflectivity, precisely tracking ability and high strength to resist against winds [9].

b) Tower: The tower is used to support the receiver at a greater height and it is prepared either from hard metallic structure or concreted construction. The length of the tower is one of the most important design factors which can be selected according to the heliostat field layout and plant total electrical capacity*[20]*.

c) Energy receiver/ Absorber: This is the receiver part for input energy to the plant. solar radiant energy gets absorbed in this part of the plant and transformed into thermal energy of the fluid which can be either directly utilized in power conversion unit or used to produce steam for turbine operation [10]. Receiver types include an external receiver that has no covering for insulation purposes and a cavity receiver consist of one or two cavities with tubes fixed inside the cavity. Due to more convection losses, the external receiver has low productivity than the cavity receiver.

d) Power conversion block: This is the core area of the plant which uses turbines to convert the thermal energy of working fluid into the mechanical energy of rotating shaft using turbines that work on the principles of a thermodynamics cycle. The Rankine cycle is the thermodynamic cycle with steam as a working fluid, the Brayton cycle uses gas as working fluid while the combined cycle is the combination of both these cycles [11]. A complete schematic diagram of a central receiver system with the Brayton cycle is shown in Figure-1.

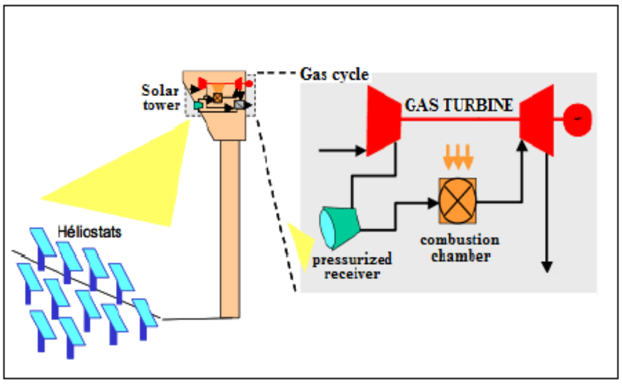

Figure 1. Central receiver system using Brayton power cycle [12]

II. METHODOLOGY

The model of the plant is based on the Brayton cycle which is modeled and simulated in TRNSYS simulation software developed by WISCONSIN University USA [13]. TRNSYS software is a simulation package with good flexibility due to the facility of addition mathematically developed models, the easily accessible supplementary modules, and the capability of interfacing with additional programs of other simulating software. TRNSYS has a wide range of applications which include solar energy systems, heating ventilation and air conditioning systems, domestic and commercial buildings, hydrogen systems, and various kinds of transient systems. An individually Programmed Model of each component called "Type" can be found in the libraries of TRNSYS and the desired Types needs to be connected in the graphical user interface to simulate a complete system. Types of all the components required in the complete model of the plant under study are present in the standard and STEC library of TRNSYS [14]. Figure-2. shows the picture of the simulation model.

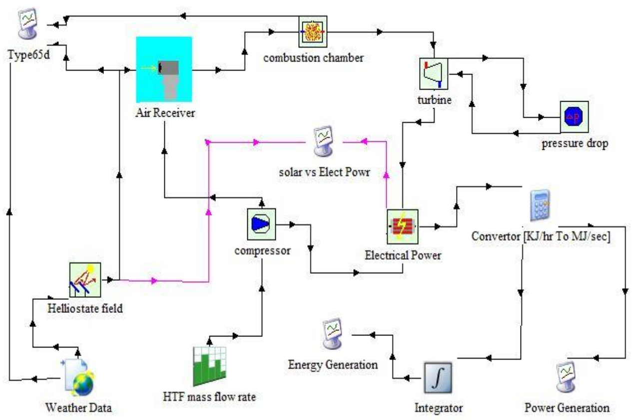

Figure 2. TRNSYS Model of Solar-fuel hybrid model

1) Location of the plant:

The prime level for considering a concentrated solar thermal plant is to choose the site for installation which is feasible from both economic and technical points of view. The site depends upon many factors out of which the average value of direct normal radiation (DNI) is the absolute necessary requirement which needs to exceed 5 Kwh/m2 per day [15]. The slope of the land greatly affects the efficiency of the plants due to associated shading consequences. higher slopes of the lands decrease the efficiency and flattening of area results in higher efficiency, therefore the recommended slopes for a CSP is less than three percent [16] and the wind velocity should not exceed 15.6 m/s [17]. DNI of some regions in Pakistan may reach up to 6 KWh/m2/day and the selected site for this work is Peshawar which has rich DNI approaching almost 4.5 - 5 Kwh/m2/day [18]. Weather data of Peshawar is available in the TRNSYS weather library in TMY2 format.

2) HTF

HTF stands for heat transfer fluid used as a working medium for energy exchange in the plant. Molten salt, man-made oils, water, and air are some of the common heat transfer fluids used in CSP [19]. The model under the study uses gas as heat transfer fluid.

3) Parameters of the Model

Parameters of a fictive Brayton cycle with steady state capacity of 5MW are taken as a reference set of values in the power conversion portion of the model which are given in table-I.

TABLE I. INPUT VALUES OF THE BRAYTON CYCLE

Parameter	Value (unit)	Parameter	Value (unit)
HTF mass flow rate	60120 (kg/hr)	Compressor inlet temperature	25 (C°)
Water mass flow rate	18000 (kg/hr)	compressor outlet temperature	372.85 (C°)
Turbine inlet pressure	15 (bar)	Pressure ratio	15 (unitless)
Turbine inlet temperature	926 (C°)	Heat rate	6333 Btu/kWhr
Turbine outlet temperature	280.35 (C°)	Fuel mass flow rate	0.166 kg/sec

Brayton cycle receives input energy from both a combustion chamber with natural gas as fuel and a solar field which consists of heliostats and a power tower with necessary frames, wirings, and pipes. Parameters of the solar field are given in tale-II.

TABLE II. SOLAR FIELD PARAMETERS

Parameters	Value (unit)	Parameters	Value (unit)
Reflectivity of mirrors	0.96	Absorber emissivity	0.80
Surface area of a mirror	100 (m^2)	Absorber fraction	0.85
No of azimuth data points	9	Aperture of receiver	15 (m^2)
No of zenith data points	7	Hot gas piping emissivity	0.80
Receiver optical efficiency	0.82	Design inlet pressure	15 bar

III. RESULTS AND DISCUSSION

The model is receiving input energy from both solar and conventional fuel and the solar energy is dependent upon the local DNI which various through the course of the day. Simulation results show that fuel consumption decreases in the times when the DNI increases. Figure-3 is the simulation plot of various output values of the model for the second January of a typical metrological year where the blue line shows the DNI of that specific day and the green line is for fuel consumption. It can be seen from the figure that the line of fuel consumption is at the lowest position when the line of DNI passes through the highest point and at the end of the day when the graph of DNI falls down, an increasing trend of fuel consumption can be observed in the graph. Moreover, the yellow line exhibits the temperature at the inlet of the turbine which goes constant due to fuel supply in the time of insufficient solar energy.

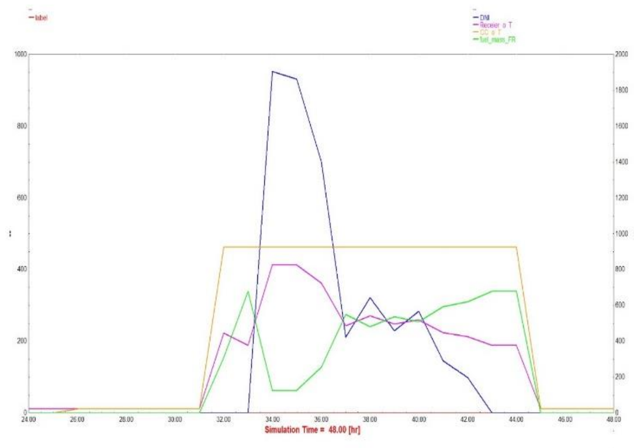

Figure 3. Simulation of model for Various parameters on 2nd January

The total energy generated when the model was simulated for the day of 2nd January of a typical metrological year is 53.6 Mwh which can be seen from Figure-4.

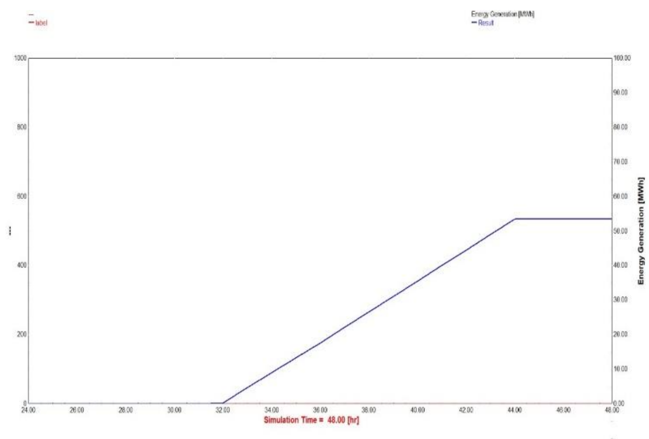

Figure 4. Total energy generated on 2nd January

The model was simulated for a typical metrological to find the energy generated for the whole year. Figure-5 shows the plot of energy produced. It can be noted from the figure that a total amount of 20717 MWh of energy can be obtained from the plant for the whole year.

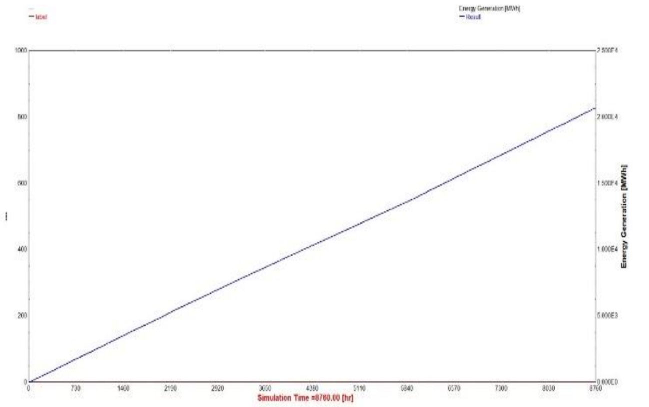

Figure 5. Annual energy generated by the model

Solar energy has a major share in the generated electrical energy and a total of 250 heliostats with an area of 100 m2 per heliostat are utilized in acquiring the solar input.

CONCLUSION

The solar thermal power plant with a total electrical capacity of 5 MW having a hypothetical Brayton cycle hybridized with natural gas as input energy was modeled and simulated for the weather data of Peshawar using TRNSYS simulation software. complete Typical metrological year and 2nd January of the same year were the reference time axes used to plot the varying energy generated from the simulation of the model.

Simulation results show that the temperature at the inlet of the turbine remains constant during low DNI hours by the utilization of natural gas as input energy. The conclusion of the current research can be summarized as that although solar energy is available in sufficient amount but its nature is transient which can be covered by adding fuel as input to a solar thermal power plant.

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A Modified Memory-Efficient U-Net for Segmentation of Polyps

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***Abstract*—**Colorectal cancer, caused by an unusual growth of tissues in a body called polyp, is the third most prevailing cancer worldwide and remained the second most cause of deaths by cancer in 2020. Early stage detection of the cancer can prevent the deaths. Computer Aided Diagnosis (CAD) system could be a major breakthrough for early detection of the cancer. The system uses image processing techniques. Among the image processing techniques segmentation has a great value. The diagnostic process results are highly dependent on the accuracy of performed segmentation. Nowadays, many supervised and unsupervised techniques are used for the task of segmentation. Deep neural networks have outperformed other state-of-the-art approaches for the task. In this paper, we present an end-to-end deep neural network for segmentation of polyps in images. The network is modified version of the U-Net architecture. The network being much more memory efficient than the U-Net architecture, inferences segmentation of the images more accurate than the U-Net. We reduce number of layers of the U-Net architecture both in the en- coding and decoding path, and introduce residual blocks and batch normalization in the encoding path to prevent learning of redundant features, to avoid over-fitting and to accelerate the training process, and in the decoding path to avoid gradient vanishing issue in long dependence of the neural network during training we use bi-directional long short term memory network with batch normalization. We train and validate the network on Kvasir dataset for the task. The network accurately segments the polyp part in the images with 92.46% test accuracy.

Keywords: Deep Learning; Deep Neural Network; Image Segmentation; U-Net.

I. Introduction

Around 18.1 million new cancer cases and 10 million deaths by cancer occurred in 2020, according to GlOBOCAN 2020. Among the cancer cases female breast cancer is the most occurring cancer followed by lungs and colorectal cancers. In terms of deaths lung cancer remained the leading cancer with around 1.8 million deaths followed by 0.9 million deaths by colorectal cancer. Colorectal cancer is caused by an unusual growth of tissues known as polyp. Polyps are like moles, which are further developed into cancer. Early stage detection of the polyps can prevent the deaths by huge margin. Computer Aided Diagnosis (CAD) system could be a major breakthrough for early detection of the cancer [1]. CAD uses images processing techniques for analysis of medical images. Segmentation has a great value in the images processing. It divides the images into affected and unaffected region. The diagnostic process results are highly dependent on the accuracy of performed segmentation. Nowadays, many supervised and unsupervised techniques are used for the task of segmentation. Supervised techniques use active contours [2,3], fuzzy sets [4,5] and machine learning algorithms like k-mean clustering [6], morphological oper- ations [7], etc. While, unsupervised techniques come under deep learning. Deep learning uses convolutional neural networks (ConvNet/CNNs) [8–10]. Over the couple of years CNNs have outperformed other approaches in this field.

Since the emergence of Artificial Intelligence (AI) in 1950s, computer scientist have been trying to build a computer that can mimic human behavior. In the following decades the field saw much advancement. But they were limited due to unsophisticated computer and unavailability of large data. CNNs are special type of Artificial Neural Network (ANN), they are used to mimics the human vision system. CNNs were first designed and developed by Yann LeCun in 1980s [11]. The network was named LeNet after LeCun and it was trained for recognition of handwritten digits in banks and postal services. A breakthrough in the field was achieved in 2012 by AI system, known as AlexNet, developed by Alex Krizhevsky [12]. The system won the 2012 ImageNet computer vision contest with 85% accuracy.

In this paper, we propose a modified memory-efficient U-Net architecture for segmentation of medical images containing polyps, as shown in figure 5. Our network is modification of the U-Net architecture 1. To make the network memory efficient we have made changes in the encoding and decoding path of the network. The paper is further organized as: section 2 touches related work, section 3 describes the proposed work in detail, in section 4 we present results of our network and comparison with the U-Net and the paper ends with a conclusion note in section 5.

II. RELATED WORK

After the success of CNNs in computer vision application, they are being used in medical field for image processing purpose. In [13], the authors have looked into the possibility of direct use of CNNs for the segmentation of tumor tissues in brain. They have used inhomogeneity correction in each channel as a pre-process for the BraTS 2013 data. A total of 6 layers of convolutions are being used with max-pooling, softmax, and fully connected layers.

Small kernel of size 3x3 have been used in [14] for automatic CNN based segmentation of brain tumor. The method consists of three steps: pre-processing, classification by CNN, and post processing. Pre-processing stage contains bias-field correction and the architecture consists of convolution layers, max pooling and fully connected layers. While, in the post processing stage they have used volumetric constrains for the removal of erroneously segmented parts, which are smaller than the pre-defined threshold.

A major breakthrough achieved in the field in 2015 by U-Net architecture, figure 1, state-of- the-art architecture for segmentation of medical images. The U-Net, presented by Ronneberger et al. in 2015, is a state-of-the-art fast trained network based on fully convolutional network [8]. The work is known as U-Net due to its architecture shape, a symmetric 'U' shape. The network consists of two paths: an encoder/contraction path and a decoder/expansion path, which are on the left and right side of the model, respectively.

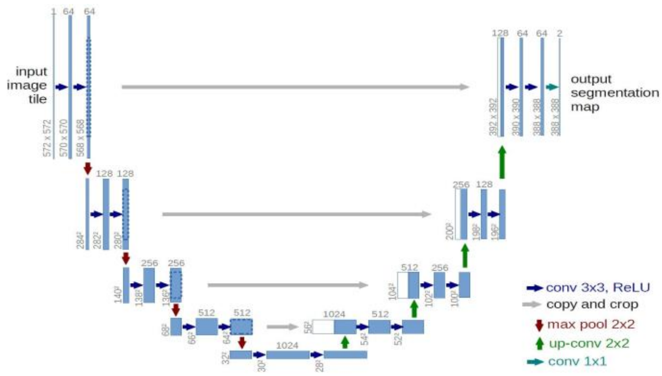


Figure 1: The U-Net architecture

The contraction path captures context and a symmetric expansion path enables precise localization. The network consists of total 23 layers of convolutions. Each second layer of 3x3 convolution, in the contraction path, is followed by a Rectified linear unit (ReLU) and a 2x2 max pooling operator with stride 2 for down sampling. And at each down-sampling the network makes the number of features doubled. While, in the expansion path up-sampling is followed by a 2x2 convolution, which at the same time halves the number channels, and consecutive two 3x3 convolution, where each layer is followed by a ReLU. At last, a final layer of 1x1 convolution is used to get the desired number of classes from each 64-component feature.

Due to the un-padding convolution layers in the contraction path the output resultant image of the network lose its boundary pixel, as example is given below in Figure 2. For the output in the yellow region the input object should be in the blue region, as the result of use of un-padding convolution. The missed part is gained then by using mirror extracting.

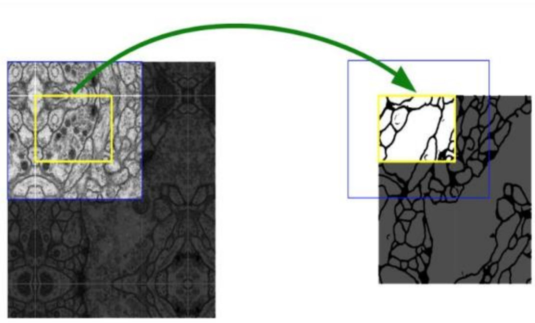


Figure 2: Seamless segmentation of arbitrarily large images by an overlap tile strategy by U-Net.

The authors of U-Net have applied the network in 2015 for segmentation task on datasets pro- vided by ISBI cell tracking challenge, the challenge began in 2012 and still available for challenge. In the first, they applied the network on dataset, PhC-U373, which contained Glioblastoma-astrocytoma U373 cells. It obtained 92 % of average value of intersection over union (IOU), and on the second dataset, DICHeLa, they achieved an average 77.5 % of IOU value. In both cases they got first position.

In [15], the authors have presented 'Automatic Brain Tumor Detection and Segmentation Using U-Net Based Fully Convolutional Networks', see Figure 3. Unlike the U-net, they have used zero-padding, which keeps the output dimension for all the convolutional layers of both down-sampling and up-sampling path. Besides the shape of U-Net, it also comprises of 23 layers and the function of the convolution layers, ReLU and max pooling are in the same order. Along the zero-padding, they have also used 3x3 convolution for up-sampling, unlike the U-Net.

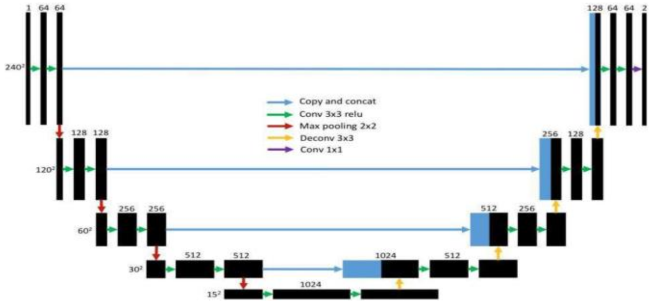


Figure3:The automatic brain tumor segmentation architecture based on the U-Net.

A 3D improved U-Net based network is presented by authors of [16]. The proposed network comprises of 3x3 convolutions, group normalization, ReLU, dropout and max-pooling layers, which are used in the contraction path. And in the expansion path 2x2 convolution layers for up-sampling, 3x3 convolution, group normalization, and ReLU are used. At last, 1x1 convolution is followed by a softmax layer. In the presented work the authors have generated heatmaps of different types of lesions by utilizing ground-truth of brain tumor from group of patients. Then, volume of interest (VOI) is created by these heatmaps, which contains advance information of brain tumor lesions. The multimodal MRIs are then integrated with VOI map and is used as input for the network, as shown below:

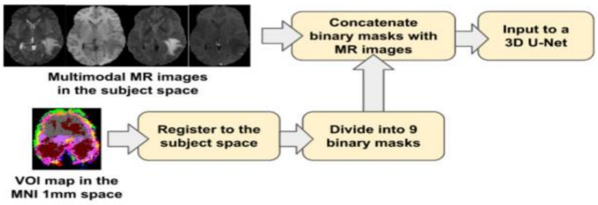


Figure 4: Pipeline of 3D U-Net

In this paper, we propose a modified memory-efficient U-Net architecture for segmentation of medical images containing polyps, as shown in figure 5. Our network is modification of the U-Net architecture 1. To make the network memory efficient we have made changes in the encoding and decoding path of the network. The next section 3 presents the proposed network in detail.

III. PROPOSED NETWORK

In this paper, we propose a moified memory-efficient U-Net architecture for segmentation of medical images containing polyps, as shown in figure 5. Our network is modification of the U- Net architecture. To make the network memory efficient we have made changes in the encoding and decoding path of the network. We introduce residual blocks [17] and batch normalization [18] to prevent learning of redundant features, over-fitting, acceleration of the training process, and to reduce number of parameters which ultimately leads to lower computational cost; and in the decoding path we take benefit of bi-directional long short term memory network [19] to avoid gradient vanishing issue in long dependence of the neural network during training.

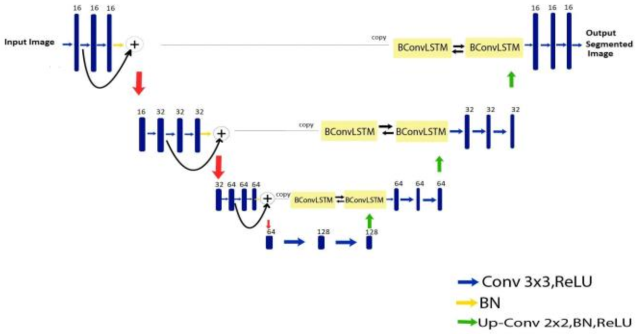


Figure 5: Our network. Comparing with the U-Net one can see the less number of layers and other modifications in the network.

The working mechanism of a CNN can be represented in equations as: If x represents an input, f represents activation function in a layer, W^n represents a kernel/filter, used to convolve over an image in a convolution operation, in an nth layer, b^n represents bias term added in the nth layer, z^n represents an output of a convolution operation with bias term in an nth layer, and a^n represents an output of the f in an nth layer, then equations for n number of layers can be:

$$z^1 = W^1 x + b^1$$

$$a^1 = f(z^1)$$

$$a^1 = f(W^1 x + b^1)$$

$$z^2 = W^2\ f(W^1 x + b^1) + b^2$$

$$a^2 = f(W^2\ f(W^1 x + b^1) + b^2)$$

Similarly, third layer activation function output can be represented by:

$$a^3 = f(W^3 f(W^2 f(W^1 x + b^1) + b^2) + b^3)$$

Likewise, nth layer activation function output can be represented as:

$$a^n = f(W^n f(W^{n-1} \ldots f(W^1 x + b^1) + \ldots + b^{n-1}) + b^n)$$

Convolutional neural network (CNN) based neural architectures are build up of convolution operation, pooling operation, activation function, etc.

In the encoding path of our network, we use residual blocks mechanism followed by batch normalization layer. Residual blocks can be represented as: if X represents an input and F represents convolution operation and activation function in a single block then

$$X = X + F(X)$$

represents a single application of residual blocks. That is, an input to some layers of convolution, activation function or max-pooling is again added to the output of the layers. In our network, we use residual blocks to two layers of convolution followed by activation function as shown in the figure 5 above. The output of the residual block again passes through batch normalization layer, the equation for batch normalization is given as:

$$BN = \gamma_c \left[\frac{I_{n,c,h,w} - \mu_c}{(\sigma_c^2 - \varepsilon)^{1/2}} \right] + \beta_c$$

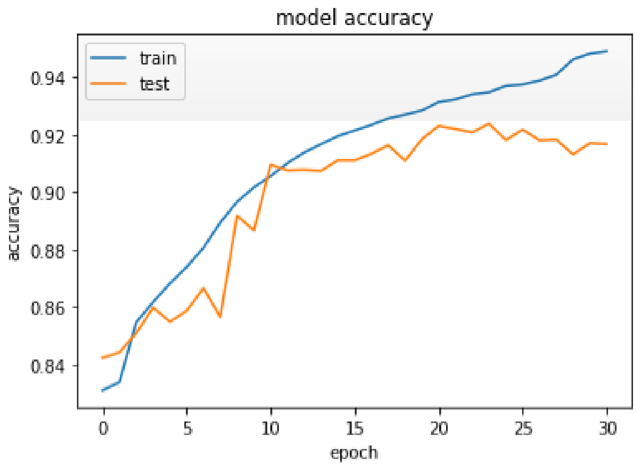
Where, $I_{n,c,h,w}$ represents n-number of images provided to a neural network at a time with c channels, h heights and w widths. μ_c and σ_c^2 are channel wise global mean and variance of the images, respectively. β_c and γ_c are learnable mean and standard deviation, respectively, while ε is kept constant as 0.00001. Batch normalization layer controls variation in distribution by calculating mean and standard deviation values of the data set as a whole by adjusting the mean to 0 and variance to 1.

While in the decoding path, we use bi-directional long short term memory network (BConvLSTM) preceded by again batch normalization layer and followed by three convolution layers, as can be seen in right side of the network given in figure 5. LSTMs are modified version of recurrent neural networks (RNNs) [20], which have been developed to overcome the gradient vanishing issue in long dependence of neural networks in training.

IV. TRAINING AND RESULTS COMPARISON

We take advantage of free graphic processing unit (GPU) provided by Google Colab for training and evaluation of the network for the task. We use Kvasir-SEG dataset for training and evaluation. The dataset contains 1000 images and respective 1000 masks, where each image contains polyp(s). The dataset comprises gastrointestinal (GI) tract images and was released for 2020 MediaEval Medico-polyp segmentation. We do not use any pre-processing techniques for the training process. We just use four type of data augmentation, RandomRotate90, GridDistortion, HorizontalFlip and VerticalFlip, to increase size of the dataset from 1000 to 5000 images and respective masks. We then distribute the dataset into 4000 images for training, 1000 for validation and 1000 for testing. All images in the dataset are then resized into 256x256 images to accommodate the training process in the GPU. The model is being developed in Keras with TensorFlow backened framework.

We start the training process with batch size 8, learning rate starting from 10^{-3}, we let the learning rate to reduce to 10^{-5} in case of not improvement in validation loss with factor 0.1 and patience 7, and 100 epochs. The network trained for 31 epochs instead of 100 epochs and the training process stopped there because of not improvement of results. Visualization of the training process which shows the model accuracy and loss given in the figure below 6.



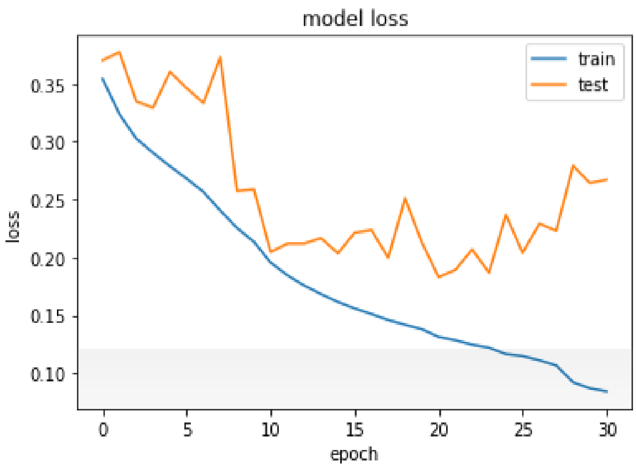


Figure 6: Training and validation accuracy and loss of our network.

Over-fitting of the training of the model can be seen in the figures above. This is due to the random selection of data for training and validation, and also small size of the dataset. During the training we achieve 94.90% and 08.43% training accuracy and loss, respectively, and 92.38% and 18.30% validation accuracy and loss, respectively. While, we achieve 92.46% and 17.71% testing accuracy and loss, respectively. Some of the results of testing of the model on the training images are given below in figure 7.

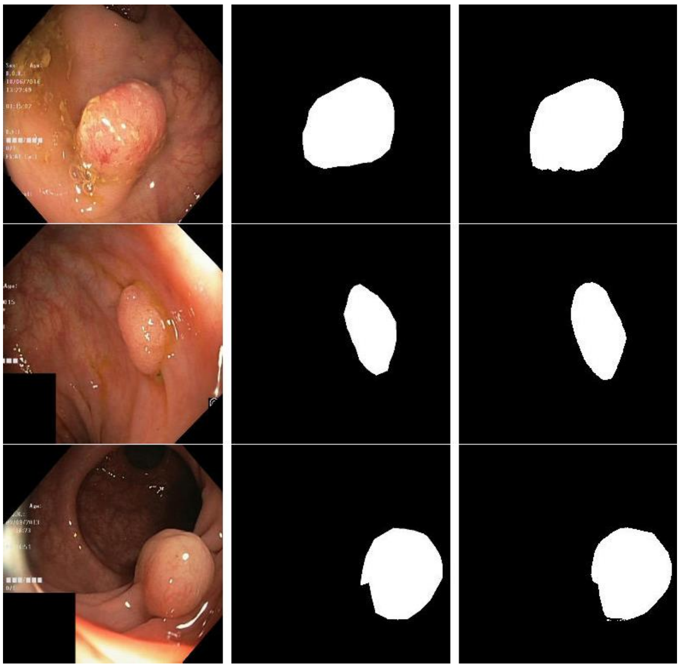


Figure 7: Segmentation results of the proposed network. Left: Image, Middle: Image mask, Right: Our network prediction.

To mitigate the over-fitting, we add 5% Gaussian noise to the input images and add dropout layers between the blocks of encoding path of the network. We also compare our results quantitatively with the original U-Net in term of accuracy, parameters and GPU time in the table 1 below.

Table 1: Quantitatively comparison of our network results with the U-Net.

Models	**Accuracy (%)**	**Parameters**	**Time Per Epoch(sec)**
Our Network	92.46	618,549	181
U-Net	91.83	2,274,501	308

We kept the same parameters for training of the U-Net on the dataset. The table shows that our network has achieved higher accuracy with much less parameters and computational cost as compare to the U-Net architecture. Experimental results show that if we provide large size of dataset to our network we can achieve much more accurate results and which will ultimately lead to good fit of the network for the task.

Conclusion

We presented a deep memory efficient neural network for segmentation of polyps. The network segmented the polyps more accuractely than the U-Net architecture with less number of paramters and quite less computational cost. It would be not unfair to say that U-Net architecture has brought a revolution in the segmentation of medical images in the field of deep learning. The network has achieved outstanding results on different kind of biomedical images. The idea has been used for different biomedical applications with some minute modifications. There are other options too for the advancement in current architecture. We can make the network even more fast and can also train for big and new datasets like ImageNet and BraTS 2018, which would improve its performance adequately.

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Energy Management in Domestic Household to Reduce Monthly Bill through Feedback

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***Abstract*—**Home energy monitoring and/or management system are tools that could be used by homeowners to increase awareness, which may eventually lead to adoption of energy saving measures. In this technologically advanced era, electricity is essential to support our daily life. People rely upon electricity to help them go through their everyday schedules either at homes, offices and even at all other places. But with the advancement in technology, the demand-supply gap is also increasing. To overcome the issue, we need to increase generation. A lot of Renewable energy generation projects are under process to produce clean and sustainable energy but, to control the problem completely, we need efficient energy utilization to avoid the wastage of energy. Consumers need to adopt low energy consumption lifestyle through awareness and easy access. Customers usually receive no information on how much various energy appliances cost to operate. If consumer attempt to conserve energy, they receive inadequate information about the energy consumption. Because conventional metering system provide electricity bill at the end of every month and most of the consumers are also unable to understand the information provided by the existing metering system because the energy charge is for kWh and details about patterns of consumption are not available. As a result, the consumer does not realize their household's consumption.

In this paper, we propose an interactive system that will allow the user to define the electricity consumption for a particular month according to their own budget. This system will continuously update the user about their consumed electricity and the current bill calculated based on tariff defined by the utility. At the same time the system will also show the expected projected monthly bill based on the previous average electricity consumption pattern. To establish this two-way flow of data we have designed a mobile application that allows a user to define their targeted electricity consumption for a particular month according to the budget. This app will communicate with the controller to collect electrical parameters and timely inform the consumer about their consumption through feedback that will display both instantaneous and processed data.

Keywords: Consumption Awareness, Smart Meter, Energy Management..

I. Introduction

Energy Management is an approach to deal with the power utilization and adjust to the changing behavior of the community mainly caused by the technological revolution [1-2]. Humanity is facing the biggest energy challenge of inadequacy and the rising energy demands. A lot of measures have been taken to overcome the shortage of electricity in Pakistan; Researcher's in [3] suggest increasing the total generation; this will require a lot of fuel for the production of electricity which makes the price unit of electrical energy to increase. Smart grids [4] are another solution to reduce energy wastage that controls the domestic user appliances in case of system overloading but this system is complex and restrict the user to compromise on their comfort. In an attempt to reduce energy losses, prepayment meters were installed to manage the energy costs that required the user to pay for energy in advance, but the system is costly and inefficient[5]. The solutions presented are not economical for a developing country like Pakistan and require a lot of investment in terms of money. So there is a need to look for better and low cost solution to overcome the issue and that is by raising awareness of the consumption and to reduce energy wastage.

We explore if energy management system can influence homeowners in such a way that they adjust

their energy utilizing practices. We identify a system as home energy monitoring system if it only provides insight, but if the system also allows control, we distinguish it as a home energy monitoring system. A smart meter is not necessary in order to be able to determine the energy utilization, but for better understanding of consumption user need to get adequate feedback [6]. The way feedback is provided is also an important characteristic of the system to allow motivation of homeowners. There are various ways in which the feedback to the households can be given:

Indirect feedback: Subsequently providing the information after reviewing the past events e.g. using energy bill.

Direct feedback: Immediate Computerized information provided in real time e.g. using smart phones or computers.

Electric Utility Companies used conventional method for providing feedback to house owners in the form of monthly bills which showed consumption for that particular month only and also exhibited the past annual summary of their total energy use.

Over the last decades this situation has changed considerably, and the preference is given to direct feedback through smart meters or devices that give visual displays.

Researchers from the European environment agency (2013) indicates that combining both form of feedbacks (direct and indirect) has, so far been the most effective in achieving energy savings and changing the consumer behavior [7]. Another research finds that communicating with the feedback devices and setting a target for energy saving by consumers themselves has the potential to yield the best results [8]. Research by Murray et al. (2015) also indicates that households and the individual appliances they use have distinct energy consumption pattern, and thus a personalized feedback approach is needed [9]. Kobus (2016) concluded that feedback should be provided frequently in real time because it enables the user to link their behavior to the consequences. The study also shows that expressing energy consumption in costs has a great impact on energy saving measures [10].

We explore how this system can provide them knowledge about the possibilities to change their behavior and get insight in the possible profit that that can be achieved. Jesper Kjeldskov et.al (2012) designed a mobile application named “Power advisor” that provided conservation of electricity through tailored information on a tablet or mobile phone [11]. Findings provided insight into people’s awareness of electricity consumption in their home and how this may be influenced through design.

Ueno ET. Al. Constructed a system known as “Energy consumption information system (ECOIS)” [12] for creating awareness at residential level and to motivate energy-saving activities. The system comprised of two parts; monitoring and distribution. Monitoring of the power consumption was done through meters and Distribution side included a lab-based computer which was used to distribute data to the information terminal for each user via email.

End-use load monitoring at the individual customer level, gives a fuller understanding of how much electricity is used for what purpose, and when, is vital information for efficient energy management.

Knowledge of load shapes is also important for calculating the cost of supplying a specific end-use [13]. The central POEM (Power-efficient occupancy-based energy management) Unit collects the data which can be displayed or transferred to other systems for analysis.

P.Ilatchiya et.al (2016) [14] designed and developed a smart monitoring and controlling for household electrical appliance in real time. The control mechanism was implemented via android application where the message was sent to mobile through GSM giving information on power consumption of each load and control was done in remote by creating popup window.

All the solutions presented were to reduce the electricity consumption but the limitation of the researches is that these are more focused on energy feedback and did not allow user interaction to enter their targeted monthly bill according to their budget.

II. System Modeling

The proposed system mainly consists of a Controller, Real Time Clock (RTC), Wi-Fi module, Relay module and LCD display.

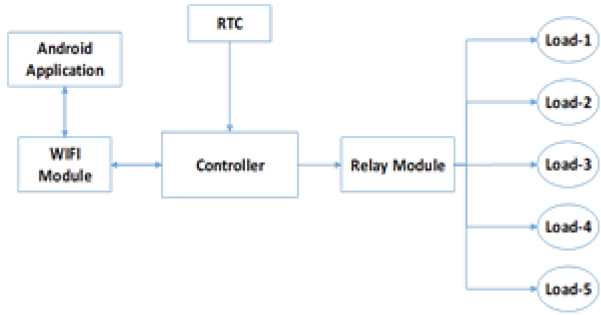

Figure 1: System Block diagram

As illustrated in Figure 1 proposed system is divided into two parts; data collection and control unit.

A. Data collection

In order to help the customers to reduce their electricity consumption and become more aware, the main aim is to know the electrical parameters of the household such as voltage and current. This data is essential for an accurate quantification of energy which will provide detailed electricity consumption and thereby calculating the power consumed.

Sensing units are used to measure the values of current and voltage, thus calculating the total power. The sensors used are ACS712 (20A) and ZMPT101B, for measuring current and voltage respectively.

Current sensor is a device which senses AC or DC current in a conducting wire and produces a voltage proportional to it. A current sensor ACS-712 (20A) is used in this project which operates on 5V and consists of linear Hall sensor circuit with a copper conduction path located near the surface of the die. The Hall IC sense the magnetic field produced by current flowing through copper conducting path and produce voltage proportional to the current. ACS 712 measure positive and negative 30Amps, corresponding to the analog output. This voltage value is then fed to controller for controlling the devices.

For voltage measurement the sensor used is ZMPT101B. It is used to measure AC voltage and has high accuracy for measuring power and can measure voltage up to 250V. The output voltage is stepped down to 5V suitable for interfacing with the controller.

B. Control Unit

Control Unit is the main brain of this project. It will receive data from mobile application as well as the loads and manipulate the data to make decisions accordingly.

Arduino MEGA 2560 is used as the central controller. The programming language is simple and can easily run on windows, LINUX and Mac. The controller stores the data assigned by the user through mobile application and compares it with the real time power. On the basis of these values, the controller is able to provide the information about the consumed units and the remaining units limit. When the consumed units exceeds the targeted units for a day, it will either inform the user in the form of a pop-up message on mobile device or will automatically switch off the optional loads and let the basic loads running.

Wi-Fi Module

Communication of the controller with other devices is done through a Wi-Fi module i.e. ESP 8266 which is serially interfaced with controller. It is a low-cost Wi-Fi microchip that can give access to Wi-Fi network (or the device can act as an access point).

C. Real Time Clock (RTC)

RTC is real time clock in the form of an Integrated Circuit. RTCs are present in almost every electronic device which needs to keep accurate time to stay updated.

In order to provide real time feedback to consumers about energy consumption, our system must keep an updated track of the current time. We have used RTC because it has low power consumption and is more accurate than other time calculating methods.

III. Simulation of Proposed System

A. Proteus model

ISIS8 PROFESSIONAL (Proteus) is used for simulation. The real time simulation of system is shown in Figure 2. The built-in library of simulator consists of thousands of devices. To meet the design requirements of the system, several components have been used which are available and can be implemented at a practical level. The connections are established, and hex file is burnt into the Arduino in simulation.

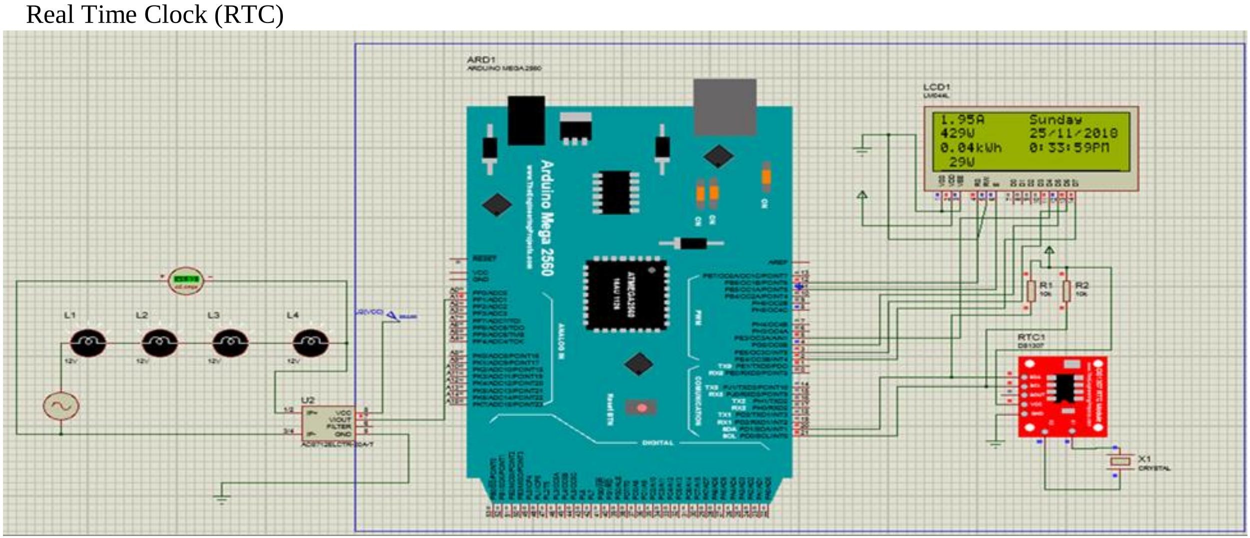

Figure 2: Proteus Model

B. Flow Chart and Algorithm

The controller has been programmed according to the effective, well defined and efficient algorithm to get required goals. We have taken five loads (L1, L2, L3, L4 and L5), two of which are categorized as optional loads i.e. L1= Air Condition, L2=washing machine and the other three loads are categorized as basic loads that always needs to be running i.e. L3=Bulb, L4= fan and L5=Refrigerator.

We have also defined two modes (strict and relax modes). In the strict mode, if the consumed energy (Ec) is less than the energy limit (EL), all the loads will remain on but if the consumed energy (Ec) exceeds energy limit (EL), controller will automatically switch off the loads categorized as optional (L1 & L2) and the basic loads (L3, L4 & L5) will keep running. In the Relax mode, user comfort is not compromised and controller will notify the consumer in the form of a pop-up message on their mobile device, if the consumed energy (Ec) exceeds the energy limit (EL). The whole operation of the controller is presented by a flow chart in Figure 3.

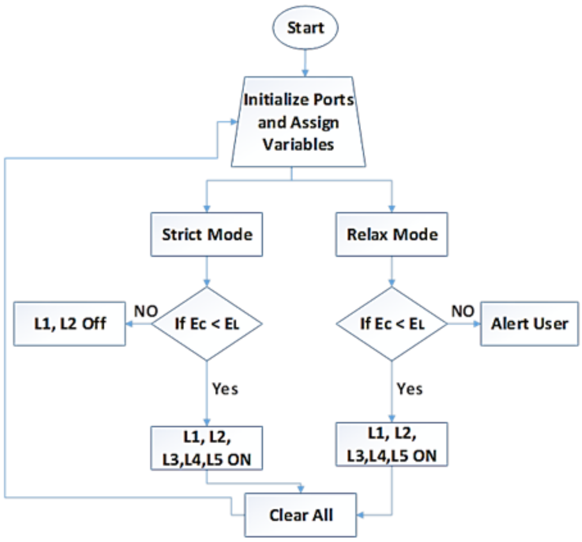

Figure 2: Flow chart

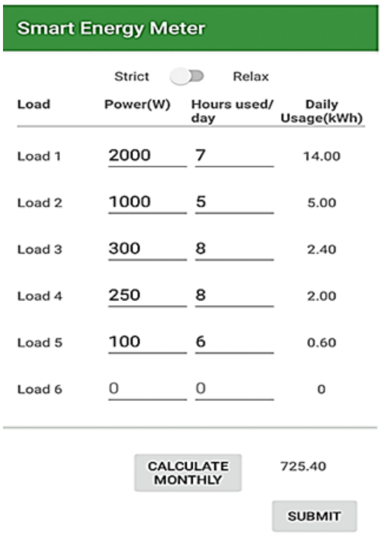

Figure 4: Slots for each load

IV. Performance Evalution

A. Android Application

A mobile application has been designed called Smart energy meter to explore different kinds of information and feedback on power consumption. This application can be used to calculate daily/monthly load's energy consumption and provide detailed and tailored information on the pattern of consumption. Figure 4 shows the main window of the application that integrates two menu items; load planning and load management. Load planning allows the user to define their targeted electricity consumption in the form of hourly usage of each appliance. Load management tab allow us to switch on and off the loads remotely from android application.

Figure 3: Application Home page

In the load planning windows, the user first assigns the rated power and daily usage hours of each load as shown in Figure 5. By using these parameters, the app will calculate total monthly KWH.

Figure 6 shows some additional options where user will enter the different slabs and their per unit price defined by utility. To get more accurate estimated bill, surcharge tax, general sale tax and fuel adjustment tax option is also included in the app. By clicking the estimated tab, it will display the total calculated monthly bill based on total KWh.

Figure 5: Additional Options

The user can make the monthly bill according to their budget by modifying the appliances daily usage hours. To activate the system, the user will press the submit button and then controller will start controlling the loads according to schedule.

During a month, any time the user can check the current bill (based on energy consumed) and expected bill (based on average consumption). Which encourage consumer to reduce the energy consumption to keep the bill within their defined budget.

B. Results

The designed system was tested several times in laboratory where we used bulbs as four different loads. After successfully evaluating the system it was properly installed at household level to further validate the results. Figure 7 shows the hardware prototype examination in laboratory and figure 8 shows complete hardware system installed at main junction box of one of the household selected to perform case study. Successful verification of strict and relax modes was also done where if the energy limit for a day exceeded, all optional loads were switched off or the user was informed by a pop-up message appearing on the android device screen. The proposed system is flexible and scalable which makes it better than the systems currently available in the market.

Figure 7: Prototype testing at lab

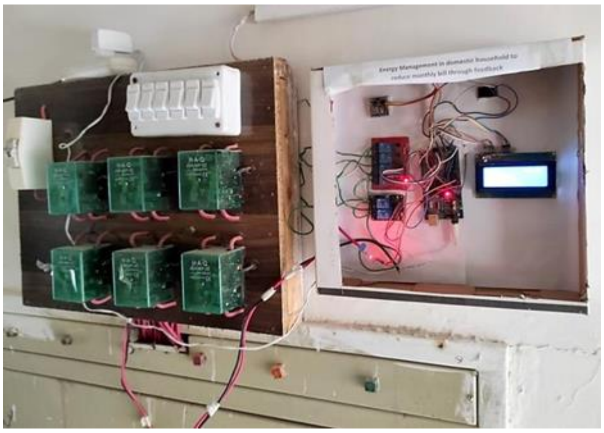

Figure 8: Hardware Installed

C. Case study

In order to accomplish the electrical energy conservation at residential level, a case study was conducted. The study was performed in 2018 for three households. House ‘A’ consisted of four family members, the House ‘B’ with seven members, and the third house ‘C’ with a total family member of nine persons. Each house comprises five bedrooms and the commonly used appliances by the families were refrigerators, air conditioning systems, electric heating systems, microwave ovens, electric kettles, fans and lights. Monthly energy meter readings were noted down for each household with and without this system.

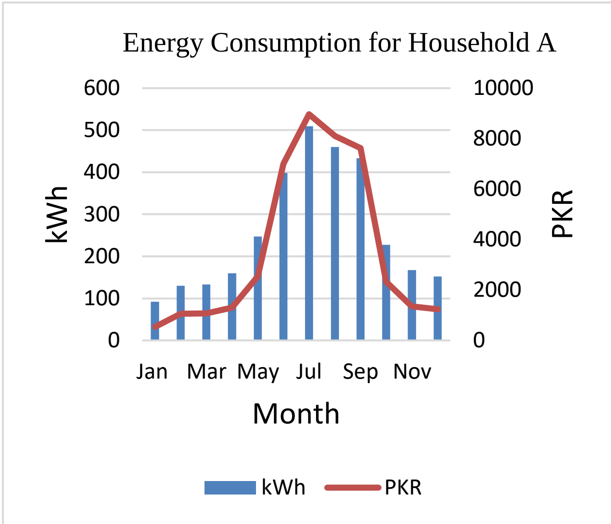

Figure 9 (a): Energy utilization of household A in 2017 before system installation

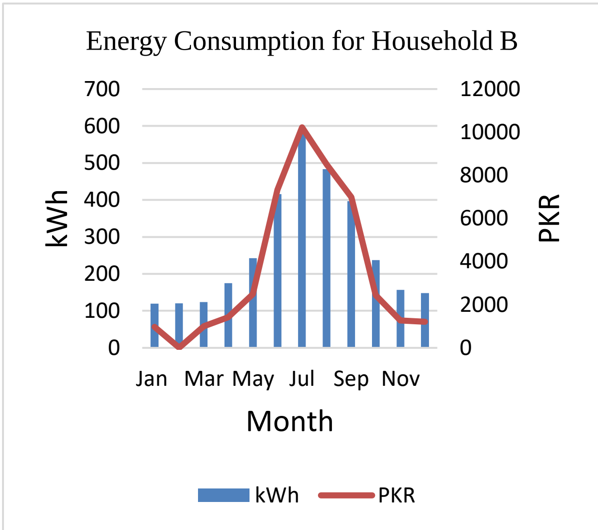

Figure 9(b): Energy utilization of household B in 2017 before system installation

Here the electrical energy conservation was achieved by using the system and defining their targeted electricity consumption. They were also advised to change their common behavior in order to avoid wastage of electrical energy and motivated them not to leave the appliances in standby modes. To carry out an effective statistical analysis, the achieved results in 2018 were also compared with the previous year 2017 meter readings for the same months.

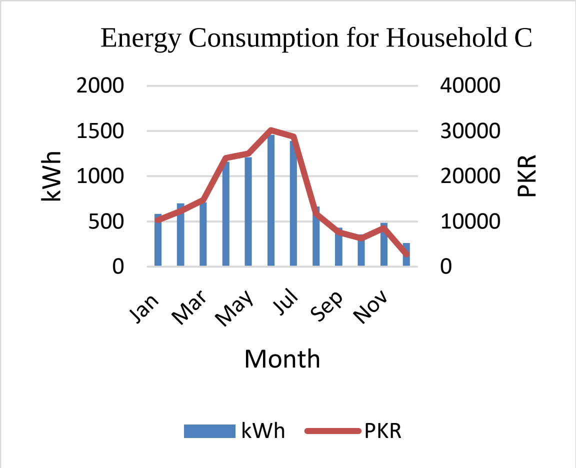

Figure 9(c): Energy utilization of household C in 2017 before system installation

The data for unit's consumption and monthly bill of three households for the year 2017, before the system was installed, is shown graphically in figure 9 (a,b,c). Household A was considered to be the most efficient consumer with least waste of resources, household B was average consumer, and household C was the least efficient consumer of electricity. For the household 'A', average consumption before the installation of system was 259kWh. For household B the average consumption was 266.5833kWh, and for household C, the average consumption was calculated to be 727.75kWh.

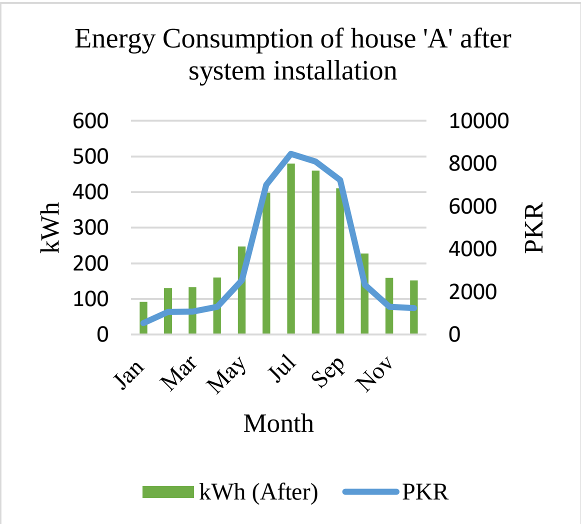

Figure 10(a): Energy utilization of household A in 2018 after system installation

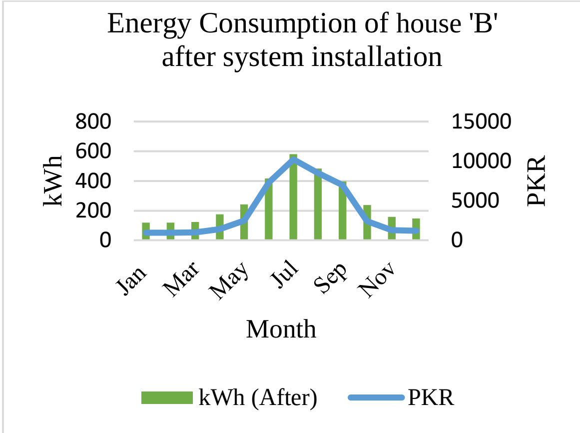

Figure 10(b): Energy utilization of household B in 2018 after system installation

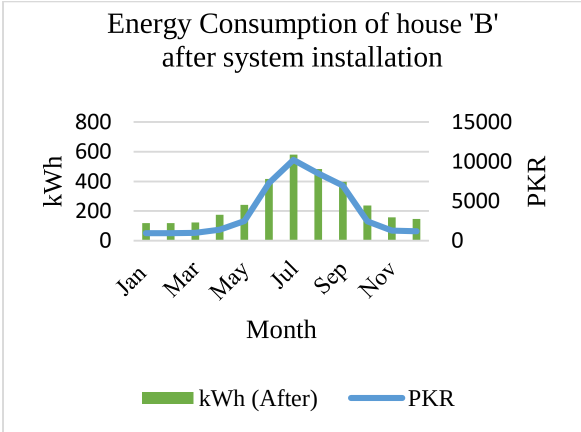

Figure 10(c): Energy utilization of household C in 2018 after system installation

But after the installation of the system in 2018 for conservation of energy, the system showed clear reduction in the consumed units, thereby reducing the monthly electricity bill. Following graphical Figure 10 (a,b,c) shows clear reduction in consumption of electricity for three household

It was concluded that the household A was much more aware of their consumptions and was using the electricity very efficiently even before the system was installed. Their average consumption in 2018 came out to be 254kWh thereby, saving 21.25kWh and on average saved 6.25% of electricity for the year 2018. Similarly the average consumption of house B came to be 267kWh and saved a total of 63kWh with a percent saving for year 2018 to be 16.41%.

On the other hand, household C was consuming electricity very generously and was worried about their increased electricity bill before system installation. But after the system was installed they became more aware and informed about the consumption and reduced their average consumption to 780.5kWh saving 291.4 kWh units of electricity with 22.75% energy saved for complete year.

D. Savings through Strict and relax mode

The mobile application named SMART ENERGY METER also has an additional feature that allows the user to plan the usage of electricity according to their own budget and is able to calculate the expected monthly bill. It further has two modes (i) Strict and (ii) Relax mode; in which if the system is in strict mode, all the unwanted loads will automatically turn off once the targeted consumption is achieved, leaving the basic loads running. While in relax mode the user gets notified in the form of a pop up message about their increased consumption.

This feature was specifically tested for summer season in the month of May and June. In order to do a comparison between the energy saved through strict and relax modes, consumer C was selected because of their already increased electricity consumption.

Relax mode (May 2018)

For the month of May, system was considered to run under relax mode. In relax mode user comfort is not compromised and controller will notify the consumer in the form of a pop-up message on their mobile device, if the consumed energy exceeds the energy limit. Consumer C set the targeted units to be 1000kWh and daily consumption units were calculated, but at the end of month the consumed units were 1285kWh. Table 1 summarizes the details about the targeted units, consumed units and average daily consumption.

Table 1 Targeted and Consumed units under relax mode
May 2018 (Relax Mode)

May 2018 (Relax Mode)	
Target Units	**1000 kWh**
Weekly Allowed	250 kWh
daily allowed	33.33 kWh
Consumed Units	**1285 kWh**
Weekly Consumed	321.25 kWh
Daily consumed	42.833 kWh
Exceeded units	285 kWh

The user tried to reduce consumption in order to meet the targeted unit's and consumed a total of 1285kW units with a total monthly utility bill of 26000 PKR. Compared to the last year bill for the same month, they were able to reduce their consumption and saved 35% of the energy for May 2018.

Strict Mode (June 2018)

To study the effect on energy conservation through strict mode Household C was again selected for June 2018. In the strict mode, if the consumed energy exceeds energy limit, controller will automatically switch off the loads categorized as optional and the basic loads will keep running. E.g. if the user has consumed their targeted units for a day at 9:00pm, their optional loads (AC, Washing Machine, dishwasher etc.) will be switched off automatically and they have to wait till 12:00am until the next day starts in order to make the optional appliances operational again. But in case of emergency, if there is a dire need, user can manually restart the devices. This will count on as the extra units consumed.

Since June is warmer than the month May, energy consumption was proportionally higher than the previous month. User set the targeted electricity units to be 1250 kWh and average daily allowed consumption was calculated to be 42 kWh, but consumed 1341 kWh by the end of June 2018 under strict mode. Table 2 summarizes the details about the targeted units, consumed units and average daily consumption.

Table 2 Targeted and consumed units under strict mode
June 2018 (Strict Mode)

June 2018 (Strict Mode)	
Target Units	**1250 kWh**
Weekly Allowed	310 kWh
daily allowed	42 kWh
Consumed Units	**1341 kWh**
Weekly Consumed	335 kWh
Daily consumed	44.7 kWh
Exceeded units	91 kWh

Their total consumed units by the end of June 2018 were 1341 kWh with a monthly bill of 27759 PKR. Compared to the last year bill for the same month, this user saved 38% of the energy for June 2018 under strict mode.

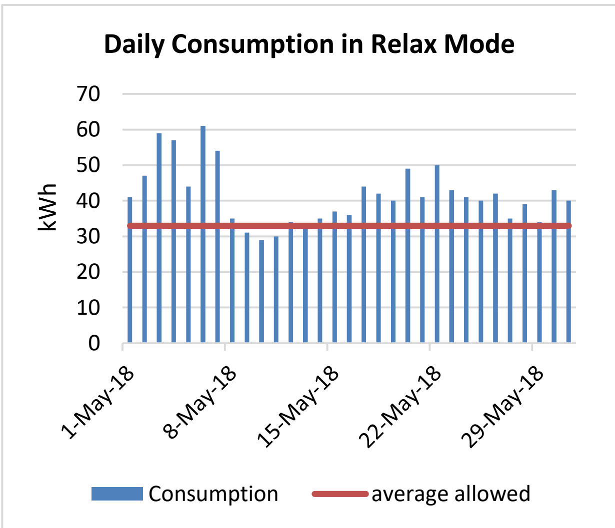

Figure 11(a): Daily consumption under Relax Mode

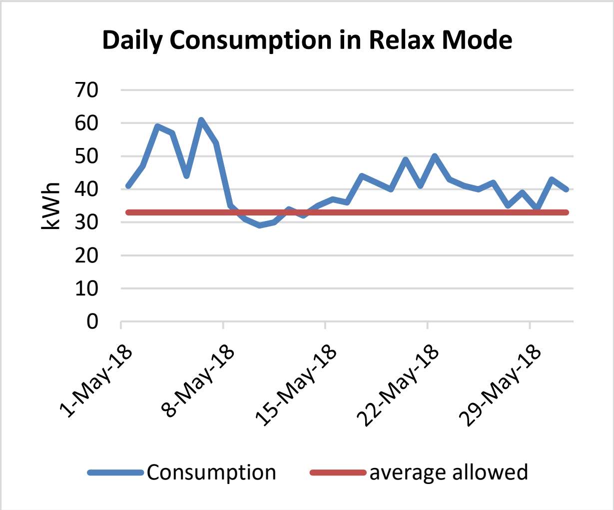

Figure 11(b): Daily consumption under Relax Mode

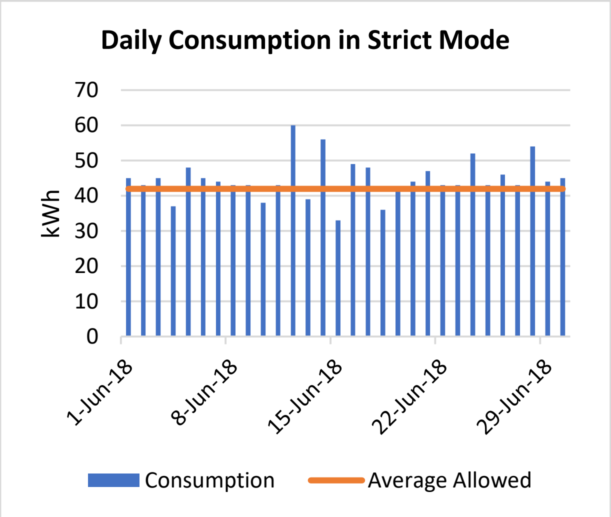

Figure 12(a): Daily consumption under Strict Mode

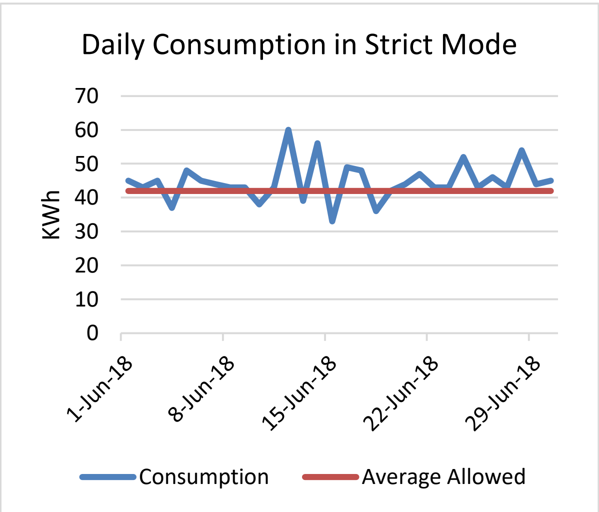

Figure 12(b): Daily consumption under Strict mode

Therefore, it can be concluded that more energy can be saved when the system is running under strict mode. Summary of the study is shown by a line graph and bar chart in figure 11 (a,b) and 12 (a,b), respectively.

CONCLUSION

In this era of technology, it is the most economical and efficient operation developed to facilitate the mankind. This project identifies that how consumers can manage their energy consumption by just using an application installed on their android devices. It is the most practical and accessible way to provide control of the loads by assigning their desired usage according to customer's budget.

Android Application has made it possible to select as many loads as you can and assign them as many units as per liking. This energy meter with addition to the app will keep user updated with the number of units consumed and calculating the expected bills. Thus letting the users know about their usage and help them reduce their monthly bills and energy consumption by better management of loads.

In order, not to compromise on the user privacy and comfort, two options for the controlling of the devices is included; (i) Strict mode and (ii) relax mode. In strict mode when the usage limit exceeds, the optional loads are automatically switched off, while in relax mode user gets notified about the usage in the form of a pop-up message.

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Sustainability Assessment of Micro-Hydropower Projects

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***Abstract*—** Micro hydro Power Projects (MHPPs) have been receiving increasing attention in the face of the growing energy demands and the high proportion of population living without grid access in Pakistan. The government has initiated a project to install 356 MHPPs in the province in 2014, which has now been extended to 1200 such projects. Unfortunately a number of these MHPPs have not been able to produce the desired results, some failing to start generation and some despite producing electricity not bringing the social, environmental and economic changes that are ideally the outcome of such projects. This paper proposes a new quantitative sustainability model specifically designed for the peculiar socio-economic and cultural dynamics of the northern areas of Pakistan. Rooted in sixty one sustainability assessment indicators across four dimensions and twenty one sub dimension and especially minted for the socioeconomic conditions of the region, the model is meant for assessment of the sustainability of an MHPP. The indicators are rated on a scale of 1 to 5 as per the International Hydropower Association (IHA)'s Hydropower Sustainability Assessment Protocol (HSAP), the overall dimension score is aggregated from the individual indicators and sub-dimensional weightages. The end output of the model is a dimension score ranging from 1 to 5. In the case study the model was applied to the MHP project installed in the Kalam Valley of the province of Khyber Pakhtunkhwa and achieved scores indicative of basic good practices of sustainability along the social, economic, technical, and environmental lines. The quantification of sustainability assessment of the MHP projects would pave wave for informed and evidence based decision-making process for the future MHP projects installed in the region. The model, albeit designed for the KP region, can be tweaked for MHPPs of any socioeconomic region by adjusting the weightages of the indicators and subdimension as per the peculiarities of that region..

***Keywords*—** Sustainable development, Micro hydro power plant, Renewable energy.

I. Introduction

Close to one-fifth of the world population lacks access to electricity as of 2017 [1]. Majority of these disenfranchised populations live in remote localities, where grid access is hard to achieve. Over 84% of these off-grid people live in rural areas, particularly in sub Saharan Africa and South Asia [2]. Economic uplift is highly dependent on provision of energy [3]. Accordingly, economic development is gauged by the per capita energy usage of a country; energy and economic growth forming a symbiotic relationship where one parameter improves the other, as in countries like Pakistan [4]. However, in the contemporary world energy access is not considered an end goal, rather a pathway to social and economic uplift [5].

In addition to the economic uplift of a country, electricity access is a significant aspect of the sustainable development. Sustainable development Goals (SDGS 3, 5, 7), envisioned by United Nations are all incumbent upon the provision of cheap and environmentally clean energy to the poor communities [6]. Familiarization with the interdependencies of sustainable systems on energy provision and its environmental impact is pertinent in the building such sustainable systems [7]. It is posited that poverty alleviation purposed energy access is far more dependent on conceptualization of the positive impact of energy on people's lives than on the understanding of the technology itself. The impact of energy itself is an overarching concept ranging from education to health and agriculture to job creation which should be treated as such when formulating policies and programs [8].

One such policy consideration for electrification of a region is the choice of energy technology for specific locations. One has to consider a plethora of issues and challenges in the selection such as the major natural energy resource of the region; vicinity to national or regional grid; customer economic dynamics; and stage of maturity of the chosen technology [9]. Moreover, the energy access should not be treated as just for the sake of energy access but a part of grand scheme of development [10]. The alignment of the regional and rural electrification with the national policy objectives, and scrutiny and stakeholder engagement are the important aspect of the sustainability of the projects [11].

Sustainability is the major challenge in the fulfilment of projects related to rural electrification. Rural community based electrification projects are prevalent all over the world, implemented by both government and non-government institutions. For sustainable projects the social, technical, economic, and environmental sustainability assessment should be carried out under the feasibility study.

The energy mix of Pakistan is heavily tilted in favour of thermal electricity generation making 68.4 % of total generation, while hydro, renewable, and nuclear power plants contributing 23.8%, 4.1%, and 3.6% respectively, of a total capacity of 29,944 MW [12]. This puts a lot of strain on the national exchequer as the fossil fuels are predominantly imported.

In addition to the cost factor of hydro electricity resources, the abundant availability of rivers and streams throughout the country and northern areas, as shown in the figure 1 and 2, is a great gift which needs to be utilized. Run of the river small scale hydropower plants have proven an economically viable and environmentally sustainable power option for rural electrification in developing countries.

In Pakistan also, estimated at 1200 MW potential, the mini micro hydropower plants (MMHPPs) can prove a vital resource in alleviating the energy crisis facing the country in conjunction with the electrification on more than 30 % off grid community [13]. To tap this potential an ambitious project was started in 2014 by the provincial government of Khyber Pakhtunkhwa province to set up 356 MHPPs in the northern areas of the province spanning 12 districts [14].Till June 2018 more than 90% of these MHPPs have been completed and the project has been extended to 1200 MHPPs..

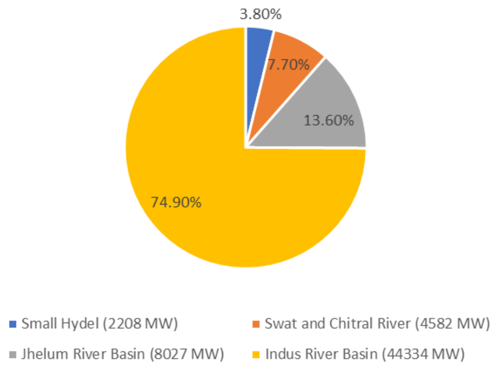

Figure 1. Distribution of Hydropower Resources of Pakistan [16]

Sustainability Assessment Tools and Studies for Hydropower Generation

Numerous attempts have been made to come up with a standard, all-encompassing definition of sustainability. For example, in one 500 plus concepts of quantification of sustainability accentuating the diversity of the concept and its measurement techniques have been compiled [17]. The world commission on Environment and Development, in 1987, published the most popular definition of sustainability as "meeting the needs of the present without compromising the ability of the future generations to meet their own needs"[18]. Besides the great many ways to define sustainability, it is usually gauged by various dimensions, which are chosen on the basis of the evaluation model used. For instance, the Three Pillar Model assesses the sustainability of a project on its social, economic, and environmental dimensions. In this study, however, the concept of sustainability is defined in the context of MHP projects as; the capacity of an MHP project in maintaining its operation with the guaranteed fulfilment of technical, economic, social, and environmental needs [19].

Since the MHPPs are usually completed with the participation and support of local population, the community ownership is the foremost deciding factor in the sustainability of the project [20]. Off grid communities, usually, are located in the far-flung areas, making it difficult to provide the resources necessary for electrification. In addition, the commercial financial sector is usually hesitant to finance off grid project. Consequently, the engagement of local community and private financial aid is a precursor for the completion and sustainability of these projects. The local community is quite adept in the art of surmounting the mobilization and transportation related challenges which to outsiders, would seem like an uphill task. On the other side, the average off grid community dweller is usually destitute and the financing of electrification projects are far outside his capacity. Therefore, the conception of innovative ideas for attracting capital for electrification projects is the crucial to the installation and sustainability, ultimately to rural development [21]. This, obviously, is not as easy as said in rural communities. The onus of such projects, eventually, falls on the government and non-government welfare organizations. The government and non-governmental organizations are not solely interested in the immediate gains from selling of the electricity; instead they strive for the social benefits and business stimulation accruing from the electrification, leading to new jobs and entrepreneurial endeavors [22]. The social benefits of electrification are not considered an automatic, and spontaneous output, rather it requires the complementary provision of avenues, and awareness to reap the maximum rewards [23]. Barring the parallel development and awareness programs, the electrification in itself is not an end to economic indigence [24].

In this study, a sustainability model for MHPPs has been developed for the niche socioeconomic dynamics of Khyber Pakhtunkhwa province of Pakistan. The sustainability model encapsulates the social, economic, technical and environmental aspects of sustainability assessment of the projects. The model is novel in the sense that the socioeconomic indicators, and resultantly the sustainability drivers, of any development project vary from region to region. This model is specifically equipped with indicators specially minted for the region capable of quantitatively assessing the sustainability of the MHPPs from the abovementioned dimensions. However with adjustments in the weightages of certain sustainability indicators in coherence with the region it is applied to, will make it applicable in any society.

II. METHODOLOGY

The study was conducted in the steps as shown in the flow chart in Figure 3.

Figure 2. Methodology of the model development

Physical survey of the MHPP site and community

The projects were physically visited by our team with surveys and questionnaires filled by the local population. A total of 100 surveys were filled out by the local populace. Based on the response to the survey questions and the physical observation scores were assigned to each indicator depending on their adherence to the good practices and the global best practices.

Table 1. Basic Information of the Case study site

Particulars	Details
Place	
Area Name	Kalam PC
District	Swat
Province	KP
Country	Pakistan
Map details	
Latitude	35_29'30.5" N
Longitude	72_34'47.5" E
Weather (Average)	13_C, 639 mm Rainfall
Elevation	2000 m above sea level
Population	
Total population	23,170
Total male	11,700
Total Female	11,470
Total no. of houses	2461

III. RESULTS AND DISCUSSION

The main result of the research is the groups of twenty two subdimensions of sustainability harboring sixty one indicators. The sub dimensions listed in the figure bear a weightage assigned on the basis of its pertinence to the overall sustainability in the particular dimension. For instance, the sustainability sub dimensions of health and education have been assigned a weightage of 25 each while the other sub dimensions carry relatively lower weightages. The weightages of these and other sub dimensions are the average of three scores assigned by individual person familiar with the projects and the social fabric of the communities where they are implemented. Each individual, usually belonging to the stakeholder institutions i.e. the provincial energy department, or the implementing nongovernmental organization, or the academia experts, also gave a rationale for assigning their respective scores. For instance, in case of education and health getting comparatively higher scores of 25 each the main argument given was that since the projects are financed by NGOs or government, with the foremost intention of all-inclusive development of the beneficiary community in which health and education improvement are the paramount parameters.

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4.1. Case Study

The developed model with all the weightages assigned to the sub dimensions and the respective indicators of sustainability was applied to an MHP project in the Kalam valley of Khyber Pakhtunkhwa Province of Pakistan. The valley is a major tourist attraction with influx of hundreds of thousands of tourists yearly. The site was taken as a case study owing to the significant population that resides within and is electrified by the MHP project being analysed. The total electrified population by the MHP project is in excess of 22000. This grants us with more diversity in terms of the challenges to the sustainability and analysis of this one MHPP site exhibits all the problems that any other MHPP in the province could come across. The aggregate dimensional sustainability scores achieved by the MHPP project are 3.19, 3.57, 3.32, and 3.79 for the technical, economic, environmental, and social dimensions respectively. A description of the various sub dimensional and indicator scores and the physical manifestation of these scores from what was observed on site is given in the following.

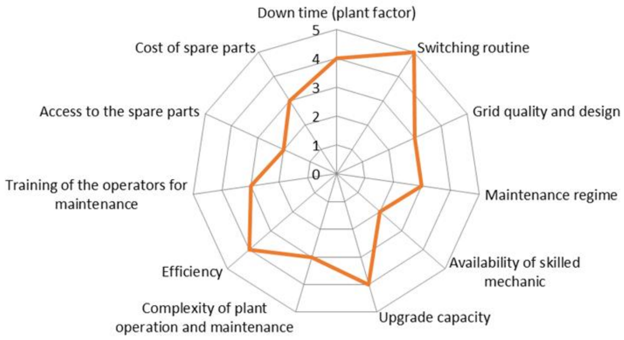

Figure 3. Technical sustainability indicator scores (Kalam MHPP)

The technical dimension with an aggregate score of 3.19 is skewed towards the lower side by the "Reliability" and "Ease of maintenance" sub dimensions with scores of 2.5 and 2.7 respectively as shown in the Table 3 and Figure 3. The reliability of operation scores less because of non-availability of skilled mechanic specializing in hydro turbine maintenance in the local urban centers.

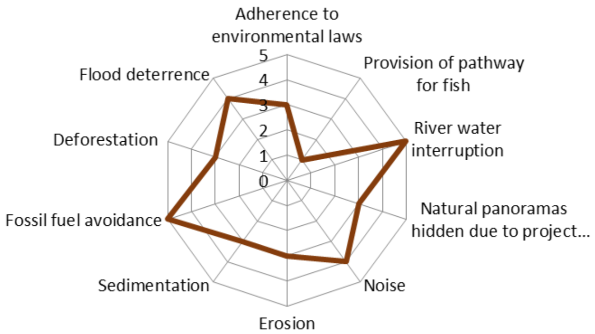

Figure 4.Environmental Sustainability indicators scores (Kalam MHPP)

This impacts the sustainability of the MHPPs quite severely as the maintenance problems which could take a few hours to fix in cases where skilled mechanics are immediately available are extended to days long downtime of plant and the subsequent electricity cutoff for the community.

Environmental sustainability, evidently is an important outcome of any renewable energy project, but in context of Kalam valley its significance is even more pertinent as it is a popular tourist destination for people in Pakistan. The environmental sustainability scores, as given in the figure 4, projects basic good practices in environmental domain. The sub dimensions "Wildlife protection" and "Climate Change Deterrence" hold the predominant weightage in the environmental sustainability potential of an MHP project for the Khyber Pakhtunkhwa province as per the experts.

The social sustainability of an MHPP is enshrined in the social welfare that is the part and parcel of the project. In this regard the Kalam MHPP project has a score surpassing basic good practices. With a score of 3.79, as shown in figure 5, on the social sustainability scale the MHPP has been bringing about positive generative social outcomes. Be it the impact of the project on local education, health, or the general perception of the local populace concerning the MHPP, the project has been a net positive. Poignantly the couple of areas where the project lacks are the equality of outcomes for the genders, and the spending of the surplus revenue generated by the project on local development projects. Albeit the women population of the beneficiary community have seen significant progress in their living conditions as a consequence of decrease in time collecting firewood, or general wellbeing from lighting in the house or heating water in the winter season burning firewood. Still the women are not involved in direct decision making affecting the operations concomitant to the MHPP. Social stigmas to women participation aside women in the community organization, for instance, could bolster the efforts to create awareness about extracting maximum social and economic output from the project by communicating with the women inside their homes, a luxury not afforded to males.

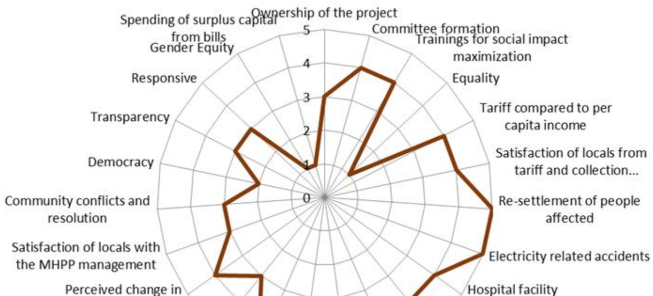

Figure 5. Social Sustainability Indicators Scores (Kalam MHPP)

Economic Sustainability of the MHPP is concomitant with two aspects: the employment of sustainable practices in the power plant installation and operation, and the economic benefits in the beneficiary community that stem from the electricity. Both of these aspects are essential parts of MHPP economic sustainability. The indicator scores presented in the figure 9, gives an overall economic sustainability score of 3.57. The figure of 3.57 can be interpreted in multiple ways such as one could say that there is a 71 percent likelihood of the sustainability of the project to complete its long term economic goals envisioned by the implementing and funding authorities. Alternatively one could say that the basic good practices are being met by the MHPP in its economic impact. The financing of the project scores 4.3 owing to the unconditional grant that financed the project as well as the local population contributing towards the project, albeit a small amount. The commercial and domestic tariff slabs in dispatching the electricity observes sustainable practices. The majority of beneficiaries were satisfied with the collection process as well.

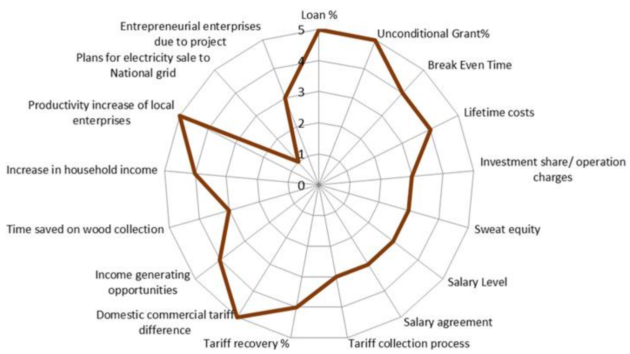

Figure 6. Economic Sustainability Indicators Scores (Kalam MHPP

In light of the scores obtained by the various sustainability indicators and dimensions, the operational strategy for a particular MHPP could be modified in the relevant indicators. Funding organizations or government could set up threshold scores based on their vision for the sustainability dimensions to streamline their monitoring of the project already installed. They can further aggregate the scores of the four dimensions as per their priorities in to a single sustainability score for an MHPP which will make the selection of the more sustainable and outcome oriented project more systematic rather than the conventional monetary cost/gains comparison.

CONCUSLION

There are no two opinions in the assertion that the MHPPs are a lifeline to the beneficiary communities. To make their fruits long lasting a sustainability assessment model was developed for the socioeconomic outlook of the hydro rich region. The model consists of 61 sustainability indicators aggregated to 22 sub dimensions resulting in a sustainability score in the range 1-5 for the social, economic, technical, and environmental dimensions of sustainability. The sub dimensional and indicator weightages could be set up according to the vision of the implementing authorities. The model was applied to the case study of an MHPP in Kalam valley of Pakistan. The MHPP obtained sustainability scores of 3.19, 3.32, 3.79, and 3.57 for the technical, environmental, social, and economic dimensions. The indicators with low scores could be stressed upon for better performance in the future to make the projects more sustainable. The sustainability model utilized here could prove a precious resource for the future projects planned by the provincial government and NGOs alike. The decision-making process involved in the selection of MHPPs out of proposed projects will become a lot simpler and well informed by the employment of such a quantitative mechanism. Although some of the indicators used here are commonly available in the literature, still they have been modified and molded in to the domestic needs and considerations. One thing to consider in the employment of this model is that it is specifically designed for small and micro scale projects and its application to large hydro projects could result in severe inaccuracies.

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Segmentation of Images with Inhomogeneous Intensity Multi-Objects

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Abstract**—**Computer vision is an influential area in which methodologies are generated to analyze and know about the charactristics and construction of a digital image and output is some meaningful information. Image processing comprises five main branches i.e image segmentation, image denoising, image registration, image inpainting and image deblurring. Image segmentation is our focus research work in context of fuzzy sets theory. The pivotal element to fuzzy sets [11] is fuzzy membership V, which acts like region descriptor, must satisfy the restriction $0 \leq u \leq 1$. Level set method (LSM) [9] is used, which is responsible to distribute and allogate the evolution curve C, which is a better way to carry out image segmentation process.

In our research work we developed a model for segmenting images with inhomogeneous intensity multi objects background having maximum, minimum, average intensities. For such achievement we changed Krinidis and Chartiz [13] fitting term by linear term in fuzzy setup. Experimental result of our model justify that our model will show better performance in those images which are suffering from intensity inhomogeneity multi objects.

Keywords: Variational model, Fuzzy sets, Image segmentation, Intensity inhomogeneity.

I. INTRODUCTION

Image segmentation is one of the busy research area of image processing. The aim and objective of image segmentation is to separate image domain into different meaningful regions, based on some similar characteristics (color, intensity, texture etc). For this purpose different technique such as thresholding [4], clustering [5], edge detection have been proposed. However, due to presence of noise, intensity inhomogeneity, outlier in images, stable and robust image segmentation is still a challenging task. In variational framework, Active contour models play a vital role for segmentation of images.

Different researchers try to upgrade image segmentation techniques. In particular, Mumfared and Shah [6], presented a well known variational segmentation model. The goal of MS energy functional is to segment a given image Z_0 into different regions in terms of intensity, color or texture etc. The energy function of MS is follow:

$$F(U,K) = \eta.length(K) + \int_{\Omega} |Z_0 - U|^2 dxdy + \int_{\Omega} |\nabla U|^2 dxdy, \quad (1)$$

where $\Omega \subset R^2$ represent image domain, K is the set of edges, η and ξ are positive parameters. This model solves image segmentation and image denoising model simultaneously. But the drawback of the model is that it is very difficult to implement.

Chan and Vase (CV) [7] proposed a region based model, which is the piece wise constant approximation of the Mumford and Shah model. They have used level set technique [9] for the minimization of the Mumford and Shah model functional [6] The energy functional of the model is follow:

$$F(c_{1,} c_2, C) = \mu.length(\mathrm{C}) + \nu.\mathrm{area}(\mathrm{inside(C)}) + \eta_1 \int_{\Omega} |Z_0 - c_1|^2 dxdy + \eta_2 \int_{\Omega} |Z_0 - c_2|^2 dxdy, \quad (2)$$

where μ, η_1, η_2, and ν are fixed positive parameters. c_1 *and* c_2 are the average intensity inside and outside of the contour C respectively. The first term in Eq.(2) is the length term make the curve smooth and the last two terms represent the fitting terms or data terms, which guide the contour towards object boundary.

CV model gives bitter result where intensity homogeneity objects in an image but may not segment images with inhomogeneous multi objects.

Wu and He [8] proposed a convex variational level set model based on the coefficient of variation which is proposed by Badshah et al. [10]. Which is strictly convex. For minimization, following is the energy functional of the proposed model:

$$E_{WH}(\phi) = \lambda \int_{\Omega} \frac{(Z_0(x,y)-a_1)^2(\phi(x,y)+1)^2}{(a_1)^2} dxdy + \int_{\Omega} \frac{(Z_0(x,y)-a_2)^2(\phi(x,y)-1)^2}{(a_2)^2} dxdy\,, \quad (3)$$

Where η is a positive tuning parameter, ϕ is a level set function [9], $\bar{a}_1$, $\bar{a}_2$ are two constant prototypes to inner and outside of the contour which is defined in the following way.

If the exterior and interior of the level set function ϕ is non empty, Then

$$a_1 = \frac{\int_\Omega (Z_0)^2(x,y) H(\phi(x,y))dxdy}{\int_\Omega (Z_0)(x,y)H(\phi(x,y))dxdy}, \tag{4}$$

$$a_2 = \frac{\int_\Omega (Z_0)^2(x,y)(1-H(\phi(x,y)))dxdy}{\int_\Omega (Z_0)(x,y)(1-H(\phi(x,y)))dxdy}, \tag{5}$$

Otherwise

$$a_1 = a_2 = \frac{\int_\Omega (Z_0)^2(x,y)dxdy}{\int_\Omega (Z_0)(x,y)dxdy}, \tag{6}$$

Here $H(\phi)$ is a Heaviside function is defined in the following way:

The minimization of the energy functional is given by the following Gradient descent flow.

$$\frac{\partial\phi}{\partial t} = -\lambda \frac{(Z_0(x,y)-\bar{a}_1)^2}{(\bar{a}_1)^2}(\phi(x,y)+1) - \frac{(Z_0(x,y)-\bar{a}_2)^2}{(\bar{a}_2)^2}(\phi(x,y)-1) \tag{7}$$

CV model is strictly convex and free of initial contour placement. This model can segment images with homogeneous intensity multi object images successfully and might not gives better result in multi-variate intensity object images.

Ali et al. [12] proposed a novel region based model in which they used Generalized averages combining with non Euclidean measure. The energy function of the proposed model is as under:

$$E(G_{v1}, G_{v2}, u) = \mu \int_\Omega [u(x,y)]^m (1(-\hat{k}(Z_0(x,y), G_{v1})))dxdy + \int_\Omega [1-u(x,y)]^m (1-(\hat{k}(Z_0(x,y), G_{v2})))dxdy \tag{8}$$

Where μ is a +ve parameter, $u(x,y)$ is a fuzzy membership function defined in (4) which is defined on [0,1]. The fuzzy function is used to reject local minima. m is a weighting exponent on each fuzzy membership function u, which is usually taken 2. This model is convex. This model work very well in those images which have noise, pepper and salt, intensity homogeneity. But this model may not work very well in those images which have sever intensity inhomogeneity multi objects. From experimental result we can easy guess that this model does not work the mentioned limitation.

Fuzzy sets [11], which have been widely used in data clustering and image segmentation is firstly introduce by Krinidis and Chatzis [1], unification active contour methodology and fuzzy sets [11]. They proposed a model fuzzy energy based active contour model [1]. For minimization they proposed energy fuctional is follow:

$$F(C, \bar{a}_1, \bar{a}_2) = \eta_1 \int_\Omega [u(x,y)]^m (Z_0 - \bar{a}_1)^2 dxdy + \eta_2 \int_\Omega [1-u(x,y)]^m (Z_0 - \bar{a}_2)^2 dxdy. \tag{9}$$

Where u(x,y) is fuzzy function which is defined on [0,1] and m is a weighting exponent usually taking 2. $\bar{a}_1$, $\bar{a}_2$ are the average prototype inside and outside of Γ. They incorporate fuzzy sets in the active contour symmetry. This model uses pseudo zero level set as the dynamic curve. The fuzziness of the energy function provides strong ability to reject local minima. The relation between pseudo level set and the evolving curve Γ is defined in the following way:

$$\begin{cases} \Gamma = \{(x,y) \in \Omega : u(x,y) = 0.5\} \\ \Gamma_1(inside\Gamma) = \{(x,y) \in \Omega : u(x,y) > 0.5\} \\ \Gamma_2(outside\Gamma) = \{(x,y) \in \Omega : u(x,y) < 0.5\}. \end{cases} \tag{10}$$

The fuzzy membership function u(x,y) is updated by:

$$u(x,y) = \frac{1}{1+\left(\frac{\lambda_1(Z_0-\bar{a}_1)^2}{\lambda_2(Z_0-\bar{a}_2)^2}\right)^{\frac{1}{m-1}}} \tag{11}$$

FEBAC gives successful result in those images having homogeneous intensities with multiple objects and might be unsuccessful in inhomogeneous intensity multiple objects.

II. Proposed Model

In this section our propose model will be discussed briefly. The main idea behind our proposed model is to segment a digital image having variate intensity multi objects. Let us assume the dynamic curve Γ in the image domain Ω, and the image is denoted by Z_0. This model is based on linear fitting terms and pseudo level set (fuzzy membership function). The energy functional of our proposed model is as under:

$$E(L_1, L_2, u) = \mu \int_\Omega |\nabla u(x,y)|\, dxdy + \int_\Omega |Z_0 - L_1|^2 [u(x,y)]^m dxdy + \int_\Omega |Z_0 - L_2|^2 [1-u(x,y)]^m dxdy. \tag{12}$$

Where $u(x,y)$ is a fuzzy membership function in (11), which must satisfy the constraint $0 \le u \le 1$, $\mu>0$ is a +ve parameter and $L_1 = a_0 + a_1x + a_2y$, s $L_2 = b_0 + b_1x + b_2y$ are linear terms. The fuzziness of the energy functional provide strong ability to deny the local minima. We will get the global minimum value of the energy functional in (12), because the model is convex. Next we will prove the convexity of the proposed energy functional.

Convexity of the energy functional

For simplicity consider the energy functional in (12) as follow:

$$f(\zeta) = \epsilon f1(\zeta) + f2(\zeta) + f3(\zeta) \tag{13}$$

$$f_1(\zeta) = \int_\Omega |\nabla u(x,y)| d\zeta \tag{14}$$

$$f_2(\zeta) = \int_\Omega |Z_0 - L_1|^2 [u(x,y)]^m d\zeta \tag{15}$$

$$f_3(\zeta) = \int_\Omega |Z_0 - L_2|^2 [u(x,y)]^{m-1} d\zeta \tag{16}$$

To show that the domain Ω is convex, for this we consider

$$f_2(\zeta) = \int_\Omega |Z_0 - L_1|^2 [u(x,y)]^m d\zeta \tag{17}$$

And let

$$F_2(\zeta) = |Z_0 - L_1|^2[u(x,y)]^m \quad (18)$$

Such that F_2: $\Omega \longrightarrow$ R, and let

$$f_2(\zeta) = \int_\Omega F_2(\zeta)\, d\,\zeta \quad (19)$$

First of all we will show that Ω is convex, for this let us consider that $z_1 = (x_1, y_1)$, $z_2 = (x_2, y_2) \in \Omega$ and for any $\gamma \in [0,1]$, we have

$$\gamma z_1 + (1-\gamma)z_2 = \big(\gamma\,(x_1, y_1) + (1-\gamma)(x_2, y_2)\big) = (\gamma\,(x_1 - x_2) + x_2, \gamma\,(y_1 - y) + y_2) \in \Omega \quad (20)$$

Ω is convex as $x_1 - x_2 \in$R and so that $\gamma(x_1 - x_2) + x_2 \in \Omega$ also $y_1 - y_2 \in R$ and $\gamma \in [0,1]$, therefore $\gamma(y_1 - y_2) + y_2 \in \Omega$. so we can write that $\gamma z_1 + (1-\gamma)z_2 \in \Omega$. Now differentiating eq. (18), w.r.t the fuzzy membership function u , we have

$$\frac{\partial F_2}{\partial u} = m[u(\zeta)]^{m-1}|Z_0 - L_1|^2 . \quad (21)$$

Differentiating again w.r.t to u, we get

$$\frac{\partial^2 F_2}{(\partial u)^2} = m(m-1)[u(\zeta)]^{m-2}|Z_0 - L_1|^2 \quad (22)$$

$\frac{\partial^2 F_2}{(\partial u)^2} \geq 0$, as m=2 obviously m is +ve , $u(\zeta) \in [0,1]$ and $Z_0 - L_1|^2 \geq 0$. Also Ω is convex, so F_2 is convex and for all $\zeta_1, \zeta_1 \in \Omega$ and $\gamma \in [0,1]$ the inequality

$$F_2((\gamma\zeta_1) + (1-\gamma)\zeta_2) \leq \gamma F_2(\zeta_1) + (1-\gamma)F_2(\zeta_2)$$

So from the above inequality, we have

$$\int_\Omega F_2\big((\gamma\zeta_1) + (1-\gamma)\zeta_2\big)d\zeta \leq \int_\Omega \gamma F_2(\zeta_1)d\zeta + \int_\Omega (1-\gamma)F_2(\zeta_2)d\zeta$$

So using back eq. (17), we have

$$f_2((\gamma\zeta_1) + (1-\gamma)\zeta_2) \leq \gamma f_2(\zeta_1) + (1-\gamma)f_2(\zeta_2)$$

From the above inequality which is the condition for convexity of a function, we can say that $f_2(\zeta)$ is convex.

In the similar way we can also prove that $f_3(\zeta)$ is convex. Thus $f(\zeta)$ is convex, being the sum of convex functions. So the Energy functional of our proposed model is convex with respective the fuzzy membership function u.

keeping u fixed, and minimizing the energy function $E(L_1, L_2, u)$ with respective L_1 i.e a_0, a_1, a_2 and L_2 i.e b_0, b_1, b_2.

$$\frac{\partial E}{\partial a_0} = 0 ,$$

$$\Rightarrow \int_\Omega Z_0 u^m dxdy - a_0 \int_\Omega u^m dxdy - a_1 \int_\Omega xu^m dxdy - a_2 \int_\Omega yu^m dxdy = 0 \quad (23)$$

$$\frac{\partial E}{\partial a_1} = 0$$

$$\Rightarrow \int_\Omega Z_0 xu^m dxdy - a_0 \int_\Omega xu^m dxdy - a_1 \int_\Omega x^2u^m dxdy - a_2 \int_\Omega xyu^m dxdy = 0, \quad (24)$$

$$\frac{\partial E}{\partial a_2} = 0$$

$$\Rightarrow \int_\Omega Z_0 yu^m dxdy - a_0 \int_\Omega yu^m dxdy - a_1 \int_\Omega xyu^m dxdy - a_2 \int_\Omega y^2u^m dxdy = 0 \quad (25)$$

We can solve the above equation for a_0, a_1, a_2 using matrix inversion method or Cramer rule.

Now minimizing the energy equation with respective L_2 i.e b_0, b_1, b_2

$$\frac{\partial E}{\partial b_0} = 0$$

$$\Rightarrow \int_\Omega Z_0 u^m dxdy - b_0 \int_\Omega u^m dxdy - b_1 \int_\Omega xu^m dxdy - b_2 \int_\Omega yu^m dxdy = 0 \quad (26)$$

$$\frac{\partial E}{\partial b_1} = 0 \Rightarrow \int_\Omega Z_0 xu^m dxdy - b_0 \int_\Omega xu^m dxdy - b_1 \int_\Omega x^2u^m dxdy - b_2 \int_\Omega xyu^m dxdy = 0, \quad (27)$$

$$\frac{\partial E}{\partial b_2} = 0$$

$$\Rightarrow \int_\Omega Z_0 yu^m dxdy - b_0 \int_\Omega yu^m dxdy - b_1 \int_\Omega xyu^m dxdy - b_2 \int_\Omega y^2u^m dxdy = 0. \quad (28)$$

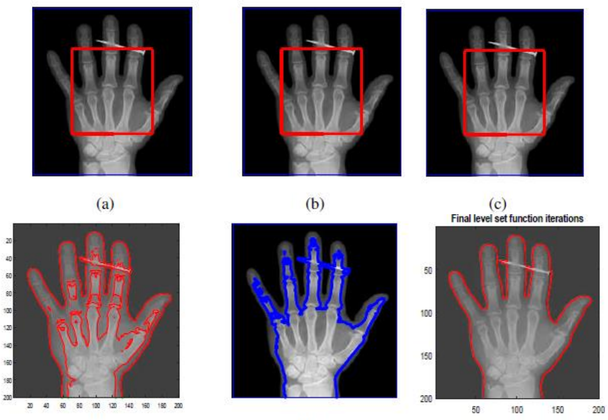
We can also solve above equation for the unknown b_0, b_1, b_2 by using matrix inversion method or Cramer rule.

Keeping L_1 and L_2 fixed and minimizing the energy functional E with respective fuzzy membership function $u(x,y)$, we will get the associated Euler-lagrange equation (evolving equation).

$$\frac{\partial u}{\partial t} = \mu \frac{\nabla u}{|\nabla u|} - m\lambda_1 u^{m-1}|Z_0 - L_1|^2 - m\lambda_2(1-u)^{m-1}|Z_0 - L_2|^2 . \quad (29)$$

III. Experimental Results

In this section we exhibits some experimental results of our model comparing with other existing models like CVL [8], FEBAC [1], Ali et al. [12]. For all experiments, image of a window of size 5 × 5. In figure (1) our model in relation to three other existing models has been tested on a real multi variate intensity image.



(a) (b) (c)

(e) (f) (h)

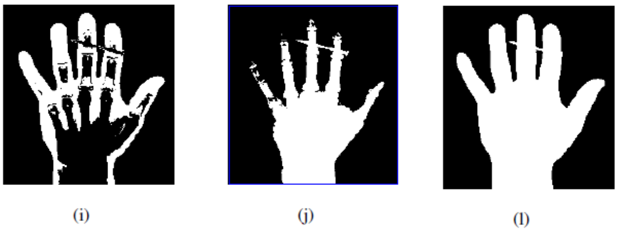


Figure 1: Performance of existing models and our proposed model on variate intensity image. First column shows the performance of Ali et al model [12], second column Krinidis Chartiz [1], third column Wu-He [8] and the fourth column shows the performance of our proposed model respectively (with JS= 0.89 with other parameters $\alpha = 0.18, \sigma = 0.5, \lambda_1 = 0.17, \lambda_2 = 1$)
. Excellent performance of our model in respect to other existing models on inhomogeneous intensity image can be viewed. Our model extract whole object in an image, while other model cannot.

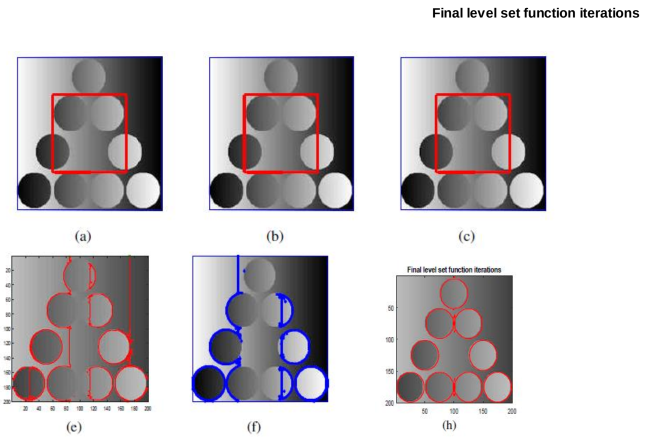


Figure 2: Result of existing models and our proposed model on variate intensity multi object image. First column shows the performance of Ali et al model [12], second column Krinidis Chartiz [1], third column Wu-He [8] and the fourth column shows the performance of our proposed model respectively (with JS= 0.887) with other parameters $\mu = 0.838, \sigma = 0.5, \lambda 1 = 0.7, \lambda 2 = 1.3$). Excellent performance in respect to other existing models of our model on inhomogeneous intensity multi object image can be observed. Our model segment very well where severe intensity inhomogeneity in the foreground.

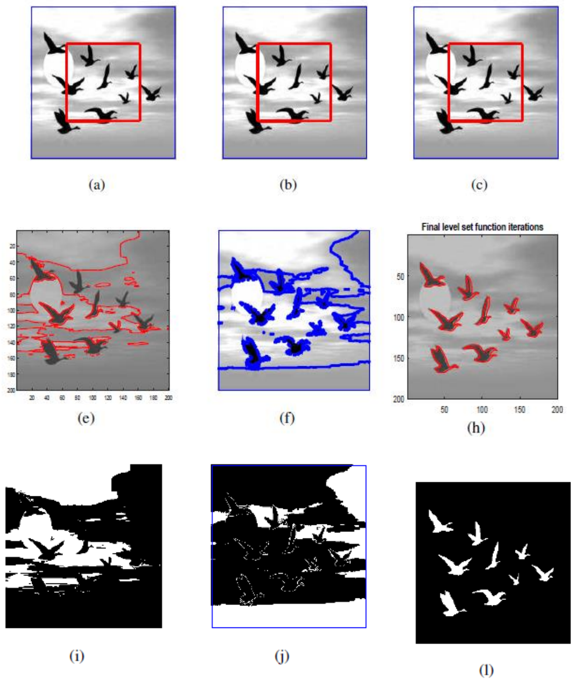
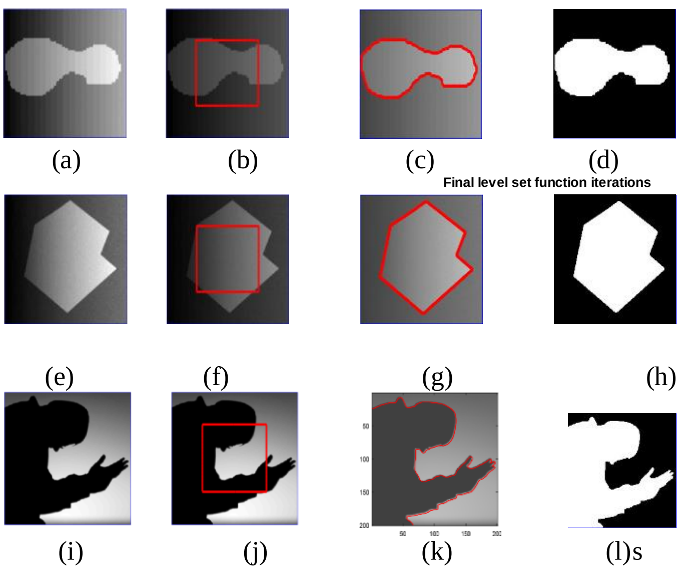


Figure 3: In figure (3), a real image with same intensity objects in the foreground but the background is cluttered. FEBAC model [1] (first column, JS= 0.32), Wu-He model [8] (second column, JS= 0.1), Ali et al. model [12], (third column, JS= 0.23), proposed model (fourth column, JS= 0.97) with other parameters $\mu = 0.01, \lambda 1 = 8 \lambda 2 = 4$ image having multi objects holding cluttered background. Our proposed model qualitatively behave very good and captured all desired objects and also quantitatively proposed model do better.



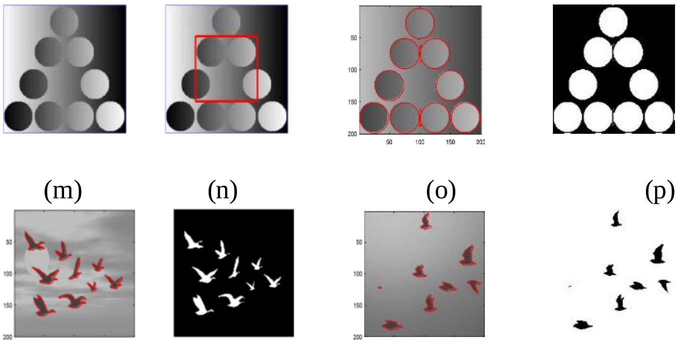


Figure 4: All these are the experimental results of our proposed model. From the first row (image (a)) it can be easily guess that our model works well in images which have low and average intensity background and foreground. From 3rd row (image (i)) result show that our model also work well in images which have high and low intensity background and foreground. From image (m) which have multiple objects with low, average, and high intensity, our model shows better performance.

Concuslion

In this research work, we suggested a new variational model based on fuzzy membership function for segmenting images with intensity inhomogeneity multi objects. Experimental results on some real and synthetic images have showed that our proposed model is more efficient and robust for segmenting images with intensity inhomogeneity, multi-intensity regions and objects. Comparisons with Ali et al. [12] model, FEBAC [1] model and also show the superiority of our proposed model in intensity inhomogeneity. The computational cost of our proposed model is far better than the said models.

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Impact of Affordable and Clean Energy (SDG 7) on Signifcant SDGs

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***Abstract*—** Energy is considered to be a vital part of the progress and prosperity of a nation. However, there are some parts of the world like South Africa, Nepal, Pakistan, India and other developing countries where some parts of people have do not access to electricity. Some of the people in the world even in Pakistan do not live a quality life and living theirs below the poverty line. There are people who do have access to electricity and quality education. They live their lives unhygienically and women are the victims of gender inequality. For this purpose, the United Nation gathers around and reached on common goals which are also called universal goals for the people and for the benefit of the planet, which are named as Sustainable Development Goals. These goals are agenda for 2030 that we together are going to achieve till 2030. One of the goals is Access to Energy of Sustainable Development Goals. SDG 7 stands for affordable and clean energy. Pakistan has remote areas, far away from the national grid, where there is no access to electricity. For this purpose, the government is electrifying those areas by using their indigenous resources. One of the best options is Micro and Mini Hydropower projects for the community. By providing the electricity we can improve their quality of life and they can play their part in a nation's economy. As these micro and mini-hydro projects are cheaper and friendly to the environment so they are the source of "Affordable and Clean Energy".

The study focused, on establishing pathways for SDG7 i.e. Affordable and Clean Energy and how this SDG7 affect other Significant SDGs in the area of Chitral. Thirteen sites of Chitral were visited and people were interviewed and investigate their lifestyle. So this study shows that this source of Affordable and Clean Energy is moving us towards achieving other Sustainable Goals. These goals can be achieved more effectively if the government organizations play their role to educate the people to make the most use of it.

***Keywords*—** Affordable and Clean Energy, Sustainable Development Goals.

I. Introduction

Energy is the engine to accelerate towards the prosperity and economy development of a country. Peoples have been living without electricity in the past, but the rate of economic development and industrialization is increased in the last couple of centuries due to an inventing of electricity. It is so true that the prosperity and progress of any country or a nation is calculated by how much per person energy is consumed [1]. For this purpose, the energy demand is increased and dependency on fossil fuel is increased in both developing and developed countries [2]. As energy is a fundament element of progress so its demand is going to be increased in the future. It is said that global energy demand to be increased from 14.5 x 10^7 GW in 2007 to 21.8 x 10^7 GW in 2035 [3] which is an increase of 49% of the total. There is a lack of electricity in developing countries in rural areas which exaggerates poverty in those areas due to the non-availability of electricity. International Energy Agency claims that about 1.3x 10^9 humanity still lives without electricity which is about 18% o of the total population [4]. Pakistan has been facing severe energy crises for couple of decades and the issue is still unresolved despite advancements in technologies[5]. Due to shortages of energy Pakistan is lacking behind in the race of progress. The actual demand for electricity varies from 16-19 Gigawatt [6]. We have sufficient installed capacity but due to losses and poor infrastructure, generation of power is too low. It's all because of poor planning and ill management. Due to advancement and rapid progress of human development the demand for power is increasing day by day and it's growing at a rate of 8% annually [7].

The world is moving towards renewable and sustainable options to generate power. Pakistan needs enough and surplus power to generate energy to accelerate its economy. As already stated that prosperity and progress of the country are calculated by per-person energy consumption in that country [8]. By looking the Figure 1, Pakistan's per capita energy consumption is very low in developing south Asian countries. Malaysia being the highest per capita consumption in South Asian developing countries. Pakistan's energy mix consists of 27% of indigenous natural gas, oil being highest of 36%, hydel instead of having higher potential 32% and rest of 5% generated from other resources like nuclear and renewable energy [9]. Hydrocarbon imports are a huge burden on the economy of the nation as we are about diminished domestic gas reserves in the near future. Domestic gas is a big contributor to the energy mix of Pakistan [10]. Pakistan has rural areas where there are no transmission lines. They are far away from the national grid. Some of the rural areas have national grid accessibility but due to lower production of energy despite being higher capacity, there are power outages in those areas about 12-18 hours [11].

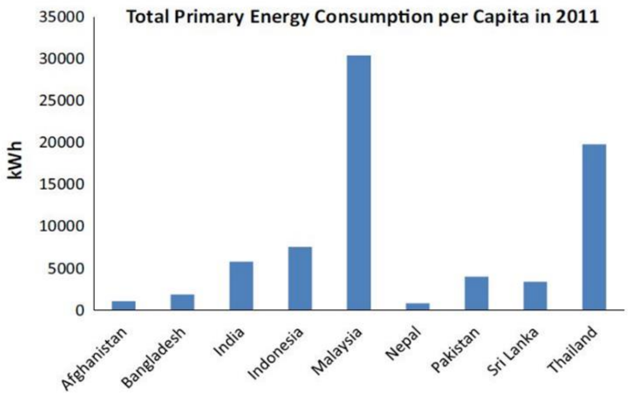

Figure 1. Comparison of different Asian countries in terms of per capita energy consumption in 2011 [9]

29.5% of the population of Pakistan lives below the national poverty line in 2013 [12]. We need affordable and clean energy in order to fulfill the basic needs of life. There are remote areas in Pakistan that have no access to the national power grid, small scale distributed energy system is the best option to give them energy. The Government of KP is installing mini micro hydropower with the help of the Asian Development Bank. These MHPs will provide affordable and clean energy which is fulfilling the SDG 7. But the question arises how this affordable and clean energy will impact on community, health and quality education. Among the most alarming of the severe impacts, is the emission of greenhouse gases methane and nitrous oxide of hydropower projects which greater global warming potential. According to one estimate, these gases have 25 and 300 greater global warming potential as compared to carbon dioxide respectively [13]. So these impacts must be analyzed that how much these projects are contributing their role to achieve Sustainable Development Goals.

It is a necessity of the day of a secure supply of resources of energy but they are not sufficient enough for advancement within society. Moreover, a development that should be sustainable requires a sustainable and consistent supply of energy resources which, in other words, should be easily available at a reasonable price at a consistent rate and can be exploited for fulfillment of daily needs which have no negative impacts on the society. The country has huge hydropower potential which should be utilized for the fulfillment of daily needs especially the northern part of Khyber Pakhtunkhwa. Those northern parts have remote areas have no direct access to the national grid or transmission lines. The country has a potential of more than 1200 MW of micro/mini hydropower which includes both mountainous regions of northern and plane areas of southern part from canal falls too [14]. So far, only 5% is being developed out of this potential [15]. Northern areas have estimated potential of more 300 MW and 400 MW through micro-hydel power plants with capacities 100 and 500 kW respectively [15]. So far, only 5% is being developed out of this potential [16]. These hydropower plants are playing their roles in achieving SDGs.

A. Sustainable Development Goals

Sustainable Development Goals called as global goals is the 2030 agenda for sustainable development of the world having different goals and targets. There are seventeen different goals in which were accepted by the world leaders in UN Summit in 2015 [17]. It ensures to eliminate all form of poverty and bringing prosperity to all and protect the environment [18]. It is a global call for action by each and every country, poor, rich to protect the planet and promote prosperity [19]. These seventeen goals addresses eradicating poverty should go on all over the globe in such a strategic way which build economic growth also solve a number of social needs like education for all, discriminating gender equality, hunger reduction, and different opportunities of earning while protecting the environment keeping in mind the climate change action [20].

Figure 2. Sustainable Development Goals [21]

Major contribution in the energy mix of Pakistan is the conventional source which is expensive [22]. Pakistan also import LNG fossil fuels to meet the requirement by producing electricity [23]. Electricity produced from conventional fuels are very expensive and not sustainable [24]. Per unit cost of the electricity generated from conventional are Rs.12/KWh and the rate of power produced from MHPs are very low [25]. Even some of the communities in Pakistan where MHPs are installed on community based give just Rs 200/monthly which is very cheap [26]. So Micro Hydro is a source of Affordable energy which compliant one part of Goal 7 of Sustainable Development Goals. The other part that energy should also be cleaned [27]. We have comparison of different technologies in Figure 3 which shows that hydro power is one of the clean energy and it does not contribute too much to carbon emission as compare to other technologies. So in this study Micro Hydro power plants is the main role actor as it is affordable and clean energy and how it affect other SDGs.

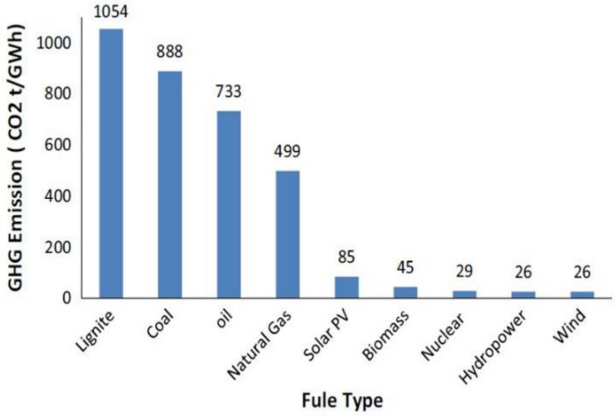

Figure 3. CO_2 emission by different technologies [9]

II. LINKING SDG 7 WITH OTHER SDGS

A. *Energy Demand and Poverty Alleviation*

Affordable and clean energy plays a vital role in poverty eradication. 1.3 billion people in the world have don not have access to electricity [28]. We have about 29.5% of the population which lives below the national poverty line in 2013 [29]. We need affordable and clean energy in order to fulfill the basic needs of life. Remote areas of Pakistan where there is no access to the national power grid, small scale distributed energy system is the best option to give them energy. Affordable and clean energy play a role in reducing poverty studied in Africa [49]. From the production of agricultural crops to the food we are getting in our kitchen, energy is required in every stage. The food system includes Agricultural production, Transportation, food processing and food handling. In this process, energy is a fundamental requirement. If the industries and households have access to affordable energy then everybody will be able to get food as it will be available at affordable rates and it will lead to progress towards SDG2 which is food security. There is a direct relation of energy and hunger [30] playing their part in eradicating it in South Africa. Energy supply has a direct impact on community health and wellbeing. Energy supply can reduce air pollution. As in many rural areas people use wood and conventional fuels for cooking and heating purposes which has a direct impact on the environment and mostly women, girls and children are affected by this pollution. 6 out of 10 affected deaths are found in women and girls [31]. Comfortable learning requires a comfortable atmosphere which requires well-lighted space, cooled and well-heated classrooms. These comfortable spaces can be achieved by energy. If there is no electricity in schools then classrooms or learning space will not be well lit which affect the education of students. Moreover, it is the era of science and students to be taught modern science and computer which requires power to be turned on. For example, the Government of Khyber Pakhtunkhwa education department has initiated a program for educating newly inducted teachers for their training by providing tablets [32, 33]. But these tablets require energy, if there is no electricity in remote areas then the teaching methodology of the teachers can be affected which will influence the quality education of the community. Thermal power plants produce pollution and affect the environment whereas hydropower plants produce clean and reliable energy. It is not only the cleanest but versatile energy too. It also provide side benefits other than clean energy. It is believed that small hydropower plants are cleaner and environmentally friendly than Mega hydro. It has no adverse impact on the environment but it has some negative impacts but these negative impacts are minimum .

B. *Sustainable and Viable Energy Sources*

Lack of access to moderate power and substantial dependence on the wasteful and unsustainable utilization of conventional biomass energizes (i.e., fuel wood, charcoal, agriculture waste and animal dung) are the two appearances and reasons for neediness. Power and other present day energy sources assume a basic part in economic and social improvement. Only they can’t mitigate destitution however they are key to supportable improvement [17]. Present day energy administrations upgrade the life of the poor in incalculable ways. Electric light broadens the day, giving additional hours to perusing and work. Present day cook-stoves spare ladies and kids from every day introduction to poisonous cooking vapor. Refrigeration broadens nourishment freshness and dodges wastage. Centers with power can disinfect instruments and securely store prescriptions through refrigeration. Assembling and administration ventures with current energy can be more profitable and can expand the quality and scope of their items along these lines making employments and higher wages [9],. In numerous nations, neediness is drawn out especially by the unsustainable accumulation of biomass and its utilization in customary, wasteful stoves [18].This makes indoor smoke contamination prompting genuine wellbeing harm, for example, respiratory illnesses, obstetrical issues, visual impairment and coronary illness. It requires extensive sums of time for fuel gathering diminishing the time accessible for other profitable exercises, for example, cultivating and training . It causes biological harm (e.g. deforestation and soil disintegration) and nearby shortage of wood in a few regions. What’s more, it draws horticultural deposits also, manure far from their utilization as compost, in this way decreasing agrarian profitability [18]. It is assessed that to accomplish the Millennium Development goals (MDGs), the quantity of individuals lacking power would require to decline to beneath 1 billion and those depending on customary biomass would need to tumble to 1:2 billion by 2015. Deliberate government activity with help from the industrialized nations is expected to accomplish these objectives, together with expanded subsidizing from both open and private sources [17]. Then again, arrangements need to deliver obstructions to access, reasonableness and supply of power and elective energizes, which are as of now accessible at sensible cost, e.g. gas-let go stoves and barrels. Access to practical energy sources should shape a focal part of more extensive advancement methodologies [19], [20], [21].

III. Pakistan Policies and Contribution to Renewable Energy

A. Transformation of economic instruements

Pakistan gave the first-ever hydel power policy in 1995 to encourage private sector contribution in meeting the energy demands by giving them a choice of site selection, giving them incentives, security packages, and fiscal incentives, etc.[34]. As global fossil fuel prices continued to increase, Pakistan gave Renewable Energy Policy 2006 to encourage development in small hydro, solar and wind technologies to overcome facing significant energy crises [35]. An organization was made (AEDB) by the Federal government in 2003 to facilitate the progression of renewable energy in the country. The objective of this organization was facilitation, promotion, and encouragement of alternate energy technologies to produce power and contribute to the overcoming of energy shortfall. Alternative Energy Development Board set up different renewable energy projects in several areas of Pakistan keeping in view the increasing demand for energy and shortfall and progress in solar energy technologies by utilizing environment-friendly energy. To alleviate the crisis of energy in the country, AEDB executed several projects. The organization has current projects of Solar Photovoltaic technologies having a capacity of 556.8 MW while there are other about twenty-eight projects which are in the development phase having installed capacity 956.8 MW [36]. Pakistan is also focusing on wind energy to make the best use of it where there are existing projects which are installed at Gharo, Jhimper area having a capacity of installation of 308.2 MW. There are other projects in these areas which are still in the development phase of 447 MW for the local area. As Khyber Pakhtunkhwa is enriched with hydropower sources, Different organizations like NGOs, a supporting program for local areas named as Sarhad Rural Support Program (SRSP), have installed about 189 MHPs (Micro-hydro projects) in the northern part of Khyber Pakhtunkhwa province electrifying different villages in which 365000 people are making benefits of these projects [37]. The province of Khyber Pakhtunkhwa has a huge potential of hydropower by which energy can be generated to overcome the energy crises in the country and meet the energy demands. For this purpose, a provincial organization named PEDO (Pakhtunkhwa Energy Development Organization) is working hard to implement mini and micro hydropower projects in the province. The organization has the vision of developing a thousand projects to promote the development of hydel potential on small rivers and canals. 356 micro-hydro plants have been initiated in the first phase in which about than 200 projects are already completed while rest of them are under development and some are still in planning phase. The purpose was to electrify the remote areas of KPK. About 2,500,000 will take the benefit of these projects. Rural areas have the main source of using energy of Biomass in which 62% are living in rural areas that use Biomass energy. There are 24% of population living in rural areas that are using or buying wood [38].

B. Potential for MMHPs in Pakistan

Our country has a huge potential for hydropower. Pakistan is an irrigation-based country with having a lot of water resources, but these resources need to be addressed to make use of it in a positive and optimum way. The country has a huge energy crisis that needs to be addressed by using the resources available in the country. Hydropower is a clean and environmentally friendly energy. The country has remote areas which are not accessible and there no electricity available. To build a transmission especially for those remote areas is not an economical way to handle the situation. The best option is to use the indigenous resources over there. One best option is the installation of mini micro-hydro projects in those areas where the community can have electricity and they are not burdened on the national grid. As the country has large hydropower systems but besides that, there are positive prospects of development of micro/mini/small hydropower. Micro/Mini/Small hydropower is one of the productive ways of generating electric power. These schemes of mini and micro hydropower can be utilized to electrify them in an economical way.

Table 1. MMHPs Potential in Pakistan [39]

No	Zone	Potential Sites	Total Potential (MW)	Range of Potential (MW)
1	AJK	40 sites	280	0.2-40
2	Gilgit Baltistan	200 sites	1300	0.1-38
3	Punjab	300 sites	560	0.2-40
4	KPK	125 sites	750	0.2-32

IV. Methodology

A. Introduction

Pathways were established keeping in mind the previous patterns that were followed in the rest of the world. The Pathways established of SDG 7 (Affordable and Clean energy) which impact other Sustainable Development Goals, addressed the research questions and the whole list of intersection of Sustainable Development Goals with electricity provided by these schemes of mini and micro hydropower. In order to collect the information and getting the knowledge of those pathways surveys and visits were conducted in the Chitral area. Chitral was so selected as it is located in remote areas of the northern part of Pakistan has a lot of villages far away from the city. Pathways were so established that covers data and information both qualitatively and quantitatively. Those pathways were established from the site visits and surveys and previous trends carrying on in the world. Surveys and visits comprise interviews, questioners, and observation of those communities. Operators of plants, heads of the community, owner of the plants, technical experts and expertise were interviewed in the field visits.

B. Research Methodoogy Framework

Different techniques having various steps were followed in order to carry out the study. Different villages from a different source of MHPs were selected so as to study the impact of community-owned projects, NGOs owned and Government running projects.

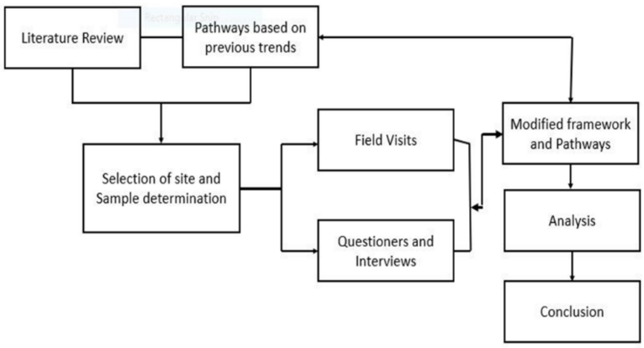

Figure 4. Research Methodology

C. Established Pathways

Pathways were established which identify the impact of Affordable and Clean energy considering the aspects of environment, good health and well being and community and other significant SDGs as mentioned below,

- Impact on deforestation of MHPs by replacing conventional fuel
- Impact on flooding in those areas
- Noise pollution due to operation
- CO2 emission due to the construction of dams (transportation used by carrying construction materials like cement etc.).
- Impact on agriculture either it may be positive or negative due to flooding or decrease in flooding caused by MHPs
- Impact on archaeological and conservation sites
- Impact of fish species as the alteration of water flow, such as broadening of stream bed and reduction of current may lead to indigenous fish species being reduced or replaced
- Impact on water pollution because wastes from running the plant during pipe cleaning
- Reduction in greenhouse gas emission
- Reduction in labor work regarding cutting wood
- Impact on quality of air in the house if conventional fuel is replaced by electric heaters
- Impact on the number of health units and their quality
- Impact on cooking either it's clean or not. (if clean cooking fuel is provided)
- Impact on births attendant by skilled personnel
- Impact of MHPs on recreational activities and sports
- Impact on life standard in terms of energy usage
- Safety precautions
- Impact on number of schools
- Impact on the standard of education if schools are electrified
- Impact on number of women education
- Impact on social interaction
- Impact on gender equality in terms of education
- Impact on opportunities of jobs
- Impact on Working Hours

D. Research Design

This analysis is established in a descriptive investigation scheme. The research is focusing on the socio-economic aspect of micro-hydro projects in remote areas. This research shows how benefit takes benefit from the project and use energy for economic activities. The study is focusing on the social and environmental impacts of distributed energy before and after the installation of micro hydropower projects. Energy is not only part of our society but nowadays it is considered as a multitrillion-dollar business hub.

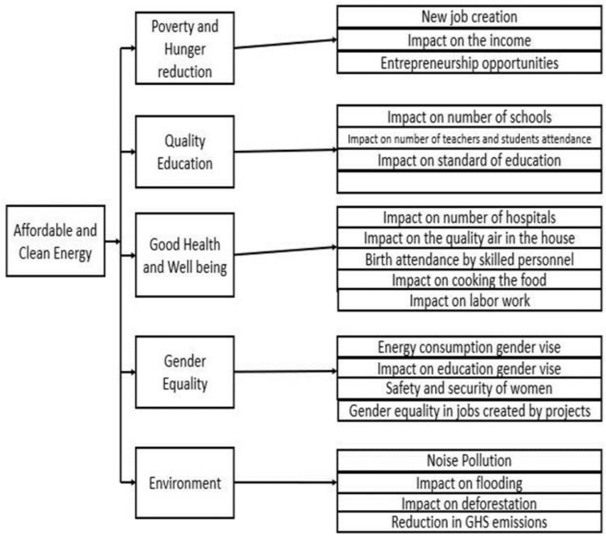

Figure 5. Established Pathways

In rural areas, there is no productive use of energy mostly people use electrical energy for lighting and cooking purpose. The projects installed by the PEDO and SRSP are less effective and has no sustainability. The community involvement is the basic issue and also the financial and social structure is not defined. Linking the community involvement (affordable and clean energy) with the social and economic analysis (SDGs 1, 2, 3, 5, 8, and 9) is the basic framework and the baseline for the social value of energy services. By bringing full time solar energy and environmentally friendly storage to villages the project offers affordable and clean energy (SDGs 7 and 13). Using local renewable energy sources keeps money in the community that would otherwise be spent on the purchase of power and fuels elsewhere. Harvesting local energy will reduce poverty in the community (SDG 1). The revenues generated and the availability of power will allow for economic growth and work in appropriate, well-lit and heated or cooled, depending on the season, circumstances (SDG 8) while training young people to help multiply the concept. Being able to work in decent circumstances will help maintain health and well-being, while the electrification of the local health centers for people as well as animals will help to improve general health in the community (SDG 3). Electrification of the local schools will allow for quality education, while the training programs necessary to build, operate and maintain new microgrids increase education leading to good jobs (SDG 4). Better chances for education improve the chances of girls and women to participate in social life and employment (SDG 5). Decreasing the dependency of power and fuels imported to the community reduces the risk of conflicts and increases the chances of peace (SDG 16). The availability of power will likely reduce the risk of food perishing, reducing the risk of hunger (SDG 2). The introduction of solar based microgrids combines with storage provides the necessary energy infrastructure for rural communities to thrive (SDG 9). Thriving create space for support to the marginalized and disadvantaged (SDG 10). The availability of power might create an opening for two-, three- or more wheeled electric mobility, allowing the community to leapfrog the use of combustion engine vehicles (SDG 11) and the noise, heat and exhaust fume pollution related to them (SDG 15).

V. EXPLANTORY ANALYSIS

Some of the sites have improved marginally because there was grid connectivity over there but most of the sites where there was no electricity before, a lot of improvement was shown. At the start when these villages were given electricity, there was a positive change in the life and lifestyle of villages in terms of using it for lighting, entertainment purposes like radio, television and some opportunities for livelihood. Later on, tourism-based activities like hoteling, tea stalls, pressing clothes for tourists and restaurants received a boost.

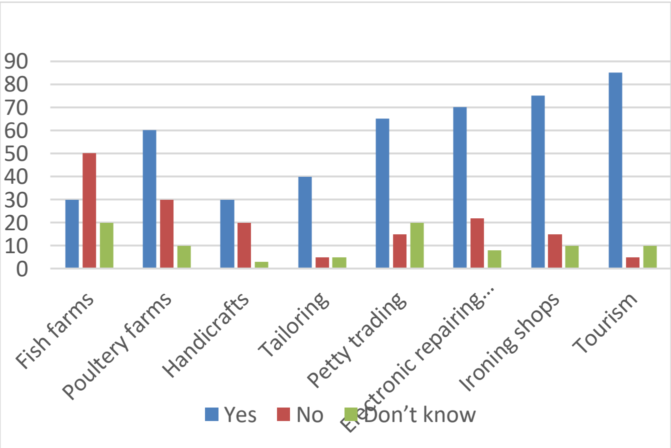

Figure 6. Results of Questioners about impact on business activities at Chitral

Some of the areas where there were no micro-hydro projects and connections were from the grid but there were power outages and lower voltages for few hours, they were improved a lot in terms of those activities after the installations of micro-hydro projects. The respondents were asked about the impact of the MHPPs in terms of social, income and other benefits.

A. Financial Capital

The main purpose of the micro-hydro scheme is the electrification of those communities and boosts their economic activities. During the study, surveys were carried out and respondent were asked about the impact on new job creation in the area. Some of the areas where there were no micro-hydro projects and connections were from the grid but there were power outages and lower voltages for few hours, they were improved a lot in terms of those activities after the installations of micro-hydro projects. The respondents were asked about the impact of the MHPPs in terms of social, income and other benefits like ironing shops, petty trading, handicrafts, poultry farms and fish farms. It has been witnessed that those projects have positive impacts on the activities which are home-based generating income operated on electricity as the spinning of wool and machines churning milk. Although these practices are followed from the past the availability of electricity has increased its productivity, efficiency and time-saving. These remote areas are also blessed with landscaping views and are famous for tourist attractions like Chitral etc. Tourist's activities have been increased after the availability of electricity as people are coming by enjoying those facilities of hoteling, restaurants and charging their cameras and phones. The other main financial benefit of those hydropower projects is the employment created over the community. Those plants need technical personnel to run the plant. So community hires diploma holders which is employment opportunity created by the scheme.

B. Natural Capital

It has seen from the history that building a dam or hydropower affects the access to natural resources in several ways by stakeholders. The main advantage goes to the sponsor of the project or the owner of the project and the rest of the community is affected by them in a negative way. Even some of the populations are forced to migrate too. But here comes the story of Chitral MHPs where communities are not migrated because these are on small scale. Although some of the households lost their access to clean drinking from those rivers due to wastages stored at the powerhouse. But they manage to take water at another nearest point which is not a big issue. In those remote areas, water is used mainly for domestic use, irrigation, milling and fish farms. Building a small micro hydropower plants can impact the financial capital of those communities by interrupting the water flow direction.

C. Social Capital

One of the successful micro-hydropower projects is the ownership of the project by the community. There are different case studies that were run by some government organizations and some were developed by the locals. Some were installed by the Non-Government Organizations. But when people over there were that who owns the project. Their answer was that we own the project and on the other government organization or NGOs claims it. The social life of the people is changed to

MHPs. People can interact with each other due to the availability of communication networks over there. People can go out at night due to lighting and can chant with each other and solve their concerns.
In this analysis, the percentage of households in government service or labor is greater or less equal. Actually, the MHP homes are situated relatively in the far-flung and mountainous area; as a result of the people over, there are not reachable to the commercial and colonial work. On the other hand, the grid-connected households are reasonably thriving in terms of productive use of energy like job opportunities, business, and overseas employment. If we talk about the ownership arrangement with respect to agriculture lands here both micro-hydro users and grid-connected households are changed. Households connected to the MHP are agriculture than grid-connected households.

D. Physical Capital

The supply of electricity has the potential to increase the physical potential of households as electrical appliances are more used by the locals. The people over the remote areas cut the wood for food cooking and heating purposes. It is a very hard task to climb up the mountains and collect the woods and bring it back home by carrying a heavy load. The availability of electricity has decreased their burden of carrying heavy woods by using electric heaters. However, most of them still use wood and animal manure for cooking and heating purposes as power voltages in some areas do not allow for an electric heater.

E. Human Capital

Human capital is positively influenced by increased use of electronic media like radio, recorders, televisions and mobile phones due to continuous and stable electric supply. In those areas, students were interviewed about their studies. Students now study even in the night due to the availability of light and complete their homework on time. It has also impact on the attendance of the students as teachers now come to schools and charge their phones and tablets at electrified schools. WAPDA and other organizations give scholarships to sons of the employers and brilliant students in the area. The Figure 7 shows the impacts on education after the implementation of projects.

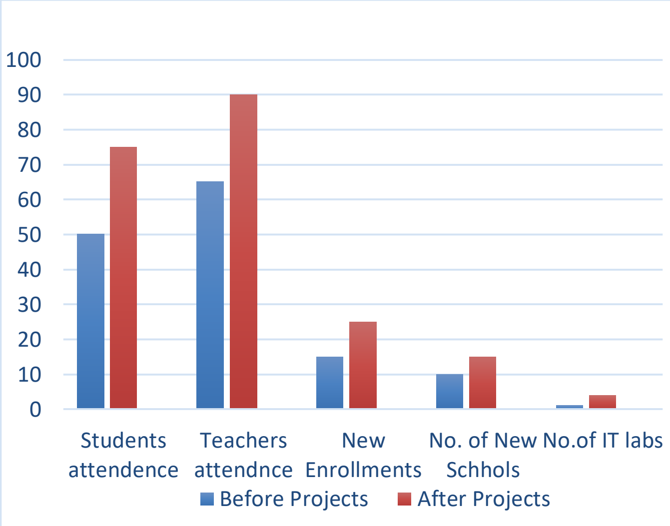

Figure 7. Impact of education

F. Gender Equality

Consistent supply of electricity in remote areas has a direct impact on gender equity especially the workload of women is affected and the impact on women's roles in the families. The correspondents were asked about the workload of the women. We came to know that most women collect fuel wood but the availability of electricity has decreased their workload. Women also participate in the financial support of the family by doing work of wool spinning and milk churning even at the night due to lights.

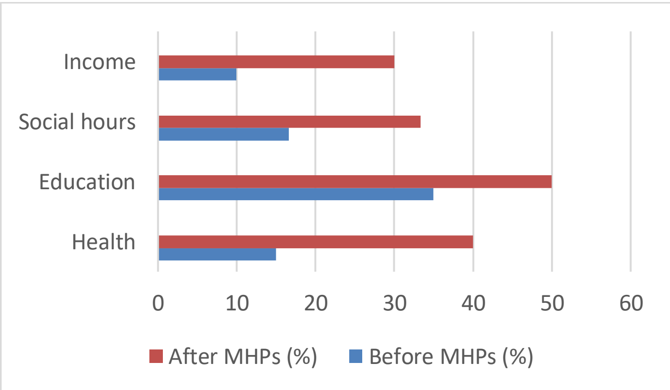

Figure 8. Impact on Gender Equality

Women feel safe during the night and lighting provides security and confidence to do work at night. Girl's participation in school and education has also been witnessed. The Figure 4.5 shows the participation of women in the income of the household, the impact on their social hours in percentage was increased from 4 to 8 hours. They can now finish their work on time and have much time for social activities. The availability of electricity also increased the enrollment of girls in schools after the installation of MHPs.

G. Case Study

In Singhor, 1 MW plant is installed by WAPDA which is a government body. Singhor, the village lies in the outskirts of the main Chitral city. An MHP with a capacity of 1 MW was installed in 1975 by WAPDA. The total cost incurred on this project was 350 million Rupees. The MHP has a total of four turbines installed. All the turbines are manufactured in Germany. The type of turbines installed are Francis and Crossflow turbines. The first two turbines having the generation capacity of 200 KW were installed in 1975, later on, the other two turbines having a generating capacity of 300 KW. The manufacturers of generators are Siemens and PEL. It has 4 step-up transformers. The two transformers have a capacity of 275 KVA & 375 KVA respectively. The electricity is distributed through 28 step down transformers. The overall head of the plant is 112 ft. It has two penstocks with diameter 33 and 45 inches respectively. The total length of the channel is 1250 ft. The forebay tank has a dimension of 25 x 15. It has mechanical governors to maintain the stability of turbine and generators speeds. The power plant has two outgoing feeders electrifying 10 villages of Chitral.

The total number of personnel carrying out operations and maintenance of the power plant are 46. Initially, the staff is trained at Mangla powerhouse. The salaries are paid by WAPDA. The amount paid in salary heads is 16 lac/month approx. The tariff rate of WAPDA is implemented for bill collection. There are no water flow issues though out the year. The plant is shut down for maintenance for 40-50 hours per month. No fluctuations issues are reported until now, however, in winters short-circuit issues occurred. Overloading has been reported during peak demand in summer and winter seasons. It generates about 3 lac kWh per month. The plant runs at a power factor of 0.8. The appliance being used by consumers are lights, fans, washing machines refrigerator. The plant also electrifies commercial shops including welding shops, carpenter shops, restaurants, mosques, and schools. The plant is standalone but can be synchronized with the grid as well. Cooking and heating is the expensive and main reason for overloading of plant. It can be solved through a gas connection to these villages. The civil structure is well maintained and was built according to the feasibility report. The operational personnel is happy because of the service structure implemented by the WAPDA. The plant to be upgraded to 5 MW generation capacity. The plan is already prepared and consultation is underway in this regard.

Conclusion

The impact of affordable and clean energy has proved that it plays a vital role in attaining all the seventeen goals of Sustainable Development Goals. Without accomplishing Goal 7 which is affordable and clean energy, other goals are impossible to achieve. Affordable and Clean energy becomes a hurdle in attaining other sustainable development goals and it becomes a key driver to achieve other sustainable development goals. By focusing on this goal other goals can be achieved easily. Sustainable Development Goals are in perfect form to be achieved but the only thing which comes to know after the study that it has not focused or touched the population of human being which is major lack of these goals. The human population is going so fast and so is the reason for miss management and resource distribution of huge populations. However, prosperity can be brought up by giving access to clean, reliable and affordable energy to all. The impacts of these projects like mini and micro-hydro projects for the remote areas can be increased if proper training is giving to the people about the operation and maintenance. The impact can be further enhanced positively if the community is given awareness about energy use. If the awareness about how to make productive use of energy is given and some training and local seminars and gatherings are arranged about the entrepreneurship opportunities by giving loans and grants then its impact will be further increased. Tourism based activities like hoteling, tea stalls, pressing clothes for tourists and restaurants received a boost. Some of the areas where there were no micro-hydro projects and connections were from the grid but there were power outages and lower voltages for few hours, they were improved a lot in terms of those activities after that when the project is hand over to the community and then installations of micro-hydro projects.

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Energy Efficient Modelling of USPCAS-E UET Peshawar Building using eQUEST Software

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***Abstract*—** Energy consumption by the domestic sector in Pakistan is 46% which is one of the highest use by any country. The Government of Pakistan has planned to save 3 Million Tons of Oil Equivalent (33,000 MW) by 2025 through energy efficiency and conservation practices. Conserving this chunk of energy without effecting quality of life and measurements to improve buildings energy efficiency is a problem to be resolved. Several studies have been conducted to evaluate the performance of implementing various sustainability measures in existing buildings via various simulation tools. The purpose of this study is to analyze a fully functional building and find the possible cost effective measurements that can be taken to conserve available energy potential using eQUEST software. The building under study is United States Pakistan Center for Advance Studies in Energy (USPCAS-E), University of Engineering and Technology (UET), Peshawar. An energy efficient model of the building is calibrated in the study in comparison with the actual billing data. The simulation results are very close to actual energy consumption of the building. The overall results indicates that the building is state of the art building with almost all necessary measures already considered but some policy propositions are needed. HVAC and lightning are the significant energy users (SEUs) here and there is a substantial potential for improvement which is presented. Some changes are made in the building occupancy scheduling and some regulations are presented for the occupants behavior change towards energy use.it.

***Keywords*—** HVAC; heating, ventilation, and air conditioning, SEUs; Significant Energy Users, MW; Mega Watt.

I. Introduction

For the socioeconomic development of any country, energy is considered to be the lifeline and most important instrument and it has become the biggest problem for the entire world because of the increasing demand and dependency on it. So, every country needs a sustainable and affordable energy supply due to increasing population, urbanization and industrialization [1]. Acute energy shortage is the supreme challenge of Pakistan facing severe energy crises since decades and currently facing an electricity shortage of almost 18 hours in rural areas while 10 to 12 hours in urban areas [2]. In addition to adopting alternatives and renewable sources of energy, a country must pay attention on effective use of energy, controlling wastage and saving of energy. Pakistan has a huge potential of saving energy in different sectors. Pakistan can save up to 1,100 megawatts of energy if its industries and households – the two main energy consuming sectors with a 74% share – try to change their behavior about energy conservation, International Project Coordinator Espier Martin Straehle [3].

Pakistan is one of the countries with the highest energy consumption for domestic use. Annual energy consumption by the domestic sector is 45.9% of the total, whereas the industrial sector, consumes about 27.5%. About half of the total energy consumed is used in buildings and/or heating, ventilation and air-conditioning (HVAC) and lighting appliances. [4]. Buildings consume about 50% of the total primary energy in Pakistan [5]. This consumption is rising at the rate of 5% annually [6] half of the total energy consumption and greenhouse gases emissions in the developed countries and fifth of the world's total energy consumption is contributed by the built environment [7]. In 2012, World Energy Outlook published by International Energy Agency (IEA) estimated that by 2035, 41% of the Total global energy saving potential will be from the building sector [8]. An analysis of the life cycle costs of buildings shows that 80 to 90% of the energy goes for operating the building [9]. The governing body for efficiency and conservation of energy in Pakistan is National Energy Efficiency & Conservation Authority (NEECA) with the aim to achieve the challenging task of energy efficiency and conservation in all sectors of economy [10].

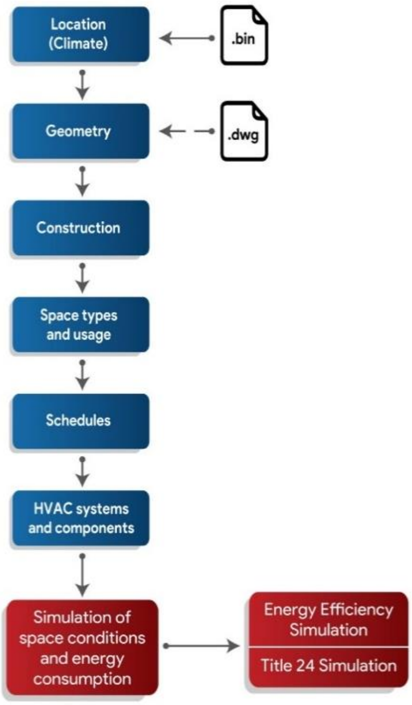

Fig. 1. General work flow in the design development wizard of eQUEST.

With the increasing interest in energy efficient building design, whole building energy simulation programs are increasingly employed in the design process to help architects and engineers determine which design alternatives save energy and are cost effective [11]. Energy simulation tools are increasingly used for analysis of energy performance of buildings and the thermal comfort of their occupants. Today, there are many building performance simulation programs with different user interfaces and different simulation engines that are capable of these analyses. The eQUEST software is most easy and quickest Energy Simulation Tool and allows users with limited simulation experience to develop 3-dimensional simulation models of a particular building design. These simulations incorporate building location, orientation, wall/roof construction, window properties, as well as HVAC systems, day-lighting and various control strategies, along with the ability to evaluate design options for any single or combination of energy conservation measures. According to the eQUEST website, ”eQUEST was designed to allow you to perform detailed analysis of today’s state-of-the-art building design technologies using today’s most sophisticated building energy use simulation techniques but without requiring extensive experience in the ”art” of building performance modeling [12].

II. ENERGY MODELING

A. *Description of the USPCAS-E, UET Peshawar Building:*

The building under study is located in Hayat-Abad Phase 5 Peshawar, an old city in the province of Khyber-Pakhtunkhwa (KP) Pakistan. It’s a three story West facing building with a plot area of 52,000 square-feet and the area covered by the building is about 19,112 ft.-sq. The city is located in an extremely hot weather zone.

Fig. 2. USPCAS-E, UET Peshawar Building.

B. *USPCAS-E Building Envelop (Materials and Construction)*

This is a state of the art building with simple brick and concrete walls of about 12 inches width and each roof is an 8 inches concrete slab. The floor to floor height is 10 feet with a floor to ceiling gap of 2.5 feet. The three stories of the building are three different shells in eQUEST placed immediately above each other. Auditorium and external reception are separate shells with auditorium immediately in west side of the building and reception at south west. Each shell/floor has internal finishing of ceramic stone tiles. The ceilings interior finish is Lay-in Acoustic tiles with no Batt Insulation. All The vertical walls are mass type.

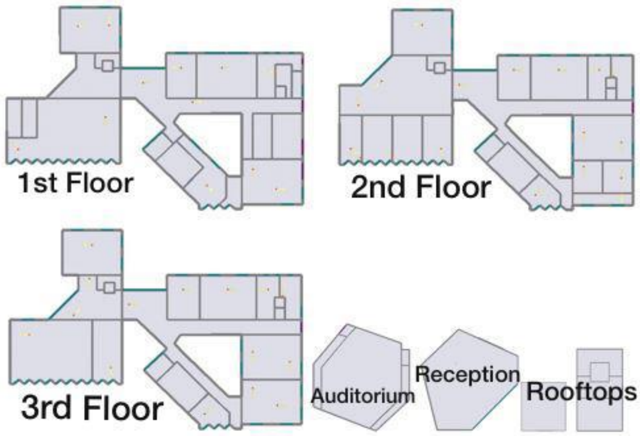

Fig. 3. 2D Model of all the shells of USPCAS-E Building from eQUEST

There are two types of doors and two types of windows defined for each floor and all the doors and windows on all sides are customizes accordingly as shown in the 3D view of the Building. There are no exterior window sheds or blinds to any floor/shell of the building as shown in the 3D view of the building in Figure 5. Any zone in any shell in the building that has some windows are considered as day-light zones and the rest as non-day light zones as shown in Figure 6. The ground floor of the building has a very strong base and is in direct contact with the earth with a 12 inches concrete with no external cavity insulation and interior finishing of ceramic stone tiles. The exterior finish of the exterior walls of the Building are Asphalt Pavement weathered with brown medium light color. The exterior walls has no board and furred insulation.

C. *Energy intake of USPCAS-E Building*

The building depends on Peshawar Electric Supply Company (PESCO) for its Electricity needs. There is no gas connection to the building. Gas is used only in the Kitchen for cooking purpose which is totally a private party concern who is handling the Kitchen and Cafeteria on contractual basis. So gas consumption in the building is not considered in the overall energy conservation considerations and is thus not considered for simulation as well. There are two Generators for back up purpose during emergency or load shedding hours. But they are not considered for the Simulation purpose because they are fulfilling the same need as connection from the PESCO.

D. *HVAC Zoning*

This is basically a School/college, University type building in eQUEST with total five defined shells and each shell have a different zoning and use pattern. The building basically includes Conference room, staff offices, management offices, class rooms, labs, auditorium, library, lavatory, staff and ladies waiting areas, Kitchen and Cafeteria etc. There are total 45 small zones in the building and is conditioned by three different systems. A central HVAC system condoning the three floors/shells of the building. Separate Split ACs in some zones of the three floors and a separate cooling system for the auditorium.

E. *HVAC System*

The HVAC system installed at the USPCAS-E building is made in Thailand by DAIKIN Industries. This company is considered among world top class air conditioning companies. The installed system has a rated power supply of 380-400 V at 50 Hz frequency. It operates at pressure range of 33-40 bar. The refrigerant used in this system is R410A having a mass of 6.3 kg.

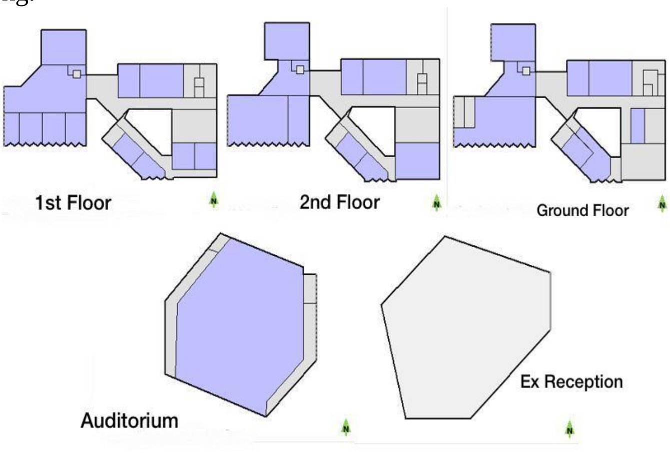

Fig. 4. Zoning pattern off all five shells with blue colored Conditioned zones and white colored unconditioned zones

This refrigerant is a replacement of the older R-22 refrigerant and is classified as the best option for air conditioning applications [10]. This refrigerant is comparatively more environment friendly and causes lesser damage to ozone layer compared to R-22. Compared to R-22, R410A is also better at absorption and generation of heat thus making it energy efficient compared to the rest of refrigerants available in the market.

F. *Building schedules and operations*

The schedules and operating hours for the models are very comprehensive. The building has different schedules for Monday to Friday and different schedule for weekends and holidays. From Monday till Friday the building is open from 9:00 am to 5 pm. On weekends and Holidays the building is almost close. Not all the zones are open from 9:00 am to 5:00 pm some are open just for one or two hours. Over all the building schedules are varying from type to type for different zones. There are total five class rooms in the building and hardly one class of 2-3 hours is conducted per day, same is the case of Laboratories, stores etc and are not open all the working day. There is a break time of about one hour daily from Monday till Friday between 12:30 pm to 1:30 pm. The schedule for auditorium and conference room isn’t defined. Both are hardly used on average an hour a day. There is no proper schedule of the Cafeteria, people come and go as they need.

III. RESULTS

The Building is energized from Peshawar Electric Supply Company (PESCO).

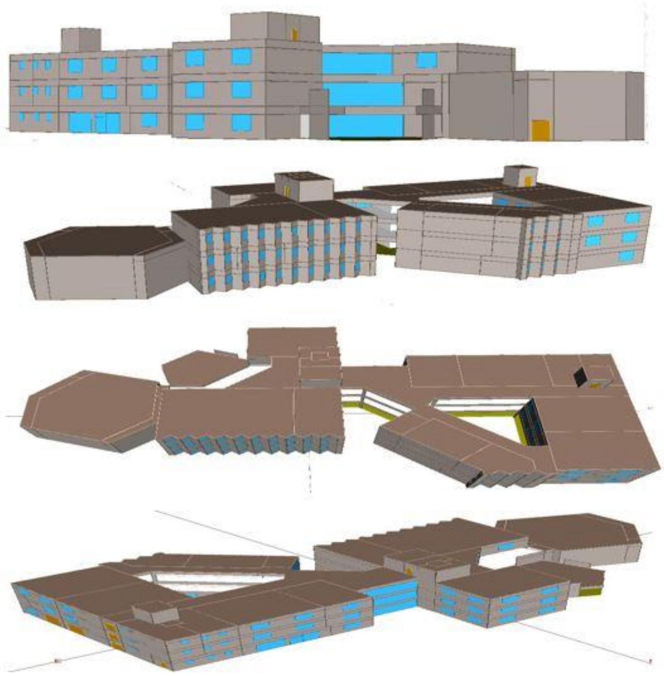

Fig. 5. 3D Model of USPCAS-E Building from eQUEST

The Building parameters that are included in the simulation process are, The building envelop, The HVAC systems, The lightning system of the Building and the miscellaneous equipment which also include the office equipment , personal equipment of the occupants and laboratory Machinery etc. The study for Gas use in the building is not considered here because the building do not have any gas connection. Gas is used only in the Kitchen portion which is totally concerned with the contractor running cafeteria. The office equipment, miscellaneous equipment, Laboratory machinery are all up to date having latest energy efficient technologies. We have mainly focused on building energy consumption parameters.

A. Electric Consumption of the Building (kWh):

The monthly Electric Consumption of the USPCAS-E Building is shown in the Graph in figure 6.1 for the whole 2019 year. It can be clearly seen from the Graph that the most of Kilo Watt hours are consumed by the HVAC system of the building. The Second Highest Consumption is by miscellaneous equipment i.e. 25% which includes office and laboratory machinery as well. The third remarkable consumption is by area lightning's shown by the yellow color in the graph in Figure 6.1. The energy consumption because of other factors can be clearly seen in the graph.

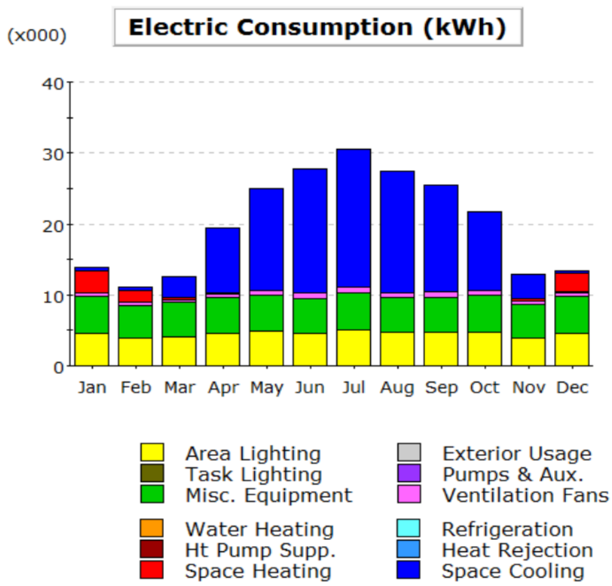

Fig. 6. Electric Consumption (kWh) of the USPCAS-E Building from eQUEST Simulation Results

The Electrical Energy Consumption of the building starts on increasing from the month of April and reaches its peak in July. This is mainly because of the hot weather of the region and thus more use of HVAC system. In July, the Total energy consumed by HVAC system according to eQUEST Simulation and ASHRAE standards for cooling is 19,420 KWh which is more than 60% of the overall consumption. After the month of July, the monthly Kilo Watt hour's consumption starts to decrease as the weather of the region tends to become less warm during winter and thus the use of HVAC also decreases. The consumption for the month of December and January are even more than that for November because the temperature of the region falls down to less than 10 degree Celsius. So more energy is consumed for the space heating purpose.

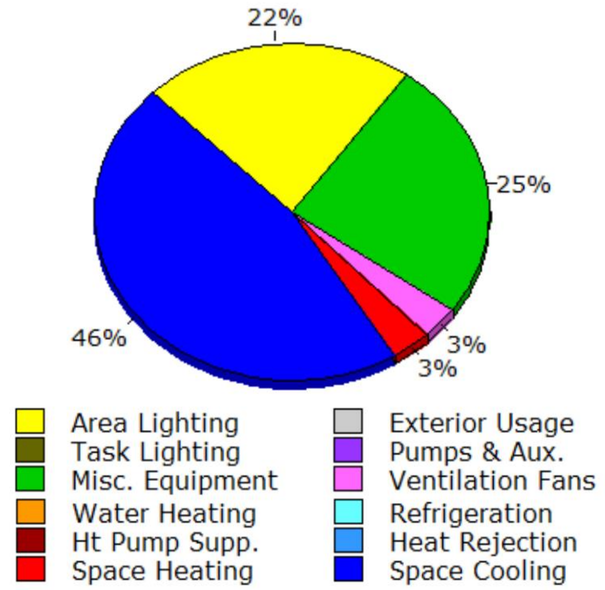

Fig. 7. Pei Graph of percentage of Electric Consumption from Simulation Results

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun
Space Cool	0.39	0.64	2.84	9.25	14.33	17.48
Heat Reject.	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-
Space Heat	3.05	1.57	0.30	0.02	-	-
HP Supp.	0.03	-	-	-	-	-
Hot Water	-	-	-	-	-	-
Vent. Fans	0.49	0.43	0.44	0.57	0.73	0.76
Pumps & Aux.	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-
Misc. Equip.	5.29	4.62	4.90	5.07	5.09	4.87
Task Lights	-	-	-	-	-	-
Area Lights	4.55	3.92	4.03	4.56	4.87	4.62
Total	13.80	11.18	12.52	19.46	25.02	27.73

	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	19.42	17.13	15.16	11.02	3.45	0.43	111.56
Heat Reject.	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-
Space Heat	-	-	-	-	0.30	2.57	7.81
HP Supp.	-	-	-	-	-	0.10	0.13
Hot Water	-	-	-	-	-	-	-
Vent. Fans	0.84	0.77	0.75	0.64	0.43	0.49	7.35
Pumps & Aux	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-
Misc. Equip.	5.29	4.90	4.87	5.29	4.68	5.29	60.14
Task Lights	-	-	-	-	-	-	-
Area Lights	5.01	4.68	4.75	4.72	3.99	4.55	54.24
Total	30.56	27.48	25.53	21.67	12.85	13.43	241.23

Fig. 8. Detail of the Electric Consumption in kWh of the USPCAS-E Building from eQUEST Simulation Result

The percentage of annual Energy Consumption by each parameter in the building is shown in Fig. 7. More than 45% of the total annual energy is consumed by HVAC system for space cooling, this is because of the extremely hot weather in summer. The second highest chunk of energy as already mentioned is consumed by miscellaneous equipment i.e. 25% and lightning of the building is the third parameter to consume more energy, it consumes about 22% of the total annual energy.

The Monthly energy consumption of each systems in the building is given in detail in the table in Fig. 8. Taken from eQUEST baseline result for year 2019. This result is produced by the eQUEST software according to LEED and AHSRAE building standards. There is some difference in the energy consumption each month between the actual data and simulation result but the total annual energy consumption is almost equal to the annual energy consumption of the building. The total actual energy consumed by the building in year 2019 is 241,600 Kilo Watt hours while the total consumed energy from simulation result for the same year is 241,230 Kilo Watt hours showing a very small annual gap between simulation and actual result. This is mainly because of using a very old weather file for simulation purpose the comparison of the actual monthly KWh consumption and the simulation result is given in table 1.

TABLE I. COMPARISON OF ACTUAL ENERGY CONSUMPTION AND SIMULATION RESULT

Month	Actual Energy Consumption KWh	Simu-lation Result KWh	Month	Actual Energy Consumption KWh	Simu-lation Result KWh
January	15,360	13,800	**July**	24,320	30,560
February	19,360	11,180	**August**	34,720	27,480
March	16,000	12,520	**September**	29,920	25,530
April	12,160	19,460	**October**	25,280	21,670
May	11,360	25,020	**November**	15,360	12,850
June	18,400	27,730	**December**	19,360	13,430

B. *Energy Consumed by HVAC System (kWh)*

It is clear from the graph in Fig 8 that HVAC System in the building is consuming the greatest chunk. The energy consumption for space cooling starts to increase from the month of April and reaches its peak in July where the total energy consumed by HVAC for cooling is equal to 19,420 KWh, it falls down to 17,130 KWh in Aug and keeps on decreasing with the weather till November where it's just 3,450 KWh. After that the weather of the region is very cold and 2,570 KWh of Energy is consumed in the building for space heating in December and 3,050 KWh in January. In the same way the energy consumed by ventilation fans increases from the month of March till July where it reaches its peak of 840 KWh and then it starts to decreases month after month till November. From November to onward till March, the change in Energy consumption by ventilation fans is not that much noticeable. The Annual Energy Consumption by Air side HVAC is 126,850 KWh out of 241,230 KWh which is more than 50% of the total Annual Energy Consumption of The Building. The HAVC system installed in the building is made by DAIKIN industries the most up to date and energy efficient available till now. Still there is some chance of conserving a valuable amount of energy from this side by changing thermostat set points and some building occupancy schedules.

C. *Energy Consumed by Lightning System in the Building*

The Kilo Watt Hours (KWh) Consumed by Lightning System in the Building are slightly changing every month. The Total annual energy consumption is 54,240 KWh out of 241,230 KWh. It is about 22.4% of the total Annual Energy Consumption. There is a significant conservation potential in this parameter of the building energy consumption which can be conserved with a small change in behavior by issuing a policy for lightning use.

D. *Energy Consumed by Miscellaneous Equipment*

Miscellaneous equipment include all Office equipment, and Laboratory Machinery as well. All the equipment used in the building are of the most advance and energy efficient technology. The total annual energy consumed by miscellaneous equipment is 60,140 KWh which is about 25%. All these equipment taken together are a Significant Energy User (SEUs). There is a substantial potential to be conserved here as well by some policy implications on occupancy scheduling and machinery use. There use schedule must be defined according to the occupancy schedule of the concerned zones.

E. Gas Consumption of the Building

As already mentioned in the start of this chapter, there is no gas connection to the building. Gas is used only in the kitchen for cooking purpose which is brought in in gas cylinders. This gas use is not considered in the study as it is concern of a private party who runs cafeteria and kitchen on contract basis. This gas is not used for any other purpose in the building.

F. Areas of Conserving Energy through Cost Effective Measures

The HVAC system, the lightning system of the building and the miscellaneous equipment are the three main components of energy consumption. The building is used as an educational facility majorly focused on advance studies in Energy. It was made exactly for this purpose so everything installed here is of the most up-to-date and energy efficient Technology. It is noticed during the whole year that the excessive billing is mainly because of the behavior of the occupants towards energy use. People are observed using air conditioning system at very low temperature during extreme summer even causing headache to some of the occupants. Excessive lightning in most of the areas of the building was found even where there was no need. Students instead of sitting in library for studying used class rooms alone, the lightning and the air-condition use for a single person although it was already available in library. Lab attendants used to spend their day inside the labs alone with all lights, HVAC system and additional equipment turned on although there was no experiment conducted throughout the week and there was plenty of space available for him in the staff offices as well. On a count, just five or six persons used auditorium for their presentation and even a normal lecture for 10-15 students was conducted so many times inside auditorium for which class rooms were already available. So there are many things that need to be monitored and changed through the use of behavior change tool which can either be a good policy or some necessary restrictions.

G. Overall Energy Efficiency Measurement

The energy conservation potential in various sectors of energy consumption is shown in the Table 6.3. HVAC system is consuming the greatest chunk out of overall energy consumption in the building and it has the greatest potential that is conservable. The second highest consumer of energy is lightning system in the building and similarly it has the second highest potential of conserving energy.

TABLE II. ENERGY CONSERVATION POTENTIAL IN VARIOUS SECTORS OF ENERGY USE

Sr. No.	**Area of Energy Conservation**	**Energy Conservation Potential (%)**
1	Package HVAC Energy Efficiency Measurement	13.53
2	Whole Building Lightning Power Energy Efficiency Measurement	10.56
3	Whole Building Miscellaneous Equipment Energy Efficiency Measurement	10.41
4	Overall Energy Efficiency Measurement	35+

Whole Building Miscellaneous Equipment which also include laboratory machinery and personal equipment of the occupants has nearly the same energy potential to be conserved as the lightning system. So the total available energy conservation potential is more than 35%. In addition to this 35% energy conservation potential in the different sectors of energy consumption, a remarkable potential can be conserved through various policy implications in the building occupancy and scheduling side. During the process of study throughout the year it was noticed that excessive space was occupied for no reason which resulted in the excessive use of HVAC and lightning causing over billing. Students were noticed studying alone in a class room, lectures were conduct for 10-15 students in the auditorium, people were seen using conference room for a meeting of 3-4 persons, elevator was excessively used to climbed just the two floors by healthy young people, computers in the Library and simulation lab were left running most of the time without any use people left there HVAC running in Labs, classes, offices even at break time, extra lightning use during the day time in various building space and this all is no doubt unfair for a building used for advance studies in Energy. Because of the above mentioned reasons, a section of policy propositions is included below to control the excessive use of energy in the building.

Conclusions and Policy Recommendations

In Pakistan numerous studies have been carried to assess the exact potential of energy conservation and efficiency improvement in buildings, transport, agriculture and industrial sectors, showing a huge gap which is a big Question for National Energy Efficiency and Conservation Authority (NEECA). This study has taken the plan that NEECA is going to adopt and will cover all the necessary areas for saving energy in a building according to a proposed standard. This research work will help the Government of Pakistan to carry their policy of effective use and conservation of energy in buildings sector through NEECA.

It is noted during the study throughout a year that excessive use of HVAC and Lightning system in the building was because of ignorant behavior towards energy saving, unidentified occupancy and scheduling. The University has paid excessive bills not because of the equipment and systems installed in the building, they are all up to date with latest energy efficient technologies. The building is state of the art building with almost all necessary measures already considered so this could be only controlled with some policy propositions in the building and proper training of the occupants. Overall Energy Efficiency Measurement show that the energy conservation potential in various sectors of energy consumption in the building is more than 35% and a remarkable potential can be conserved through various policy implications in the building occupancy and scheduling side.

A. Policy for Building Occupancy:

A good behavior towards energy use and conservation can save a lot of energy. This can be achieved through proper trainings, seminars and sign boards at various points. The building is used for advance studies in energy and the behavior of the occupants must change accordingly. Following are some policy points that must be considered for a positive change in behavior towards energy saving:

- A seminar must be arranged for the current occupants of the building on impact of behavior change on energy use and energy conservation
- A similar event must be arranged for every fresh enrolled batch
- Any new recruited person in the staff or faculty must go through a meeting with expert of behavior change in this regard
- Cardboards and signboards must be used in support of energy conservation where necessary
- Elevators to be used only by disabled, luggage careers and old age people

B. Policy for Behavior Change:

A lot of energy throughout the year is wasted because of uneven and useless occupancy, thus extra use of HVAC and lightning system. This was a serious issue that needed attention. Therefore following important rules must be imposed strictly and immediately to tackle the loss and save energy:

- Class rooms shall remain close during the time of no class
- No class shall be conducted in auditorium
- Lab engineers and lab attendant shall remain in labs only during lab class or during use of the lab for private party and they must be given a space in other offices. labs shall remain close in rest of the time
- Students for their self-study and personal use must use library space
- Conference room and video conference room shall be used for the dedicated purpose only and not for individual use
- No class room, conference room or any other room is to be used for self-study or individual occupancy

C. Policy for Building Scheduling:

This is also a serious point of concern to conserve energy. Most of the students have hardly three classes a week. Some of them have just to work on their research topics. The schedule of the classes must be so well defined that the building is as less occupied as possible to prevent the excessive use of HVAC and lightning system. So the following points must be taken serious while making a schedule for the building;

- Students from different streams studying the same subject shall share the same time slot and building space
- Students working on their thesis shall occupy a slot in a simulation lab or library and there must be a defined schedule for them
- The schedule of the labs shall be defined for each class and shall be strictly followed
- For commercial use of each lab there must be a dedicated day mentioned on the website
- Auditorium shall be used according to defined schedule with respect to activities of the whole week
- The duty timings of the building must be strictly followed

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Carbon Footprint Estimation for an Oil & Gas Industry

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Abstract**—** The rapid increment in the amount of greenhouse gases entering the atmosphere is badly impacting life on planet for almost all living organism including human. Nations from all over the world is doing efforts to reduce the amount of greenhouse gases mainly from main made activities in which burning of fossil fuel is the biggest source of today greenhouse gases. The purpose of this research is to recommend a suitable methodology for the estimation of carbon footprint for an oil and gas industry. This research explains how an oil and gas industry can estimate their own carbon footprint in a very easy and simple way. Step by step method is discussed to calculate carbon footprint from all direct emission sources and indirect emission sources like, stationary combustion sources, mobile combustion sources, vented sources and fugitive emission sources in detail. Once the carbon footprint become known to us, a comprehensive plan for its mitigation can be developed and applied which will ultimately lower the overall emission of the industry.

Keywords**—** Carbon footprint, Oil & Gas Industries, Greenhouse Gases, Estimation, GHG

I. Introduction

If we define the term carbon footprint, it is in fact the total amount of unwanted greenhouse gases (GHGs) which is emitted as a result of an activity or in development of a product. All these greenhouse gases are multiplied by their respective global warming potentials and usually expressed in equivalent tons of carbon dioxide (CO_2) and is called carbon footprint of the activity or product [1]. When someone drive car, he contributes to his personal carbon footprint by emitting greenhouse gases, resulting from the burning of fuel in his car engine, while the amount of carbon footprint depends upon the quantity fuel and type of fuel and car. Similarly, heating one's house in cold weather by burning oil, coal, wood or natural gas, etc. also contribute to his personal carbon footprint. Even the burning of glucose inside human's body for the production of body energy also cause the generation of a greenhouse gas i.e. carbon dioxide. In short, all those activities which involve burning of fossil fuel like coal, gas, oil, all generate certain amount of greenhouse gases.

A. Greenhouse Gases and Kyoto Protocol

Greenhouse gases are those which have the ability trap heat in atmosphere. Due to these gases the average temperature of the earth is increasing day by day, causing global warming effect and climate change. Rising of sea level due to melting of glaciers in the Antarctica and the Himalayas is considered is a great threat for coastal cities. To counter with this global challenge for the first-time serious measures were taken as a result of which 84 countries from all over the world signed an international agreement on 11th December 1997 at Kyoto, Japan known is Kyoto protocol. Under this contract, 5.2 percent of overall emission reduction was targeted compared to1990 level [2]. Emission reduction was focused from the following six greenhouse gases:

- Carbon dioxide (CO_2).
- Methane (CH_4).
- Nitrous oxide (N_2O).
- Sulfur hexafluoride (SF_6).
- Hydrofluorocarbons (HFCs).
- Perfluorocarbons (PFCs).

1) Carbon dioxide: Carbon dioxide is the largest contributor to the global greenhouse gas emission entering the atmosphere resulting mainly from combustion of fuel to produce energy for industrial purpose and everyday usage. Additionally, a large amount carbon dioxide is emitted during certain chemical reactions inside industries. Volcanos eruption, heavy blasting and agriculture are also the sources of carbon dioxide to atmosphere. The Global warming potential of carbon dioxide is taken is unity. It is removed naturally by plants during a biochemical reaction called photosynthesis as a part of natural carbon cycle.

2) Methane: It enters to the atmosphere during the transportation and production, and processing of natural gas, oil and coal. Beside this, methane also enters to atmosphere during livestock, agriculture activities, and decay of organic solid wastes. The global warming potential of methane gas is 25.

*3) Nitrous oxide***:** It is emitted in large amount during some chemical reaction and in small proportion during combustion of fossil fuel. The global warming potential of Nitrous oxide is 298.

4) Sulphur Hexafluoride: Sulfur hexafluoride is a powerful greenhouse gas. The effect of the release of one kilogram of SF_6 over a period of 100 years is equal to that of 23,500 kg of carbon dioxide. It has commercial applications, including semiconductor processing and transmission of electricity, and a variety of medical applications.

5) Fluorinated Gases or F-Gases: HFCs and PFCs are collectively called as fluorinated gases. As they do not harm the ambient ozone layer, F-gases are also used as replacements for ozone-depleting compounds. F-gases, however, are potent greenhouse gases, with a global warming effect up to 23,000 times higher than that of carbon dioxide (CO_2) and a large increase in its levels is observed [3].

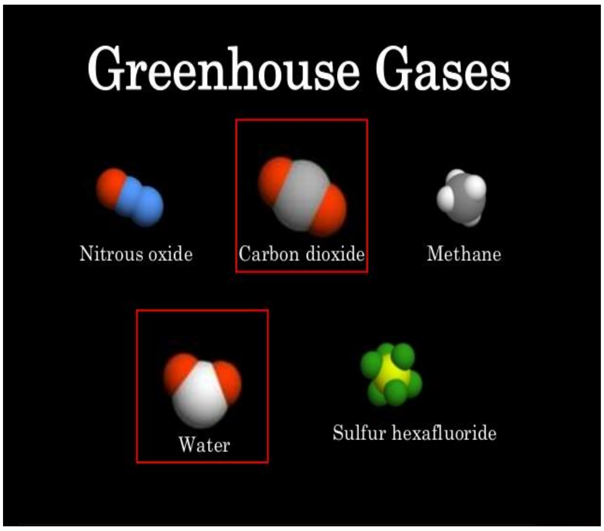

Figure 1. Kyoto Greenhouse gases

B. Sources of carbon footprint /ghg emission

1) Heat and Electricity Generation: According to 2010 emission statistics, about one-fourth of the global greenhouse gas emission is caused by the burning of fossil fuel like natural gas, coal and oil for the production of heat and electricity to fulfil the increasing need of power all over the world, so contributing to global greenhouse shares more than any other sector.

2) Industry: Compared to global emission up to 2010, twenty one percent of the global greenhouse gas emission is caused by the industrial sector. A variety of chemical, mechanical and mining processes are carried out inside industries producing hundred of thousands of commercial products. Most of these industrial activities are directly or indirectly producing greenhouse gases which enters to the atmosphere.

3) Agriculture, Forestry, and Other Land Use: Livestock and agricultural activities to fulfil the food and shelter requirements of mankind is also a main source of greenhouse gas emission with a share of twenty four percent of 2010 global emission. The population of the world is increasing day by day, so the need for their food, shelter is also increasing. New housing societies, new towns and cities are causing deforestation, increased waste material and many more.

4) Transportation: Billion of people use small and big vehicles for themselves and their goods movement from one place to another all over the world. These vehicles are mostly operated by burning of fossil fuel like gasoline and diesel producing greenhouse gases. In 2010, 14 percent global emission came from the transportation sector.

5) Building: Fuel is burnt inside homes and building for the purpose of heating and cooking. In 2010, six percent of the global greenhouse gas emissions were from this sector. Emission coming from electricity consumed in this sector is excluded and is already counted in the electricity and heat generation sector.

6) Other Energy: It is ten percent of 2010 global greenhouse gas emission and involves all those emissions related to energy sectors but not directly related to electricity and heat generation, extraction and refining of fuel and transportation etc. [4].

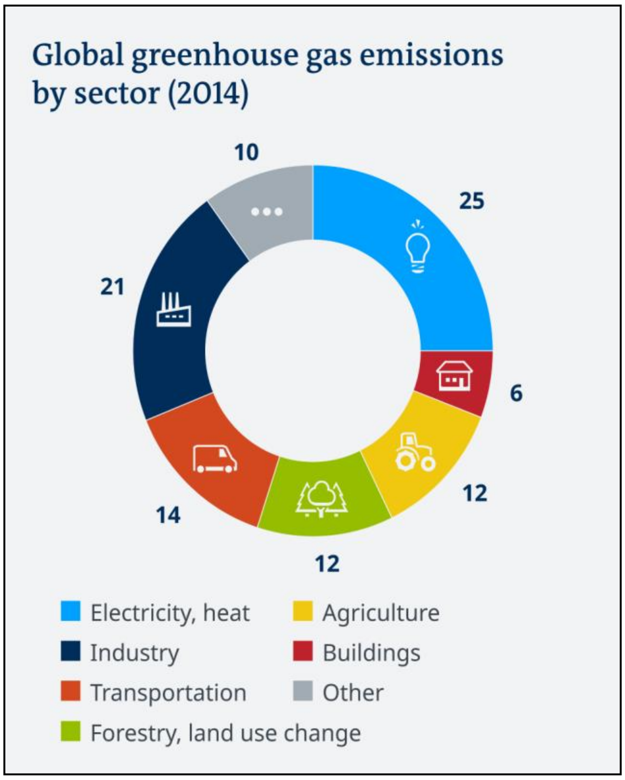

Figure 2. Global greenhouse Gas emission by Sector (2014)

Fig. 2 shows the graphical representation of the percentage of various economic sector contributing to global greenhouse emission in which heat and electricity have the greayest share of all.

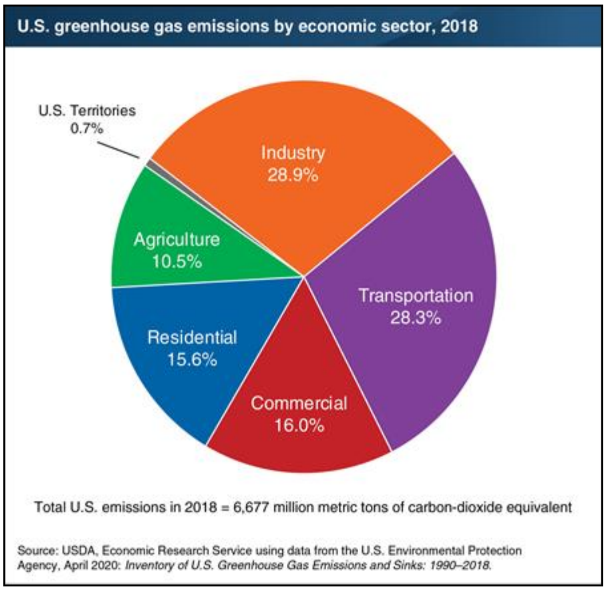

Figure 3. US Greenhouse Gas Emissions by Economic Sectors, 2018

II. CARBON FOOTPRINT'S ESTIMATION IN OIL & GAS INDUSTRY

The oil and gas received from wellhead are normally in the form of mixture of natural gas, crude oil and water. For the purpose of separation of the three-phase mixture into commercial standard products, there is always an oil and gas production and facility are required. Such facility consists of a complete phase separating system, utility system, power generation system, LPG extraction system, crude stabilization system, pneumatic system, instruments digital control system, Fire extinguishing system, water treatment systems, compression units, heating and cooling system which are required for the design process. In an oil and gas industry, a multitude of operations and equipment are involved which burn fossil fuel(s). Each process and equipment consume energy either directly or indirectly. Energy production usually contributes to a lot of carbon emissions to the environment. Gas leakages also occur from various equipment, pipelines, valves, etc. thus contributing to carbon footprints. Waste gas streams are flared, which is a continuous source of carbon emissions in an oil and gas industry. Likewise, oil and gas facility have a large number of static and rotary heavy equipment and variety of operation which leads to emission of huge amount of greenhouse gases in which carbon dioxide, methane and nitrous oxide are more prominent [5]. To estimate the carbon footprint of oil and gas industry following three steps are required:

- Identification of emission sources.
- Collection of data.
- Calculation of carbon footprint.

A. *Identification of emission sources.*

The very first step in the estimation of carbon footprint of an industry or a product over their life stages is to list out all the sources which directly or indirectly emit greenhouse gases to the atmosphere. All the emission sources are categorized on the basis of type greenhouse gas and way of emission. Table 1 shows a number of greenhouse gases emission sources for an oil and gas industry. However, Following are the two major categories of greenhouse gases emission sources.

1) Direct Emission Sources: This form of emission is from sources which are operated and managed themselves by the reporting organization like combustion sources which include turbines, engines, boilers, heater, flares, etc. point sources like process vents, condensate storage tanks, pneumatic devices (gas-driven) non-routine activities including maintenance and ATAs, Non-Point Sources e.g. fugitive type emissions all are the direct sources of emission.

2) Indirect Emission Sources: Some companies do not generate their own power and heat and purchase it from other power producing companies. So, the emissions which comes from the activities not controlled by the reporting company but are the consequences of the activities and operations of reporting company like purchasing of electricity etc. are termed as indirect emission sources.

TABLE I. SOURCES OF OIL AND GAS GHG EMISSION SOURCES AND CLASSIFICATION

S. No.	Greenhouse gases Emission Sources	Category	Type of Emission
1	Hot oil heaters	Stationary combustion sources	Direct Emission Sources
2	Furnaces		
3	Reciprocating compressor's engines		
4	turbines		
5	Electric generators		
6	Boilers		
7	Flares		
8	Residential camp kitchen		
9	Heavy lifting cranes	Mobile combustion sources	
10	Trucks		
11	Company owned vehicles for transport		
12	Hydrogen plants	Process emission sources	
13	Amine units		
14	Glycol dehydrators		
15	Fluid catalytic cracking unit		
16	Crude oil storage tanks	Vented emission sources	
17	Gas blanketed water and chemical tanks		
18	Chemical injection pumps		
19	Evaporating ponds		
20	Gas driven pneumatic devices		
21	Pressure relief valves		
22	Valves	Fugitive Emissions	
23	flanges		
24	connectors		
25	pumps		
26	compressor seal leaks		

27	Electricity generation (off-site)	Energy purchasing	Indirect emission sources
28	Steam generation (off-site)		

B. Collection of Data

Prepare preliminary data sheets and/or survey forms to gather

information. Identification and revalidation of potential emission sources by conducting on-site survey. Obtaining / recording all the relevant information from each source by reviewing fuel usage records, monthly / ATAs reports, interviews, etc. Beside all the most important thing in data is the amount of fuel used by a specific equipment, fuel flow rate, activity hours and the composition of the fuel used by a specific equipment. The carbon footprints' estimation is focus on following three prominent greenhouse gases inside oil and gas sector.

- Carbon dioxide (CO_2)
- Nitrous oxide (N_2O)
- Methane (CH_4)

The selection of above three GHG is made due to their noticeable prevalence and significance in oil and natural gas industry operations.

All conversions from volume to mass basis and vice versa are assumed at standard temperature and pressure conditions, i.e. 14.70 psia pressure and 60.0 °F temperature (which is equivalent to 1.01325 MPa and 15.60 °C) using the ideal gas law (PV = nRT). In estimating emissions, 100 % oxidation of carbon is assumed. Fuel Properties: The compositions and properties of fuel(s) as provided by the relevant section(s) are used in estimating emissions from fuel combustion. Quantities are expressed in SI units; units are expressed as and otherwise. The reporting year should be specified [6].

C. Calculation of Carbon footprint

There are a large number of proposed estimation methodology, while the selection of carbon footprint estimation approach depends on the availability of data, purpose of analysis and type of organization. However, the best suitable approach is "Fuel Analysis and Mass Balance Approach [7]."

1) Calculating Emissions from Combustion Sources

- Find total fuel consumed through out the year by multiplying fuel flow rate and activity hours.
- Find composition of the fuel used by doing laboratory tests.
- Calculate the molecular weight of fuel mixture.
- Convert the weight percent composition of fuel mixture to mole percent composition.
- Calculate the carbon content of fuel mixture.
- Calculate CO_2 emissions from the combustion of gaseous fuels using (1),
- $$ECO_2 = FC \text{ x } MW_{Mixture} \text{ x } Wt\ \%\ C_{Mixture} \text{ x } \frac{44}{12} \text{ x } \frac{1}{\textit{molar volume conversion}} \quad (1)$$
- Calculate CO_2 emissions from the combustion of liquid fuels using (2)

$$ECO_2 = FC \text{ x } D \text{ x } Wt\ \%\ C_{Mixture} \text{ x } 3.667 \quad (2)$$

- CH_4 and N_2O emissions are calculated separately using (3) and (4)

$$E_{CH4} = E_{in} \text{ x } EF_{CH4} \quad (3)$$

$$E_{N2O} = E_{in} \text{ x } EF_{N2O} \quad (4)$$

2) Calculating Emissions from Mobile Combustion Sources

Emission from mobile sources like company vehicles etc. can be readily calculated by using (5), (6) and (7)

Total fuel consumed =

Total distance covered /Fuel used per unit distance (5)

Total CO_2 emissions =

Fuel (consumed) × Emission Factor × 0.001 (6)

Total non-CO_2 GHG emissions =

Mileage × Emission Factor × 0.001 (7)

3) Calculating Emissions from Point Sources:

Calculate CH4 emissions for glycol dehydrator using (8) and (9)

$$E_{CH4} = V \text{ x } EF_{CH4} \text{ x } \frac{\text{Mol \% CH4 (facility)}}{\text{Mole \% CH4 (default)}} \quad (8)$$

$$E_{CO2} = E_{CH4} \text{ x } \frac{\text{Mol \% CO2 facility}}{\text{Mol \% CH4 facility}} \text{ x } \frac{MW\ CO2}{MW\ CH4} \quad (9)$$

4) Calculating Emissions from Non-Point Sources:

Calculate the Fugitive Emissions using the facility-level average fugitive emission factor for gas processing plants from Table 6-2 and using (10) and (11)

$$E_{CH4} = V \text{ x } EF_{CH4} \text{ x } \frac{\text{Mol \% CH4 (facility)}}{\text{Mole \% CH4 (default)}} \quad (10)$$

$$E_{CO2} = E_{CH4} \text{ x } \frac{\text{Mol \% CO2 facility}}{\text{Mol \% CH4 facility}} \text{ x } \frac{MW\ CO2}{MW\ CH4} \quad (11)$$

5) Calculating Emissions from Indirect Sources:

The purchase of energy is the major source of indirect emission in oil and gas industry. When fuel is combusted to generate electricity or to produce heat, steam, or cooling water, Carbon dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O) are emitted. Calculate the emissions from the use of electricity purchased from national grid using (12), (13) and (14)

$$E_{CO2} = E \text{ x } EF_{CO2} \quad (12)$$

$$E_{CH4} = E \text{ x } EF_{CH4} \quad (13)$$

$$E_{N20} = E \text{ x } EF_{N2O} \quad (14)$$

After calculating the tons of greenhouse gas emission carbon footprint can be calculated by summing out the product of each of greenhouse gas with respective global warming effect [8].

CONCLUSION

Estimation of carbon footprint is always the first step to reduce the greenhouse gas emission from an industry. A set of policy and procedures may be set forth for the assessment, reporting and mitigation of GHG and carbon footprints. The parameters like volume, pressure of the gas stream, temperature, operating flow rate, etc. may be optimized according to the system capacity to yield better performance and fewer emissions. A GHG emissions inventory should be developed and maintained at the plant. The potential GHG emissions sources should be identified and periodic monitoring may be done over a range of condition

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An Analytical Approach to Find DG Integration Capacity by Load Analysis

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Abstract— With time the electrical power demand and so the DG penetration has increased highly. As the present conventional power systems structure is not well-suited with these energy generation schemes. Therefore to house this high diffusion of distributed generation proper planning is required. This study offers an analytical approach to compute the optimum site and size of installing DG unit for minimizing power losses. The power injections from DG units deviate the system's power flows, thus effecting voltage steadiness and the system losses. In the proposed mathematical model, the maximum size of integrating DG at each bus is calculated using the load and injecting power at each bus. The given mathematical model is simulated in MATLAB. The maximum size and site of DG integration is found with a decreasing power losses of the system.

Keywords— Distributed Generations, Optimal size, Power injection; Power loss.

I. Introduction

The generation from renewable sources and its penetration in the power system is widening frequently due to the ecological and financial concerns. Mostly renewable energy is integrated to the power system using Distributed Generation techniques. The generation of electrical power/energy by the connection of distributed generating units to the power system at sub transmission or distribution levels is termed as DG [1]. DG units integration help in overcoming the losses that occurs in transmission of electrical energy into remote areas, whereas in DG the electricity is generated at the distribution side where it is mainly consumed. On the other hand increasing the generation capacity may require to upgrade transmission and/or distribution system or even building of new facilities additional to the existing ones to make sure that the supply meets the demand. In DG units integration the weight is shared on the distribution side which results in delaying or even complete removal of such up-gradation making it cost and time effective. DG units integration promote the generation of electrical energy from renewable sources [2].

An electrical power system generally consist of organized processes connected to each other namely generation, transmission and distribution. In Pakistan where there is centralized generation system and the power flow is unidirectional i:e from top to bottom, the generation totally depends on few or minor count of huge power plants. The transmission of power is in the upper voltage level to the far remote load areas in the lower voltage level. Water And Power Development Authority (WAPDA's) power division is organized into distinct commercial units including ten distribution companies (DISCOs), one transmission companies (TransCo) (National transmission and dispatch company NTDC) and four generation companies (GENCOs) [3]. DG integration will decentralize the current system making it more reliable and may lead to bidirectional power flow [4]. It also highly increase consistency of the power system and lower the possibility of disturbance in occurrence of any line failure by providing substitute transmission path [5]. Implementing this system will encourage consumers to initiate their own generation facilities to fulfill their energy requirements, and if they are having enough resources to generate surplus energy they can even be paid by selling it to the grid. Excessive rise in electricity charges and shortfall can be controlled by promoting small or even large scale private businesses.

As the system was not initially designed to house this generation, with DG growing penetration it will cause intense modifications in the network design, maintenance and working of distribution systems. In order to minimize problems and take full advantage of benefits, DG integration requires proper planning to encounter these needs starting from best location to all the way the quantity and capacity of units, use of best technology and network connection type [2].

Bulk electrical energy user (i:e railways and large industries etc.) which takes electrical energy straight from transmission and sub transmission system, and in the same way they could be fed directly by DG.

II. Important Factors of DG System Planning

Following are the few very important and deciding aspects of DG integration, each of them will be briefly discussed.

A. Technical and organizational advantages

DG empowers additional effective management through peak cutting or trimming; it allow the consumers to flexibly manage their energy requirements in maximum demand hours with local electrical energy generation units through appropriate planning of storing energy. This will lower the burden on consumer by reducing electricity cost and also reducing load burden.

DG Integration into electric network offers the essential balancing power sources; it raises the system overall consistency (in tackling of the main generating units outage) and removes the requirement of further funds on spinning reserve units [6].

- Reducing power loss by postponement of huge transmission and distribution (T&D) and rectifying power factor.
- Decreasing the frequency of load shedding and to provide more dependable power sources for crucial practices, by coupling of energy storage system like involvement of uninterruptable power supply (UPS), fuel cells and diesel engines, and
- Steadying the tumbling regularity in electrical power system in occurrence of spontaneous generating unit outage and unexpected load flood [7].

Moreover, nature of DG make installation, constructing and placement simpler and speedy, increased sensitiveness for load deviation pursuing and regulation, and lesser footprint necessity [8].

B. Financial advantages

The financial/economical advantages of DG system are found on both sides of electrical power (supply and demand). On the supply side i:e. load serving entities (LSE) and utility firms, it is attained by neglecting the requirement of investing allot of funds on upgrading and expanding T&D, particularly in far isolated regions. Economic efficiency can also be accomplished by dropping operational rate determined by peak shaving [9].

On the demand side too, DG economic efficiency is established. A financial evaluation found that the electricity costs compulsory on the users is considerably reduced in DG system employment with proper modification in electricity tariff alteration, with accomplishment of LSE co-benefit [10].

Moreover, lesser energy charges of DG system are related to employment of substitute lower prices fuels. Particularly, in areas with considerable economic similarity among conventional fuel (coal, fuel oil, etc.) and gas, highly significant bill reduction towards users can be achieved through fuel exchanging DG system combined with gas based power generating units [11]. Similarly, low-price biogas from landfill can also be used in implementation of DG system.

C. Environmental advantages

Penetration of energy from renewable sources into electric power system in the form of DG can perform a significant role in dropping gaseous toxin discharges and influence on atmosphere changes [12].

Per annum carbon discharges reduction by up to 1.08 million tons was observed in province Jiangxi due to DG integration into power network with the incorporation of power from wind sources at a proportion of 0.16% [13]. Optimal DG system situation with renewables like incorporation of wind power and solar PV systems on buildings with zero-energy indicated that ecological cost can be reduced by 99% [14]. Furthermore, postponement of T&D expansion across the ecologically delicate ranges and jungles is attainable with DG penetration [15].

III. PROPOSED METHODOLOGY

A. DG effect on power system

The overall effect of DG on the system losses and voltage stability is briefly discussed below.

1. System losses without DG unit

The overall effect of DG on the system losses and voltage stability is briefly discussed below.

Eq. (1) commonly recognized as "exact loss formula", represents the overall real losses (P_L) in a distribution network having N number of buses [16].

$$P_L = \sum_{i=0}^{N}\sum_{j=0}^{N}\left(\alpha_{ij}\left(P_iQ_i + Q_iQ_j\right) + \beta_{ij}\left(Q_iP_j - P_iQ_j\right)\right) \tag{1}$$

Where $\alpha_{ij} = \frac{r_{ij}}{V_jV_j}\cos\left(\delta_i - \delta_j\right)$, $\beta_{ij} = \frac{r_{ij}}{V_jV_j}\sin\left(\delta_i - \delta_j\right)$

$V_i\angle\delta_i$ represent the complex voltage of the i[th] bus; and $r_{ij} + jx_{ij} = Z_{ij}$ are the ij[th] component of (Z_{bus}) matrix with $(Z_{bus}) = (Y_{bus})^{-1}$; the real powers are represented by P_i and P_j while Q_i and Q_j represents the reactive power injected at buses i and j correspondingly.

2. System losses with DG unit

Eq. (2) and (3) correspondingly represents the real power introduction to the system at bus i at the point at which DG unit is situated [17].

$$P_i = P_{DGi} - P_{Di} \tag{2}$$

$$Q_i = Q_{DGi} - Q_{Di} = a_iP_{DGi} - Q_{Di} \tag{3}$$

Here $Q_{DGi} = a_iP_{DGi}$, P_{DGi} & Q_{DGi} are correspondingly the real and reactive power introductions at bus i by DG unit, a_i = (symbol)tan($\cos^{-1}$(Pf_{DGi})) and {symbol = +1 when DG unit is delivering reactive power and for DG unit taking reactive power symbol = -1}; P_{Di} and Q_{Di} correspondingly represents the real and reactive loads at bus i; pf is the DG unit's operational power factor at bus i. Putting P_i and Q_i from Eq. (2) and (3) into Eq. (1) for P_L, we can find the overall real power losses from Eq. (4) when the DG is connected.

$$P_{LDG} = \sum_{i=0}^{N} \sum_{j=1}^{N} [\alpha_{ij}((P_{DGi} - P_{Di})P_j + (a_i P_{DGi} - Q_{Di})Q_j) + \beta_{ij}((a_i P_{DGi} - Q_{Di})P_j - (P_{DGi} - P_{Di})\, Q_j))] \quad (4)$$

Let the power system consist of an overall n number of buses then the current injected at bus i is given as,

$$I_i = Y_{i1}V_1 + Y_{i2}V_2 + Y_{i2}V_2 + \ldots Y_{in}V_n \quad (5)$$

Here Y is the admittance of the n bus system, where $Y_{ij} = |Y_{ij}|(\cos\delta_{ij} + \sin\delta_{ij})$ and δ_{ij} is the angle of ij^{th} component of the Y_{ij} matrix. By simplifying Eq. (5)

$$I_i = \sum_{j=1}^{N} (Y_{ij} V_j) \quad (6)$$

Also $I_i = I_{ai} + jI_{ri}$ where I_{ai} is the real or active part of the injecting current while I_{ri} represent the reactive part of the injecting current at bus i. By knowing I_i and voltage of the i^{th} bus P_i and Q_i can be found as follows.

$$P_i = I_{ai}V_i \quad (7)$$

$$Q_i = I_{ri}V_i \quad (8)$$

B. Proposed procedure

Using eq. (1), Eq. (2) and Eq. (3) the active power losses is given by Eq. (9).

$$P_L = \sum_{i=0}^{N} \sum_{j=1}^{N} [\alpha_{ij}(P_i P_j + (aP_i + aP_{Di} - Q_{Di})Q_j) + \beta_{ij}((aP_i + aP_{Di} - Q_{Di})P_j - P_i\, Q_j)] \quad (9)$$

The overall active power losses is minimum if the partial derivative of eq. (9) with respect to P_i becomes zero.

$$\frac{\partial P_L}{\partial P_i} = 2 \sum_{j=1}^{N} \alpha_{ij}(P_j + aQ_j) + \beta_{ij}(aP_j - Q_j) = 0 \quad (10)$$

By simplification

$$\frac{\partial P_L}{\partial P_i} = \alpha_{ii}(P_i + aQ_i) + \beta_{ii}(aP_i - Q_i) + \sum_{\substack{j=1 \\ j\neq i}}^{N} (\alpha_{ij}P_j - \beta_{ij}Q_j) + a\sum_{\substack{j=1 \\ j\neq i}}^{N} (\alpha_{ij}Q_j + \beta_{ij}P_j) = 0 \quad (11)$$

Rearranging Eq. (11).

$$\alpha_{ii}(P_i + aQ_i) = -\beta_{ii}(aP_i - Q_i) - A_i - aB_i \quad (12)$$

Where $A_i = \sum_{\substack{j=1 \\ j\neq i}}^{N} (\alpha_{ij}P_j - \beta_{ij}Q_j)$ &

$B_i = \sum_{\substack{j=1 \\ j\neq i}}^{N} (\alpha_{ij}Q_j + \beta_{ij}P_j)$

Using Eq. (2) and (3) to replace P_i and Q_i in Eq. (12).

$$\alpha_{ii}(P_{DGi} - P_{Di} + a(aP_{DGi} + Q_{Di})) = -\beta_{ii}(a(P_{DGi} - P_{Di}) - (aP_{DGi} - Q_{Di})) - A_i - aB_i \quad (13)$$

By simplification

$$P_{DGi}(\alpha_{ii} + a^2\alpha_{ii}) = \alpha_{ii}(P_{Di} + aQ_{Di}) + \beta_{ii}(aP_{Di} - Q_{Di}) - A_i - aB_i \quad (14)$$

Now rearranging Eq. (14).

$$P_{DGi} = \frac{(\alpha_{ii}(P_{Di} + aQ_{Di}) + \beta_{ii}(aP_{Di} - Q_{Di}) - A_i - aB_i)}{(\alpha_{ii} + a2\alpha_{ii})} \quad (15)$$

The optimal integrating DG capacity at bus i is given by equation. (15)

As the power losses is minimum when the DG power factor reaches to power factor of the load, therefore for minimum losses power factor of DG is given by Eq. (16)

$$Pf_{DGi} = Pf_{Di} = \cos(\tan^{-1}(Q_{Di}/P_{Di})) \quad (16)$$

C. Computational procedure

Step-1: Run "base case load flow" to calculate P_L from eq. (1).

Step-2: Find the power injection into each bus using Eq. (7).

Step-3: The DG power factor can be found by using Eq. (16).

Step-4: Using Eq. (15) to find the size of DG at each bus. Reactive power at each bus can be calculated by Eq. (3).

Step-5: Run "load flow with DG unit" and find the losses of the system after DG integration using Eq. (4).

D. Case Study

The recommended technique has been subjected to a test on a 5 bus radial distribution system with various characteristics demonstrated in figure 1. The line impedances and the line charging admittances data of the given system are specified in Table 1. On the basis of the data given in Table 1 the Y_{bus} matrix is formed which is given in Table 2. It is to be mentioned here that the sources and their internal impedances are not taken into consideration in the making of Y_{bus} matrix.

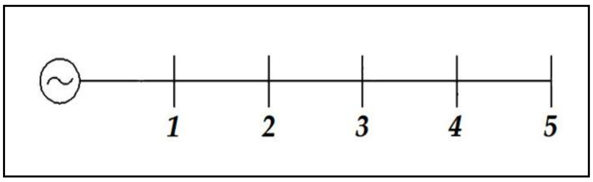

Figure 1. Single line diagram of test system.

TABLE 1. THE LINE IMPEDANCES AND CHARGING ADMITTANCES.

Line (Bus to Bus)	**Impedence**	**Line Charging (Y/2)**
1 - 2	0.02 + j0.10	j0.030
2 - 3	0.04 + j0.20	j0.025
3 - 4	0.05 + j0.25	j0.020
4 - 5	0.10 + j0.50	j0.075

The system initial data including bus voltages and its angles, the active and reactive power generation as well as the load at each bus is given in Table 3. The base value used for active and reactive power given is 100MVA.

TABLE 2. Y_{BUS} MATRIX

	1	**2**	**3**	**4**	**5**
1	1.9231 – j9.5854	– 1.9231 + j9.6154	0	0	0

2	– 1.9231 + *j*9.6154	2.8846 – j14.3681	– 0.9615 + *j*4.8077	0	0
3	0	– 0.9615 + *j*4.8077	1.7308 – j8.6088	– 0.7692 + *j*3.8462	0
4	0	0	– 0.7692 + *j*3.8462	1.1538 – j5.6742	– 0.3846 + *j*1.9231
5	0	0	0	– 0.3846 + *j*1.9231	0.3846 – j1.8481

The findings of the proposed procedure is given in figure 2, with the reactive power in accordance to the load power factor. The injecting current at each bus along its angle is demonstrated in figure 3. The losses found before and after DG integration is given in Table 4, a significant amount of decrease in the system loses can be noticed. The bus system after DG integration is demonstrated in figure 4.

TABLE 3. SYSTEM INITIAL DATA.

Bus no.	**Bus voltage**		**Power generated**		**Load**	
	Magnitude (pu)	***Angle (deg)***	***P (MW)***	***Q (MVAr)***	***P (MW)***	***P (MVAr)***
1	1.05	0	174.6	72.59	12	3
2	1	0	0	0	96	62
3	1	0	0	0	35	14
4	1	0	0	0	16	8
5	1.02	0	48	0	24	11

The results are compared with another analytical model based on multiobjective index (IMO). The comparison is given in figure 5. It is observed that the same trend has been followed by both methods regarding DG size, however small changes can be noted in the values.

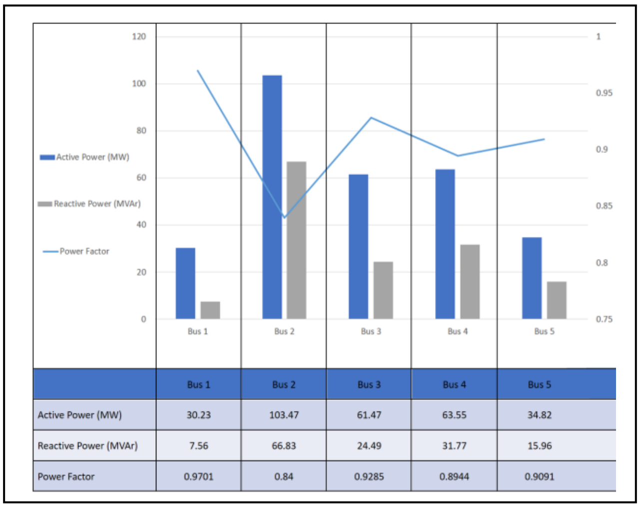

Figure 2. DG capacity found at each bus.

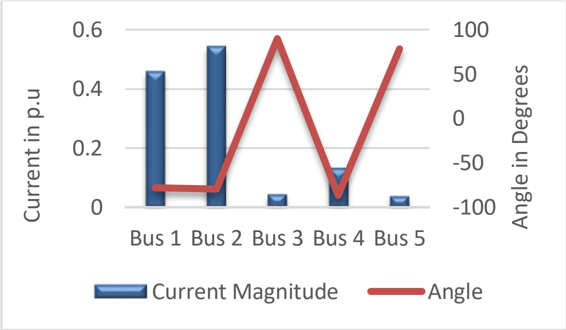

Figure 3. Injecting current at each bus.

TABLE 4. SYSTEM LOSSES.

	Without DG unit	**With DG unit**
System losses	6.6 MW	0.37 MW

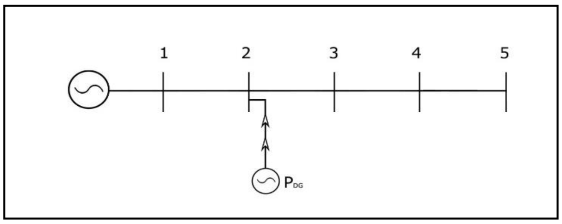

Figure 4. Given system after DG placement.

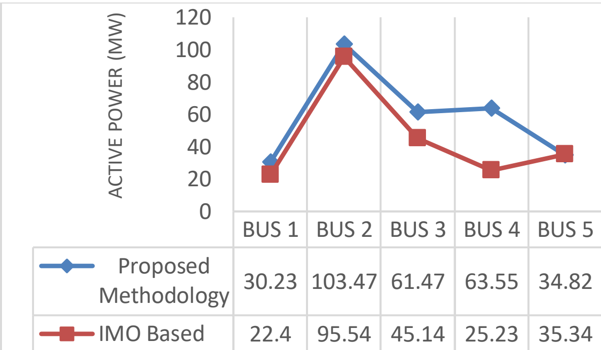

Figure 5. Comparison with IMO based methodology.

CONCLUSION

This study focus on modeling a mathematical prototype in order to calculate the maximum permitted size of a DG unit which is considered to be added into the system at the best suitable location. For a parallel purpose, the study also suggest some other mathematical models. The goal of the study was to find a further fruitful mathematical prototype by considering power losses in the system, before integration of the DG unit into the system. For this objective the exact loss formula is applied, then a general mathematical prototype is attained with the help of equations. The given mathematical prototype is subjected to a 5 bus test system. The maximum permitted DG size is found with the help of given mathematical prototype. This mathematical prototype uses the power injection and the load at each bus in a proper way to enhance the size gained.

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Comparative Analysis of Capacitance Finding Techniques of a Solar Cell

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Abstract— Variable capability of the PV module depends on the ability of the photovoltaic cell to be standard. Finding this parameter is not as easy. The finding of capacitance of photovoltaic cell needs high accuracy instrument. Two ways are going to be mentioned during this analysis, one is Electrical phenomenon spectrographic analysis (IS) and alternative one is RLC circuit methodology. The most straight forward methodology for locating capacitance a PV module. The electrical event spectroscopy is the most common way to check the dynamic nature of PV modules. Supported by these methods, the AC parameters, capacitors and dynamic and series registrations of photovoltaic cells will be set. Check out the following signal (Voltage or Current) device. The test device electrical effect will be calculated by taking significant AC voltage and current. The test device electrical effect spectrum will be detected by AC signal frequency variable. Duty equivalent circuit is supported, its components will be determined by capacitance in case of serial fitting method and parallel resistance and photovoltaic cell. Electronic devices are constructed as a load of photovoltaic cells. The ability of photovoltaic cells to detect the frequency of oscillation of gas by menstrual cycle, which happens promptly to connect the electrical device to a photovoltaic cell. By assembling completely different Indicators in photovoltaic cells. The frequency effect on photovoltaic cell capacities has been studied considering the low intensity of capacitance with frequency. This analysis introduces an easy and effective methodology to work out the electrical Capacitance of the photovoltaic cell.

Keywords— Solar Cell, PV Module, RLC Methodology, Impedance Spectroscopy, Renwabale Energy.

I. Introduction

Solar cells are one of the most important sources of renewed energy. Several solutions to measuring the risk of recycling (PV) use as a reproducible power source to respond to pollution control have been developed. Because of current non-linear voltage (I-V) properties of PV components, it is not easy to install electrical parameters. In the past decade, PV has been transformed as a result of the electronic standards of electric cells. An electrical examination of the units was conducted. DC and AC [1], focused on the electrical parameters in each study. The most widely used technologies for checking the dynamic nature of photovoltaic units are the specifications of the IS-[2] power supply. This protocol supports AC parameters, capacitors, dynamic resistance, and limitations of electric cells. Test Device electrodes react and start from AC voltage. Changing the AC signal, frequency will detect the electrical resistance spectrum. Electrical equivalent circuit is supported, it's series and parallel resistance is determined by theoretical formula and therefore capacitance is determined in case of electric cells. An RLC is designed as a load for circuit electric cells, as it is made by an electrical device. The electrical cell's capability is measured in the frequency of the electrical cells, by adding completely different parameters; the study of electric cell capacitors is done by frequency difference, which reduces the ability to increase frequency.

After reducing the carrier's concentration, the electro cell would be reduced to at least 14 cell capacities after it was radiated [3]. After the hot spots, the capacity of the PV panel will increase[4]. The amount of additional squares in the manner of reproducing energy, in some cases, is considered a practical alternative to common source energy. Photovoltaic technology developed and maturity was cheaper than alternative energy sources. . Solar panel power containers require high Power and high efficiency to use high-speed switch load controllers. In order to design an economical and reliable switch loading controller, it is necessary to verify the cell capacity and cell code.

Once the electrical appliance is working while working outside the door, the difference between temperature for the given operator voltage can change the cell or panel operative status. The AC Parameters of cell have been calculated in completely different cell temperatures, in which the dark condition absorption resistant cell bias voltage (forward and vice versa) changes under qualitative analysis techniques. At any voltages the cell capacitance with temperature would be increased. High Power System is well connected to the load system and attracts it seamlessly. Therefore, the load panel must be forced to provide the battery with continuous power, so that the energy will be generated at a specific level. As such, the electrical cell or panel is necessary to switch between the batteries and therefore the shunt switch is quickly required. The electrical cell is often designed as a parallel RC network. Due to the gift of capacitance in electrical cells, The AC parameters, in particular, the ability of PV cells are a factor of deterioration in the functionality and reliable method of the charging controller. Photovoltaic cell capacitance is the combination of transition and diffusion capacitance. Transition capacitance is on one side of the sudden PN-junction profile. The resistance of solar cell is the combination of dynamic resistance and static resistance.

II. SOLAR CELL CAPACITANCE AND ITS TYPES

Solar cell is a PN junction or we can say series connected PN junctions [5]. It has a photo generated current source which is connected in parallel. A PN junction is a simple diode and diode itself has series and parallel resistance. Solar cell is often characterizing by its capacitance [6]. The capacitance of the cell is directly with area, thus device with massive area can have large capacitance. The photovoltaic cell Capacitance is that the combination of 2 capacitances, one is junction capacitance (Cj) and different is diffusion capacitance (Cd). Junction capacitance is additionally referred to as transition capacitance. the entire Capacitance of a photovoltaic cell is that the addition of each transition and diffusion capacitance. The diffusion capacitance Cd is usually dominant on the far side Vd=0.8Voc, wherever Voc is that the electrical circuit voltage of the electric cell. The junction or transition capacitance is dominant over a voltage vary of 0-0.7Voc and in reverse bias. If the voltage vary is confined to Vd <0.7Voc then the electric cell capacitance is given by its junction capacitance only.

A. Jucnction Cpacitance.

Junction capacitance could be a capacitance of PN junction diode once it's connected in reverse biased. In traditional parallel plate condenser conductor permits the physical phenomenon, there's medium between parallel conducting plates that doesn't permit physical phenomenon. once voltage is applied against it, charges began to accumulate on electrodes and voltage won't move through the medium however the medium can permit field to flow although it once vast range of charges accumulates on electrodes, electrodes stores the charge and therefore the ability to store charge is understood as capacitance.[6]

$$Q = CV \tag{1}$$

Arranging for C

$$C=Q/V \tag{2}$$

C is that the capacitance, Q is the charge and V is the voltage. When reverse voltage is applied across PN Junction, regions P and N behaves as electrodes these two regions have less resistance, depletion region is made that act as stuff medium with high resistance. These 2 regions permit the charge to store in an electrical field. The power of storing charge is named capacitance that is termed as PN junction diode as junction capacitance.

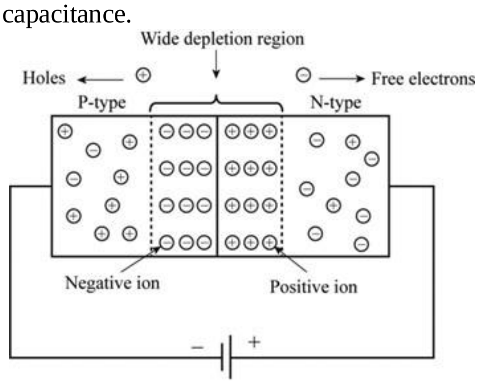

Figure 1. PN Junction diode under reverse condition

When reverse voltage is applied across PN junction diode, the holes from P kind region moves far away from the junction and electrons from N kind region move far away from the junction thus as a result the dimension of the depletion region can increase. The depletion region act as a material medium and stores electrical phenomenon. once voltage across the junction will increase the depletion region will increase however the dimensions of P and N region decrease that decrease the flexibility of storing charge.

Thediode with larger depletion region and large P and N regions will store additional electrical phenomenon. The diode with broad depletion region and little P and N regions will store less electrical phenomenon. So the voltage which is appied is reciprocally proportional to junction capacitance beneath revere bias condition

$$Cj=A/W \tag{3}$$

Cj is the junction capacitance, A is the area of P and N regions and W is the width of depletion region.

B. Diffusion Capacitance.

When PN Junction diode is connected in forward bias the capacitance is made, this capacitance is thought as diffusion capacitance and is denoted as Cd. This capacitance is way bigger than the junction capacitance. Throughout this biasing the potential barrier r depletion region is reduced and also the P and N regions will increase. The charge carriers move far away from the junction and so recombine. The density of charge carriers is higher close to the junction and decays once the gap will increase. So during this case charge is holding on in each side of the junction and varies with applied potential. Thus modification to blame with reference to the applied voltage lead to capacitance that is termed diffusion capacitance. Diffusion capacitors are the charge carrier transport between the 2 terminals of the device. Once current is flown through conductor thus there's some charge within the method of transit during a specific moment, the present changes to completely price once the voltage is modified to a special value, thus different quantity of charge are going to be transit in numerous circumstances. The full amendment is quantity of charge transit divided by the full voltage inflicting its diffusion capacitance [7].

$$Cd=(dQ/dV)\ t \tag{4}$$

"t" is the transit time, dQ is the change in charge and can be represented in form of voltage and current, dV is the change in voltage [8].

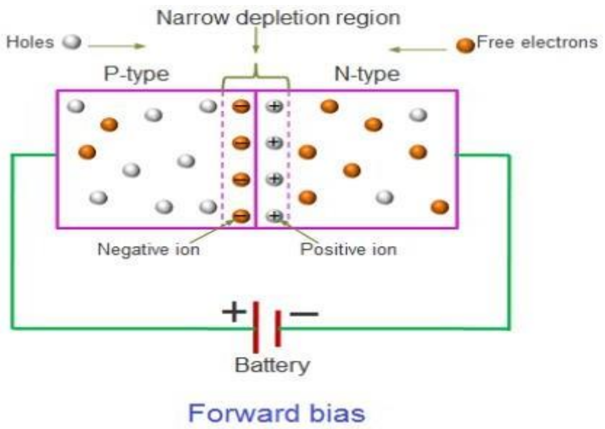

Figure 2. PN Junction diode under forward bias

III. METHODS AND TECHNIQUES

A. *Impedence spectroscopy.*

Almost everyone knows the definition of Electrical Resistance. It is ability of electrical circuit to stop the flow of electrical current and can be shown by relation with V and I.

$$R=V/I$$

The real world contains Electrical elements which show much more complex behavior. These elements force us to abandon the concept of resistance and its parallel we use impedance. [9].The efficiency of solar cells can be measured using frequency domain technologies. Frequency domain uses a small signal during the technique operation, calculating criteria and returning values. In cellular technology, a cellular voltage is transmitted from a small circuit to an open circuit, so the value of the solar cells is a combination of short circuits and open circuits. There are some advantages and disadvantages for this domain to measure solar domains. In recent studies effectiveness of a solar cell is reduced. [10][11]. Therefore, an experimental sample was developed to find the strength of the solar cell using the impedance spectroscopy technology.

- Priciple of impedence spectroscopy:

Impedance Spectrum Analysis may be featured with some or all electrical resistive measurement and analysis of connected functions. Once the plotting is complete, plotting has been completed in the complex plane during this setup, and then the device's shortest signal model is explained. In impedance spectroscopic analysis, the complicated impedance that is (R + jX) of a tool that is below take a look at is measured. This measure is completed directly within the frequency domain; sizable amount of frequencies is applied to it always 2 or 3 decades. During this technique a strictly curved voltage is applied, this voltage can have completely different frequencies, in doing so amplitude is measured of the device, real and imagined elements of the ensuing current of that frequency is measured. The ratio of the applied voltage and also the ensuing current is set which supplies the electrical resistance each real and imaginary part of a complex number of the device below take a look at. A plot is drawn between R and JX on a Fancy Plane between R and JTX, which provides an electrical resistant spectrum of equipment for different frequencies. The resultant circuit parameters are calculated as a result. The resistive Rp and the electrical equipment are attached in the Cp parallel electrical resistance spectrum. Touching the basic part of this spectrum can be the plane figure of the fourth quadrilateral related to the real radius and if the radius is removed from the original if the radius is RP / 2. If the network line shows resistance availability. The shape of this spectrum depends on the device's surrounding parameters, which changes the parameters depending on the frequency and allows you to configure the variable parameters by configuration [31]

- Experimental Setup:

Experimental structure Electromotive Interface (ECI), Frequency Research Analyzer (FRA), Laptop, Solar Cell, Figure 4 , which is measured capacitance.

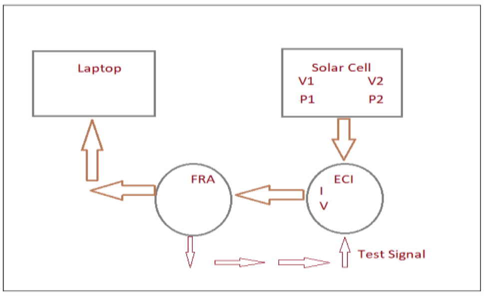

Figure 4. To measure Capacitance of solar cell by experimental Setup.

a) The experimental setup is designed in the figure shown above. In these step voltages V_1 and V_2 are measured between 2 points of solar cell that is P_1 and P_2.
b) The solar cell is then connected with ECI which further connect to FRA.

c) Voltages between points P_1 and P_2 are measured with meter and the resistance is set from 0.1 to 5k ohm.

d) The ECI gives stable voltage to testing unit.

e) Test signal of sinusoidal waveform is given to the ECI from FRA for testing purpose. This signal is of varying frequency. i.e $10^3\ to\ 10^7\ Hz$ .Testing signal of <10mV is applied to avoid distortion.

f) Personal laptop is connected to the FRA for simulation purpose.

g) FRA gives the real and imaginary outputs by varying the frequency.

h) The time (T) is noted when signal is applied.

- Testing Setup:

i) The frequency of 10Hz to 100Hz is used in conjunction with an electrical voltage less than 10mV

j) The real and imaginary breaking parts of the grid are measured from 1Hz to 10 kHz. (28).

k) Similar bandwidth is used and negative Y-Axis.

l) Impedance spectrum consists of two trials.

m) The first parameter of the RC scheme is calculated for the large semiconductor. In point "C" the imaginary (Z) size is equal to the actual (Z) size that is, R3.

n) The spectrum 2 is 5 kHz, and the X3 is 7.28 kΩ

o) Parallel to this parallel component X3, the parallel capacity of Ceq is 9.98nF. For similar frequencies, the serial bandwidth values are taken over the measured data and calculated for values corresponding to R3, X3, and Ceq. These values are presented in Table 1.

p) More precisely, the above figures will be at the maximum value of X3 interactions.

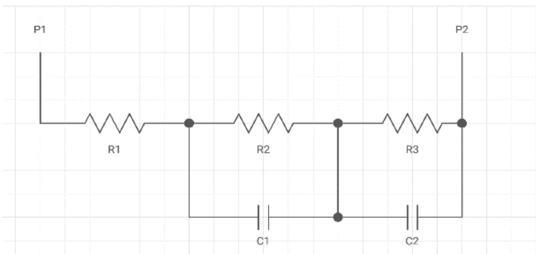

Figure 5. Equivalent Circuit

Table 1. Calculated values of R_2, X_3, and C_{eq} for different frequency.

Frequency (Hz)	R_3 (kΩ)	X_3 (kΩ)	C_{eq} (μF)
1	6.80	5.25	9.98
5	7.28	7.28	10.2
10	8.16	9.33	11.3

B. RLC Resonance Method:

This method is based on the behavior of the RLC (Resistor Inductance Capacitor) schemes. An inductance is used as a variable load for solar cells. The method can be used in light conditions, starting at 1 W / m3. The simulation is done in Orcad PSpice 9.1 version.

- Connection Behaviour

RLC connection is an electric program with a resistor (R), Inductor (L) and Capacitance(C). It's serials or parallel. The name of the switch is received from the letters used in the components of this network, where the order of the components differs from RLC. The Radio transmitters and television equipment are used to select radio frequency. A turn on this role is often known as long term relationship. The RC connection can be used as a low pass filter, or high pass filter. For example, tunes application group transition filtering is an example. The RCL filter is termed a second class circuit. This means that Communication voltage or electrical circuit can be explained in the differential equations in a secondary order. You can add three mode modules, R, L and C into different systems. The three components of the parallel range and the three components are more convincing and understandable to analyze the most effective. However, there are other arrangements, some actual practical schemes. One of the frequently encountered problems is the resistance of induct. Inductors are usually constructed with metal bombs whose resistance are usually not desirable, but often has a significant impact on the connection.Ac and DC equivalent is shown in figure 6 and 7.

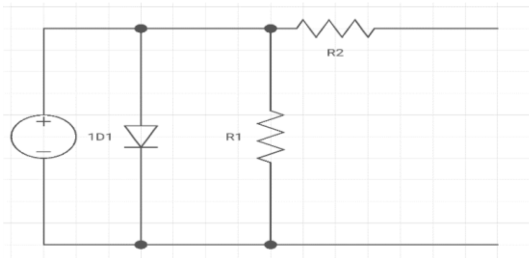

Figure 6. DC Equivalent of solar cell

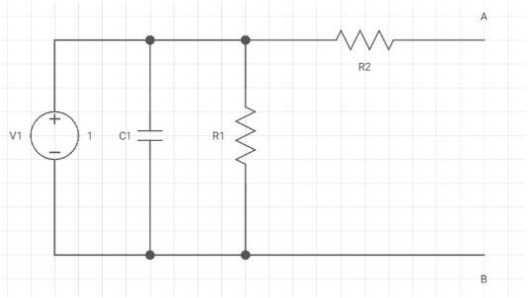

Figure 7. AC Equivalent.

C_1 is equal to the parallel circuit of diffusion and junction capacitance while R_1 is equal to the parallel circuit of Shunt and diffusion resistance. V_1 is the voltage applied against the cell.

- .Mathematical Form

$$V = V_p \operatorname{Sin}(\omega t + \varphi) \tag{5}$$

In the above equation at resonance condition we have a resonance frequency which is given by eqaution 6.

$$\omega = \sqrt{(\omega_0^2 - \beta^2)} \tag{6}$$

Above equation is used for finding resonance frequency at amplitude of Vp, φ is the phase angle in the very first condition of the resonance frequency. The third important factor is the damping co-efficient β. This factor depends on capacitance, consequently, ω_o is the natural frequency which show in equation 7.

$$\Omega_o = 1/\sqrt{LC} \tag{7}$$

Where L is the inductor connected we will use inductor of different values in this thesis to find capacitance, while C is the capacitance of solar cell attached. β shown in the resonance frequency equation is the damping ratio co-efficient. For this method to be applied damping co efficient must be less than the natural frequency of the test setup to get an underdamped oscillation. We will take the logarithmic decrement 'δ' of any two successive peaks at time t and T and this logarithmic decrement is generally between two peaks which can be shown as follows:

$$\delta = \ln(x(t)/x(t + nT)) \tag{8}$$

In the above equation x (t) is the peak at time t, x (t + nT) is the other peak with n number of peaks. In this method we take n=1, now taking natural log of the above equation:

$$\delta = \ln x(t)/x(t + T)$$

$$\delta = \ln x\, e^{-\beta t}/xe^{-\beta(t+T)}$$

$$\delta = \ln e^{\beta T}$$

$$\delta = \beta T \tag{9}$$

Where in the above equation T = 2πf.

Capacitance is calculated at f = ω / 2π, knowing the cost of the coil induction and the determinant frequency, as well as the resulting power fluctuation. Putting value of T in Equation 9.

$$\delta = \beta \times (2\pi f)$$

$$\beta = \frac{\delta}{2\pi f} \tag{10}$$

Putting values of β in above equation of resonance frequency:

$$\omega^2 = \omega_0^2 - \left(\frac{\delta}{2\pi f}\right)^2 \tag{11}$$

As $\omega^2 = 1/LC$

$$\text{so} \quad \omega^2 = \frac{1}{LC} - \left(\frac{\delta}{2\pi f}\right)^2 \tag{12}$$

So by Re Arranging for C we get

$$C = \frac{1}{L\left(\omega^2 - \left(\frac{\delta}{2\pi f}\right)^2\right)} \tag{13}$$

As $\omega = 2\pi f$,> $\delta = \beta 2\pi f$

By putting values of ω and δ we get:

$$C = \frac{1}{L(2\pi f + \beta 4\pi^2 f^2)} \tag{14}$$

Above Equation 14 will be used for finding capacitance of cell at different frequency.

IV. RESULTS

A. *Capacitance Vs Inductance*

Taking different values of L keeping frequency 50 Hz and β=0.2 we found different values of C in the Table 2, the trend can be seen in figure 7.

Table 2. Capacitance with Different Inductance

L [H]	C [nF]
50	998
70	713
90	554
100	500

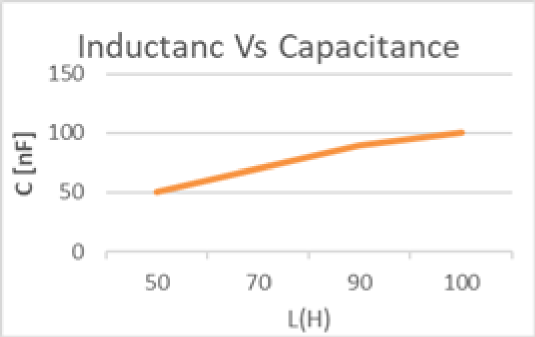

Figure 7. Plot Capacitance against Inductance.

B. *Capacitance vs Frequency*

By keeping inductance value constant we can take different values of frequency to study the behavior of capacitance with the frequency. Now taking Inductance Value L=50H and β=0.2 we change frequency from 50 kHz to 100 kHz. We will take different interval under this range. Results are shown in Table 3 and plot can be seen in figure 8.

Table 3 Capacitance with different frequency

β	Capacitance (nF)
0.1	1906
0.2	998
0.4	500

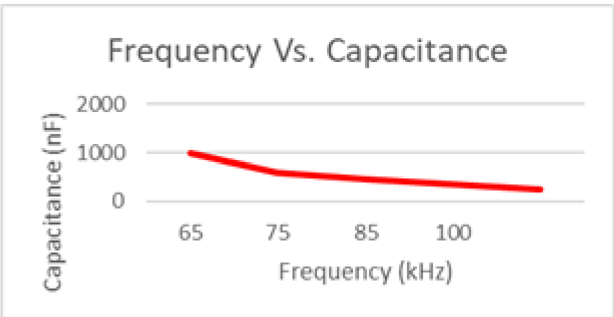

Figure 8. Plot Frequency Vs. Capacitance.

C. *Capacitance Vs β*

Now we take different β values ranging from 0.1 to 0.8 but it should be less than resonance frequency. Keeping inductance 50H and frequency 50 Hz. Again we will use Equation 14 results are shown below in Table 4 and plot can be seen in figure 9.

Table 4. capacitance with Different β

β	Capacitance (nF)
0.1	1906
0.2	998
0.4	500

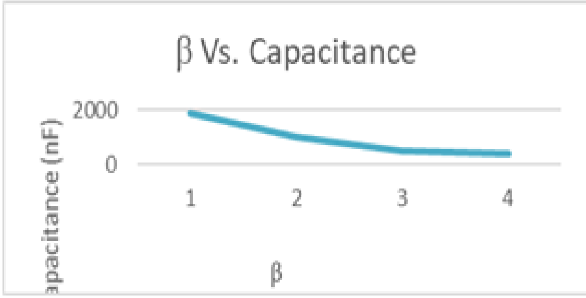

Figure 9. Plot Capacitance against β

V. PRACTICLE DEMONSTRATION

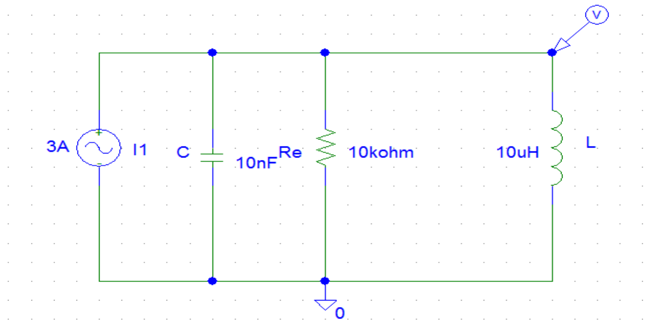

Figure 10. Experimental setup

Experimental setup is being shown in figure 10. Equivalent Circuit is drawn in simulation software Orcad Psice 9.1 version.Transient response of the above circuit is simulated from 0 to 10ms.The current source is set on 3A. Current and voltage waveform is created which is shown below.

By Changing the values of Capacitance and frequency we get different values of current across inductor which act as a load and capacitor. I_1 is set to different values the results are shown in the table Table 5.

Table 5. I_1 with frequency and Capacitance.

Frequency [kHz]	I_1 [A]	Capacitance [nF]
10	3	10
35	12	11.2
65	18	11.8
95	25	12.1

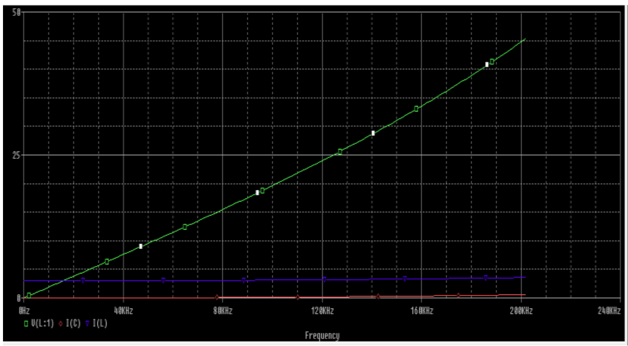

Figure 11. Capacitance Against frequency and Current.

We changed the values of inductor in the circuit from 10µH to 50µH with the changing frequency. By doing so we get different values of capacitance.

Table 6. Capacitance with F and L.

Frequency [kHz]	Inductance [µH]
10	10
35	25
65	35
95	50

Table 6 values can be shown in figure 12.

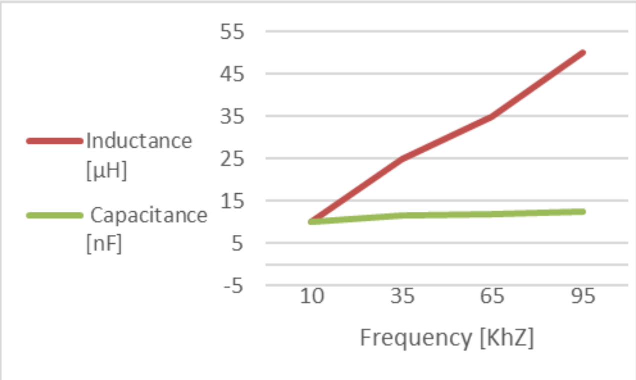

Figure 12. Inductance, Capacitance, Frequency Plot

The changing inductance and frequency gives the same result as show in the Table 6.

CONCUSLION

The capacitance introduces a dynamic parameter of PV components, and can be analyzed as PV modules can provide quality and health information. In this research I am using solar cells and PV. I suggested the RLC method that guarantees the efficiency of the panels. Continuous continuity in this method and open circuit points, L1, is believed to be connected to a solar cell. Method which is very easy to work with is RLC and the external signal which is required in IS method is not important in RLC method, which reduces processing costs. The value of the function used by this method is based on the results based on repeated spectral analysis. Various indicators, solar cells, and photovoltaic panels can be used in many frequencies, approximately one (10-50 kHz). Solar cell capacitance increased from 10µF to 12.5 µF. In addition, the results indicate an increase in the ability to learn solar cells. In order to minimize the minimum depth of collapse, the β value will be always less than the resonance frequency ω. In addition, file-assisted installation methods must be used to generate capacity at different frequencies. The calculation of solar cell capacitors has a precise impact on the urgency and accuracy of genetic frequency stability. The advantage of the IS method is that, this method provides information about all three dynamic parameters, but a large loss of this method means that it requires an external signal that must be included in the device under test. It requires an external channel capable of producing signals whose purpose can be used for testing. The cost of these devices being used is high, when the test is made in light conditions.

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Implementation of Energy Management System in Power Generation from Gas Processing Field of Pakistan Oil and Gas Sector

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Abstract**—**World energy demand is increasing day by day due to increase in population and economic growth. This increase in demand expands range of energy sources to renewable energy production, however, world still depends mostly on fossils fuels for its energy need. Reservoir of fossil fuels are being depleted and these energy sources needs to be utilized efficiently. To extract fossil fuels from reservoirs and convert them into useful form of energy for end users, oil & gas industry is working across the world. In this article, Pakistan oil and gas processing field was considered for implementation of energy management system. It was found that two gas gensets are in continuous operation to keep running its process, but the energy demand of the field can be achieved by operating single genset. This can significantly reduce the operations and maintenance expenditure on site. It was observed that by implementing energy management system in the field, organization can save 80M PKR cost per year and reduce carbon emission to environment. Saving energy will achieve the goal of economic development, energy security and environmental protection.Furthermore, this study provides information about energy audit procedures and basic framework for Oil and Gas sector industries to look into cost saving and energy management practices. It is also recommended that organization shall develop strategies for implementation of energy management in all areas, energy benchmarks shall be developed, energy conservation awareness shall be created among the staff.

Keywords**—**Energy Management System, Cost Savin, Oil and Gas Sector.

I. Introduction

Global economic growth and success dependent on Oil and gas and it will remain crucial to worldwide for decades to come. Global warnings of climate change, however, result in a focus on the amount of energy needed to produce these hydrocarbon-based fuels, and more unconventional sources and methods continue to increase output energy intensity. Due to these challenges the oil & gas sector recognizes that use of fossil fuels causes atmospheric green house gas (GHG) concentrations, and the emission shall be minimized. [1] Both environmental protection and energy security can be achieved through Energy efficiency and conservation. End users may have most of the possibilities for saving energy. Moreover, producing oil and gas industry also utilized oil and gas in its own operations, therefore energy management implantation is necessary to save energy wastage [1] Depletion of traditional hydrocarbon energy resources makes the production of energy from difficult environments is becoming increasingly complex. In order to ensure that Oil & gas will continue to available, industry is focusing efforts on energy efficiency, while addressing energy security and environmental concerns in the best, most cost-effective way. [2]

Energy efficiency and energy conservation are two different things; however, in reducing the amount of energy used both can play a role. Energy efficiency is about the energy strength of a job in order to allow less energy to produce the same product or service. Awareness to new more efficient technologies can achieve this. On the other hand, conservation of energy is different, it is generally related to culture, human behavior and operational procedures. This means using less energy by reducing usage (e.g. shutting off equipment when not needed) or removing unnecessary tasks and loss of energy, rather than using less energy to do the same. Improving energy efficiency is an important issue for oil & gas companies which can contribute by implementing changes in their processes, planning and investments. [3,4] Improve productivity, lower operating costs and reduce environmental impacts can be achieved through Energy efficiency and proper energy management techniques. Through energy efficiency and conservation, finite natural resource life can also be extended and help to keep energy affordable to consumers by reducing investment and operating costs to connect new energy resources to meet increased demand. Oil and gas companies need to raise awareness of the benefits of energy efficiency & management and encourage the sharing of best practices. [4]

Saving energy will help us in financial and environmental benefits. Energy management may help to reduce energy consumption of a company by implementing energy management policies.

In Pakistan we need to be focused on energy management as most of the time we either intentionally or un-intentionally wasting the energy, although energy production is also very important, but the same importance shall be given to energy management as well. This research will help us to identify area where energy management techniques can be applied.

This research is based on Pakistan Gas processing field where Currently, two gas gensets are operating parallelly, although the available load can be fulfilled by only one gas genset having capacity of 3100 KW, that result in energy wastage, fuel wastage and higher maintenance cost. This research will help us in identifying true load available and requirement of genset to be in operation, either one or two based on the requirement.

In oil and gas industry in Pakistan, no importance is being given to energy management. As most of the time fuel is available free of cost as Oil or gas well is being drilled and same gas is utilized as a fuel so there is no cost of fuel, however cost incurred on maintenance of gensets. If one gas genset is in operation at a time this will save fuel cost as well maintenance cost because maintenance is dependent on running hours and the most important is that there will be no energy wastage.

II. Methodology

This is purely field based study in which all the data has been gather for energy optimization. 03 Gas Engine are installed at the field to fulfill the energy demand of the plant. As per normal operation 02 gas gensets are in operation and 01 genet are standby. This research has been conducted to verify that plant energy demand could be fulfilled by operating single genset.

To evaluate the requirement of the genset operation, following strategy has been adopted.

- Calculate total energy demand of the plant.
- Review Total energy production of installed system
- Analysis of the available actual data, log sheets, to verify the energy demand of the plant.
- Cost optimization of the system by operating single genset despite of 02 gensets.

A. Generator Set Sizing and Ratings Methodology:

Generator set is the most expensive and critical part in a plant. Therefore, many factors must be considered when determining the proper size or electrical rating of an electrical power generator set.

Calculating total energy demand of the plant for exact genset sizing, following scenarios are considered.

1) Capacity for Normal and Essential Peak Load Demand

The generator is sized to supply the kVA needed at startup and during normal running operation. It also providesvoltage control through the use of a brushless exciter and voltage regulator. Together the engine and generator provide the energy necessary to supply electrical loads in many different applications encountered in today's plant operation. If generator is not capable to meet required demand of voltage and Frequency, generator will trip, therefore proper sizing of the generator is very important that will provide necessary load during startup and during normal operation.

2) Capacity by Voltage Drop during Motor Starting on VFD & DOL.

The generator set must be able to supply the starting and running electrical load. It must be able to pick up and start all motor loads and low power factor loads and recover without excessive voltage dip or extended recovery time.

Nonlinear loads like variable frequency drives, uninterruptible power supply (UPS) systems and switching power supplies also require attention because the SCR switching causes voltage and current waveform distortion and harmonics. The harmonics generate additional heat in the generator windings, and the generator may need to be upsized to accommodate this.

3) Capacity Considering GENSET Overload Capability

For this calculation, following conditions has been considered.

All electric generators have a maximum capacity based on two things—the capacity to generate electricity, and the engine that drives that generator.

The greater the load, the more work the engine must do.Operating the generator beyond the rated capacity of the generator causes an overload condition because the generator is overloaded by the demand placed upon it. The breaker will trip, so to avoid the unwanted situation, two different conditions are considered.

- All Loads are in operation except one largest motor on VFD (200 kW).
- All Loads are in operation except one largest motor on DOL (75kW).

4) Capacity Considering Essential Load

In this scenario all the essential load is considered to be operative and calculate the demand load of the system. Standby load and other unnecessary loads are not considered in it.

B. Analysis of the Available Actual Data, Log Sheets

Log sheets maintained by operator on daily basis to record the necessary parameters. All the available data will be analyzed and observe the actual energy demand throughout the year. This data will provide the actual energy demand as these records the actual parameters and provide the true picture of energy demand.

C. Cost Optimization of the System

Maintenance is necessary for all equipment for reliable operation of the plant. Different types of maintenance are planned throughout the year to ensure equipment availability at all time. Heavy cost is also linked with maintenance to procure spare parts and outsourcing of services, if required, for performing maintenance. In this research all the related cost of preventive maintenance will be calculated for both spares and services and compare it with the genset operation, that if single genset can fulfil the requirement then how much will be saving.

D. Total Load Overview

Sizing calculation for GAS GENSET is based on the data listed in following table. Total plant is calculated and below table shows the different type of available load in plant.

III. Results

Electrical department daily monitored several parameters of the genset, it also includes real power of the plant. All the data from the log sheets have been compiled in the following tables. Data have been logged04 time daily at different time i.e 0800 hours, 1400 hours, 20000 hours and 0200 hours to monitor any variation in parameters. Single sheet has been considered each month to compile the real power of the plant.

Below graph depicts that maximum load reach only 2,320 KW in the month of June 19 which is only 75% of the single engine capacity and 01 engine can easily handle this load as the capacity of the engine is 3100 KW.

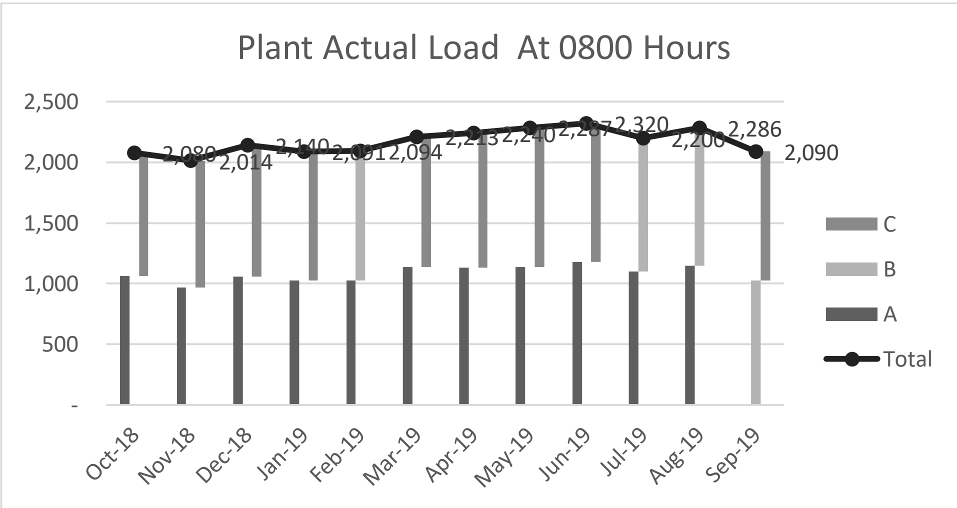

Fig.1 Monthly Actual load at 0800 Hours

Below graph depicts that maximum load reach only 2,685 KW in the month of April 19 which is 87% of the single engine capacity and 01 engine can easily handle this load as the capacity of the engine is 3100 KW.

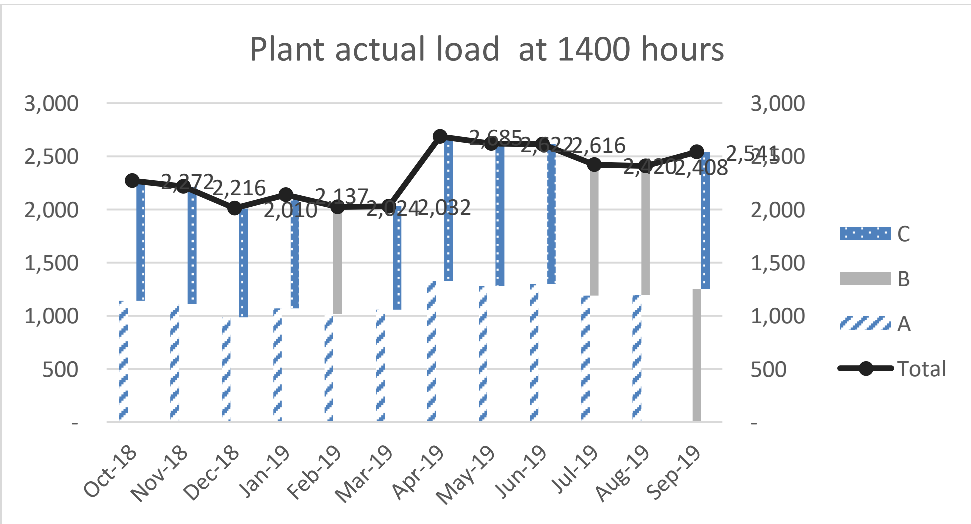

Fig.2. Monthly Actual load at 1400 Hours

Below graph depicts that maximum load reach only 2,586 KW in the month of June 19 which is 83% of the single engine capacity and 01 engine can easily handle this load as the capacity of the engine is 3100 KW.

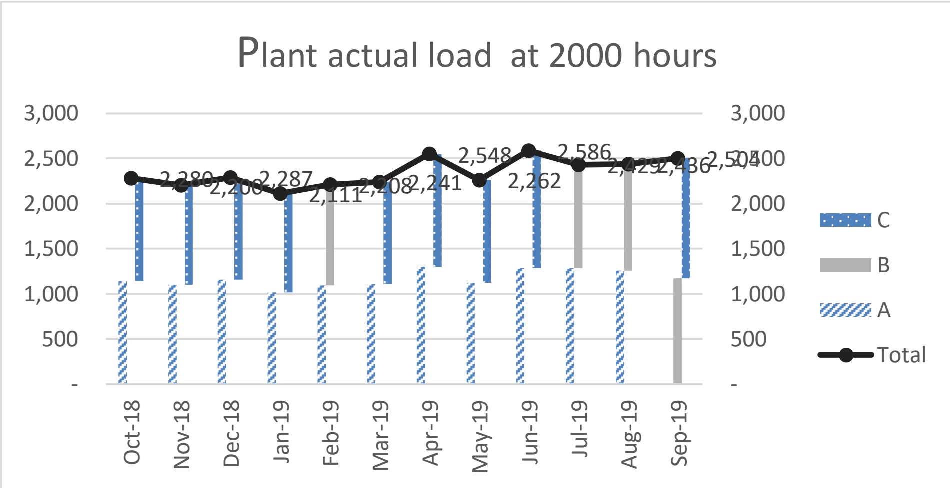

Fig.3. Monthly Actual load at 2000 Hours

Below the graph depicts that maximum load reach only 2,586 KW in the month of June 19 which is 83% of the single engine capacity and 01 engine can easily handle this load as the capacity of the engine is 3100 KW.

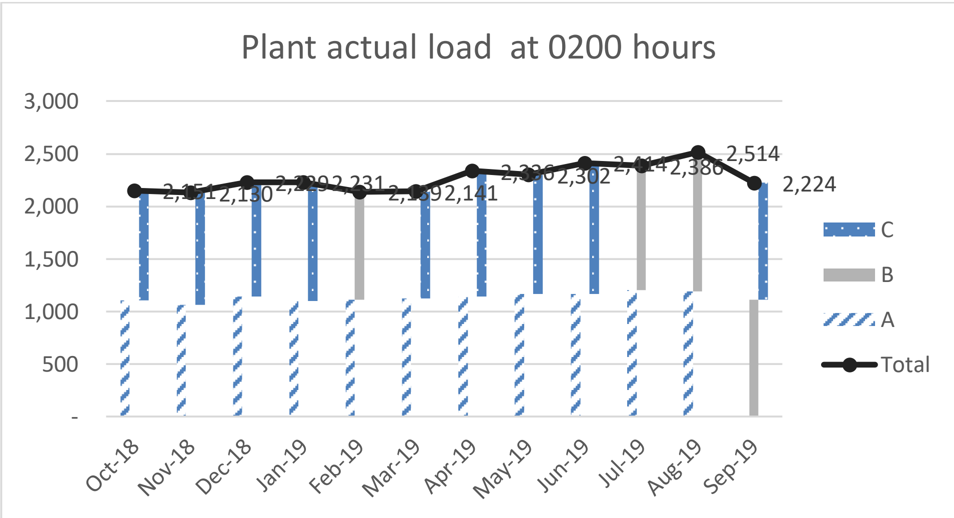

Fig.4 Monthly Actual load at0 200 Hours

IV. Disscussion

As it depicts in the above chapters that power requirement of plant can be fulfilled by operation single generators instead of 02 generators soby implementing energy management system, we can save maintenance cost incurred.

Maintenance work which takes place depending on the number of operating hours is divided into maintenance levels. All the maintenance work listed must be carefully performed according to the maintenance schedule specific to the genset.

Table 1

Maintenance Schedule

OH	E10	E40	E50	E60	E70
300	X				
3,000		X			
6,000		X			
9,000		X			
12,000			X		
12,300	X				
15,000		X			

18,000		X			
21,000		X			
24,000				X	
24,300	X				
27,000		X			
30,000		X			
33,000		X			
36,000			X		
36,300	X				
39,000		X			
42,000		X			
45,000		X			
48,000					X

A *Operating Personnel*

E10 is type of maintenance that is due once after commissioning and after replacement of the cylinder heads respectively. E20 is daily inspection round to be carried out by maintenance personnel to check parameters.. E30 is periodic maintenance (small scale). E40: It is periodic maintenance (medium scale) that is due after 3000 hours.

B *Service personnel*

E50 is periodic maintenance (extended scale) that is due after 12000 hours.. E60 is Interim overhaul maintenance that is due after 24000 hours. E70 is Major overhaul of equipment and due after 48000 hours. Maintenance work dependent on operating hours.

C *Total Cost Saving*

Below table shows maintenance cost incurred on single genset in 5.5 years. If both genset operate in parallel, then double cost i.e 800M will be incurred but as we have seen that plant requirement can be fulfilled with only one genset so 400M cost can be saved by operating single genset.

Table 2
Cost of the project

Maintenance Type	**No. of Maintenance**	**Service Cost**	**Spares Cost**	**Single Cost Maintenance**	**Total Cost**
E40 -3000 Hours	12	264,000	4,200,000	4,464,000	53,568,000
E50 - 12000 Hours	1	1,500,000	17,600,000	19,100,000	19,100,000
E60 - 24000 Hours	1	3,000,000	100,000,000	103,000,000	103,000,000
E50 - 36000 Hours	1	1,500,000	17,600,000	19,100,000	19,100,000
E70 - 48000 Hours	1	6,000,000	200,000,000	206,000,000	206,000,000
Total				**351,664,000**	**400,768,000**

CONCLUSIONS

An organization energy wastage not only affect the organization itself but most of other things are related with it, it alsoaffects country economy environment and society. Energy management techniques is the process of making decisionregardingactual energy requirement of the organizations and avoid wasting of energy that benefits not only organization but society as a whole and minimizing its effect on environment. This is achieved by ensuring that energy management techniques have been implemented in the company.

It is evident from the log sheet data that real power of the plant reaches maximum of 87% capacity of 01 genset and that can be handle by operating 01 generators instead of operating two gensets. Also, it is evident from the above data that power requirement increases in summer season that is from April to August and in rest of the season power requirement is under 75%.

By operating single genset, we can save 80M PKR cost per year.Also, reliability of the equipment can be improved as currently genset have not been operating on the capacity for which they are designed and operating under load which may cause wear & tear problems and in long run will affect the overall life of the equipment.

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Flow Velocity Simulation of Wind Turbines by Computational Fluid Dynamics (CFD)

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Abstract— Rapid transition towards renewable, wind is having potential of 14TW. Flow simulations attracted worldwide scholars to optimize wind power production and wind farms. In present work NREL 3MW wind turbine under k-ε RANS model is simulated at two velocities i.e. 10m/s and 15m/s to calculate the flow and pressure distribution over wind turbine. With these variables velocity magnitude, dynamic pressure, wake effect and turbulent dissipation rate results are generated, compared and analyzed. Accurate results are shown in near wake regions. At 10m/s fluctuations in velocity magnitude are recorded less, which leads to less pressure drop and less intensified wake downstream, The distance covered by 2nd wake is recorded more while at 15m/s there are more fluctuations in velocity magnitude this results more pressure drop and provide favorable conditions for turbulent wakes. The distance of 1st and 2nd wake is recorded almost equal while the 1st wake intensity is more. The computational time by k-ε model require less time and provide good results.

Keywords— NREL, National Renewable Energy Laboratory, RANS, Reynolds Averaged Navier-Stokes Equation Remote.

I. Introduction

Increasing demand of energy in each country leads to global economic development. These economic developments causes major energy shortfall in countries. As world is moving towards renewable and sustainable energy, wind energy has one of the rapid growth rate among renewable energy resources. From 2001, installed capacity of wind energy flew from 24GW to expected 817GW in 2021 [1]. The overall capacity of the wind projects is to be doubled in coming recent years [2]. Till 2035 the share of wind energy will be 35% alone in electricity generation worldwide [3]. Current cumulative installed wind capacity is shown in Fig1. In last decade different innovative techniques are used to optimize the wind power output. These include different analytical and numerical models. Analytical wake models (kinematic wake models) uses velocity deficient profiles, which is obtained from experimental or theoretical work [4]. However the simplicity and efficient computation of this model cannot solve complex problems of fluid mechanics and aerodynamics of wind turbines [5]. A numerical model is mostly relayed on Computational Fluid Dynamics (CFD) which shows more flexibility and accuracy for different wind velocity and terrain features. Most researchers use CFD models for the designing of wind farm or wind turbine.

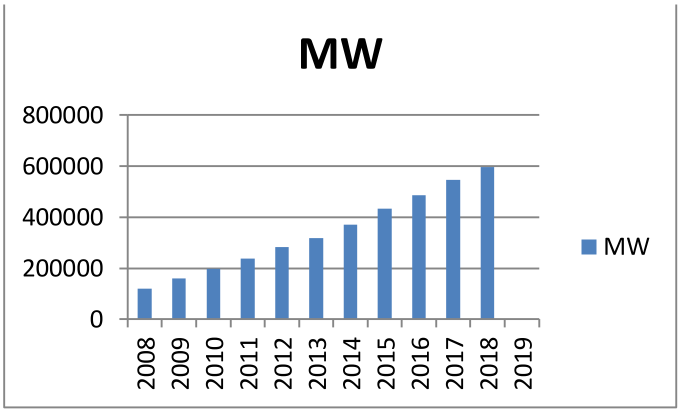

Fig. 1. Cumulative installed wind capacity globally 2001-2018 [6]

Innovations of computer bring Computational fluid dynamics. Complex Navier stroke equation involves fluid flow of viscous compressible, which describe the mechanism around wind turbine blades. Actual fluid flow and field are simulated to obtain realistic results [7],[8] studied wind farms comprising of two three wind turbines. Rotor diameter and wake field is analyzed. [9] Use Ansysis software to analyze wake characteristic using over set grid method. The power production curve resembles the practical data.

Disadvantages of CFD include long time of circulations, meshing overlapping and sheared topology for high computational accuracy best hardware is required. Time reducing is the main objective in CFD, high knowledge of CFD models and its applications is required to gain desired and accurate results [7]. Ref [10] shows that at specific conditions k-ε model have not mutual agreement with the experimental data under specified conditions some other models are developed by scientist. [7] shows that computation time is large for some specific geometries, timing of these computation can be reduced by proper meshing and selecting mesh type and size.

In last decade wind turbines are installed in the large wind farms. These wind farms are associated with two major issues; Power production reduction because of wake velocity deficit and Dynamic load on blades of wind turbines because of turbulence increase. These issues are also affected by layout and velocity of air. The production of second row or back turbines are affected by the wakes due to dissipation of energy

from 1st row turbines [11]. The wake dynamics are also associated with the blade length of wind turbine, air velocity and distance between two wind turbines measured in rotor diameters. The problem is effect of velocity on the flow velocity distribution over wind farm, and the effect of pressure distribution over wind turbine [12].

In this study RANS model on ANSYS fluent is used to study velocity and pressure distribution of NREL 3MW wind turbine. k-epsilon model is used to investigate velocity and pressure distribution over 10m/s and 15m/s of air. The results of simulation model are used to show the wake effect of the 1st row turbine downstream.

II. NUMERICAL MODEL

A. Incompressible Navier-Stroke Equation:

These are set of complex equations which give a complete set of models for the turbulent flow, but these equations cannot be solved easily. The non-linear convective terms in turbulent flow contributes to a wide range of time and length graph [13]. For example, largest turbulent scales are 1 km, where the smallest scale is 1mm in atmospheric boundary layer (ABL) [14]. Inside the blade boundary layers, the scales are even smaller. The Reynolds number (Re) shows the range of scale, l blade and wake encountered large values of Reynolds number calculations leads to computer simulations extremely expensive. Solving all scales in flow, known as direct numerical simulation, is not feasible [15]. The Navier-strokes equation is shown mathematically below.

$$u = 0 \tag{1}$$

$$\delta u/\delta t + (u.\nabla)u = 1/\rho \ \nabla \ p + v \ \nabla^2 \ u \tag{2}$$

B. Reynolds Averaged Navier-Stroke Equation (RANS)

In this set of equation the Navier-stroke equation is de-composed into mean and fluctuating component and solution variables are exact. In the given equations u and u0 present mean and fluctuating components [16].

$$u(x,t) = \bar{u}(x) + \acute{u}(x,t) \tag{3}$$

In momentum and continuity equation if we substitute these condition that taking time mean and making velocity term average (u) this gives the below equation

$$\delta\rho/\delta t + \delta/\delta x_i(\rho u_i) = 0 \tag{4}$$

$$\delta/\delta t(\rho u_i)+\delta/\delta x_j\ (\rho u_i u_j\ ) = -\delta p/\delta x_i+\delta/\delta x_j$$
$$[\mu(\delta u_i/\delta x_j+\delta u/\delta x_i+2/3\zeta_j\delta u_l/\delta x_l)]+\delta/\delta x_j(-\rho u_i u_j) \tag{5}$$

The above equation is known as Reynolds averaged Navier-stroke equation because its present average values of velocities and other variables. New terms are added in the equation −ρuiuj is known as Reynolds stresses and these must be molded to get accurate solution [16]–[18].

C. The k- ε turbulence model

In Reynolds averaged Navier-Stokes equations, k-ε turbulence model calculated eddy viscosity by two transport equations for ε (turbulent dissipation rate) and k(turbulent kinetic energy).This model is famous for turbulent flow in industry, heat transfer simulation and fluid flow simulation. Further models includes in eddy viscosity are, Renormalization group (RNG), and realizable k- ε turbulence model. Similar transport equation used for turbulent kinetic energy and turbulent dissipation rate.

Difference among eddy viscosity and, k- ε turbulence model is the turbulent viscosity calculation, in the equation generation and destruction term, and Prandtl number give the turbulent diffusion of k and . The mathematical model is shown below

$$\frac{\delta\rho}{\delta t} + \frac{\delta}{\delta xi}(\rho ui) = \frac{\delta}{\delta xj}\left[\frac{ut}{\sigma t}\ \frac{\delta k}{\delta x\ j}\right] + 2\mu tEijEij - \rho\varepsilon \tag{5}$$

$$\frac{\delta(\rho\varepsilon)}{\delta t} + \frac{\delta(\rho\varepsilon ui)}{\delta xi} = \frac{\delta}{\delta xj}\left[\frac{\mu t}{\sigma e}\ \frac{\delta\varepsilon}{\delta x\ j}\right] + C1\varepsilon\ \frac{\varepsilon}{k}\ 2\mu tEijEij - C\ 2\varepsilon\rho\ \frac{\varepsilon^2}{k} \tag{6}$$

Time scale and turbulent length is shown by k-ε turbulence model, which determines turbulence by solving two transport equations for k and. Main assumptions in this model are the turbulent flow and neglecting the effect of molecular viscosity [19], [20]. [21], [22] shows that this model has nearest values to the experimental data however [22] predicts that, as the dissipation proportionally increases the prediction of turbulence become less contracted.

III. SIMULATION SETUP

A lot of wind turbines and its types are present in literature but we chose the wind turbine, which are mostly use in wind farms, the turbine use in this article is NERL 3MW and its specifications are specified in Table 1.

TABLE I SPECIFICATIONS OF WIND TURBINE [7].

Rotor Diameter	129m
Rated Power	2:9MW
Swept Area	113070m^2
Orientation	3 blades, Upwind
Blade Length	61m
Hub Height	87m
Inboard Twist	12:3 deg
Hub Diameter	3m
Material	Fiberglass Reinforced With Epoxy Resin
Cut in, Rated, Cut Out	3:5m/s; 14:5m/s; 25m/s

The geometry of wind turbine is drawn in Spice Claim, in which 2D and 3D geometry of the given turbine are formed with proper dimensions according to specification shown in Table 1. Another software known as Design Modeler is used to specify or define area of interest like inputs, outputs, stationary and moving domains. The following Fig2 will show the geometry of wind turbine.

In these simulations analyzing zones are meshed finer to gain computational accuracy. Important zones are wind turbine and the enclosure downstream, which show the turbulence effect and pressure distribution. In simulations the impellers of wind turbine are meshed finer in a cylindrical enclosure with tetrahedral mesh structure and then embed in a whole rectangular domain the Fig3 will show the mesh of simulations. There are about 172,302 nodes and 966,207 elements.

Free flow conditions are adopted at the inlet of enclosure with constant speed of wind chosen 10m\s and 15m\s respectively and outlet of the boundary is at atmospheric conditions. The density of air is taken as 1.225kg\m3 and density of fiber glass is taken as 2.719kg\m3. In mesh Interfaces section, the source is selected as enclosure and wind turbine or propeller is select as target to define the contact regions.

Modeling or setup is the heart of simulation process here we select the model, the selection of model is mostly depend upon type of research and literature study. Every model has its own limitations and advantages; here literature helps in your research. The model here is selected is advanced model of RANS known as k- ε turbulence model in which dissipation, distribution of pressure and aerodynamics are considered. The software use here is ANSYS 2019 in which Ansysis Fluent solver is used.

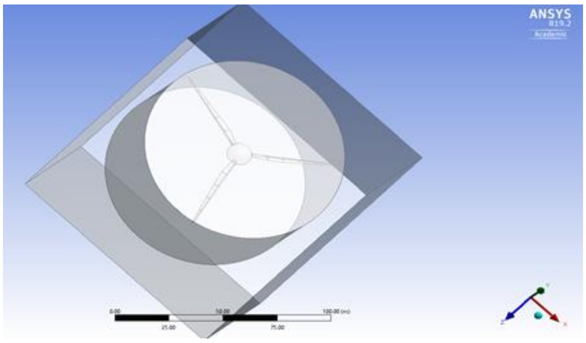

Fig. 2. Geometry of the project

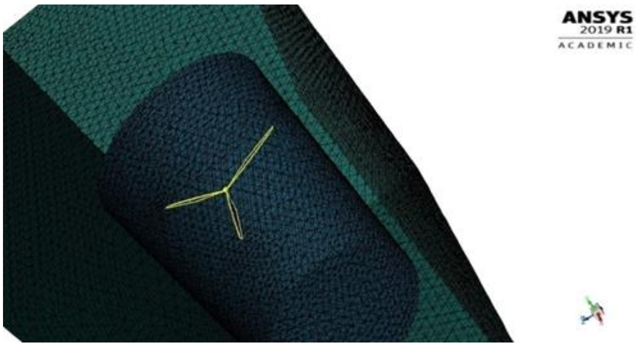

Fig. 3. Mesh of the project

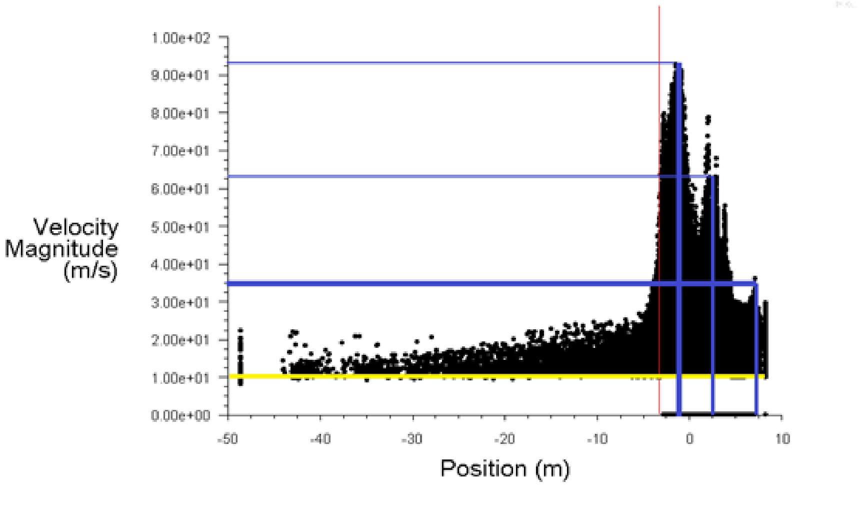

Fig. 4. Velocity Distribution at 10m/s

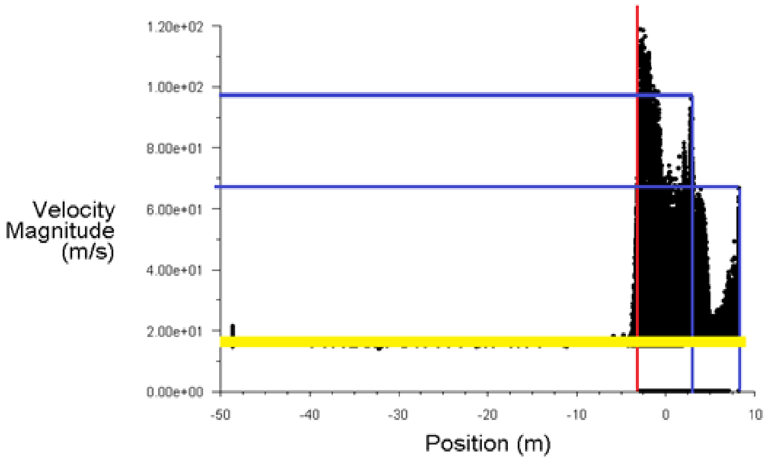

Fig. 5. Velocity Distribution at 15m/s

IV. RESULTS AND DISCUSSIONS

In this study, velocity distributions of wind are studied over wind turbine with respect to 10m/s and 15m/s of wind speed. The wake dynamics, Dynamic pressure and turbulent dissipation are compared.

A. Velocity Distribution

The wake field calculations are obtained from the velocity distribution graphs. In which the velocity of air changing with its position (gradient) is shown. The velocity distribution is shown in the following Fig 4, 5.

The red line shows the position of wind turbine in Fig4 and 5, yellow line shows the input velocity of wind. The peaks shows wake effect, as one wake is going to dismiss formation of next wake starts subsequently due to pressure drop. Downstream of wind turbine the pressure-drop gradually dismisses and the wake dynamics is calculated. As we see the distance covered by 1st wake in Fig4 is 3.75m while in Fig5 its about 7m. The distribution of 1st wake in 15m/s is about 47 percent more. There is sudden velocity increase and drop which leads to more pressure drop. In 15m/s the top speed attain is about 115m/s and slowest is about 68m/s. 10m/s shows a relative good result and smooth pressure drop the maximum and minimum velocities attained in 1st wake is 93m/s and 47m/s respectively.

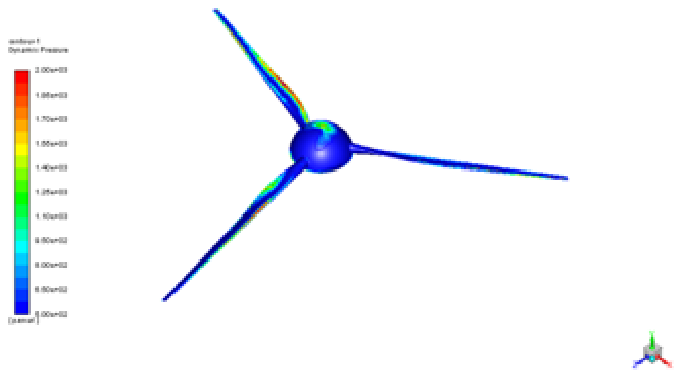

Fig. 6. Pressure Distribution at 10m/s

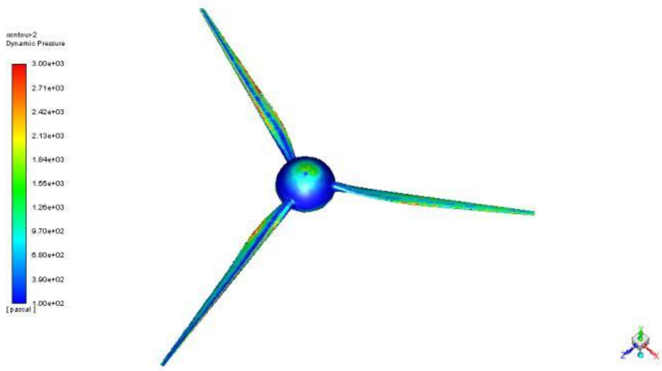

Fig. 7. Pressure Distribution at 15m/s

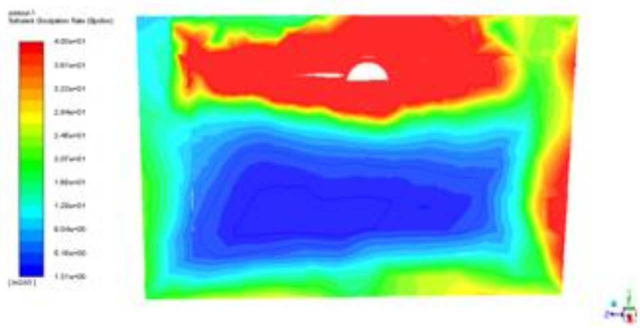

Fig. 8. Turbulent Dissipation Rate ( )

In 2nd wake the distance covered by 10m/s is about 4.7m, in 15m/s it is about 5m/s the percent increase is almost same but the difference here is intensity of the wind and pressure drop which leads to fatigue load on downstream turbine. The maximum velocities at 10 and 15m/s attain in second wake is 63m/s and 98m/s respectively. The minimum velocities are 30m/s and 27m/s respectively. This huge pressure drop at 15m/s show the maximum intensity of the wind where instillation of turbine will cause serious fatigue load.

B. Pressure Distribution

The pressure inserted by a fluid in motion is known as dynamic pressure. The k-ε model provides a reasonable result in near wake region. The following Fig 6, 7 shows the counter of pressure distribution on the blades of wind turbine. The figures show that the dynamic pressure at thrust section is observed. Pressure distribution in both cases is concentrated at tips and thrust sections of the wind turbine blades. Pressure at front side of wind turbine is observed as compared to the back side. As we can see there more pressure distribution is at 15m/s than 10m/s.

C. Turbulent Dissipation (ε)

Turbulent dissipation rate is the conversion of turbulence energy into heat energy due to eddies. The contour of the turbulence dissipation is shown in the Fig8, is rated higher near wind turbine causing turbulence and eddies, these eddies are converted into heat energy. Turbulent dissipation rate is rated more in 15m/s as higher pressure drop and turbulence is formed. This dissipation leads to formation of steam on the surface of blades which produce noise and additional load on the blades.

CONCLUSIONS

In this study, simulations of velocity distribution, pres-sure distribution and turbulent dissipation of NERL 3MW wind turbine are simulated over k-ε model. These variables are conducted in two different velocities of air i.e. 10m/s and 15m/s. The results obtained are compared for wake calculation downstream and dynamic load. The both results show accurate distribution in near wake region. The result of velocity distributions lead to wake formation. At 15m/s there is significant pressure drop in 2nd wake and distance covered by 2nd wake is almost equal to 1st wake which shows the pressure drop downstream but intensity of the 1st wake is higher. Fluctuations are recorded more and velocity becomes stabilize more than three wakes downstream. While at 10m/s there is also same pattern but there is intensified and smaller distance covered by first wake as compared to second wake the pressure drop is recorded smaller and velocity is moving towards inlet conditions. The fluctuations of velocity become stable downstream after second wake.

The pressure distribution is calculated by near flow regions of k-ε model which is useful in aerodynamics of wind turbine and optimal wind farm design. The results suggest that dynamic pressure is generated downstream more in 15m/s. The tips and thrust section of wind blades observe more pressure and the profile is almost same in both conditions. In transport equation all three flows are integrated i.e. heat, mass and momentum transfer. Turbulent dissipation rate is useful in calculations of heat transfer but it has effect on the flow. Heat generation leads to velocity and pressure increase and this effect is mostly recorded at near wind turbine regions. The intensity is recorded more in 15m/s which leads to more pressure drop and attain fatigue load on the blades of wind turbine.

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Design Analysis of Mini/Micro Hydro Power Generation Plants in Northern Districts of Khyber Pakhtunkhwa

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***Abstract*—** Energy access in global challenge faced by more than 1 billion people. Pakistan, to address the challenge, has developed access strategy of decentralized energy system. In northern hilly areas of country, Hydel resource has been tapped through mini-micro hydro projects. However, the sites are remotes located in hilly terrain, making transportation of machinery a challenging task increasing initial cost. Similarly, loss of head caused by slope in water channels and laborious construction of concrete channel in rigid and sharp rocks further aggravates the situation. This study undertakes case studies of mini-micro Hydel power projects and looks for technically feasible solutions. New design techniques have been revealed relying on piping and pumping of water and construction composition. Concrete channel is replaced by piping structure and water is pumped from intake to fore bay at different angles of inclination and pipe diameters and accordingly the pump power is observed. Due to variation in slope, the net head also varies which has a direct impact on the output power from the plant. The power of pump is subtracted of the power generated by the plant which results in net power. Two actual design examples are considered from a rural area of Pakistan and using statistical analysis techniques the influence on the total output power is analyzed under different scenarios.

***Keywords*—** Pump Power, accessibility, Fore bay, Remote Location.

I. Introduction

Pakistan is blessed with sufficient Hydel resources, capable to meet the ever-increasing demand of energy. Energy is core commodity required for economic uplift and development of country masses. It's vital role in reducing poverty, enhancing productivity and opportunities cannot be ignored. The government of Pakistan is striving best to fulfill the energy needs across the county. The challenge of access is particularly prevailing in remote and hilly areas, where grid extension is not feasible due to wheeling charges, lower population density and capital infrastructure requirement. However, alternate approach of access through decentralized energy systems has been adopted. Country wide initiatives has been taken including solar house system, biomass to energy projects, wind projects and hydro projects based on geography of resources availability. In Khyber –Pukthunkhwa, the northern hilly areas are rich in feasible sites for min- and micro hydro-power projects.

The provincial government of KP in its efforts to meet SDG7 target of universal energy access, is taking keen interest to develop the culture of small scale hydro power scheme. The special feature of mini-micro hydro power projects like modular design, ease of maintenance and lower capital cost, make them highly feasible. Therefore, Pukthunkhwa Energy Development Organization (PEDO) under the Energy and Power department is currently doing the hydropower projects in the 12 northern districts of Khyber Pukthunkhwa. These projects are off-grid community based initiatives providing affordable energy to households and local businesses.

In first phase of projects, 356 mini-micro hydro schemes have been completed across northern districts. In construction and commissioning phases, major challenges have been identified. These challenges are both technical and non-technical in natures. The scope of this research is constrained and deals only in technical domains. Therefore, we will only present technical issues faced in first phase of projects.

A. *Initial Cost is High*

All of the hydropower based projects counts for high starting cost. This high initial cost is categorized as

- Topographic study, feasibility study and the environmental Impacts study cost high.
- Mechanical and Electrical equipment's cost.
- Civil work and infrastructure for site access cost.

The electrical and mechanical equipment's like turbine, generator, transformer cost is not site specific means that it doesn't depend on characteristics of site. While that of civil structure cost mainly varies with site requirements and specifications.

B. Site access and transportation issues

This is one of the main challenges in construction. Most of these MHP projects are implemented in the remote locations of the country. While for high capacity sites the turbine of high discharge and the generator transformer of high rating will be required. So it is difficult to transport this heavy electrical and mechanical setup to targeted location having no proper road and access points. In addition, there is a risk associated with transportation, mainly of damage to machinery and workers physical hazardous.

C. Building Channel in rigid rocks

The civil work in hilly areas in rigid rocky terrain is highly costly, challenging and un-safe. Significant cost is allocated along with machinery and large workforce. Normally, excavation is needed while in some cases the blasting is even required which is costly and danger too. So care is required with enough cost also that is why the alternate options to this channel construction is discuss which is also aim of this research work.

D. Issue of Environment

These hydro power projects are mainly constructed in the northern districts of Pakistan. These northern districts are mostly mountain with altitude of about 4450 meters. The temperature in this region varies from 40 C0 to 15C0 in winter. As the temperature decrease down below the 10 C0 in the month of October to December the setting time for the concrete also increase causing decrease in the strength of concrete channel and thus increasing the delay and cost of the project. The goal of our research is also to introduce new way instead of constructing concrete channel.

E. Power Channel Slope

Water is transported via a channel from canal to the forebay tank with certain velocity. A slope is introduced in the channel in order to make flow possible through simple gravitational forces. However, this in parallel results in losses in available head. For instance, the 500 meter of the channel will be provided with 2 meter of the slope which ultimately will cause the 2-meter decrease of net head. Alternative mechanism with high cost benefit ratio will be investigated in this research work.

II. MODELING AND DESIGNING

A. Analysis Framework

Through analysis framework we will observe the effect of variation in pipe diameter and inclination on the net power and pumping power. Three different cases are considered regarding the position of intake point A with respect to the fore bay point B. The following notations are used representing these cases.

- AB^{+} If the forebay point B is at higher level than intake point A
- AB If the forebay point B and intake point A are at the same level
- AB^{-} If the forebay point B is at lower level than the intake point A

The head loss h_L is identified for various diameters of the pipe resulting in the variation of pumping head h_P and thus pumping power W_P, from which we can identify the net output power of the plant for different diameter and inclination of the pipe. Matlab and Excel will be used for visualization of various effects due to changes in design.

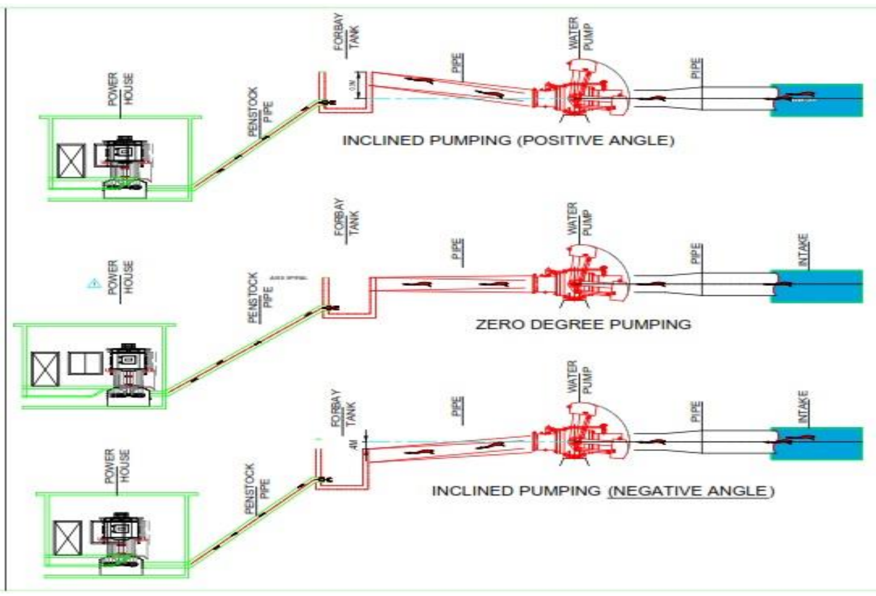

Fig .1

B. *Mathematical Formulation*

According to Yunus et al [1], the pumping power required for pumping water of discharge Q can be written as

$$W_P = \frac{Qg\rho h_p}{\eta_p} \quad (1)$$

Where $\rho = 1000\ kg/m^3$ the density of water is, $g = 9.8m/s^2$ is the gravity acceleration, h_p is pumping head while η_p is the overall efficiency of the pump. If we consider A and B as the intake and fore bay points and $V_A, V_B, P_A, P_B, Z_A, Z_B, and \alpha_A, \alpha_B$ as the average velocities, pressures, water heads and kinetic energy correction factors at points A and B respectively, then we can write,

$$\frac{P_A}{g\rho} + \alpha_A \frac{V_A^2}{2g} + h_p + Z_A = \frac{P_B}{g\rho} + \alpha_B \frac{V_B^2}{2g} + h_L + Z_B \quad (2)$$

Where h_p the pumping is head and h_L is head loss given by,

$$h_L = \frac{fLV_{avg}^2}{2Dg} \quad (3)$$

WhereL is the length of pipe, f is the friction factor, D is the pipe diameter, g is the gravity ofacceleration and V_{avg} is the average velocity of water in the pipe. The relations for friction factor and average velocity are given by,

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{2.51}{R_e\sqrt{f}} + \frac{\varepsilon}{3.7D}\right) \quad (4)$$

$$V_{avg} = \frac{Q}{A_c} \quad (5)$$

In which A_c is the pipe'scross sectional area, ε is roughness coefficient of pipe whose value for different materials is give in the table 3.1 and R_e is Reynold's number given by

$$R_e = \frac{\rho V_{avg} D}{\mu} \quad (6)$$

Where μ is the viscosity of water. The value of kinetic energy correction factor in equation (2) is 1.05 for fully developed turbulent flow and 2 for fully developed laminar flow. The output power of the plant can be computed as

$$P = \rho Qgh \quad (7)$$

While the motor is powered from the same plant, the net output power of the plant can be computed as

$$P_{net} = P - W_P \quad (8)$$

Here we will consider two actual design examples of Pakistan 500 KW Kotkay mini hydro power plant designated by site A and 500 KW Beyari mini hydro power plant designated by site B with design specifications as shown in the table 1.

Table .1

Parameters	Site A Specs	Site B Specs
Discharge (Q)	2.37m³/s	1.92m³/s
Gross Head (Hg)	30.920m	38.8m
Head Loss in Penstock (Hf)	1.61m	2.04m
Lengh of Power Demand (L)	336.90m	564.02m
Head Loss due to Slope in Power Channel (Cs)	1.350m	2.256m
Net Head (Hn=Hg-Hf-Cs)	27.96m	34.5m
Total Output Power (P)	500KW	500KW

In this section, mathematical calculations will be carried out for the three different cases as discussed above. The AB^- case will be discussed first taking a 1.3 meters diameter of pipe and with forebay level 0.4 meters down the intake level. From table 3.2 taking the design specifications for site A, the average velocity can be calculated using equation 3 as

$$V_{Avg} = 1.8\ m/s$$

$$R_e = 2317755.474$$

$$f = 0.010122$$

Head loss can be calculated using equation 3 given by

$$h_L = 0.43\ m$$

Using equation (2) with

$$Z_A = 0.4\ m, Z_B = 0m, P_A = P_B, V_A = V_B, \alpha_A = \alpha_B, h_L = 0.43m$$

We have

$$h_P = 0.03\ m$$

Using equation (1), the pumping power can be computed as

$$W_P = 1.05\ KW$$

Using equation (7), the electrical power of the plant can be computed as

$$P = 516.8\ KW$$

$$P_{net} = P - W_P = 515.8\ KW$$

For the case AB with 1.4 meters' diameter of pipe and using design specifications of site A we can write

$$W_P = 11.5\ KW$$

$$P = 524\ KW, P_{net} = P - W_P = 512.5\ KW$$

Taking the AB^+ case with pipe diameter of 1.7 meters and intake level 0.3 meters down the forebay level, the average velocity, friction factor, Reynolds's Number and head loss can be computed as

$$W_P = 16.13KW$$

The output power of the plant and net power can be calculated from equation (7) and (8) respectively as

$$P = 529.4\ Kw, P_{net} = P - W_P = 513.3\ KW$$

From the above three cases we calculated net output power of the plant and pump power at for the specified diameter of pipe.

III. RESULTS

A. Variation in pump power with varying pipe inclination and diameter

In this section we will analyze the effect of varying slope and diameter of pipe on the net power and pumping power of the plant. This section includes the effect of variation in pipe's inclination and diameter on the pumping power required for pumping water is discussed. The graph shows the relationship between varying inclination (in meters) and pumping power (in KW) where the pipe diameter is kept constant at 1.3 meters. The three portions of the graph (AB+, AB and AB-) represent three different positions of fore bay with respect to the intake. The pump power is zero at the start because of its natural flow under the influence of gravity and hence no pumping power is required. As the fore bay level moves upward with respect to the intake point, the pumping power start increasing for both site A and B. This increase is more for site A as compared to site B and the reason is heavy discharge of site A as shown in the table1.

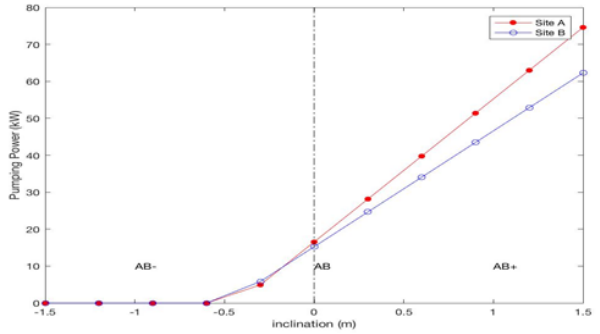

Fig.2

From the graph we can see that as the inclination is varied from -1.5 to -0.6, the pumping power is zero because of natural flow of water due to gravity. Further increasing Forebay level causes pumping power to start developing. Comparing the two graphs for site A and B on certain inclination, Pumping power for site A is high as compared to site B because of more discharge of site A as compared to site B.

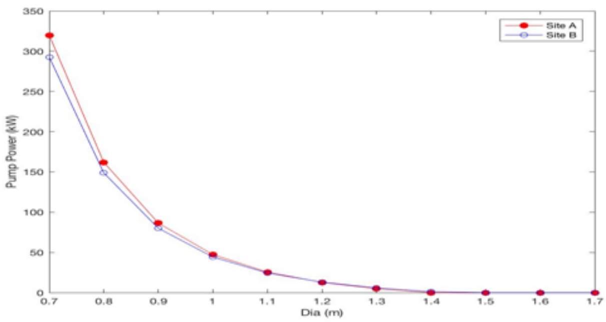

Fig.3

The above graph shows variation in pump power with respect to varying pipe diameter. As the pipe diameter increases, pump power decreases and vice versa. Comparing the graphs of site A and B for a certain diameter of pipe, the pump power for site A is higher than site B due to heavy discharge of site A as compared to site B.

B. Variation in net power with varying pipe inclination and diameter

In the previous section we discussed the pipe's inclination and diameter effect on the pump power. This section will cover the effect of varying pipe inclination and diameter on the net output power output of the plant.

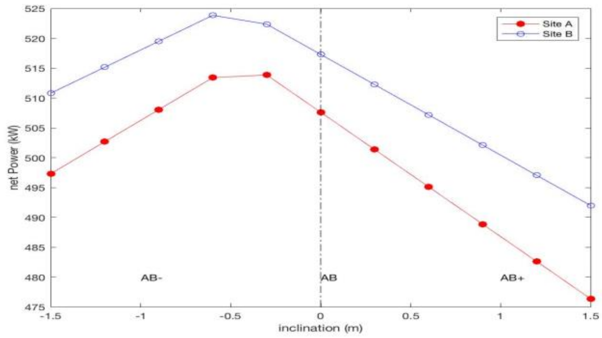

Fig.4

The above graph shows variation in net power with respect to varying inclination. The graph shows that net power is increasing as the inclination varies from -1.5 to -0.6 and then start decreasing. The reason is that as the forebay level rises, the net power increases due to increase in net head but the pump power is also developing and at a certain point the effect of increasing pumping power become dominant as compared to increasing head.

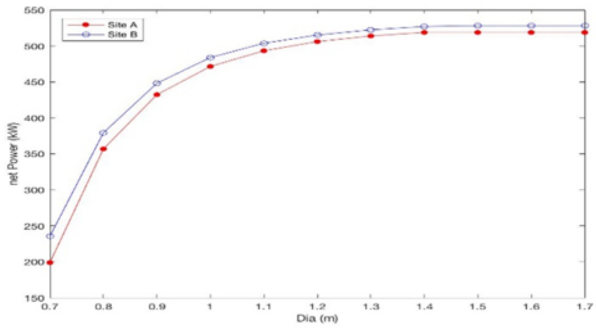

Fig.5

The graph shows variation in net power as compared to varying pipe diameter. The graph shows increase in net power with increasing pipe diameter. This increase is due to reduction in pump power with increasing pipe diameter which causes net power to increase.

CONCUSLION

The head loss and reduced output power in mini/micro hydro power projects is due to slope in concrete channels. The concrete channel's construction in hard rock is a difficult task as the construction of these channels, especially in case of huge discharge, is a time consuming and difficult job. Significant hindrances are also posed in the transportation of heavy machinery such as hydroelectric power turbines, materials for penstock and generators to remote locations. In this research these problems in relation to the MHP projects are analyzed from the design aspect for two locations in Mansehra district of KP. Novel approaches for design are implemented. The design is based primarily on the process involved in the water pumping operation and pipe placement structure.

Three design techniques (AB, AB-, AB+) were used and the results were plotted using Matlab computer program. Comparing with the conventional design, some extra power was generated in the AB case (pumping water at the same level). The power was observed to increase upon an increase in the diameter of the pipes beyond 1.2 meters; however the concomitant high pump power makes the project cost unbearable (due to installation of such a huge power pump). So, it will also be a matter of concern to give an initial startup for such a high power pump. To overcome this problem, the water was pumped through negative inclination (AB- case) and its effect was analyzed on the pump power, pipe diameter and net power. The results were plotted by varying pipe diameter and its slope. These results were comparatively better as more power was obtained at the cost of less pumping power. Both the problems of initial startup as well as the capital cost can be solved using this technique. Initially pump can be powered from other sources such as battery storage, or through solar power and then shifted to the power obtained from the MHP. The water was then pumped through positive inclination (AB+ case) so that some extra head and thus power could be obtained. Although this technique resulted in the increased power generated from the plant but at the same time the pump power was so high that the net power reduced.

If we compare the results of both the plants (A and B), the net power output of the later one was more than the first one due to the lengthy channel and less discharge of site B as compared to A. So these techniques can give the best results for the plants having less discharge and lengthy channels.

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Comparison of Sound Pressure Level of Conventional and Modified Mufflers by using CFD Analysis

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Abstract— The reduction of noise emitted from the exhaust of internal combustion engine is a real challenge for all automotive industries. Mufflers are designed to reflect sound waves produced by the engine in such a way to cancel the effect of each other by destructive interference between the incoming waves from engine cylinder and reflected waves from the muffler of 2 stroke motorbike engine. Numerical simulation is carried out to study the sound pressure level (SPL) and flow variable like velocity and pressure of conventional and proposed modified reactive muffler. In numerical investigation of Conventional muffler and modified muffler the path of exhaust gases in which it flows is analyzed through large eddy simulation and then Fflowcs Williams and Hawking model are utilized to predict the Sound pressure level of conventional muffler and modified mufflers by using the time flow history of large eddy Simulation at the receiver location and the result of proposed modified muffler are compared with conventional muffler. By comparing the Sound pressure level (SPL) results of conventional and modified mufflers show that the sound pressure level of modified muffler - 01 are 5dB less than the conventional muffler and the sound pressure level of modified muffler - 02 are 15dB less than the conventional muffler which produce sound pressure level of 80dB.The output velocity of exhaust gases is also drop down from 259.1 m/s of conventional muffler to 182 m/s in modified design-2. So the stack pressure inside the expansion chamber of modified muffler-02 is less than the conventional muffler which creates high back pressure so our objective is achieved.

Keywords— Sound Pressure level, conventional Muffler, Noise, Large Eddy Simulation.years.

I. Introduction

The Muffler is a device which reduces the amount of noise emitted by the engine. Muffler is connected to the exhaust pipe of internal combustion engine of motorbike so that to suppress the acoustic flow waves which is produced during the combustion process. All internal combustion engine produce noise of different levels. The intensity and magnitude of noise level depend on the development of vehicles' by means of scavenging, the type of fuel, number of cycles etc. The main purpose of the muffler is to reduce the noise of the engine exhaust before going toward into atmosphere. Mufflers are mostly used to reduce the intake and exhaust noise from pumps, compressor and internal combustion engine. Presently two type's techniques are used for noise control one is active technique and the other is passive method. Active noise techniques for noise control are emerging, but nowadays mostly used passive method to control exhaust noise. Passive mufflers are categorized to reactive or dissipative based on their attenuation. Reactive muffler reflects sound waves back towards the engine cylinder and dissipative muffler used porous media to absorb the sound due to exhaust gases. Internal combustion engine equipped with an exhaust muffler to suppress the acoustic pulses generated during the combustion process. A highly intensity pressure wave generated by the combustion in the engine cylinder propagates along the exhaust pipe and radiated from the exhaust pipe termination. An exhaust system in a motorcycle consists of three parts namely exhaust header, exhaust tube, and exhaust muffler as shown in Fig 1. In all muffler tail pipe length can have an important effect. The tail pipe acts as a resonant cavity that couple with the muffler cavity Due to increased environmental concern requiring less noise emission combined with reduced emission of harmful gases.

Figure 1. Bike muffler[1]

For this purpose, a lot of people has done work in the field of acoustic. In 2016 N. Deshmukh et all. [1] Study the effect of radial jet at the upstream of muffler on temperature and acoustic pressure. The radial jet was introduced at different reservoir pressure at the downstream of a muffler. The simulation study has been carried out to find the temperature and pressure distribution of inside the muffler with and without the radial jets and experiments were carried out to validate the results.

In 2013 D. Tutunea et all.[2] studied the fluid dynamic performance of exhaust muffler by using CFD analysis. He simulated the pressure distribution of muffler in CFD and pressure loss is predicted. In 2016 Shaoqi Zhou et all.[3]is presented his work on flow induced noise simulation using detached eddy simulation and finite element acoustic analogy methods to study the performance of exhaust muffler. In 2015 puneetha et all. [4] Analyze four different model of exhaust muffler and concludes the best for least pressure drop. Back pressure is obtained from flow field analysis virtual simulation for back pressure testing is performed in computational fluid dynamic analysis using Acusolve CFD.The back pressure generated across the muffler is determined by measuring the mass flow rate at inlet and outlet of exhaust muffler. In 2016 Suyog, s Mane et all. [5] Studied back pressure of exhaust muffler using CFD simulation to avoid tedious experimentation and the flow simulation is carried out by using K-ε turbulent model. Because K-turbulent model is most suitable for the simulation having less converging time. Total four cases have been analyzed including the base model three modification has been made in the geometry. By reducing the baffle spacing produce less back pressure with the reduction of back pressure of 9.60%. In Ayush Lal. [6] Studied flow field of exhaust muffler using CFD Analysis to select optimum design for IC engine. Two muffler has been modeled and CFD simulation of both muffler is carried out in Ansys fluent. Based upon gas flow analysis the optimum model is selected In 2015 Pradyumna et all. [7] is presented his work on CFD analysis of flow through a resistive muffler of LCV diesel engine by simulating the flow inside the muffler and study the internal flow which effect the performance of muffler. The method is used to study the pressure distribution is simulated and pressure loss is predicted for structure modification. The experimental results verify the Assembly performance of muffler that modified one is better than the original. From the literature review and all other aspect some findings are highlighted below

- As the diameter of perforation is increased the back pressure reduce sharply and perforation has a remarkable effect on back pressure
- As no of perforation is increased the back pressure reduces and low back pressure can improve fuel economy
- The CFD simulation software is used for modeling and simulation. the simulation gives the information about the Velocity field, pressure field, sound pressure level, density etc

Now here in our work two different modifications is made in the conventional muffler by changing the perforation hole, exhaust pipe length and then the modification is studied for sound pressure level and other flow variable which affect the noise of exhaust muffler.

II. METHODOLOGY

A. 3D CAD Model

Ansys workbench 18.1 design modeler is used for CAD modeling of exhaust mufflers as shown below. Two different modifications are made in conventional muffler and analyzed it individually in Ansys Fluent 18.1 by LES simulation. With the help of CFD simulation the muffler design is optimized.

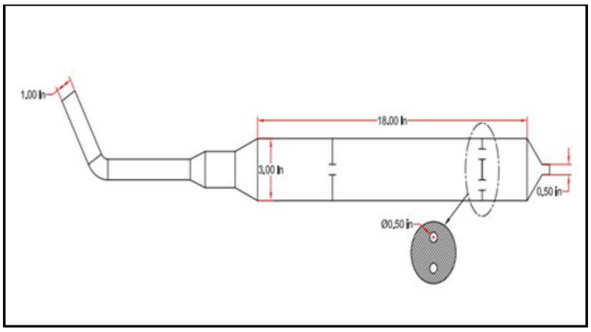

Figure 2. Layout of conventional Muffler

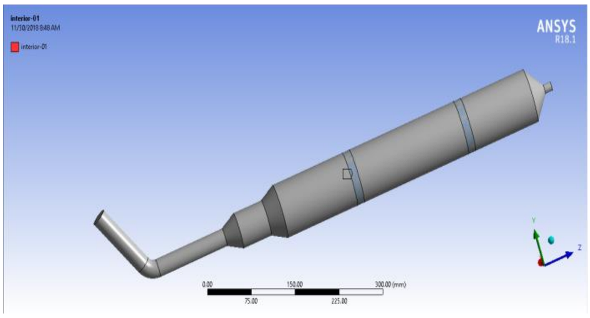

Figure 3. CAD Model of conventional Muffler

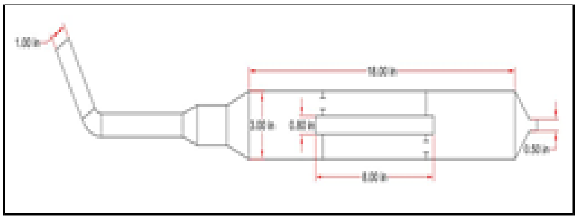

Figure 4. Layout of Modified muffler -01

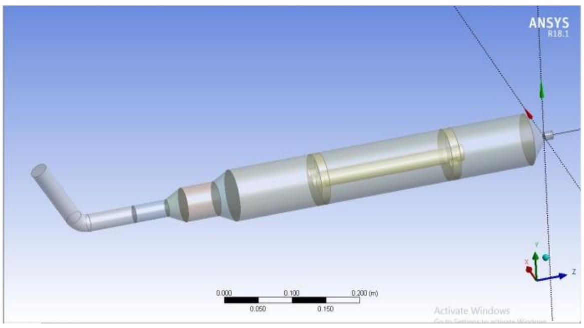

Figure 5. CAD Model of Modified muffler-01

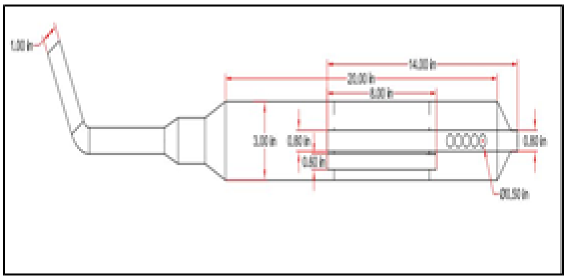

Figure 6. Layout of Modified muffler -02

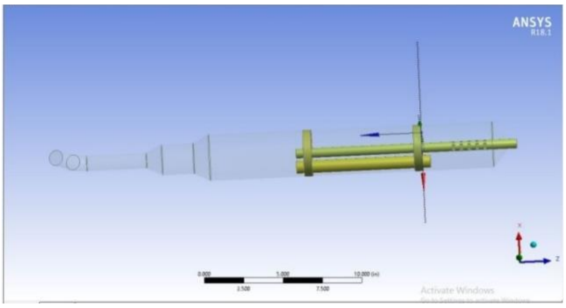

Figure 7. CAD Model of Modified muffler-02

III. ACOUSTIC MESH AND BOUNDARY CONDITION

An Ansys workbench is used for meshing the exhaust mufflers. The structure acoustic mesh has to be created having spacing of 2mm in order for better performance and fine mesh requirement of LES simulation for accurate solution.

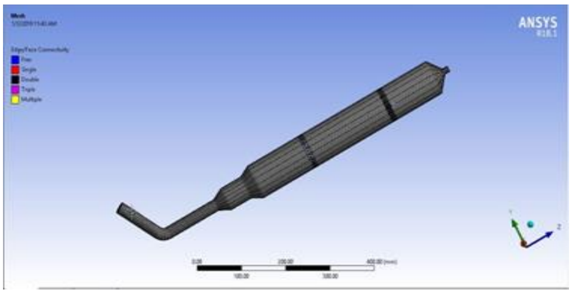

Figure A. Conventional muffler

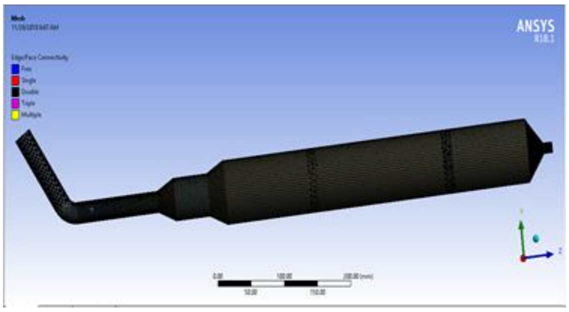

Figure B. Modified muffler -01

The minimum grid size is 1mm resulting in total of 1.5 million to 2 millions of elements. The working fluid is gas with the density modeled assuming the ideal gas condition. The boundary condition in this case consist of inlet velocity 50 m/s, outlet pressure is set as atmospheric pressure so velocity and pressure data has been measured at the outlet boundary of exhaust muffler and consider as a permeable boundary Fourier transform take the pressure values from the time history of LES simulation to evaluate the sound pressure Level at the receiver location through FWH model. As given figures A, B, C.

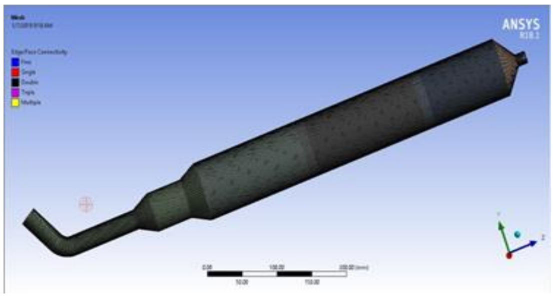

Figure C. Modified muffler -02

IV. RESULT AND DISCUSSION

Firstly, the large eddy simulation is performed for all geometry as shown in figure below then from accurate time history of flow variable at outlet boundary to predict the sound pressure level at the receiver location through Fflowcs Williams and Hawking model and the result of proposed modified muffler are compared with conventional muffler.

A. Conventional Muffler

In conventional muffler as the exhaust gas is enter into the muffler chamber having an inlet velocity of 50 m/s there is an inner plate with a single hole which guide the flue gases to inter into the 2nd chamber where they expand and pass through another perforated plate having two hole equally spaced and the gas enter into the 3rd chamber and expelled out to the atmosphere as shown in fig 8.The standard muffler is a reflective type have 18in expansion chamber length during expansion the gases energy is lower due to destructive interference. The simulation result of conventional muffler as shown in fig 8 show that velocity at the outlet is 259.1 m/s which is higher than the inlet velocity 50 m/s which is due the pressure rise in the expansion chamber due to stack up gas flow between the expansion chamber and outlet of pipe which push the exhaust gases with higher velocity and this also indicate high back pressure. In fig .8 CFD simulation result conventional muffler show the variation of velocity from inlet to outlet of exhaust muffler and the plot in fig 9 indicate that conventional muffler produce a sound pressure level of 85 dB.

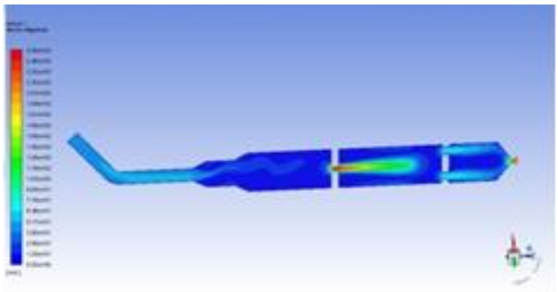

Figure 8. Velocity distribution of Conventional Muffler

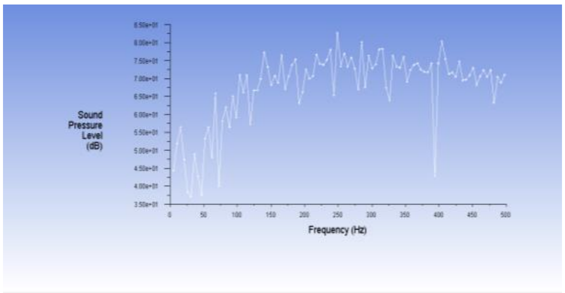

Figure 9. Sound pressure level of Conventional muffler

B. Modified Muffler-01

In fig 10 shows the flow analysis which is carried out for modified muffler-01. The modification we made that we place a pipe between the 1 & 2nd chamber which carries 70% exhaust gases directly from 1st chamber to the 3rd chamber which help to reduce the effect of gas flow stack up in the expansion chamber. In modified muffler-01as the exhaust gas enters into the 1st expansion chamber a part of total gas flow straight into the 3rd expansion chamber and the remaining gas is pass into 2nd chamber through 1st hole and guided into the 3rd expansion by the 2nd hole in the plate where they interfere with the gas come out straight from 1st expansion chamber to the 3rd expansion chamber due to middle pipe. A destructive interference occurs in the 3rd chamber due to which the pressure inside the cylinder chamber is reduce which is turn reduce the outlet velocity from 259.1 m/s to 232 m/s as shown in fig 10. The plot in fig 11 show that the modified muffler -01 produce sound pressure level of 80dB.

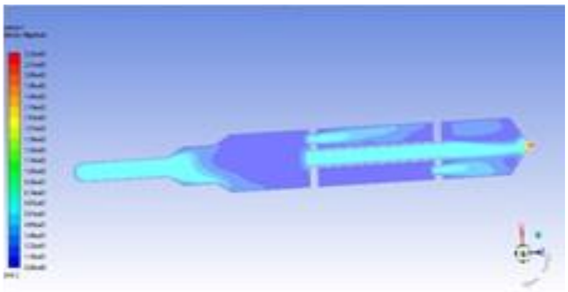

Figure10.velocity distribution of Modified Muffler-01

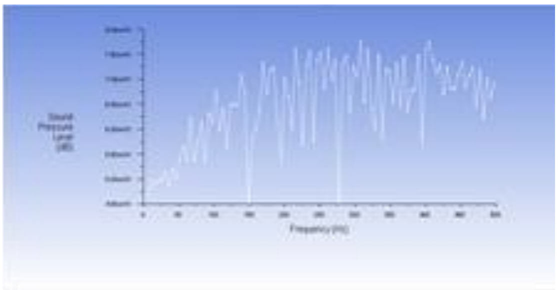

Figure 11. Sound pressure level of Modified muffler -01

C. Modified Muffler-02

In fig 12 shows the flow analysis which is carried out for modified muffler-02. In modified muffler-02 as the exhaust gas enter into the 1st expansion chamber a part of total gas flow straight into the 3rd expansion chamber and the remaining gas is pass into 2nd chamber through perforated hole and guided into the 3rd expansion by the 2nd hole in the perforated plated where they interfere with the gas come out straight from 1st expansion chamber to the 3rd chamber expel through small perforation hole in the pipe which lower the pressure wave pulses and due to middle pipe which take exhaust gases from 1st to 3rd chamber reduce the pressure stack inside the cylinder chamber which create the high back pressure so reduction in velocity occur at the outlet of exhaust muffler from 259.1 m/s to 182 m/s as shown in fig 12.The plot in fig 13 show that the modified muffler-02 produce sound pressure level of 70dB.

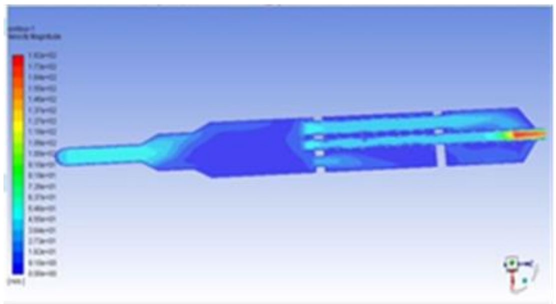

Figure 12. Velocity distribution of Modified muffler -02

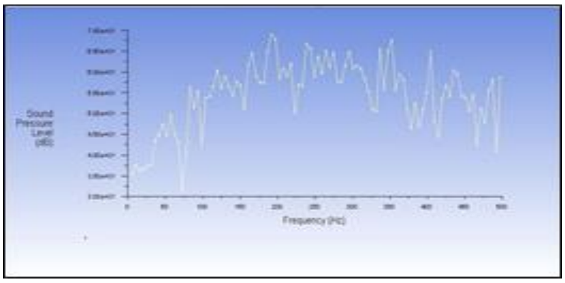

Figure 13. Sound pressure level of Modified muffler -02

TABLE I. NUMERICAL RESULT OF SOUND PRESSURE LEVEL

Mufflers	Modified Muffler	Conventional Muffler	Percentage Reduction
Muffler-01	80 dB	85dB	5.8 %
Muffler -02	70dB		17.6 %

TABLE II. COMPARISON OF PRESSURE & VELOCITY OF CONVENTIONAL AND MODIFIED MUFFLERS

Velocity (m/s)			
Mufflers	**Modified Muffler**	**Conventional Muffler**	**Percentage Reduction**
Muffler-01	232 m/s	259.1m/s	10.4 %
Muffler -02	182 m/s		29.4 %
Pressure (Pa)			
Muffler-01	28060.57	36850.68	23.85 %
Muffler -02	24454.04		33.64 %

CONCLUSION

Comparative numerical study of sound pressure level (SPL) of exhaust muffler of 70cc motorbike is carried on modified geometries including the base geometry which is taken as reference geometry. After the flow analysis of exhaust muffler show that more sound reduction of about 15dB occur in muffler-02 which is more than muffler-01 of 5dB as compared to conventional muffler produce a sound pressure level of 85dB. Modified muffler-02 produce less stack pressure as compared to conventional muffler because the outlet velocity of modified muffler-02 muffler is less as compared to modified muffler-01 and conventional muffler so we say that modified muffler-02 is the best optimized design.

It can also be concluded that our study is limited to 70cc Honda motorbike so the study can be extended to more complex geometries of other vechicles by considering the back pressure and maintenance issues which affect the performance of exhaust muffler in attenuating the noise.

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Energy Efficiency Assessment and Implementation Plans with Referance to the Case of Chashma Sugar Mills Unit-1 Dera Ismail Khan

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***Abstract*—** Energy efficiency assessment is an important tool to save energy and improve the financial gain of an Organization. Almost all the Small and Medium enterprises conducting energy audit in order to save energy and minimize energy consumption per unit product. The energy conservation is a cost effective with short payback period and modest investment

There is a bright scope of energy conservation in Pakistan in various sectors like Sugar. Textile, Cement, Fertilizer, Agriculture, Chemical process, Manufacturing, Pharmaceutical Industries. Pakistan is among the world's top-10 sugarcane producers, the potential of producing electricity from bagasse is huge. Currently there are around 83 Sugar Mills in Pakistan producing about 3.5 Million metric tons of Sugar per year with total crushing capacity 597900 TCD.which cane produce approximately 3000 MW electricity during crushing season. In Pakistan most of the industries are still using the out dated technologies; inefficient equipment's and are following inefficient operating practices. But some of the progressive industries have already using the up to dated and efficient technology and are reaping the benefits of reduced energy consumption

This paper shows the Comparison of specific energy consumption of inefficient machineries and energy efficient machineries in Chashma Sugar mill unit-1 District Dera Ismail Khan. Before implementation of efficient machineries bagasse consumption per ton sugar production was 2.35 Tons, Sugar losses in bagasse was 1.98 (pol % bagasse), steam economy was 48.2 % and bagasse saving was 70368 per season. After implementation of up to dated and energy efficient technologies the stated valves will be 1.75 Tons, 1.7 %, 35 % & 138613 Tons per season respectively. The overall energy saving is 25 % with a payback period of less than 03 years.

***Keywords*—** Energy Efficieny, Payback analysis, High Pressure Boiler & Turbine, Falling Film Evaporator, Fiberizer

***Abbreviation* —**Ton per hour (TPH), Ton Crushing per day (TCD), Million (M), Kilo watt (KW),Mega Watt (MW)

I. INTRODUCTION

The abrupt depletion of the conventional fuel resources around the world is sending shockwaves around the global energy markets. The fossil fuels are slated to concede their economic viability around the third quarter of the proceeding century. The lifecycle costs of the use of fossil fuels on the world climate are a matter of deep concern to the environmental conservation organizations. All the countries have started experiencing the adverse impacts of the climate change in form of loss to human lives as well as to the economies. This gloomy scenario has pushed the governments to look for means of abating the creep of the climate change in to their countries. Kyoto protocol was the first unanimous consensus of the countries to come up with ways of mitigating the fast recession of globe in to apocalyptic conditions. This struggle to limit the advancement of global average temperatures below two degrees over the preindustrial revolution era has brought the world to an agreement on restricting the utilization of fossil fuels.

Industry has remained the most intensive consumer of energy around the world for the past 50 years and is projected to remain the main user for the foreseeable future as shown in the figure 1. This trend suggests that the countries making more efficient and effective use of energy in industry are bound to achieve greater benefit for the same cost. The dynamics of global energy use are also undergoing a major paradigm shift. For the first time in history the energy demand of the developed world will be lower than the combined energy demand of the developing world [1].

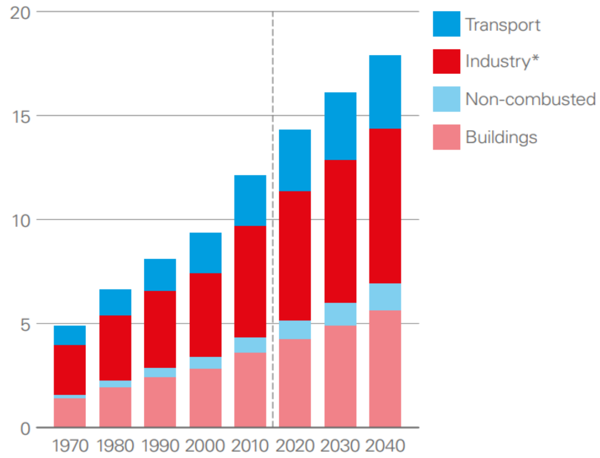


Figure 1. Global energy use projections by sector [2]

This is in part due to the growing population but more than that it is a product of the enhanced energy efficiency in the industries in developed countries. Developed world, on average, exhibit greater productivity per unit energy consumed than the developing economies. A significant factor behind this greater productivity is the improvement in the industrial energy efficiency in developed world achieved through extensive energy resource assessment.

The Paris Climate Agreement of 2016 [3] was a formidable achievement in the struggle for global climate conservation. The world leaders agreed to set stringent controls on emissions in their countries through incorporation of greater share of renewable energy resources in their energy mix. Renewable energy has already been growing at an appreciable pace throughout the world for the past decade. Among the new energy generation capacity addition the renewable have been continuously outpacing the conventional fuel installations. International Energy Agency (IEA)'s renewable energy report for the year 2017renewable energy projects with a cumulative addition of 167 GW far surpassed the additions from coal (57GW) and coal 29 (GW) as shown in the figure 2 [4].

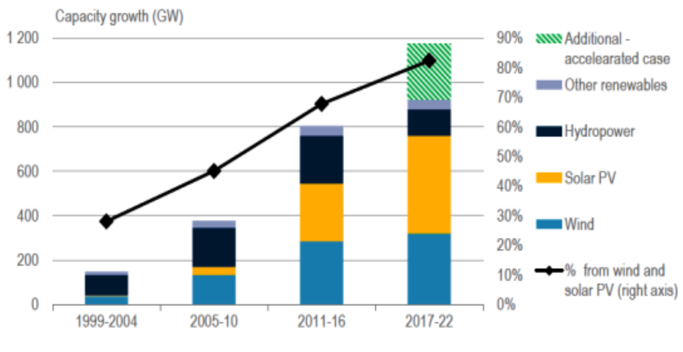


Figure 2. Renewable energy Projections 2017-22

There is however another resource that is even cheaper and less time consuming as compared to the conventional energy resources and renewable energy resources. The energy efficiency improvement in all energy consuming sectors has been proven more economically and temporally beneficial as compared to all the resources as shown in the figure 3. Energy efficiency enhancement in industry is considered a low hanging fruit which gives better return per unit time and capital investments.

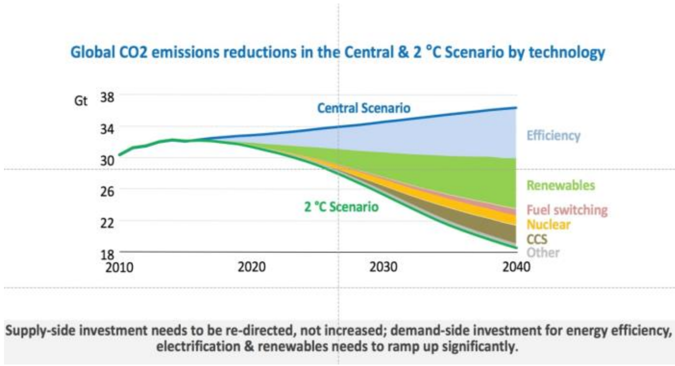


Figure 3. Energy efficiency as most effective resource for carbon mitigation and inhibiting climate change [5]

The story of Pakistan's energy woes is not hidden from anyone. For the past 15 years the country has been facing the brunt of energy shortages of varied extent and time. For a decade in between i.e. from 2008 to 2017 the energy shortages were at their most extreme. This inadvertently leads to negative impact on the economy. All around the world the economic growth is directly linked with the consumption of energy per capita as shown in the figure 4. If, for some reasons, the energy supply line is tented the economy suffers. Countries such as Taiwan, Korea, and China provide best avenues to test this relationship having achieved exemplary economic growth through energy use.

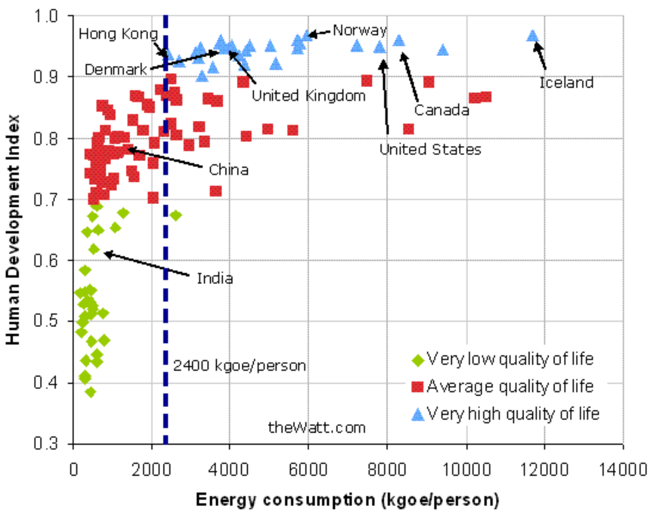
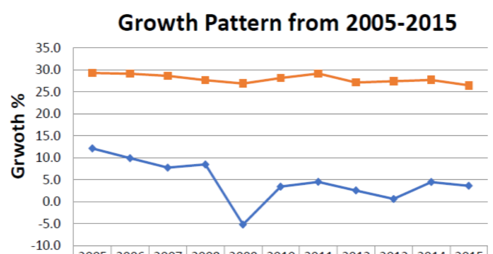


Figure 4. Energy consumption as a determinant of development [6]

In Pakistan the energy shortages have directly impacted the industrial growth of the country. The cycle is simple: the energy shortages and the subsequent interruptions in the industrial output resulted in a greater demand for the dwindling energy supply. This distortion in the demand supply cycle resulted in energy price hike further compounded by the stagnant energy efficiency capacity of the industries. This resulted in close to one fifth of the domestic manufacturing industry moving their production out of the country. The data for industrial energy consumption as percent of the national energy consumption paints a vivid picture of this dilemma when compared with the national industrial growth data as shown in the figure 5.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Industrial Growth of output %	12.1	9.9	7.7	8.5	-5.2	3.4	4.5	2.5	0.6	4.5	3.60
Industrial Electricity consumption %	29.29	29.11	28.62	27.65	26.89	28.14	29.19	27.14	27.42	27.71	26.47

Figure 5. Industrial growths vs. the electricity supply to the industry for Pakistan [7]

It is clear from the above graph that there is a direct link between the energy supply and the industrial growth of the country. The approximately 5 % of drop in electricity consumption is more a function of the dropping energy availability and the resultant rise in electricity prices during the period. This follows that the country could have achieved a far greater industrial and economic growth had the energy supply been stable. But there is another factor which could have significantly offset the shortage of electricity supply in the industries the apt utilization of the energy efficiency resource. The past 50 years of the industrial growth around the world suggests that there has been a decrease in the amount of energy utilized for achieving the same unit of economic growth as shown in the figure 1.6. As evident during the start of the 1990s the energy use for producing a unit of economic output was considerably greater than in the year 2015. Another point worth noticing is the low energy efficiency in the low income countries such as Pakistan.

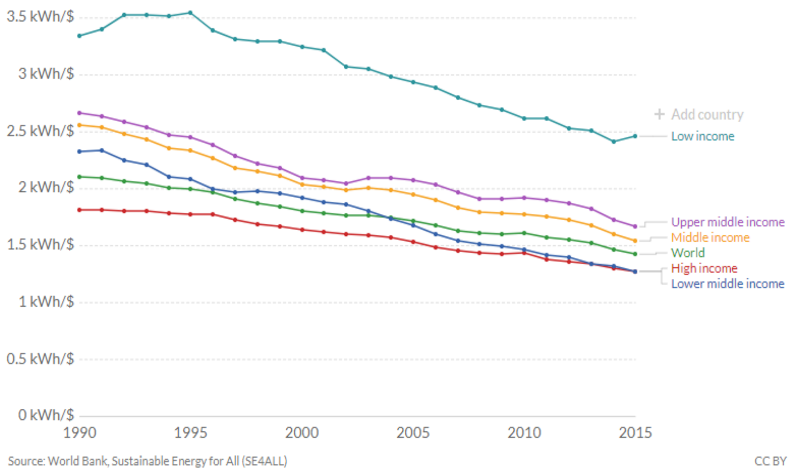


Figure 6. Comparison of the energy input to produce a unit of economic output over the years [8]

Accordingly Pakistan has also experienced a decreased level of energy efficiency in industry. This factor leads to lower competitiveness of the products at international level.

Sugar industry of Pakistan, the 6th largest contributor to the global sugar supply line, is one of the most energy intensive industries. Eighty fours sugar mills are currently operating in the country employing close to 300,000 people in the country and contributing 20 billion to the national tax regime. With all this the energy consumption in the industry has been largely absorbed by the captive power generation from the bagasse that is a byproduct of the sugar manufacturing. Considering the stressed energy supply line of the country and the global climate conservation problem it is of utmost importance that the energy efficiency resource assessment must be carried out for the industry to come up with energy savings opportunities [9].

II. Case Study

Chashma sugar mills limited unit-1 has established in 1991. It is located in district dera Ismail khan Khyber Pakhtunkhwa Pakistan. It has total Crushing capacity of 12000 Tons per day (Avg 11500 TCD). It has 12 Mw Power Plant. Total Energy demand within the facility is 8 MW (Low pressure steam turbine & boiler) the major steam consuming areas are Mill House & Power house. The exhaust steam from turbine is de-supper heated at 130 degree centigrade before utilize in process house for heating of juice, syrup & Massecuite

A. Energy Flow in the facility

The sugar industry operational mode is seasonal. It operates from December to March for four months. In these operational days, the plant is powered by facility owned generated energy through cogeneration bagasse plants using bagasse of the production process. In off seasons, the facility is connected with WAPDA only using energy for residential colony and day to day office operation of mill. In general two major energy formats are used:

- Bagasse as primary source
- Steam as secondary source of bagasse
- Electricity as tertiary source from steam and used for facility operations.

In total bagasse about 76 % is burnt whereas remaining is saved and either compacted and sold out.

B. *Steam Flow in the facility*

The bagasse is used for steam generation in five different water tube Boilers. Two boilers are having 80 Tons/hr. steam production capacity; whereas other two have 40 Tons/hr. and one smaller with 12 Tons/hr. Total available steam capacity within the facility is 252 Ton/hr. Total steam demand of the factory is 230 TPH. The steam carrying thermal energy both serve process operations as well as power generations as shown in Figure 7. Consumers of steam are:

- Mill house
- Power house

The exhaust steam from the Mill & Power House is utilized in Process house for Heating juice, Condensate is then return to Boiler.

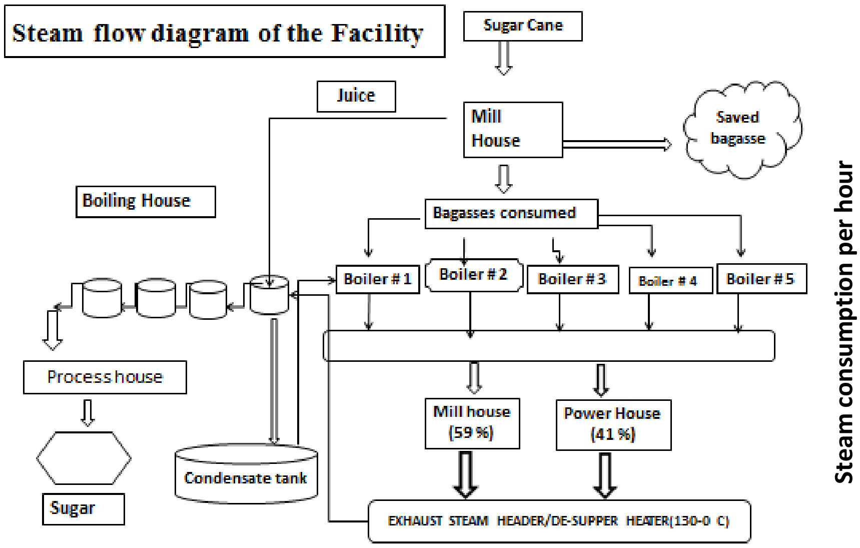


Figure 7. Steam flow within the facility

C. *Boiler House Energy Flow*

Boiler house function to provide steam for electric power generations and milling operation. The facility owned five boilers out of which four boilers are operational and one is stand by. Total designed load 252 Ton/hr. as given in table I and as shown in figure 8.

TABLE I. DESIGN AND OPERATIONAL DETAILS OF BOILERS

Description	Design load (TPH)	Running load (TPH Avg)	% Load
Boiler -1	40	36	90
Boiler -2	40	37	92.5
Boiler -3	80	77	96.2
Boiler -4	80	78	97.5
Boiler -5	12	Stand by	
Overall load on boiler house	252	228	95

TABLE II. SECTION WISE OVERVIEW OF STEAM CONSUMPTION IN THE FACILITY

Description	Actual Steam consumption (TPH)		% steam consumption
Mill House Tendam-A	72	135	59
Mill House Tendam-B	63		
Power House	93		41
Total	**228**		**100**

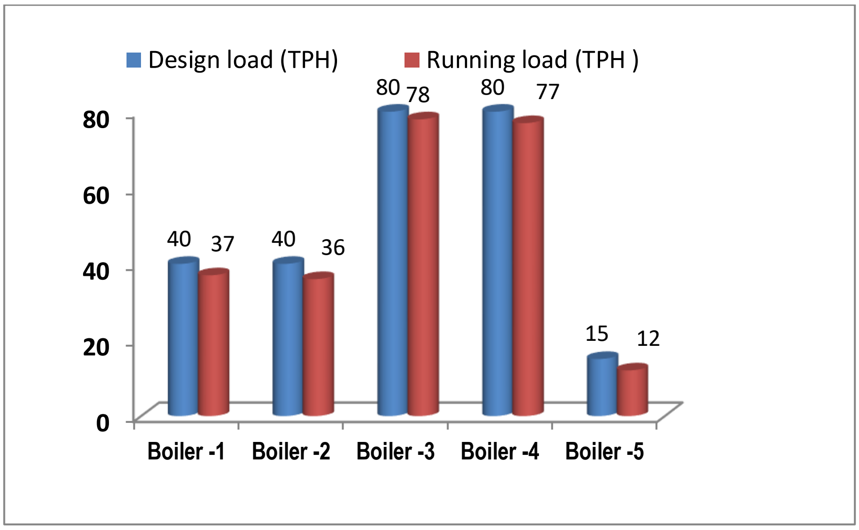


Figure 8. Comparative Investigation of Design Vs. Operational Load of boiler house

The consumption of steam is further elaborated in Table II and Figure 9 where it can be observed that mill house and power house are the two main consumers of steam generated

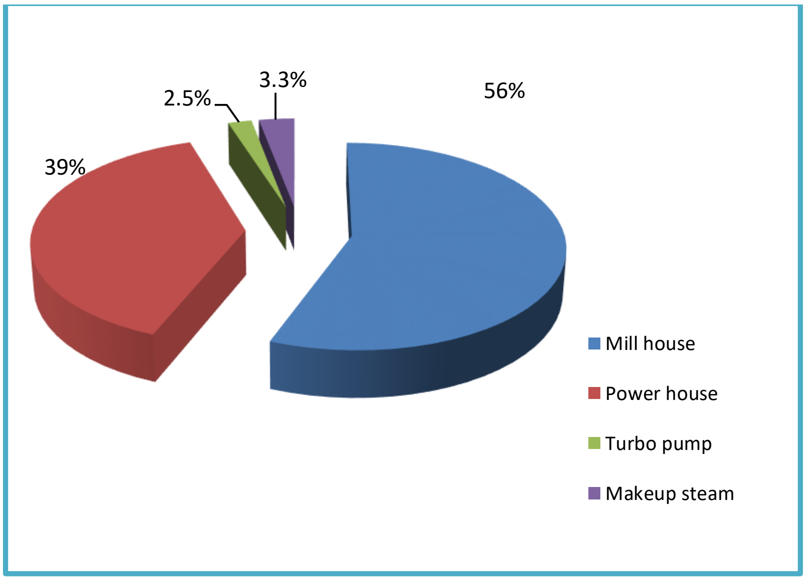


Figure 9. House wise steam consumption in the facility

D. *Power House energy Flow*

Power House is one of the SEUs considered for investigation. It mainly comprises of four back pressure Impulse turbine having total capacity of 12 MW. The system requirements stand around 8.1 MW whereas one turbine of 2MW is held for stand by purposes to facility during emergency hours as shown table III.

TABLE III. INSTALL & RUNNING LOAD OF POWER HOUSE

Description	Installed Power (MW)	Running Power (MW)	% Load
Turbine-1	02	Stand by	-
Turbine-2	02	1.6	80
Turbine-3	04	3.2	80
Turbine-4	04	3.3	82.5

Overall load on power house	**12**	**8.1**	**81**

E. Electricity Consumption Patterns

The electricity evacuated from power house to feed various sections and processes along with their accessories requirement as shown in Table IV. Process house is the major consumer followed by mill house and boiler house.

TABLE IV. OVERVIEW OF DEMAND IN DIFFERENT SECTION OF THE FACILITY

Sr. #	Description	KW	% load
1	Process house	3170	39
2	Mill house	2175	26
3	Boiler house	1280	16
4	Injection and spray pumps	1175	15
5	Colony	300	4
	Total	**8100**	**100**

III. METHODOLOGY

I have adopted 10 steps methodology:

Step-1. Plan and organize, Walk through Audit, Informal Interview with Energy Manager, Production / Plant Manager

Step-2 . Conduct of brief meeting / awareness program with all divisional heads and persons concerned

Step-3 Primary data gathering, Process Flow Diagram & Energy Utility Diagram

Step-4. Conduct survey and monitoring

Step-5. Conduct of detailed trials / experiments for selected energy guzzlers

Step-6. Analysis of energy use

Step-7. Identification and development of Energy Conservation (ENCON) opportunities

Step-8. Cost benefit analysis

Step-9. Reporting & Presentation to the Top Management

Step-10. Implementation and Follow-up

IV. DEVELOPING BASE LINE SCENARIO OF MILL HOUSE

There are two Milling Tandem, T.A & T.B each having 04 No's Crushers with a crushing capacity of 6000 & 5500 tons per day respectively. Cane passes through crushers, juice extracted and send to Boiling house for further process to produce refine sugar. Back pressure impulse turbine is used to drive the crushers. After juice extraction bagasse is send to Boiler house and is used as a fuel for steam generation. About 76 % bagasse burnt and the remaining 24 % saved for selling out. Significant energy saving opportunity exist in mill house, therefore mill house is our prime focus in this case study to increase the profitability of the facility and reduce losses.

A. Bagasse Saving calculation of the existing system

Crushing rate = 11500 TCD = 479 TPH (Tandem-A 6000 & Tandem-B 5500 TCD)

At normal practice sugar mill can produce 32 % bagasse on Cane.

Total Bagasse produced = 479 x 0.32 = 153 TPH Total Steam demand of Mill house both tandem =135 TPH (Tandem-A =72 TPH & Tandem-B= 63 TPH

Total Electric load of Process house, Boiler house & Colony = 8.1 MW

Steam demand = 8.1 x 11.5 = 93 TPH (turbine steam consumption = 11.5 kg/kw/hr.)

Total steam demand of the existing system = 228 TPH Steam to bagasse ratio of the existing boilers = 1.96 (Avg valve reported during previous 03 season

Bagasse consumption at 1.96 Steam to bagasse ratio = 228/1.96 = 116 TPH

Total Bagasse saved = 153 – 116= 37 TPH Bagasse saved per season at 80 % work hours = 0.8 x 37 x 24 x 120 = 85,248 Tons

Steam % on cane of the existing Rising film Robert type Evaporators = Total steam(TPH) / Total Cane crushed (TPH) = 228/479 x 100 = 48 %

Sugar production @ 10.5 % Avg recovery = Total crushing

x recovery % = 479 x 10.5 % = 50 Tons

Sugar production per season at 80 % working hour s = 0.8 x 50 x 24 x 120 =115200 Tons

Bagasse consumption per ton sugar production =116 /50 = 2.32Tons

B. Developing Energy Efficient Scenario

Scenario # 1

i. Sugar Saving:

Crushing rate = 11500 TCD = 479 TPH

Total Bagasse production = 353 TPH (at 32 % on cane) Sugar production = 50 TPH (at 10.5 % avg recovery) Pole before improvement = 1.98 (Avg of the previous 03 years of both tandem)

Bagasse Pole after improvement will be = 1.7 % Pole % saved = 1.98 – 1.65 = 0.33% of bagasse Sugar saved = 50 x 0.33 % = 0.165 TPH

Total sugar saved per season = 0.8 x 0.165 x 120 x 24 = 380 Tons (Pole is pure Sucrose/Sugar)

Amount saved at Rs.90/kg = 380000 x 90 = Rs. 34,200,000/- (Sugar current rate without sale tax = Rs.90/kg)

ii. Bagasse Saving:

The following calculation will best explain the total bagasse saving obtained by applying the recommended ECMs (Energy conservation measure) in Mill house. Steam Consumption of Mill House in the improved system is calculated below

Total electric load of Mill House (TA & TB) in the improved system = 16 MW (Tandem-A =8 MW, & Tandem-B= 8 MW.

Total Steam demand to generate 16 MW electric power = 16 X 6 =96 TPH (steam consumption of hp boiler = 6 kg/kwh)

Total load of Process house, Boiler house & Colony = 8.1 MW Steam demand = 8.1 x 6 = 49 TPH

Total steam demand of the improved system = 145 TPH Total bagasse consumption 145/2.4 = 60 TPH (at 2.4 steam to bagasse ratio)

Extra bagasse saving in the improved system = 116 – 60 = 56 TPH Extra bagasse saving per season = 0.8 x (56 x 24 x 120) = 129,024 Tons (36 %)

Amount saved @ R.S 5500 per ton =129,024 x 5500 = R.S 709,632,000 /- Per season

Total saving = sugar + bagasse =34,200,000+709,632,000= R.s 743.2 Million Per season

Total estimated budget of the said project (scenario # 1) = R.s 1000 Million /- Payback period = 1.5 Season Bagasse consumption per ton sugar production =60 /50 = 1.2 Steam % on cane = 145/479 x 100 = 31 %

C. *System Optimizations*

At present there are two milling Tandem, tandem-A &tandem-B each having 04 No's mills which are drive by back pressure impulse turbine which consumed steam. In this case study I have developed two scenarios in order to save energy (Bagasse).

Scenario # 1:
Recommendation

- Replacement of drive units i.e. Turbine by VSD Motors
- Replacement of Unigrator with Fiberizer
- Installation of 5th Mill
- Replacement of Robert type Evaporator by Falling film Evaporator to increase overall Heat transfer co-efficient & reduce steam economy
- Installation of 01 No high pressure boiler under the following specification

H.P Boiler (65 Bar, 160 TPH & 480-490 Degree Centigrade)

- H.P non condensable steam turbine 26 MW for VSD Motors that is to be installed in Mill house for Cane preparation and Cane crushing mechanism

By doing such practices Juice extraction will be increased i.e. Sugar losses in bagasse will be minimized. Preparation index (P.I) will be improved (90 % +).Bagasse moisture will be decreased. Extra Bagasse will be saving for selling out. Steam % on cane will be reduced.

D. *Total Additional revenue and Payback analysis (Scenario # 1)*

The total revenue generated by the implementation of recommended ECMs along with the payback analysis are listed in the below table V.

TABLE V. TOTAL SAVING & PAYBACK ANALYSIS (SCENARIO # 1)

Description	Qty (Tons)	Unit Price (R.s)	Additional revenues
Sugar saving after Reduction in pol % bagasse	380	90/kg	34.2Million
Extra Bagasse Saving after Installation of VFD in Mill House & HP Power house	129,024	5500/ton	709.6 Million
Total Additional revenues			**743.8 Million**
Total estimated budget for the project scenario # 1			**1000 Million**
Payback analysis			**1.4 Seasons**

V. DEVELOPING ALTERNATE SCENARIO FOCUSED ON DSM SCENARIO # 2 COGENERATION

A. *Recommendation*

01 No High Pressure Bagasse fired water tube Boiler having Steam capacity = 160 Ton per hour,Temperature = 489-490 degree centigradeLive Steam Pressure = 65 bar, Steam to bagasse ratio = 2.4,

01 No high Pressure condensable steam turbine with the given specification, Generation capacity = 26 MW, Steam consumption 6 kg/kwh (recommended by manufacturer), Live steam temperature = 489-490 degree centigrade Live Steam Pressure = 65 bar

i. Saving via Cogeneration :

Steam consumption of high pressure steam turbine 26 MW = 6kg/kWh

Total steam consumption = 26 x 6 =156 Tons per hour = 120 x 24 =3744 tons per day

Total bagasse consumption @ 2.4 steam to bagasse ratio = 3744 /2.4 =1560 tons per day

Extra bagasse saved after improvement = 129,024 Tons per season(calculated in scenario #1)

Number of days the given high pressure steam turbine generate electricity by utilizing the saved bagasse = 129,024/1560 = 83.7 days (12 Weeks)

At 80 % load 26 MW Turbine would produce Power = 16 MW

Electricity provide to grid = 16000 x 24 x 83.7 = 41,783,040 kWh

Price of single industrial unit = R.s 15 per kWh Total revenue generated = 626.7 Million PKR

It means that if we used the saved bagasse as a biofuel within the facility it will generate 41,783,040 kWh electrical energy which is to be sell out to grid by the mill, generate a total revenue of 626.7 Million PKR.

VI. Screening Tests of Recommended ECMS

After detail analysis and calculation of the recommended up to date and energy efficient technology the following results will be obtained table VI and table VII.

TABLE VI. Overview of the result for the present Operation and Future Scenarios

Description	Present System	Improved system
Crushing (TCD)	11500	11500
Pol % bagasse	1.98	1.65
Preparation index %	80-82	90-92
Steam % on Cane	48	31
Bagasse consumption	76 %	40 %
Bagasse saving (Ton)	24 %	60 %
Fuel/bagasse Consumption per ton Sugar production	2.32 TPH	1.2 TPH
Extra bagasse saved in the improved system per season (Tons)		**129,024 (36 %)**

ii. Sugar Saving (same as in case of scenario # 1)

Crushing rate = 11500 TCD = 479 TPH

Total Bagasse production = 353 TPH (at 32 % on cane)

Sugar production = 50 TPH (at 10.5 % avg recovery)

Pole before improvement = 1.98 (Avg of the previous 03 years of both tandem)

Bagasse Pole after improvement will be = 1.65 %

Pole % saved = 1.98 – 1.65 = 0.33% of bagasse Sugar saved = 50 x 0.33 % = 0.165 TPH

Total sugar saved per season = 0.8 x 0.165 x 120 x 24 = 380 Tons (Pole is pure Sucrose/Sugar)

Amount saved at Rs.90/kg = 380000 x 90 = Rs. 34,200,000/- (Sugar current rate without sale tax = Rs.90/kg

Total amount saving = Sugar + Electricity = 34.2 + 626.7 = R.s 660.9 Million

Total estimated budget for this project = R.s 1000 Million Payback period = 1.5 Seasons

TABLE VII. Total saving & payback analysis (Scenario # 2)

Description	QTY	Additional revenues
Unit of electricity saved in case of cogeneration from bagasse	41.78 Million kwh	626.7 Million @R.s 15/Unit
Sugar saved as in case of scenario # 1	380 tons	R.s 34.2 Million @ R.s 90/Kg
Total Additional revenues scenario # 2		R.s 660.9 Million
Total estimated budget for the project scenario # 2		1000 Million
Payback period scenario # 2		1.5 Seasons

Concuslion

Provision of energy at affordable prices is vital for industrial productivity. Being centric to energy crises, Pakistan's industrial units suffer adversely as result of high prices, energy insecurity and load shedding. Sugar Industry though uses of the available bagasse for power generation and steam utilities, however, the recent research studies carried in developing countries, highlights needs of assessing energy resource potential in sugar industries. This research work addresses the research opportunity available in assessing real time energy conservation and energy efficiency potential available in Chashma Sugar Mills. The research based on standard practice reviewed the energy and material flows in the facility. Based on Significant Energy Uses concepts, further detailed investigations aligned with ASHARE Level Three audit were carried to assess the available energy conservation measures, energy efficiency opportunities, system optimizations possibilities and energy efficiency resource prioritization based on economic and financial indicators like payback period, IRR etc. The overall outcomes have been normalized using Energy Performance Indicators like steam (bagasse) consumption/ton sugar production has been used.

It has been revealed that mill house and power house are two main SEUs responsible for approximately 59 & 41 % steam consumption respectively. The research recommends usage of high pressure water tube Boiler and high pressure steam turbine. With this setup steam to bagasse ratio increases also steam consumption of high pressure turbine is low (6kg/kWh) as compared to low pressure (11.5 kg/kWh). In the present system approximately 24 % bagasse saving and 76 % consumed while in the improved setup 60 % bagasse will be saved and the remaining 40 % will be consume. Thus the improved system will add 36 % extra bagasse to the facility. This whole project will cost 1000 Million PKR with a payback of 1.4 Season in case of scenario-1 and 1.5 Season in case of scenario-2

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Solar Energy Technical Potentials Analysis of Khyber Pakhtunkhwa based on GIS and Multi-Criteria Method

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***Abstract*—** Pakistan is located just above the tropic of Cancer; this offers most optimal locations on the globe for Photovoltaic power generation. Khyber Pakhtunkhwa has an average solar insolation value more than 5.0KWh/m^2/day, which is very appropriate for Photovoltaic deployment. But Photovoltaic power generation trend shows considerably less progress in this region. The aim of this research is to assess the solar potential for photovoltaic power generation in Khyber Pakhtunkhwa province by identifying feasible sites both technically and economically for a utility-scale solar power park installation. The feasible sites were identified using Geographic Information Systems (GIS) software. This process uses Multi-Criteria Analysis method to meet different criteria such as solar irradiation, slope and aspect combined with proximity to transmission lines and roads plus a number of limiting factors. The final results showed that 8% (8,000 km^2) of the research area is highly suitable for installing utility-scale photovoltaic parks. A total of 18 sites with suitability value of 9 and area greater than 6 km^2 have been identified in South and South western part of Khyber Pakhtunkhwa. In addition, 70 areas of suitability value between 7 and 8 having areas 2-4 km^2 have been identified. Calculations were carried out to find the technical potential for power generation. The results showed that appropriate amount of feasible areas are available for large scale PV installations, with adequate power generation potential.

***Keywords*—**: Energy, Irradiation, Renewable, Suitability, Technical.

I. Introduction

Renewable energies are the fastest growing source of energy and considered to be the solution for achieving power system sustainability. According to International energy agency renewables will provide 30% of the total power demand in 2023, as it was 24% in 2017.It is forecasted that during the period from 2018 to 2023, 70% of the world power generation growth will be provided by renewables [1]. For solar plant, large area is required which causes adverse influence on biodiversity, land use, and land cover. Ideally, solar installations should be situated on vacant, low productivity agricultural land or on barren land and lands covered by bushes to minimize such impact. Non-ideal sites are extreme far off location, insecurity and high degree of development and covered by forest [2]. The distance of solar park from urban population is also very important. The Solar plant installed near load centers will have to cover a smaller distance and the transmission lines required to transfer the energy produced will much less, thus reducing energy loss and cost of the energy supplied to consumers [3, 4]. However, choosing suitable sites for harvesting solar energy is not a straight forward task. It is based on multiple sets of physical, environmental and socio-economic criteria in order to decide optimum geographic locations. Hassan et al. [5] used GIS-AHP method for site selection for solar power park in Saudi Arabia. Two type of criterion were considered i.e. technical and economical. Technical criteria involve are solar irradiation and the air temperature. Economic criteria involve slope, aspect, Vicinity to power lines, vicinity to cities and vicinity to highways. The constraints considered were high slope, land use and protected areas comprising of industrial cities, agricultural land, national parks, holy places and wildlife sanctuaries. The study was divided into four steps. First step was ruling out unsuitable sites. In second step an Analytical hierarchy process method was used to find out the priority weight and relative importance of all criterions. The next step involved overlaying different criteria maps as an input criteria according to their relative weights obtained in step 2 (AHP) to create an integrated analysis. The weighted sum overlay accepts the scaled inputs, and adds them together. In final stage a land suitability index was developed to show the potential sites suitability distribution for solar PV installation.

Carolina et.al [2] applied Geographical Information System (GIS) and multi criteria method to assess the solar energy potential for electricity generation in Europe. Factors determining the overall suitability (proximity to Electrical grid and transportation network, slope, aspect, solar irradiation and Population) and different Constrains were identified. Unsuitable area identified were forest, wetlands, water bodies, and land use whereas undeveloped and short vegetation areas were considered as the suitable location. Slope was identified as the main suitability factors for land suitability criteria. (Slope between 16 and 30 was considered poor while above 30 were restricted), solar irradiation (below 900kWh/m^2 fall in Poorest regions), Proximity to Road network (5000 m cut-off value), the distance to the existing electrical network (grids) and population considered as small as possible. All the individual criterion factors maps integrated in single layer using weighted linear addition technique in GIS to evaluate the total suitability. As a validation exercise comparison between existing solar powers parks and suitable sites was carried out. The comparison indicates that existing solar power parks matched European suitability model overlaid in the study.

II. METHODODLOGY

Khyber Pakhtunkhwa, Pakistan is selected as study area on the bases of its ideal conditions for solar installation and large area. The total area of the Province is 101,741 square km of mix terrain, and has annual average irradiance values greater than 1760KWh/m^2 according to the National Renewable energy laboratory (NREL) solar database. Steps involve are:

Calculate the total suitable area;

- Find out how much renewable energy resource is present within the calculated areas;
- Finally calculate the amount of electrical energy that could possibly be generated from that available area, based on currently available PV technology [6].

A. *Land suitability criteria:*

Land suitability is based on the following six criteria and number of limiting factors.

i. Solar Irradiation (kWh/m^2)

The NREL is a leading industry for renewable energies projects development and installation. The data provided by NREL is most credible and is being referenced in literature of a lot of scholars. NREL is US based organization that provides free data, and have compiled a number of useful datasets for utility-scale or large distributed renewable energy development. The Solar data used in this study was acquired from the National energy laboratory. When assessing potential sites for PV projects, the most important parameter to consider is solar radiation levels [6 - 8]. The solar analyst tool in the ArcGIS software was used for solar irradiance analysis and mapping [9]. The solar irradiation (GHI) for Khyber Pakhtunkhwa is divided in 5 classes. Solar irradiation for the study area is illustrated in Figure 1.

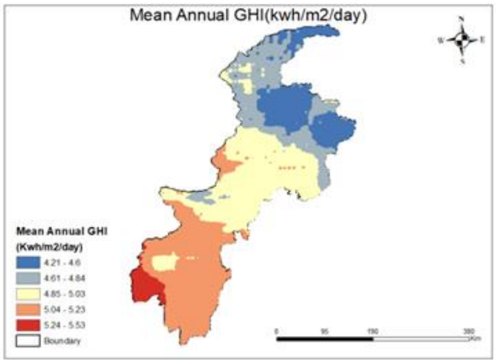

Figure 1. Mean Annual GHI

Electricity generation from solar energy could be the most appropriate source of energy to cope with the rising electricity demand because the pattern of global solar irradiation exactly follows that of electricity demand. It varies accordingly with seasonal variation [4]. Figure 2 shows Seasonal Variation of Solar Irradiation.

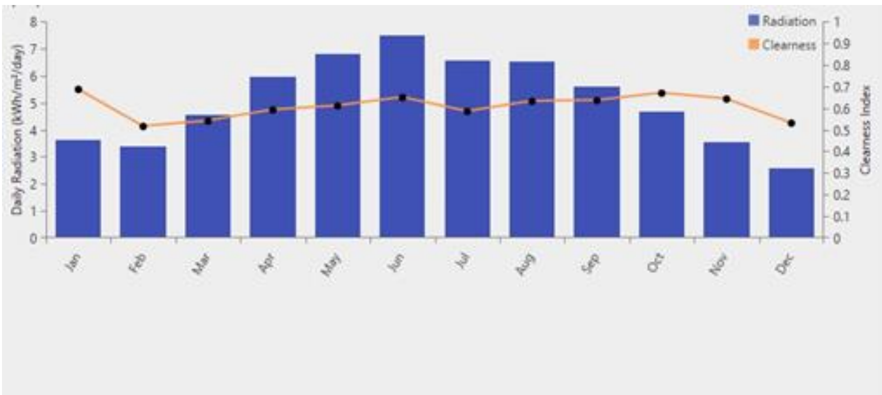

Figure 2. Seasonal Variation of Solar Irradiation

ii. Slope

Level plains or minor steep slopes require less construction cost as compared to high slopes areas. So, for economic feasibility flat terrains are vital for utility-scale PV parks [10]. For slope calculation Spatial Analyst toolbar (slope tool) in ArcGIS used. For an entire area a slope raster is created. This slope raster enables to get an impression of the steepness of the terrain, that can be used the output for further analysis. Results for slope are illustrated in Figure 3.

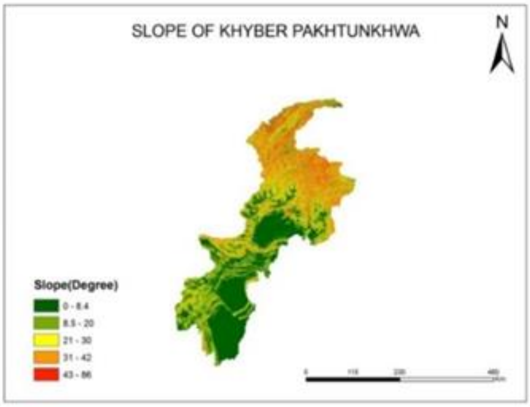

Figure 3. Slope of study Area

Lands having Slope value less than 5 ° are highly suitable for PV installation whereas 5-10° considered as moderately suitable [11]. Figure 3 shows the slope of study area.

iii. Aspect

Spatial Analyst toolbar in ArcGIS calculates the maximum rate of change in value between two neighboring cell. Aspect has a direct influence on solar radiation. In northern hemisphere, the slopes facing north are mostly shaded, whereas slopes facing south receive more solar radiation because these are tilted towards the sun and the earth do not directly shade these areas. Figure 4 shows result for aspect.

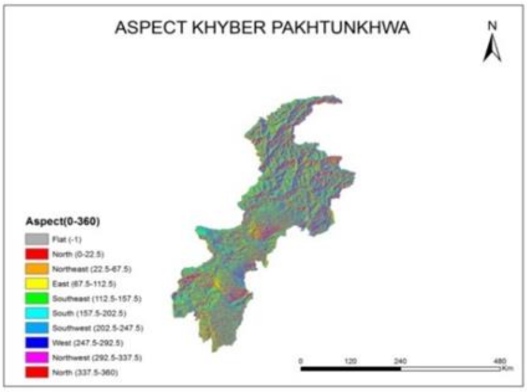

Figure 4. Aspect of study Area

iv. Elevation

ASTER DEM (30m) has been use for calculating the aspects values. Figure 5 shows Elevation of Khyber Pakhtunkhwa.

v. Distance to Transmission line and Road Network

Distance of a PV park from transmission lines is important because of two main reasons; resistance of conductor is directly proportional to length of the conductor so electrical losses in transmission lines increase with the increase in length. Secondly constructing new power lines can raise the overall cost of the project [12]. The distance between the source and transmission line was considered as one key factor [6-8,13,14,15]. The distance functions in Spatial Analyst tool was used to find proximity to electrical network. Figure 6, displays the distances from transmission line.

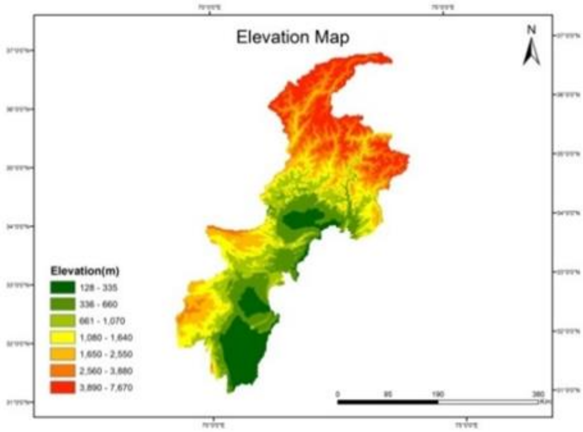

Figure 5. Elevation of KPK

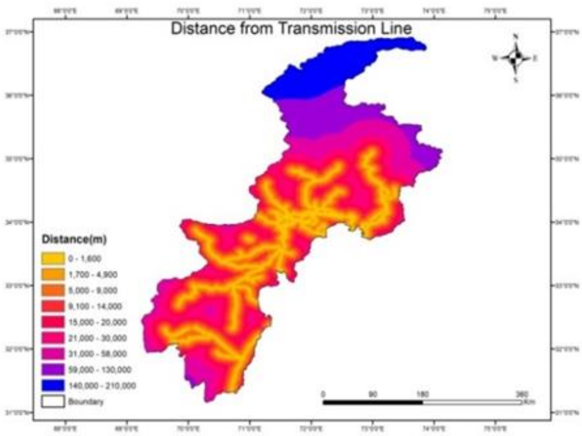

Figure 6. Proximity to transmission line

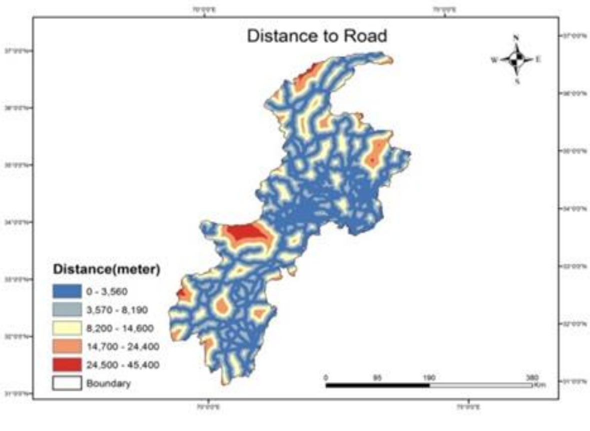

Figure 7: Proximity to Roads

Areas < 250 meter are excluded from the study, to counter the decrease in module efficiency and damage caused by social activities, such as dust due to traffic or any other reason and construction activity [16]. Accessibility to potential sites proves to be an important factor. Road accessibility is necessary for construction, installation and maintenance throughout the life of solar park. Solar power park proximity to a main road considered an economic factor [7, 8,12, 14, 15]. Figure 7, shows Proximity to Roads.

vi. Land use and Land cover

Land cover and land use were considered as constraints in this study. Most common restrictions and Constraints applied for Utility-Scale solar site are Parks, Water, Wetlands, Forests, Wildlife Areas, Urban lands, cultivated and protected land [7-11, 14-16]. These constraints are excluded from the suitability model. Gaussian Maximum Likelihood algorithm of supervised classification was used to extract different features. The result is shown in figure 8.

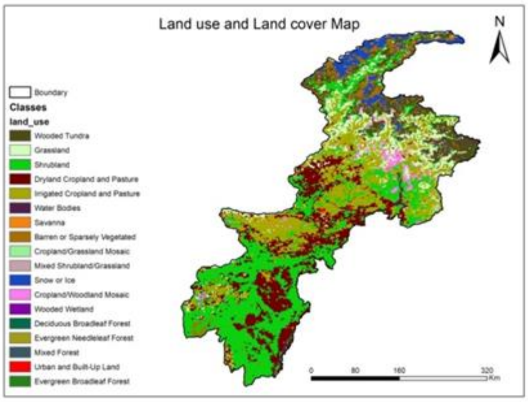

Figure 8: Land use and Land Cover

B. Analytical hierarchy process

Analytical hierarchy process (AHP) offers the perfect compromise solution for contradictory objectives [17]. AHP method has been employed to calculate weight for different parameters which give importance of a parameter for decision making. Table I shows Pair wise comparison matrix.

TABLE I. PAIR WISE COMPARISON MATRIX

Elevation	**Road**	**T/L**	**Slope**	**Aspect**	**DNI**	**Pair wise compression matrix**
7	5	5	3	2	1	DNI
6	3	3	2	1	0.25	Aspect
5.00	3	3.00	1	0.33	0.2	slope
2.00	1.00	1.00	0.30	0.25	0.16	T/L
2.00	1	1.00	0.33	0.25	0.16	Road
1	0.5	0.5	0.20	0.16	0.11	Elevation

On applying AHP method [17], weight of each criterion is obtained and is shown in Table II.

TABLE II. PERCENTAGE WEIGHT OF EACH FACTOR

Category		**Priority**	**Rank**
1	DNI	0.4	1
2	Aspect	0.24	2
3	Elevation	0.04	3
4	T/L Network	0.075	4
5	Road	0.075	5

Before overlay each criteria layer is reclassified using reclassify tool into classes. When we reclassify a raster, a new raster is created with the reclassified values. The new value is based on a ranking scheme usually 1 to 9. In the third stage, final result has been modelled by applying weighted sum overlay method using the ArcGIS software. Weighted sum overlay technique involves overlaying various factors maps (irradiation, slope, distances to road and electrical network) according to their relative weights obtained from AHP. A suitability index has been prepared to categorize the province on the basis of potential solar harvesting site based on the weight of contributing factors. Restriction factor like "GHI" less than 4 KWh/m^2/day and lands having slope higher greater than 10° were excluded. Slope less than 5° are most suitable [7, 13]. The suitability index map ranging from 1-9 has been generated. The suitability model is based on six model criteria and restriction factors. Table III shows topographic and metrological factor rating and Table IV economic factors rating. A priority values ranging from 1-9 has been assign to each factors and the corresponding values by considering various economic, environmental as well as technical aspects. Sites considered extremely suitable were assigned a rating of 9, whereas sites with the least suitability were set a rating of 1 or restricted.

TABLE III. TOPOGRAPHIC AND METROLOGICAL FACTOR RATING

GHI	**Rating (GHI)**	**Aspect**	**Rating (Aspect)**	**Slope**	**Rating (slope)**
<4	Restricted	Flat(-1)	9	0-5	9
4.2-4.6	5	North (0-22.5)	1	5-10	8
4.61-4.84	6	NE (22.5-67.5)	2	11-30	Restricted
4.85-5.03	8	E(67.5-112.5)	3	31-42	Restricted

5.04-5.23	9	SE(112.5-157)	8		
5.24-5.53	9	S(157.5-202.5)	9		
		W(247.5-292.5)	9		
		NW(292.5-337)	4		
		N(337-360)	1		
		SW(202-247)	8		

TABLE IV. ECONOMIC FACTORS RATING

Distance from network	Rating (Distance from network)	Distance to Road	Rating (Distance to Road)	Land cover
0-0.5	Restricted	0-3.5	9	Barren land
0.5-6.5	9	3.5-8.2	8	Other
6.6-18	8	8.3-15	7	
19-30	6	16-24	5	
31-43	3	>25	1	

Applying the above rating, restrictions and Weighted overlay technique. The suitability model is obtained as shown in figure 9.

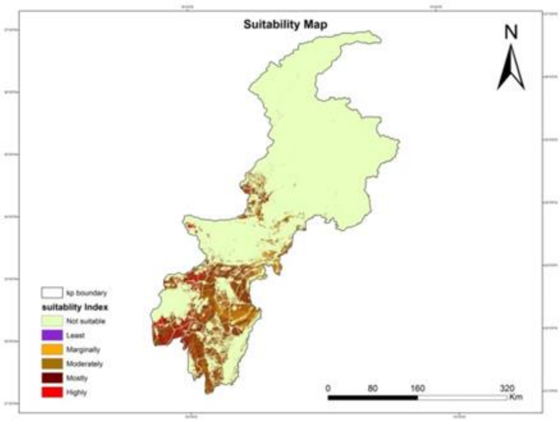

Figure 9: Suitability Map

C. Site selection Results

The Constrains, for instance agricultural land, urban areas, protected areas (National park, holy places etc.) and roads were excluded from the study. The last step in identifying the best suitable sites was to make sure that the potential sites have sufficient area for installing utility scale PV Park. Figure 10 indicates the potential sites for the study area. For utility-scale solar PV power park areas having area greater than 1 km^2 and suitability index from 8-9 are consider to be that the potential sites [6].

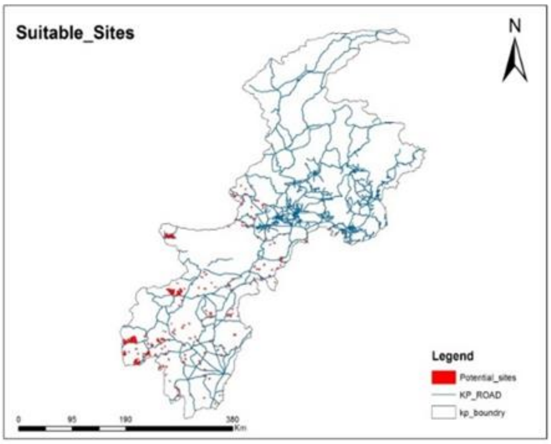

Figure 10: Final suitable sites

TABLE V. SUITABILITY INDEX

Suitability index	Scale
Not Suitable	0-5
Least	5-6
Marginally	6-7
Moderately	7
Highly	8-9

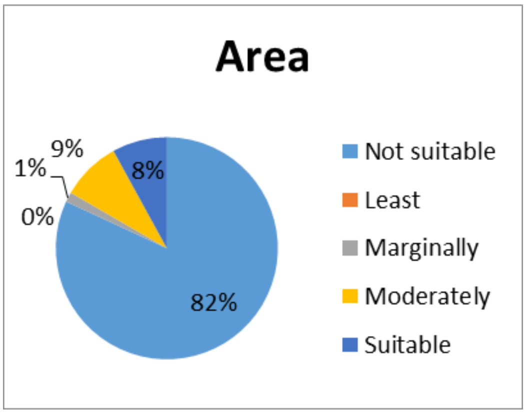

Figure 11: Suitability Index

The result of MCDM-GIS integration showed that 8% (8000 km^2) of the concern area is highly feasible for installing solar Photovoltaic power parks as shown in figure 11.

D. Electrical potential Assessment Methodology

Total Solar Insolation in the suitable area [6].

$$I_{Total}/year = Area \times \frac{I_{Avag}}{m^2}/day \times 365 \quad (1)$$

$$I_{Total}/year=8\times10^9 m^2\times5kwh/m^2\times365$$

$$I_{Total}/year=14{,}600\times10^9 \text{ kwh/year}$$

Total electrical energy generation

$$\frac{KWH}{Year} = I_{Total} \times \eta \quad (2)$$

$$\frac{KWH}{Year} = 14{,}600 \times 10^9 kwh/year \times 0.15$$

$$\text{Total generation}=2{,}190 \times10^9 \text{ kWh/year}$$

CONCLUSION

The method used in this research work successfully identified feasible sites (areas) for photovoltaic deployment based on different criteria and multiple stages of evaluation. This research work has tried to address the problem in two ways, first presenting the results in cartographic form, which provide a significant amount of information. Secondly through the use of tables and graphs that provides a quantitative view of the results, creating a relation between values and their respective locations in space. The research consists of two main parts, in first step a site suitability analysis was conducted and in second, calculation for technical potential and power generation capacity was carried out. The overlaid results obtained from the analysis showed that 8% area is highly suitable and 10% of the study areas have moderate suitability levels. The total insolation for suitable area is $14{,}600\times10^9$ kwh/year. This insolation can be converted into electrical energy using PV panels having efficiency of 15% with optimum tilt angle. The electrical energy generation after all the necessary calculation equals to be 2,190 $\times10^9$ kWh/year. For utility-scale projects areas less than 1km2 were excluded from the suitable areas to make sure that total size of the land is large enough to be considered for a project. The results of the research indicated that, substantial amount of suitable sites with adequate power generation potential are available for a utility-scale Photovoltaic installation. So it can be concluded that the study area is very feasible for on grid or off grid system PV deployment. Particularly the area far away from the national grid off grid solar PV can be very good choice.

FUTURE WORK

This research can be extended in future:

- A survey on social and political acceptance will be very supportive.
- Finding out the solar sites and the effect on voltage profile on proximate electrical buses, maximum power injection limits and transmission line losses.
- The proposed methodology is flexible, it can be easily modified and additional physical, environmental and planning economic can be included in it.
- Expand the work to evaluate the economic costs, benefits, risks and hazards associated with developing the selected sites.
- The proposed methodology can also use for other renewable energy system such as biomass, hydropower and geothermal.

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Performance Evaluation of Micro Hydro Power Plant using Cross Flow Turbines in Northern Pakistan

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***Abstract*—** Micro Hydro-power Plants (MHPs) play a key role in electrification and economic development of remote rural areas where the government grid system power supply is limited. A field study was conducted to evaluate the performance of crossflow turbines in District Shangla, Pakistan during 2019. The relevant data was collected to find the actual and potential power produced, transmission losses, number of households served and installed capacity of MHPs for detailed analyses. A relatively higher power was generated by MHPs with flow discharges ranged from 0.600 to 0.800 m3/s and head of about 10.00 m. The power produced at generation points varied from 8.496 to 48.574 KW with overall average of 25.782±11.971 KW. About two-third of the MHPs performance in term of average overall efficiency (67.56±11.63%) was found higher as compared to the overall efficiency (37.80±8.79%) of the remaining one-third of MHPs where the installation was not according to the site requirements. The number of Households per MHP ranged from 15 to 250 with overall average of 88±55 and energy demand of 1420±474 watts per household. The total transmission line loss in MHPs studied varied from 0.08 to 1.84 per km with overall average of 0.71±0.58 KW per km. With proper design and installation of MHPs more energy can be generated to minimize the gap between demand and supply in the rural areas.

***Keywords*—** Efficiency, Flow discharge, energy demand, Transmission losses and hydro power generation.

I. Introduction

Pakistan is blessed with enormous natural hydropower resources and possesses potential of hydropower development of 42,000 MW. Out of which small portion of about 7,000 MW (16.7%) has been exploited including 13,000 MW micro hydro power [1, 2]. Energy demand is increasing at the rate of 10% per annum and the gap between supply and demand is increasing day by day [3]. The long hours of power outages have become common place in the country in general and in rural area in particular, which is affecting the economic growth and development. As reported by the Asian Development Bank (ADB, 2019) that due to energy crisis in Pakistan about 2 to 3% of Gross Domestic Products (GDP) was affected. There is a great need for reliable and low-cost electricity which is expected to supports socio-economics development process and can minimize the gap between supply and demand.

In Pakistan's hilly areas, some of the localities are located outside of the National Grid but there is a great potential for development of micro hydro power [3]. Electricity can be generated from waterfalls that exist in the hilly area which can produced energy with low cost and play a role in economic development of country in general and rural areas in particular. The hydro turbine converts water pressure into mechanical shaft power that can be drive is an electrical power. The cross-flow turbine is commonly used for generation of micro hydropower power with low head and can work under variable flow conditions [4].

The efficiency of cross flow turbines depends on flow discharge, net head, runner, nozzle angle and size, diameter of the turbine, runner length, runner speed, number of blades and other factors. In general, the cross-flow efficiency under various flow conditions 0.4 to 0.6 Q/Qmax ranged from 75 to 80% [5]. Similarly, maximum turbine efficiency of 80% was reported with low head and different flow rate [6].

At present, small micro hydro power systems use impulse turbines and reaction turbine and theses have low efficiency ranges from 30-40% [7]. Agnew Turbine which was modification an axial micro hydro of Kaplan type, and was developed by join research team of university of Glasgow and the Iranian Research Organization for Science and Technology (IROST) and obtained an efficiency of 62%. With slight modification in Kaplan type to Agnew Turbine resulted 23% higher efficiency [8]. In Francis Type Turbine in small hydro system with medium head an efficiency of about 90% can be achieved, while in smaller heads lower efficiencies have been reported [9].

Distribution of electricity from small hydro units, resulting Power losses, Voltage Profile, Power Quality, Excess Voltage, Voltage Fluctuation and Reliability are the major problems that need to be properly investigated. The Power Losses depend on consumers distance from distribution load Centre of the generating units. These are further divided into two classes' higher reduction of losses and small reduction of losses. In voltage Profile are usually changing at substation transformer by use of voltage regulator and capacitor on the feeder [10]. Power Quality depends on ideal Sinusoidal voltage and current wave form in which current and voltage should in balance [11, 12]. To protect system from degradation in power quality it is important for network operator to minimize short circuit capacity. In Excess Voltage cause the voltage profile of feeder lines to deviate from the desired range [13-17]. While voltage fluctuation in the main distribution system resulting the relative fluctuation in the local lines system. Hence the voltage output changes with short time and this fluctuation cause over or under voltage at the end point of the customers [12, 18-19].

The factors that could affect the power generation of a MHPP are Amount of water flowing in specific time (Water Discharge), the height of water fall (Available Head), Overall Efficiency (Turbine, Drive system, Generator) and Losses (Headrace to End users).The losses that affect the power generation and efficiency of the MHPPs are the channel losses, Penstock losses, Turbine losses, Generator losses, Transformer losses and transmission line and distribution losses [20], H is the available head (meters) and Q is the water flow (m3/sec).

In Pakistan, a significant number of Micro hydro power plants (MHPs) have been installed for provision of electricity to remote rural communities by government and non-government organizations during the last few decades. The cross-flow turbines are commonly used in these MHPs. Out of theses, 20 number of MHPs were selected for detail study during 2019-2020 in which cross flow turbines were used. This research study was conducted to evaluate the performance of MHPs in District Shangla of Khyber Pakhtunkhwa, Pakistan.

II. Research Methodology

A. *Study Area:*

The study was conducted in District Shangla of Malakand Division of Khyber Pakhtunkhwa, Pakistan. The total geographical area of District Shangla is about 1586 km2, population of 757,810 with total number of Households 64,391, about 8 person per household and consists of three sub division Alpuri, Puran and Besham. Water resources in the district depends on rains and snow. There are about 248 small snow glaciers. The average flow discharge of Shangla river before the water enter into the Khan Khawar dam is about 35 m3/s.

Figure 1: Location map of District Shangla (Adopted from Wikipedia)

The water resources are depending on the snow and rain. The annual rainfall is approximately 1,416 mm and snow seasons about 1 to 2 m snow is falling which is the main source of the water and it is used for the domestic, agriculture and also for the hydro power generations in shown in “Figure 1”.

B. *Data Collection*

In District Shangla significant number of micro hydro power have been installed by government and non-government organizations during the last decade. Out of these 20 number of micro hydro power were studied in detail is given in “Table 1”.

A structured questionnaire was developed to collect technical data related to micro hydro power installed at different locations in District Shangla as well as detail information from concerned stakeholders related to number of households served, number of poles ,distance between the poles, number and types of energy usage, number of operation hours per day, date of installation, major maintenance problems, size of penstock pipes, total head , types of turbine, year of installation, power generation, the losses in power generation and distribution, development of models for power generation at various operational conditions and the optimum power generation efficiency.

C. *Potential Power (Pn)*

For assessment of power generation data related to head and flow discharge, information related to type of turbine, year of installation, potential power produced on the basis of net head and actual power produced data was collected and recorded. Flow discharges were determined through a current meter and head was assessed through GPS and was verified by appropriate surveying equipment. The net head losses were determined from Bernoulli’s equation. The potential power that can be generated is given by equation as follows:

$$\mathrm{Pn} = \rho \times \mathrm{g} \times \mathrm{Q} \times \mathrm{Hn}$$

Where Pn is the potential power in watt, ρ is the density of water in kg/m^3, g is the gravitational constant m/s^2, Q is flow rate in m^3/s and Hn represents the flow net head in m.

D. *Actual Power (Pa)*

The actual power produced was computed from the current and voltage recorded at the output panel of each MHP. The actual power produced by MHP is given by equation:

$$Pa = 1.73 \times V \times I \times cos\phi$$

Where Pa is the actual power produced in watt (W), V shows the voltage and I represent the current in amperes which were determined in the field through digital Multimeter, clamp meter and cosϕ is the power factor taken as 0.8.

E. *Overall Efficiency ((η$_o$)*

The overall efficiency (ηo) of MHPs were determined from actual power (Pa) recorded divided by potential power (Pn) that can be produced by using the following equation:

$$\eta_0 = \frac{Pa}{Pn} \times 100$$

F. Losses in Power Generation and Transmission Line

The power produced at source was found from the voltage and current then at consumers (household's level) the voltage and current were also recorded as well as the type of wire, thickness and length of the wires to find the losses in power generation and transmission in the systems.

G. Data Analyses

The installed capacity of the MHPs studied ranged from 15 to 50 KW with average of 29.45 KW and with coefficient of variation of 36.01 %. At the site, the available head ranged from3.35 to 19.81 m with overall average of 9.63 ±4.92 m. Accordingly net head varied from 3.20 to 19.80 m with overall average of 9.05±4.90 m. The flow rate varied from 0.070 to1.252 m^3/s with overall average of 0.544±0.283 m^3/s during the months of July and August, 2019. The Consumers' Power demand per household in the studied area ranged from 524 to 2637 watts with overall average of 1420±474 watts and coefficient of variation of 33%. The number of Households varied from 15 to 250 with overall average of 88±55 per Micro hydro power plant installed at the site is shown in "Table 1".

The total length of transmission lines per MHPPs ranged from 2.286 to 7.315 km with overall average of 3.918±1.537 km and coefficient of variation of 39.221. The power produced at generation points varied from 8.496 to 48.574 KW with overall average of 25.782±11.971 KW and coefficient of variation of 46.43%. The total transmission line loss in MHPs studied varied from 0.08 to 1.84 KW per km with overall average of 0.71±0.58 per km and coefficient of variation of 81.16%.

TABLE I. SELECTED PARAMETERS OF MHPS

S. No	Name of the MHP	Capacity (KW)	Flow Rate Q(m^3/s)	Gross Head (m)	No. of House holds	Demand per Household (Watt)	Total Length of TL (km)
1	NAWAZABAD	30	0.458	7	60	1158	2.74
2	MATTA AFGHAN	30	0.500	5.58	60	1783	4.11
3	KHWARAH KALLI	25	0.155	14.8	62	1218	2.74
4	KUZZ KANA	30	0.619	3.96	124	1131	5.49
5	KUZZ KANA	35	0.619	4.57	133	524	7.31
6	RANEZO	30	1.252	3.96	100	953	4.94
7	BAR KANNA	25	0.790	4.82	30	1885	4.39
8	BAR KANNA	25	0.790	4.82	30	1911	2.74
9	CHORBUTT	15	0.070	19.81	50	1493	2.29
10	AJMAIR BARAI PIR KHANA	40	0.672	11.58	160	889	6.40
11	LARAI AIMAL KHAN	20	0.640	10.06	45	2637	4.21
12	LANDAI KUZ PIR KHANNA	20	0.097	18.29	15	1431	2.74
13	TAUHEEDABAD LINOWNAI	25	0.389	13	80	1342	2.93
14	SAKHI ABAD BASI	16	0.340	3.35	60	732	2.47
15	MATA AGHWAN	24	0.322	13.72	80	1812	2.74
16	BAND KHWARGAE	25	0.359	9.75	150	1500	2.74
17	BAND KHWARGAE MEERABAD	50	0.720	9.14	250	1425	5.49
18	DHERIA KAGADAN	50	0.742	14.32	80	1611	5.94
19	DHERIA KAGADAN	50	0.559	9.14	100	1419	3.66
20	PHOSTANO SHELAWAI KUZZ KHANNA	24	0.790	10.97	90	1547	2.29
Maximum		50.00	1.252	19.81	250	2637	7.315
Minimum		15.00	0.070	3.35	15	524	2.286
Average		29.45	0.544	9.63	87.95	1420	3.918
STD		10.61	0.283	4.92	54.99	474	1.537
CV (%)		36.01	52.053	51.12	62.52	33.00	39.221

III. Results and Discussion

A. Actual Power and Flow Discharges

The relationship between actual power produced and flow discharges of 20 MHPs studied is shown in “Figure 2”. It can be seen from the figure that a significant positive correlation was found between actual power produced and flow discharges. In general, the actual power produced increased with flow discharges from 0.070 to 0.800 m3/s beyond that the actual power did not show any significant increase with flow discharges. It can be concluded that flow discharged beyond 0.800 m3/s. may not significantly increase the actual power of cross flow turbine which is in conformity with other researchers [21].

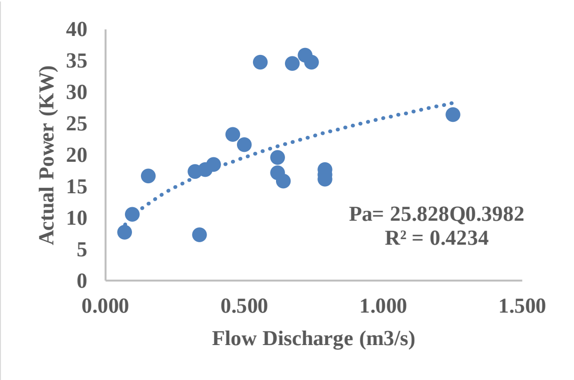

Figure 2. Relationship between actual power and flow discharges

B. Actual Power and Net Head

The relationship between actual power and net head of flow is shown in “Figure 3”. A significant correlation was obtained between actual power and net head of R2= 0.3442. It is obvious from the figure that the maximum actual power that can be produced by using crossflow turbine with the net head of about 10.0 m.

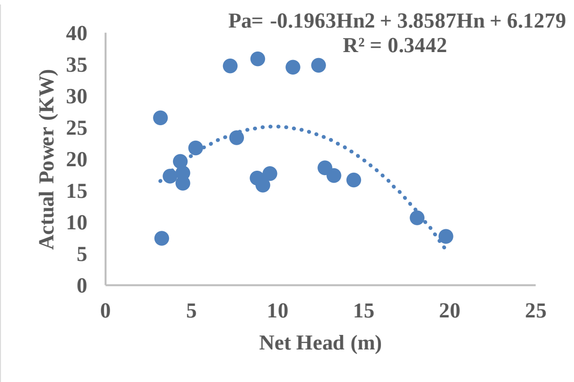

Figure 3. Relationship between actual power and net head.

If the net head is lower or greater than 10 m relatively lower actual power was produced. Similar results were reported by other researchers who found that crossflow turbine is suitable for medium and low head, which is less than 10 m [22].Therefore, it can be concluded that maximum actual power can be produced from crossflow turbine the net head should be in the vicinity of 10 m and net head over or below that range may not produce optimum power.

C. Potential and Actual Power

“Figure 4”, shows the relationship between actual and potential power. A significant correlation was obtained between actual power and Potential power with R2= 0.6064. The potential power that can be generated by using the available flow and net head ranged from 11.00 to 90.20 KW with overall average of 39.65±21.15 KW with coefficient of variation of 53.33%. The actual power produced by MHPs at the sites ranged from 7.34 to 35.88 KW with overall average of 20.55± 8.67 KW and coefficient of variation of 42.22%.

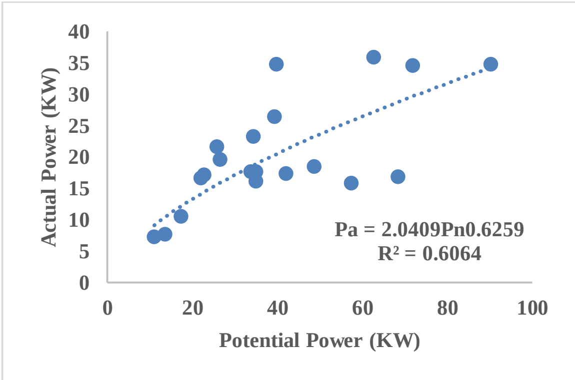

Figure 4. Relationship between Actual power and Potential Power (KW)

D. Actual Power Produced and Generator Capacity

The actual power produced and generator installed capacity is given in “Figure 5”. It can be seen from the figure the significant correlation (R2=0.9023) was found between the installed capacity and actual power produced. It can be concluded that all the generator installed produce relatively better efficiency as desired.

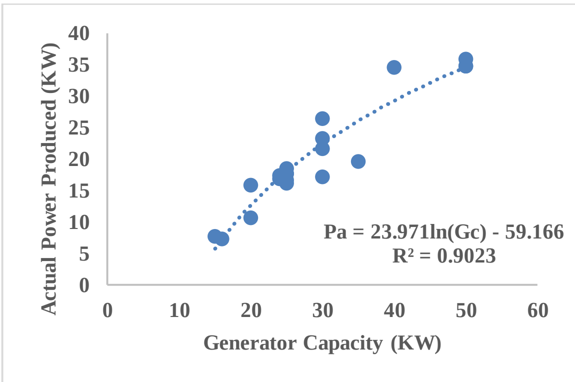

Figure 5 Relation between Actual Power Produced and Generator Capacity (KW)

E. Overall Efficiency (□o)

The overall efficiencies of the MHP’s studied are given in “Figure 6”. It can be seen from the figure that the efficiencies ranged from 24.76 to 87.31 with overall average of 57.61± 17.95 and coefficient of variation of 31.40%.

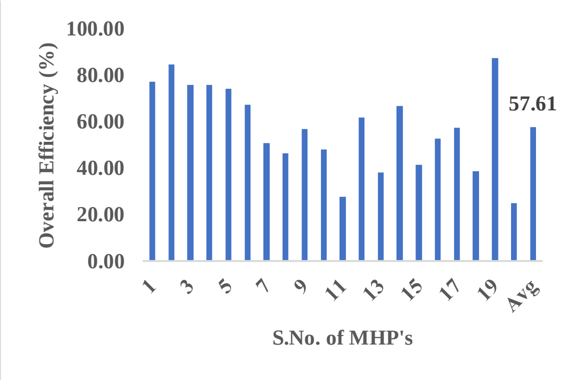

Figure 6: Efficiency of MHPPs

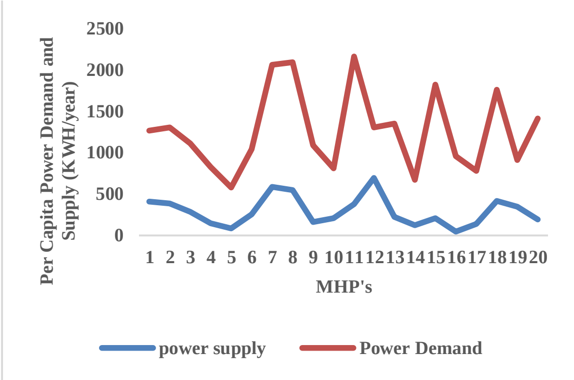

Figure 8. Annual Power demand and supply of MHPs

Further all MHP’s were divided into two groups. Based on their performance, in Group-1 MHP’s with overall efficiency of greater ⩾50% were placed, while in Group-2 consisted of MHP’s with overall efficiency of less than <50% is shown in “Figure 7”. A Statistically significant difference was found between two groups as per T-Test. In Group-1 the overall average efficiency of 67.56±11.63%. As compared to Group-1, The overall average efficiency of Group-2 was significantly lower (37.80±8.79%) then Group-I. Some of main reasons for low overall efficiency of MHP’s of Group-2 were the turbine and generator units were not proper design as per site requirements. By proper designing and replacement of turbine and generator in Group-2 as per site requirements, the generation’s capacity of the MHPs can be enhanced by one-third.

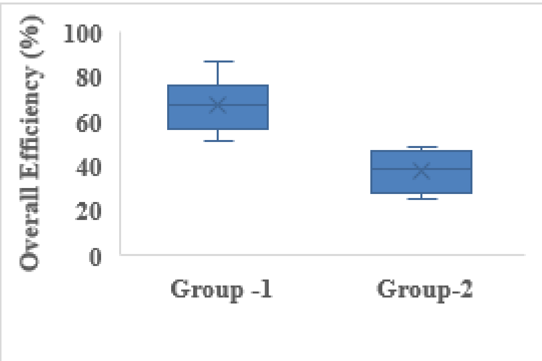

Figure 7: Comparison of overall efficiency of different groups

F. Annual Power Demand and Supply Per Capita

The annual power demand and supply per capita of different MHPs is shown in “Figure 8”. The annual power demand per capita of community being served by the MHPs ranged from 574 to 2166 KWH with overall average of 1265±487 KWH. On the other hand, the power supply per capita per annum varied from 42 to 694 KWH with overall average of 291±176 KWH. It can be seen from a “Figure 8” the demand is four folds more than supply. As compare to the annual average consumption per capita in Pakistan of 448 KWH reported by World Bank, 2018. The annual energy consumption in the study area was about half of the electricity used in Pakistan.

Conclusions

The actual power produced increased with flow discharges from 0.200 to 0.800 m3/s beyond that the increase was relatively low. Maximum power can be produced by using cross flow turbine with the net flow head of about 10.0 m beyond or below that head the power produced was lower. A significant correlation was obtained between actual power and potential power, which means that most of MHPs were working according to the design. For the cross-flow turbine a better efficiency was obtained when the flow discharge ranged between 0.6 to 0.8 m3/s. The overall efficiencies of twenty MHPs were found to be 57.61± 17.95%. The annual per capita power demand was four folds more than the energy supply. The micro hydro power plays an important role in energy demand of rural remote areas and should be encouraged.

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Analysis of Mechanical Properties of Carbon Fiber Reinforced Concrete based on Ansys Composite Model

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***Abstract*— In order to study different carbon fiber contents and it's influences on mechanical properties of concrete, ANSYS materials composites were synthesized to carry out numerical simulation. Here are the results of numerical analysis: The addition of carbon fiber composite can greatly improve the compressive strength of concrete. Among them, the mechanical properties of concrete with 1% carbon fiber content and 2% carbon fiber content are basically the same, but there is no clear improvement in flexural performance. Therefore, the enhancement of mechanical properties of concrete by fiber is closely related to its content. The study of the change between them can effectively reduce the loss of fiber, but also conducive to the promotion of fiber reinforced concrete.

Keywords— Composite Material Model, Fiber Content, Concrete, Compressive and Flexural.

I. Introduction

In recent years, with the rapid development of civil engineering, the social demand for materials is increasing, especially in light weight and high strength, so many carbon fiber composites have been developed and applied in life. the basalt fiber performs better than polypropylene fiber in terms of flexural strength[1-3] ; while carbon fiber performs best, researchers has found that in terms of bending performance, polyvinyl alcohol fiber Better than polypropylene fiber [4-8]. Fiber content has an iMPact on the mechanical properties of concrete; Cai Na's research shows that when the content of polypropylene fiber is in the range of 1.2% to 1.6%, the compressive strength decreases [9-13]; Fang Shengen's research shows that when the content of glass fiber is 0~ When the content is between 20%, the compressive strength of concrete increases with the increase of the content, and the strength decreases when the content exceeds 20%. Research by Li Kun et al. has shown that the compressive and flexural strength of concrete increases with the increase of the content of basalt fiber [14-16]. Fiber type, content and dispersion will affect the mechanical properties of foam concrete. In order to further analyze the mechanical properties of fiber concrete, this paper analyzes the compressive and flexural properties of concrete with different carbon fiber content through Ansys software based on previous research. the study.

II. Subjects

Through the material design function of material in the ansys software, analyze and design non-doped concrete, composite concrete with 1% carbon fiber content, and composite concrete with 2% carbon fiber content. The basic physical properties are determined as follows through the performance analysis function in materials：

TABLE I. Basic physical properties of the test materials

Materials	Elastic Modulus MPa	Poisson's Ratio	Shear Modulus MPa	Density kg/m^2
Carbon Fiber	2.3e5	0.2	9000	1800
Concrete	3e4	0.18	1.27e4	2300
Carbon fiber concrete （1%）	33979	0.18	12627	2290
Carbon fiber concrete （2%）	35956	0.181	12536	2285

By synthesizing different amounts of concrete, it can be found that the elastic modulus changes greatly with the increase of the carbon fiber content, and the density shows a downward trend due to the lower carbon fiber density, Poisson's ratio and shear modulus The change is minor.

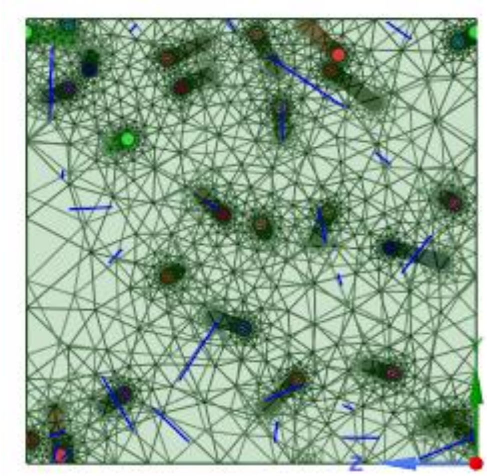

Figure 1. 1% carbon fiber composite concrete

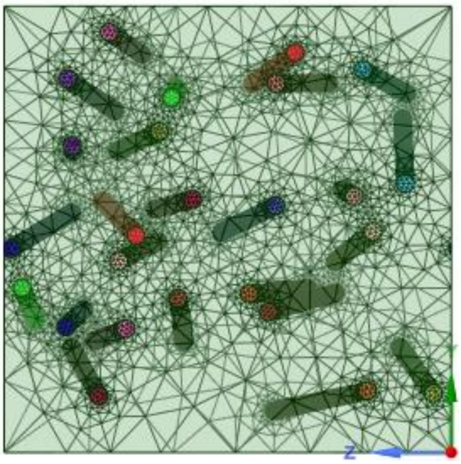

Figure 2. 2% carbon fiber composite concrete

III. ANSYS ANALYSIS

Computer simulation technology is increasingly used in the field of material design. When the experiment is relatively troublesome and the cost of the experiment is high, the use of numerical analysis for pre-analysis can improve the success rate of the experiment. Numerical simulation mainly uses a set of control equations (algebra or Differential equations) to describe the change relationship of the basic parameters of a process, and use numerical calculation methods to solve in order to obtain a quantitative understanding of the process (or a certain aspect of a process), and perform dynamic simulation analysis on the process, and judge on this basis The pros and cons of the process or plan, predict defects, optimize the process, etc. The basic feature of the numerical simulation method is to discretize the solution domain of the boundary value problem of differential equations, and reduce the original requirement to satisfy the field equation everywhere in the solution domain and the analytical solution that satisfies the boundary conditions everywhere on the boundary. The numerical solution of a set of algebraic equations derived from the field equations and boundary conditions at a given discrete point (node).

A. Numerical analysis of compressive strength based on ANSYS

Analyze the compressive strength of the 150mm*150mm*150mm standard test piece of composite concrete design synthesized by ansys materials, fix the bottom surface of the test piece, and monitor the points in the test piece, as shown in the figure below：

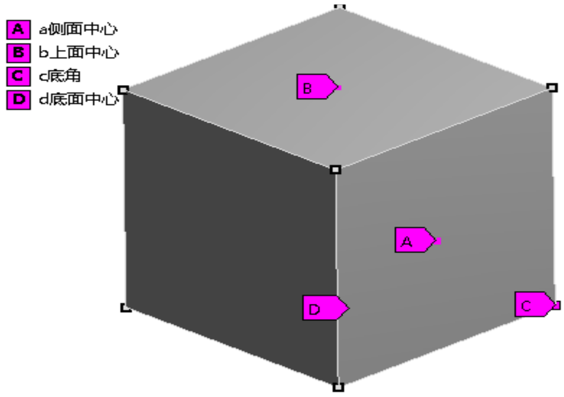

Figure 2. Monitoring point of the test piece

This test adopts transient dynamics design to facilitate the observation of the strain changes of each monitoring point during the force process.

Experimental design: Apply 0.2MPa pressure to the top surface for 100s. And ensure that the grid meets the grid independence.

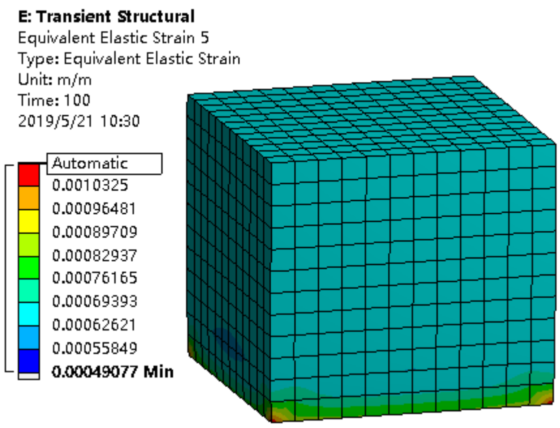

Figure 3. The compressive strain cloud diagram of the specimen

Figure 3 shows the strain of the specimen during the compression test: it can be found that the specimen has the largest strain at the four vertices of the fixed surface. In order to study the influence of different fiber content on the stress-strain curve of concrete, by analyzing the carbon fiber concrete specimens with 1% fiber content and 2% fiber content when no fiber is added, the stress-strain curve of the monitoring points is observed as shown in Figure 4 Shown：

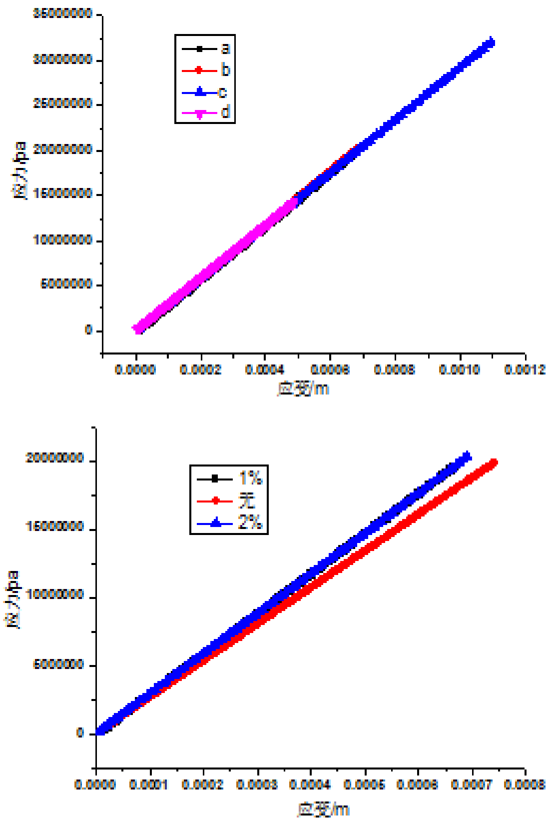

Figure 4. The stress-strain curve of the monitoring point under the 1% content of the compression test and the stress-strain curve of the same monitoring point with different content.

Through the stress-strain curves of different monitoring points of the same test piece and the same monitoring point of different materials, it can be found that the stress-strain curves of each monitoring point of the same material are basically the same, although the stress conditions are different. CoMPared with the addition of fibers, the compressive strength of the case without fiber is significantly increased, but there is no obvious change under the fiber content of 1% and 2%. Therefore, when making fiber concrete, special attention should be paid to the fiber content to prevent Under the condition of meeting the compressive strength, unnecessary material waste is caused.

B. Analysis of flexural strength test based on ANSYS

During the transient dynamics test, a 150mm*150mm*550mm specimen is used, one end is fixed and restrained, and the other end is applied with 0.2MPa pressure for 100s. The test meets the requirement of grid independence, and two monitoring points are selected as shown in the figure below :

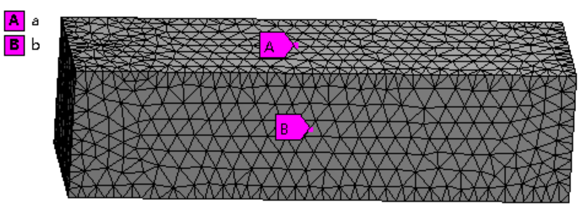

Figure 5. The flexural test grid and monitoring points

Obtain the following flexural strain cloud diagram：

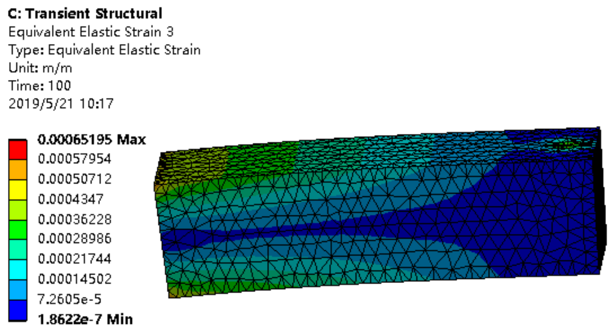

Figure 6. Strain cloud diagram of flexural test

The flexural strain cloud diagram shown in Figure 6 shows that the strain in the middle part is small and the strain on both sides is relatively large. In order to further understand the changes of the specimen under the action of continuous pressure, the stress-strain curve of a and b in the specimen is monitored, As shown below：

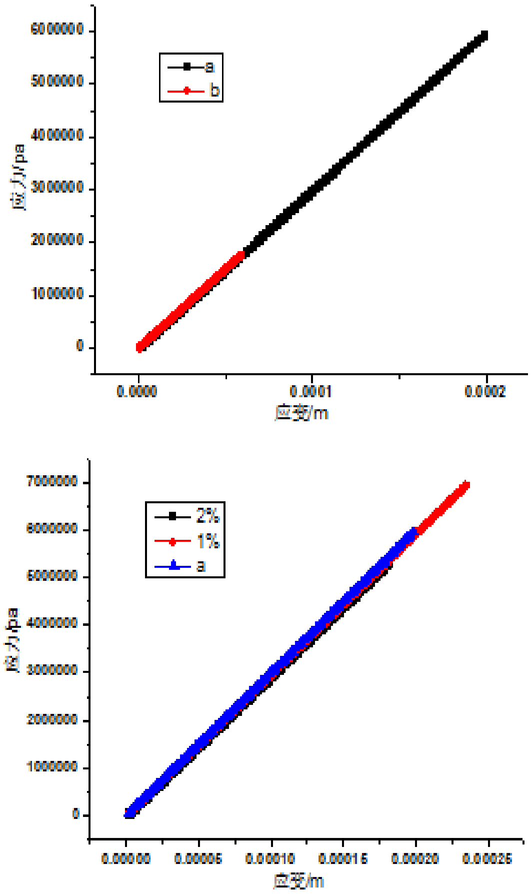

Figure 7. The stress-strain curve of the monitoring point under the 1% dosage of the flexural test and the stress-strain curve of the same monitoring point with different dosages.

It can be seen from Figure 7 that the stresses experienced by the monitoring points of the same specimen may be different, but the stress-strain curves are basically the same. At the same time, the same monitoring point is selected for the different content of concrete, and it can be found that the concrete specimens with different fiber content are The change in flexural resistance is not obvious.

IV. Discussion

The study found that the concrete with different fiber content showed different mechanical properties, while the mechanical properties did not show a certain relationship, and at the same time, there was no reinforcement in the direction of flexural strength, which is basically the same as that of Li Jingjun and Wang Jianchao [12-16] The research results are similar, mainly due to the structure of concrete itself. In the theory of compound mechanics, carbon fiber concrete is regarded as a fiber-reinforced system. The stress, elastic modulus and strength of carbon fiber concrete are calculated based on the mixing principle. According to the distribution and orientation of the fiber in the fiber matrix, the fiber direction coefficient is introduced, and the correct selection of the fiber direction coefficient is one of the main factors that determine the fiber reinforcement effect. In the theory of fiber spacing, it is based on the principle of linear elastic fracture mechanics to explain the effect of fibers on the generation or suppression of concrete cracks. Concrete is a brittle material. Therefore, if you want to enhance its mechanical properties such as bending resistance, compression resistance, and tensile resistance, you should start with the fiber distribution direction. After carbon fiber is added in multiple directions, the viscous stress between the fiber and the two sides of the concrete crack will affect the cracked concrete. Expansion has an inhibitory effect and increases its power.

V. Summary

In this paper, the following conclusions can be reached by analyzing the compression test and flexural test of concrete with different fiber content:

(1) In the compressive test: when the fiber is added, the compressive performance of the concrete shows an enhanced effect, but the fiber content continues to increase and there is no better effect, so the addition of fiber to the concrete will have a peak.

(2) In the flexural test: the effect of the concrete specimen after adding the fiber is the same as the flexural effect of the fiber-free concrete specimen, so the carbon fiber cannot enhance the flexural resistance of the concrete.

(3) In order to analyze the reinforcement mechanism of fiber concrete, the fiber distribution direction should be considered and the discrete element method should be used to further study its mechanism.

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Analysis of Health of Transformer using Different Loading Conditions

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***Abstract*—**Transformer is one of the most crucial and expensive part of the power system. Any failure in its components may cause major loss to the economy of a country. The healthy operation of the transformer actually ensures the reliable and secure operation of the power system. Keeping in mind the importance of the transformer, this study mainly focuses on the online health monitoring of the transformer in order to detect the fault in its initial stages. This study provides cost effective, real time online monitoring system for the health of the transformer. Real-time data of the transformer is recorded through phasor measurement unit (PMU). Signal to noise ratio (SNR) of voltage and current of the transformer has been calculated. The width of signal to noise ratio is employed as an indicator for the occurrence of fault in the transformer. When transformer operates in its normal conditions the width of SNR band is small, when fault occurs in the transformer the width of SNR band starts to increase. As fault in the transformer continues to increase the width of SNR also increases. Thus this technique can help the transformer operators to take significant steps in order to mitigate the fault before major accidents.

Keywords: Signal to Noise Ratio (SNR), Health Monitoring, Transformer and Phasor Measurement Unit (PMU).

I. INTRODUCTION

A power grid is a potent being, and its health needs to be monitored at all times. Transformer plays vital role for the reliable and continuous operation of the power system. Therefore, transformer is one of the most significant constituents in the power grid. Its condition has the major impact on the stability of the power grid. . Large power transformers are complex in design and operation. Transformer condition monitoring and assessment of their remaining life is most salient task for transformer operators. Transformer condition monitoring covers many areas closely related to transformer structure and operation. The condition of the insulation system contributes significantly in deciding the life span of a transformer. Similarly, winding/core integrity, bushing, and tap changer health are also important in maintaining the overall reliable operation of a transformer [1].Transformers can transfer the required electricity to the residential, commercial and industrial areas to fulfil the electricity consumption demand. But overloading of transformer can significantly affect its health which may result in the instability and outage of the power system and multiple monetary losses to the distribution companies. The transformer failure could affect major equipment of the interconnected power subsystems and, thereby, cause switching off of the latter by means of relay protection [2].Like other parts of power system, many different types of faults also effect the health of the transformer. As a result of these faults serious economics losses are faced by the consumers, it also greatly impact the social conditions of a country. Hence effectual and accurate fault analysis and health monitoring should be done in order to detect the fault, monitor the transformer health and to remove the associated affects to the lowest possible level.This study will mainly focus on the distribution transformer and it will develop the more accurate, cheap and efficient monitoring method for the health of the transformer on the basis of different load change. If the distribution transformers are operated under the normal conditions for which they are designed for, then they have long life span.

Figure 1 Faulted pole top Transformer

However, their life span eventually decreases if they are overloaded and operated in under abnormal conditions resulting in unexpected failures and loss of electrical power supply to a greater number of consumers which may affect the overall system reliability and efficiency. Transformer overloading and un-necessary cooling are the main aspects for the internal damages and failure in the distribution transformer. Explosive failure may occur due to the re-energizing of the pole top transformers that contain an undetected internal fault which is very dangerous to human life. Such event is shown in the Figure 1 [3].

In Pakistan, the transformers are monitored physically by a lineman but this monitoring is not scheduled due to which proper data is not present. This type of monitoring cannot give data about over-loading, overheating of transformer oil and windings or any internal fault. Neither can it give any indication about the health of transformer. Every one of these variables can essentially decrease transformer life [4]. These parameters greatly affect the health of transformer and thus causes many financial losses. Therefore, there should be a system that can provide an indication about the health of the transformer, so that the operators can be able to take quick actions before the occurrence of any major accident. This can assist in extending the life and performance of the transformer. Transformer has the most important place in the electrical network. It is the expensive equipment in power industry, any inadequacy in transformer can result in life long interference and repairing of the transformer components are costly and very time-consuming. Hence as an important part the study of the faults and failures of the transformers is also very important. Therefore, the purpose of this research study is to propose a stable, reliable and less time consuming real-time health monitoring system, analyse all the operating parameters of the transformer i.e. voltage and current and to detect any internal abnormal conditions in its initial stages. This will help to identify problems before any major failure or accidents which can results in significant cost savings to the distribution companies and ensures greater reliability to the consumers. In this study an online monitoring of the main operational parameters i.e. voltage and current of the transformers will be provided that will give useful information about the health of the transformers. And also this study will provide the technique that can save the transformer from serious failures because on the bases of the information alert alarms can be used for the predictive maintenance of the transformer. This will also help the consumers to make best use of their transformers and keep it in working condition for larger duration. Power transformers provide a connection between the generation and distribution of produced energy. Such static equipment is subjected to different types of disturbances during operation in generation and distribution stations and thus it can lead to catastrophic failures [5]. Power transformer occupies almost 60% of the total investment that's why it is one of the most complex and costly units of power system. Due to the complexity and expensiveness of transformer components, proper monitoring and maintenance of transformer components are the important tasks in the field [4]. Transformers can transfer the required electricity to the residential, commercial and industrial areas to fulfil the electricity consumption demand. But overloading of transformer can significantly affect its health which may result in the instability and outage of the power system and multiple monetary losses to the distribution companies. During transformer operation, they are continuously open to thermal, mechanical and electrical stresses. Environmental disturbances also effect the transformer operating conditions because transformers are open to unpredictable conditions that they are not designed for [6]. Thus researches should be done to perform effective and suitable fault analysis and health monitoring techniques in order to analyse all types of transformers, detect all types of faults in the transformer and diagnose their respective effects on the consumers and the economy.

A. *Phasor Measurement Unit (PMU)*

It is the instrument which is used in the electrical grid to measure different electrical quantities like voltage, current and frequency. For synchronization PMU uses a similar time source. GPS mostly provide the time synchronization which helps to measure synchronized real time values of electrical quantities. Voltage and current signals can be measure with the help of potential transformers PTs and current transformers CTs in the power system but using PMUs can provide voltage magnitude and phase angle, current magnitude and phase angle and frequency. Particularly high transient goals can be achieved by using PMU, in the order of 30-60 estimations for every second. This helps in examining the unnecessary events in the power system. This type of benefits are not possible when Supervisory control and data acquisition (SCADA) is used in the grid that create one reading after 2 or 4 seconds. The data which is given by PMU is further used in order to take different control actions. The reporting rate of PMU is quite fast and for the system of frequency 50Hz and 60Hz its reporting rate is presented in the table 1 below [7].

B. *Transformer Health Monitoring*

Transformer is a very important component in the power system. It provides the connection between the generation and the customers. Now a days, transformers are present in wide area therefore, health monitoring of transformer has become a serious problem. Because transformer is exposed to the environment which effects its various properties such as thermal, electrical and physical properties. As the greater number of transformers are present in power system manual monitoring has become impossible for the operators of transformer. Therefore, many techniques have been developed for the online monitoring of transformer so that it can be prevented from any catastrophic failure that causes major damage to the customers and distribution companies.

There are many diagnostic tests and condition monitoring techniques employed for the analysis of the health of the transformer. The main parts of the transformer like Tap-changer, bushing, winding Integrity, paper and oil Insulation and Magnetic circuit, require good condition monitoring methods for their reliable operation.

II. METHODOLOGY

The detailed methodology for monitoring system of the transformer in real time is proposed in this paper. This study is actually based on programming of real time data provided by PMU using MATLAB programming. PMU is connected with transformer at Sheikh Muhmandi grid station in Peshawar. PMU provides magnitude of voltage, phase angle of voltage, magnitude of current, phase angle of current, frequency and power of the transformer at a very high rate usually 60 cycles per second. Using this data a technique is developed to monitor health of transformer at low cost and with less time consumption. Signal to noise ratio (SNR) based technique is used to monitor health of transformer. With the help of real time

PMU data healthy and unhealthy conditions of transformer are observed by calculating the signal to noise ratio of magnitude and phase of voltage and current of the transformer. Band of SNR is observed which clearly shows the difference between healthy and unhealthy conditions of transformer.

A. *Signal to Noise Ratio (SNR)*

The definition of SNR which is used in this study is the reciprocal of coefficient of variation i.e. the ratio of mean of a signal to the standard deviation of a signal [4].

$$\text{SNR (in dB)} = 10*\log \frac{\mu}{\sigma} \qquad (2.1)$$

In Eq. 2.1, μ is the total mean of a signal or expected value while σ is the standard deviation. It is very tough to observe different signals provided by PMU (i.e. currents (A) and Voltages (V)). However, SNR (in dB) is a relative criterion and therefore, it can be employed to compare different signals and generate signals for awareness [4].

TABLE I. PARAMETERS OF 3 PHASE TRANSFORMER

Parameters	Values
Rated voltage	12KV
System voltage	11KV
Frequency	50 Hz
Maximum current	653 A
Rated capacity	13 MVA

III. RESULTS & DISCUSSION

Different results have been obtained with the help of the data provided by PMU. At first the raw data was plotted and then signal to noise ratio was observed using this data.

A. *Results of Raw Data of PMU*

Data is collected from the transformer in the form of current and voltage. Figure 2 and Figure 3 shows the magnitude and phase of 3 phase current obtained through PMU. Figure 4 and Figure 5 shows the magnitude and phase of 3 phase voltage.

B. *Signal to Noise Ratio of Current Mangnitude*

At first the SNR of current magnitude was calculated as it gives clear indication of fault in the transformer. The variation in the value of SNR is shown in figures 6, 7, 8 below reflects the occurrence of fault in transformer.

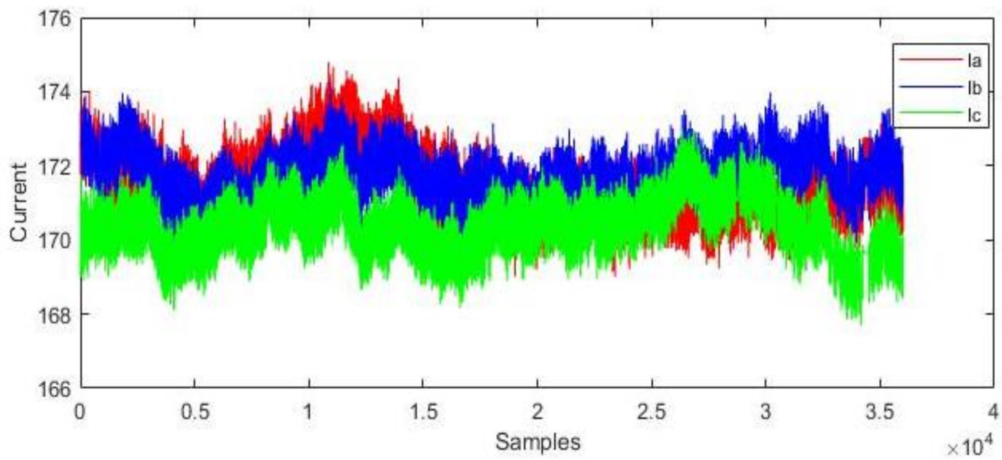

Figure 2: 3 phase current magnitude

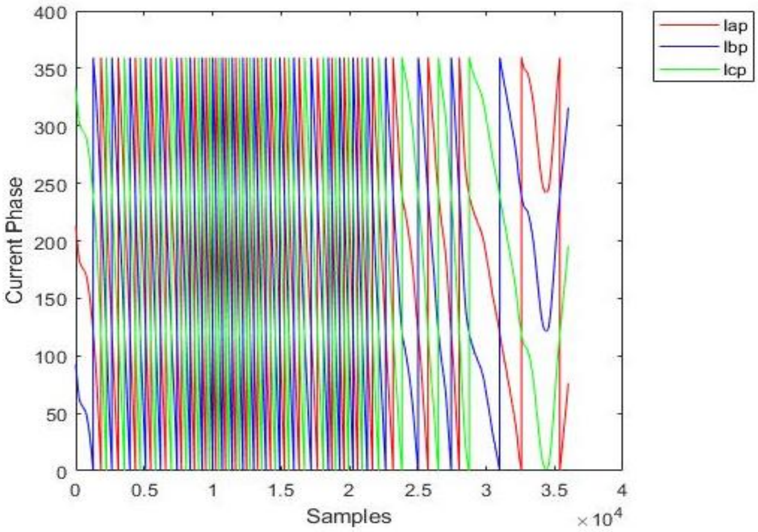

Figure 3: 3 phase currents phase angle

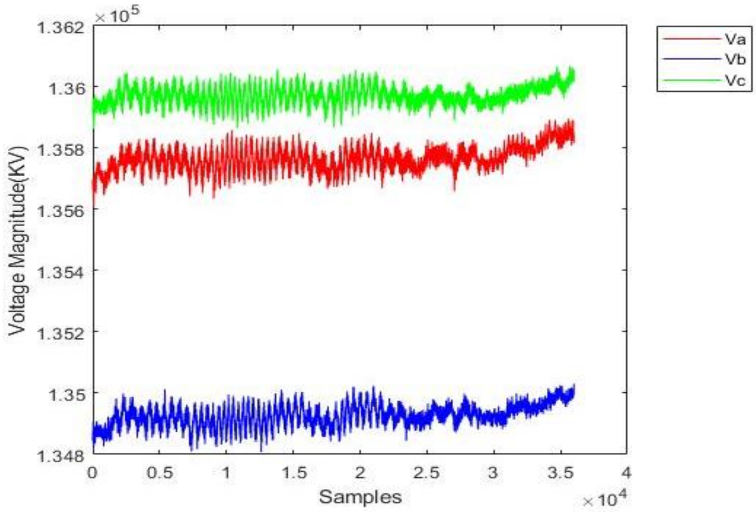

Figure 4: 3 phase voltage magnitude

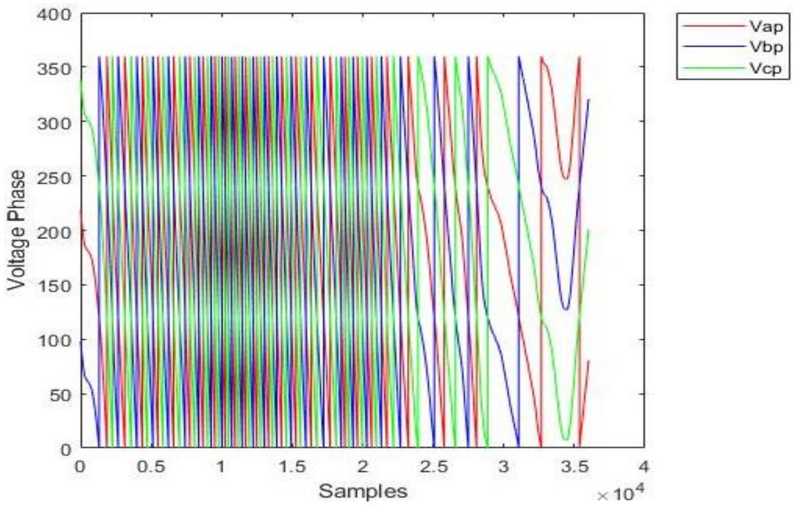

Figure 5: 3 phase voltage phase angle

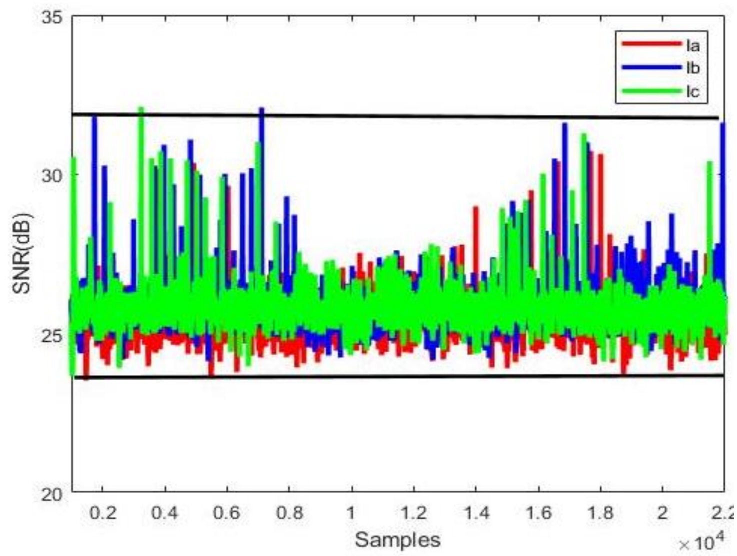

Figure 6: SNR of Transformer current (I) samples 1-22000

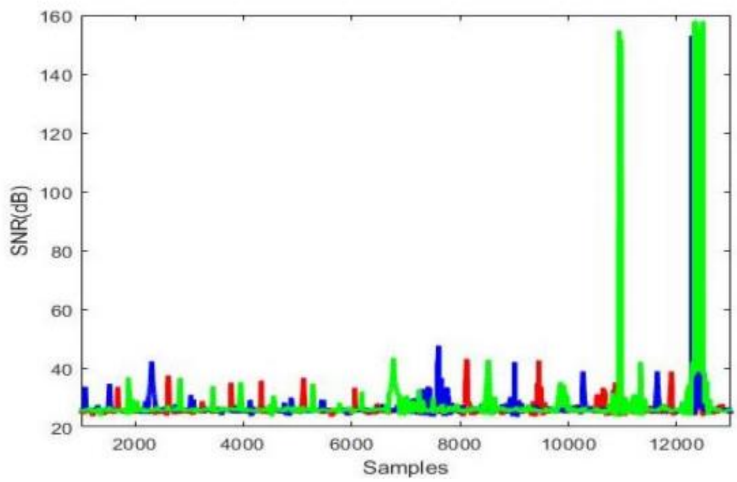

Figure 7: SNR of Transformer current (I) samples 22000- 35000

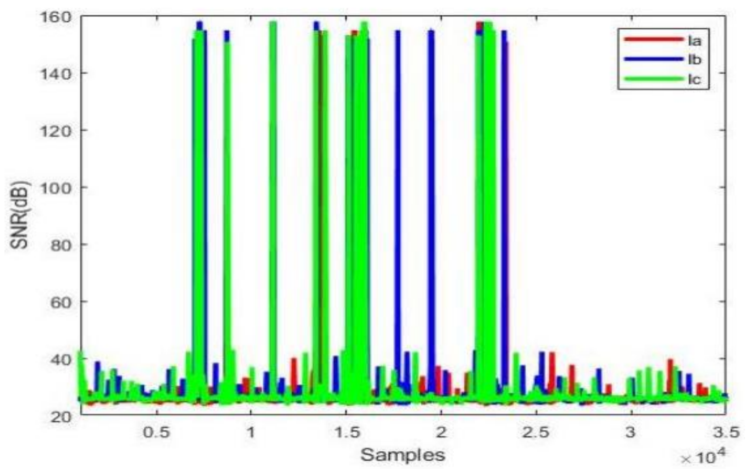

Figure 8: SNR of 3 phase current (increase in phase A)

From figure 6 – figure 7 it was observed that some abnormal power system event has occurred because the value of SNR of current magnitude was first varying from 25 dB to 31 dB when 22000 samples were analysed after that from samples number 22000 to 35000 the value of SNR was not same as before, it increases as fault started to grow. The increased value of SNR for sample number 22000 to 35000 can be seen in fig 7. As the data continues in sheet 2, the value of SNR of that data was also analysed and it was observed that fault continues to grow causing the increase in the value of SNR of phase A as shown in figure 8. And the value of SNR for phase B and C is still high which depicts the existence of fault in all the three phases. Consequently, if fault in transformer grows with time and it is not monitored properly, then the value of signal to noise ratio (SNR) of voltage and current of transformer also continues to increase.

CONCLUSION

Direct observation or analysis of raw current magnitude, angle, real and imaginary components did not give any conclusive indication regarding the nature or occurrence of any power system event (or deterioration of health of an asset).With the help of SNR it is concluded that as the fault increases in transformer the value of SNR of all the phases of transformer also increases. We can also conclude that as the transformer reaches to failure the value of SNR or SNR width increases. By continuously monitoring the real time data of transformer and analysing its signal to noise ratio width we can easily predict the health of transformer. If the value of SNR remains constant it means that transformer is working in normal conditions but if continuous increase in the value of SNR is observed, then this is the indication of poor health of transformer which tells the operator to do predictive maintenance of transformer before the occurrence of any unnecessary power system event. Thus this technique can prevent major transformer failure and ensures reliable operation of power system.

FUTURE WORK

Many researchers have done researches for the health monitoring of the transformer to increase the life of a transformer using different techniques that includes the use of different sensors and controllers. But these methods are sometimes slow due to the slow output of a sensor. Before this study to get real time data of the transformer was not possible in Pakistan. This paper has mainly focused on the online monitoring of the transformer to find the optimal results which should be cheap and less time consuming, the actual and real time data of transformer was analysed in this study and the results can be further used for the health monitoring of transformer where the measurement sensors are present. Pakistan has only one PMU connected with transformer in Sheikh Muhmandi grid station in Peshawar. By increasing the number of PMUs in Pakistan we can further implement this study for the reliable and secure operation of transformers.

Author Contributions: Conceptualization: S.J; methodology: S.J, A.H; software: S.J.; validation: S.J; formal analysis: S.J; writing—original draft preparation: S.J. A.H; supervision: Abdul Basit.; project administration: A.B.

Conflicts of Interest: The authors declare no conflict of interest.

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Effects of Dispersed Generation on Voltage Profile and Power Losses

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Abstract— With the rapid increase in need of electricity, electric power system is becoming complex day by day. Different types of generating units and loads are connected with one another to form a huge generating, transmitting and distributing network. Pakistan is being confronted with acute shortage of electric power and measures need to be taken on short terms to tackle these problems. In Distributed generation, DG can be utilized efficiently in such cases due to the reason that DG can be on site generation with less time of installation and generating electricity. However, integrating a DG unit with a distribution system causes some disparities if some issues like proper sizing, capacity and location are not taken into consideration. Theses disparities can be related to voltage profile, stability, power losses, harmonics etc. which can cause damage to different electrical devices and units. Particularly, this research work covers the adverse effects on voltage profile when a DG unit is being integrated with the distribution system without taking its size, capacity and location into consideration together with the methods for alleviating these effects. A 132 kv residential feeder has been taken as a test case. Which is further modeled in Electrical Transient Analyzer Program ETAP. Various tests are taken into consideration to analyze the effects of DG on distribution system. Different cases are being analyzed taking system with and without DG unit installed at different busbars. It has been observed that significant improvement in voltage profile occurred when DG is inserted in system with proper consideration of size location and capacity.This research work can help expanding power system in future and tackling different issues related to voltage profile in distribution sector worldwide and particularly in Pakistan**.**

Keywords— Renewable Distributed Generation, Distribution System Operators, Cross-Linked Polyethylene, Load Tap Changing, Combined Heat and Power.

I. INTRODUCTION

Electrical Power system comprises of three subsystems i.e. a generating system, transmission system and distribution system. Demand for electrical power has increased up to great extent and usually this demand is fulfilled by electricity generating stations i.e. Hydro, thermal and nuclear power stations etc. Figure 1.1 shows a brief presentation of electrical generating station, then a transmission system and at the end a distribution system. [1]. Capacity of Electricity generating stations can vary from micro to macro [2]. In order to transmit electrical power from generation point to the consumer, several transmission systems are being used. [3].

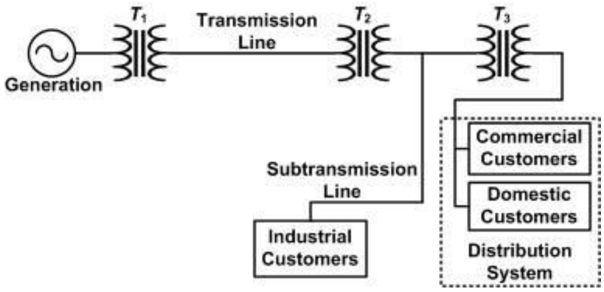

Figure 1. Electrical Power system [1]

The data revealed by the renewable global status report declares that the total electrical power comprises of 79.5% fossil fuels and remaining percent is non-fossil fuels. About 2.2% of electrical energy is being generated from nuclear sources, nearby 11% from non-conventional sources such as geothermal, wind0and solar0etc. Figure 2, [4] [5] shows the energy production from different sources.. Due to these reasons, generation of electricity must also be increased according to the needs. According to energy data source, demand for electricity is mounting at the rate of 1.4% annually and being assessed to increase till 2020 [6]. However, it requires a numerous time for construction and a massive investment too. To overcome these problems there should be a fast and improved solution that will take minimum time to be in service [7].

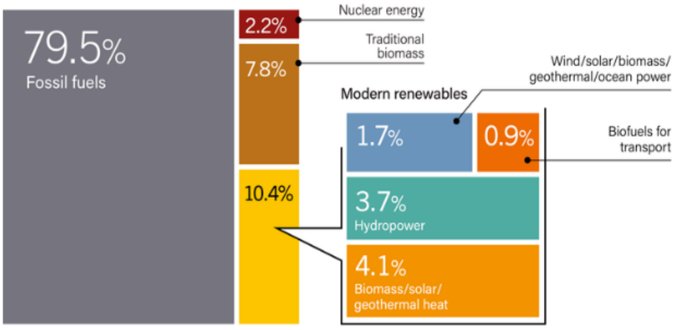

Figure 2. Distribution of power generation from various sources [5]

To overcome the gap between electrical energy supply and demand, Dispersed Generation has become the most suitable option. Small generating units that can generate electricity on-site, when joined within the distributed system is known as Distributed generation [8]. DG comprises of enormous technologies, like Wind Turbine system, Gas Turbines, Photovoltaic cells etc. If power is being generated by a DG unit through non-traditional or renewable energy source it can be mentioned as a renewable dispersed power generation [9] [10]. Together, traditional and non-traditional (renewable) energy can be utilized for generation of electrical power [4]. Conventional energy resources can be Combustion engine, fuel cells etc., while non-conventional energy can be the energy obtained from sun, wind or heat from inside of the earth etc. A DG unit along with the capability of energy storing capability is known as Distributed source of electrical energy. Proper study and mechanism is needed to gain out the maximum efficiency from DG. Location of installation, size and type must be chosen accordingly [4]. Some worse conditions might also occur if theses parameters are not considered properly like false triggering (flow of power back into the transmission system) [11] [12]. Some of the positive effects that are entitled with the DG when integrated with a distributed system are improved voltage profile, power losses reduction, improved transmission and the of distribution congestion, security enhancement and in achieving the aim to use a green and environment friendly energy resources [13]. On the other hand, injection of DG in distribution system has also some negative impacts if its size and proper installation location is not considered. These can be voltage rise, flow of power from distribution network back into transmission network, worst power value when islanding (network is being cut down from the utility but distributed resources are still connected) which can harm the consumer's appliances [14].If a un-deterministic DG unit of larger capacity is linked to the network, it may have bad impact of voltage rise. To overcome this problem different alternative approaches are anticipated in this research work.

II. Methodology

For load flow analysis, the loads are being considered at different intervals.To make the system at steady state i.e. at static position, very short intervals are being chosen because in such a short interval the load change cannot be too much and can be chosen a constant. Such kind of discrimination is known as Quasi static operating condition i.e. considering that the load and power flow on a transmission line remain constant for very short interval of time [26].

A. Voltage Controlled Bus

A specific kind of bus, explicitly preferred and detailed on the basis of voltage0magnitude and real power0is called PV0bus or voltage-controlled0bus. In this kind of bus, reactive0power and phase angle0are not being taken into attention. At some per-defined0points, voltage0regulators are installed0which continuously0keep on checking0the voltage0levels.

B. Mathematical Modeling

For various outcomes and calculations, Newton Raphson method can be used along with the Gauss Seidel iteration method.

$$I_{Bus} = Y_{Bus} x V_{Bus}$$

Also for any specific Bus \K"

$$I_K = \sum_{n=1}^{N} Y_{Kn} V_n$$

Complex Power

$$S_K = V_K I_K^*$$

$$P_K + jQ_K = V_K [\sum_{n=1}^{N} Y_{Kn} V_n]^*$$

Where K = 1, 2, 3 ...N

For Complex Power

$$I_K = \frac{P_K + jQ_K}{V_K^*}$$

Also, $I_K = \sum_{n=1}^{N} Y_{Kn} V_n$

$$I_K = Y_{K1}V_1 + Y_{K2}V_2 ++ Y_{KK}\, V_K ++ Y_{KN}\, V_N$$

From the above equation

$$V_K = \frac{1}{Y_{KK}[I_K - (\sum_{n=1}^{K-1} Y_{Kn}V_n + \sum_{K+1}^{N} Y_{Kn}V_n)]}$$

$$V_K = \frac{1}{Y_{KK}[\frac{P_K+jQ_K}{V_K^*} - (\sum_{n=1}^{K-1} Y_{Kn}V_n + \sum_{K+1}^{N} Y_{Kn}V_n)]}$$

Where K = 1, 2, 3... N

Gauss-Seidel Iterative Procedure

Typically initially a is used i.e. j V_i j= 1 and $i_{(0)} = 0$. For estimation of V_K, this particular method is utilized.The results being obtained in the first iteration are used further to have a more accurate result in the second iteration.

$$V_K^{i+1} = \frac{1}{Y_{KK}[\frac{P_K+jQ_K}{V_K^{i*}} - (\sum_{n=1}^{K-1} Y_{Kn}V_n^{i+1} + \sum_{K+1}^{N} Y_{Kn}V_n^{i})]}$$

III. SYSTEM ANALYSIS AND MODELING

ETAP software is operated for making the test model of Rahman baba feeder and then analysis is being made for the voltage profile and power reduction. Figure 3, shows a single line diagram for the trial-based distribution feeder taken. The particular 11KV feeder being taken into account is situated at Rahman baba grid station Dora road, Peshawar, Pakistan, being energized from a bus bar of 132KV in compliance with a 31.5/40 MVA transformer. The energizing basis for this particular feeder is 132 KV bus bar being taken by means of a power grid with a short circuit measurement of 1800.00 MVA.100 MVA is chosen as a base for this data. A lumped load with a power factor of 0.85 lagging is taken and this load is being energized from seven different distribution transformers of various capacities. A particular category of cable being utilized for the analysis is 3-phase overhead aluminum conductor with insulation of cross-linked polyethylene. Span of every single cable is being chosen 700 meters, having a cable class percentage of 100%.

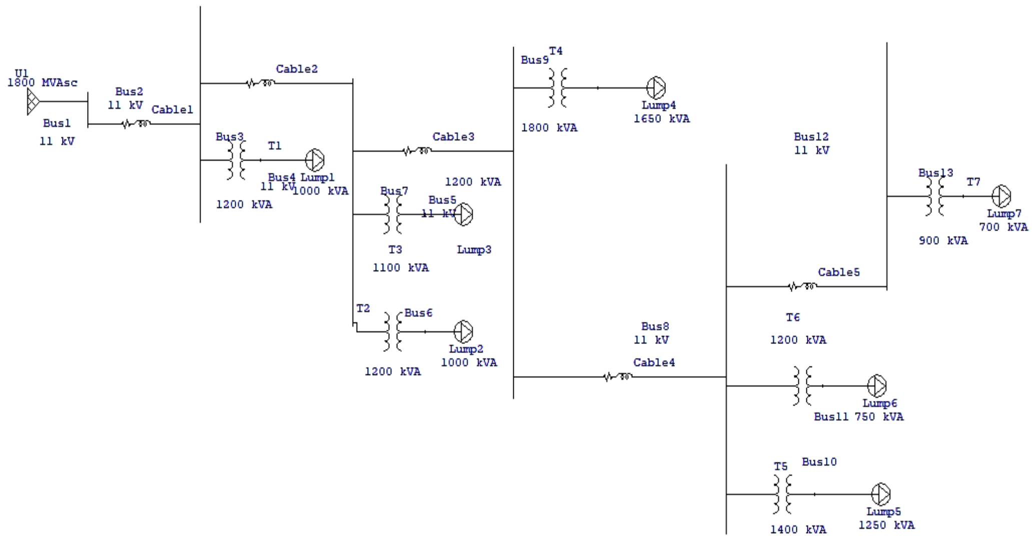

Figure 3. Circuit diagram of the Test feeder

IV. CASE-I

Three scenarios are taken into consideration in this research work regarding the size, type0and location0of DG unit with reference to the impact on voltage profile and system losses. Similarly, along with these three scenarios, five different cases are discussed. In this particular case, analysis of the system is being made without integrating a DG unit into the system. This case will be considered as a base or reference case for studying all other cases. Practically picked data will be used and the results so far gained will be used for understanding the other cases.

D. CASE-II

In the second case, two categories of DG units are opted for analyzing the impact on voltage profile and losses of the scheme i.e. a synchronous generator and induction generator. Two sub scenarios are taken as follows

E. Scenario-1

Synchronous generator is being chosen as a DG unit. A synchronous generator acting as a DG unit having generating capacity of 2 MW will be installed at different locations or buses of the distribution system. It will inject only real power and we will consider power factor to be unity. Such type of sources occurs in the first category. This particular type of DG unit will be injected at various locations, these are, first, this synchronous generator acting as a DG scheme will be connected with bus-4. In second case, the same DG component is added at bus 8.

F. Scenario-II

Induction generator being chosen as a DG component. Induction generator acting in place of DG component having same capacity as in the above case i.e. 2 MW owing lagging power factor of 0.85 is installed at various locations or bus bars of the distribution hub. In this case, reactive power is being engrossed by the arrangement. Such natures of sources occur in third category i.e. different induction generators used in generation of electricity from wind. Two different locations are selected for installation of such DG unit, these are , At first, this DG component will be added at bus-4. The same DG component will be added at bus-8 like the previous case.

TABLE 1. SYNCRONIOUS AT BUS NO.4

CKT/Branch	From To Bus Flow		To from Bus Flow		Losses		% Bus Voltage		% drop in voltage magnitude Vd
ID	MW	Mvar	MW	Mvar	KW	KVAR	From	To	
Cable 1	6.538	4.405	-6.465	-4.353	72.4	52.3	100.0	98.9	1.13
Cable 2	5.623	3.785	-5.568	-3.745	84.3	42.5	98.9	97.9	0.98
T1	0.843	0.568	-0.836	-0.518	7.1	50.1	98.9	95.6	3.23
Cable 3	3.723	2.481	-3.675	-2.463	37.4	18.8	97.9	96.8	1.09
T2	0.839	0.567	-0.832	-0.516	7.2	51.1	97.9	94.6	3.25
T3	1.006	0.697	-0.995	-0.616	11.5	81.4	97.9	93.6	4.31
Cable 4	2.297	1.522	-2.247	-1.513	36.6	8.4	96.8	95.2	1.62
T4	1.379	0.940	-1.366	-1.846	13.3	94.3	96.8	93.2	3.62
Cable 5	0.585	0.392	-0.582	-0.391	3.3	0.6	95.2	94.8	0.42
T5	1.038	0.708	-1.028	-0.637	10.0	70.7	95.2	91.6	3.56
T6	0.624	0.413	-0.620	-0.384	4.1	29.3	95.2	92.7	2.46
T7	0.582	0.391	-0.576	-0.357	5.9	34.4	94.8	91.6	3.20

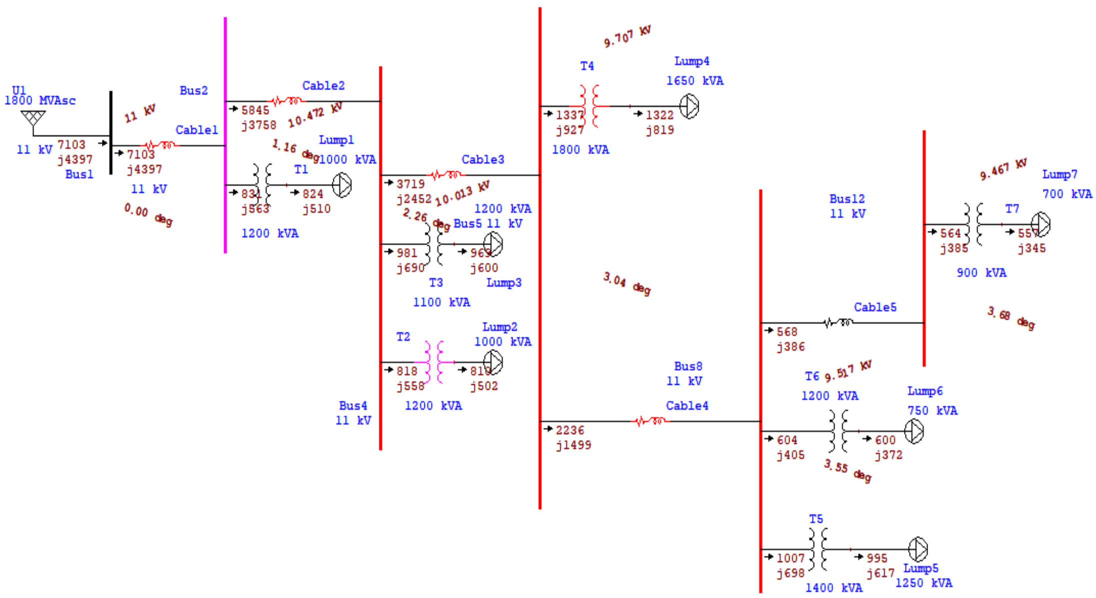

Figure 4. Without DG Component

G. Scenario-IIA

A DG unit having capacity of 2.00 MW is integrated with the system and connected at bus-4 with a unity power factor.The calculations and outcomes from this scenario are depicted in figure 5.3. A DG component having capacity of 2.00 MW is added with the network at bus-4 with a unity power factor. In this case, the load being connected with the feeder is fed mutually by power grid and DG unit. The voltage levels and other conditions are taken in real time. After simulation and analysis, when results are compared with the previous case, an improvement has been noticed in voltage concerned with bus number 4, 5, and 8. Table 1, illustrates the losses. The voltage changes and drops that occurred during this analysis from bus to bus is also described.

H. Scenario-IIB

In this scenario, A DG component having capacity 2.00 MW is being added with bus-8 and power factor is chosen unity. The results after the simulations and analysis for scenario-1B of case-2 at busbar-8 are shown in figure 5.4. A DG component with capacity 2.00 MW is being integrated to system at bus-8 with power factor of unity. Same as the previous case, the load is being handled through power grid and the DG unit jointly. After the analysis of this case and comparing the results with the previous case, it has been noted that a better voltage profile along with less losses have been observed once the same DG component is installed at bus-8. During these calculations, the power depreciation being occurring at several positions like transformers, cables and various lines of distribution system. A detailed description of the power flow direction is also being shown i.e. flow of power from and towards the branch. Different voltage drops from bus to bus are also shown along with the bus voltages.

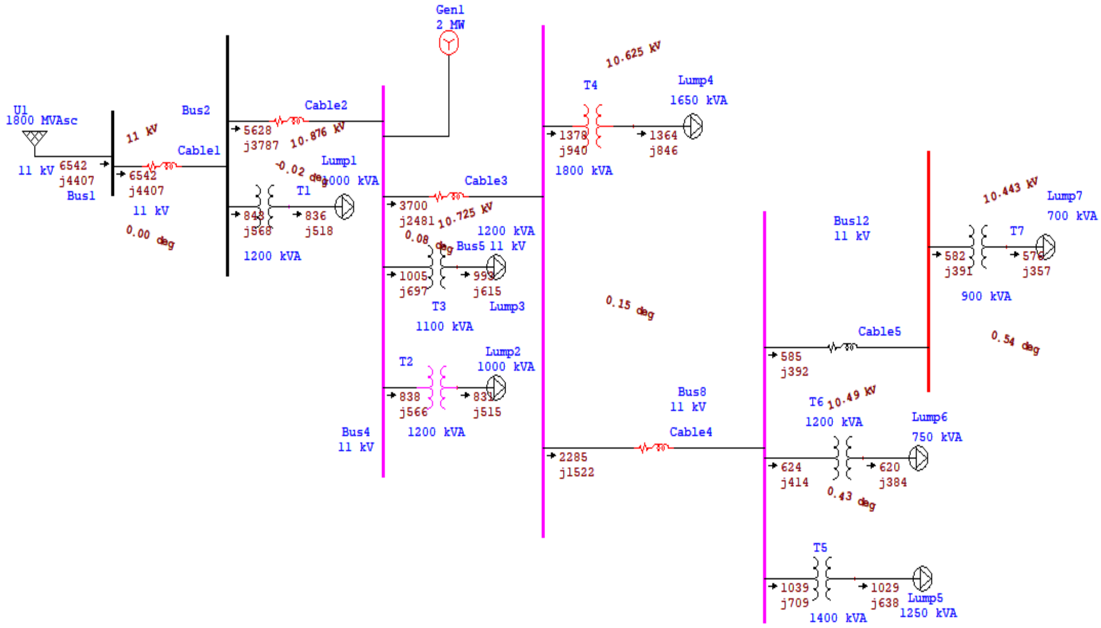

Figure 5. DG component added at bus 4 contributing solitary Active power

I. *Case-III*

In this scenario, an induction generator is taken as a DG component. Taking this particular case into consideration, an induction generator is being chosen for DG unit owing a power factor, 0.85 lagging. As usual, induction generator works with lagging power factor and absorbs reactive power, same is the case here, reactive power is absorbed and active power is being provided with the system. Two buses are in critical state, i.e. bus 4 and 8, DG unit is integrated at these two buses.

J. *Scenario-IIIA*

In this case a WTG having capacity 2.00 MW is being added at Bus-4 taking power factor of 0.85. Figure 6, shows the results of load flow analysis from this scenario when a WTG is being added to the distribution network. A DG unit of capacity 2.00 MW is added at bus 4 having power factor of 0.85 lagging. Same as the previous case, real power is being given to the system while reactive power in the same manner is being taken owing to the reason that induction machines work with lagging power factor. After the analysis and results, it can be clearly observed from the results that the voltage profile is very much better as compared with the scenario-1, Scenario-IIA and scenario-IIB. In this particular case, the WTG is connected with bus-4. Power flow can also be seen from and towards different busses. Different voltage drops are also shown i.e. from bus to bus and bus voltages also. Table 2, shows the outputs from this particular case.

TABLE 2. INDUCTION GENERATOR AT BUS NO.4

CKT/Branch	**From To Bus Flow**		**To from Bus Flow**		**LOSSES**		**% Bus Voltage**		**% drop in voltage magnitude Vd**
ID	MW	Mvar	MW	Mvar	KW	KVAR	From	To	
Cable 1	4.473	5.634	-4.412	-5.59	60.2	43.5	100.0	99.0	0.99
Cable 2	3.569	5.023	-3.524	-4.990	45.0	32.5	99.0	98.2	0.85
T1	0.843	0.568	-0.836	-0.518	7.0	50.0	99.0	95.8	3.22
Cable 3	3.677	2.486	-3.653	-2.469	23.8	17.2	98.2	97.5	0.65
T2	0.840	0.567	-0.833	-0.516	7.1	50.6	98.2	94.9	3.24
T3	1.007	0.698	-0.996	-0.617	11.4	80.6	98.2	93.9	4.30
Cable 4	2.271	1.527	-2.261	-1.520	9.2	6.6	97.5	97.1	0.40
T4	1.383	0.942	-1.369	-0.849	13.1	93.1	97.5	93.9	3.60

Cable 5	0.587	0.394	-0.587	-0.393	0.6	0.4	97.1	97.0	0.10
T5	1.046	0.711	-1.036	-0.642	9.7	69.0	97.1	93.6	3.51
T6	0.628	0.415	-0.624	-0.387	4.0	28.5	97.1	94.7	2.42
T7	0.587	0.393	-0.581	-0.360	5.8	33.4	97.0	93.9	3.15

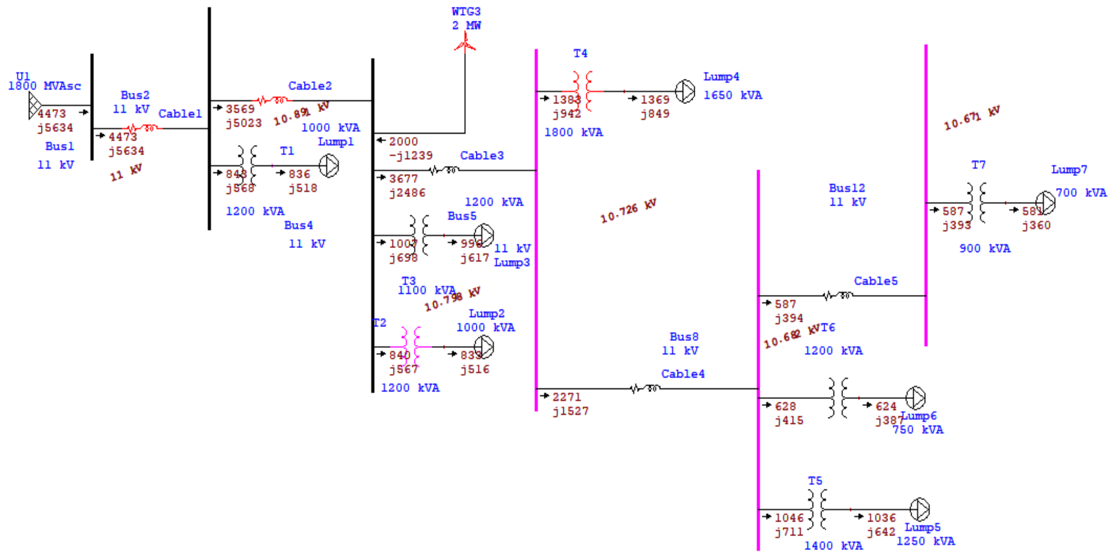

Figure 6. WTG component 2.00 MW added at busbar 4

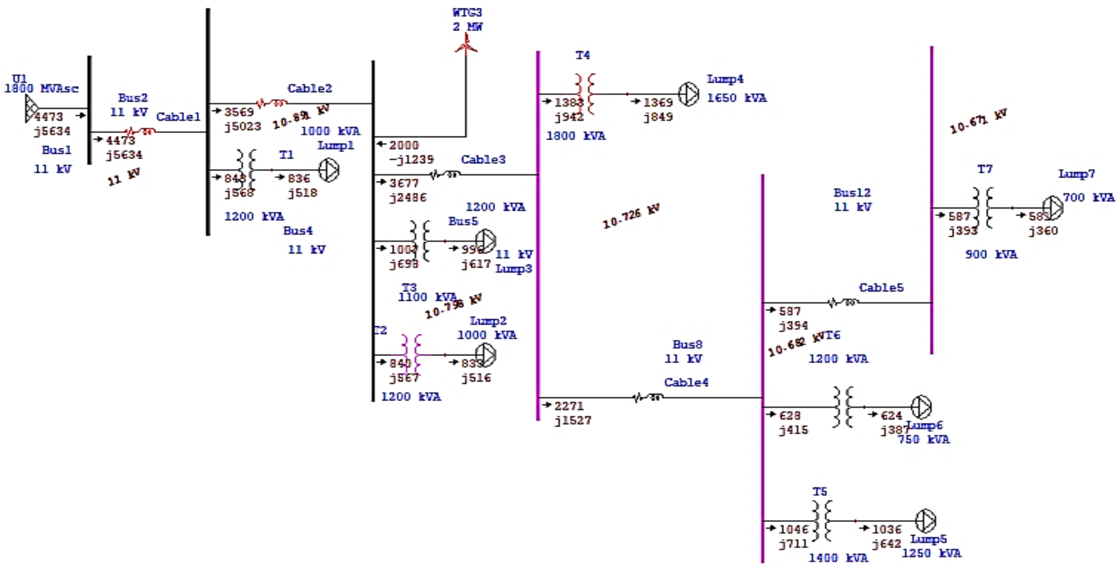

Figure 7. WTG0component 2.00 MW added at busbar 4

K. Scenario-IIIB

In this scenario, a wind turbine generator of 2.00 MW is integrated with the system and installed at bus-8 taking the power factor of 0.85. The busbar used in this case is busbar-8. The results and different outcomes from this particular case are shown in Figure 7, Load is being suckled commonly by the power grid and the DG unit integrated with the system.

L. output results from different cases

Results and outcomes from various cases has been analyzed and sorted out for a best possible scenario. Table 3, is presenting the power given and taken from the system.

TABLE 3.POWER GIVEN BY DG

Case	Scenario	DG Inoculated Power		Grid Inoculated Power	
		MW	MVAR	MW	MVAR
1	1	0	0	7.03	4.39
2	2A	2.00	0	6.538	4.405
2	2B	2.00	0	6.553	4.406
3	3A	2.00	-1.550	4.473	5.634
3	3B	2.00	-1.550	4.587	4.355

M. Investigation of Voltage Profile

Voltage profile varies accordingly with the type of DG unit integrated with the system. Various type of voltage profile occurs for various type of DG units. A detailed description about the voltage levels with DG units installed at various buses is given in Table 4.

TABLE 4. VOLTAGE LEVELS WITH DG UNITS INSTALLED AT VARIOUS BUSES

Bus number	Case-1	Case-II		Case-III	
		Case-IIA	Case-IIB	Case-IIIA	Case-IIIB
1.	11	11	11	11	11
2.	10.472	10.876	10.875	10.891	10.723
3.	10.013	10.725	10.725	10.798	10.557
4.	9.707	10.625	10.625	10.726	10.472
5.	9.517	10.49	10.446	10.682	10.454
6.	9.467	10.443	10.4	10.671	10.442

N. Case-1

While taking this particular situation into consideration, not any DG unit is inserted in to the network. Figure 8, gives a block and graphical appearance while Table 5, gives numerical depiction of the depreciation in voltages along with the route from power source to load in different buses. The reason that the depreciation in voltages occur is because of the impedances.

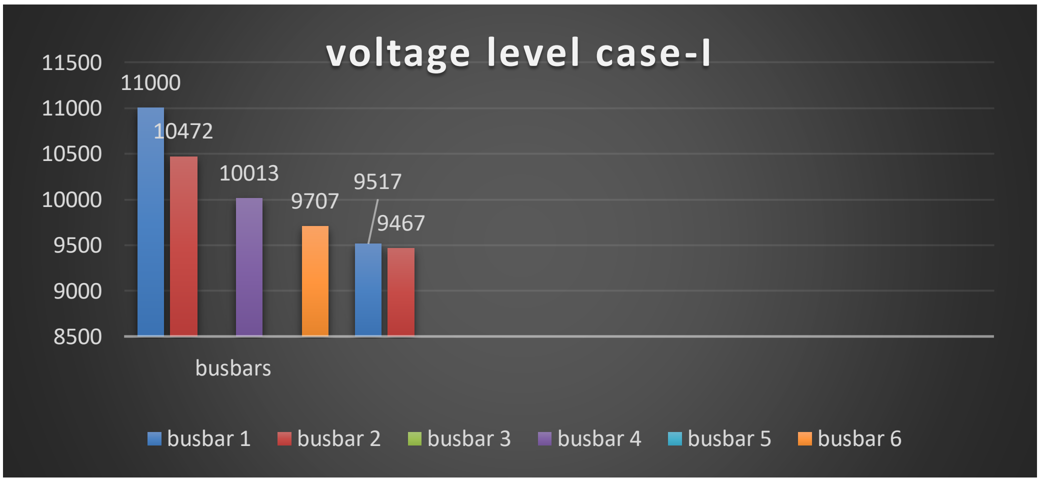

Figure 8. Volatge level at case-1

TABLE 5. VALUES OF VOLTAGE LEVELS FOR CASE-1

S. No	Busbar	Voltage (kv)
1.	1.	11
2.	2.	10.472
3.	3.	10.013
4.	4.	9.707
5.	5.	9.517

O. Case-II

Two unlike type of states are considered and discussed in this particular case Scenario-IIA and Scenario-IIB. A DG unit of 2.00 MW is integrated at two buses i.e. bus-4 and bus-8.

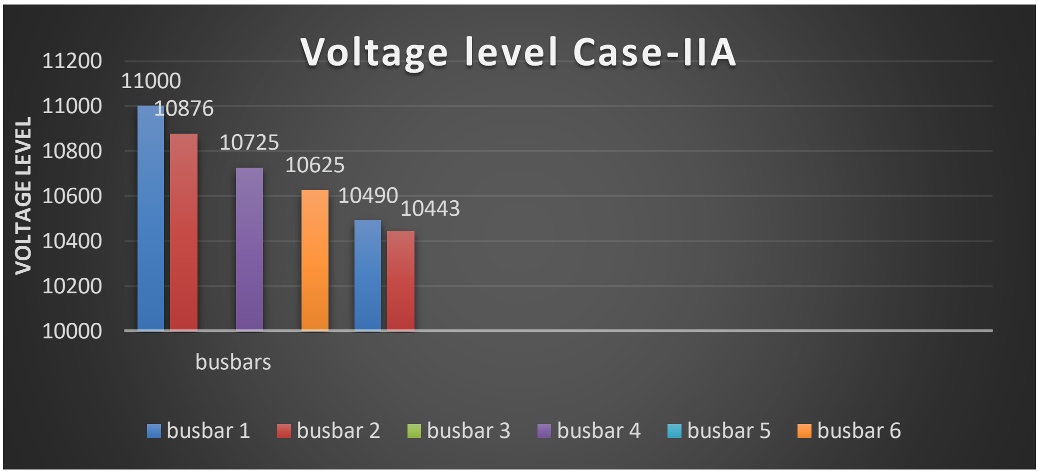

Figure 9. Voltage level at case-II A

Operating power factor of these buses is taken as unity in order to have only active power integrated in to the network with no reactive power being captivated from the system. When a DG unit is installed at these two specific locations, it has been observed that the voltage profile has been improved in both of the buses i.e. bus-4 and bus-8, but busbar-4 depicts a more positive image. So, a suitable location for putting in DG unit is bus-4. Figure 9, represents Case-IIA along with the comparison with topmost case in which no DG is added to the network depicted in Figure 10.

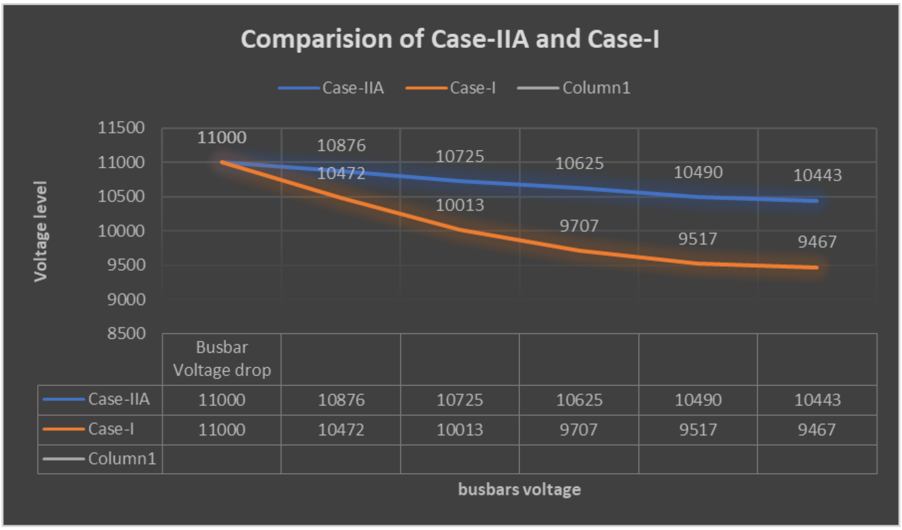

Figure 10. Comparison of Voltage levels at case-1 and case-II.

Similarly, as discussed earlier, two buses were noted in critical condition i.e. bus 4 and 8. Formerly bus 4 was chosen for the addition of DG, in this particular Case-IIB , bus 8 is opted, Figure 11, depicts Case-II

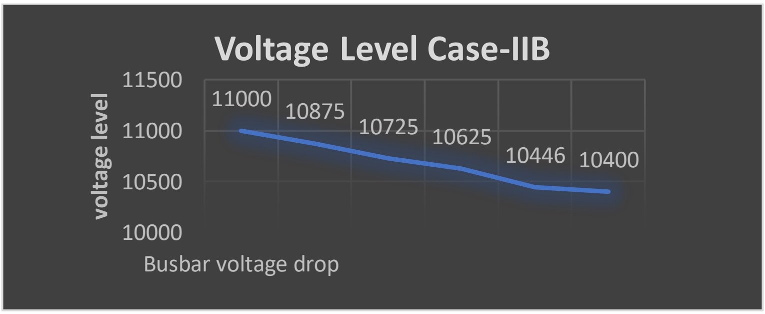

Figure 11. Voltage levels for Case-IIB

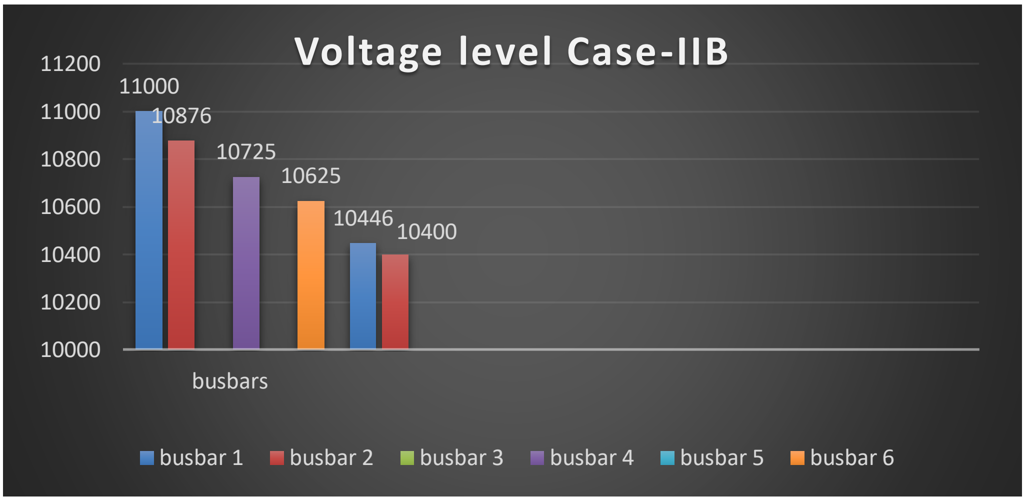

Figure 12. Voltage level for Case-IIB

After comparing case-I and both situations of Case-II in Figure 13, it can be noted that opting a proper location, size and busbar has significantly improved the voltage profile in comparison with the case where no DG was added in to the system.

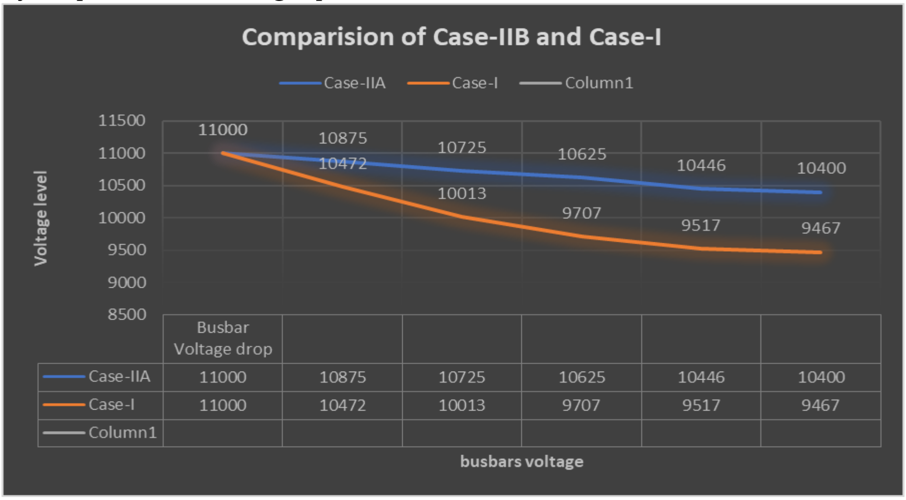

Figure 13. Comparison of Voltage levels at Case-IIB and Case-1

P. Case-III, (Scenario-IIIA And Scenario-IIIB)

In scenario-IIIA and Scenario-IIIB, a DG unit having capacity of 2.00 MW and a specific type i.e. WTG is being integrated with the system. In the previous case, only active power was being inserted and no reactive power was taken, here, reactive power is also taken by the system due to the nature of WTG. Figure 14,15 and 16 depicts the outcomes when a WTG is added at busbar-4 and bus-8 respectively. It can be noted that busbar-4 has more positive impacts if compared with the former bus bar.

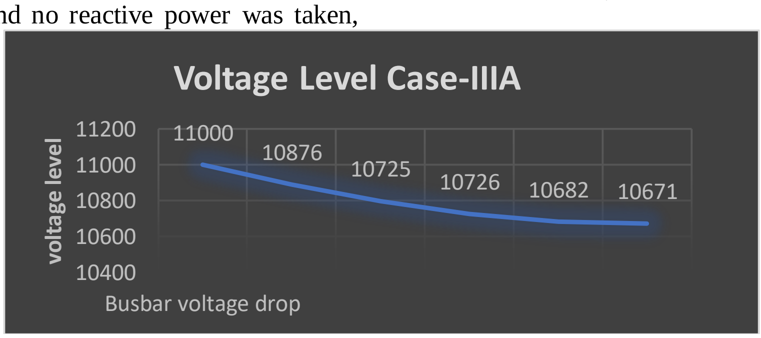

Figure 14. Volatge levels for case-IIIA

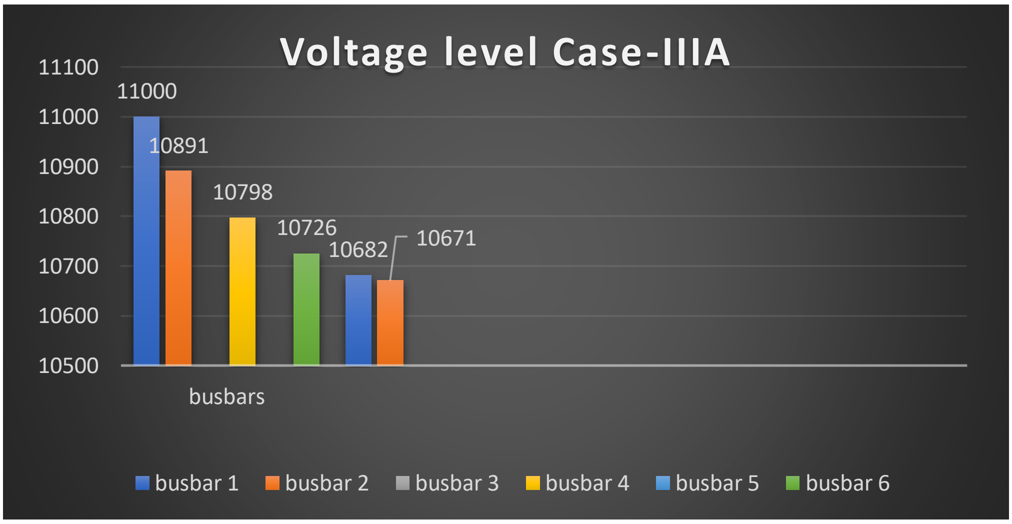

Figure 15. Volatge levels for case-IIIA

After the outcomes being gained from the simulations and ETAP software, a comparison has been made between Case-I and Case-III being depicted in Figure 16, it can be noted that the best suitable location for this particular type and capacity of DG is busbar 4.

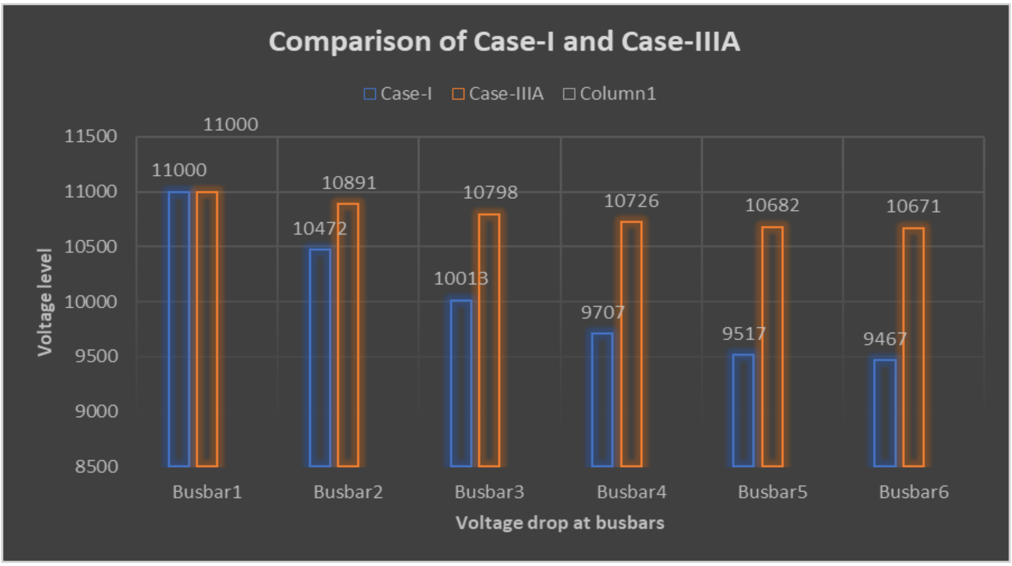

Figure 16. Voltage comparison values of Case-1 and Case-IIIA

Q. *Investigation of Power Losses*

Power losses varies with the type of DG used and also with the location of installation of DG i.e. minimum losses has been noted when a wind turbine generator of 2MW is installed at busbar 4. Similarly, the case where no DG has been injected is noted to have maximum losses. The following cases shows different types of losses occurring in this analysis.

R. *Case-1*

While taking this particular situation into consideration not any DG has been integrated in to the grid. The depreciation being noted in this particular case is about 1026KW. The impedance of different lines, current flow and some constant losses i.e. transformer losses contribute to the total losses.

S. *Case-II*

Case-II comprise of sub two cases i.e. in one case synchronous generator being used as DG unit has been integrated at bus 4 and then at bus 8. It has been observed that losses have been depleted if compared to the previous case. Case-IIA and Case-IIB has 293.1KW and 361KW power reduction respectively.

T. Case-III

Case-III, just like the previous case consists of two cases. In one case a WTG has been installed at busbar 4 and in the other case the same wind turbine generator has been integrated with the grid through busbar 8. Load is being mutually fed by grid and DG unit both. After comparison, busbar 4 shows less amount of losses compared to bus 8. The following figure illustrates these losses. Case-IIIA and Case-IIIB has 196.9KW and 362.9KW losses respectively.

U. Comparison of power Losses

By comparing all cases i.e. the one in which no DG has been inserted into the system, the other one in which a synchronous generator is used as a DG and similarly the third and last case which consists of a Wind Turbine Generator, it has been noted that power reduction can be lessened if a DG unit is implanted at appropriate site (in this particular situation Case-IIIA). Similarly, the size and type of DG must be nominated in accord to system necessity. The table 6 and Figure 17 show the different losses combined.

Figure 17. Different power losses

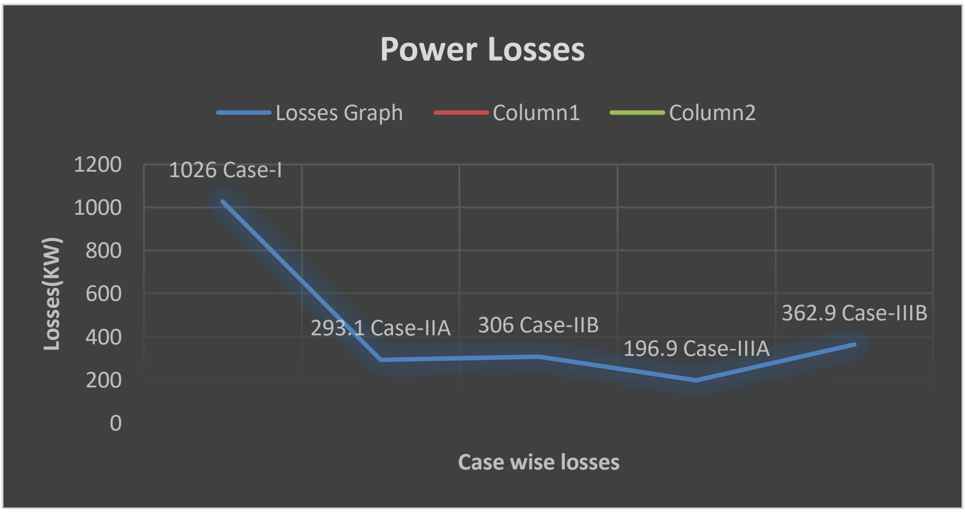

Figure 18. Comparison of power Losses in all Cases

TABLE.6 DIFFERENT POWER LOSSES

Case Number	Power losses (KW)
1.Without DG	1026
2.DG unit with unity power factor at busbar 4 and 8	293.1
	306
3.A wind turbine Generator installed at busbar 4 and 8	196.9
	362.9

CONCLUSION AND FUTURE WORK

Demand for electrical energy is increasing day by day due to rapid increase in population and their increased requirements. Electrical energy flows from generating power stations to load centers through different channels which makes the system more complicated and lots of power losses occur through these channels. Due to the vast gap between the generated electrical power and consumer's demand , load is being shed off from the generation. To tackle this gap, electricity generation must be increased. Keeping in view these circumstances, DG is a feasible and optimal alternative to tackle these problems. In order to have maximum outcome from the installation of DG in a distribution system, some parameters must be analyzed properly. If appropriate location, type and size of DG unit are not assessed, then problems like eccentricity of voltage from its demarcated extent and power losses can happen. Voltage regulation must remain minimum in order the appliances to work efficiently. This research work represents and evaluate the impacts of DG integrated with a distribution network. Various scenarios are taken with and without DG units, analyzed and evaluated for the results. From the analysis and study of case 1, when there was no DG unit integrated with the system, from the outcomes of the losses, voltage deviation has been noticed which caused a low voltage at various buses and links, in addition to some buses that are noted in critical codition.When Wind Turbine generator acting as a DG unit was injected in the same case keeping proper location, size and capacity into consideration as discussed, it was noticed from the results that the voltage profile has become better comparatively and the optimum site for induction of DG unit is bus-4. This research work covers an important and most occurring problem in a distributed system i.e. deviation of voltage pattern after a DG unit is inducted within the system. Today, our country is confronted with a dire need of electricity generation. Different alternatives can be used to tackle this problem. But most of them are time consuming and cannot start their generation in less time. DG can be used as an alternative to overcome this problem. DG is being used widely throughout the world for generation of electricity on a smaller as well as larger base, prominence has been made to improve and make the voltage profile better and the losses be minimized. In addition, this research can be advanced by considering harmonica, protection and short circuit analysis into consideration.

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Virtual Inertia Emulation in a Hybrid Micro Grid Based on Diesel Generator and Wind Power Plant

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***Abstract*—** Micro-grids with high renewable penetration have low inertia and it leads to frequency stability problems. Virtual inertia emulation provides active power to system during transient time to improve dynamics frequency stability. In this study, derivative technique is used to calculate the derivative of frequency for virtual inertia emulation. Simulations results confirm that frequency dip occurs in case of contingency and virtual inertia control reduces this frequency deviation. It helps to improve overall frequency stability and prevents unnecessary load shedding.

Keywords— Power System Stability, Micro-grids, Renewable Energy Sources, Frequency Control, Virtual Inertia.

I. Introduction

Envirnmental concerns, energy policies and giving access to electricity in remote areas have encouraged distributed generation and increasing penetration of RES in power system [1]. Distributed generation introduced a new concept of a small-scale power system known as micro grid. A micro grid is a group of power grids with RES sources and loads, and it can be identified as an independent system [2]. The concept of micro grid has played a vital role in the development of electricity market. However, it reduced the inertia of the system due small size, inverter/converter based technology of RES, and led to frequency stability issues [3]. Power system based on synchronous generators follows the frequency regulations. Inertial response, primary frequency control and automatic generation control attenuate the system dynamics and decrease frequency deviation of the system, so that system instability, cascaded outages and blackout can be avoided [4]. Thus, the main concern about the safe operation and control of today's and future micro-grid is its dynamic stability as system inertia is decreasing due to increasing penetration of RES.

A novel technique known as virtual inertia emulation address these stability issues. Virtual inertia is a combination of control algorithm, power electronics circuits, energy sources and energy storage systems, which emulates the inertial behavior of synchronous generator in RES, based micro-grid [5]. Several studies of virtual inertia emulation have discussed in the literature. Bryant et al [6] described the challenges of frequency control in Australian's power system due to increasing share of renewable power generation. Obaid et al [7] described challenges and new methods to control frequency of future power system. The virtual inertia injection in multiple PV systems of autonomous micro grid is discussed in [8]. Unlike synchronous and wind turbine, solar photovoltaic system does not possess any type of kinetic energy and it does not injects any inertial property in power system. DC link capacitor's voltage is adjusted to add virtual inertia and it injects or absorbs power when frequency changes occur. Kerdphol et al [9] proposes a new technique, which simultaneously injects the virtual inertia and virtual damping in a micro grid using derivative frequency approach. A virtual inertia control technique, VISMA or VSG is applied to imitate the virtual inertia and virtual damping in RE generating sources, which is the dynamic behavior of synchronous generator. In [10], frequency dynamics of hydropower system are modeled which helps to injection of virtual inertia. In [11], all techniques which are used virtual inertia emulation in micro grid are discussed and compared. Novel approaches are applied and proposed to inject inertial response in both voltage source and current source inverter. Bevrani et al [12] describes application of virtual inertia in frequency control of power grid. In this paper, the dynamics of the frequency deviations caused by parallel operation of the grid and VSG are analyzed, and the stabilization effects provided by VSGs are confirmed. In [13], optimization of emulated inertia is discussed. It is important to explore that where to place this inertia optimally as it is considered that placement of inertia has significant impact on power system performance. Some global as well as local optimal solution of virtual inertia problems are presented in [13].

This paper presents the $\frac{df}{dt}$ technique of virtual inertia emulation. Virtual inertia power is calculated based on ROCOF of the system. VI loop helps to maintain the frequency stability of the micro-grid based on conventional and RES generating units during transient time. The reminder part of this paper is arranged as; Section II explains the modeling of micro-grid, occurance of contingency and design of virtual ineria loop. Section IV shows the behavior of frequency with and without virtual inertia emulation. Finally, conclusion are presented in section V.

II. METHODOLOGY

The methodology include simulations of micro grid in MATLAB/SIMULINK, injection of a perturbation on micro grid and its analysis, emulation of virtual inertia loop on perturbed system and its analysis.

A. Modeling of Micro Grid

To access the system having shares of conventional power sources and RES, a model of micro-grid based on diesel generator and wind power plant is designed on MATLAB/Simulink. The connection of grid side inverter of wind turbine with diesel through transformer and filter L is similar with simple integration of inverter with grid. The voltage and current are measured at the point of common coupling, which are transformed from a,b,c sequence to d,q,0 sequence. PLL is used to measure frequency and phase angle.

The measured value of three-phase voltage and current are sent into the power calculations block to measure the instantaneous value of active and reactive power. These measured values are compared with the $P_{,ref}$ and $Q_{,ref}$ and sent it to PI controller. PI calculates error between measured value and desired values and tries to minimize it. The control of active and reactive power is called outer control loop and its purpose to generate a reference dq sequence ($I_{d,ref}$ and$I_{q,ref}$) current. These reference dq currents are sent to the inner loop that is called current control loop where measured dq currents are compared with these reference currents and error is minimized by PI controller. The reference output voltage must be equal to the voltage and frequency at PCC. This reference voltage is sent to the PWM generator that generates the trigger signal for voltage side inverter.

B. Occurance of Perturbation

The rating parameters of the system are shown in table. An initial load of 400 KW is connected with the system, at $t = 10\,sec$, a step load of 100 KW is added and behavior of the frequency is observed during transient time.

TABLE I. PARAMETERS OF THE SYSTEM

Sr. No.	Parameter	Rating
1	diesel generator	300 KW
2	wind power plant	200 KW
3	transformer rating	500KVA
4	frequency	50 Hz
5	V_{abc}	380

C. Virtual Inertia Loop

In order to meet the contingency of load and generation imbalance, an algorithm is developed based on energy storage system, inverters and control loops called virtual inertia. It plays the role of kinetic energy released in synchronous generator when load-generation miss-match occurs and works as a function of frequency decay and ROCOF. It activates only when frequency deviations occur and becomes inactive when frequency goes back to nominal position (50Hz). Wind power plant inverter is operated below its maximum power and some

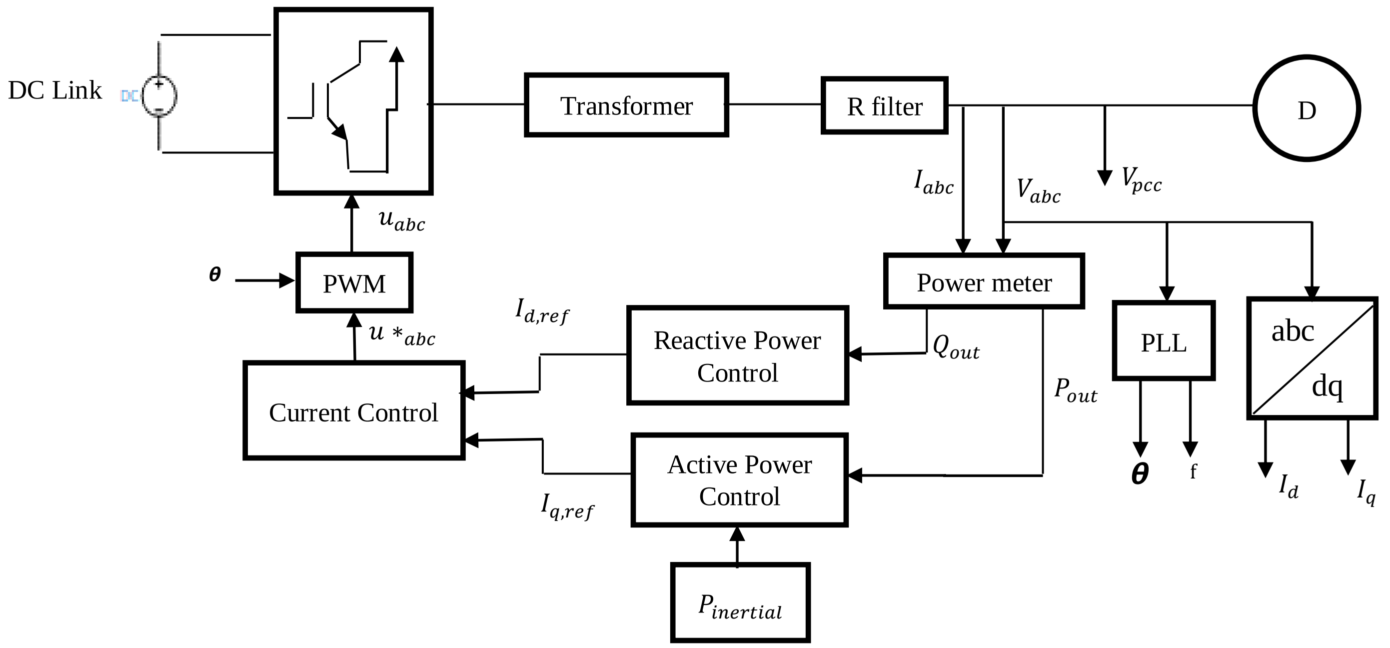

Figure.1 Modeling and control of micro-grid

power is kept in reserves. Virtual inertia loop is coupled with this reserve power and it activates during transient state when ROCOF occurs. Inverter supplies reserve power to load in proportion to ROCOF and it is calculated as follows:

$$P_{vsg} = K_I \frac{d\Delta\omega}{dt} \tag{1}$$

Where P_{vsg} is virtual inertia power, K_I is inertial constant and $\Delta\omega$ is frequency deviation. The designed virtual inertia loop is shown in figure (2).

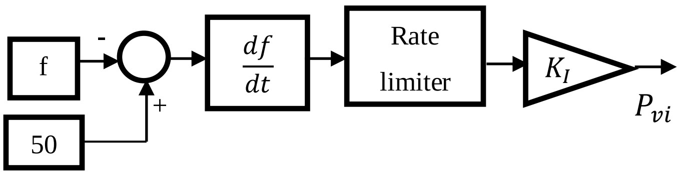

Figure 2. Virtual inertia loop.

III. RESULTS

The research work consists of one conventional power plant (synchronous generator) and one RES power plant (wind power plant). The results are discussed the active power flow and frequency deviations with and without virtual inertia emulation.

A. *Active Power Flow*

The power generation of wind power plant is shown in figure (3), which is constant 200KW. The power drawn by the load is called the active power of the system. Initially, it is 400KW and after that 100KW load is added at t=10sec., figure (4) shows the active power of the system.

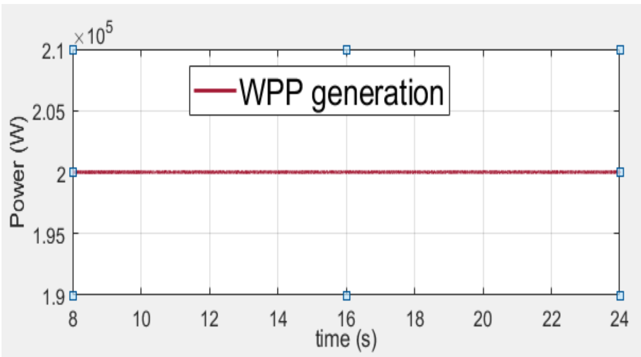

Figure 3. Wind Power Generation

It is cleared from the figure (3) that wind power plant supplies 200KW power to load and figure(4) shows that load power varies from 400KW − 500KW. The extra power comes from diesel generator. It supplies 200KW power initially and 100KW extra power when step load is applied. Figure (5) shows the power production of diesel generator.

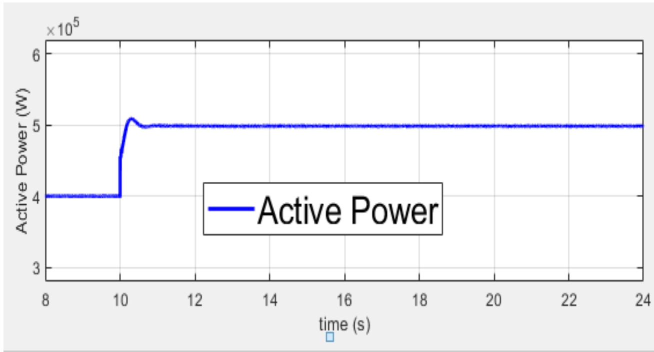

Figure 4. Active Power.

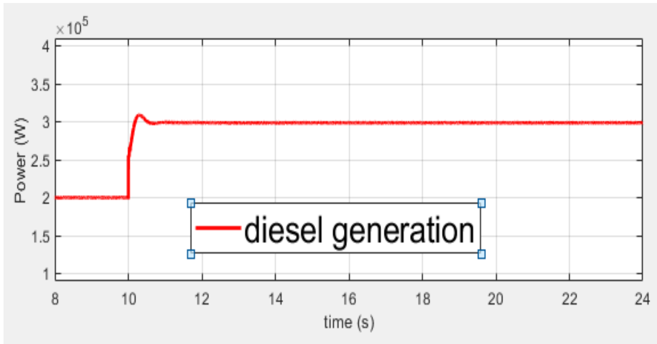

Figure 5. Diesel generation

B. *Frequency Behavior*

A frequency dip occurs at $t = 10sec$ when step load is applied without virtual inertia emulation. Figure (6) shows that frequency deviated from 50 Hz to 49.28 Hz. Activation of virtual inertial loop provides active power during transient time, catches the ROCOF, and improves the frequency nadir. Figure (7) shows the comparison of frequency with and without the application of virtual inertia loop. It is seen that virtual inertia emulation improves the frequency from 49.28Hz to 49.4 Hz. It increases the stability, resiliency and reliability of power system with high penetration of RES and encourages the installation of micro grids.

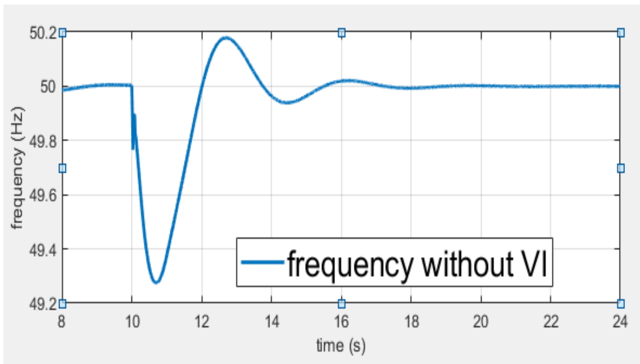

Figure 6. Frequency behavior without virtual inertia

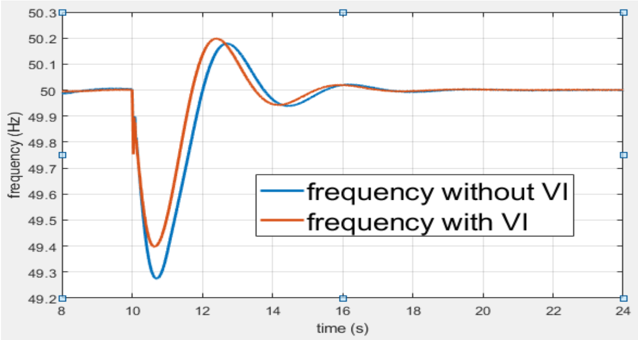

Figure 7. Frequency comparison with and without virtual inertia.

CONCLUSION

Power system is shifting from large conventional power plants to small DG and RES based generating units. They have small size and posses power electronics technologies. Hence, they have low inertia and consequenlt todays power system is facing frequency stability issues. Virtual inertia emulation is a technique used to improve frequency stability while supplying active power to system during transient time as a replica of kinetic energy in synchronous generator. In this research study, a methodology of virtual inertia emulation is applied on a micro grid having shares of conventional as well as RES. Simulations results confirm that when a contingency is applied in form of step load at $t = 10sec$, frequency dip occurs during transient time and it may lead to shutdown to some portion of the system. Proposed virtual inertia emulation technique improves this frequency decay, increses the transient frequency stability and ensures the safe operation of the system.

Future work on this area of study can be done by considering virtual damping emulation along with virtual inertia. Consideration of virtual damping can give better performance. Optimal placement of virtual inertia and virtual damping can also be added. Cost analysis and optimization of virtual inertia for designed system needs to be done. A hardware prototype of virtual inertia can be developed and verified.

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Online Monitoring of Distributed Generation Systems

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Abstract— As renewable energy is intermittent in nature, its integration in to the power grid is challenging task. Hence remote monitoring and data acquisition of various performance parameters from the renewable energy systems has become of paramount importance. Round the clock monitoring of the system ensures the stable and reliable operation of the system, by proper management, in this way an individual at a remote location can know whether the system is producing sufficient energy or not which is essential for its stable operation. This feature can be ensured by the use of real-time performance monitoring. If it is observed the sources is not working properly then an immediate remedy can be done to it before it sets in a chain of events and make things worse. The proposed monitoring system formulates unified data acquisition standard for distributed RES and real-time monitoring of RES such as solar PV. The system is an IoT server based using an Arduino to send the real-time power production to the cloud for remote access by the operator or the owner.

Keywords— Distributed Generation Systems (DG), Photovoltaic (PV), Internet of Things (IoT) and Power Plant Management Platforms (PPMPs)

I. Introduction

Drawbacks or disadvantages of the conventional power generating systems are slowly and gradually becoming more and more prominent with time due to the advancement and development of the society. To cope with the disadvantages of conventional power generating systems the world is moving in the direction of developing renewable or new energy systems. New energy commonly called renewable energies engulfs various green energy sources such as wind energy, solar energy, biomass energy. Furthermore, energy from small hydro power stations can also be categorized as RES. The characteristics of RE like, being pollution-free, clean and resource regenerating are drawing glaring attention of the people towards these it. Hence, the development and application of RE is becoming unavoidable trend of smart grid development which is based on internet information technology and is supplemented with grid supply.

In Pakistan, at present the RE and new energy projects have entered into a phase of rapid expansion due to which a lot of problems are becoming prominent. The main problems faced by the experts in development and application of DG projects are as follows:

First and foremost is that of safety problems which cannot be found immediately and easily because of the decentralized generation equipment, complex operation environment, low manual routing efficiency.

Due to external environment the power quality,short circuit current, voltage shape and other performance parameters of these generation projects are greatly obstructed. Therefore, abnormal or unusual fluctuations can't be notified in time.

As there are various types and scales of these generation projects; Furthermore, these projects are also deployed on the scattered locations, the protocols of communication are also different for distributed new energy and RE generation projects. Therefore, it is difficult to obtain centralized management, statistics and dispatch for these RE generation projects.

Due to the above mentioned problems the utilization of these RES and the sustainable development of relevant industries are severely impeded by the above mentioned problems. Therefore, in order to ensure stable, safe and efficient operation of these scattered generation projects a monitoring platform and a centralized data center for remote and real-time monitoring of the various performance parameters and closely analyzing the relevant data of these generation projects are in dire need to be developed and built.

In order to support your system effectiveness and obtain proper output from your system, efficient equipment is required along with a number of other factors which affect your system efficiency and effectiveness. Hence, the importance of carefully watching and monitoring the distributed new energy and RE generation system closely for its production has increased many folds during the last two decades. By monitoring the production and other parameters of these generation systems various issues can be identified as when your system is not performing at its best potential. An online distributed energy and RE generation monitoring system has the capability of analyzing the real-time consumption and generation of the energy, optimizing the energy usage, various parameters related to the performance, analyze and supervise the functioning and progress of different components used in these distributed new energy and RE generation plant. The online DGs monitoring solution takes data from various remote DG systems and give information about the energy production of your system along with the information about the energy being supplied to the grid in real-time. The online DG monitoring solution is centralized i.e. a person sitting at one place can monitor the scattered distributed generation sets and ensure their best possible operation by interpreting the real-time data.

While designing and implementing a power system with distributed generation, selection of the DG monitoring solutions holds great importance. The information regarding system performance by monitoring of various performance parameters can be provided by online remote monitoring solutions. The information or data can be obtained on any portable device such as your cell phone, allowing the personnel who is monitoring the system a leverage to view the data anywhere on the device with internet access.

RE based Power Plant Management Platforms (PPMP) helps installers with easy integration and enable the supervisors of these systems to get real-time view of how much energy has been generated and how much has been supplied to the grid. By interfacing a web browser with your DG system a cloud-cloud based solution for monitoring can be incorporated and integrated in the RE based system. This provides highly interactive tool to the plant managers to optimize their decisions and accelerate the alignment with business goals by getting real time access to the key performance parameters or metrics.

An online monitoring system is not all about showing the energy generation and consumption data, it also provides information and helps us understand the setup of the system. Detection of various problems in RE generation systems such as defects in panel strings of a solar PV plant or blades of wind mill in wind energy plant and recommending repairs after detection of these defects. Furthermore, historical data from the system can also be tracked. For example, in order to know that how weather has effected the power production of the system in the past and what future prospects it can have, a monitoring systemcan help us achieve that as well because it offers data on historical weather-based data based on that information we find weather based performance of the system. Many existing online monitoring and management systems usually installed at homes, offices and other local systems monitor a single generation station that is why in all these cases a single monitoring object is found. Hence, there is no concrete report of that there exists a real-time monitoring platform which is inclusive of the evaluation of operation and generation capacity of DGs which are multiple and scattered.

II. MODELING AND DESIGNING

A. Prototype Development

In hardware implementation and development of the prototype, gaining the basic concept of hardware development is of key importance. Concepts of using burden resistance, using a breadboard, making proper connections and connecting capacitors for filtering results for accurate results.

As Arduino Uno only reads voltage signals. Whereas, the output of current sensors i.e. of CT, is a current signal. The Arduino Uno can't read current signals therefore there is a need for the conversion of the current signal from the CT into the equivalent voltage signal for the Arduino to read. For this purpose, we use a burden resistor. As we know that only the voltages between 0V to 5V can be handled by anArduino thus it is essential to convert the current signal into the voltage signal that lies within this acceptable range. In order to achieve that a burden resistor is added to the circuit. As the signal obtained from the CT is alternating and changes between negative and positive value. For maximizing the measurement resolution, the maximum voltage at burden resistance should be:

$$\text{(Maximum accepted voltage)} / 2 \tag{1}$$

As we know that the maximum accepted voltage here is 5V so the answer comes out to be 2.5V. Now the calculation for better burden resistance value is done:

$$R(\text{burden}) = U(\text{sensor}) / I(\text{sensor}) = 2.5V / 0.0707A = 3.5\Omega \tag{2}$$

The value 35.4Ω comes out to be the ideal value of the burden resistance, as the resistor is not a current resistor therefore we use a 33Ω resistor. As we also know that an Arduino cannot measure negative voltage, so inorder to make the value measurable by the Arduino we add 2.5V to U (sensor).

So we add:

Two resistors i.e. R1 and R2 as shown in the figure 1. We choose 10kΩ value for R1 and R2 because it avoids too much of the energy consumption.

The capacitor C1value is chosen to be 10uF which shows that it has a low reactance which is of the order of few hundred ohms and thus provides an alternative path for the flow alternating current (AC) to bypass the resistor and reduce the error in the values.

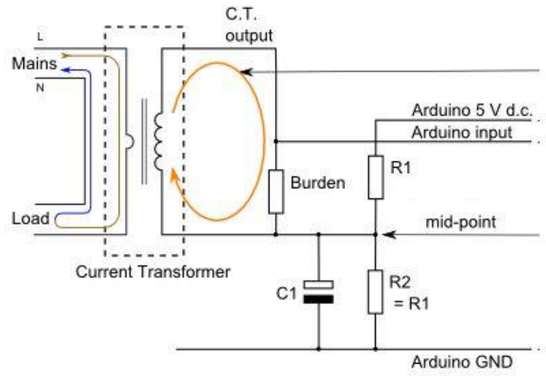

Fig. 1

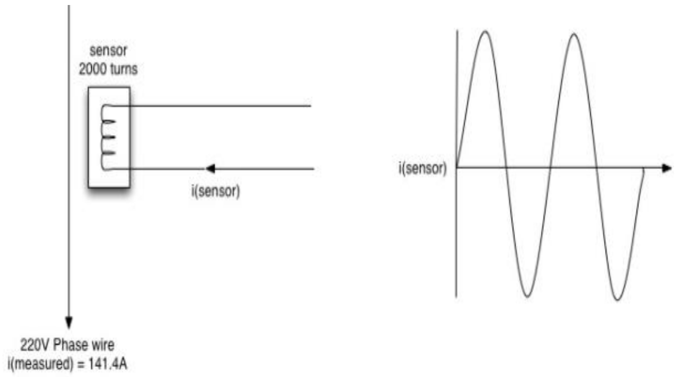

Fig. 3

B. *Interfacing the sensors with Arduino*

The sensors used here are YHDC 100A current sensors. The sensors measure the current of the line and generates a signals that is in direct proportion to the amount of current flowing in the line.As discussed earlier the Arduino Uno can't read current signals therefore there is a need for the conversion of the current signal from the CT into the equivalent voltage signal for the Arduino to read as shown in figure 2. It means that in order to interface a CT with an Arduino the use of burden resistor is very essential.

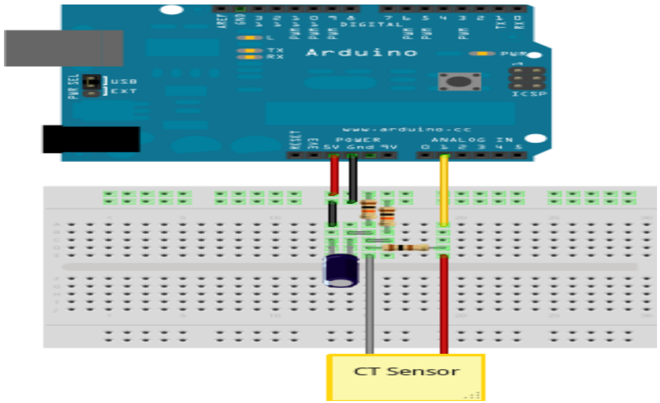

Fig. 2

The current that is measured by the CT is AC current. The CT sensor is standardized to measure a maximum of 100A AC, this 100A is actually the RMS value so therefore we need to find the maximum peak current that the CT sensor can handle shown in figure 3.

So it is essential to measure the peak current first:

i(measured)= $\sqrt{2} \times$ i(rms_current)= 1.414×100A = 141.4A (3)

The output current of the sensor is defined by its number of turns; here in this case it is 2000

i(sensor)=i(measured) / nb_turns = 141.4/2000 = 0.0707A (4)

C. *Connecting the Arduino Uno and the Thing speak cloud via internet*

For sending data to ThingSpeak cloud server using an Arduino UNO that has a built in Wi-Fi module i.e. ESP8266, it is essential that the Arduino board is connected to a network. There is a library for ThingSpeak in Arduino. In order to obtain the functionality of ESP8266 it is essential to download and install this library. The library is thus used by the Arduino device which enables it to send data to ThingSpeak cloud server. A user account is required on the ThingSpeak cloud, in the account various channels are thus created. Each channel has its own channel ID and name. So for Arduino to send the data to the desired channel the particular channel ID is provided in the code which is later burned on the Arduino board. The channel has the feature of storing the data for indefinite time. The Arduino board send data to the ThingSpeak cloud every milli second which is displayed on the channel field. More than one value can be sent to ThingSpeak cloud server as the server can support up to 8 different channels. To send multiple value to ThingSpeak from an Arduino, you have to use ThingSpeak.setField(#,value) for each value to send to a separate channel and then use ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey) to send data or information to ThingSpeak cloud.

Fig. 4

III. RESULTS

This section explains in detail the results obtained from the research after the successful development of the prototype. The main objective of the research was defined in the first chapter. The chief points of the objectives were to develop a centralized online monitoring system for RES based on the principle of distributed generation which is cheap. The advantage of having such a monitoring system is that in case of any abnormal behavior of any of the generation plants the owner or the operator of the plant is notified and necessary control actions can be taken. Furthermore, proper monitoring ensures reliable operation of the system so that maximum output can be obtained from the system.

A. *Explanation*

The developed prototype was installed on various remote locations on RE generation plants. One prototype was installed on IRA Fulton school, one was installed in Engineering research center (ERC), Tempe, Arizona. Each prototype was connected to the internet and the sensors were clamped on each phase of the inverter output. The sensors senses current of each phase and as the voltage is constant i.e. 110 volts in USA it calculates the corresponding power generated. Whereas in Pakistan as the voltage is 220 volts so based on the measured current the corresponding power is calculated by the Arduino code and sent to the ThingSpeak cloud.

B. *Results obtained from Engineering Research Centre (ERC)*

1) *Background*

The solar power generating plant on ERC has a 6000 VA rated apparent power output with a rated frequency of 60 Hz. It is an on grid system with 24 solar panels and used the concept of net metering. Each solar panel has a peak power output of 180 W with a maximum power voltage of 44.3 V, maximum power current of 5.76 A. The panels are connected in such a way that there is a series connection of 3 panels in 8 rows. The general block diagram of the on grid system of ERC is shown as under figure 5.

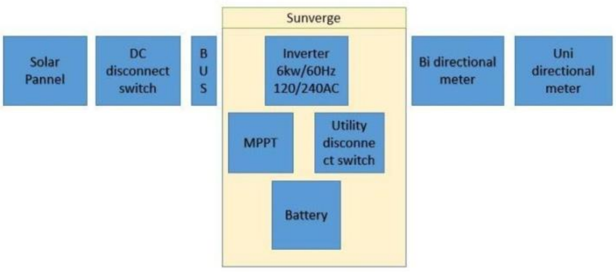

Fig. 5

The results obtained from the on-grid system of solar PV installed on top of the ERC building are as under:

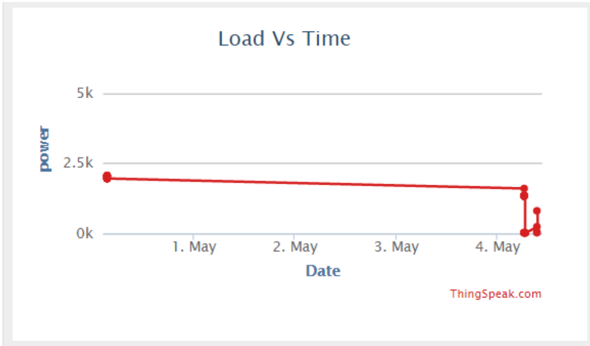

Fig. 6

The y-axis show power while x- axis shows time in the above figure 6. The Load Vs Time graph is from "ThingSpeak" which is cloud accessible data server. The power is decreasing with time. Apart from graphical visualization of the power production, we can also get a .csv file which can be used for further analysis of the system.

C. *Results obtained from IRA Fulton School of Engineering*

The solar PV generation plant on rooftop of IRA Fulton school of engineering is identical to that of Engineering Research Centre (ERC) with the same equipment, ratings and output. The results obtained from the on-grid system of solar PV installed on rooftop of the building are as under:

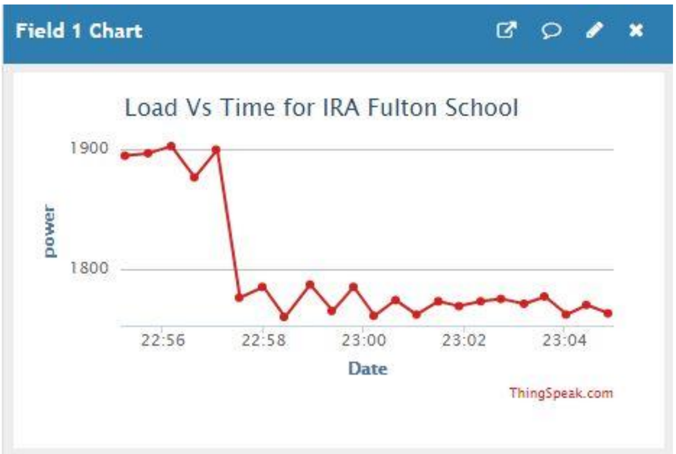

Fig. 7

The y-axis show power while x- axis shows time in the above figure 7. The Load Vs Time graph is from "ThingSpeak" which is cloud accessible data server. The power is varying with time as evident from the graph. This feature gives an operator an opportunity to monitor various distributed generation systems in real time. Apart from graphical visualization of the power production, we can also get a .csv file which can be used for further analysis of the system.

CONCLUSION

This research aimed to resolve the problems faced by the experts in development and application of distributed energy generation projects. The problems faced by them were as follows:

First and foremost is that of safety problems which cannot be found immediately and easily because of the decentralized generation equipment, complex operation environment, low manual routing efficiency. Due to external environment the power quality,short circuit current, voltage shape and other performance parameters of these generation projects are greatly obstructed. Therefore, abnormal or unusual fluctuations can't be notified in time. As there are various types and scales of these generation projects; Furthermore, these projects are also deployed on the scattered locations, the protocols of communication are also different for distributed new energy and RE generation projects. Therefore, it is difficult to obtain centralized management, statistics and dispatch for these RE generation projects and expensive monitoring system.

The developed system which is explained in the paper successfully resolved the above problems. The developed system is an Arduino and IoT based online monitoring system which is cost effective and is centralized. The Arduino gets its input from the sensors i.e. CTs. The CTs measures the current flowing in the line and send it to the Arduino. The Arduino reads the sensor data and through coding it calculates the corresponding power. It then uploads the current along with the corresponding power values to the ThingSpeak cloud every millisecond. The ThingSpeak cloud stores the data, we can also visualize the data and power flow in the form of graphs. Furthermore, we can obtain a .csv file from ThingSpeak which can also be used for further experimentation. The online monitoring system for RE based DG system based on Internet of Things (IoT) technology is developed in this paper which provides certain technical services for users, including monitoring of remote DG systems. By monitoring the DG system we can real-time data, the data obtained can be analyzed and evaluated to ensure efficient operation of the system and obtain maximum output from it. For assessing the system'sperformance and also for timely detection of possible breakdowns of the facility monitoring of the DG system is frequently employed. This monitor could show the unusual operating condition of the system. All new or existing RE generation projects that lies within dominion of this system, the performance parameters are acquired in real time and in a centralized way which are then available for the operator to view. The system will steadily explore and connect to various other clean energies and deeply mine and analyze the data to further promotion of popularization of the developed prototype for monitoring of new energy and renewable energy in energy field.

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Comparative Analysis of MPPT Techniques for SEPIC Based PV System

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Abstract— In this paper comparative analysis of maximum power point tracking techniques has been conducted to achieve highest magnitude of power from photovoltaic array. The algorithms proposed in this paper for extracting peak output from photovoltaic array are Perturb and Observe, Incremental Conductance, and Fuzzy Logic Control. There are some limitations with conventional converters i.e. Buck-Boost converter. When the operating voltage exceeds normal voltage as the voltage becomes high, the conventional converters fail to carry high voltage and current. Apart from this the ripple contents also increase abnormally due to the large impedance in the conventional converter. Similarly these converters cannot track maximum power point faster and effectively. In that case Single Ended Primary Inductor Converter (SEPIC) is the best choice instead of the conventional buck-boost converter, which is employed with the aim of extracting maximum output from the photovoltaic array. The aim of this study is to compare three MPPT techniques under varying environmental conditions with respect to maximum power extraction and speed of tracking time. SEPIC is used instead of conventional buck-boost converter in order to achieve maximum efficiency and less ripples. Also it can track maximum power point (MPP) faster than Buck-Boost Converter. Comparative analysis of three most extensively used MPPT techniques have been conducted in Simulink/Matlab.

Keywords— Maximum Power Tracking (MPPT), Photovoltaic (PV), Perturbed and Observe (P&O), Incremental Conductance (IC) and Fuzzy Logic Control (FLC)

I. INTRODUCTION

Global warming and energy policy is becoming a major issue on the global program during the last few years. Advanced nations are planning to act on climate change. For instance, Europe has scheduled to significantly reduce carbon dioxide emissions to at least 20% below 1990 levels and generate at least 20% of its power consumption from renewable power by 2020 [1]. In this respect, as it is a green source, it has a critical role. The only emissions related to PV seem to be from the manufacturing of their modules. They produce power from solar irradiation without producing greenhouse gas emissions. PV panels generate more energy for their production in their lifetime, which is around 25 years. They can be mounted in that regions if there is no other use, like towers and deserts. They can generate power for isolated areas in which electrical energy is unavailable. The first category of installations is regarded as an off grid system and is often the most cost-effective solution for supplying power in remote locations. However, plenty of the photovoltaic generation comes from grid tied systems in which the energy is supplied to the power grid. Moreover, it is an emerging sector in western countries like Germany, which is the most influential in the market in generating energy through photovoltaic from 2010. PV generation at the other hand is more expensive than other means because of the equipment's needed. It is being encouraged by governments with incentives, anticipating the equipment to develop so that it becomes profitable in just the coming years [2]. Improving the efficiency in photovoltaic plants in order to enhance the energy generated is an important element as it will boost the income, thus lowering the price of electricity produced in order to come up to the price of the energy generated from extra resources.

There seem to be three key elements which influence the photovoltaic system's efficiency: panel's efficiency (ranging from 9 to 15%), efficiency of the inverter that ranges from (95-98%), and lastly the efficiency of MPPT is about 98%. So by detecting the MPP with improved technique is more easier and simple method instead of improving the generation unit which is costlier and time consuming process [3]. MPPT control algorithms are essential since PV modules have nonlinear I-V characteristics with a common point where maximum power can be produced. This unique point varies with both panel temperature and the conditions for irradiance. Throughout the day, both conditions change and vary based on the season of the year. In addition, owing to varying the ambient factors like those of clouds, irradiation can alter quickly. The detection of MPP correctly is very essential for maximum power generation. A number of MPPT control techniques are already released in recent years [4]. They vary in several respects in sophistication, some needed sensors, and other may vary due to efficiency and cost. Furthermore, if one similar result can be achieved with a simpler and less costly, it is useless to use a costlier or more complex technique. This is why some of the methods suggested are not being used.

Photovoltaic cells directly convert sunlight into electrical energy [5]. Many commercial PV modules currently use two categories of PV cells: thin-film and crystalline silicon. The first category is known as PV's 1st generation Consisting of monocrystalline and multicrystalline. These cells generate electricity from extremely sophisticated poly-silicon feedstock through crystalline silicon semiconductor material. The former are reliable than the latter, however they are not cost effective [6]. Similarly the second category of PV cell that is thin film is termed as PV's 2nd generation. In which power is generated from semiconductor's thin layers, Manufactured from copper indium di selenide, amorphus silicon, cu induim galium di silenide, cadmium tellurid. A PV cell circuit is revealed in the **Error! Reference source not found.** with a source of current which is connected parallel to diode, shunt and series resistances R_S , R_{SH}. There is a significant correlation among current I_g and irradiance i.e. the current I_g varies directly with irradiance.

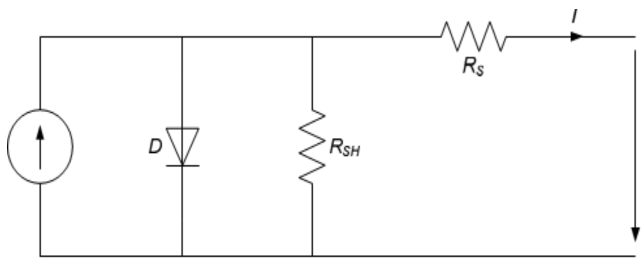

Fig. 1 Equivalent circuit of PV Cell

II. MAXIMUM POWER TRACKING TECHNIQUES

The irradiance and temperature curves are the two most vital factors which intluence the output power characteristics of the PV system. And these two are momentarily maintained by solar irradiation and temperature. As discussed, there will be blunt changes in the values of solar radiation during the day as shown in Fig. 1. A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the Thevenin impedance of the circu it (source impedance) matches with the load impedance. In this way, Maximum power point tracking technique is necessarily used to improve the efficiency of the solar panel.

A. Perturb and Observe (P&O)

Hill climbing is another name given to P&O because either term applies to the same approach established on how they are executed. It incorporates disturbances of the converter's duty-cycle and disturbance of coupling capacitor linking PV array and operating voltage of the power converter [7]. The P&O technique frequently increases or decreases the PV's voltage output across the terminals and relates the strength of the previous cycle gained across the current cycle. If the voltage is directly related to power as if one increase the other also rises, as a result device for controlling the position adjusts in that way; then the operating point moves in the reverse way. Once the current position of shift is identified, the current changes at a constant rate. Such level is a factor to be modified to allocate stability among rapid feedbacks through fewer consistent variation of the state.

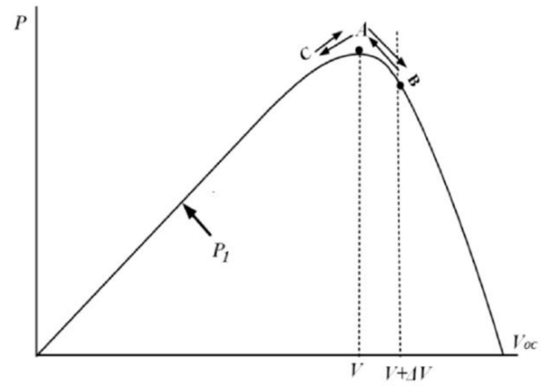

Fig. 2 PV curve for P&O

A prevalent issue in P&O algorithm can be observed each MPPT cycle is disturbed by the array terminal voltage; so once the MPP is acquired, output power shifts towards the optimum, owing to a reduction of energy in the scheme. That is particularly exact in steady or gradually changing environmental situations. A modified adaptive P&O technique by changing the step size of disturbance can be used to fix this issue, in which an intelligent control regulator adjusts the step size of disturbance to a broad level once the energy shifts mainly owing to environmental variability in a wide spectrum. The Flow chart of P&O can be viewed from the Fig. 3.

B. Incremental Conductance

The Slop of V-P becomes zero around MPP, that's the cause of Incremental conductance. The slop on the left side is positive while it becomes negative at the right.

- $\Delta V/\Delta P$ =O at MPP
- $\Delta V/\Delta P$> O LHS of the curve
- $\Delta V/\Delta P$< O RHS of the curve

By comparing the increments in both voltage and power, MPP can be determined. Flow chart of the IC can be seen in the Fig. 4.

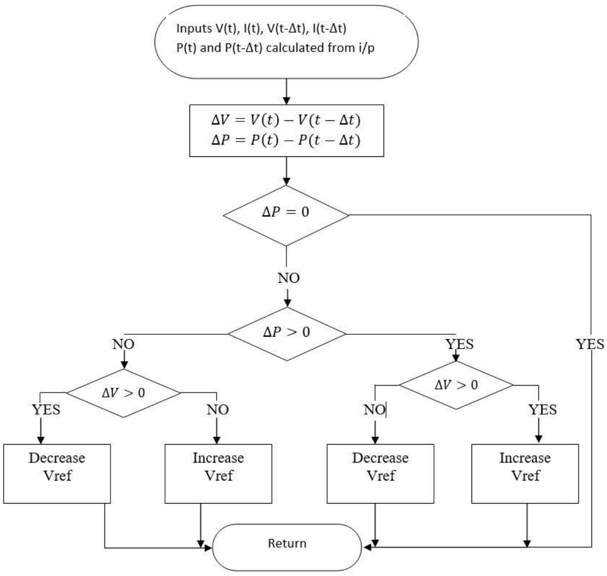

Fig. 3 Flow chart of P&O

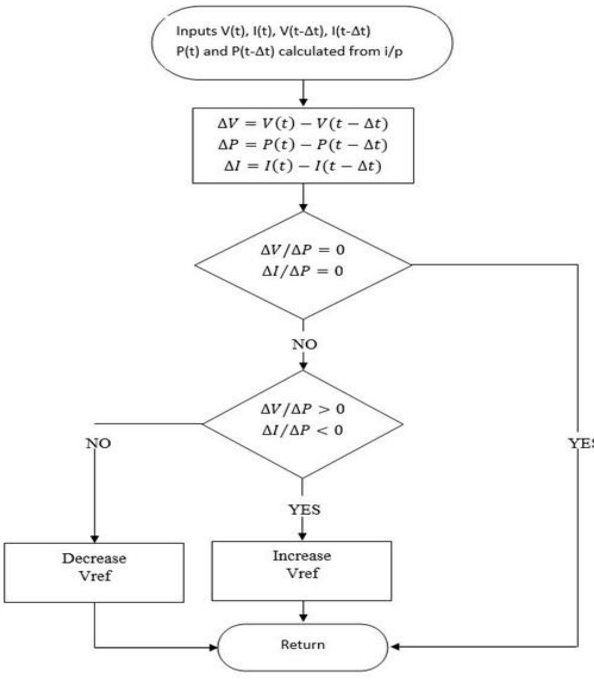

Fig. 4 Flow chart of IC

C. *Fuzzy Logic Control (FLC)*

Fuzzy logic control is becoming trendy over the past few years, since it can withstand ambiguous signals, doesn't entail an exact computational illustration, and thus can manage irregularity. Once FLC develops, microcontrollers have also helped [8]. The fuzzy logic has three different phases: fuzzification, defuzzification and inference system [9]. Fuzzification involves converting quantitative flat inputs into descriptive quantities, depending on membership levels of some groups. Membership functions can be applied to connect rank to all syntax words. The numbers of membership functions that are utilized reckon on the exactness of the regulator; however they generally vary from 5 to 7. PB stands for Positive Big, NB-Negative Big, ZE-Zero, NM-Negative Medium, PM-Positive Medium, PS-Positive Small are the seven fuzzy levels can be seen in figure. The range values of numerical variable are labeled as a, b and c. In certain samples, the MFs are selected in a less symmetrical or otherwise configured way for improved integration.

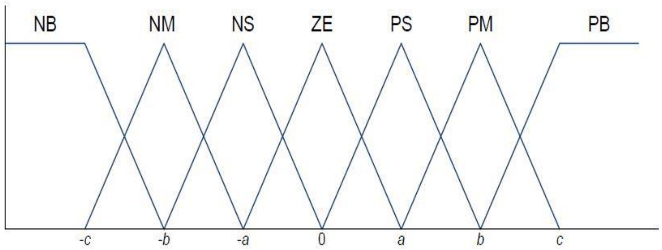

Fig. 5 Membership functions

III. MODELING AND DESIGNING

A. *System Configuration*

In this paper, three MPPT algorithms are modeled using Matlab tool Simulink. They are P&O, IC and FLC. Each algorithm is discussed in detail. Now the proposed models are presented here. Each proposed model comprises of PV array, SEPIC converter, MPPT algorithm and DC-link capacitor. Furthermore, designs also include voltmeter, ammeter, displays and scopes.

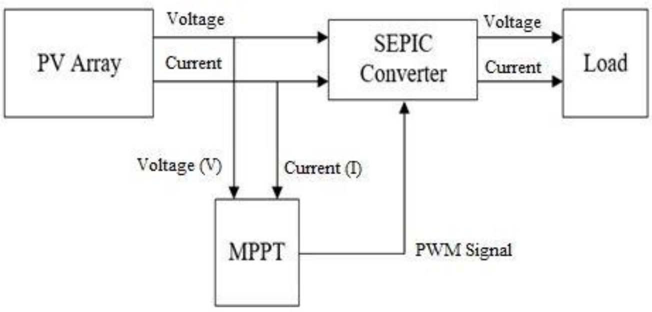

Fig. 6 Basic block diagram of system configuration

1) *PV Array*

The PV array chosen for the design is ‘Trina Solar TSM-250PA05.08. The array consists of only 1 module. The parameters of PV module are represented in the TABLE 1 .

TABLE I. PV MODULE PARAMETERS

Characteristics of Parameters	Specifications
Maximum Power (MPP)	249.86 W
Voltage at MPP (V_{MPP})	31 V
Current at MPP (I_{MPP})	8.06 A
Open Circuit Voltage(V_{OC})	37.6 V
Short Circuit Current(I_{SH})	8.55 A

1) DC Link Capacitor

The PV output is connected directly to the DC coupling capacitor. This capacitor significantly reduces the ripple contents of PV voltage and current. The capacitor chosen for all the three design is rated as $3uF$.

2) SEPIC Converter

Single Ended Primary Inductor Converter is chosen instead of conventional Buck-Boost converter. It consists of two inductors L_1 and L_2, two capacitors C_{in} and C_{out}, a MOSFET and a diode. The value calculated for L_1, L_2, C_{in} and C_{out} are given in the TABLE 2.

TABLE II. SEPIC COMPONENTS SPECIFICATIONS

Componets	Value
Inductutor L_1	5µF
Inductutor L_2	5µF
Input Capacitor C_{in}	15µF
Output Capacitor C_{out}	2000µF
DC Link Capacitor C_m	3mF

B. Perturb and Observe (P&O) algorithm

It consists of PV array, the SEPIC converter, P&O algorithm. Input current, voltage from the PV are supplied to the multiplier to obtain input power. The P&O MPPT block as shown in the figure are supplied with two i/p i.e. PV i/p's voltage [V_{pv}] and PV i/p's current [I_{pv}]. PV i/p current & i/p voltage and their product i.e. input power are connected to the displays. To obtain their input waveforms, scope is used. Current measuring instrument and voltmeter are connected in the output. Similarly, O/P current, O/P voltage and O/P power are also coupled to the displays. Scope 2 is used to demonstrate the output waveforms of the voltage and power. To simulate the proposed model powergui is used.

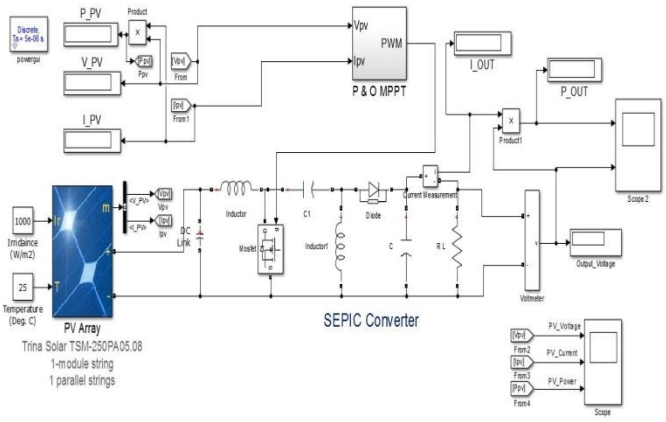

Fig. 7 Simulink Model of P&O

The flowchart for P&O as described in Fig. 3 is implemented here. The P&O controller has two i/p, [Vpv] & [Ipv] i.e. i/p voltage and i/p current of PV. The controller has one output i.e. PWM.

C. Incremental Conductance (IC)

The controller design is based on the following steps.

- $\Delta V/\Delta P$ =O at MPP
- $\Delta V/\Delta P$> O LHS of the curve
- $\Delta V/\Delta P$< O at the RHS of the curve

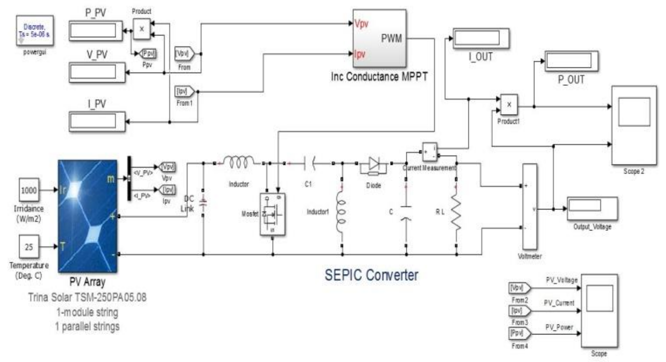

Fig. 8 Simulink Model of IC Algorithm

This model is similar to the previous model; the only difference is the controller used here is IC instead of P&O. Similar to the P&O; IC has also two inputs and one output.

D. Fuzzy Logic Control (FLC)

The third and the last MPPT technique we designed is Fuzzy Logic Control. The FLC algorithm consists of three parts. In the first part E and ΔE are calculated. Then FLC is connected across it. FLC is further coupled to the PWM generator. Thus the output i.e. PWM is generated and given to the MOSFET.

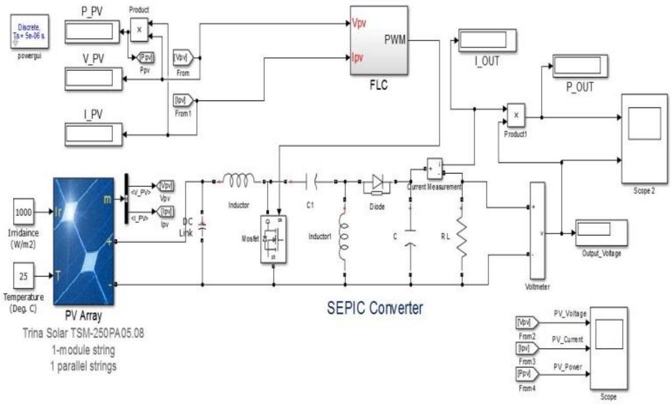

Fig. 9 Simulink Model of FLC Algorithm

FLC is defined for the set of rule is known is rule base or fuzzy rule algorithm. Rule Base is shown in the TABLE 1. We implement this rule base for the FLC to work properly. The .fis file also creates along with it. This file contains the membership functions as presented in rule base. As from the figure inputs are connected to the error and change of error block. E and ΔE are defined in this block. Then the two are connected through bus bar to FLC. Output of the FLC is also displayed. PWM generator and FLC are connected through the summer and displayed to output.

IV. SIMULATION RESULTS

These algorithms are simulated in the Matlab tool Simulink. The input and output curves for voltage, power and current are obtained. The results are displayed below in the TABLE 3. These algorithms are simulated for different temperature and different irradiance level that will be presented in the Table 2. Results are obtained by selected the temperature 25℃, 35℃, 40℃ and 50℃. The irradiance is selected ranges (1000W/m^2 - 500W/m^2). But the all curves are obtained for temperature 25℃ and irradiance of 1000W/m^2.

Fig. **10** visualizes the output curve of power for P&O algorithm. The curve is smoother as we are using SEPIC, the curve seen from the simulation using Boost converter, carrying a lot of ripple contents. This curve is obtained while taking the STC and keeping irradiance constant.

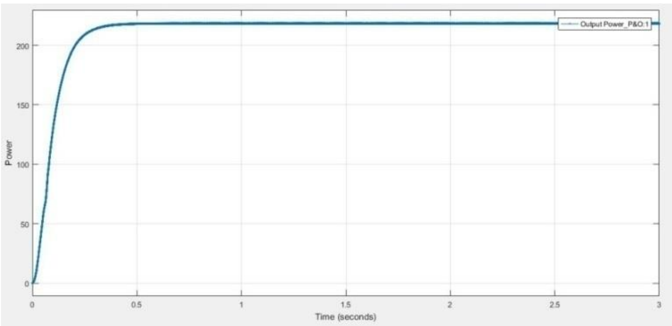

Fig. 10 Output Power of P&O

The peak power extraction from PV using P&O is $218W$. As the PV selected for the simulation has ratting $250\ W$, so the efficiency for P&O MPPT technique can be calculated by: $\frac{Output\ power\ of\ MPPT}{Input\ power\ from\ PV} \times 100\% = 87.2\%$

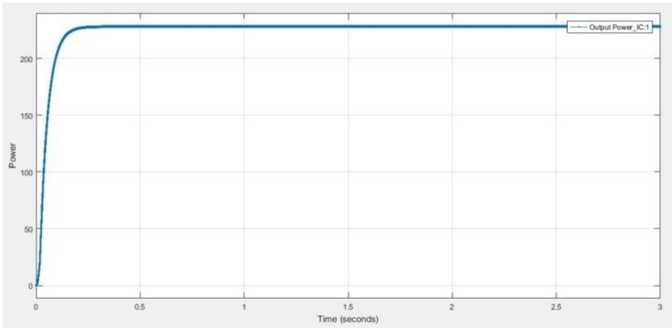

Fig. 11 Output Power curve of IC

Comparing it with the output curve of power for P&O algorithm, this curve contains less ripple contents. The power extraction from PV using IC method is $228W$ i.e. MPP. The efficiency for this method can be calculated as: $\frac{Output\ power\ of\ MPPT}{Input\ power\ from\ PV} \times 100\% = \frac{250}{228} \times 100\% = 91.2\%$.

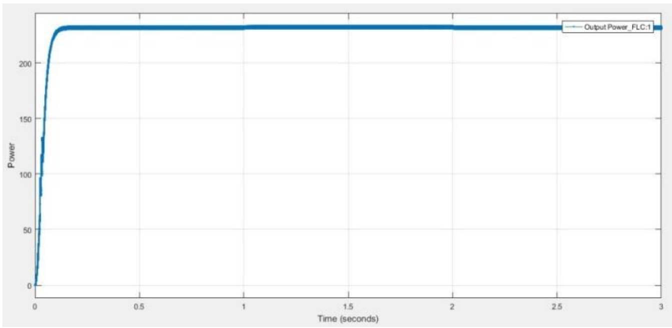

Fig. 12 Output Power curve of FLC

Comparing it with the output curve of power for P&O algorithm and IC algorithms, the FLC can extract more power than the other two algorithms. The MPP for FLC algorithms is 234.4W. It is most efficient than the two methods. The ripples at the start of the curve i.e. at the slop are due to tracking the MPP. MPP is tracked by transitions in the membership's functions.

All the three models are simulated under varying environmental conditions. In the first case temperature and irradiance, both were kept constant while analyzing the input and output curves for the proposed models. In the second case, which will be presented here in the table, the temperature will be kept constant i.e. 25℃ and irradiance will be varied from 1000W/m^2 to 400W/m^2. In the third case irradiance will be kept constant i.e. 1000W/m^2 and temperature will be varied from 25 ℃ to 50 ℃. Output power and efficiency of the three algorithms are shown in the tables under varying conditions.

TABLE III. MPPT EFFICIENCY UNDER VARYING IRRADIANCE

Irradiance (W/m^2)		1000	800	600	400
Power from PV curve		249.9	200	149.8	99.16
P&O MPPT	Power(W)	218.2	176	134	89.69
	Efficiency	87.3	88	89.4	90.4
IC MPPT	Power(W)	228	184	139	90
	Efficiency	91.5	92	92.7	90.7
FLC MPPT	Power(W)	232.5	186	141.1	94
	Efficiency	93	93	94.1	94.7

FLC is more efficient than IC and P&O MPPT techniques under varying irradiance keeping the temperature constant i.e. 25°C. The power extraction by FLC is 232.5W from a 250W solar panel at irradiance of 1000W/m2, while the power extracted by IC and P&O are 228W and 218.2W respectively. The efficiency of FLC is 93 and it increases as the irradiance level is goes on decreasing, this is the main advantage of FLC than the other two techniques. Similarly IC is more efficient than P&O as the power extraction by IC is more than power extracted by P&O. Similarly, the efficiency of these MPPT techniques at different temperature. From the table it is concluded that FLC is more efficient than P&O and IC methods. Also it can be concluded that efficiency decreases, as temperature increases.

TABLE IV. MPPT EFFICIENCY AT DIFFERENT TEMPERATURES

Temperature (°C)		25	40	50
Power from PV curve		249.9	234	223.5
P&O MPPT	Power(W)	218.2	202	194.2
	Efficiency	87.3	86.3	86.8
IC MPPT	Power(W)	228	213.2	203.1
	Efficiency	91	91	90
FLC MPPT	Power(W)	232.5	217.6	205.7
	Efficiency	93	93	92

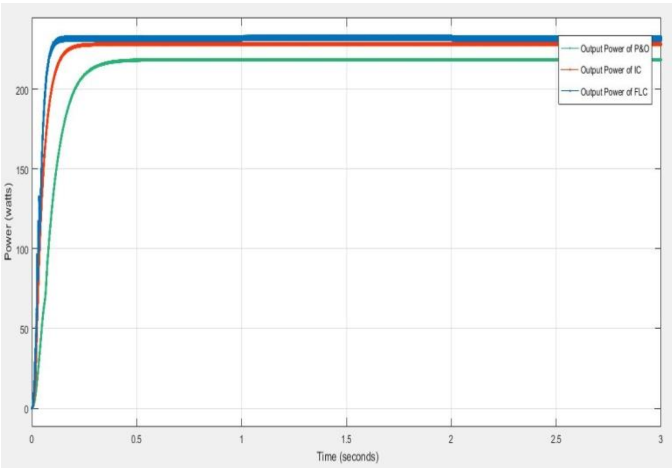

Fig. 13Comparison of the Output Power curves

It is concluded that FLC is more efficient than IC and P&O MPPT techniques at varying temperature. The power extraction by FLC is 232.5W from a 250W solar panel at 25°C, while the power extracted by IC and P&O are 228W and 218.2W respectively. Moreover, the efficiency of FLC at 25°C, 40°C and 50°C is 93%.

Final comparison of the three MPPT techniques on the basis of output power curves are shown in the Fig. **13**. It can be concluded that FLC is more efficient than IC, which is further more efficient than P&O i.e. for the same input power, the power extraction by FLC is better than IC and P&O.

CONCUSLION

Fuzzy Logic Control (FLC) is the best MPPT technique than Perturb and Observe (P&O) and Incremental Conductance (IC). The Power extraction by FLC is 232.5 watts from the input power of 249.9 w. It is more efficient than the P&O and IC as the Efficiency of FLC is 93% and the tracking time is 1.2 seconds which the fastest time to track maximum power point (MPP) than the other two techniques.

TABLE V. COMPARISON ON THE BASIS OF POWER, EFFICIENCY AND TRACKING TIME

Irradiance (W/m^2)		1000
Power from PV curve		249.9
P&O MPPT	Power(W)	218.2
	Efficiency	87.3
	Tracking Time(s)	0.27
IC MPPT	Power(W)	228
	Efficiency	91.5
	Tracking Time(s)	2.1
FLC MPPT	Power(W)	232.5
	Efficiency	93
	Tracking Time(s)	1.2

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