Project Completion Report

Nurturing, Mentoring, Evaluation & Research (NMER)

Indus Earth Trust (IET), in collaboration with Pakistan Poverty Alleviation Fund (PPAF) has completed the Nurturing, Mentoring, Evaluation & Research (NMER) project in four villages. The project provided the local community with the energy community resource persons (Energy CRPs) who will maintain and operate the solar mini-grids in their respective villages. Trainings, awareness sessions and community theatres were conducted as part of the project that contributed towards sustainability of the JLINE project.

2018

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EXECUTIVE SUMMARY

Indus Earth Trust (IET) under the supervision of Pakistan Poverty Alleviation Fund (PPAF) successfully installed solar mini-grids in four different villages in Thatta, Sindh. The project as titles “Just light is not enough (JLINE)”.To ensure the effectiveness and sustainability of the project a follow up project was initiated by IET. The project was strategically titled as Nurturing, Mentoring, Evaluation and Research (NMER). The goal of the project was to train the community with necessary skills required to operate and maintain the solar mini-grids. Community awareness regarding solar mini-grids was also one of the key objectives of the same project. Solar training workshops were arranged for the community to provide them with Energy CRPs. Awareness sessions and community theaters were organized to enhance the level of awareness within the community.

People from all the villages participated with great zeal in all the activities arranged by IET in their respective villages. Five people from each village were selected who were trained by our team to equip them with the skills required to operate and maintain the solar mini-grids. These trained CRPs were later designated as Energy CRPs in their respective villages and it only became possible through these CRPs that we implemented a proper billing and record keeping system in all the four villages. Awareness sessions also proved to be very useful. A lot of the problems were solved then and there during the awareness sessions while strategies were made to solve future problems and issues. Furthermore, the community learned a lot of useful lessons in an entertaining way through the community theater especially designed for them to address the solar mini-grid issues and challenges.

I. Introduction

In 2015, in coordination with Indus Earth Trust (IET), Pakistan Poverty Alleviation Fund (PPAF) embarked on a pilot project—Just Light Is Not Enough (JLINE) to explore the potential for distributed generation and mini-grids in rural areas of Sindh—utilizing renewable energy based hybrid solutions. The objective of this pilot was to provide mini grid energy policy, strategic energy enhancement and provision of plans for village based clusters leading to access to grid quality power based on available financing options.

The pilot included electricity access study in 20 villages of Thatta district (medium to high hazard risk assessment) based on a pre-defined criteria. Following this study, in 2016, four of the twenty villages were financed and have now developed solar based mini-grids. Village Organizations made contributions of labor and funds to invest in the projects. These 4 village pilots were completed and handed over to their village organizations between July and September of 2016.

PPAF has been in the renewable energy based generation and distribution business since 2001. But JLINE is different and a major step ahead. The key differences between this approach and other existing renewable energy interventions at village and household level are:

a) Explicit community based planning and integration of the energy provision with economic and social outcomes including power for livelihoods and

b) Provision of grid quality electricity managed sustainably by development of village based independent power producers.

To further enhance the sustainability of the JLINE project, NMER project was intiated by IET under the supervision of PPAF.

Objectives of Proposed NMER Project

• Nurturing the beneficiary communities regarding the operation, maintain sustenance and development/replication of interventions under the JLINE project.

• Enhancing direct and indirect employment opportunities linked to the JLINE projects in the 4 villages.

• Monitoring and evaluating the impacts of the JLINE projects on the households—including, but not limited to utilization patterns, demand growth, purpose of use change [structure of demand change], and impacts on livelihoods (including change in industry, agriculture, and services), gender, migration, education, and overall quality of life.

This report contains description of all project activities in detail. The report has four main parts:

- Training of Energy CRPs
- Community Awareness Sessions

- Community theaters
- Monitoring and Evaluation of mini-grids

II. Training Energy CRPs

As a follow up to enhance capacity of beneficiary communities for effective utilization of solar energy systems, PPAF together with Indus Earth Trust (IET) is undertaking project for mentoring and nurturing of the beneficiary communities in the operation, maintenance of the mini grids and promotion of different interventions for productive use of renewable energy. Having established latest technology solar PV, batteries, LED lighting and power outlets in villages which hitherto had no power, the challenge is for the village organizations to adapt to the new opportunity and maximize the benefits into a sustainable long-term success. Risks include missed maintenance activities and system decline if not properly managed.

The ability of the village to seize the opportunity will be enhanced by continuous support from technical and social expertise. To arrive at a sustainable point of strong local knowledge, expertise and resources able to maintain the power supply for the long term, gradual capacity building is required. This project is aimed to nurture the community capacity to maintain and enhance their energy system by providing ongoing support and expertise through the crucial early years of the project.

Solar Energy training Workshop

Pertaining to the ongoing social and technical challenges occurring at the four mini-grid in the four allocated villages, Indus Earth trust decided to arrange a training workshop, as a part of the nurturing and monitoring regime, to educate, facilitate and equip the local community with the necessary skills required to ensure the sustainability of the installed solar systems. Hence, we selected a team five individuals from each village on the basis of commitment, eagerness to learn new things, education and availability. A total of 20 villagers were selected for the training workshop from all the four villages.

Energy CRPs

These 20 people selected (5 persons for each village) will be Community resource persons (CRPs). The goal of this training is to equip the CRPs with necessary skills to sustainably and efficiently run the solar PV system on their own. These team of five members each can be further classified as two technical persons responsible for cleaning and maintenance of the PV system, two persons responsible for billing while one person has been allocated for data collection and record keeping. The technical persons will look after the solar systems, keep them clean, and inform IET in case of emergencies. The personnel dedicated for bill retrieval will collect monthly bills from each house and enterprise/livelihood and will then submit the collected amount in their community bank account. Record keeping person will keep and maintain a record for all the maintenance and financial activities on a monthly basis.

List of the participants who attended this training workshop :

Village	Name
Jaffer Jokhio	Abdul Jabbar
	Nizam Uddin
	Aashiq Ali
	Ghulam Hussain
	Khalid hussain
Ishaque Jokhio	Bashir Jokhio
	Shahrukh
	Wazir Ahmed
	Altaf Jokhio
	Eidu Jokhio
Hamzi Sammo	Zain ul abddin
	Niaz Ahmed
	Shahbaz Hamzo
	Zikrya Ali
	Mola Bukhsh
Bachoo Kolhi	Dhuna Bai
	Prem Chand
	Krishan Mola
	Shehr Banoo
	Fatima Hamoo

Training salient points

Following are the key topics and activities for the solar energy training workshop.

- Introduction to Solar Photovoltaic, its importance and working
- Basics of the individual components used in Solar systems
- Solar PV system operation
- Solar Panels' cleaning and maintenance
- Batteries' cleaning and maintenance
- Safety precautions, emergency handling, meter reading, record keeping
- Solar panels' cleaning and maintenance hands on training
- Batteries' cleaning and maintenance hands on training
- Demonstration on how to effectively take meter reading and maintain log sheets
- Practical demonstration of safety measures to be needed during maintenance.

Figure 11. Solar Energy Workshop

The training was modeled in to two parts. First part included PowerPoint presentations, white board demonstrations, questioning answering sessions while the second part was solely dedicated for on-site hands on training. First session started in the morning at 10 A.M. on 08th March, 2018. The session started with the mandatory attendance and followed up with a detailed introduction of the goals of and objectives of the training workshop. An Ice breaking session was then conducted in which the participants introduced themselves, talked about their education, interests and other activities.

Figure 12. Ice breaking session

Figure 13. Introduction to Workshop

The presentation was started with the basics of solar photovoltaic which gradually led towards more advanced and individual component based topics. Each component involved in the solar PV system like Inverter, batteries PV panels; charge controller was discretely discussed in detail.

Participants asked insightful question during the entire session and their queries were aptly addressed.

Figure 14. Introduction to Solar Energy

Figure 15. Discussion on mini-grid components

Figure 16. Discussion on Inverters

After a short lunch break, the session continued smoothly. The after break session was focused mainly on PV system maintenance and cleaning operation. Participants were told about the dos and don’ts of the systems. Lastly, a detailed description on how to accurately read energy meters was eloquently delivered. A questioning answering session followed the entire presentation where the participants asked perceptive questions.

Figure 17. Presentation on PV system cleaning and maintenance

On-site training

The second session was conducted on the mini-grid site where all the participants gathered in groups of five. They were physically demonstrated on how to operate and maintain all the key components of the system. Participants showed keen interest and as a matter of fact they were given the hands on opportunity to experience the cleaning and meter reading operations. Participants learned the right method to clean the solar panels, furthermore, they also learned how to take reading from energy meters effectively. Overall, the training workshop proved to be fruitful for the participants.

On site demonstration consisted of the following activities:

- Solar panels' cleaning and maintenance hands on training
- Batteries' cleaning and maintenance hands on training
- Demonstration on how to effectively take meter reading and maintain log sheets
- Practical demonstration of safety measures to be needed during maintenance.

Figure 18. On site demonstration on PV system components

Figure 19. Demonstration on Panel cleaning

Figure 10. Demonstration on meter reading

Figure 11. On-site, hands on training

III. Awareness Sessions

As a part of the Nurturing and Mentoring phase Indus Earth Trust has successfully conducted the planned solar mini-grid awareness sessions in all four villages, namely, Bachoo Kolhi, Jaffer Jokhio and Ishaque Jokhio and Hamzo Sammo. The response of these sessions was astounding. The community actively participated in these sessions with great zeal and zest. They discussed their problems and came up with strategies to solve those problems. They also realised the importance of duly payment of their monthly bills and now the look forward to pay their bills on time.

The session covered a discussion on a broad spectrum of topics exclusively related to solar mini-grids.
Following are the key points that were discussed during awareness session;

- Introduction to Solar Photovoltaics, its importance and working
- Basics of the individual components used in Solar systems
- Solar PV system operation
- Do's, Don'ts, safety hazards and safety precautions for the system
- Effective usage of solar energy generated by the system
- Promotion of livelihood activities to enhance the usage of surplus energy

- Importance of monthly bill payment
- Billing mechanism, bill collection, bill deposition methodology
- Awareness to build a sense of ownership for the system within the community
- Awareness towards the pathways that leads to sustainability

Sessions at Bachoo Kolhi

The sessions at Bachoo Kolhi were conducted on 11th May, 2018. Participants were divided into five manageable groups of 20 to ensure comprehension of the session. Each group was given a separate time slot. The session followed on a set pattern. The participants were given a leaflet. The leaflet contained all the information in an easy to understand format. The leaflet was designed keeping in mind the understanding level of the community as well as the long term goals of the mini-grids. The contents were in Sindhi with visual representation. The session then followed with the attendance of the participants in each session. (The attendance sheets can be found at the end of this report.) All the key points were discussed with the community in detail as mentioned in the contents of the session. The participants were informed about the importance and purpose of the community sessions at first. Later, a detail discussion on system components, maintenance and precautions was pursued. A great deal of emphasis was made on the monthly bill payment. Women were especially encouraged to take part in the improvement and functioning of and optimized bill payment system. They were also told how the bills are collected, where the money is deposited and for what purposes that money will be used. At the end they were encouraged to enhance their livelihood activities. Subsequently, a question answer session followed. The participants asked inquisitive questions, discussed their problems and came up with strategies to solve those problems.

“Just light is not enough”


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Sessions at Jaffer Jokhio

The following sessions were conducted on 15th May, 208 by IET team. The sessions were conducted on a similar pattern as Bachoo Kolhi in the groups of twenty persons each. The system at Jaffer Jokhio is in mint condition and people are also very well aware about the system. In fact, the people demanded an expansion of the existing system as the current system is falling short of their demand.


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Sessions at Ishaque Jokhio

The sessions at Ishaque Jokhio were conducted on the next day on 16th May, 2018. Already aware of the social conflicts at Ishaue Jokhio, we tried to resolve a lot of the conflicts among community factions. Apart from discussing the pre-defined awareness material, we also came up with new strategies and solutions in cooperation with the community.

Sessions at Hamzo Sammo

The sessions at Hamzo Sammo were conducted on 25th May, 2018. An emphasis on bill payment and proper electricity utilization was made. Following are a few pictures of the sessions conducted.

“Just light is not enough”

These awareness sessions proved to be really productive and fruitful. The sessions actually have instilled in the community a new vigor and sense of ownership for the mini-grids. Our priority focus during these sessions was awareness and education of women as they are the primary end user and beneficiaries of solar mini-grids. Women too participated in the sessions very keenly. Deriving a conclusion from these sessions we believe that the solar mini-grid billing system can be tremendously improved by directly dealing with the women faction for the payment of monthly bills. Moreover, our dedicated energy CRPs were also introduced in their local communities during the awareness sessions which in turn imbued a sense of recognition in the CRPs.

IV. Community Theater

On 29th and 30th June community performance were arranged in all four villages. The goal of these performances was to make the community aware about the importance solar mini-grids and to educate them how to take care of the mini-grids. Theaters seemed to be the perfect way to do this in an entertaining way. A local enthusiastic performing arts group was consulted to convey the message to the community through a performance in a convincing and effective way. Arrangements for theaters were made by the IET team in all the villages. Community attendance to the theater was more than expected. Women, children and men all took part in the activity with great excitement. The basic plot of the play was a setup of a small off-grid village where people use candles or kerosene oil for their energy requirements and pay hefty amounts to barely meet their energy needs. Then, the village was introduced to solar technology that changed their lives. Through role playing they were also informed where the fund from monthly bills would be collected and how that amount will be utilized. An emphasis was on consequences if they stop paying bills and stop taking care of the solar mini-grids. Awaz theatre group was engaged to perform in Sindhi and Urdu.


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INDUS EARTH TRUST
COMMUNITY THEATER
ON
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THATTA, SINDH
JUNE 2018


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“Just light is not enough”

V. Monitoring & Evaluation of mini-grids

Apart from achieving the NMER objectives IET extended its efforts to further evaluate the technical and social aspects of the mini-grids. This part of the report mainly revolves around elaborating the incongruities between the planned, designed and actual financial as well as technical scenarios with in the four villages. The Photovoltaics (PV) system sizes for all four villages are shown below.

Table 1. PV System Sizes

Village	Installed Capacity (kW)
Jaffer Jokhio	14
Ishaque Jokhio	19.5
Hamzo Sammo	9.6
Bachoo Kolhi	12.5

The IET mini grid research report was taken into account to obtain design parameters of the PV system while field visits were performed to acquire the actual operational parameters of the running systems in the fields. Battery arrangements were observed and battery bank capacities were calculated. Meter readings from the energy meters were noted consecutively for a couple of days for the month of January 2018 to obtain the actual daytime as well as night consumptions of each village on a per day basis.

Current consumption trends and Surplus Energy

The energy generated from the system can be easily calculated by considering the geographical location of the system, PV panels' rating, and tilt as well as azimuth angle. Moreover, the predicted consumption was calculated by taking in to account the power rating of each electrical device installed in the village and multiplying it with the estimated number of hours it will be used. This predicted consumption include household and livelihoods consumption combined at the time of installation. However, the current scenario of consumption in the villages is different form the predicted and it was observed by strictly monitoring the meters for a week to get the actual trends of consumption within each village.

Table 2. Predicted Energy consumption by one home

Utility	Power (W)	Total usage hours (hrs)	Energy requirements of one home

			(Wh/day)
Home light	9	7	63
Kitchen light	4	5	20
Outdoor light	9	14	126
Mobile charger	5	13	65
Street light	12	10	120
Total Power required (W)	39 W	**Total Energy required for one home**	394 Wh/day

The table above shows the estimated energy and power consumption by a single home in a village. Similarly, the estimated total consumption was simply calculated by multiplying the total number of homes with the energy consumption of a single home. Furthermore same method was applied for livelihoods in each village.

Once the consumption is calculated, we need to calculate the system size by accounting for the radiation intensity at our location. An easy and accurate way to do this is to use an online tool available at http://globalsolaratlas.info/. It provides accurate system sizes for the given location. The PV system size can also be calculated using a simple formula given below;

$E = A * r * H * PR$

E = Energy (kWh)

A = Total solar panel Area (m^2)

r = solar panel yield (%)

H = Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

r is the yield of the solar panel given by the ratio: electrical power (in kWp) of one solar panel divided by the area of one panel.

Using this formula the total PV panel area can be calculated. Given the type and power rating of the panels we wish to use for our system the number of panels required can be easily calculated.

Actual generation, predicted consumption and actual consumption on a per day basis for each village is given as under.

Table 3. Actual vs. Predicted Electricity consumption

Village	Estimated Generation/day (kWh)	Predicted Consumption/day (kWh)	Actual Consumption/day (for January 2018 (kWh)	Excess energy (kWh)	% Energy used
Jaffer Jokhio	46.916	43.698	38.02	8.9	81.03%
Ishaque Jokhio	65.347	57.899	19.95	45.397	30.5%
Hamzo Sammo	32.205	30.542	8.34	23.865	26%
Bachoo Kolhi	41.889	38.062	12.68	29.209	30.2%

Following is a clustered bar chart that helps to visualize the consumption trends in all villages. The gap between energy generated by the PV panels and consumed by the communities can easily be seen in this chart.

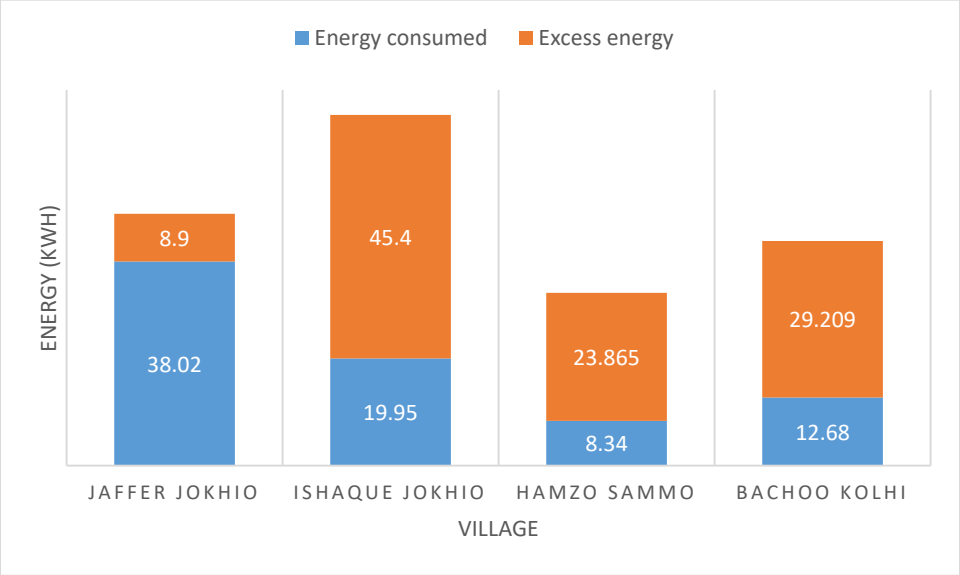


Figure 12. Relative consumption chart

Furthermore, the excess energy in each system has also been reported. It can be easily inferred from the table below that only Jaffer Jokhio is consuming its energy effectively. It will likely have an adverse effect on the batteries of other villages as they are not being utilized at all. Soon the capacity of the batteries will diminish.

Table 4. Excess energy in the system

Village	Total 24 hours consumption	Excess energy (kWh)	% Excess energy

(kWh)			
Jaffer Jokhio	38.02	8.9	18.9%
Ishaque Jokhio	19.95	45.397	69.4%
Hamzo Sammo	8.34	23.865	74%
Bachoo Kolhi	12.68	54.57	69.7%

Moreover, the status of the storage system in the villages was also checked. There are 24 batteries installed in series on each system. Each village's battery storage capacity is given as under. The battery depth of discharge (DOD) has been set to 50% according to design. A survey was also performed to monitor batteries in the field. All the batteries in all four of the system are arranged in series connection. The inverter is programmed to sync at 48V. Each battery is 2V and hence 24 batteries in series will exactly produce a voltage of 48V. DOD stands for depth of discharge. The batteries were designed to operate at 50% DOD which means that only 50% of the batteries' capacities should be utilized in order to obtain the desired cycle life from each battery.

Figure 13. Battery survey in the villages

Table 5. Battery specifications and capacity

Village	No. of batteries	Amp-hour capacity (Ah)	Battery voltage (V)	Arrangement	Battery Capacity (Wh)	Usable Battery Capacity with 50% DOD (kWh)
Jaffer Jokhio	24	1200	2	series	57,600	28.8
Ishaque Jokhio	24	1500	2	series	72,000	36
Hamzo Sammo	24	800	2	series	38,400	19.2
Bachoo Kolhi	24	800	2	series	38,400	19.2

The life cycle of batteries is around 5 years with 50% DOD. But as the DOD is decreased, the life cycle increases.

To further zoom in to the system performance, the day and night time consumption profiles were recorded separately for the village Jaffer Jokhio.

Table 6. Day and night time energy consumption

Village	Daytime consumption (kWh)	Night time consumption (kWh)	Total consumption over a period of 24 hours (kWh)	Average Energy consumption/hour (kWh/hr)
Jaffer Jokhio	10.51	27.51	38.02	1.58

Table 7. Surplus energy in the system

Village	Battery stored energy used during night	Surplus energy during night (kWh)	Surplus energy during day (kWh)
Jaffer Jokhio	95%	1.29	8.8

Note:

One important thing to notice is that the night time and daytime consumptions are interrelated to each other. The total surplus energy reported is the amount of energy available for day and night time. If in any scenario the night time consumption is increased, the daytime surplus energy available will decrease in effect concurrently.

Furthermore, the villages were visited to note readings from all the cluster and livelihood meters. Findings are given below;

Table 8. Cluster readings

Village	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Clusters (total till date) (kWh)
Jaffer Jokhio	2900.58	6659.59	3694.66	1351.25	1505.74	16111.82
Ishaque Jokhio	7642.97	5742.02	532.05	1.11	7.71	13925.86
Hamzo Sammo	769.93	620.94	931.32	820.25	346.84	3489.28
Bachoo Kolhi	584.64	37.06	3775.1	1775.14	-	6171.94

Table 9. Livelihoods' readings ('-' represents no meter)

Village	Livelihood meter 1	Livelihood meter 2	Livelihood meter 3
Jaffer Jokhio	1621.53	457.75	-
Ishaque Jokhio	469.01	190.1	7.71
Hamzo Sammo	-	-	-
Bachoo Kolhi	55.24	-	-

Table 10. Jaffer Jokhio's livelihood meters

Table 11. Ishaque Jokhio's livelihood meters

Table 12. Bachoo Kolhi's livelihood meter

Excess Energy

By looking at the data trends, it looks like that the systems have a lot of excess energy that goes unutilized. But there are a couple of factors that needs to be understood to contemplate the utility of this excess energy in the system.

- There are seasonal variations. This report shows energy trends for December only. Another very important factor is that the systems were initially designed keeping in mind that the overall village consumptions will increase over time as the number of households and enterprises gradually increase over the years.
- Crab plants operate seasonally for 3-4 months each year but the systems had to be designed by estimating the maximum power consumption. When the crab plants are not working, the designed energy consumption of the crab plats will reside in the system as excess.
- A lot of the LED lights and mobile charging ports installed at the beginning have fused or are out of order. This factor also contributes to the decrease energy consumption by each village.
- During field visits, it was observed that the systems were turned off during the day and hence the consumption for that specific period of time plummets to zero. However, the consumptions during the day are already low even when the system is up and running.
- Livelihoods should be further emphasized and promoted to increase energy consumptions with in each village. Moreover, we have observed that there are other potential buyers of the electricity in the vicinity of the villages. This arena can be explored to sell electricity to nearby potential customers in order to improve system’s performance and increase system revenues.

Still evident from the data above, there is a lot of surplus energy in the system that goes unutilized during day as well as at night time. So in order to use this surplus energy, we can promote new businesses and livelihoods in the communities. In this way the economic condition of the villages will surely improve which will in turn also increase the system revenues or returns. A training module has been designed to train the local residents of the villages so that they can become more aware about the system and hence can better utilize the energy.

Expected design billing vs. Actual billing Scenario

All the four systems were designed to be billed for electricity consumption as per the set tariff detailed below;

Table 13. Designed subsidized billing scenario for all villages

Customer	Monthly flat fee	Usage charge per kWh	Average total monthly bill	Metering system
Household	Rs 200 per HH	Rs 16/ kWh	Rs 340/ month	metered by cluster of HHs
Enterprise	Rs 600 per HH	Rs 16/ kWh	Rs 1,720 /month	metered by each enterprise

Households pay a monthly bill of PKR 350 each. All the households are connected to four or in some cases five clustered meters, hence, to bill each house individually on the basis of actual consumption by that house is not possible. Livelihoods have also been billed a fixed rate of PKR 650 till now as the initial revenues from the enterprises is low and some enterprises are using minimum electricity. However, to install each household with a separate meter is proposed. The quotation for the meters was requested, from Transpower Industries (Pvt.) Ltd., and is attached to this report. A single meter costs around PKR 1500+GST.

Table 14. Billing details (Jaffer Jokhio)

S.NO.	MONTH	AMOUNT
2016	October -16 TO November-16	10,000
	November-16 To December-16	15,000
	TOTAL BILLING 2016	**25,000**
2017	December-16 to january-17	13,000
	January -17 to February	13,000
	March-17 to April-17	20,950
	April-177 to May-17	20,000
	May-17 TO June-17	15,000
	June-17 TO July-17	18,300
	July-17 to August-17	13,900
	August-17 to September -17	10,000
	September to october-17	14,700
	October -17 TO November-017	16,000
	November -17 TO Dec-017	16,000
	TOTAL BILLING 2017	**170,850**
	TOTAL BILLING Amount 2016-17	**195,850**

Figure 14. Billing files of Jaffer Jokhio

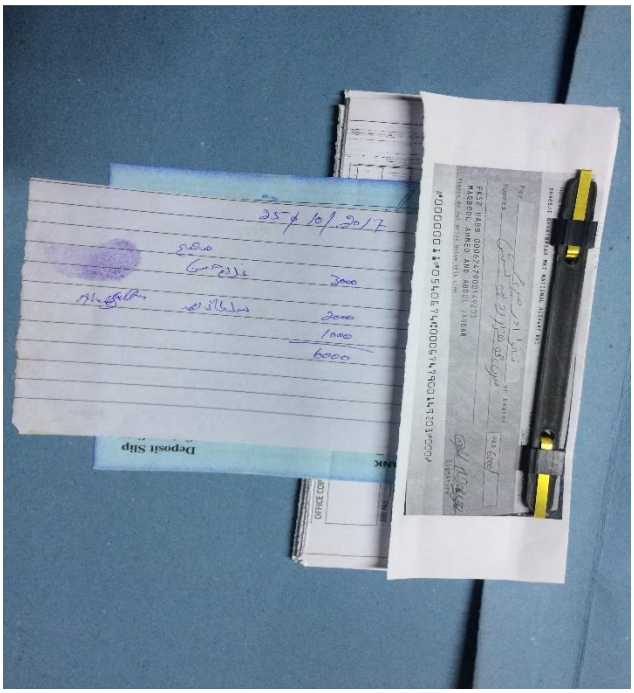


Figure 15. Monthly billing details (Jaffer Jokhio)

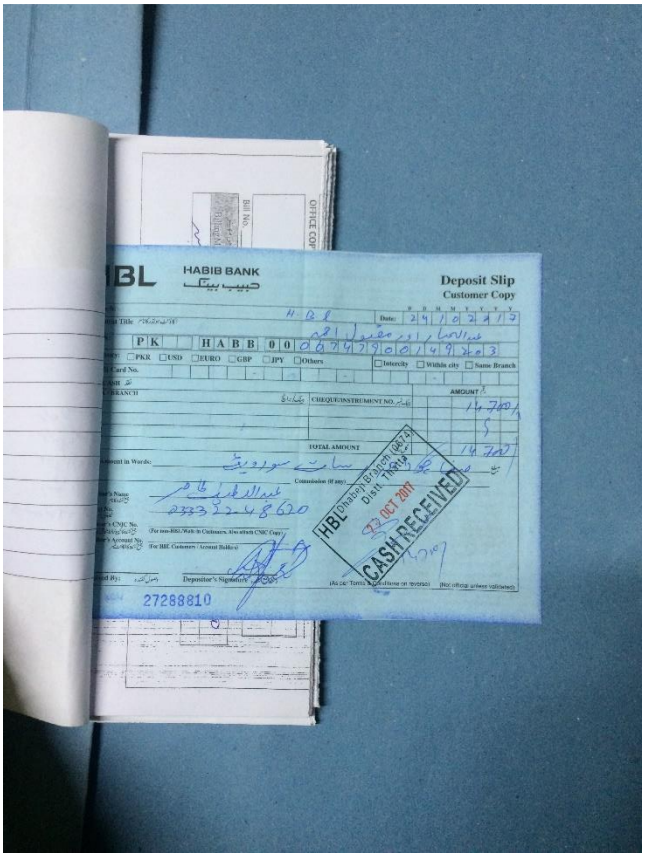
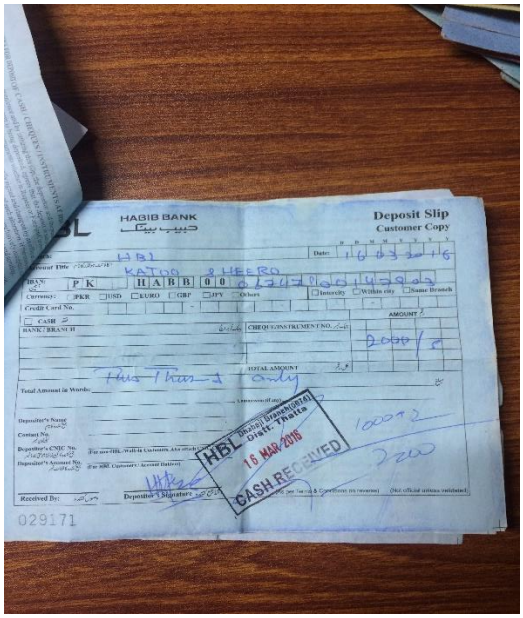


Figure 16. Cash deposit slips for Jaffer Jokhio

Table 15. Billing details (Bachoo Kolhi)

S.NO	MONTH	AMOUNT
1	Mar-16	16,500
2	Jun-16	15,000
3	Aug-16	10,000
4	Oct-16	10500
	TOTAL	**52,000**



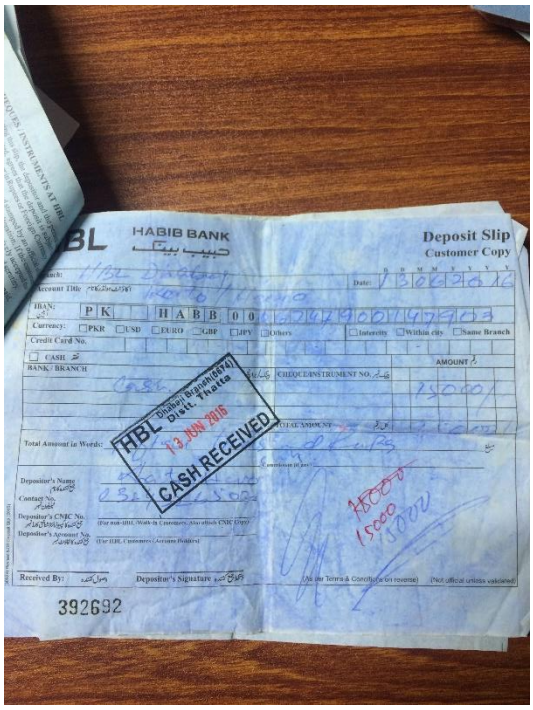


Figure 17. Bachoo Kolhi Cash deposit slips

In case of Livelihoods, discrete unit based bills can be generated as each livelihood station is installed with a separate energy meter. But, up till now this strategy has not been practiced in the field and livelihoods have also been charged a fixed bill of PKR 650. The reasons being sporadic business activity and low revenue generation from the livelihoods.

“Just light is not enough”

Figure 18. Livelihoods survey in all 4 villages

A survey was carried out to check the status of all the livelihoods in all the four villages. There was a noticeable difference in the designed and actual livelihood scenario. Both the crab processing plants in Bachoo Kolhi and Ishaque Jokhio are not functional at the moment as they operate seasonally only. Connection of two Confectionery shops has been cut by field operator due to noncompliance with bill payment agreement. Bill collection from Jaffer Jokhio is very good while that of Bachoo Kolhi is also satisfactory. Major findings are listed in the table below;

Table 16. Livelihoods assessment

Village	Expected Livelihoods	Actual Livelihoods
Jaffer Jokhio	01 Community restaurant, 01 Confectionery shops, 01 Cold drink shop, 01 Vegetable shop	01 Community restaurant, 01 Confectionery shop, 01 Cold drink shop, 01 Laundry shop
Ishaque Jokhio	03 Confectionery shop, 01 Cold drink shop, 01 Crab processing unit	01 Confectionery shops, 01 Cold drink shop 01 Crab processing unit
Hamzo Sammo	03 Confectionary shops	No initiatives
Bachoo Kolhi	05 Confectionery shops, 01 Community restaurant, 01 Crab processing plant	01 Confectionery shops, 01 Community restaurant, 01 Crab processing plant

The estimated bill recovery has also been calculated keeping the livelihoods' bills constant (PKR 650). The recoveries from Jaffer Jokhio and Bachoo Kolhi are 87% and 68% respectively. Recovery from other two was 20%. But now after implementation of the new billing system the conditions

have improved and we see an increasing trend in bill recovery. Some of the people have shifted their enterprise from the allocated villages in the hope of better opportunities while a few others have sold their initial assets and bought livestock from that. Crab processing plants operate seasonally and had to be accounted for in the system's total capacity according to maximum power consumption. One major reason for noncompliance to billing are internal conflicts on community level within some villages. These are social issues that can be resolved through trainings and awareness sessions.

LIVELIHOOD SURVEY

Following are the main reasons we analyzed by conducting a survey in the relevant villages;

- Low revenue generation from the types of enterprises being established.
- Better business opportunities in the nearby market areas.
- Crab processing plants are seasonal and are only in function for 3-4 months in a year.
- A general trend of selling the enterprises and buying livestock in exchange was found.
- Some of the businesses are very weakly linked to energy usage (For e.g., A tea stall that only uses a 13 W bulb)

“Just light is not enough”

Figure 19. Survey pictures

Table 17. Billing scenario (actual vs. designed)

Village	No. of households	No. of businesses (expected scenario)	No. of businesses (actual scenario)	Estimated Bill Recovery (PKR)	Actual Bill Recovery (December 2017) (PKR)	% Recovery
Jaffer Jokhio	80	4	4	18,400	16,000	87%
Ishaque Jokhio	78	5	3	17,400	3480	20%
Hamzo Sammo	64	3	none	14000	2800	20%
Bachoo Kolhi	53	7	3	14,800	10,000	68%

Data collection from the systems

We have been recording meter readings from the field manually for the a few days but it is not an efficient way to record data. The data record is very limited, it is highly susceptible to human error and the process is unsustainable. We have observed a lot of errors and inconsistencies in the readings reported by field operators due to which data reliability and authenticity decreases.

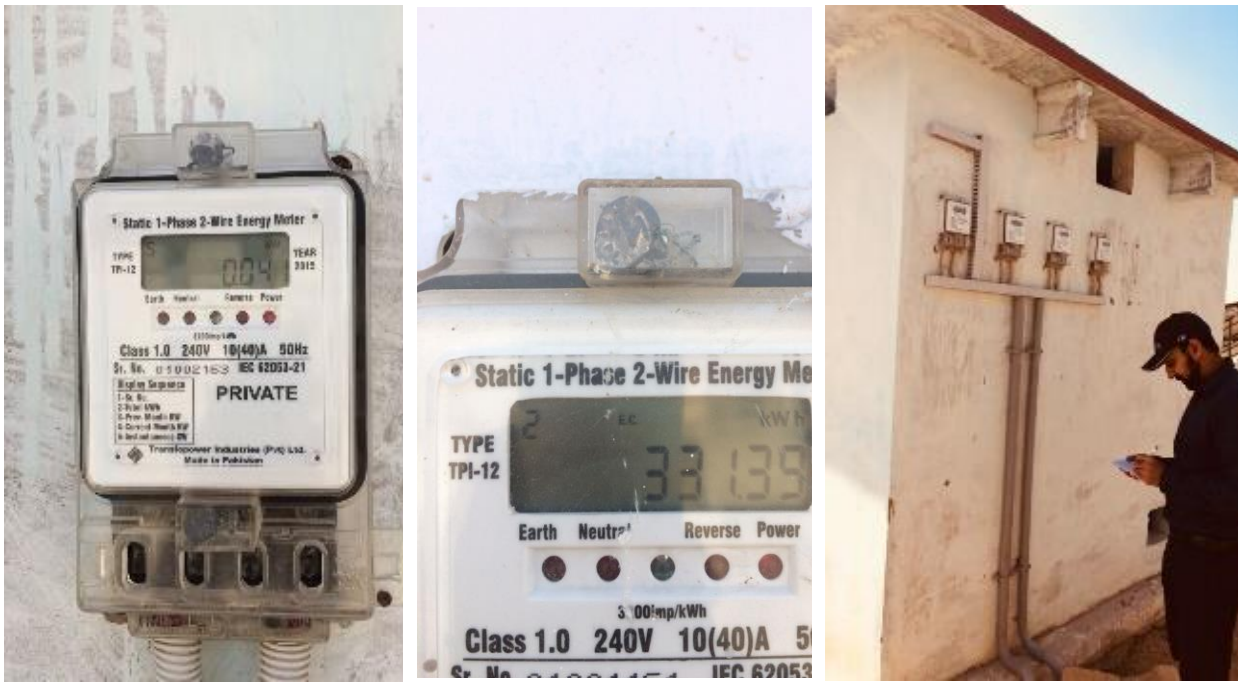


Figure 20. Meters and Meter readings

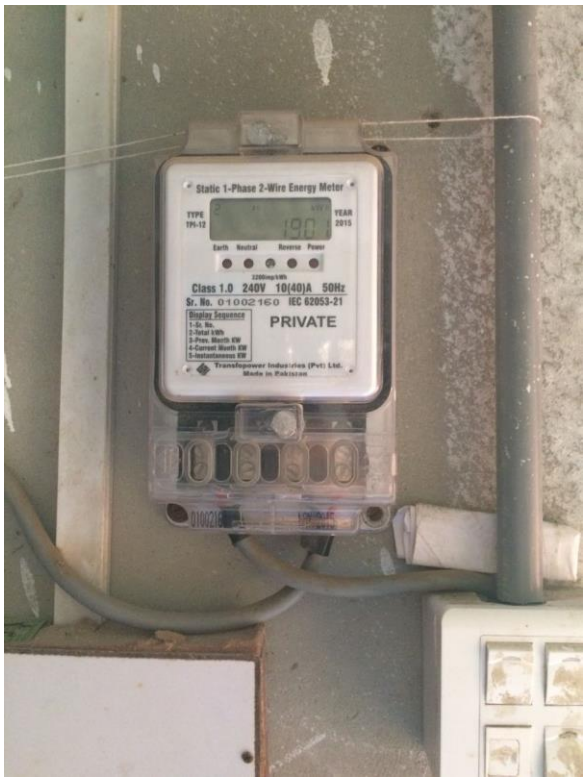


Figure 21. Field operators learning to note meter readings

VI. Suggestions

We have looked into all the possible options for better data retrieval and collection from the solar systems. The inverter (Schneider Electric, Conext XW+7048, hybrid 4.5 kVA) installed in field were inspected by the engineer to check any option for data collection using a microSD card, external drive or even LAN cable. None of the options are possible with the existing inverters. To further verify this, engineer from Schneider electric was contacted to justify our findings. The engineer informed that the only way to extract data from our inverters is to connect it with a Combox. No other storage and connecting device would be compatible with our inverters. (The manuals for Combox and Inverter are also attached with this report)

Figure 22. Conext XW+7048 inverter in villages

The inverter uses Xanbus Control Panel to display real time information only. Given below is a description of the Inverter from the Schneider manual itself;

"The Conext SCP features:

• A liquid crystal display which provides graphics and text describing real time operation and status information.

• LED event and warning indicator.

• Internal clock which is used to control time-dependent Conext XW+ settings.

• Buttons to select configuration menus, customize Conext XW+ functions, and clear faults and warnings."

Figure 23. Conext Combox monitoring device

In order to extract any real time based integrated data from the inverter it must be coupled with the Conext Combox device that can also remotely send the data to any internet connected computer. The Combox also needs an internet access (for e.g. PTCL broadband or any network wingle device). The cost of a combox is around PKR 70,000 each, PKR 2,80,000 for the four comboxes needed in four villages. (Quotation for the Combox from Schneider electric has been attached with this report).

Another cost effective solution we have figured out is to install GSM/GPRS enabled smart meters to each of the solar system. The smart meter will remotely provide access to the energy, active and reactive powers, voltages, current profiles. We can access the data from any computer and the system records and stores data twice a day. Microtech Industries was contacted to get a quotation for their three phase meters (A quotation for their three-phase meters is attached to the report). Systems above 5kW would require a three phase meter. The cost of one meter is PKR 18,000+ GST and a charge of PKR 8,000 (annually) for data transfer services. Manual for the 3 phase meter and software used to access data has been also attached to this report.

Figure 24. Microtech 3-phase meter

Table 18. Display specifications of the 3-phase meter

Window	Description
1	All Segments
2	Date
3	Time
4	Energy kWh (Total)
5	Energy kWh T1
6	Energy kWh T2
7	Energy kvarh (Total)
8	Energy kvarh T1
9	Energy kvarh T2
10	Max. kW (MDI)
11	Max kW T1 (MDI)
12	Max kW T2 (MDI)
13	kW Cumulative (MDI)
14	kW Cumulative T1 (MDI)
15	kW Cumulative T2 (MDI)
16	Number of Resets (Count)
17	Instantaneous Active Power (kW)
18	Instantaneous Power Factor
19	Average Power Factor - Current Month

To summarize there are two feasible options for data collection;

- **Schneider Electric Conext Combox Communication device**
- **Microtech Industries smart GSM based energy meters**

VII. Lessons Learned

These projects have been a learning experience for IET. Key learning outcomes are given below:

- Project timeline was three months. Such projects needs careful planning, sophisticated surveys, meticulous designing strategies and efficient implementation. We have learned that a time period of at least nine months is required to coherently and systematically implement such a project addressing al the social and technical challenges.
- The systems were carefully designed by analyzing the energy needs of each village but there is still a margin to predict the energy demands in a better and optimized way through rigorous surveys and the use of sophisticated simulation tools so that the energy demands meet energy generation more precisely.
- Although clustered meter approach is cost effective it is not feasible in the long run and every individual connection should be provided with a separate energy meter for better control and regulation.
- Smart meters are a great option to remotely excess data for the system and this feature is highly recommended in the future systems.
- Energy CRPs needs to be trained on-site during system installation phase instead of at a later stage.

VIII. Conclusions

IET under the supervision of PPAF have practically setup four off grid solar mini-grid stations in four different villages with completely different dynamics. It has since changed the lives of hundreds of people living in those villages. IET feels proud that it was trusted with the responsibility given to it by PPAF and it also feels accomplished by successfully completing the project. Regardless of the difficulties and setbacks it faced during the implementation and operation of the mini-grids, we tried our best to give back to the community in the best way possible. Although the mini-grids are not yet perfect but we have nudged the community towards a path of sustainability. We look forward to do the same great work in future and learn from our challenges to improve our performance.