International Journal of Engineering Works
https://www.ijew.io/
ISSN-p: 2521-2419
ISSN-e: 2409-2770
Vol. 9, Issue 09, PP. 156-165, September 2022
https://doi.org/10.34259/ijew.22.909156165

Energy Demand Analysis for Distributed Energy Systems

Ahmar Ali[1], Syed Kamal[2], Waqas Ahmad[3], Jawad Ahmad[4], Sheraz Khan[5]
[1,2,3,4] Energy Management and Sustainability, University of Engineering and Technology, Peshawar, Center for Advance Studies in Energy (CAS-E)
ahmerali54@yahoo.com[1]
Received: 05 August, Revised: 15 August, Accepted: 24 August

***Abstract*—**Energy is one of the most significant drivers for socio economics sustenance and is a perquisite for sustainable development in the today's modern world. Pakistan is a developing country which is sixth most populous country in the world. For Pakistan energy shortfall has become a major constrain in the economic development. The supply and demand gap is 6,000 MW during the peak hours at electrified areas. while there are still one fourth (51 million) of population who have no access to electricity. To provide these rural communities electricity government of KPK has installed off grid minimicro hydro projects on the agricultural canals to ensure reliable, affordable energy to the rural parts of the country. The purpose of this study is to analyze the performance of MMHPs in fulfilling the energy demand of communities.

This methodology of study is designed to transition from simple survey that focuses on measurement based outcomes to more comprehensive data collection methods. The survey contain all the information about current situation, proposed technologies, sources of energy, member of household, ages of dweller, number of appliances and use of appliance. These questionnaires also included micro hydro performance and issues related fulfilling the energy demand.

The results show that most of the MMHPs were not installed properly as in almost every case the actual production production is less than 80% of rated power. It also shows that most of the electricity produced by MMHPs are consumed for lightning purposes. The results elaborate that MMHPs are able to produced maximum electricity during the summer season as the peak demand is also in summers. There is no proper arrangement for stability as well as safety of the system. Considering the satisfaction level most of the residence they are satisfied with the timely availability of electricity. Consideration of other sources is neglected. The improved MMHP installations require better funding for construction; the way tariffs are structured and revenue collected requires further improvement.

***Keywords*—** SDGs, Affordability, Energy Demand Analysis, CDM, SE4ALL.

I. INTRODUCTION

Almost everything in this world needs energy. It is the essential need for human lives. Our dependence nowadays is mainly based on electricity and due to inclination in population, industrialization and rise of economy the use of energy increases day by day. International energy agency in 2011 [1] mentioned that need of energy increases expeditiously in the past 25 years throughout theworld and rate of it will be increased in the coming years. Thus to meet the rapid increase in demand it is very important to analyze and control the reliable supply of electricity. Pakistan being developing country failed to fulfill the need of electricity. It was because of the previous wrong policies that the gap between supply and demand reach to almost 6,000 MW during the peak hours at electrified areas. while there are still one fourth (51 million) of population who have not access to electricity [2] The rapid increase of demand motivated finding the alternate sources for providing cheap electricity. As Pakistan is agricultural based country and most of its agriculture is watered through canal. These canals can play an important part to power to the northern part of KPK where grid accessibility is very difficult in this scenario Pakistan opted for off grid electrification as a cheap and reliable solution as compared to grid extension. Despite of water availability and efficiency these hydropower lead to poor energy production moreover there is lack of skilled personal who has to operate these power plant. In this research various aspects of hydropower regarding the energy production and full filling the demand would be analyzed and various recommendations of these problems would be given. Modern electricity has changed today's societies and its functioning such that without electricity the existence of these societies would be impossible, still 1.1 billion people in world lack access of electricity [6]. Sub-Saharan Africa and south Asia are the regions with the largest population without access. 37% of world population without electricity access is comprised of south Asians[7]. Most of the people in these region lives in the remote areas where access of the grid is impossible or sometimes uneconomical. For them off grid is the only solution in order to provide them with electricity. That off-grid can be solar, hydro or wind [7].Community based micro/Pico hydro is well developed in Kenya [8]. These micro hydro as rural

electrification is environmental friendly and helps in the improvement of social and economic values that lead to better life, improvement of health and education facilities [9]. Though the availability of power in micro off grid system are low and its services provided are more basic [10].For rural electrification, small-scale hydro in most of the cases running of the stream with no water stockpiling is the most economical and ecological benevolent innovation [1]. There are several issues related to small hydro power these issues need to be addressed to make it successful power producer. In northern areas of Pakistan exists the capacity of production of 1200 MW micro/mini hydro power. Less than 5% is being produced out of this potential [11]. For small-scale hydel plants with limits of 100 and 500 kW each, an expected capacity is of 400 MW. [12].This province has been given very large power potential. Local government is trying hard to explore these opportunities to take care of consistently expanding energy demand. Pakhtunkhwa Energy Development Organization (PEDO) trying hard to give power to the national grid and to a few regions through off-grid arrangements. [13].For Literature Review we would be considering similar examples that has applied small scale Renewable based off grid system. These studies will diversify our views about the cases considered in literature review. It will also help us in understanding the implementation of rural electrification.

II. LITERATURE REVIEW

A. Hydro Power

Every form of life on this planet is supported by water as a key resource. Human civilization has suffered a lot due to the increasing release of greenhouse gases 4 (GHG) from increasing industrialization. The risk and reality of environmental degradation has appeared in previous few decades. In this situation renewable energy is the only solution for energy provision. Hydro is the major source in appearance of important renewable sources of energy [14]. In order to reduce carbon dioxide (CO2) emission and achieve sustainable development goal The clean development mechanism (CDM) of Kyoto Protocol provides incentive to invest in emission reduction project. Hydro power can be an interesting factor because it directly reduces GHG and contribute to sustainable development goal.

1) Current Status

In all form of renewable Hydro power either large or small, has very importance worldwide in-terms of electricity generation. The World Hydro Power Atlas 2000 [2], published by the International Journal of Hydro power and Dams, reported that the world's actually practical hydro potential is evaluated at 14,370 TWh/year, which equalize 100% of the present worldwide power requirement. The financial feasibility extent of this is at present is viewed as 8080 TWh/yr. providing 19% of the planet's electricity from an installed capacity of 674 TW as shown in fig.2.1. 135 TW of new hydro capacity is expected to be commissioned in the period 2001 to 2010. All other renewable gave together under 2% of worldwide utilization [1].

2) Rural Electrification in South Asia

Electrification by all method always has positive impacts on society about 42% population of world having no electricity belongs to south Asia. In spite of different efforts the situation is not getting better [4].All government priorities are to restrain renewable for specific areas where there is no access of grid electrification. Despite agriculture countries like Bangladesh and Pakistan where country has biomass resources these countries are not trying to generate electricity from these resources. India has not tried to utilize from there micro hydro resources available in mountain regions[15]. similarly, Nepal need to tackle its electricity shortages with double approach. first by increasing grid and second by utilizing micro hydro potential in hilly areas.

3) Examples From Developing Countries

Afghanistan National Development Strategy (AND)[16] is trying to develop new strategy based on micro scale power generation from hydro Provisional Reconstruction Teams (PRTs) are implementing the ANDs vision. The key effort is implementing these projects with local who will take care of these projects after commissioning. Similarly, during the implementation, the cost sharing through land donation is another feature of the project.

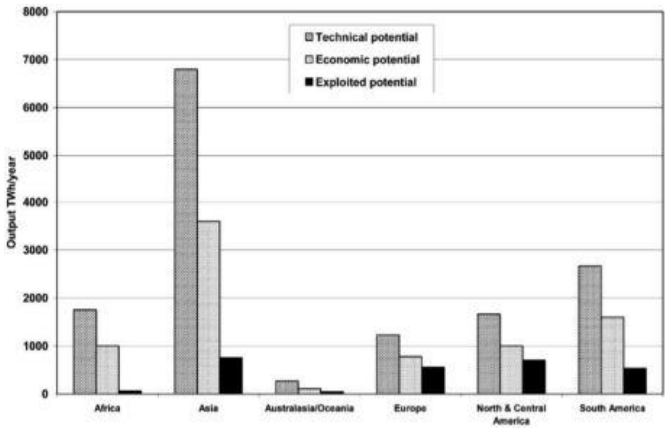

Figure 1. Hydro Power Potential in Developing Countries

B. INTERNATIONAL PROGRAMS IN PAKISTAN

Pakistani government are focused on large power producer dam as well as mini micro hydro projects in these projects Pakistan is mainly supported by Germany, Asian Development Bank (ADB), Japan International cooperation Agency (JICA), World Bank (WB), and USAID.

1) Pakistan Green Renewable Energy forum

There are different organizations from Germany these are investing in Pakistan in power sectors these are KfW that is investing in hydropower similarly GiZ in Renewable and energy efficiency and conservation German support to renewables in Pakistan in the "Pakistan-German Renewable Energy Forum" (PGREF), which are advancing the solar, wind, hydropower and biogas technologies in Pakistan.

2) USAID Programs

USAID is helping in advancement of infrastructure. it is also helping in policy reforms so as to enable the energy sector to work cost effectively. USAID has added 1,013 MWs from

new or renovating dams and thermal power plants it has also added 1,447 MWs from up gradation in the transmission and distribution system this it has produced 2,240 MWs of power for the national grid. it has also installed 250,000 new meters which helped in getting accurate reading of electricity used [21].

3) SE4ALL

In 2013 Pakistani government with UN Global Initiative Sustainable Energy for All (SE4ALL).SE4ALL was started by UN Secretary General Ban Ki-moon in 2012. The main purpose of this initiative was reducing carbon emission and providing energy all the people on the planet. The three key challenged that has to be addressed were [7] • ensuring providing of modern energy services • increase the rate of global energy efficiency by two times • increase the renewable in share of energy mix by two times These keys challenges cannot be eliminated in Pakistan without dealing with poor governance structure, adapt water for power generation, boost micro financing in rural areas, advocacy of energy efficiency and conservation projects and improving R&D in renewable technologies [23].

4) Energy for All Intitiative

In 2008 Asian Development Bank (ADB) started Energy for All initiative to eradicate poverty through energy in Asia. In 2009 regional Energy for All was launched in Pakistan and objective was to provide energy to rural communities For this purpose mini micro hydro power were installed and subsidy were provided on solar hydro system [24].

C. Energy Demand

The demand of energy describes is the need of energy to run household commercial or industrial machinery. Demand arises mostly in the use of electrical or electronic appliances, heating and cooling processes and cooking. To install these power plants correct estimation are required [25].

1) Factor Affecting Energy Demand

According to author [17] It is almost impossible for having standards for electricity use as it differ with respect to location, population and social standards. In calculating the energy demand it is very important to identify the characteristics of household. It is common practice of having increase in the size and capacity of plant by 30% to coup up with the increasing yearly demand. The electricity consumption is effected by different factors. Normally the demand of electricity depends upon seasons and climate. Parameters, economical boundary condition. outside temperature plays a significant role in the heat requirement but climate factors as wind speed, global irradiation effects cannot be ignored while calculation the heat demand. Similarly, the variation in the seasons also has great impact on the energy use. During the weekdays the energy demand usually tends high than weekends. Moreover, vacations and holidays also effect energy use. 8 Similarly timing also has impact on the demand as during specific time the demand tend high. Another study indicates that not only income level of community but also industrialization and commercialization affect the energy demand significantly. Carbon dioxide (CO2) emission has huge impact as compared to other factors involving the energy demand [26]. Hence it is fair to presume that percentage increase of GDP is related with increase of less equivalent percentage use of energy. In making different decisions accurate analysis and forecasting is the key. Accuracy of method can be find out by different measures such as Root mean square error (RMSE), mean absolute error (MAE) and mean absolute percentage forecast error (MAPE) [27].

2) Energy Data Management

The process of managing the generation and consumption of energy is called energy management. The purpose of this process is to decrease the demand, cost and pollutant emission. With the decentralization energy management has to look for solution toward efficiency and conservation [28]. To minimize energy consumption computer based energy management merge application from mathematics and informatics. Since there is enormous information optimized data management is to be used.

III. METHODOLOGY

As per IEA building industry consumed 29% of the total primary energy 2009 out of which 30% is produce by growing power sector [38]. Pakistan energy sector consume total of 32% of the total energy used is the highest percentage of any sector in energy consumption. For distributed system almost 75% of energy is consumed by residential sector[39]. There are efforts required to reduce the percentage of energy. In order to achieve efficiency Pakistan has introduced National energy efficiency and conservation Agency (NEECA) that work under water and power ministry. It all started as USAID project in 1985 by the name of National Energy Conservation Centre (ENERCON). In 1986 it was made and autonomous body under the planning and division ministry. In 1996 it was transferred to environmental ministry and in 2011 it was transferred to ministry of water and power [40]. NEECA works for improving energy efficiency in transportation, Agriculture, textile and Building sector. Building industry consumed 29% of the total energy used in 2009 Khyber Pakhtunkhwa is province located in northwest of Pakistan it is major electricity producer of country from hydro power plant because of its location it has large number of mountains. After 2010 flood where many of power plant were flooded or washed out. The transmission and distribution infrastructure of rural areas were completely damaged [41]. in rehabilitation and reconstruction, it was found out that distributed generation would reduce significant cost than extending grid to mountainous region. Government of KPK with the help of Asian development bank aimed to construct 1000 mini micro hydro plants in the rural mountainous region [42]. These micro hydro projects have the capacity from 20 kilowatts (KW) to 1500 KW. These projects are also intended to be transferred to local communities after maintaining for certain time [43] as the production of this energy is mainly used for household the objective of this chapter is to provide methodology for the energy performance and evaluation of the MMHPs through different case studies from different locations of the province.

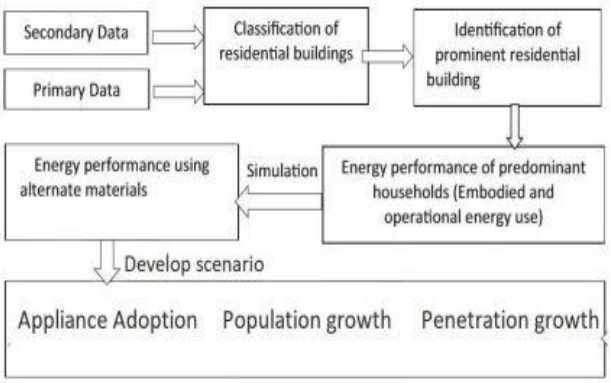

Figure 2. Methodology

A. Classification of Households

The classification is done using data from surveys of different MMHPs. This data is collected as primary data from different MMHPs installed in various location to find the common methodology.

1) Based on the Use of Electricity

In the locations where these MMHPs were installed. 70% of electricity were used by household 20% for commercial like shops and offices 8% restaurants and 2% for other purposes.

2) Based on Condition of Households

Considering the survey out of all the houses 49% are good condition 30% livable and 20% are dilapidated.

a) Material of Construction

In these location 70% of houses are owned while the rest are on rent basis. The predominant house size is 4 to 6 persons in house. these houses have maximum of 2 rooms (70 %) followed by four rooms (10%).

b) Main Source of Lightnings

From the data it can be gained that 97% of the houses used electricity as main source of lightning while wood and other fossil fuels are also used in low percentages.

c) Number of Stories

According to survey in most of the areas all the houses are single storied except some location of swat where 90% are single and the rest are double storied.

d) Operational Energy

Use of energy after construction may be termed as operational energy they can be calculated from energy bills, audits. This value give relationship to building behavior and building characteristic. [44]. It is found out that the operational energy can determined by finding building design, pattern of use of appliances, behavior of the occupants.

B. Energy Consumption Pattern

From the data it can be seen that energy use for the day timing between 10 AM to 2 PM and from 7 Pm to 10 PM is at peak time during the night time most of electricity is consumed through lightning, heating and cooling. it can also be seen that during these timing the occupants are at home which made the electricity consumption high. it can also be seen that energy consumption various with 144 Seasons. Similarly, the energy production varies with season as well as timing. Demand also varies with region.

C. Load Profile

For the load profile at least one-hour resolution data is collected during the four-week period. Similarly, monthly electricity bills are collected to get full view load profile for the year. They fulfill the requirement for making load profile. literature also shows that load profile vary day to day with season and regions. as load is always driven 15 by occupant behaviors, routine and patterns. Construction of house also affects the load profile. Through these load profiles one can also find out the behavior based on the different of peak value and consumption. Load profile includes Average energy required (KWH), Average Energy demand (KW), Time and value of peak hour, Average Peak demand at night, Average Peak demand and low Hours.

1) Linked Survey Household Data

The energy bill can be linked to survey data that household behaviors that have the potential to produce small population statistics. These behaviors can be measure with existing population statistics such as number of persons in household, income type. These types of data are having very relevance for policy maker's household size especially number of rooms is very important in order to know the swarming. That can be used to make determined efforts to deal with the problem of housing. The literature also found out that number of floors is directly effecting the electricity consumption. In most of surveys the household income is neglected yet it has very large impact on the electricity consumption. We can also build link between electricity demands with income level. Income is a dominant measure of finding economic well-being. Lack of this information is flaw on population statistics. Literature also suggest that generating of statistics only on the basis of energy consumption is oversimplification as there are several others factors involved in it. Finding only number of residence but determine their ages, structure presence of child can be very difficult. The data that can be collected during the survey is house composition, number of members in house, presence of children and middle age persons.

2) Profile Indicators and Household Characterestics

The data that we collected through survey is presented in the table. There can be number of indicator that can be measured from household load profile. These characteristic can be base load, peak load, mean load it can also provide ratios such as peak to off-peak load. Timing of each load is an important factor. Load profile provides a number of information while keeping the privacy and eliminating large number of data. This procedure can also rectify data. Profile indicator can also differentiate between household considering the key element of the load such as timing and extent of peak load. These types of indicator can provide great help if the same Were taken in to large scale data from households. Some of the calculation 164 was also measured during the mid-week on assuming the behavior of household that can be study for children and employment for men.

3) Calculating Household Features from Load Profile

The given factors in the following table 3.1 shows the key characteristic of household load profile that they predict different attributes. we contend that investigating the estimation of such indicator, for this reason, require three fundamental advances. The first is to utilize multi-level impact system to recognize whether the family unit can predict the load profile indicators.as given the number of children and other member of the household has to be known through the survey.

4) Socioeconomic Factor

Household electricity consumption is mostly defined by a lot of socio economic factors. These factors are

- Member of household
- Family structure that includes the number of children, number of teenage, number of old aged
- Age of the person responsible for household income of the person responsible for household
- Education level of the person responsible for household.

Parameter Description Base Load (KW) The minimum required power Time and value of peak hour (KW) The maximum power requirement at certain time Load factor Ratio of base to peak load average peak load at lunch (KW) power requirement between 11 am to 2 pm Evening consumption factor ration of average load at evening to average load Total energy required (KWH) Total energy required for household to run appliances

- Income of the household
- Monthly disposal income
- Socioeconomic status of the person responsible for household

The following section provides the details of socioeconomic factors. Referring to the authors that have studied the impact on the energy consumption.

a) Number of Members in Family

Number of occupants has been severely studied in the literature. Most literature suggests that number of dwelling has directly on the electricity consumption. as number of members increase the electricity consumption also increases with it [50] [51] [52]. Leahy and Lyons [53] concluded that houses having single occupancy consumed significantly less electricity than houses with two or more occupancy concludes that single occupant consumed almost 19% less electricity than two or more occupants' houses. Yohanis el al [46] studied the daily consumption per floor for single or multi occupants in Northern Ireland and concluded that household having four or more occupant consumed great amount of energy and electricity consumption while the three members has very small gap between them. Tiwari [54] studied the five occupants as compare to two he concluded that five occupants have 23% more electricity use as compare to two occupants. This study also concluded that with the addition of single person the electricity increases by 7.7%. In another study by Zhou and Teng [55] found the increase of electricity by increase of single person is 8%. While Brounen et al [56] found out the increase of electricity by single person is 21%.Some authors have studied the effect of electricity with the size and type of dwelling. Bartiax and Gram [57] studied that types of dwelling that are detached, semidetached and apartment in Belgium. He found out that the number of occupant's effect hugely on the electricity consumption in detached and semidetached houses but in apartment the case is different as it does not have that effect in the with increase of members. In Japan and in Austria this study [58] has considered the use of electricity appliances with the number of members and found out that it has huge impact on the use of electrical appliances and for lightning particularly. Genjo et al [59] found out that the energy consumption could increase 230KWh with the increase of single person. In contrast to that Filipino and pachauri [60] concluded that size of household had inverse effect on the electricity consumption he explained it as the household having member greater than six had less electricity use per person than the household having fewer members. Some authors considered the effect of household on energy as trifling. Louw et al. [61] concluded that member of household have insignificant effect on low income African households, as most of the appliances were share between the household. Bartush et a.[62] examined the member of household to annually electricity use in Sweden and he concluded that the using of heating system has almost no effect on the number of household. Similarly Kavousian et al. [63] studied the electricity consumption through smart meter data with the number of household he found out a nonlinear relationship between energy use and number of households. He concluded that large household have low per capital energy use than small houses these conclusion were similar to the conclusion of [64].

b) Family Structure

From the literature it is known that family composition (having children, teenager, adults and elders) have great effect on the energy use in residential households. but in some studies it is also found out that it effects the electricity use insignificantly McLougen [48] study shows the increase use of electricity by having child in family as compare to family having no children. Broumen [56] also concluded that family consumed on fifth extra electricity for having child than family having adult only. and this percentage increase with child age as according to author children used electrical appliances including television, computer, gaming devices extensively. This kind result were also concluded in Weismann et al.[52] In opposite the previous studies Bartiaux [65] showed that the presence of children from age of 0 to 9 years has negative effect on the electricity demand. it shows that the average electricity consumption decreased significantly. This effect can also be found in Danish houses in Gram-Hanssen et al. [57]In case of US Cramer et al.[66] showed that under 3 year of children do not affect the electricity use but having children above 3 had huge in fact on electricity use. Leahy and Lyons [53] also showed that electricity consumption of household having children and household without children have almost same energy consumption Some studies showed the teenage effect on the consumption Gram-Hanssen showed that average

energy use for family having teenager whose age is between 13 to 19 years was very high than family having no children .Bartusch et al.[67] showed huge increase in energy demand for heating for household having teenager in Sweden Leahy and Lyons[53] showed that single parent family energy parent use 10.4%demand is significantly high than two parents family. it also shows that 19 single of more energy than dual parents per week. Zhou and Teng [55] showed that Chinese family with household responsible person aged above 50 years used approximately 3% more energy than family having younger responsible person. It also showed that old people reside in house for longer time that is why it energy consumption increased as compared to younger people contrary to that Brounen et al. [56]showed that older family responsible person used 2-4% less energy than younger aged. They also argued that older stay at home for more time but their activity is a lot reduced than young aged person which reduced the energy uses.

c) Age of the Household Responsible Person

Age of HRP have great effect on the energy consumption. Yohanis et al.[46] showed that the household behavior is dictated by HRP and thus has great role in energy use that is why age of HRP has great influence on the electricity use. HRP whose age is between 50 to 65 their electricity consumption has been lower as compared to household whose HRP age is below 50 and above 65 years Leahy and Lyons [53] showed that family having HRPs between 45 and 64 consumed very significant amount of electricity as compared to HRPs in between 35 to 44 years. But after the age of 64 the electricity consumption decreased drastically. Yohanis et al. [46] also showed same result for Northern Ireland, They showed the significant increase in electricity use where HRPs age is between 50 to 65 year. Mostly the electricity was consumed during day time the HRPs age after 65 reduced household use of electricity. McLOughlin et al. [48] showed that energy used in Irish family having HRPs at age between 18 to 35 years were lower than other age categories such as 36 to 55 and 56 plus. According to author it is the salary at that age which is lower that reduced the energy consumption. author also suggested that large consumption may be may be because of having children at household thus increase the occupant and their stay at home. Same as previous studies Kavousian et al. [63] showed that US families HRP between 19-35 and olderthan 55 consume less electricity. He also suggested that older HRPs use electricity more consciously than younger. Where are HRP with young age have to been involved in full time job and spend most of their time outside of house. Filippini and Pachauri [60] showed that Indian HRP has age less than 45 years tend to use lesselectricity.

d) Education Level of HRP

Household energy consumption have been showed effected differently compare to Education level of HRP. Gram-Hassen et al. [57] showed that level of education have negative impact on electricity use in Denmark. Similarly, household occupant having more education tend to decrease electricity consumption significantly as compared to household having less education. It has been calculated that household having primary education tend to used 200KWh more than having higher education. Zhou and Teng [55] observed that in China household having less education tend to use less electricity than those having higher education Leahy and Lyons [53]observed that Irish families having more than primary education consume 6.4% more electricity per week than those having primary education. Cramer et al. [66] revealed that the effect of education on electricity consumption in household is insignificant.

e) Household Income

The effect of income on electricity use has been extensively studied. Almost all the cases the increase in income cause the increase of electricity According to Yohanis et al. [46] the Irish family with 10,000 euro used 2.5 times less energy than family having income of 30,000 euro per annum. Author also explained families having higher income have more number of people and have large dwellings similarly their number of appliances are also increased. Wyatt [69] evaluated that the families having income 10,000 euros used 1.9 times less electricity than those having 75,000 euros per annum. Similarly Santamouris et al.[70] showed that income of the household is directly proportional to the electricity consumption in Greece, Low income household tend to use 1.6 times less energy than high income household. Genjo et al. [59] found out the relationship of energy use with income as linear according to author the energy use for high income household increases by 350 KWh. Santamouris et al. [70]studied the income of household and their relationship with energy consumption they revealed that low income household used 38% less electricity than high household income . Author also explained that it is mainly because of less installed appliances and their reduced use. Munley et al.[71] also revealed that in US and Austria the families with lower income used less electricity as compared to high income families Santamouris et al. studied energy cost per m2 and suggested that low income household have high energy use per person as compared to high income their studied also showed that high income household pay 57% less per person per m2 There have been other studies that has showen the effect of income on energy use but they also identied less significant effect of income on the energy demand some authors showed that there is not any significant effect of household income on energy demand.

f) Disposal Income

Disposal income has significant positive impact on the energy demand of residential household. It has directly effect on electricity consumption in almost all the studies Specially Leahy and Lyons [53] showed that Irish household who has one unit of disposal income reduced the energy consumption reduced by 4% per week similarly according to McLougen [48] with increase of 1% disposal income for household in Dutch the electricity consumption increase by 11%.

IV. RESULTS

Kalam, a valley in northern KP province of Pakistan has been taken as a case study. The main theme of this study is to identify the importance of micro hydro projects in fulfillment of Sustainable Development Goal number 7 that is providing affordable and sustainable access to energy. Its technical and social impacts on the residence. It is also to identify the need of

rural areas and role of MMHPs in fulfillment of these needs. In swat different MMHPs have been installed through different organizations. For our case study we have selected two MMHPs installed in the Kalam which helped in electrifying 22000 populations throughout the valley. The details were collected through different questioners from locals, operators, government and non-government organizations. Before the implementation of MMHPs in Kalam, WAPDA was responsible to supply electricity to the whole area. WAPDA electricity supply in Kalam valley was in worst conditions, the electricity was provided only for few hours which greatly affect the lifestyle of those people living in Kalam are only provided a few hours of WAPDA electricity. The availability of MMHPs in this district has decreased electricity poverty. MMHPs have compensated WAPDA power shortage and restored electric power in the region. The commissioning of MMHPs in Kalam has improved the economic, health and educational factors of the society. PEDO and SRSP are working together and implementing different MMHPs in northern regions. Most of them are running and are in good condition.

A. Location of the Valley

Kalam valley is situated in high mountains having green fields, natural lakes and famous places for tourists due to its natural beauty located in Swat, KPK province of Pakistan having coordinates of 35.4902-degree North 72.5796 degree east. It has many water streams which can generate electricity using hydro power. According to Pakistan Bauru of statistics the 6th population and housing census 2017 Kalam has total population of 84,434 with 9,820 number of household.

B. Energy Demand analysis

After the survey the data is analyzed and energy consumption break up. It is shown that over 50% of consumption for lightning and 13% for heating similarly for Misc. consumption that includes ironing, washing use of different appliance also consume a good portion of electricity.

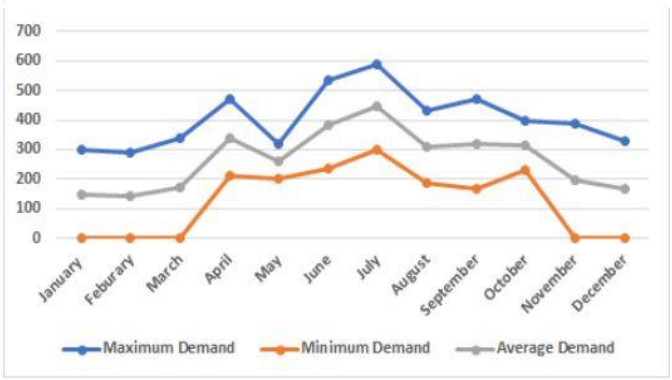

Figure 3. Monthlly Energy Demand

The use of light energy is also high because of use of incandescence bulb which consumer very high electricity. This type of analysis helps in understanding the use of electricity as compared to daily electricity consumption that is derived from monthly billings.

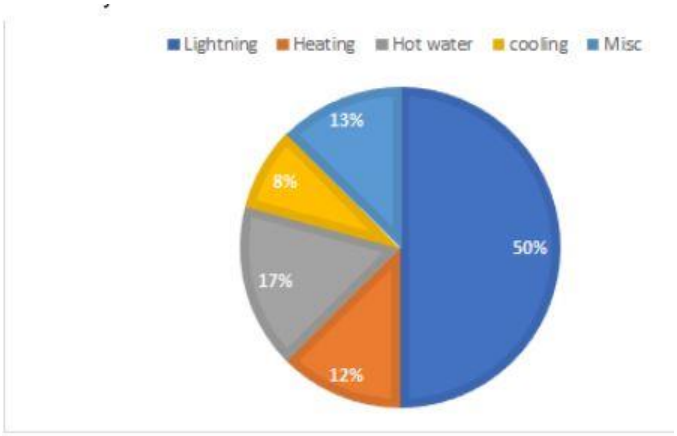

Figure 4. Energy Consumption Breakup

The hot water requirement for hilly areas where there is snow in winter and moderate weather in summer is very high. but as use of wood this burden on the MMHP is reduced similarly water heating is also done through gas cylinder. There is no consumption of electricity for cooking purposes as all the cooking is done through gas cylinders and firewood that young family member has collected throughout the day. There is also cooling consumption of about 8% that is because of refrigerators for chilled water as well for food perseveration mostly in hotels. It can also be seen from fig 4.7 that most of energy is consumed through lights the use of lights starts from evening during night at 9 to 10 pm where all the commercial use of lights are at peak it reaches to its peak and after mid night the use of light reach to a steady level. It can also be seen that cooling appliances is used during the day timing when there is a lot of sunlight similarly miscellaneous appliances are also used during the day time. It can also be seen that energy consume by household is mostly at time of 7:00 am to 12:00 pm and 3:00 pm to 8:00 pm where most of the community member at their houses especially in household where children is present, the energy consumption is even more high. Similarly, in commercial areas most of the energy is consumed during 10:00 am to 1:00 pm and 3:00 pm to 10:00 pm especially in evening time where most of the electricity is consumed by lights.

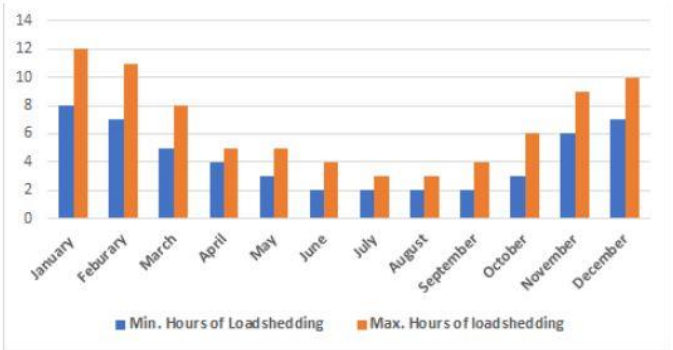

Figure 5. Hours of Loadshedding

It can be see that most of energy is consumed during June July months when there is huge inflow of tourist from other places. During the off season from November to February this

area is covered with snow and not accessible most of the local migrates to other part of the province like Mardan, Charsadda, Peshawar the energy demand decreases.it can be seen from fig.4.6 that load shedding also increases in winter season up to 12 hours though the number of residence in the valley decrease significantly still the water flow is so low that electricity production cannot full fill the demand of community. While in the month of June, July where the residence as well as the tourist influx increases but productions able to full fill the demand in that season.

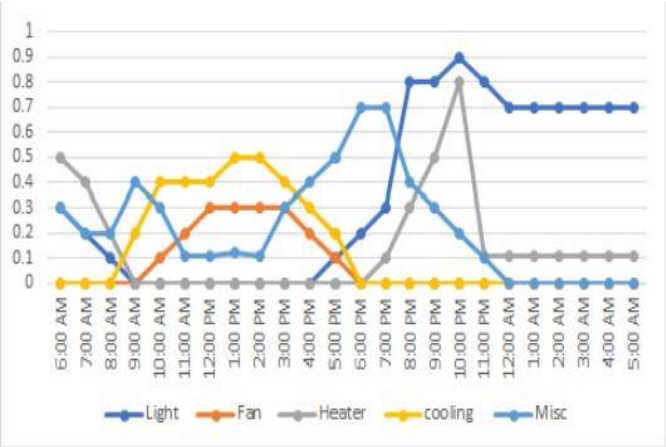

Figure 6. Energy Consumption Pattern

C. *Stability of Systems*

To find out the stability of the system question were asked from different member of community about the light fluctuation, damage to appliances and black out for the whole out of 30 persons 20 replied as the no harm or damaged were seen by the electricity. 7 responses were their appliances or cell phone charger were damaged by the MMHPs 3 answered in having no knowledge about the stability of system. There was blackout recorded for 2 days because of heavy rainfall and wind.

D. *Safety*

Safety in these distributed systems is a great issues a lot of times they are made by local contractor who do not follow standardize procedures while their construction. a lot of power I have visited do not use proper boundary wall which endanger the life of children and animals of surrounding houses. Similarly, a lot of time the operator does not have technical knowledge and are not provided with Safety equipment's which makes his life in danger while operating the power plant. In distribution system there were no circuit breaker installed and power that runs through the lines are directly connected to load such as fan, bulb, television as water in canal are not consistent. Which makes fluctuation that can damage these appliances similarly, the wooden poles are used for the distrusted lines. Which is life threatening specially in rainy seasons. Similarly, there is no emergency response plan for electrical injured person. In some areas the distributed lines are connected to the trees which is cause a lot of problems for the communities it also creates short-circuit or damaged the generator.

E. *Satisfaction Level*

The data has revealed that most of the community members are satisfied from the electricity provided to them. We divided the satisfactory level into four categories where we have given number from 0 to 3. 0 means not satisfied, 1 stands for little bit satisfied similarly 3 for fully satisfied. In light availability most of people were satisfied. similarly, energy availability also got some high score as these MMHPs provide almost 22 hours of electricity for the day which is a lot better than grid provided electricity but in cooking most of community members were not satisfied as they still use firewood's for cooking which has to be collected during the day time.

CONCLUSION AND RECOMMENDATIONS

The advancement and promotion of the profitable utilization of renewable power and the capabilities to support and deal with the maintenance as well creating jobs through small businesses were presented effectively In some areas deforestation has also been sensed due to these projects. It increased the health facilities and attendance in education. It is fulfilling the energy demand of community in great way but at same time project developers are confronting problems if they want sustain these project communities have to provide with technical and management skills to build and operate these MMHPs

MMHPs being the reliable source for community have huge implants on lives as it consistently provides electricity. Access of light has given extra time for student to study at night similarly the lights at night also provided a sense of safety for rural communities from animals. In some of the cases the reliability of these MMHPs is a question mark as they are very vulnerable to flood and other places there were no planning to reduce the impact of the flood that is produced in the community because of the these MMHPs

There is no planning for the use of other sources like biogas and solar in additional with the MMHPs as in some communities these MMHPs are not able to fulfill the basic need of the community and to increase the capacity of operated MMHP is not an option.

These MMHPs have great impact on the livelihood of the community. As they improved their living standards. provide cheap and easy medical facilities as well as educational institutions have been improved with access of electricity. The work load on the children and women have been reduced. The decreasing in the pollution also impacted positively on the overall health of communities

REE project has to enhance the quality of MMHPs by preparing manpower so they obtain the ability to build and operate these MMHPs. They have to educate manufacturer to assemble better turbine Most of the MMHPs operates below the rated power it is due to inappropriate civil structures, inadequate control mechanisms, in-efficient turbine technology as well as poor overall design and ineffective management and capacity In some areas these MMHPs were installed on irrigation canals which were solely used for agricultural purposes when they were operated they lower the level of water which is making it difficult for farmer to irrigate their

land cause conflict between different community members. Keeping in view all the above findings, the project together with partner organizations has to develop a comprehensive strategy on how to improve MMHP installations, covering planning & construction, operation and maintenance as well as integrating social and economic aspects. As a result of the technical assistance and support provided to the public and private sector, electricity supplies to the large number of households and businesses will become more reliable. The project developers and implemented has to follow the standards laid down for setting up MMHP installations. Keeping in view the long term experience and support of the project in MMHPs in Pakistan there are still lessons to be learnt for further the donor community; and project developers and implementation agencies must share their knowledge better to address the short comings in MMHP development. Also the improved MMHP installations require better funding for construction of MMHPs; the way tariffs are structured and revenue collected requires further improvement. The concept of Community Based Utility Companies has to be scaled-up and disseminated for improved operation and maintenance. Lastly the PURE initiatives/concept has to be included as an integral part of the project planning instead of being an added-on activity. This will ensure that generated electricity can cater for the needs of future business/income generation activities.

REFERENCES

[1] Oliver Paish. Small hydro power: technology and current status. Renewable and sustainable energy reviews, 6(6):537–556, 2002.

[2] Wolfgang Schellong. Energy demand analysis and forecast. In Energy Management Systems. InTech, 2011.

[3] Kyung-Bin Song, Young-Sik Baek, Dug Hun Hong, and Gilsoo Jang. Short-term load forecasting for the holidays using fuzzy linear regression method. IEEE transactions on power systems, 20(1):96–101, 2005.

[4] IEA.Internationenergyagency2010outlook. 2010.

[5] energy pedia. Electricial accessin pakistan, 2016.

[6]JohnConti,PaulHoltberg,JimDiefenderfer,AngelinaLaRose,JamesTTurnure, and Lynn Westfall. International energy outlook 2016 with projections to 2040. Technical report, USDOE Energy Information Administration (EIA), Washington, DC (United States). Office of Energy Analysis, 2016.

[7] Zbigniew Chmiel and Subhes C Bhattacharyya. Analysis of off-grid electricity system at isle of eigg (scotland): Lessons for developing countries. Renewable Energy, 81:578–588,2015.

[8] P Maher, NPA Smith, and AA Williams. Assessment of pico hydro as anoption for off-grid electrification in kenya. Renewable Energy, 28(9):1357–1369, 2003.

[9] Badri Prasad Bastakoti. The electricity-livelihood nexus: some highlights from the andhikhola hydroelectric and rural electrification centre (ahrec). Energy for Sustainable Development, 10(3):26–35, 2006.

[10] Dave Weatherspoon, Anthony Ross, et al. Designing the last mile of the supply chain in africa: Firm expansion and managerial inferences from a grocer model of location decisions. International Food and Agribusiness Management Review, 11(1):1–16, 2008.

[11] Mohammad Umar and Anwar Hussain. Micro hydro power: a source of sustainable energy in rural communities: economic and environmental perspectives. The Pakistan Development Review, 54(4 PartI &):487–505, 2015.

[12] Munawar A Sheikh. Energy and renewable energy scenario of pakistan. Renewable and SustainableEnergy Reviews, 14(1):354–363, 2010. 40

[13] PEDO. Hydrop power potential in KPK. 2016.

[14] Afreen Siddiqi, James L Wescoat Jr, Salal Humair, and Khurram Afridi. An empirical analysis of the hydropower portfolio in pakistan. Energy Policy, 50:228– 241, 2012.

[15] Debajit Palit and Akanksha Chaurey. Off-grid rural electrification experiences from south asia: Status and best practices. Energy for Sustainable Development, 15(3):266–276, 2011.

[16] Michael Hallett. Distributed power in afghanistan: The padisaw micro-hydro project. Renewable Energy, 34(12):2847–2851, 2009.

[17] Rohit Sen and Subhes C Bhattacharyya. Off-grid electricity generation with renewable energy technologies in india: An application of homer. Renewable Energy, 62:388–398, 2014.

[18] Juozas Abaravicius. Demand side activities for electric load reduction. Department of Energy Sciences, Lund University, 2007.

[19] GJ Raw and DI Ross. Energy demand research project: Final analysis. 2011.

[20] Peter Bailey, Oracha Chotimongkol, and Shinji Isono. Demand analysis and optimization of renewable energy: sustainable rural electrification of mbanayili, ghana. 2007.

[21] USAID. Addition of power through energy effeciency,2011.

[22] Japan International Cooperation Agency. JICA 2016 Annual Report, 2016.

[23] Sustainable energy for all and Ministry of Finance - Implementation and Economic Reforms Unit (IERU), 'Pakistan. Rapid Assessment and Gap Analysis, 2014,15.

[24] Asian Development Bank. Energy for All,2009.

[25] CP Chu, DJ Lee, and CY Chang. Energy demand in sludge dewatering. Water Research, 39(9):1858–1868, 2005.

[26] HT Pao. Forecasting energy consumption in taiwan using hybrid nonlinear models. Energy, 34(10):1438–1446, 2009.

[27] Sung HyunKim,TaeHeonKim,YoungdukKim, and In-Gang Na. Korean energy demand in the new millenium: outlook and policy implications, 2000–2005. Energy Policy, 29(11):899–910, 2001.

[28] Steve Doty, Wayne C Turner, et al. Energy management handbook. Fairmont PressLilburn,GA,2009. 41

[29] KumarBiswajit Debnath andMonjurMourshed. Forecastingmethods in energy planning models. Renewable and Sustainable Energy Reviews, 88:297–325, 2018.

[30] Yanhua Chen, Yi Yang, Chaoqun Liu, Caihong Li, and Lian Li. A hybrid application algorithm based on the support vector machine and artificial intelligence: An example of electric load forecasting. AppliedMathematicalModelling, 39(9):2617– 2632, 2015.

[31] Diyar Akay and Mehmet Atak. Grey prediction with rolling mechanism for electricity demand forecasting of turkey. Energy, 32(9):1670–1675, 2007.

[32] L Ekonomou. Greek long-term energy consumption prediction using artificial neural networks. Energy, 35(2):512–517, 2010.

[33] Stephen P Curram and John Mingers. Neural networks, decision tree induction and discriminant analysis: An empirical comparison. Journal of the Operational Research Society, 45(4):440–450, 1994.

[34] Mehdi Forouzanfar, Ali Doustmohammadi, M Bagher Menhaj, and Samira Hasanzadeh. Modeling and estimation of the natural gas consumption for residential and commercial sectors in iran. Applied Energy, 87(1):268–274, 2010.

[35] Gang Xu and Weiguo Wang. Forecasting china's natural gas consumption based on a combination model. Journal of Natural Gas Chemistry, 19(5):493–496, 2010.

[36] Remus Boata and Marius Paulescu. Application of fuzzy logic to forecast hourly solar irradiation.

[37] Shuai Wang, Lean Yu, Ling Tang, and Shouyang Wang. A novel seasonal decomposition based least squares support vector regression ensemble learning approach for hydropower consumption forecasting in china. Energy, 36(11):6542–6554, 2011.

[38] Adam Sieminski. International energy outlook 2013. US Energy Information Administration (EIA) Report Number: DOE/EIA-0484, 2013.

[39] department of energy. Pakistan energy outlood. US Energy Information Administration (EIA) Report Number: DOE/EIA-0484, 2013.

[40] department of energy. National energy effeciency and conservation agency. 2018.

[41] ministryofagriculture.Annualfloodreport2010. 2010.

[42] Ali Hazrta bach. construction of mini micro hydro project. 2010.

[43] Ali Hazrta bach. construction of 1000 mini micro hydro project. 2014.

[44] Ifigeneia Theodoridou, Agis M Papadopoulos, and Manfred Hegger. A typological classification of the greek residential building stock. Energy and Buildings, 43(10):2779–2787, 2011. 42

[45]ChristianBeckel,LeynaSadamori,andSilviaSantini.Automatic socio economic classification of households using electricity consumption data. In Proceedings of the fourth international conference on Future energy systems, pages 75–86. ACM, 2013.

[46] Yigzaw G Yohanis, Jayanta D Mondol, Alan Wright, and Brian Norton. Real-life energy use in the uk: How occupancy and dwelling characteristics affect domestic electricity use. Energy and Buildings, 40(6):1053–1059, 2008.

[47] Steven Firth, K Lomas, A Wright, and R Wall. Identifying trends in the use of domestic appliances from household electricity consumption measurements. Energy and buildings, 40(5):926–936, 2008.

[48] Fintan McLoughlin, Aidan Duffy, and Michael Conlon. Evaluation of time series techniques to characterise domestic electricity demand. Energy, 50:120–130,2013.

[49] Stephen Haben, Jonathan Ward, Danica Vukadinovic Greetham, Colin Singleton, and Peter Grindrod. A new error measure for forecasts of household-level, high resolution electrical energy consumption. International Journal of Forecasting, 30(2):246–256, 2014.

[50] Merve Bedir, Evert Hasselaar, and Laure Itard. Determinants of electricity consumptionindutchdwellings.Energyandbuildings,58:194–207,2013.

[51] Geoffrey KF Tso and Kelvin KW Yau. Predicting electricity energy consumption: A comparison of regression analysis, decision tree and neural networks. Energy, 32(9):1761–1768, 2007.

[52] Daniel Wiesmann, Inês Lima Azevedo, Paulo Ferrão, and John E Fernández. Residential electricity consumption in portugal: Findings from top-down and bottom-up models. Energy Policy, 39(5):2772–2779, 2011.

[53] Eimear Leahy and Sean Lyons. Energy use and appliance ownership in ireland. Energy Policy, 38(8):4265–4279, 2010.

[54] Piyush Tiwari. Architectural, demographic, and economic causes of electricity consumption in bombay. Journal of Policy Modeling, 22(1):81–98, 2000.

[55] Shaojie Zhou and Fei Teng. Estimation of urban residential electricity demand in chinausinghouseholdsurveydata. EnergyPolicy,61:394–402,2013.

[56] Dirk Brounen, Nils Kok, and John M Quigley. Residential energy use and conservation: Economics and demographics. European Economic Review, 56(5):931– 945,2012. 43

[57] Kirsten Gram-Hanssen, Casper Kofod, and K Nærvig Petersen. Different everyday lives: different patterns of electricity use. In 2004 ACEEE Summer study on energy efficiency in buildings, pages 1–13, 2004.

[58] Reinhard Haas, Peter Biermayr, Josef Zoechling, and Hans Auer. Impacts on electricity consumption of household appliances in austria: a comparison of time series and cross-section analyses. Energy Policy, 26(13):1031–1040, 1998.

Ahmar Ali (DOB 10 July,1995) belongs to Charsadda KP. He has secured Bachelor's degree in Electrical Engineering (Power) from University of Engineering & Technology Peshawar, Pakistan in 2017, and a Master's degree in Energy Management and Sustainability from Center for Advance Studies in Energy (CAS-E) UET Peshawar, Pakistan in 2019. Energy research training from Arizona state university Arizona, US.

[59] Kahori Genjo, Shin-ichi Tanabe, Shin-ichi Matsumoto, Ken-ichi Hasegawa, and Hiroshi Yoshino. Relationship between possession of electric appliances and electricity for lighting and others in japanese households. Energy andBuildings, 37(3):259–272, 2005.

[60] Massimo Filippini and Shonali Pachauri. Elasticities of electricity demand in urban indian households. Energy policy, 32(3):429–436, 2004.

[61] Kate Louw, Beatrice Conradie, Mark Howells, and Marcus Dekenah. Determinants of electricity demand for newly electrified low-income african households. Energy policy, 36(8):2812–2818, 2008.

[62] Demba Ndiaye and Kamiel Gabriel. Principal component analysis of the electricity consumption in residential dwellings. Energy and buildings, 43(2-3):446–453, 2011.

[63] Amir Kavousian, Ram Rajagopal, and Martin Fischer. Determinants of residential electricity consumption: Using smartmeterdata to examine the effect of climate, building characteristics, appliance stock, and occupants' behavior. Energy, 55:184– 194, 2013.

[64]RoryVJones,AlbaFuertes,andKevinJLomas.Thesocio economic, dwellingand appliancere lated factors affecting electricity consumption in domestic buildings. Renewable and Sustainable Energy Reviews, 43:901–917, 2015.

[65] Françoise Bartiaux and Kirsten Gram-Hanssen. Socio-political factors influencing household electricity consumption: A comparison between denmark and belgium. In ECEEE Summer Study Proceedings, volume 3, pages 1313–1325, 2005.

[66] James C Cramer, Nancy Miller, Paul Craig, Bruce M Hackett, Thomas M Dietz, Edward L Vine, Mark D Levine, and Dan J Kowalczyk. Social and engineering determinants and their equity implications in residential electricity use. Energy, 10(12):1283–1291, 1985.

[67] Cajsa Bartusch, Monica Odlare, Fredrik Wallin, and Lars Wester. Exploring varianceinresidential electricityconsumption: Householdfeaturesandbuilding properties. Applied Energy, 92:637–643, 2012. 44

[68] Ian G Hamilton, Philip J Steadman, Harry Bruhns, Alex J Summerfield, and RobertLowe. Energy efficiency inthe britishhousing stock: Energydemandand the homes energy efficiency database. Energy Policy, 60:462–480, 2013.

[69] PeterWyatt. Adwelling-level investigation into the physical and socio-economic drivers of domestic energy consumption in england. Energy Policy, 60:540–549, 2013.

[70] Mattew Santamouris, Konstantinos Kapsis, Dimitrios Korres, Iro Livada, C Pavlou, and Margarita Niki Assimakopoulos. On the relation between the energy and social characteristics of the residential sector. Energy and Buildings, 39(8):893–905, 2007.

[71] Vincent G Munley, Larry W Taylor, and John P Formby. Electricity demand in multi-family, renter-occupiedresidences. SouthernEconomic Journal,57(1), 1990.

[72] Keith J Baker and R Mark Rylatt. Improving the prediction of uk domestic energy-demand using annual consumption-data. Applied Energy, 85(6):475–482, 2008.

[73] Alex J Summerfield, RJ Lowe, HR Bruhns, JA Caeiro, JP Steadman, and T Oreszczyn. Milton keynes energy park revisited: Changes in internal temperatures andenergyusage. Energy andBuildings, 39(7):783–791, 2007.

[74] Bodil Merethe Larsen and Runa Nesbakken. Household electricity end-use consumption: results from econometric and engineering models. Energy Economics, 26(2):179–200, 2004.

How to cite this article:

Ahmar Ali, Syed Kamal, Waqas Ahmad, Jawad Ahmad, Sheraz Khan, "Energy Demand Analysis for Distributed Energy Systems", International Journal of Engineering Works, Vol. 9, Issue 09, PP. 156-165, September 2022. https://doi.org/10.34259/ijew.22.909156165.