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# Economic Impact Assessment of Mini Micro Hydel Power Projects in Khyber Pakhtunkhwa

Ijaz ur Rahman[1], Maoz[1], Tanvir Ahmad[1]
[1]United States Pakistan Center for Advanced Studies in Energy UET Peshawar, Pakistan
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***Abstract*—** The exhaustion of the fossil fuel supply of the world is an understood eventuality, considering the pace at which these resources are being exploited the world over. More so when the global energy requirements are increasing without much interruption; suffice to say the current state of operations in the energy arena is not going to last long. Alternative energy resources, in this worldview, provide an auspicious avenue of fulfilling the burgeoning human thirst for energy. The impact of these alternative energy resources utilization will be twofold: the satiation of the energy demand, and the culmination of the global warming resulting from the incessant use of the fossil fuels. The urge for alternative resources of energy is key to survival and demand of future. In comparison to all the alternative resources of energy, Hydro power present better results in terms of efficiency and long term viability.The viability of Hydro Power is subject to its high initial cost and major construction with no return in the initial phase of construction. This work is aimed at presenting the technical and financial aspects of Micro-Hydro power. The financial assessment is based on the Net Present Value (NPV), Internal Rate of Return and Benefit to Cost Ratio (B/C). Apart from the social benefits to the residents and improving the quality of life, the financial feasibility is tested on the basis the above parameters and results shows the micro hydro are feasible in the lights of mentioned parameters. The proposition is tested and implemented on three different case studies, i.e. Ajmera Hydro power plant, Bersa Payen and Sheri Dumrai HPP. The data shows successful results in the all the mentioned cases.

***Keywords*—** Biogas, Social impact, Livelihoods, rural development, Environment

## I. Introduction

The exhaustion of the fossil fuel supply of the world is an understood eventuality, considering the pace at which these resources are being exploited the world over. More so when the global energy requirements are increasing without much interruption; suffice to say the current state of operations in the energy arena is not going to last long. Alternative energy resources, in this worldview, provide an auspicious avenue of fulfilling the burgeoning human thirst for energy. The impact of these alternative energy resources utilization will be twofold: the satiation of the energy demand, and the culmination of the global warming resulting from the incessant use of the fossil fuels. The global consensus on keeping the world temperature hike post industrialization below 2 degrees is ushering in a new era of increasing dependency on renewable energy harvesting techniques at the expanse of shunning away the centuries long use of conventional fuels. Resultantly a drop in the installation of power generating facilities operating on the conventional fuels can be seen from reports delineating the energy outlook of the yesteryears [1]. Another trend noticeable in the recent years is the shifting of global energy usage patterns where the developing countries of Asia and Africa are increasingly using more and more energy and slated to leave the developed western economies for the first time in 2020 in terms of energy usage [2].

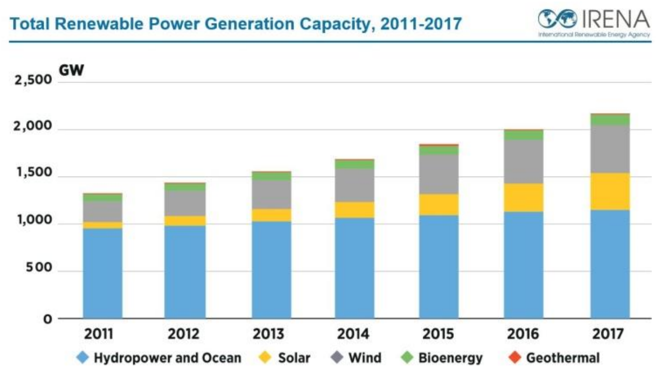



Figure 1. World renewable energy capacity addition by resource since 2011 [1]

Renewable energy installation as evident from the graph above has been at the forefront of energy growth endeavors for the past decade. The increased demand has inevitably lead to slashing of prices as per Swanson's law which predicts decrease of 20% in a technology's price for every doubling of demand[3]. International Energy Agency report for the outlook of world energy installation puts renewable growth at a higher pace than the conventional energy resources with 167 GW of new installation against a 57 GW coal power plants installations and a 29 GW gas power plants. Furthermore, the forecasts paint an even greener picture prognosticating upwards of 920 GW installations of renewable energy extraction facilities by 2022 as shown in the figure. This, fortuitously, has been an improvement on the previous forecasts and if true will put renewable energy at 30% of world energy applications by 2022 as shown in figure 1[1].

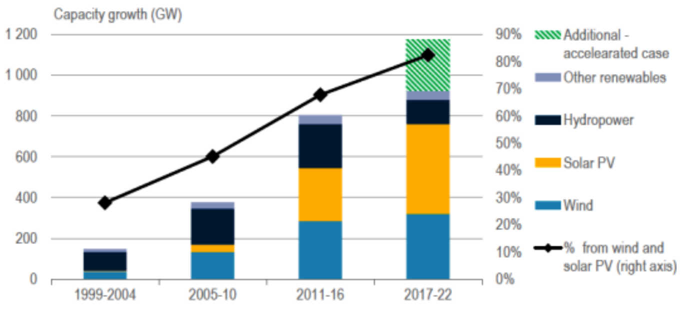
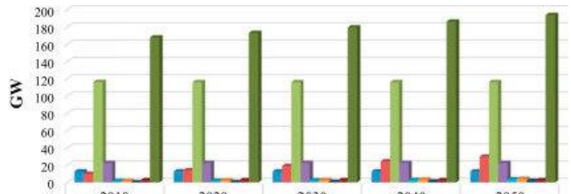



Figure 2. Figure 1 Renewable energy Past and Future [2]

In Pakistan the electricity mix is heavily tilted towards non-renewable thermal power plants making up 35.2% of total energy pie. Renewable energy, albeit a less time consuming and cleaner option, is not prevalent in the country[4]. The country has been able to achieve 80% electrification for the last twenty years and the energy consumption in TOE has reached 79 million in comparison to the 34 million TOE in 1994-95 but the overall makeup of the energy mix and the non-availability of much of the generation potential has pushed the country towards the incessant load shedding which severely disrupts the everyday lives and economic activities of the country[5]. Moreover the abundance of renewable energy potential in the country also make it an obvious low cost tool for handling the energy shortage and price hike[6]. The potential of the country as shown in the table below gives ample opportunity for cheap energy generation at the doorsteps of the consumers to bypass the transmission and distribution charges over larger distances[7]. Only one resource coastal wind power has the potential to generate 50000 MW electricity, with northern areas also have some wind potential and so does the Sindh Gharo sector[8]. The renewable past and future shown in figure 2.




| | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| Wind (grid connected) | 12.8 | 12.8 | 12.8 | 12.8 | 12.8 |
| Solar PV (DCNT) | 9.9 | 14.1 | 19.1 | 24.5 | 29.9 |
| Solar PV (CNT) | 116.2 | 116.2 | 116.2 | 116.2 | 116.2 |
| Solar thermal (CNT) | 22.6 | 22.6 | 22.6 | 22.6 | 22.6 |
| Biomass (field residues) | 1.7 | 2 | 2.5 | 3 | 3.7 |
| Biomass (animal waste) | 1.6 | 2.3 | 2.8 | 3.4 | 4.1 |
| Biomass (MSW) | 0.2 | 0.4 | 0.7 | 1.1 | 1.9 |
| Small Hydro | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| Total | 167.7 | 173 | 179.3 | 186.1 | 193.9 |

Figure 3. Pakistan renewable energy generation projections 2010-2050

The energy demands have remained elusive from the capacity growth for the past decade in the country with the demand growing at an astounding rate of 8% compared to economy growth, on average, of 3-4%[6]. The contemporary power generation scenario is heavily dependent on imported fuels, 36%, and indigenous depleting natural gas resources, 27% [9] as shown in the Figure 4. Albeit the energy crisis has to some extent been curtailed, the cost on economy of the imported hydrocarbons is telling and diminishing the growth rate[9].

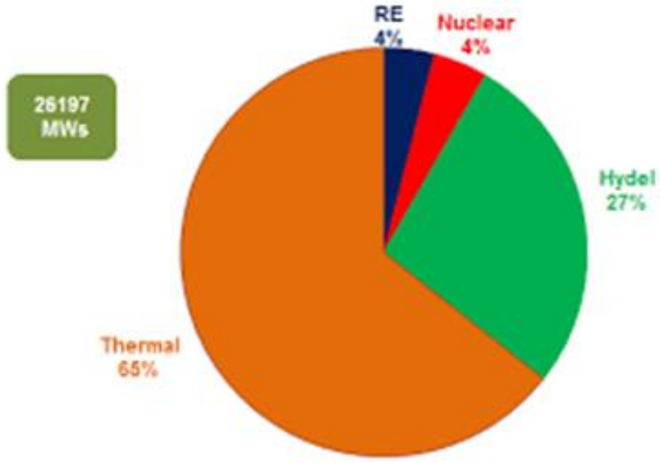



Figure 4. Figure 2 Pakistan's Energy mix 2017

Sooner than later the policy formulators would have to start thinking on the lines of sustainable renewable energy options for a self-reliant durable economic growth[10].In addition to the expensive kWh produced using imported fuels another big concern for Pakistan's power sector is the remote unelectrified communities which stands over 25% of the population[11]. Owing to the remote and diasporic nature of this disenfranchised population the gird access would be too costly to be worth the economic output promised[6]. Renewable energy technologies owing to their prevalence and ease of adoption are a ray of hope for these communities [12]. The Figure 3 is shwon Pakistan renewable energy generation projections 2010-2050.

Foremost among the renewable energy technologies and the most mainstreamed is the hydropower responsible for 19% of worldwide electricity generation[13]. The distinction of Large, small, and mini, micro hydropower makes the technology most suitable for vast outreach and application. Small hydro with its run of the river power generation also alleviates the environmental concerns concomitant with the large hydro dams, in addition to the low cost of electricity generation [14]. A further division of the hydro power generation technologies has been made into mini/micro hydropower which encapsulates the hydropower projects of less than 1 MW capacity. Recent estimates put mini/micro hydropower potential in the northern districts at 1200 MW[15]. Unfortunately, only close to 5% of this potential has yet been realized[16]. Furthermore an additional potential of 300 MW and 400 MW exists in the northern areas of Pakistan for installing 100 kW and 500 kW power projects respectively and The figure 4 is shown Pakistan energy mix 2017 [5].

The province of Khyber Pakhtunkhwa has vast resources of Hydropower generation and the provincial government has been leaving no stones unturned for tapping its potential through its mini/micro hydropower projects, first step towards which was the provincial power policy of 2016, the first of its kind after the 18th amendment[17].

Energy and Power Department of the province of Khyber Pakhtunkhwa and Pakhtunkhwa Energy Development Organization (PEDO) has initiated various projects of off grid electrification of remote communities of the province. In this initiative the pilot project consisted of 356 MHPP projects in the province through various non-government al organizations[18]. The project has recently been extended to second phase where 1200 MHPP projects have been planned for installation in the province[19].

The project aims to provide electricity access to 240000 households[19] across the province in remote areas by 2021[16][5 prop]. The details of the project are given in the table 1 and 2 below.

TABLE 1 BREAKDOWN OF THE 356 MHPP PROJECTS BY GOVERNMENT OF KHYBER PAKHTUNKHWA (PHASE 1)

| S. No. | No. of MHPs | Capacity (MW) | Stream | Estimated No of House holds | Start | Planned Completion |
|---|---|---|---|---|---|---|
| 1. | 310 | 29.04 | Stream | 104,000 | 20-2-2015 | 2018 |
| 2. | 46 | 5.67 | Stream | | 1-2-2017 | |
| Total | 356 | 34.69 | | | | |

TABLE 2 MHPP PROJECTS PHASE II BY KP GOVERNMENT

| Sr. No. | No. of MHPPs | Capacity (MW) | Stream/Canal | Estimated No of House holds | Planned Completion |
|---|---|---|---|---|---|
| 1. | 512 | 37.41 | Stream | 159,000 | 2021-22 |
| 2. | 160 | 15.72 | Canal | | 2021-22 |
| Total | 672 | 53.13 | | | |
| Total | 1028 | 87.82 | | | |

The 356 MHPPs are distributed among various districts of KP with an estimated cost of PKR. 5501.66 million PKR detailed in the table 3.

The projects, albeit a commendable initiative, would require a thorough consideration to the impact aspect of the project for achieving far reaching impact[12]. Energy in itself is not a goal but rather an alleyway to the fulfillment of national prosperity objectives. That is why the socioeconomic, specifically economic, impact of electrification is a key focus in modern power projects. The figure 5 below gives ample evidence to support this claim where the energy usage per capita of a number of countries around the world are plotted against their human development index (HDI)[11].

TABLE 3 SCOPE AND LOCATIONS OF THE 356 MHPP PROJECTS

| Name of Scheme | Districts | Capacity (MW) | Cost (M.Rs) |
|---|---|---|---|
| Construction of 356 Mini/Micro Hydropower projects in Khyber Pakhtunkhwa | Swat, Buner, Shangla, Lower Dir, Upper Dir, Chitral, Mansehra, Abbottabad, Batagram, Torghar & Kohistan | 35.6 | 5501.66 |

It is obvious that the provision of energy in sufficient amounts is directly correlated to the national prosperity[20]. That however is not the full picture as some countries, as seen from the figure, have achieved more human development for relatively same per capita energy consumption. This puts the need of energy projects' economic impact study into perspective [21]. As can be seen Pakistan has a mild energy consumption of around 450 kWh per person yearly and that directly translates in to a meager HDI of 0.52 and allots it rank 150 among the 189 countries listed [19].

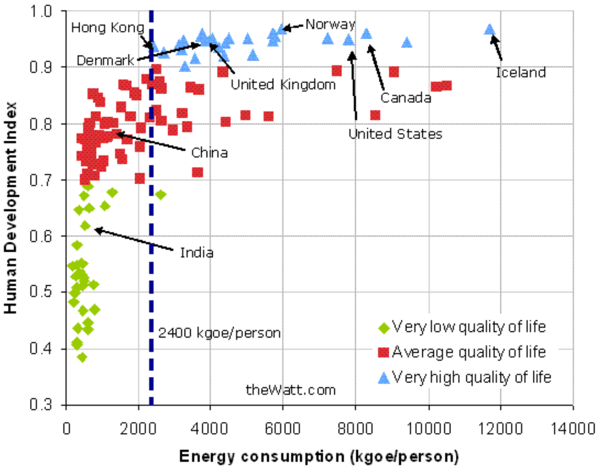



Figure 5. HDI-Energy Nexus[10]

In the contemporary world struggle with poverty alleviation, energy access projects need to take in to account the social and economic impact that stem from these projects. Countries world overachieve disproportionate social and economic development from similar energy consumption per capita[22]. From the figure 5, Denmark for instance, achieves similar HDI from half the energy consumption as Canada [19].

In this context the MHPP projects attain even more importance as they are targeted at the remote, economically and socially disadvantaged communities of the world and in Pakistan[23]. These projects provide a golden opportunity for leapfrogging these disadvantaged communities out of their economic destitution. The objectives of this thesis, given in the next section, are a first of its kind endeavor in Pakistan for successfully evaluating the economic progress that the installed MHP projects have brought about in the lives of the benefiting communities[24]. This thesis will provide basic primary knowledge of the ways in which the economic impact can be furthered and will prove a precious resource for the energy policy and power projects implementing agencies to better plan these projects for elevated benefit to the society[25].

## II. METHODOLOGY

The study was carried out in the Battagram District of Khyber Pakhtunkhwa province of Pakistan. The district shown in the figure 6 lies mostly in the northern mountaineous region. Three MHPPs were chosen for the study from within the district's premises. There are tens of MHPPs installed but these three were chosen because of their easier accessibility and data availability. The three MHPPs are listed in the following.

1. Ajmera Hydro power plant
2. Bersa Payen
3. Sheri Dumrai HPP

The main point of this analysis was presenting the technical and financial aspects of Micro-Hydro power. The financial assessment is based on the Net Present Value (NPV), Internal Rate of Return and Benefit to Cost Ratio (B/C). Apart from the social benefits to the residents and improving the quality of life, the financial feasibility is tested on the basis the above parameters and results. The technical work is based on evaluating the soundness of the civil works, equipment, and distribution network designs and the ensuing implementation on ground.

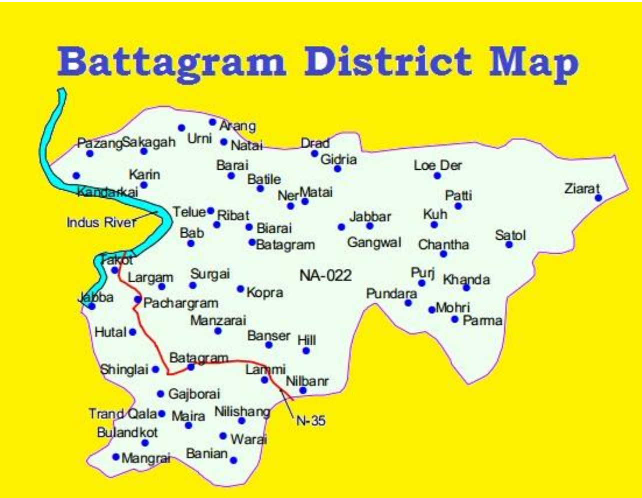



Figure 6. Geographical map of District Battagram

*Technical terms and parameters*

*CapitalCost*

Capital cost of any small hydro project entails the following

*Direct cost*

Which includes the following

*Civil works*

Electromechanical equipment

Other direct cost, like laborer etc.

*Indirect Cost*

Indirect cost includes

(i) Land establishment
(ii) Financing cost
(iii) Local area development charges
(iv) Interest during construction for commissioning the project
(v) It also contains initial capitalized spares

## III. RESULTS AND DISCUSSIONS

### *1) Techno-Economic Impact Analysis of Ajmera Micro Hydro Power Station*

#### *a) Stream Hydrology*

The Ajmera power project is located on the right bank of Ajmera Stream which is one of the two main source streams of the Nandihar Khowar. Discharge of the stream has been calculated on four years hydrological data by using catchment area method. For this purpose, daily discharge data of four years recorded at the Batli Ajmera Gauge station has been used of the Pakistan. As the Hydrological study and analysis given below shows that for three months (November, December and January) discharge in the Khowar have chances to be reduced below the design discharge. Hence, imported Francis Turbine of 400 kW is proposed to be installed at Ajmera MHP. So, the unit will remain operational throughout the year in case of low discharge without any remarkable decrease in power generation.

This Power Project (Ajmera) is located on the bank of Ajmera Khwarr and an important of the two stream in Batagram. The optimum flow rate of the stream is calculated on the basis of five years of hydrological data by deploying catchment area technique. The data is constantly collected and monitored through gauge station at Batli Ajmera. The hydrological data suggest variation in flow rate from the months November, December to January. The flow data from the tables below shows that the flow falls below designed flow in some months. The head vs flow rate suggests the installation of Francis turbine as shown in the figure 7 below.

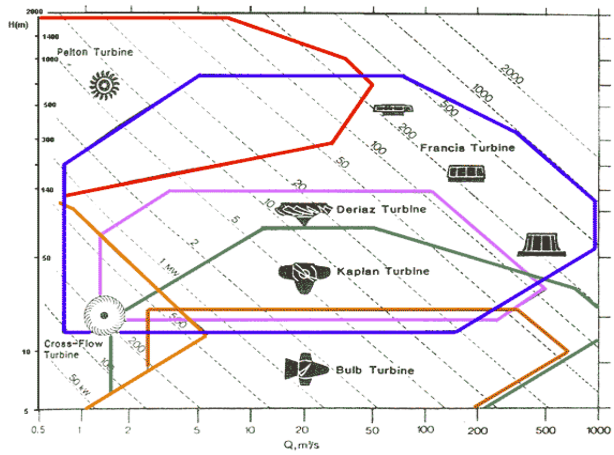



Figure 7. Turbine selection chart

#### *b) Design Flow by Catchment Area Method*

The design flow is calculated from the gauge station data installed at Ajmera. The daily discharge values are computed in the hydrograph to find the optimal flow as shown in figure 8.

The catchment area is found from the high points of the contour map. The area of 442 km2 is selected for this purpose.

The catchment area is shown in the diagram below.

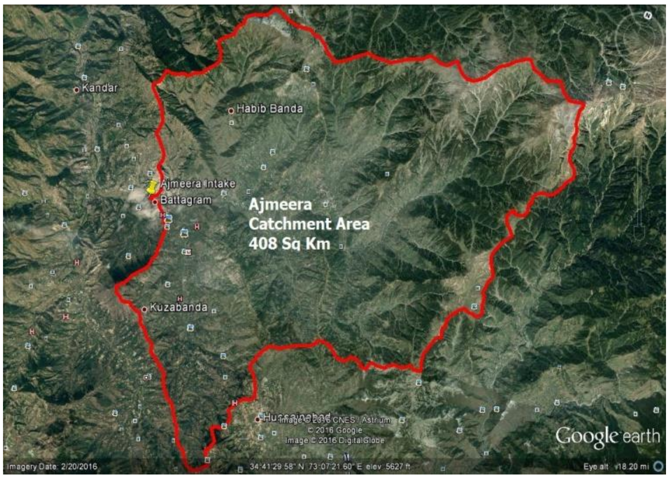



Figure 8. Catchment area at Nandihar Khwarr

The design discharge is found from the above data as shown in the Hydro-graph in figure 19, 20.

The design flow rate for this project is thus comes out to be 159 cusecs.

*c) Power Calculation (Energy Production)*

The power potential of a scheme is theoretically calculated by the following given formula shown in equation (A). The design flow calculation in figure 9 and flow duration curve for Ajmeera shown in figure 10.

The energy (kW) is calculated using the famous equation;

$$\mathbf{P = \eta * g * Q * H} ----------\text{III-1}$$

| Years | Annual Mean Discharge (Guage Station) CMS | Annual Mean Discharge (Design Station) CMS Qd= Ad/Ag x Qg | |
|---|---|---|---|
| 2010 | 8.03 | 7.396 | Qd= Design station Discharge |
| 2011 | 8.1 | 7.460 | Qg= Gauge station Discharge |
| 2012 | 6.76 | 6.226 | Ad= Catchment Area of Design Station |
| 2013 | 9.14 | 8.418 | Ag= Catchment Area of Gauge station |

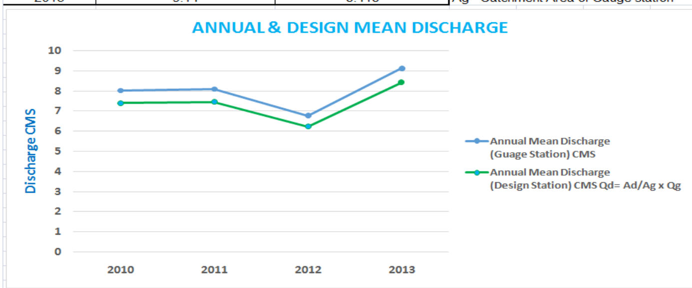



Figure 9. Design Flow Calculation

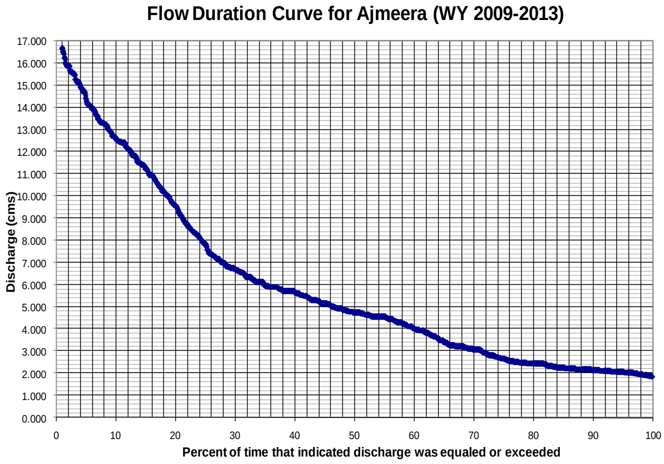



Figure 10. Flow Variation, Curtesy, PEDO

Where

| | | |
|---|---|---|
| $\eta$ | = | Overall efficiency coefficient |
| P | = | Power in (kW) |
| H | = | Net head (m) |
| Q | = | Design discharge (m3/sec) |
| g | = | Acceleration due to gravity |

*d) Energy Calculation*

The energy generated by HPP station in each year depends strictly on the flow rate, which fluctuates round the year. The energy calculated by using the above equation gives only the theoretical value for better understanding. The daily production is given by

$$ED = pa \times h$$

Where

| | | |
|---|---|---|
| $Pa$ | = | Average power daily (MW) |
| $ED$ | = | Energy output, Daily (MWh) |
| h | = | Hours in a day |

the annual energy production is

$$EA = ED \times d$$

Where as

| | | |
|---|---|---|
| $ED$ | = | Daily average output (MWh) |
| $EA$ | = | Annual Daily energy output (MWh) |
| $d$ | = | Nos. of days in a year |

*e) Number of Units*

On the basis of average daily production and maximum flow availability a total of 500 kW is calculated for Ajmera power station.

*f) Efficiency of Electromechanical Equipment*

As per design Francis Turbine (Imported) is suited for this site. Normal efficiency of the turbines is 86% and based on the site parameters the peak efficiency may reach 92% (Highest). Therefore, the overall efficiency of the scheme for the Ajmera site is approximately 80%. Efficiencies of major electromechanical equipment are given in the following table 4 and 5.

Francis turbine is proposed for the Ajmera site based on the turbine selection chart. The efficiencies are high for Francis unit and vary between 85-93%. The generator have has comparative efficiency, thus the overall efficiency of the station is about 80%.

TABLE 4 EFFICIENCIES OF E & M EQUIPMENT

| S.no | Component (Type) | Efficiency (%) |
|---|---|---|
| 1 | Turbine (Francis) | 90 |
| 2 | Generator (Brushless) | 91 |

*g) Energy Production and Installed Capacity*

As the Hydrological study and analysis given above shows that for three months (November, December and January) discharge in the Stream (Khwar) have chances to be reduced below the designed discharge. Hence, imported Francis Turbine of 500kW capacity is proposed to be installed at Ajmera MHP. So, the unit will remain operational throughout the year and no remarkable decrease in power generation can be observed for the said three months in case of low discharge. Direct coupled single unit of 500kW power plant is proposed to be installed at Ajmera Power Plant. Power plant shall remain operational throughout the year at full capacity except for the months of November, December and January. The selected turbine is necessary to address the electricity requirement of the area. Annual energy from the plant will be 2625.00 MWh as per given formula.

The hydrological data shows drastic changes in the flow, especially reduction in flow is seen in the months of November, December and January; wherein the flow falls below the design conditions. The energy production is seen to be lesser than theoretical value. The Francis unit will be operational round the year and 500 kW production rate could be considered for calculations. The turbine serves to provide energy for the local community. The annual energy production is calculated as while, installed capacity is 500kW.

$$\frac{\text{Energy production}}{\text{year}} = \text{Plant capacity} * \text{Plant factor} * \text{hours in a year}$$

TABLE 5. COMPONENT DETAILS

| S. N | Component Details | Rs. Mn. |
|---|---|---|
| 1. | Vertical axis Francis unit with wicket gates assembly adjusting to optimal flow to avoid fluctuation in power output | 30 |
| 2. | Brushless electric generator for converting rotational mechanical energy to electrical energy | 20 |
| 3. | Miscellaneous power plant equipment | 10 |
| 4. | Electrical transmission line costs | 10 |
| | | |
| | Total | 70 |
| | Insurance at 3% | 6 |
| | Total | 76 |
| | Erection and commissioning @ 10% | 16 |
| | Total | 82 |
| | Unforeseen & contingencies L.S. | 10 |
| | Grand Total | 92 |

$$\frac{Energyproduction}{year} = 500kW * 0.75 * 8750$$

$$= 3282.30\ MWh$$

This amount of energy could be extracted in one year, considering the condition that plant is in running condition and there are no emergency shutdowns for prolonged period of time.

*2) TECHNO-ECONOMIC IMPACT ANALYSIS OF BURSA PAYEEN MICRO HYDRO POWER STATION*

*a) Hydrology*

Bersa Payen Khwarr is one of the important streams in Rashang UC (Union Council), Tehsil Allai, District Batagram. This is a perennial stream, meaning its water rising from rain fed springs. The flow pattern at Bersa Payeen Khwarr is a function of winter and summer precipitation. The details are given in Table 6.

*b) Environmental Impacts*

This project is an ideal ecofriendly scheme and commissioning of the project cast no harmful impact on the environment, habitat, flora and fauna. Some of the features and presented below.

TABLE 6: FEATURES OF BARSA PAYEN

| **Village:** | **Bersa Payeen** |
|---|---|
| Union Council: | Rashang |
| District: | Batagram |
| Length of power Channel (Rft): | 115 Round ft |
| Households: | 38 Nos. |
| Distance from Batagram: | 58 Km |
| Plant factor: | 75 percent |

| | |
|---|---|
| Total Capacity : | 15 kW |
| No of Units: | 01 |
| Size of Power Channel: | 2.00 x 1.75 Ft |
| Generator (brushless): | 15 kW |
| Design Discharge: | 8.5 cusecs |
| Diameter and thickness of penstock | 14 inches, 4 mm |
| Annual Mean Discharge: | cusecs |
| Minimum Discharge | 10 cusecs |
| Gross Head: | 32 Ft |
| Net Head : | 30.6 Ft |
| Crossflow Turbine : | 15 kW |
| **Total Annual Energy Production:** | **88.80 MWh** |

*c) Project Location*

The location of the proposed project is 34°48'38.11"N & 73°06'57.10"E. The proposed project is located at 58 km via main Allai road, from Batagram town. This site a very suitable choice for the installation of Hydro Power scheme. The water enters the headrace tunnel to the forebay on the bank of Nulla/ Stream. The water at tail race discharges directly into open atmosphere into the Bersa Khwarr/ Stream.

*d) Hydro Power Potential*

Hydro-Power potential is calculated by considering maximum flow availability in the stream throughout the year. This energy produced from the project is utilized by mostly households and some commercial uses. The energy from the project is a step for better prospects of the community. The site is capable of producing 15 kW power (theoretical basis). The available head for energy production is 33 feet, while the design discharge is 9.5 cusecs. The project suitability can also be confirmed from the fact that this area has no grid connectivity and the demand for electricity is maximum for the community. The supply demand balance suggests that the project should be installed on priority basis.

*e) Stream Hydrology*

The project is located on the right bank of the mainstream (Bersa stream) and is one the important tributary stream of Allai Khwarr. Flow rate (Discharge) is calculated on the basis of 6 years hydrological data using the famous catchment area technique. The gauge station for data collection used was Banna Allai installed on the stream of Barsa Payeen. The unit is operational round the year with no significant decrease in power generation.

*f) Flow rate using Catchment Area Method*

The annual flow pattern at Barsa Payen, recorded at Banna gauge station is used for the design of electromechanical equipment. The flow rate could also be determined using the float method.

The total catchment area at the gauge station at Allai Khwarr was 280 km2. The map presented below taken from google map and the red circle shows the bounds of the catchment area. It is about 10 % of the total catchment area.

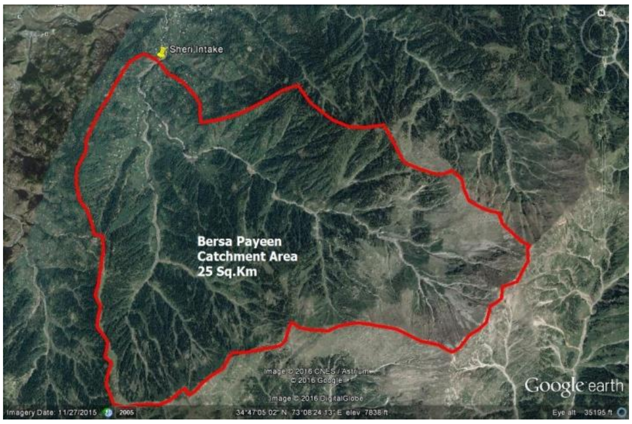



Figure 11. Catchment Area at Allai Khwarr Gauge Station

| Years | Annual Mean Discharge (Guage Station) CMS | Annual Mean Discharge (Design Station) CMS Qd= Ad/Ag x Qg |
|---|---|---|
| 2003 | 4.975 | 0.444 |
| 2004 | 4.131 | 0.369 |
| 2005 | 5.197 | 0.464 |
| 2006 | 5.304 | 0.474 |
| 2007 | 5.442 | 0.486 |
| 2008 | 5.264 | 0.470 |

Figure 12. Design Discharge calculated from the Gauge station data

The comparative discharge graphs and that of Bersa Payeen Intake with Flow Duration Curve are given below:

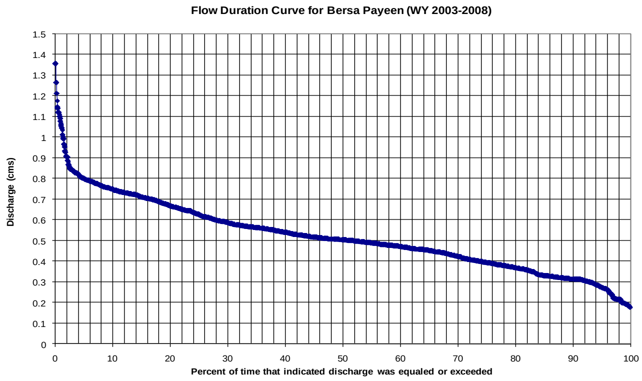



Figure 13. Flow pattern of discharge as seen from the 6 years of data

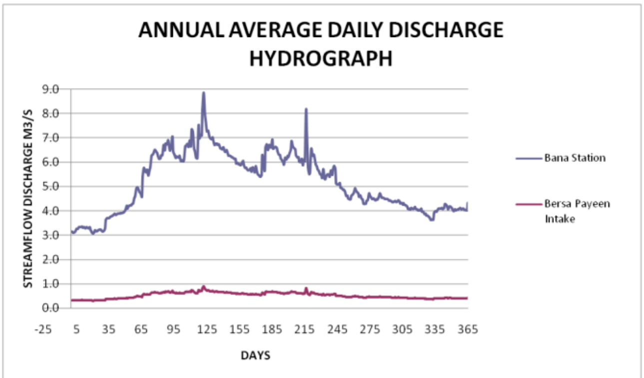



Figure 14. Discharge variation in year

The design discharge is thus 20.11 Cusecs for the proposed project at Bersa Payeen

Cross Flow turbine is proposed for the Bursa Payeen site based on the turbine selection chart. The efficiencies are high for Francis unit and vary between 85-93%. The generator has comparative efficiency;thus, the overall efficiency of the station is about 80% as shown in table 7 and table 8.

TABLE 7. EFFICIENCIES OF E & M EQUIPMENT

| S.no | Component (Type) | Efficiency (%) |
|---|---|---|
| 1 | Turbine (Single unit Cross flow) | 88 |
| 2 | Generator (Brushless) | 91 |

*g) Pre-Feasibility Economic Analysis:*

TABLE 8. DETAILS OF BERSA PAYEEN HPP

| **Head** | **32 feet** | **Penstock Length** | **50 feet** |
|---|---|---|---|
| **Overall Efficency** | 80% | Economic life | 25 Years |
| **Yearly geneation** | 88.08 Mh | Selling Price | 9/unit |
| **Capacity** | 15 kW | | |

TABLE 9. COST BREAKDOWN OF AJMERA HPP

| **Investment Cost Turbine, Generator and Civil Additional Station, Equipment (Multi-unit)** | **Price in Million PKR** |
|---|---|
| Penstock | 0.4 |
| Transmission Line | 0.7 |
| Others (access, miscellaneous site construction) | 1.6 |
| Contingencies at 11% - 20% | 2 |
| Indirect at 20% | 2 |
| Cross Flow Turbine | 0.6 |
| Generator (Brushless) | 0.7 |
| Total Investment Cost (IC) | 6.9 |

### *3) TECHNO-ECONOMIC IMPACT ANALYSIS OF SHERI DUMRAI HYDROPOWER*

Sheri Dumrai is located on the bank of Allai Khwarr in Union Council Bateela, Tehsil Allai, Batagram. The flow is perennial, i.e. arising from spring (rain fed). The flow variation is observed in summer in winter due to pattern of precipitation.

Some of the salient features of this projected are presented in table 10 below.

TABLE 10. SOME FEATURES OF SHERI DUMRAI HP

| | |
|---|---|
| Village: | Sheri Dumrai |
| Union Council: | Bateela |
| District: | Batagram |
| Cropping Zone: | Kharif & Rabbi Crops |
| Distance from Batagram: | 54 Km |
| Households: | 20 Nos. |
| Total Capacity : | 15 kW |
| No of Units: | 01 |
| Plant factor: | 75 percent |
| Lengthof power Channel (Rft): | 20 Round feet |
| Size of Power Channel: | 2.33 x 2.00 Ft |
| Length of Penstock Pipe (Rft): | 28 Ft |
| Annual Mean Discharge: | 30 cusecs |
| Minimum Discharge: | 20 cusecs |
| Design Discharge: | 15.5 cusecs |
| Gross Head: | 17 Ft |
| Net Head : | 16.1 Ft |
| Diameter and thickness of penstock: | 20 inches, 4 mm |
| Crossflow Turbine : | 15 kW |
| Generator (brushless): | 15 kW |
| Total Annual Energy Production: | 87.60 MWh |

*a) Environmental Impacts*

The project is much suited one opt to its environmental friendliness and posing no harm to natural habitat and horticulture, flora and fauna. Deforestation is avoided to major extent in pulling out this project.

The economy of Batagram depends on natural resources and agricultural subsistence to a major extent. Despite this fact, no proper irrigation system is developed in this area. The forest also is hub to medicinal plants. Livestock; goat, cattle, sheep and poultry contribute to the livelihood of community. Literacy rate is poor and cheap labor also contribute to the livelihood of community.

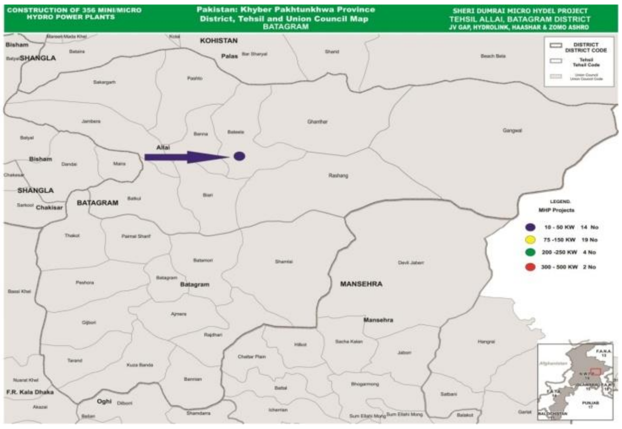



Figure 15. ap of Batagram, Proposed project location, Courtesy PEDO

*b) Hydro Power Potential*

Hydropower potential and tapping the energy from this resource can studied in an area on the basis of maximum availability water and head for major portion of the year. Batagram has both, and the energy obtained from hydro would serve two purposes; electrifying the village and encouraging small startup and established businesses. The data collected from the Sheri Dumrai site suggests a hydropower potential of 15 Kilowatt. The available head is 17 feet, while the optimum flow rate is 15.5 cusecs. The important factor for electrifying this area is, most of the area has no or poor grid connectivity and the community faces long hours of load shedding, thus there is a demanded need of hydropower in this area.

*Design Flow by Catchment Area Method*

The design flow is calculated from the gauge station data installed at Sheri Dumrai . The daily discharge values are computed in the hydrograph to find the optimal flow.

The catchment area is found from the high points of the contour map. The area of 442 km2 is selected for this purpose.The catchment area is shown in the diagram below.

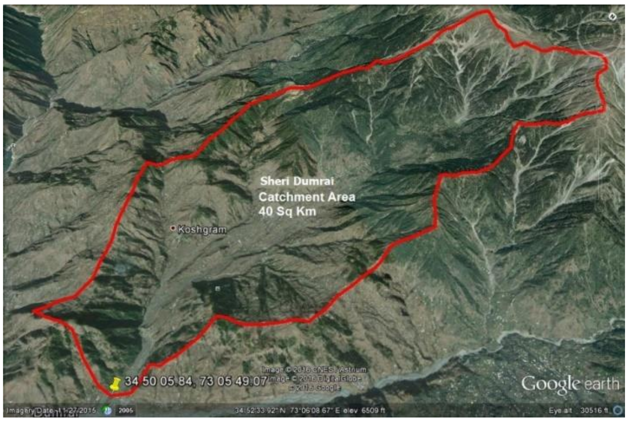



Figure 16. Catchment area at Nandihar Khwarr

**Annual Mean Discharge Table**

| Years | Annual Mean Discharge (Guage Station) CMS | Annual Mean Discharge (Design Station) CMS Qd= Ad/Ag x Qg | |
|---|---|---|---|
| 2003 | 4.975 | 0.711 | Qd= Design station Discharge |
| 2004 | 4.131 | 0.590 | Qg= Gauge station Discharge |
| 2005 | 5.197 | 0.742 | Ad= Catchment Area of Design |
| 2006 | 5.304 | 0.758 | Ag= Catchment Area of Gauge |
| 2007 | 5.442 | 0.777 | |
| 2008 | 5.264 | 0.752 | |

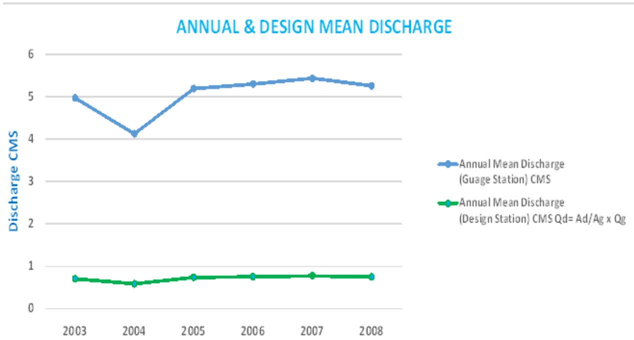



Figure 17. Design Flow Calculation

The design discharge is found from the above data as shown in the Hydro-graph above: Flow Variation is presented here in Figure 18. And annual average daily discharge hydrograph shown in figure 19 and figure 20.

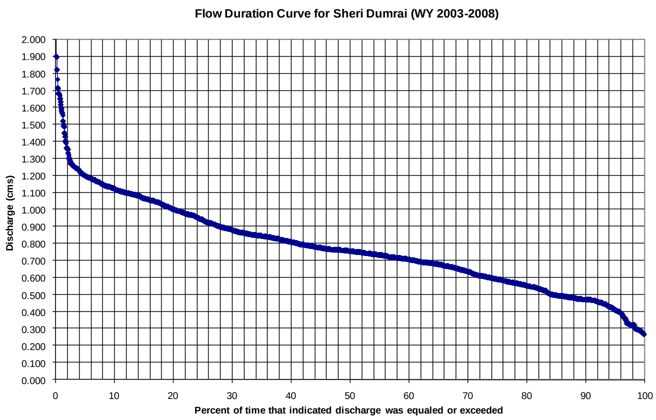



Figure 18. Flow Variation, Courtesy, PEDO

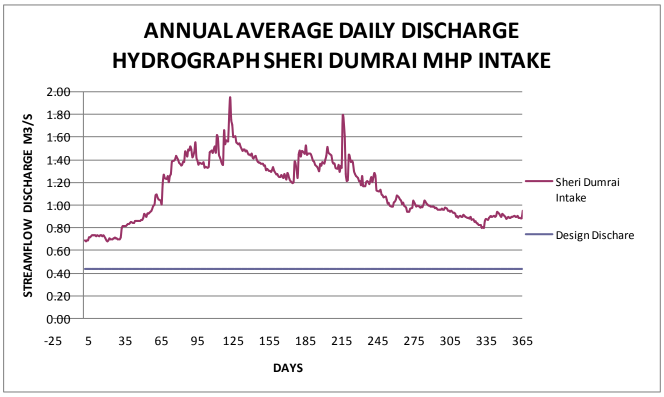



Figure 19. Figure Annual Average Daily Discharge Hydrograph Sheri Dumari MHP Intake

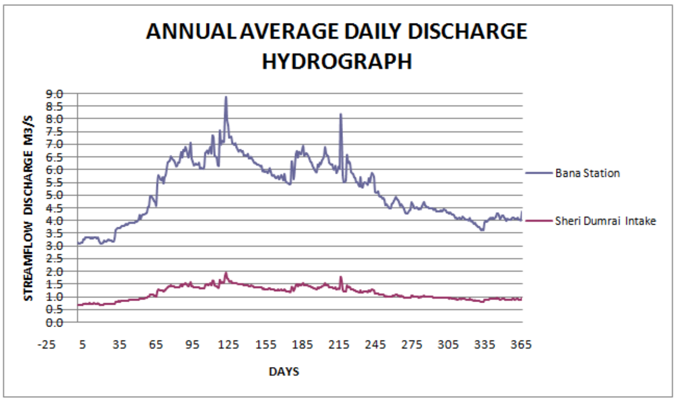



Figure 20. Figure Annual Average Daily Discharge Hydrograph

### *c) Determining Economic Feasibility*

A project is said to be economically viable when the benefits streams exceeds the costs streams. The Internal Rate of Return (IRR) method is also a reasonable approach, and it is the discount rate at which the costs and benefits becomes equal. IRR compares the return rate from the project with the opportunity cost of alternatives. If the IRR is greater than the interest rate/ opportunity rate, the project is economically viable. The Ajmera project analysis is performed the all the installed capacities under study.

### *d) Pre-Feasibility Economic Analysis:*

The detail of Ajmera micro hydro project and its cost breakdown is given in table 11 and table 12.

TABLE 11. DETAILS OF AJMERA MICRO HYDRO PROJECT

| **Head** | **32 feet** | **Penstock Length** | **50 feet** |
|---|---|---|---|
| Overall Efficiency | 80% | Economic life | 25 Years |
| Yearly generation | 87.60 MWh | Selling Price | 5/unit |

TABLE 12. COST BREAKDOWN OF AJMERA MICRO HYDRO PROJECT

| **Investment Cost Turbine, Generator and Civil Additional Station, Equipment (Multi-unit)** | **Price in Million PKR** |
|---|---|
| Penstock | 0.4 |
| Transmission Line | 0.7 |
| Others (access, miscellaneous site construction) | 1.6 |
| Contingencies at 11% - 20% | 3 |
| Indirect at 20% | 2 |
| Cross Flow Turbine | 0.65 |
| Generator (Brushless) | 0.7 |
| Total Investment Cost (IC) | 7.95 |

## CONCLUSION

The exhaustion of the fossil fuel supply of the world is an understood eventuality, considering the pace at which these resources are being exploited the world over. More so when the global energy requirements are increasing without much interruption; suffice to say the current state of operations in the energy arena is not going to last long. Alternative energy resources, in this worldview, provide an auspicious avenue of fulfilling the burgeoning human thirst for energy. The impact of these alternative energy resources utilization will be twofold: the satiation of the energy demand, and the culmination of the global warming resulting from the incessant use of the fossil fuels. The urge for alternative resources of energy is key to survival and demand of future. In comparison to all the alternative resources of energy, Hydro power present better results in terms of efficiency and long term viability.The viability of Hydro Power is subject to its high initial cost and major construction with no return in the initial phase of construction. This work is aimed at presenting the technical and financial aspects of Micro-Hydro power. The financial assessment is based on the Net Present Value (NPV), Internal Rate of Return and Benefit to Cost Ratio (B/C). Apart from the social benefits to the residents and improving the quality of life, the financial feasibility is tested on the basis the above parameters and results shows the micro hydro are feasible in the lights of mentioned parameters. The proposition is tested and implemented on three different case studies, i.e. Ajmera Hydro power plant, Bersa Payen and Sheri Dumrai HPP. The data shows successful results in the all the mentioned cases.

Firstly, a broad and comprehensive study of the technical and economic aspects of hydropower, installed in the north part of Khyber Pakhtunkhwa e.g. Bersa Payen, Sheri Dumrai etc.

District Batagram. The key technical aspects are presented, like the flow pattern from catchment area and the anticipated hydropower that could be tapped from the HPP. The next phase is the proper selection of hydropower unit, in this case was cross flow unit. The cost of all the major units including construction and repair and maintenance is introduced in the thesis. After commissioning the power production and the revenue streams generated thus have been computed. The future streams of benefits against all the cost have been taken in the calculation to find out the key parameters for financial viability of the project, such as; Benefit to Cost Ratio, Internal Rate of Return, Net Present Value etc. The results depict a clear and vivid picture of financial viability in terms of all the parameters mentioned above.

The case studies of Bersa Payen and Sheri Dumrai have also been assessed in the similar fashion; showing successful results in terms of the parameters defined to assess financial viability. The implementation of HPP apart from its successful viability, also draws impeccable impact on the wellbeing of society and uplifting the social status of community

## CONFLICT OF INTEREST

The author declares that there is no conflict of interest in the execution and publication of this research.

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**Ijaz ur Rahman** is a postgraduate researcher at United States Pakistan Center for Advanced Studies in Energy at University of Engineering and Technology Peshawar, Pakistan. He is studying Energy Management and Sustainability at MS level after doing his undergraduate degree in Mechanical Engineering. His research interest include finding ways to maximize the social and economic benefits of the distributed energy systems with an end goal of poverty alleviation through sociotechnical models. This paper is a part of his Masters degree research studies.