Pakistan Poverty Alleviation Fund

Restoring Hope, Securing the Future, Ending Poverty

"Just Light is not enough"

Solutions for improving energy access in Rural Sindh

Commissioned by the Pakistan Poverty Alleviation Fund (PPAF)

Conducted by Indus Earth Trust and Demian Natakhan (Enhar)

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FINAL REPORT

IET
INDUS EARTH TRUST

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An associated Consolidated Financing Agreement PPAF-III Between Pakistan Poverty Alleviation Fund & Indus Earth Trust (IET) has resulted in input from IET throughout this report.

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Glossary of Terms and Abbreviations

CO	Community Organisations
ESMAP	Energy Sector Management Assistance Program
FGDs	Focus Group Discussions
GOP	Government of Pakistan
HH	Household
IET	Indus Earth Trust
KElectric	K-Electric is a Pakistani vertically integrated electric corporation involved in generating, transmitting and distributing power to around 20 million inhabitants of Karachi.
kWh	Kilowatt-hour
Kunda	Informal unmetered electricity supply.
LSO	Local Support Organisation
Micro Grid	Island grids with generation capacity under 10 kW
Mini Grid	Island Grids with generation capacity total 10kW-200 kW
MW	Mega Watt
PO	Partner Organisations, which PPAF engages for implementation of sustainable development activities. Indus Earth Trust is the PO appointed for the Just Light is not Enough program.
PKR	Pakistani Rupee
PPAF	Pakistan Poverty Alleviation Fund
PSA	Population Score Assessment
PV	Solar Photovoltaics
Rs	Pakistan Rupees, at time of writing exchange rate approx. 105 Rs = 1 $USD
SMGP	Solar Mini-Grid Project
USD	American Dollar
VO	Village Organisation; formal body which manages village matters
WAPDA	The Water and Power Development Authority is a government-owned public utility maintaining power and water in Pakistan. Duties include Generation, Transmission and Distribution of Power.

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1. Executive Summary

The lack of appropriate energy infrastructure has left much of rural Pakistan without light or power. The demand for reliable electrical power is widespread and over 140 million people in Pakistan have no access or inadequate access to power. A focus on local energy sources which can raise the level of economic development through improved access to energy is required. Renewable decentralised energy technologies are cheaper and more technologically advanced than they have ever been due to market growth worldwide. Coupled with major improvements in energy efficiency of home appliances and the development of mobile computing technology, this means energy solutions are more affordable than in previous decades.

Energy access in rural areas of Pakistan in this decade can therefore consider localised solutions as an economic alternative to main grid extension. Socio-economic sustainability will provide confidence within rural communities to depend on their own resources and relieve the continuous expectations from Government and Civil Society.

Progress has been made through several initiatives in Pakistan including hydro mini grids in KP Province however most projects have tended to focus on the provision of basic lighting for communities.

The "Just Light is Not Enough" project was conceived to provide sufficient power for enterprise development in villages in addition to basic lighting needs. The Pakistan Poverty Alleviation Fund (PPAF) appointed Indus Earth Trust to undertake all associated social mobilisation and implementation activities to deliver this pilot program.

The recommended approach to village energy access is to firstly assess the current baseline, population, poverty status and desired livelihood outcomes. A questionnaire energy audit of the village existing expenditure should be conducted in the first instance. Covering lighting and other energy, this provides information on current costs of energy at the village, which will be replaced by electric power.

Within this project a sample of 20 villages was investigated and it was found that around 45% have no access to any electricity and the other 55% suffer from high load shedding and tariff escalation challenges.

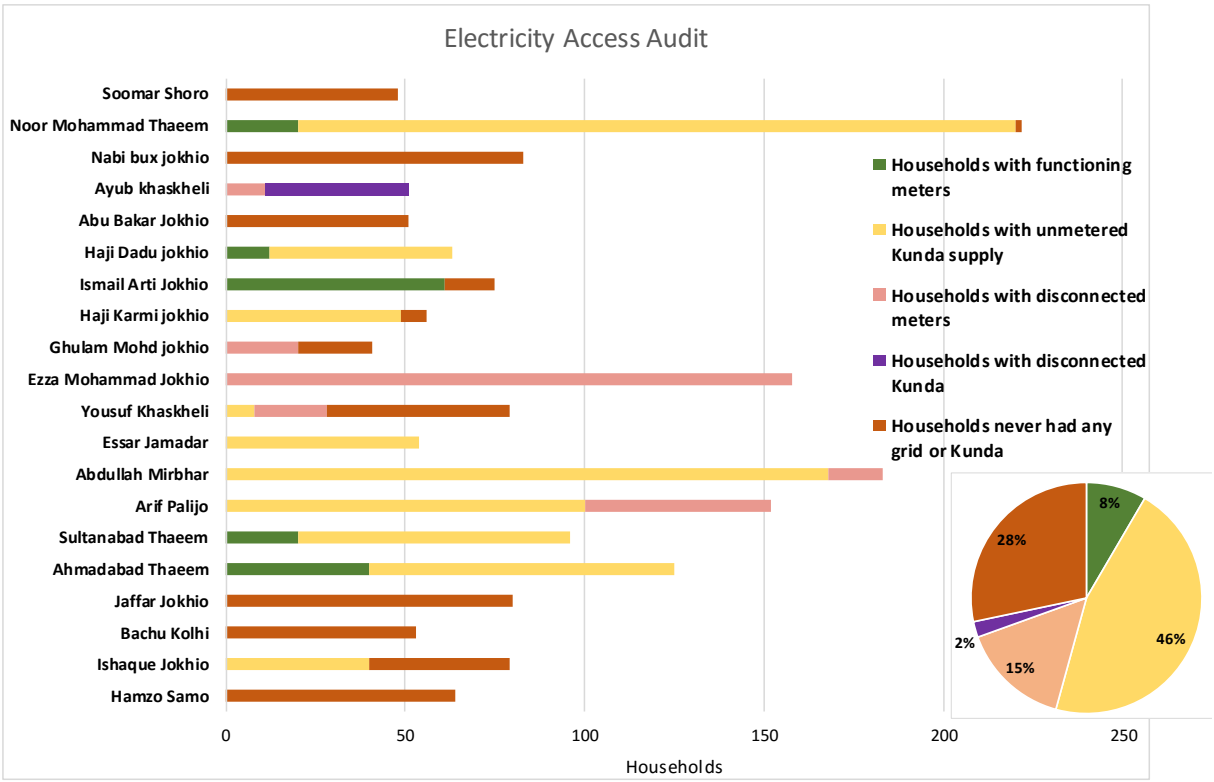


Figure 1-1: Electricity access baseline results for 20 villages in Thatta region, Sindh

As well as existing energy access, the social engagement by IET with each village included community meetings which discussed the potential for livelihood enhancement through electrical generation. At the meetings, willingness and ability to pay for communal energy infrastructure was also discussed.

Using the international Energy Sector Management Assistance Program (ESMAP) approach, an energy supply for rural communities should have the following characteristics:

- Provide medium or high amounts of power in the context of the community
- Be available over 16 hours per day
- Provide reliable supply
- Be priced affordably
- Be legally accessible and usable
- Be convenient
- Be healthy and safe

Technology design options were considered by engineers including independent consultant Demian Natakhan, to deliver an electricity supply sufficient to supply light and power for livelihood enhancement activities. A priority was given to utilising local renewable energy sources.

Solar photovoltaic and battery combinations were selected based on previous local success with this technology, low maintenance requirements and ubiquitous availability of solar resource at all villages. Wind power was considered at Hamzo Samo village where a reasonable wind resource exists, but was ruled out due to maintenance difficulty compared to solar PV. Biogas is an option in some villages and was considered as a cooking fuel replacement, however this program focussed on electrical power solutions.

The program budget allowed for some pilot minigrid systems to be implemented on a subsidised basis. Four villages were selected by IET based on social, economic and geographical criteria which included the level of success from prior interventions.

Social engagement was undertaken by IET with all villages to ensure that the village contribution in both cash and in-kind labour would boost the local sense of ownership of the systems.

Modelling of village electricity demand was undertaken and solar and battery sizing undertaken accordingly. An example of system modelling is shown in the Figure below:

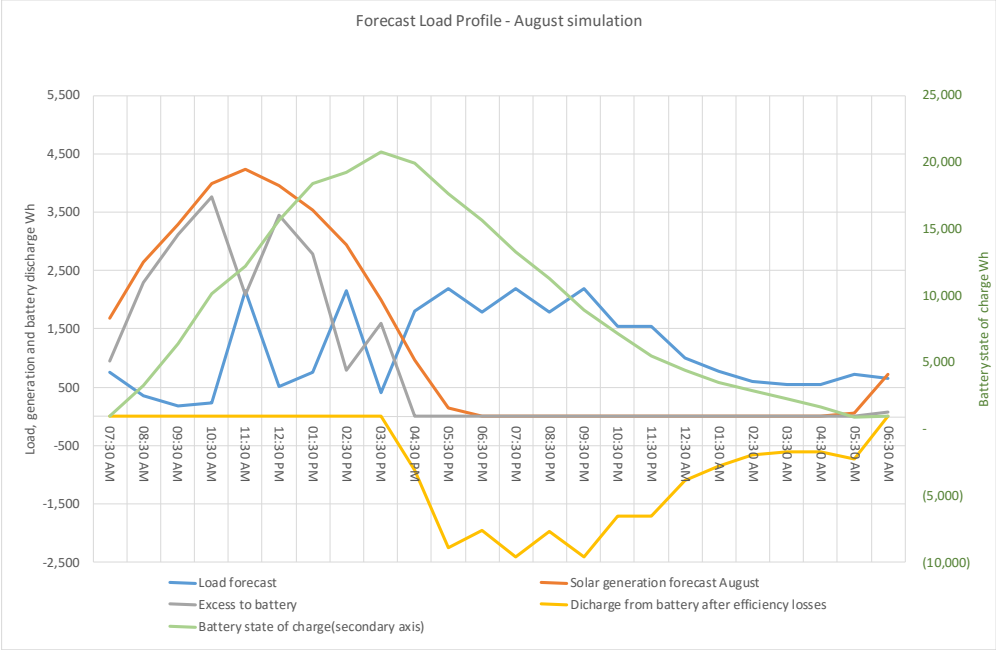


Figure 1-2: Bacho Kohli whole village power forecast (August weather scenario)

The modelling considered the following loads: each household receives 1 LED light in kitchen, 1 in main room, 1 outdoor light, and a USB mobile phone charger. Community street lamps are provided in several locations. Livelihood growth is factored in with multiple businesses or 'enterprises' identified at each village and relevant power loads determined including fans, refrigeration, pumps, irons and other appliances essential for business operation.

Requests for quotation were issued by IET for the required minigrid systems to reputable solar firms in the region. High quality components were specified including solar panels, inverters, batteries and cable type. Warranty lengths were maximised to ensure long term system reliability.

The inverters selected are Schneider hybrid inverters with online remote monitoring functionality.

Nizam Energy was appointed to undertake installation of the solar battery mini-grid at all four villages, based on track record and capacity.

Village engagement included contribution of cash and providing labour on the civil works components.

The photo below shows the solar array foundations at completion, security wall and gate, control building to house batteries and inverter plus cable trench digging:

Figure 1-3: Solar array foundations and control building at completion, Hamzo Samo

Figure 1-4: Solar panels being installed at Hamzo Samo village

The operation of the systems was the subject of extensive engagement with the community and IET. An operation and maintenance plan was developed by IET and presented to each village, which is outlined below:

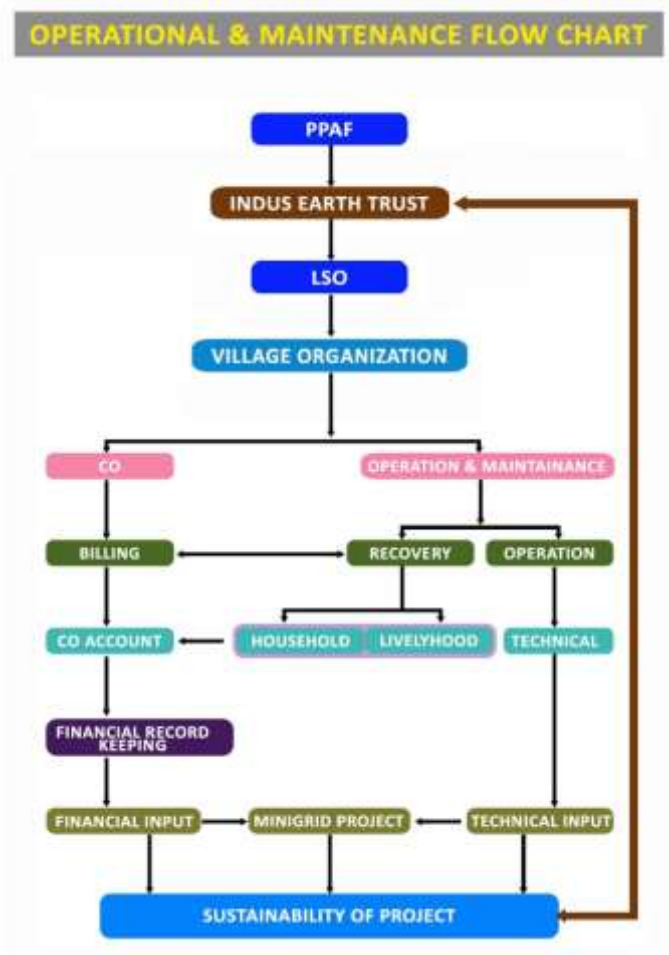


Figure 1-5: Operational and Maintenance responsibilities flow chart by IET

Energy policy design for other villages was developed as a toolkit for wider deployment:

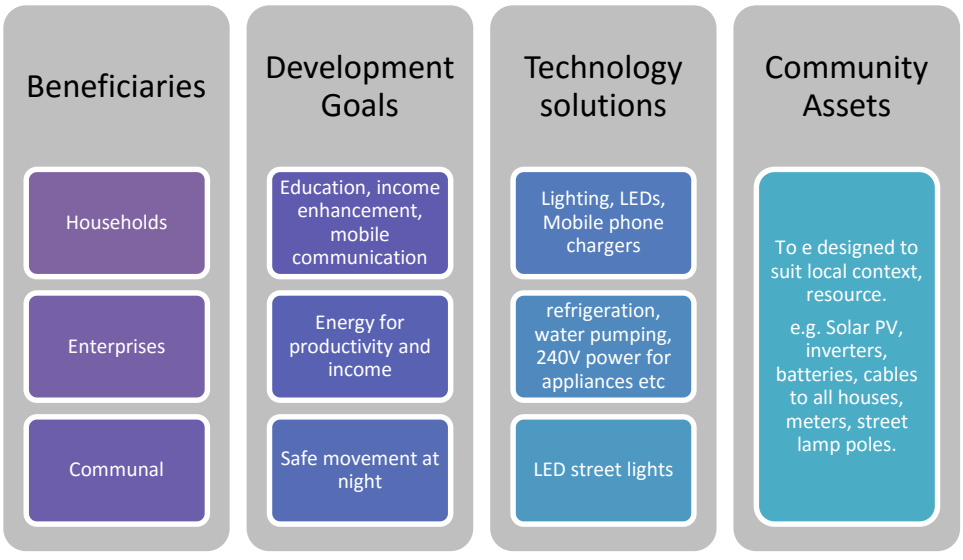


Figure 1-6: Energy Policy template development for village based clusters

Using the baseline data gathered, and the template developed, energy policies can readily be developed for remaining 16 villages and this approach can be adopted for wider uptake nationally.

IETs detailed interviews with the 16 village VOs and other CO members was indicative of the high level of desire for consistent and reliable electricity supply. Village residents frequently stated that they wanted to be independent and not rely on the main grid service. Trust in government grid electrification initiatives is very low due to previous promises being given by local government which have not been fulfilled. After noting what the capital costs might be, 12 villages stated that they were willing and would be in a position to contribute 25-35% of the capital costs themselves, with a 5% down payment, as long as they were able to pay the remainder over a 5 year period.

Actual capital and operational costs for a village system are as follows:

Table 1-1: Recommended tariffs for a subsidised scenario at Jaffar Jokhio village

Village/Community Organisation Name:	**District:**	**Union Council:**
Jaffar Jokhio	Thatta	Tehsil MirPur Sakro
Total No. Households	**Total No. Enterprises**	
80	5	
Capital Cost for installation of system	**Solar PV capacity**	**Battery capacity**
Rs 5,639,010 / USD $53,705	14 kW	58 kWh

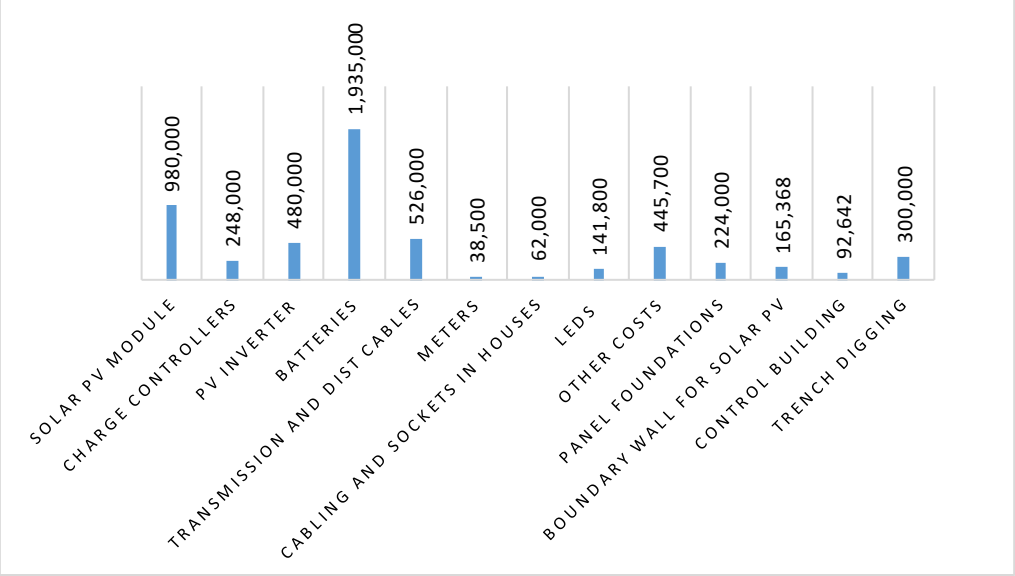


Figure 1-7: Capital cost example by for village minigrid at Jaffar Jokhio village

Table 1-2 : Operation and routine maintenance costs

Description of routine annual Opex item	Annual Opex PKR	Annual USD
First 2 years maintenance by Nizam included	0	-
Cleaning panel, 2 days per month, Rs 300/day	7,200	69
Year 2 onwards: scheduled maintenance - PV/inverter	22,050	210
Year 2 onwards: scheduled maintenance - batteries	30,000	286
Year 2 onwards: scheduled maintenance - control building & frames	30,000	286
Billing reading and bill admin	33,000	314
Debt collection from clusters and businesses	13,200	126
Internet subscription	5,000	48
Other admin/overheads	20,000	190
		-
Total (excluding equipment replacement)	160,450	1,528

Equipment replacement costs are itemised below.

Table 1-3: Equipment replacement costs over 20 years

Description of Equipment Replacement cost over 20 years	20 yr cost PKR	20 yr cost USD
Replacement of batteries (3 times)	- 3,356,016	- 31,962
Replacement of inverter (once)	- 432,000	- 4,114
Replacement of charge controllers (3 times)	- 496,000	- 4,724
Replacement of meters (once)	- 38,500	- 367
Replacement of LEDs (every 2 years)	- 1,276,200	- 12,154
Replacement of sundry equipment	- 1,337,100	- 12,734
Total	**- 6,935,816**	**- 66,055**

The baseline energy audits identified that households are currently paying an average of Rs500-Rs2,000 per month for lighting from kerosene and candles. The monthly bills arising from a minigrid providing solar-battery LED lighting is lower than current expenditure on kerosene and candles in most cases as illustrated in the tables below.

Table 1-4: Recommended tariffs for a subsidised scenario at Jaffar Jokhio village

Customer	Initial Connection Fee	Monthly flat fee	Usage charge per kWh	Average total monthly bill	Metering system
Household	**None**	**Rs 200 per HH** USD$1.90	**Rs 16/ kWh** USD$0.15/kWh	**Rs 340/ month**	metered by cluster of HHs, VO to apportion HH payments per cluster

Enterprise	**None**	**Rs 600 per enterprise** USD$5.71	**Rs 16/ kWh** USD$0.15/kWh	**Rs 1,720 / month**	metered by each enterprise

In order to investigate the opportunity for other village clusters to establish similar energy solutions without subsidy, a loan scenario was considered. In this scenario, the village organisation funds 50% of the capital costs through cash contributions from each household and enterprise owner as well as in-kind labour contribution from village residents. The remaining 50% would be required to be obtained in the form of a loan. Micro credit loans are available at 25-35% interest rates with 1-2 year repayment terms. These terms would create high costs in the initial 1-2 years and it is therefore recommended that alternative models are considered. Philanthropic or government backed loans of 13% interest rate and 3 year repayment terms are assumed in a financial model which determined the required tariffs in an unsubsidised scenario as follows:

Table 1-5: Recommended tariffs for an unsubsidised scenario at Jaffar Jokhio village

Customer	Initial Connection Fee	Monthly fixed fee	Usage charge per kWh	Average total monthly bill	Metering system
Household	**Rs 26,000** per HH	**Rs 200 per HH**	**Rs 60/ kWh**	**Rs 770/ month**	metered by cluster of HHs, VO to apportion HH payments per cluster
Enterprise	**Rs 63,000** per enterprise	**Rs 800 per enterprise**	**Rs 60/ kWh**	**Rs 5,500 / month**	metered by each enterprise

The affordability of the up-front capital cost, unfamiliarity and lack of market development are barriers to widespread uptake of island minigrids. This sector is a major opportunity for strategic government and donor intervention, which will also stimulate private sector engagement. Financial support and more favourable loans along with knowledge and capacity provision are key opportunities for sector leadership.

Grant subsidy schemes could be established and tailored to deliver required energy access affordability based on poverty scorecard levels or at standardised rates. Phased ramp down of the subsidy percentage over several years could be implemented to encourage private sector and community leadership to ramp up. This has been proven to be effective in establishing market confidence and lowering prices, for example in a Bangladesh Solar Home system subsidy program.

To examine the impact of a range of subsidy levels, modelling for subsidy scenarios applicable to solar PV minigrids in Sindh was undertaken. A summary of findings is shown in the Figure below:

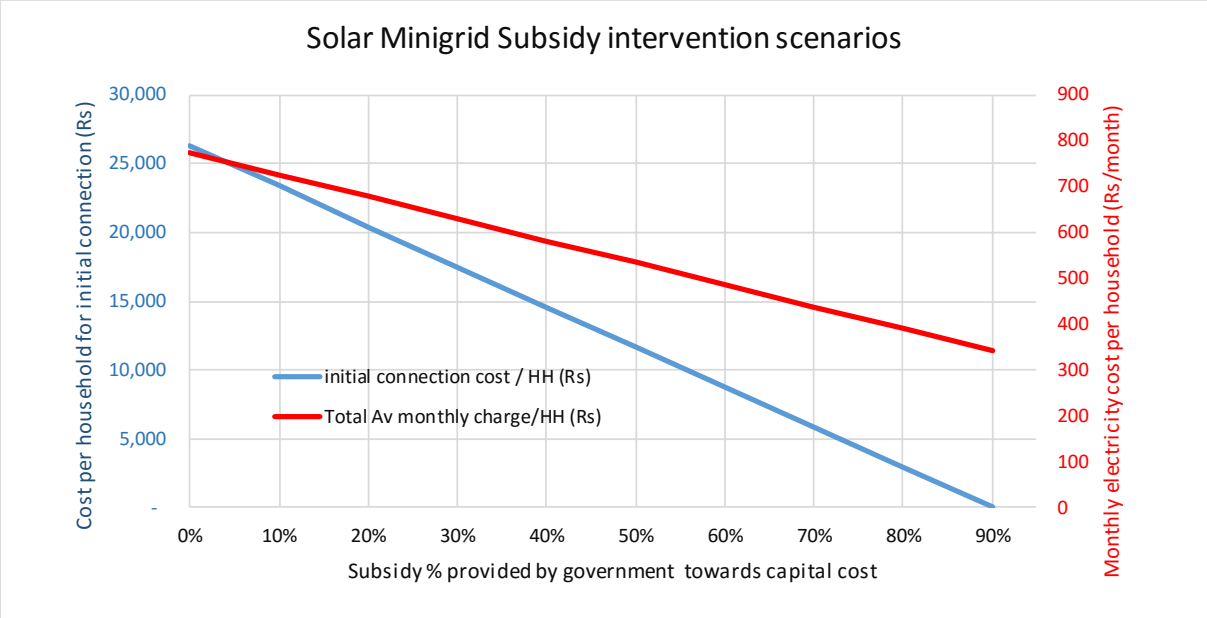


Figure 1-8: Solar minigrid subsidy intervention scenarios

Rural communities in many areas are likely to find more success with island minigrid systems than waiting for grid connection and meters to be provided.

Government subsidy and donor schemes can have a major influence on stimulating sector growth, especially where knowledge-sharing is maximised.

Local bottom-up growth of rural energy access solutions is also likely to continue through commercial enterprises providing household and minigrid level solar solutions. Solar lighting is a rapidly expanding commercial market in Pakistan, and household level solar battery products are also being launched on the market.
Coordination between grid electrification departments, PPAF and NGOs is encouraged, in order to prioritise off grid minigrid solution activities in areas least likely to receive affordable grid connections in the medium to long term.

Strategic investigation of energy access throughout rural regions is recommended to ascertain the lowest energy access areas, and where greatest savings to the national and regional treasuries can be obtained through avoidance of grid line extension through minigrid development.

Regulatory mechanisms to promote minigrid customer safety and consumer choice is required at regional and national levels.

1.1 Social Implications of intervention

It is important to understand what affect light for each home and, especially electric supply for enterprise development will have on the communities and villages in the region.

Education of individuals and communities of the immediate and long term benefits of the new power supply is important. This is required to create real community ownership and leadership of the minigrids; and achieve long term sustainability of the energy access enhancement. Education is a key mitigation against the risk that local ownership and responsibility for a subsidised minigrid is low leading to system failure.

It is important that a proper social mobilisation programme be continued wherever a Mini Grid proposal is to be implemented. Literacy in the villages without a reliable electrical energy supply is very low, and in some cases literacy among women and children is non-existent.

However, it is has been noted how eager communities are willing to learn as they can appreciate that this type of intervention is for their benefit. It has been observed that in several villages' energy efficient wood burning stoves are being used for cooking. This is a positive indicator that communities are becoming aware that using less fire wood wherever possible results a reduction in health issues, deforestation and workload; in addition it indicates a positive attitude to energy efficiency and behavioural change.

Given a strong community desire for improved energy access, improvements in technology efficiency and reductions in capital cost due to global market growth in solar battery equipment, the opportunity for improving energy access in rural Pakistan is very large.

By strengthening government/donor subsidy intervention and capacity building program, plus private sector initiatives, significant energy access enhancement can be achieved in rural Pakistan on a wide and far reaching scale.

Monitoring of the current pilot minigrids is highly recommended in order to promote correct usage and maintenance of the systems. Publication of project information including monitored data is recommended to maximise the knowledge sharing and 'knock-on' impact of these pilot projects.

2. Introduction

2.1 About the Pakistan Poverty Alleviation Fund

Pakistan Poverty Alleviation Fund (PPAF) is the lead apex institution for community-driven development in the country. Set up by the Government of Pakistan as an autonomous not-for-profit organization, PPAF enjoys facilitation and support from the Government of Pakistan, The World Bank, International Fund for Agricultural Development (IFAD), KfW Entwicklungsbank (Development Bank of Germany) and other statutory and corporate donors. PPAF aims to be the catalyst for improving the quality of life, broadening the range of opportunities and socio-economic mainstreaming of the poor and disadvantaged, especially women.

The core operating units of the PPAF deliver a range of development interventions at the grassroots/community level through a network of more than 125 Partner Organizations (PO) across the country. These include social mobilization, support for livelihood, enterprise and employment, access to credit, skills development, infrastructure and energy, health, education and disaster management. Externally commissioned independent studies have demonstrated positive outcomes and impact of PPAF interventions on the lives of benefiting communities related to their economic output, household incomes, assets, agricultural productivity skills and other quality of life indices.[1]

2.2 Background

PPAF has been working in the Renewable Energy (RE) sector for more than 10 years and is now expanding this program to become a sector developer in this field. Approximately 30-40% of the rural population in Pakistan have no access at all to the grid[2] while those who have legal and illegal grid connections experience a highly unreliable supply due to extensive load shedding caused by major under capacity of power generation. There is a need to utilize the available renewable energy resources for the benefit of rural, poor communities. The international donor community is now focusing on financing renewable energy and climate change initiatives, therefore PPAF and its partners wish to position themselves to accept the challenge and play its role in an effective manner.

PPAF has worked on the deployment of renewable energy projects since 2003 by financing small community scale hydropower projects, based on the demand from the community and requests from partner organizations; and the investments were then extended to other RE technologies like solar, wind and biogas in 2006. PPAF is now moving towards making rural communities energy independent. It is doing this through an expert group supported by key partners to upscale the renewable energy activities in Pakistan. This group formed in 2015 will work to shifting the paradigm by promoting the spread of RE technologies with a focus on quality and creating awareness within the masses to make projects more sustainable.

PPAF has coordinated the development of Hydropower minigrids in Khyber Pakhtunkhwa (KP) region and detailed information on the outcomes of this program are provided reported in a report published in 2014 [1] and described on the PPAF website at http://www.ppaf.org.pk/HRE/HRE_Home.html
This KP project is now expanding to solar minigrid deployment scheduled for construction in 2016.

Improving the long-term viability of local energy supplies is a key driver. PPAF's support for energy projects is planned with a view towards energy self-sufficiency and livelihood creation for communities.

2.3 Objectives

The challenge faced in many rural regions of Pakistan is to meet the energy gap faced by the millions who live in energy marginalized communities. This is a broad challenge and a wide spectrum of approaches are needed to address it. There are social, economic and technological aspects to the energy challenge all of which must be addressed.

[1] Further information about the PPAF is available at http://www.ppaf.org.pk/
[2] Asian Development Bank briefing, citing 'Pakistan 2025 – One Nation, One Vision '

The eventual goal of this program is to fill the 'gap' in the provision of power to energy marginalized communities—completing their 'access to energy'—to enhance their ability improve their quality of life and economic outcomes. This effort complements the on-going Government of Pakistan focus on enhancing grid power provision around the country.

In order to fill the gap in the provision of power to energy marginalised communities, locally sustainable approaches are of key importance. Behaviours and social norms are important as well as technology approaches in this regard. Demand side solutions through efficient energy usage and smart ways of using energy to achieve economic benefits are essential. Localised affordable and reliable generation solutions of various kinds are another key solution. Renewable power resources including solar photovoltaics have important roles to play, along with other resources including biogas and wind power are needed where appropriate. Backup generation through diesel power is important as a temporary baseload power option.

Leadership in Energy Sector Development

The formation of a sector leader such as a Renewable Energy Development Company in Pakistan was discussed at a meeting between PPAF and Project Partner organisations on 9th October 2016 in Islamabad.

Mr. Amer Durrani, Senior Advisor to the CEO, PPAF highlighted the goal of making rural communities energy independent would require a Group with PPAF supported by key partners to upscale renewable energy activities in Pakistan. He stressed on shifting the paradigm to promote the spread of renewable energy technologies with a focus on quality and creating awareness within the masses to make projects more sustainable.

The 'Just Light is not Enough' program provides a template which other Partner Organisations and stakeholders can utilise to further energy provision in marginalised areas of Sindh and throughout Pakistan.

The creation of standalone minigrids is appropriate for locations remote from grid power provision and in areas where grid electrification is unlikely in the medium or long term. Such locations may establish long term power solutions through standalone minigrids which if appropriately managed and maintained in the long run, enable sustainable growth of energy supply to growing communities. By promoting sustainable minigrid solutions, grid infrastructure investment can be deployed elsewhere.

Where grid power provision is available on an intermittent basis, or scheduled to be constructed in the short to medium term, local hybrid minigrids can be developed which integrate with the grid when available and can switch to standalone mode when grid outages occur.

Where grid power provision has been previously established, but has been disconnected due to inability to pay the rates being charged, a locally owned and operated minigrid offers a solution.

PPAF has commenced exploring the potential for distributed generation and mini-grids in selected areas of Sindh—utilizing renewable energy based hybrid solutions. A pilot program is being implemented by Indus Earth Trust (IET) under PPAF III. It includes implementation of mini-grid systems in 4 villages in 2016, and research of 20 villages plus development of energy policies.

This document is the feasibility, research and baseline report which accompanies this program.

The current project focusses on the region of Sindh however the findings and recommendations are also applicable in other regions of Pakistan.

The objective was to develop a Feasibility Report and Baseline for 20 villages as representative of the region. This report is intended as a valuable educational resource for other energy provision projects for marginalised communities throughout Pakistan.

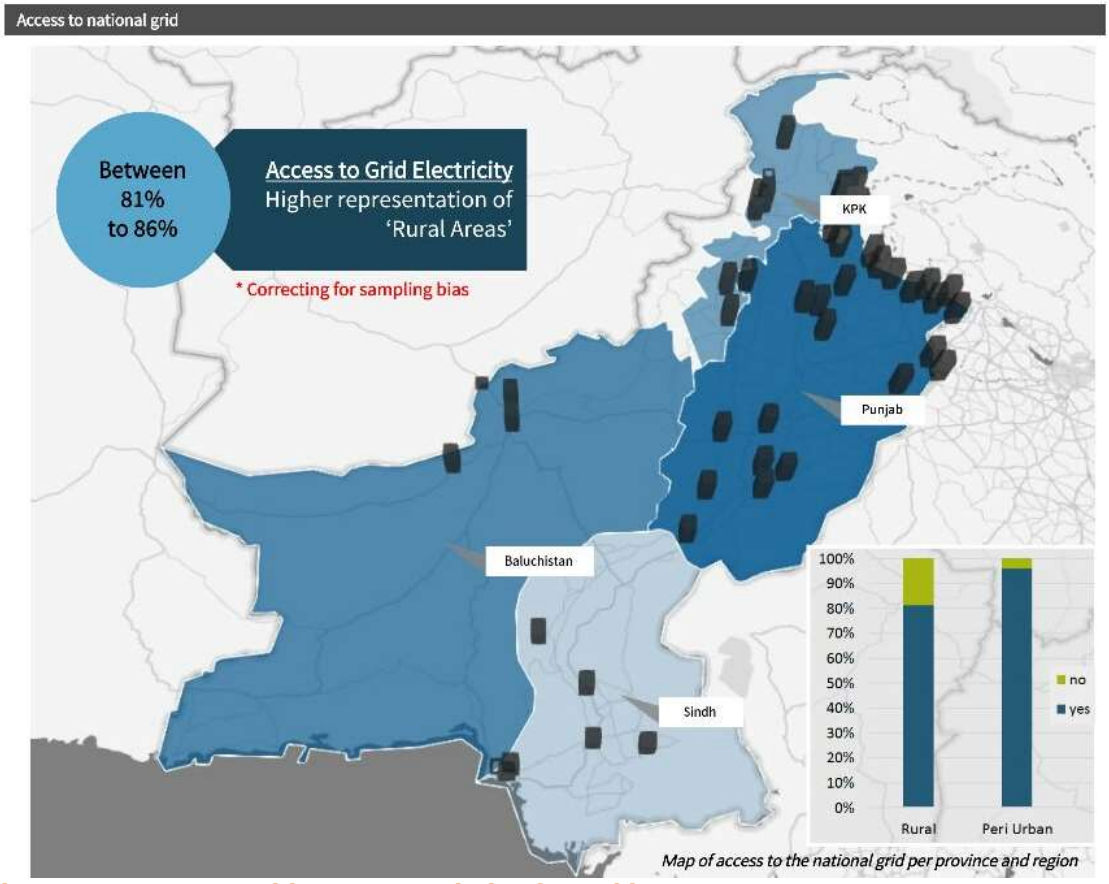
A linked objective of PPAF is to provide energy policies and strategic energy enhancement and provision plans for village based clusters. This will provide a road-map for Partner Organizations, PPAF, Donors, and Government to intervene and enhance energy access in these areas.

2.4 Grid Energy access in Pakistan

Research by MicroEnergy International published in 2014 for the PPAF [7][3] stated that according to IEA 2013 report, only 67% of the national population is connected to the national grid, of which 93% live in urban areas (IEA, 2013). This means that 63.8 Million people, living primarily in rural regions in Pakistan, did not have access to grid-supplied energy. The IEA 2013 report referenced 2011 data hence progress and developments in Pakistan in the intervening years are not reflected in the statistics.

An Asian Development Bank briefing cites the Pakistan 2025 report, noting that only 57% of the rural population has access to electricity. In some rural districts, electricity penetration is below 20%.

Recent work in 2015-16 by the Energy Sector Management Assistance Program (ESMAP)[4] includes analysis of energy access in Pakistan. The sample locations were selected with a specific proportion of off grid communities chosen rather than random sampling. This study includes only limited sample locations, and large areas remained un-surveyed due to security concerns. The ESMAP sample size and location bias means the results may not provide robust estimates of overall rural electrification rates. Rural electrification rates nationally are estimated to be around 57% and in some regions much lower. Among 20 villages surveyed in Thatta region of Sindh for the Just Light is Not Enough project, it was found that 45% of households had no access to electricity grid of any kind.



Grid access

Figure 2-1: ESMAP grid access statistics for Pakistan, 2016

Research by MicroEnergy International in their 2014 report estimated that 9.9 Million households nationwide had no access to the electricity grid and therefore are requiring electricity solutions. Given that the national population is increasing, even if the percentage grid access is improving as suggested by ESMAP data, the total market for off grid power solutions remains of the order of 10 million households.

[3] "Market assessment for scaling up off-grid solar electrification program in Pakistan", prepared by MicroEnergy International (MEI) and Partners in Sustainable Development (PSD) On behalf of the GIZ , 2014.
[4] Energy Sector Management Assistance Program (ESMAP) household energy access surveys Pakistan

Intermittency of grid power due to strain on the infrastructure and frequent outages, mean that grid access usually provides unreliable power supplies; the total market for distributed energy solutions in areas of intermittent power supply is much larger than the off grid market. Estimates in a 2015 report by Lighting Pakistan[5] are that over 55 percent of those on-grid in Pakistan experience an average load shedding of over 12 hours per day, see Figure 2-2 below.

The Lighting Pakistan report stated that "At a conservative estimate, over 144 million people in Pakistan are currently either off-grid or suffering severe under-electrification (those who have working grid connections, but do not receive adequate supply). This equates to a market of almost 22 million households for solar lighting products in Pakistan."

The estimated rates of electrification presented in the IFC study indicate lower grid access than the ESMAP estimate, as shown in Figure 2-2 below:

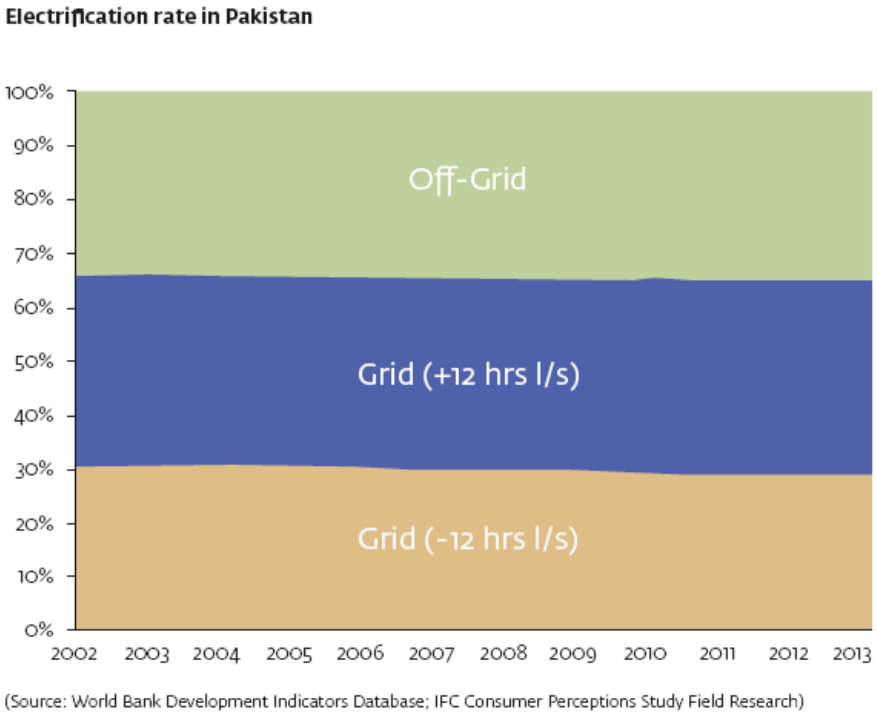


Figure 2-2: Electrification rates in Pakistan, 2015 IFC lighting report

[5] Pakistan Off-Grid Lighting Consumer Perceptions Study Overview, 2015, by Lighting Global, funded by International Finance Corporation (IFC) in partnership with UK Aid

The Lighting Pakistan report also considers load shedding analysis by region, illustrated in Figure 2-3 below.

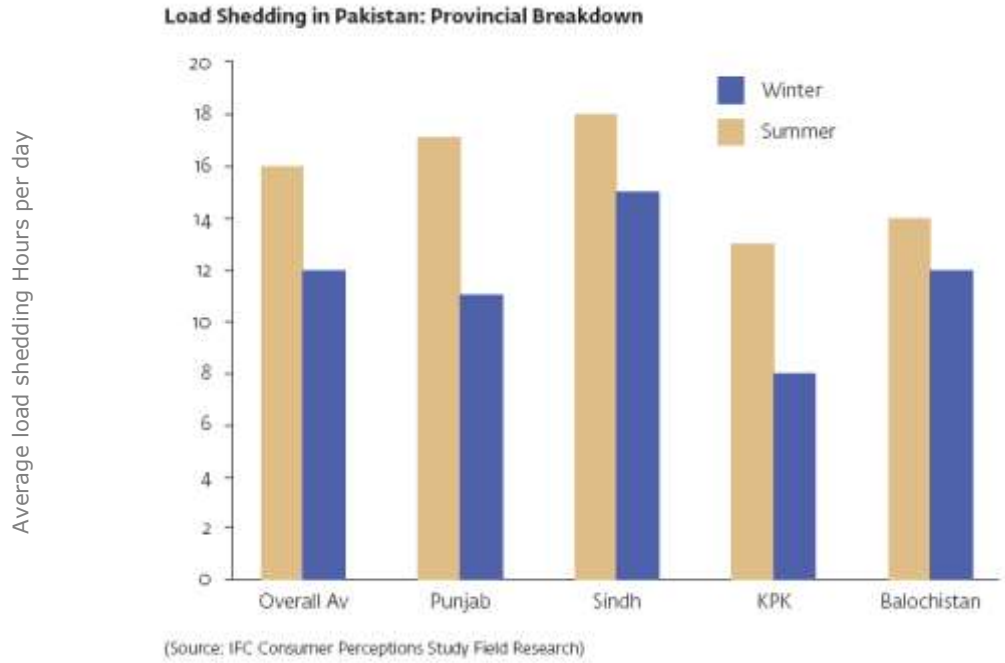


Figure 2-3: Load shedding analysis by region, IFC 2015 lighting report

Informal unmetered electricity supply is illegal but commonplace in the region. The local term for illegal wires connected to the electricity distribution system is "Kunda" which has gained large prevalence. Kunda supplies can be the subject of complex payment systems which, since they are unmetered, are subject to political manipulation and can see communities connected at a certain price; then price ratcheting until the connection becomes uneconomic. High prices charged for meters in some locations can dissuade customers from installing meters in areas where the grid is technically available.

2.4.1 Load shedding: no end in sight

According to the National Power Regulatory Authority (NEPRA) industry report 2014 and Alternative Energy Development Board (AEDB), Pakistan's electricity consumption is increasing at rate of 3 to 4 % per year. National electricity demand in 2014-15 was 26,454 MW and it is forecast to rise to 56,847 MW by 2024-25. The existing energy mix is as follows: Thermal power is 16,633 MW (66.46%), Nuclear is 787MW (3.2%), Wind and solar is 356MW (1.45%), Hydel Is 7,116 MW (28.90%). [6, 7]

By 2013, the deficit between grid connected demand and supply of electricity generation was already around 4,500– 5,500 MW[8]. This enormous shortfall has led to daily load shedding of 12-16 hours across the country, particularly during summer months. The supply-demand gap has continued to grow and now reaches 7,000 MW at times [9] .

This demand-supply gap constrains the reliability of power supply especially to rural areas where there is 12-20 hours per day of load shedding compared to 8-10 hours for urban areas.[9]

2.4.2 Evaluating Energy Access

The Sustainable Energy for All initiative (SE4ALL) is a multi-stakeholder partnership between governments, the private sector, and civil society. Launched by the UN Secretary-General in 2011, it aims to ensure universal access to modern energy services by 2030.

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[6] National Power Regulatory Authority [NEPRA] and the Hydro-carbon Development Institute of Pakistan [HDIP],
[7] Article by Faiz Mohammad Bhutta 11th Feb 2016,
http://www.altenergymag.com/article/2016/02/renewable-energy-readiness-of-pakistan/22821
[8] "National Power Policy 2013" - *Government of Pakistan*, 2013.
[9] Pakistan 2025, One nation – One Vision, published 2014

> *"Without access to modern energy, it is not possible to achieve the Millennium Development Goals, the eight-point global agenda adopted by the United Nations in 2000—whether reducing poverty, improving women's and children's health, or broadening the reach of education. Energy facilitates social and economic development, offering opportunity for improved lives and economic progress."*[10]
>
> *"September 2013: Recognizing that sustainable energy is central to eradicating poverty, increasing food production, providing clean water, improving public health, empowering women and addressing climate change, the Prime Ministers of Pakistan, H.E. Muhammad Nawaz Sharif, H.E. Jens Stoltenberg of Norway, and the Minister for Development Co-operation of Denmark, H.E Christian Friis Bach have agreed to push for a goal on sustainable energy for all as part of the post-2015 development agenda.*
>
> *Outlining the goals and targets that his government has established in promoting sustainable energy, Prime Minister Sharif noted that the Pakistan National framework was aimed at the (a) generation of cheap energy; (b) exploitation of immense renewable and sustainable energy potential and (c) a culture of energy conservation and responsibility.*
>
> *Underscoring the importance of the initiative in moving the world forward, the three leaders also agreed to continue their engagement with the Sustainable Energy for All initiative and the United Nations to ensure promotion and inclusion of a goal on sustainable energy for all through the inter-governmental process towards a post-2015 Development Agenda."*[11]

The measurement of Energy Access is a focus of SE4All and provides a means of measuring energy access globally:

> *Up until now, access to electricity has been measured as having a connection or by use of electric lighting, while access to modern cooking solutions has been measured based on the use of non-solid fuels. However, these binary metrics fail to capture the multifaceted nature of energy access, and may not reflect the impact that many interventions have on improving access.*
>
> *The multi-tier approach goes beyond the traditional binary measurement of access to a measurement approach that reflects all aspects of energy supply. Under this approach, energy access is determined by examining how a household's electricity and cooking technology measure up against the following eight attributes: capacity; duration and availability; reliability; quality; affordability; legality; convenience; and health and safety.*
>
> *All common types of energy sources (electricity, fuels, as well as fuel stacking) are included, and the measurement can be applied to all dimensions of energy use-household, productive, and community uses. It also enables the calculation of an index of access to energy, while allowing for disaggregated analysis, and highlighting gaps and opportunities for improvement.* [12]

2.4.3 Progress in Technology and Policy Support

The recent rapid developments in affordable long life LED lighting technology means it is now possible to provide electrical lighting far more efficiently than previous bulb technology could achieve. LED lights now readily available in Pakistan achieve a 60-80% energy saving compared to filament bulbs and a 40-50% saving compared to fluorescent bulbs.

This significant improvement in lighting technology means that costs for power generation and battery storage in respect of meeting lighting requirements are far lower than they were even 5 years ago, and therefore it can be expected that the uptake of lighting in off grid and marginalised areas will accelerate significantly.

In relation to policy, the Pakistan Government has exempted solar PV panels and associated inverter equipment from import tax which enables a reduced cost to be provided to end customers in Pakistan.

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[10] http://www.se4all.org/our-vision_our-objectives_universal-energy

[11] http://www.se4all.org/2013_10_31_pakistan-norway-denmark-push-international-targets-sustainable-energy

[12] ESMAP website https://www.esmap.org/node/55526

Forecasts by IOREC[13] at their 2012 conference on off-grid renewable energy indicates that mini grids will provide nearly half of the electrification required to deliver energy access for all in developing Asia by 2030:

FIGURE 1 ELECTRIFICATION APPROACH REQUIRED TO ACHIEVE UNIVERSAL ACCESS BY 2030 BY REGION (AS % OF GENERATION)
(BASED ON IEA, UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP), UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO), 2010)

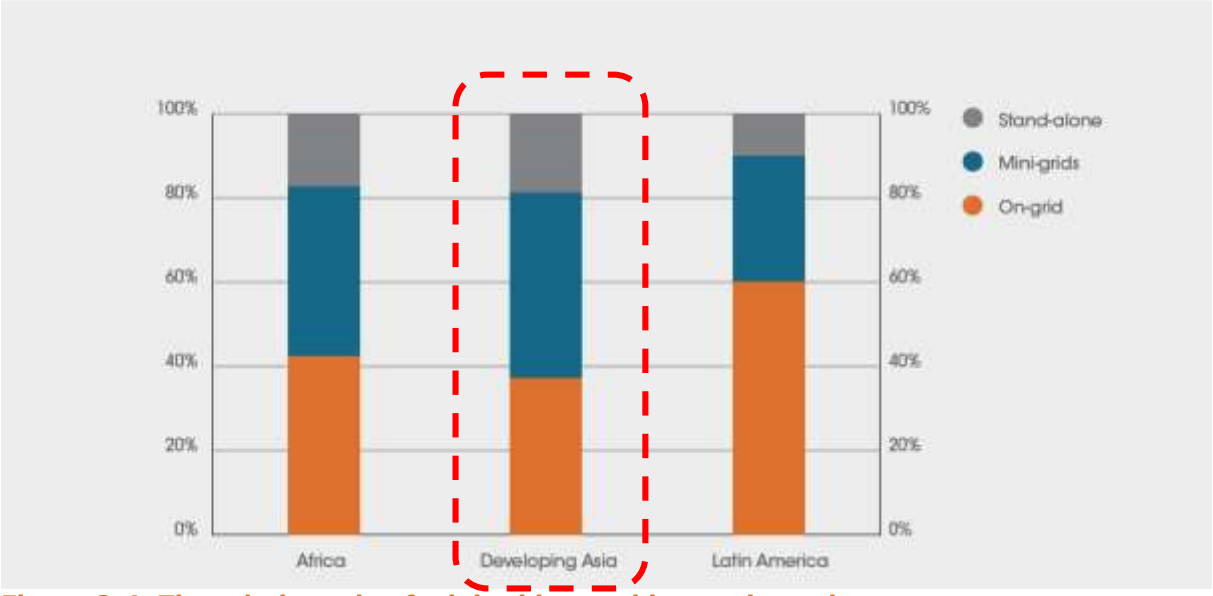


Figure 2-4: The relative role of mini grids to achieve universal energy access

2.5 The future of Micro Credit in Pakistan

The micro credit industry is strengthening in Pakistan and the availability of credit is extending to customer groups who are beyond the scope of traditional banks.

Commentators such as the former Governor of the State Bank of Pakistan, Syed Salim Raza predict an increasing availability of credit to lower income individuals and communities. In a vision for how Pakistan will be in 2025, in an article forwarded to IET, he writes:

> *"Credit is now much more accessible for smaller borrowers. Peer to peer lending, in the hands of financially experienced managers, has evolved rapidly. This was stimulated by capacity developed within the country's top Rating agencies that enabled them to issue ratings for small businesses – based on credit histories of company payment records, and on payment records for the individual owner/entrepreneur collected from credit cards, utilities, phone and other bills – all data that the Rating agencies track assiduously. Such records are also available for individuals, facilitating personal and consumer lending."*

A meeting to discuss micro credit was held on 19th March 2016 between Demian Natakhan (independent consultant), Shahid Khan (IET) and Mr Zubyr Soomro, Chairman of PPAF and CEO of Hikmah Consulting in Karachi.

Market estimates are 3.5 Million borrowers of micro finance out of the national population of ~200 Million. Market forecasts are for the number of borrowers to grow from 3.5M to ~10M by 2020.
There are a total of 51 micro finance institutions in Pakistan including 10 banks. These institutions are within 3 categories: micro finance , poverty alleviation and banks. Of the 51 institutions, 30 institutions are not banks. Competition in this sector is accelerating in Pakistan. Mausan is a micro finance association which has run for 10 years, and is considered among the best industry associations in country. It produces a quarterly magazine called Microwatch which gives breakdowns of which micro finance entities are lending in which areas etc.
Further commentary on micro credit is provided in section 5 below.

[13] Source: IOREC 2012 International Off-Grid Renewable Energy Conference KEY FINDINGS AND RECOMMENDATIONS

2.6 Research Project Region

In accordance with the Terms of Reference (TOR) set by PPAF, a broad catchment has been considered within Sindh's Thatta District.

Figure 2-5: Catchment area considered in the Sindh's Thatta District

The initial program involved selection of 20 villages in Thatta District based on the following criteria.

- Have a "cluster" of at least 50-100 households (HHs) with a positive inclination towards adoption of such interventions—ease of 'uptake' once the solutions are discussed and finalized.
- Have some earlier livelihoods, microfinance, and community infrastructure interventions—with potential for deepening and saturation.
- Not restricted to off-grid areas—can be on-grid and 'marginalized'.
- Potential of livelihoods and social enhancement by enhancement/provision of uninterrupted power evident.

The review of village options has been undertaken through verbal interviews, multiple survey visits and community meetings.

Table 2-1: Villages included in Research

Project ID	Village Name	House Holds	Union Council
1	Hamzo Samo	64	GHARO
2	Ishaque Jokhio	79	GHARO
3	Bachu Kolhi	53	Dhabeji
4	Jaffar Jokhio	80	Dhabeji
5	Ahmadabad Thaeem	125	GHARO
6	Sultanabad Thaeem	96	GHARO
7	Arif Palijo	152	GHARO
8	Abdullah Mirbhar	182	GHARO

Project ID	Village Name	House Holds	Union Council
9	Essar Jamadar	54	GHARO
10	Yousuf Khaskheli	79	GHARO
11	Ezza Mohammad Jokhio	158	GHARO
12	Ghulam Mohd jokhio	41	GHARO
13	Haji Karmi jokhio	53	GHARO
14	Ismail Arti Jokhio	70	Dhabeji
15	Haji Dadu jokhio	63	Dhabeji
16	Abu Bakar Jokhio	51	GHARO
17	Ayub khaskheli	51	Dhabeji
18	Nabi bux jokhio	83	GHARO
19	Noor Mohd Thaeem	222	GHARO
20	Soomar Shoro	48	Dhabeji

A map showing the village locations is provided below:

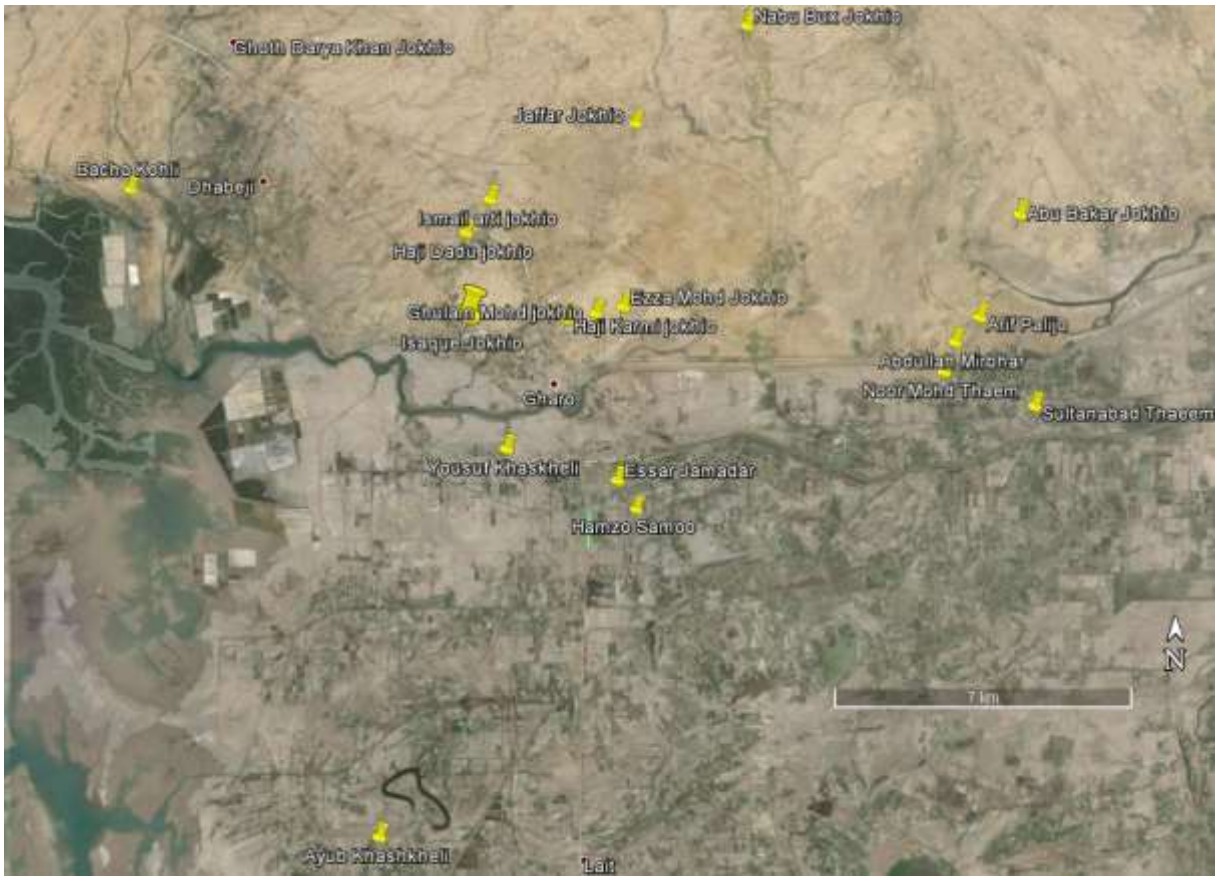


Figure 2-6: Location of 20 villages included in assessment

Micro Energy International (MEI) in 2014 completed a large review on Microfinancing solar home systems (SHS) in Pakistan [7].

While this focussed on individual household systems rather than minigrids, pertinent research from this report relating to Sindh district Thatta includes:

- **Perception of Impact of Energy access on income:**

  - Men……70%
  - Women…..60%
- **Thatta. 81% aware of what a Solar House System (SHS) is.**
  - I5% owned one themselves.
- **Willing to purchase SHS:**
  - 12.1% men.
  - 7.2% women.
  - overall nearly 50% less than Punjab
- **Reasons for unwilling to purchase a SHS.**
  - 40% Women……too expensive.
  - 15% men……too expensive.
- **Respondents willing to take a microloan finance for SHS.**
  - 50% Overall said yes.
  - 34% overall said no.

Soon Valley Development Programme is running a micro finance programme for the purchase of SHS and communities are fully sensitized to the system.

MEI notes that at FGDs the communities requested:

- high quality products, warranties for 100% replacements in warranty period.
- Continuous end user training
- Batteries fully charged every week.
- Regular maintenance.
- Training and Maintenance Manuals.
- Hot line connections with POs (engineers).
- CO should be able to contact PPAF if PO not doing their job.

This indicates a reasonable level of awareness among rural communities of solar home lighting products in the Thatta region. In some villages solar-battery lighting products are in use at individual household levels. In many villages however, solar PV has not yet been adopted as an energy source.

3. Baseline

In regards to identifying villages as a sample for participation in the program, IET has visited over 20 villages.

The villages were selected to be representative of a range of common scenarios where an energy gap exists including variations on the following factors:

- **Grid availability scenarios**:
  - existence of functional grid,
  - abandoned or disconnected grid,
  - Kunda unmetered systems and metered systems
  - Grid never been installed
  - Large and small distances to grid
- **Energy resource availability**:
  - Solar resource availability is high at all villages
  - Biomass dung resource available at some villages
  - Wind resource available at some villages
- **Ownership of land**
  - Most long-established villages own their land however in one case a newer village does not own its land

The process is to undertake initial assessment, interviews, and questionnaires and then evaluate the responsiveness of the community organisation (CO) to demonstrate their appetite and aptitude for livelihood enhancement through community energy infrastructure. The villages which score well in these assessments are then selected for implementation of physical infrastructure in the form of a mini grid providing power to dwellings and businesses.

3.1 Energy Requirements

Village energy considerations include:

- type of energy currently used:
  - wood, kerosene, coal, electricity usage
  - where grid power exists and is functional, the current expenditure on metered electricity and Kunda electricity is considered, as well as connection charges for meters
  - where grid power is not available, the current expenditure on electricity alternatives, which would be switched to electricity if a grid or minigrid becomes available
  - Purposes for which energy is used: cooking, lighting, cooling, refrigeration, enterprises

- requirement for energy under a future livelihood enhancement and lighting scenario:
  - energy requirement for lighting through LEDs in each enterprise and house
  - mobile phone charging in each household
  - enterprise electricity usage for pumps, refrigeration, fans, irons, and other appliances

3.2 Livelihood Considerations

Village livelihood considerations include:

- livelihood creation opportunities arising from new power supply
- scale of electricity requirement to run the desired enterprise

3.3 Questionnaire process

A questionnaire for each house hold was prepared and social mobiliser staff from IET sat with each householder in 20 villages to gain information and learn the village requirements.

Figure 3-1: Completed questionnaires returned from field visits

Over 1,500 questionnaires were completed by the social mobiliser team at IET.
These were then manually entered into 20 spreadsheets, one for each village, which summarised the data into pie charts for each village.

3.4 Electricity Access summary

From the investigation of 20 villages, an overview of existing electricity access was obtained. This is summarised in Figure 3-2 below:

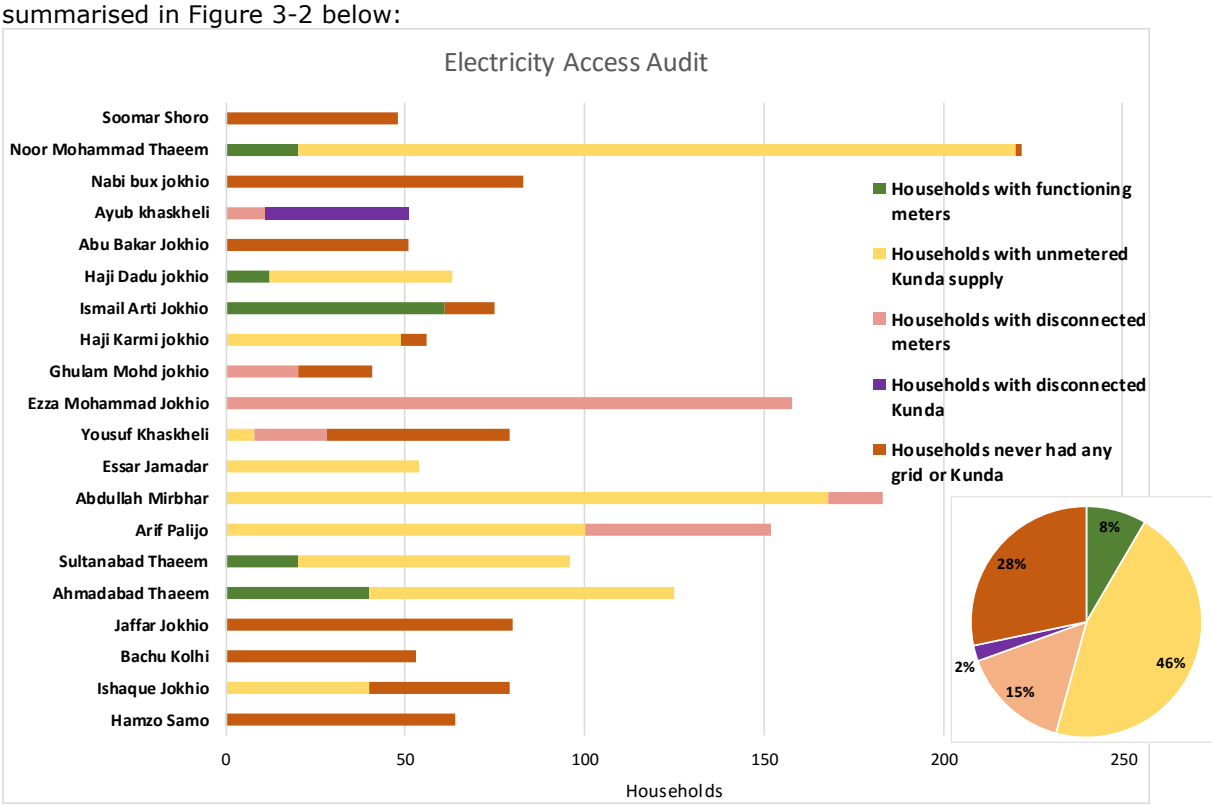


Figure 3-2: Electricity access baseline results

From the surveyed villages, 45% have no access to any electricity due to either: no grid lines near the village, or previously utilised unmetered supply having been cut off, or installed grid and meters never having been switched on (Nabu bux Jokhio).

The remaining 55% have intermitted access to electricity through either metered supply or unmetered 'Kunda' supply suffering from load shedding as high as 20 hours per day.

3.5 Village Assessments

This section summarises the visits and assessments of 20 villages.

The CEO of Indus Earth visited 20 villages, some were visited on multiple occasions. During the meetings specifically organised to respond to this energy program, a description of mini grids was provided as follows:

"The entire Mini Grid concept was explained in detail. All CBO members and VO were present. A capital cost estimate of the system at Rs.50 lakhs was discussed in order to provide awareness. The community was advised they will have to deposit at least 5% of Mini Grid total. A credit system can be organized to pay back over 5 years. Over and above each HH will have to pay an agreed tariff and each enterprise, which is the main purpose of this electric provision, will have a meter installed. Charges will be according to units used.

"Great emphasis is being given in explaining to each community, the essence of this programme. That it is not just a light in each person's house. It is a "commodity" that is there to help change their life styles. It is a once in a life time opportunity. It will be up to each community to take absolute ownership and look after this "commodity" for their and their children's life times.
Many hours have been spent explaining this by all social mobilisers, senior management, including the CEO, to both the men and women. That each community is going to contribute in kind or cash and also have to pay for the supplied energy, helps to take ownership and therefore a level of sustainability.
Many have asked what will be the situation if we want to increase the electric energy. We have told them that first they must make what is there, work. When they (the respective communities) have understood the value of this "commodity" then they are in charge to increase at their convenience, costs being borne by them alone. IET can give technical advice whenever needed."

Shahid Khan, CEO of Indus Earth Trust.

Energy audit results and povery scorecard data for each village is provided in Appendix A below.

3.5.1 Hamzo Samo

Table 3-1: Hamzo Samo village assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Hamzo Samo	Thatta	Gharo
Latitude:	**Longitude:**	**Tehsil:**
24°42'41.00"N	67°36'9.27"E	Mirpur Sakro
Total No. Households:	**Total No. Buildings**	
64	91	
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
On 3rd Feb 2016 a community meeting was held.	CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	LSO: Gharo. Kursheeda Begum. COs: 4 male and 2 female.
Existing livelihood activities in village:		
Existing income by men is laboring on farms. Women make "chatais" and excellent quality relis. Electricity will help improve output.		
Existing grid power supply provision in village:		
No grid power supply is available to this village. The nearest power line is approximately 1km away.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
• Hamzo Sumo has a regular supply of fresh water from a nearby canal. Electric supply will allow water to be pumped to crab pond. This pond is already in		

existence but has remained unused as a regular supply of water was not possible before.

- Kitchen gardens will be implemented by almost all households.
- List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply:
- List from the Men:
  - 2 Nos Cold drink shop. 2 employees.
  - 3 No tailoring shop. 3 employees.
  - Making Chattais. 10 employees.
  - Crab farming. 2 employees.
- List from the Women:
  - Making Karas, Relis, pillows. 8 women.
  - Tailoring . 6 women.
  - Chattais being made by women. 8 women.

Assessment Notes:

- Initial assessment of likelihood of successful uptake
  - The enthusiasm and proactive response of this community points to high likelihood of successful uptake.
- Existing energy use estimate from audit
  - See audit pie charts below.
- Forecast energy demand estimate
  - consumption ~26.5 kWh/day, peak demand ~3.1kW
- Recommended energy solutions
  - Solar PV and battery system is suitable for this site, with metering for clusters of households and businesses.
- Recommended energy policy approach:
  - A minigrid with shared ownership
  - Large distances between some clusters of households requires separate systems to avoid excessive cable lengths and costs

Map of village

Existing grid line (in green on left) relative to Hamzo Samo village

Photos

Tour of village Hamzo Samo, Feb 2016

Community meeting at Hamzo Samo, Feb 2016

3.5.2 Ishaque Jokhio

Table 3-2: Ishaque Jokhio village assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Ishaque Jokhio	Thatta	Gharo
Latitude:	**Longitude:**	**Tehsil:**
24°45'1.95"N	67°33'45.00"E	Mirpur Sakro
Total No. Households:	**Total No. Buildings**	
78	116	
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
On 21st Jan 2016 a community meeting was held	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	LSO: Gharo. Kursheeda Begum. Attended by twenty Community members. Including CO 1., 2 and 3. President, Secretary and Treasurer. COs: 3 male and 2 female.
Existing livelihood activities in village:		
25 men work in Government jobs. Others do mostly laboring whenever it arises in adjoining towns.		
Existing grid power supply provision in village:		
A 'kunda' grid supply to approx. 40 houses exists. The village has built a line connecting the whole village to the main grid, though this line is an unmetered 'Kunda' system.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply: • List from the Men: ○ 2 No tailoring shops. ○ 4 No shops (confectionery, vegetable, fish/meat). ○ 2 No hotels selling snacks and tea. ○ Cultivate 10 acres to grow saleable produce. (Water pump established in two locations from electricity). • List from the Women: ○ Kitchen gardens with practically every HH. (water supply to provide water in storage tanks). ○ Relli making, sewing and embroidery. Make these at home at night. IET's CEO Shahid Khan enquired how the CLF programme was going. In 5 months there has been a profit earned of Rs.400,000. He then stated that if a similar financial system was to be implemented would the community pay approximately Rs.4 million for the Mini Grid system as explained. It was a unanimous positive reply.		
Assessment Notes: • Initial assessment of likelihood of successful uptake ○ The enthusiasm and proactive response of this community points to high likelihood of successful uptake. • Existing energy use estimate from audit (see Appendix A) • Forecast energy demand estimate ○ consumption ~50.5 kWh/day, peak demand of ~5.7kW • Recommended energy solutions ○ Solar PV and battery system likely to be suited to this site, with metering for clusters of households and businesses • Recommended energy policy approach: ○ A minigrid with shared ownership		

Map of village

Ishaque Jokhio with existing unmetered Kunda electricity line location in yellow

Photos

Community meeting of Ishaque Jokhio villagers at IET training centre, Feb 2016

3.5.3 Bacho Kolhi

Table 3-3: Bacho Kolhi Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Bacho Kohli	Thatta	Mirpur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24°46'45.42"N	67°29'5.52"E	Dhabeji
Total No. Households:	**Total No. Rooms**	**Total population:**
53	58	251 (2012)
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
3rd Feb 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	COs: 1 female and 2 male. LSO Dhabeji. Saleh Mohd Jokio.
Existing livelihood activities in village:		
Existing income is mostly from crab collection from Mangroves near the village. These crabs are sold to 3rd parties. It was proposed that the community clean the crabs and pack them so they get a better price higher up the supply chain. Electricity supply will allow existing clean water supply (from mains) to be pumped to existing water tanks. Some laboring is also done in nearby farms. Women make high quality Relis. Power supply will enable them to increase output.		
Existing grid power supply provision in village:		
No grid power supply is available to this village		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply: • List from the Men: ○ Crab farming. The use of electricity to pump water for washing and processing crabs was specifically identified by the villagers interviewed. ○ Hotel. 2 persons. ○ 5 shops. Confectionary and vegetables. 5 persons. ○ Men to learn sewing, using existing machines. • List from the Women: ○ 20 women to concentrate on Reli (embroidered bed cover/duvet) making. ○ 53 women to concentrate on sewing making clothes. • Kitchen gardens to be implemented by all HHs.		
Assessment Notes: • Initial assessment of likelihood of successful uptake ○ The enthusiasm and proactive response of this community points to high likelihood of successful uptake. • Existing energy use estimate from audit (see Appendix A) • Forecast energy demand estimate ○ consumption ~33 kWh/day, Peak demand ~3.7kW • Recommended energy solutions ○ Solar PV with battery system with metering for clusters of households and businesses ○ Strong local wind resource could mean wind turbine viable however the solar PV favoured due to lower maintenance costs and complexity • Recommended energy policy approach: ○ A minigrid with community ownership		

Map of village

Photos

Community meeting at Bacho Kohli, 3rd Feb 2016

Batcho Kohli community meeting 3rd Feb 2016

3.5.4 Jaffar Jokhio

Table 3-4: Jaffar Jokhio Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Jaffar Jokhio	Thatta	Mirpur Sakro
Latitude	**Longitude**	**Tehsil:**
24°47'34.57"N	67°36'10.00"E	Dhabeji
Total No. Households:	**Total No. Rooms**	**Total population:**
80	108	381
Total No. LED lights 9W	**Total no LED lights kitchen 4W**	**No of mobile phone charge sockets**
195	62	62
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
3rd Feb 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	Attended by 40 members of the community. 25 women and 15 men (some men were at work in the town). LSO: Dhabeji. Saleh Mohd Jokio. VO: President and General Secretary. Cos: 4 male and 4 female.
Existing livelihood activities in village:		
Existing income by men is mostly in Gharo Town. Labouring in the fertilizer factory and Water Pump in Dhabeji. There are a few with full time jobs with Government Institutions. Women make Relis and stich clothes.		
Existing grid power supply provision in village:		
No existing grid power supply is available to this village. The nearest grid line is estimated to be 3.8km distant to the south-west.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply: • List from the Men: ○ Hotel. Run by 3 persons. ○ Dhobi. Run by 2 persons. ○ Vegetable shop. No1. ○ Vegetable shop No2. ○ Cultivate 10 acres of ground. 2 persons. • List from the Women: ○ Green house gardening. Extra water. From electric power to pump. ○ Kitchen gardening. Extra water from electric power to pump. There is a ¾ inch water supply from the mains that comes to this village at night for about 10-12 hours which is potable. The electric supply will allow this water to be pumped into existing storage tanks for use by the village. This community also reiterated that if they had been approached to fund their own Mini Grid at a cost of Rs.4M they would do so. It should be noted that Jaffer Johkio has received CLF funding.		

Assessment Notes:

- Initial assessment of likelihood of successful uptake
  - Pro-active community with livelihood enhancement agenda
- Existing energy use estimate from audit – see Appendix A
- Forecast energy demand estimate
  - consumption ~36 kWh/ day , peak demand ~3.6kW
- Recommended energy solutions
  - Solar PV and battery system with metering for clusters of households and businesses
- Recommended energy policy approach:
  - Creation of a minigrid with community ownership

Map of village

Photos

Community meeting at Jaffar Jokhio 3rd Feb 2016

3.5.5 Ahmadabad Thaeem

Table 3-5: Ahmadabad Thaeem Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Ahmadabad Thaeem	Thatta	Gharo
Latitude:	**Longitude:**	**Tehsil:**
24° 44' 02.943" N	67° 53' 29.523" E	Mirpur Sakro
Total No. Households:	**Male, female population:**	**Total population:**
125	308 male, 343 female	651
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
23rd March 2016 Also previous visits by IET	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	3 were present
Existing livelihood activities in village:		
This village is 70 years old. It has roads, concrete houses, Schools. This is a very prosperous village. There are 25 trucks owned by 25 men, earning Rs 2,000 / day. There are 8 people with government jobs. There are 15 people who own 5-10 acres of land, earning an average of Rs 10,000/month. Livestock of cows, buffalos and goats are owned. There is 1 teacher who earns Rs 25,000 / month from high school		
Existing power supply provision in village:		
Main grid supply was installed in 1983. Approximately 40 households have meters, costing Rs 2,000/month. The rest work on Kunda, paying between Rs 500 – 1,000 / month. Load shedding is 8-10 hours/day.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
• Existing livelihoods are seen to be satisfactory by the representatives met.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ Existing prosperity is high especially truck industry.
  ○ The level of existing power access is satisfactory and there is little interest in investing in an alternative system
• Existing energy use estimate from audit – see Appendix A
• Recommended energy solutions
  ○ Household level solar PV battery installations are recomended to provide increased reliability of supply compared to load shedding
• Recommended energy policy approach:
  ○ Energy gap is smaller than many other villages
  ○ Interest in an alternative supply is low
  ○ A greater number of legal meters should be offered
  ○ Social mobilisation should be undertaken to encourage villagers to take on legal metered systems. If this becomes adopted, then opportunities to enhance businesses will open up.		

Map of village

Village map showing existing main grid lines in green. Kunda lines not mapped.

Photos

Ahmedabad Thaem showing existing grid lines in background

3.5.6 Sultanabad Thaeem

Table 3-6: Sultanabad Thaeem Village Assessment

Village/Community Organisation Name, age	**District:**	**Union Council:**
Sultanabad Thaeem 60 year old village.	Thatta	Mir PurSakro
Latitude:	**Longitude:**	**Tehsil:**
24 43 57.33	67 41 43.641	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
96	271 male, 225 female (2012)	496 (2012)
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	

Existing livelihood activities in village:

Income streams for men include: Owning 200 cows and 20 buffalos. Milk is sold at Rs 40/kg and sell 3 kg/day/animal, keeping 1 kg for home usage. Residents also sell butter at Rs 600/kg.
20 Men also own 1-5 acres of land. Men earn about Rs 18,000/month from farm seasonal labouring. 4-5 people are government employees, earning Rs 15,000/month.
Enterprises: There is 1 tyre shop, 1 general store, 2 tailoring shops, 4 hotels, 1 ironing shop, 1 other general store.
Women help making milk and butter and labouring on the agricultural land.

Existing power supply provision in village:

Grid power supply is available to this village since 1983, installed by WAPDA.
20 people have meters and the rest have Kunda.
Load shedding is for average of 14 hours day and night, meaning supply is approx. 10 hour/day.

Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.

Types of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply:

- The villagers are commercially aware and if they desired can already create livelihoods.
- With a more reliable power supply, they could further enhance their livelihoods.

Assessment Notes:

- Initial assessment of likelihood of successful uptake
  - This is a prosperous village. It has less need for energy access enhancement than some other villages.
  - The existing standard of living is satisfactory.
- Existing energy use estimate from audit (see Appendix A)
  - Most houses have TV, fridges, lights and fans.
  - Kunda users pay Rs 500 -1000/month
  - Metered users pay Rs 3,000 – 5,000/month.
- Recommended energy solutions
  - No desire or need for a mini grid.
  - Solar-battery home systems may be affordable to increase continuity of supply
- Recommended energy policy approach:
  - The existing grid system needs to be made legally available to the rest of the inhabitants, replacing the Kunda system.

Map of village

Sultanabad Thaeem showing existing main grid line approx. location in green. Kunda lines not mapped.

Photos

Sultanabad Thaeem showing existing grid lines

3.5.7 Arif Palijo

Table 3-7: Arif Palijo Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Arif Palijo	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil**
24 45 5.202	67 40 57.703	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
152	361 male, 364 female	725
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
15th March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	
Village organisation (VO) structure		
This is a 200 year old village. The VO here is for 4 villages: Arif Palijo, Adam Palijo, Abdulla Mir Bahar, Ali Bux Shadi Iai. The VO is called Mala Palijo.		
Existing livelihood activities in village:		
About 50% of the male workforce are labourers in fishing sector. They go as far as Hawkesbay and Somniani in Balochistan during the fishing season. Men can earn up to Rs.50,000/week in the jelly fish season. Ordinarily fishing provides between Rs. 5,000-7,000 per month. 2% of the workforce are labouring in the field. Government employees are about 5% of the workforce. IET provided in 2012 via asset transfer programme of livelihoods; livestock, a confectionary shop, several donkey carts.		
Existing power supply provision in village:		
There is main grid supply here but WAPDA has cut their supply in January 2016 as bills being sent amount to Rs. 900,000 which, according to the meters, do not tally with usage. Villagers dispute the validity of these bills and are unable to pay. Many visits by the villagers to the WAPDA office in Hyderabad have been to no avail.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ The Mini Grid system and Micro Credit was explained. Not everyone was convinced that a Mini Grid is affordable by the community. They wanted a few days to discuss amongst themselves.
• Existing energy use estimate from audit (see Appendix A)
  ○ Lighting: Community spend Rs.30/day on candles i.e. Rs. 900-1,000/ month.
  ○ They also spend Rs. 1,200 per kerosene lantern/month.
• Recommended energy solutions
  ○ This community would benefit from energy access enhancement however trust in offered energy solutions is low and must be first established before any intervention
• Recommended energy policy approach:
  ○ Re-visit the village in 1 year to determine grid supply outcomes and attitudes
  ○ Possible replacement of whole metered system in with a solar PV battery minigrid to provide enhanced reliability and continuity of supply		

Map of village

Arif Palijo with existing grid line (approx. location) shown in green.

Photos

Arif Palijo site visit

3.5.8 Abdullah Mirbhar

Table 3-8: Abdullah Mirbhar Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Abdullah Mirbhar	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24 44 46.303	67 40 37.102	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
182	415 male, 410 Female	825
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
15th March 2016	IET: CEO. Shahid Khan,	
Existing livelihood activities in village:		
This is a 200 year old village. Labouring is a key income source: Rs.500 average daily wage from fishing in boats. Agriculture: Labouring at Rs.300/day. These are erratic sources of income.		
Existing power supply provision in village:		
WAPDA supplied electricity to the village 25 years ago. Previous metered usage was about Rs.300-500 per month. Most community members were receiving bills of Rs.10,000 per month. Electricity was cut 3 months ago due to payment issues. No grid power supply is now available to this village. WAPDA has removed the meters.		
Assessment Notes: • Initial assessment of likelihood of successful uptake ○ From the discussion on 15th March, this community is hesitant about Mini Grid. They don't trust energy interventions in light of their recent experience with removal of meters. ○ IET's view is that a Mini Grid at this community would be risky in terms of uptake and engagement at this stage. • Existing energy use estimate from audit – see Appendix A • Recommended energy solutions ○ Solar PV battery minigrid • Recommended energy policy approach: ○ Continue discussions with community, show case study examples of successful minigrids in other villages when available. Once trust increases, engage in further project development and social engagement. ○ A full minigrid system could provide lighting and livelihood power to the whole village, with greater reliability than the previous metered system.		

Map of village

Photos

3.5.9 Essar Jamadar

Table 3-9: Essar Jamadar Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Essar Jamadar	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24°48'7.13"N	67°58'58.06"E	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
54	154, 160	314[14]
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
23 March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	Attending 30 persons including 20 women. Men in field.
Existing livelihood activities in village:		
Income. 150 men work as labourers. Earn Rs.6000/mnth/person. 40 women work in the fields. Earn Rs. 1500/mnth/person. 1 confectionary shop. Milk production from cows for community is 80 kilos/per. Keep 20 kilos per day for themselves. Sell 60 Kilos at Rs. 40/kilo. Assets. 18 cows. 80 buffaloes.		
Existing power supply provision in village:		
Main Grid, built 1998, runs past their village. Kunda has been supplied to all HHs in the village, each pay Rs.250/month. They get 4 hrs supply per 24 hrs.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
Unlike all the other villages, the community do not own their land, even though they have attempted many times to approach the landlord about land ownership. Livelihood enhancement through light and gas will be embroidery and sewing businesses for women. The presence of solar fridges could enhance shop businesses and milk product manufacture and vending such as cheese, yogurt and butter. Butter is sold at Rs 600/kg. Another NGO called NRSP is working at this village which has provided 4 latrines, and a catholic mission which has built a school. A major problem caused by not having light is that snakes come into their houses and have bitten several children (not fatally). The women excel in embroidery, basket weaving and sewing. Enterprise development here by providing an alternative biogas energy source will allow them to use cleaner fuel for cooking and improve their health, reduce timber destruction in the forests.		
Assessment Notes: • Initial assessment of likelihood of successful uptake ○ Low likelihood for minigrid uptake, but portable equipment uptake such as solar lanterns extremely high likelihood of uptake. ○ High potential uptake for a community biogas system		

[14] Population has increased after IETs interventions from 2012 including a bridge, road, community centre and a shop. Others within their Hindu community who lived elsewhere, were able to see how the lives were improving for this community.

- Existing energy use estimate from audit: see Appendix A
- Recommended energy solutions
  - Community willing to pay up Rs.1000/lantern to purchase solar lanterns with USB mobile phone charger.
  - Biogas digester and gas provision for cooking
- Recommended energy policy approach:
  - The village is very compact due to 80 buffalos taking up a lot of space
  - Investment in a mini grid is questionable due to non-ownership of the land meaning risk to the community and any potential lender of landlord repossession.
  - Solar lanterns should be adopted throughout
  - Solar fridges should be adopted in several locations. Solar fridge estimated cost 25,000 per fridge.
  - A possible biogas system could be adopted however non-ownership of land a barrier to long term investment, so would need to deliver a payback of <2-3 years

Map of village

Map of village showing existing grid line to south (green)

Photos

Community meeting at Essar Jamadar, 23 March 2016

3.5.10 Yousuf Khaskheli

Table 3-10: Yousuf Khaskheli Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Yousuf Khaskheli Established 1960.	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24°43'28.20"N	67°43'17.50"E	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
79	199 male, 213 female (2012)	412 (2012), 475 (2016)
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
23rd March 2016	IET: CEO. Shahid Khan, Social mobiliser Mohammad Akhtar , Social mobilisers Gul Khtoon	Attending 15 men from village. CBO head present.
Existing livelihood activities in village:		
Vocational income: Labouring : 8-10 persons in town. Agriculture : 30 persons. Milking : 15 persons. ~100 persons earn Rs.6000-8000. Assets: 29 cows. 2 rickshaws and 1 confectionary shop and 1 shop in Gharo selling cold drinks etc. Women look after the 29 cows. Milk costs Rs.40/kilo to sell. Sell 2 kilos/day and keep 2 kilos for themselves. Some women make butter of which they sell 1-2 kilos per day for Rs. 600/kilo. 16 women are under training at the community centre for embroidery and stitching. IET has completed training for enterprise development here for 37 persons. (70% were women). This consisted of Milk enterprise and livestock health.		
Existing power supply provision in village:		
Main Grid supply runs past the village. The village received WAPDA connection in 1994 to 20 HHs. Cost of electricity was free for 1 year. Unregistered meters paying Rs. 200-300 to collectors. After this officials increased cost to Rs.2000/ month. The community could not afford to pay this increased tariff and the supply was subsequently cut off. Adjacent grid now has Kunda's attached to 8 HHs. These pay Rs.500-1000 per month to WAPDA collectors.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply: • List from the Men: ○ Training for carpentry and plumbing can be increased ○ Additional 2 or more shops can be created ○ A restaurant could be opened ○ A dairy enterprise could be established • List from the Women: ○ Vocational training centre for women can be increased		
Assessment Notes: • Initial assessment of likelihood of successful uptake ○ Meeting was held at night with entire community and all the above was discussed in detail. ○ The entire community have agreed that having a Mini Grid system is desirable and agreed to develop a payment system, where financial details will be discussed at a later stage.		

- Existing energy use estimate from audit – see Appendix A
- Recommended energy solutions
  - Possible biogas digester using cow dung and other digestable wastes
  - Solar PV battery
- Recommended energy policy approach:
  - Hold FDGs and develop a minigrid plan with community
  - Establish a minigrid with community ownership

Map of village

Yousuf Khaskheli village with defunct power lines shown in green

Photos

Community meeting at Yousuf Khaskheli 23rd March 2016


Solar battery system used at a shop in Yousuf Khaskheli

Existing power poles which were installed and have since had power lines removed and are not functioning

3.5.11 Ezza Mohammad Jokhio

The following 3 villages are located adjacent to each other:

- Ezza Mohammad Jokhio
- Ghulam Mohd jokhio
- Haji Karmi jokhio

Details on each village are provided separately below, and the outcomes from a community meeting attended by all 3 villages on 15 March 2016 are then presented. An additional meeting was held at Ezza Mohammad Jokhio on 23rd March which is also detailed below.

Table 3-11: Ezza Mohammad Jokhio Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Ezza Mohammad Jokhio This village was registered with the government in 1985. It covers 60 acres of land.	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24°45'14.20"N	67°35'58.55"E	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
158	369 male, 363 female	732
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
16th March 2016 and again on 23rd March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	16/3/16: Joint meeting with 2 other adjacent villages 23/3/16: 4 were present including president, secretary and treasurer who intend to approach community.
Existing livelihood activities in village:		
Male income: 900 men work, 20 in poultry farms (earning Rs 8,000/month), stone labourers working on roads. Own 6 shops in the village. There are 25 employees who work in the government. There are also 20 men working in tea factory earning Rs 9,000/month. Women are involved in sewing but there is no income from this. IET has completed an extensive training course here including skills training for both men and women. There is a TCF school in the village.		
Existing power supply provision in village:		
WAPDA grid power supply was installed to this village in 2012. 105 electricity meters were installed 1 year ago but there is no power available through the line because the supply has never been connected. Their Member of the National Assembly (MNA) whose political party is PLMN has requested KElectric to make the connection. However KElectric has not agreed to connect the village. KElectric has stated that since WAPDA installed it, it should be WAPDA to activate the supply. The WAPDA head office is in Hyderabad and community members have been to the WAPDA office several times. There is piped natural gas available to each household for cooking, which is a metered supply.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ The community members met are very agreeable to having a mini grid installed.
• Existing energy use estimate from audit: see Appendix A
• Recommended energy solutions
  ○ Solar PV battery system with possible diesel generator to reduce battery costs		

- Recommended energy policy approach:
  - Follow standard approach recommended in this report

Map of village

Photos

Community meeting at Ezza Mohammad Jokhio

Existing grid line at Ezza Mohammad Jokhio, disconnected Kunda

3.5.12 Ghulam Mohd Jokhio

Table 3-12: Ghulam Mohd Jokhio Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Ghulam Mohd Jokhio	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24°45'9.10"N	67°35'35.81"E	Gharo
Total No. Households:	Male, female population:	Total population:
41	95 male, 97 female	192
Date(s) visited by PO:	PO staff present at visit	No of CO members present
16th March 2016	IET: CEO. Shahid Khan	Joint meeting with 2 other adjacent villages
Existing power supply provision in village:		
WAPDA supplied main grid to all 3 villages in 2008. There are 7 PMTs and 120 meters between the 3 villages. KESC (K Electric) refuses to supply power as they say they did not provide grid. PLMN provided grid. Local Member of the National Assembly has filed the issue - she has spoken to K Electric and is awaiting an outcome. The village has a functioning gas and water supply.		
Map of village 		
Photos  Community meeting at Ghulam Mohd Jokhio		

3.5.13 Haji Karmi Jokhio

Table 3-13: Haji Karmi Jokhio Village Assessment

Village/Community Organisation Name:	District:	Union Council:
Haji Karmi Jokhio	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
24°45'5.11"N	67°35'10.81"E	Gharo
Total No. Households:	Male, female population:	Total population:
56	148 male, 143 female	291
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
16th March 2016	IET: CEO. Shahid Khan	Joint meeting with 2 other adjacent villages
Existing power supply provision in village:		
WAPDA supplied main grid to all 3 villages in 2008. But as noted above the metered system has not been operational. Unmetered Kunda supplies to 49 household were confirmed during the questionnaire with 7 households having no power supply at all. Village has a functioning gas and water supply.		
Map of village 		
Photos 		

Table 3-14: Meeting outcomes from 3 villages

Date(s) visited by PO:	PO staff present at visit	No of CO members present
16th March 2016	IET: CEO. Shahid Khan	Joint meeting with 3 villages. The meeting was held with all three CBO reps present.
Existing livelihood activities in village:		
• Ezza Mohammad Jokhio • Ghulam Mohd jokhio • Haji Karmi jokhio Men: 90% involved in laboring in Gharo, Karachi, Thatta. Earnings between Rs.10,000-15,000/month. Women: 5% work. Embroidery, sewing, tailoring, mostly make Chatai's. Earn approx. Rs. 2,000 to 3,000 / month.		
Existing power supply situation in village		
There are 7 PMTs and 120 meters between the 3 villages. KESC (K Electric) refuses to supply power as they say they did not provide grid. PLMN provided grid. Local MNA has file - she has spoken to K Electric and is awaiting an outcome.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
Many would start their own businesses such as tailoring, shops with fridges and or freezers, hotels, and a machine that wraps up "Papar". Apparently one individual has this machine but has no power to run it. All 3 CBOs stressed that they would like vocational training for both men and women. (welding, carpentry, computer skills and access for women's training in becoming better skilled in embroidery and stitching).		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ No one is concerned if and when the main grid comes back. It will continue to be unreliable providing mostly 6-8 hours electricity. Plus the political situation is such between WAPDA and K Electric that any resolution seems far away. Villagers are aware of K Electrics erratic billing system, where the consumption is nowhere near the bills claim.
  ○ This leads to a high degree of interest in an alternative power supply to the village
 	
• Existing energy use estimate from audit
  ○ It should be noted that at the moment all 3 villages rely on kerosene lanterns. Costs vary between Rs.8000 to Rs.12,000 per month.
  ○ There is a TCF school here with 300 children. They provide their own power generation.
 	
• Recommended energy solutions
  ○ Solar PV battery hybrid
• Recommended energy policy approach:
  ○ There is much potential in these 3 communities. The CBOs are very keen to have provision of electricity as they cannot get any further in the standard of living for themselves and their families. These 3 communities would be a good place to provide Mini Grids. However much work will need to be completed by Social Mobilisers before any grid system is applied.
  ○ All 3 CBOs have expressed great interest in this programme and are willing to put up to a 5% deposit and raise another 15 % in cash. The rest they are willing to take on credit from any system that provides the best conditions.
  ○ An ongoing program of minigrid business creation in the 3 villages is recommended, with collaboration between the 3 villages a likely strong point and price reduction factor due to economies of scale.		

3.5.14 Ismail Arti Jokhio

Table 3-15: Ismail Arti Jokhio Village Assessment

Village/Community Organisation Name:	**District:**	**Union Council:**
Ismail Arti Jokhio	Thatta	MirPur Sakro
Latitude:	**Longitude:**	**Tehsil:**
24°46'36.12"N	67°34'7.34"E	Gharo
Total No. Households:	**Male, female population:**	**Total population:**
75	228 male, 201 female	429
Date(s) visited by PO:	**PO staff present at visit**	**No of CO members present**
15th March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	
Existing livelihood activities in village:		
This village was established in 1890. Men earn most income from labouring and working in Gharo. earning Rs.5000 to Rs.15,000 per month. Some involved in fishing from Gharo Creek and sell fish by the road side. Women do embroidery, sewing and making pillows. Earn approx. Rs.1000-1500 per month.		
Existing power supply provision in village:		
Main grid supply provided by MPA in 2014. Only 60 households applied for meters. MPA paid for their connections. Other 14 HHs have no electric power. Unable to apply Kunda as the wiring will not allow. Others who want to apply for meters are asked for Rs. 100,000 advance by KESC officials, but cannot afford to pay this.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
No detailed discussion took place regarding enterprises proposed by the community to increase income generation from a reliable electricity supply.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ The community expressed willingness to pay for the Micro Grid system as explained to other villages, using a micro credit or other lending system.
  ○ Earning capacity just about possible to support a Micro Grid system
• Existing energy use estimate from audit:
  ○ Households without meters and grid electricity rely on kerosene lanterns and candles. See Appendix A
• Recommended energy solutions
  ○ Solar PV battery /diesel hybrid
• Recommended energy policy approach:
  ○ Hesitate to consider this village owing to its deep connections with various politicians, who would use the energy supply via Micro Grid to their political advantages. Perhaps even prevent an off Grid supply as the PMLN is committed to electrifying every village in their vote bank, via only mains supply.		

Map of village

Photos

Ismail Arti Jokhio showing existing grid lines

3.5.15 Haji Dadu Jokhio

Table 3-16: Haji Dadu Jokhio Village Assessment

Village/Community Organisation Name:	District:	Union Council:
Haji Dadu Jokhio	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
24°46'14.78"N	67°33'40.45"E	Gharo
Total No. Households:	Male, female population:	Total population:
63	173 Male, 157 Female	330
Date(s) visited by PO:	PO staff present at visit	No of CO members present
15th March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	
Existing livelihood activities in village:		
The village is 50 years old. Men mostly involved in Labouring. Own their own land approx. 30 acres. Grow vegetables and wheat to sell in the market. There are 37 cows and 15 goats in the village. There is 1 shop and a electrician in the village. Men earn approx. Rs.8000 to Rs 15,000 per month. Women earn approx. Rs.3000/month making Relis and embroidery.		
Existing power supply provision in village:		
Main grid supply exists to 12 houses, Kunda supply exists in 51 houses.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
No detailed discussion took place regarding enterprises proposed by the community to increase income generation, which would be enabled by a reliable electricity supply.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ Both men and women keen to have solar system. Under their control and more reliable in hours of energy provided.
  ○ Willing to pay for the Mini grid. Discussed costs at Rs.40-50 lakhs. They were willing to pay deposit and gather savings from all who were interested in being involved. Rest of funds would be on a Micro Credit or other Funding programme to pay back within 5-7 years.
  ○ Importance of ownership and responsibility was discussed very seriously.
• Existing energy use estimate from audit
  ○ Bills for Grid varies from Rs.3000 to Rs.4000 per HH. Bills for Kunda fixed at Rs.500/month. KESC.
  ○ Lights in every house are energy savers.
• Recommended energy solutions
  ○ Hybrid using solar PV, battery and possibly diesel
• Recommended energy policy approach:
  ○ Community have the earning capacity to support Micro Grid. They are willing to take on the system and improve enterprises in village.
  ○ Develop policy in line with standard template		

Map of village

3.5.16 Abu Bakar Jokhio

Table 3-17: Abu Bakar Jokhio Village Assessment

Village/Community Organisation Name, age:	District:	Union Council:
Abu Bakar Jokhio Age of village is ~100 years.	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
24°46'23.29"N	67°41'31.87"E	Gharo
Total No. Households:	Male, female population:	Total population:
80		900
Date(s) visited by PO:	PO staff present at visit	No of CO members present
23rd March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	15 were present, all men.
Existing livelihood activities in village:		
Majority of men work in Gharo, on a salary, average income Rs 12,000/month. 400 men are working. Women: 2-3 women make clothes for ladies One existing shop sells wheat, rice, sugar confectionaries.		
Existing power supply provision in village:		
No grid power supply is available to this village, has never been. There is no water in this village so they get water from donkey cart 2km journey		
Assessment Notes: • Initial assessment of likelihood of successful uptake ○ Having explained the costs and the reach of a micro grid system, the villagers emphatically said they do not want such a system. They are looking for a solar supply to them free of cost. This point was adamantly made. ○ If they had to spend 4-5 Million rupees they would instead ask the government to supply them with the main grid. ○ It was explained to the villagers that the main grid when it comes will only give electricity for 4-5 hours and they will end up paying Rs 5,000 – 6,000 /month/household as per previous village experiences. ○ The villagers rejected the concept of a minigrid outright stating they are not interested. • Existing energy use estimate from audit – see Appendix A ○ Use torches which cost 200-300/month/household ○ Use kerosene lanterns at Rs 114/litre, costing Rs 12,000 /month for the whole village • Recommended energy solutions : possible solar PV battery diesel hybrid • Recommended energy policy approach: ○ Return to village in 1-2 years to determine level of interest ○ Present case study information about other successful energy interventions and encourage visits to case study sites.		
Map of village		


Abu Bakar Jokhio
N
300 m

3.5.17 Ayub Khashkeli

Table 3-18: Village Name Village Assessment

Village/Community Organisation Name:	District:	Union Council:
Ayub Khashkeli	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
24°38'31.14"N	67°32'32.64"E	Gharo
Total No. Households:	Male, female population:	Total population:
51		400
Date(s) visited by PO:	PO staff present at visit	No of CO members present
23rd March 2016	IET: CEO. Shahid Khan, Social mobiliser Mohammad Akhtar , Social mobiliers Gul Khtoon	8 community members present including head of CBO, all main members of the community.
Existing livelihood activities in village:		
Village is approx. 100 years old. Men: Income is from fishing, agriculture, labourers, selling wood which they cut in the forest. Average income Rs 9,000/month Women: Reli making, embroidery, agricultural labour at harvest time picking tomatoes and chillis. Average income for women is Rs 3,000 /month. Assets: The community owns 40 cows, 15 buffalo and 30 goats. The milk generated is used by the community themselves, not sold externally.		
Existing power supply provision in village:		
WAPDA was supplying the village with power until 4 years ago. WAPDA increased the price from Rs 250/month to Rs 5,000/month. Villagers who had meters and couldn't pay had meters taken away by WAPDA. The Kunda system is in 40 households. They were paying Rs 200 / month which has gone up to Rs 5,000. No villagers are paying this amount therefore nobody in the village has grid access. A few houses still have connection but supply is intermittent and weak.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ Community has advised they would be willing to pay Rs 200,000/month to have a minigrid system installed, which is Rs3,921/month/household.
  ○ This indicates a good chance of successful implementation
• Existing energy use estimate from audit
  ○ 6 hand pumps for washing clothes and drinking
  ○ See Appendix A
• Recommended energy solutions
  ○ A solar PV battery hybrid possibly with diesel
• Recommended energy policy approach:
  ○ Develop a minigrid with community ownership		

Map of village

Village showing existing grid line approx. location. Kunda lines not mapped.

Photos

Village meeting at Ayub Khashkeli, 23 March 2016

3.5.18 Nabib Bux Jokhio

Table 3-19: Village Name Village Assessment

Village/Community Organisation Name:	District:	Union Council:
Nabib Bux Jokhio	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
		Gharo
Total No. Households:	Male, female population:	Total population:
54		900
Date(s) visited by PO:	PO staff present at visit	No of CO members present
23rd March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	6 including president of CBO and general secretary
Existing livelihood activities in village:		
Income streams are as follows: Men: 20 in government employees, 10 in railways, 15 in water board. Income varies from Rs 15,000 / month to Rs 30,000 / month for these individuals. Labourers in farms mostly chicken farms, income streams Rs 8,000-9,000/month. Women's vocations and income sources: None noted. Many of the youth do labouring tasks. Approx 10% of this village is educated and literate.		
Existing power supply provision in village:		
No grid power supply or Kunda has ever been available to this village.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply: • Community has asked for women and men to be trained in vocational activities including carpentry, plumbing, electrician and welding trades • This points to enterprise potential in this village		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ Reasonable likelihood
• Existing energy use estimate from audit
  ○ Kerosene lanterns are used, costing Rs 1,500/month/household
  ○ Candles are used which cost Rs 800-900/month
  ○ Total lighting bill is approx. Rs 2,500/month/household
• Recommended energy solutions
  ○ Solar PV battery minigrid costing less than Rs2,500/month/household
• Recommended energy policy approach:
  ○ Develop a minigrid with community ownership		

Map of village

Photos

Nabi Bux Jokhio village

3.5.19 Noor Mohammad Thaeem

Table 3-20: Noor Mohammad Thaeem Village Assessment

Village/Community Organisation Name	District:	Union Council:
Noor Mohammad Thaeem	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
24°44'23.70"N	67°40'27.80"E	Gharo
Total No. Households:	Male, female population:	Total population:
222	464 male, 453 female	917
Date(s) visited by PO:	PO staff present at visit	No of CO members present
16th March 2016	IET: CEO. Shahid Khan, Regional Head. Dr. Abdulla Rajpar, Senior Engineer. Siddique Jan Palijo	
Existing livelihood activities in village:		
This is a prosperous Village. There are many shops including 3 hotels, barber shop, car repair shop several cabins selling cigarettes/sweets/pan. 60 persons are employed by Government. 40 persons work in Gharo. 200 people work in private companies who deal in meat distribution. 100 people have their own land, area is 8-10 acres.		
Existing power supply provision in village:		
Main Grid supply has been provided by WAPDA. Meters are installed in 40 houses. Kunda connections to 180 houses. These can be shut off any time by officials visiting village. 2 houses have no power at all.		
Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.		
The community appear relatively satisfied with their current access to energy. There was list of enterprises discussed to increase income generation, which would be enabled by a reliable electricity supply.		

Assessment Notes:
• Initial assessment of likelihood of successful uptake
  ○ Community quite content in the main grid supply even though there is 8-10 hours load shedding.
• Existing energy use estimate from audit
  ○ Metered electricity customers pay Rs. 1,500-3,000 per month.
  ○ Kunda customers pay Rs 500/HH/month
  ○ Rest of community use Kerosene lanterns and candles. These are the poorest in the village.
• Recommended energy solutions
  ○ Solar PV minigrid costing <Rs2,500/month/household would be competitive to replace the existing Kunda and metered system
• Recommended energy policy approach:
  ○ Energy efficiency measures across the village should be adopted
  ○ Household level solar PV generation should be encouraged
  ○ A solar minigrid could be valuable but may be hard to get support for due to relative satisfaction with current system		

Map of village

Village map showing existing grid line. Kunda lines not mapped.

Photos

3.5.20 Soomar Shoro

Table 3-21: Soomar Shoro Village Assessment

Village/Community Organisation Name:	District:	Union Council:
Soomar Shoro	Thatta	MirPur Sakro
Latitude:	Longitude:	Tehsil:
24°44'50.22"N	67°32'12.30"E	Gharo
Total No. Households:	Male, female population:	Total population:
48	109 male, 105 female	214
Date(s) visited by PO:	PO staff present at visit	No of CO members present
26/3/2016	IET: COO; Aijaz Abro,	8 Members including CO Leaders

Existing livelihood activities in village:

1. Fishing
2. Fishing Labourer
3. Salt Greek Labourer
4. Civil Works Labourer

Existing power supply provision in village:

There has never been any grid power supplied to this village.

Potential of livelihoods and social enhancement by enhancement/ provision of uninterrupted power.

List of enterprises were proposed by the community to increase income generation, which would be enabled by a reliable electricity supply:

- List from the Men:
  - Tailoring
  - Cold Drink Shop
  - Milk SHOP
  - Confectionary
  - Hotel
- List from the Women:
  - Rilly Making – Not Commercial
  - Embroidery
  - Tailoring

Assessment Notes:

- Initial assessment of likelihood of successful uptake
  - Moderate likelihood of uptake of an energy access upgrade
- Existing energy use estimate from audit:
  - China LED Cell Battery are in use. Every Household has china LED battery. Photo attached below
  - Candles are used for lighting.
- Recommended energy solutions
  - Solar PV battery hybrid with possible wind turbine due to good wind resource expected from open water adjacent
- Recommended energy policy approach:
  - Develop minigrid with community ownership

Map of village

Photos

Community meeting at Soomar Shoro, March 2016

Battery powered LED light currently used in households

4. Moving to Implementation

Under the PPAF funded program in 2016, funds were available to implement a minigrid in a selection of villages. Therefore it was possible to select several villages to take through to implementation phase as part of this program.

4.1 Selecting Villages for Implementation

A selection process was undertaken led by IET.

A strategic selection approach was taken in order to sample a cross section of typical rural communities. This included three goals discussed with the PPAF:

1. The majority of sites were to be chosen where there was no electric supply system available nor was there any possibility of grid based electricity being supplied in the foreseeable future.
2. Also a hybrid scenario was to be selected for at least one village which does have access to Main Grid supply with high load shedding.
3. In addition to solar PV, consider other alternative energy sources, such as wind and bio gas.

Figure 3-2 of the report shows the range of energy access at villages, e.g. 6 villages have no access to electric power.

Importance was given to the number of village members who attended focus group discussion meetings and by the communication "manner" especially by women.

The criteria used for selection of villages included:

- Where both a high level of desire for development and a willingness to act was identified
- Where a strong degree of understanding was demonstrated of what benefits improved power supply can bring to their livelihoods
- A strong track record of successful interventions where village had previously increased their livelihoods levels, proven through monitoring by IET through use of poverty scorecard levels.
- A strong desire expressed in the village to adopt the presented energy improvements
- Indication that the village residents have the capability to pay electricity bills and create livelihood income from the improved power supply
- Practical considerations included distance from IET main offices to manage travel time, also important for monitoring the projects in future
- Balance projects across two Union Councils: 2 in Gharo and 2 in Dhabeji

Goals of the Project Organisation when selecting villages to implement:

- To cover a wide range of income levels to evaluate the impact at each income level
- To engage a cross section of the cultures and clans who inhabit Sindh:
  - Kolhi (Hindu), Jokio,
- To cover a range of household number and population sizes
- To cover a range of village geographical sizes including villages which are spread out over larger distances, such as Hamso Samo, and investigate the technical solutions to this and community management outcomes
- To cover a range of grid access scenarios including no grid, inoperable grid and limited grid
- To cover a range of geographic distance to roads and grid
- To cover a range of prior development/intervention status including some villages with no prior development interventions

The selected villages are described in the table and figure below:

Table 4-1: Features of four selected villages

Feature	Hamzo Samo	Bachoo Koli	Jaffar Jokio	Ishaque Jokio
Tribe age, social ranking	Oldest tribe in region, Muslim	Lowest caste in Hindu community	Jokhio tribe, Muslim	Jokhio tribe, Muslim
Overall poverty level	Moderate	poorest of the four	Relatively higher income levels	Relatively higher income levels
Education levels	Average level of literacy among the four	Very low literacy	Average level of literacy among the four	Higher level of education and literacy

Feature	Hamzo Samo	Bachoo Koli	Jaffar Jokio	Ishaque Jokio
Existing Livelihoods	Engaged in fishing, crab farming.	Crab collection from Mangroves near the village, bedspread making.	Labouring in fertilizer factory and Water Pump in Dhabeji. Few Government jobs. Women: Relis and stich clothes.	Lots of small businesses, labour options.
Existing energy access	No existing grid, 1km from nearest line	No access and far from grid	No access and far from grid	Existing Kunda line to village
Geography	Spread over larger distances. Close to main road and grid.	Remote - Very far from main road and grid.	Remote - Very far from main road and grid.	Close proximity to main road and has existing grid access.
Prior level of interventions	IET previously provided water, handpumps & asset transfers (livestock)	No prior interventions.	Livelihood projects in 2014	Water and handpumps, assets and livelihoods around 2014

Figure 4-1: Four villages identified for implementation

4.1.1 Preparing Selected Villages for implementation

Focus Group Discussions (FDG)s were carried out on 21st Jan and 3rd Feb 2016 in in the four selected villages.

FDGs were carried out by IET representatives: CEO. Shahid Khan. (SK), Regional Head. Dr. Abdulla Rajpar (AR), Senior Engineer. Siddique Jan Palijo (SP).

Discussion agenda for all four villages:

- SK, AR and SP explained thoroughly the purpose of this Mini Grid project. That it is not just for lighting each house; electric power is being provided so that a community can prosper through its use by establishing small scale businesses, appropriate entrepreneurship, convert saline water to a potable level or use existing water lines with added pump to increase flow of water.
- Maintenance of the entire system is the community's responsibility. They have to take ownership and employ 2 young literate men in the village who will be trained by IET in the basic technical knowhow of the system. IET explained that up to 20% electric power can be lost if panels are not kept clean.
- It is necessary to remember that this supply of electric power is not free. It has to be paid for by each individual at a rate established by the community in consultation with IET.

- Duration (hours per day and night) of electric supply to the village will be agreed by the community and IET.
- Those who have establish a business will have meters installed. Their rate will be as per usage. Where only lights are being provided, then that rate will be fixed.
- Considerable time was taken in explaining that additional use of power in houses has not been calculated. Therefore no one can add a TV of radio or any other appliance as the system will not allow it. Safe guard systems have been installed in the system to create cut offs where extra load is being used. There is no provision for fans in the system.
- It is essential that women understand that their contribution to the village economy is paramount to the success of this whole venture. That the improved health of their children will relate to the income earned by providing nutritional food, proper clothing and looking after the elderly and sick.
- Both men and women will establish kitchen gardens with the extra water supply being provided for by the Mini Grid.
- Both female and male Social Mobilisers were present in explaining all the above in Sindhi so as that it was properly understood.
- Explained that a co-operative or similar will be established in the village that will be their responsibility to collect dues, maintain equipment and make sure that children do not come near the Mini Grid or try to dig up power supply as it could be dangerous.
- Q&A followed where all issues raised were answered.

PROJECT COMMITTEE MEETING FOR THE FOUR MINI GRID STATIONS IN GHARO AND DHABEJI.

Held at the Mehran Training Centre. *7th March 2016.*
Meeting was chaired by Shahid Khan.
Present from IET were:
Dr. Abdullah Rajar.
Siddique Jan Palijo.
Chanesar.
Gol Khatoon- Social Mobiliser.
Saqib Quarishi- Social Mobiliser.

The purpose of inviting the 16 Project committee persons was to explain in detail what their responsibilities are when each mini grid is handed over to the communities.

The following was explained to all present:
Each committee will be responsible for the overall working of the Mini Grid system.
One person from these four persons will be in charge and responsible for the system in making sure it is operating properly. He will be paid a salary which the Village Organisation (VO) will decide as to his rate. However this should be based on income generated in each village.
The operator will be trained by IET engineer so that he is able to solve small issues and report correctly if there are further complications that he is unable to resolve.
He will be responsible for overall maintenance of the entire system. Cleaning solar panels is essential as there is a drop of 40% efficiency if panels are dirty. This was explained many times so that the committee members understood the reasons for keeping panels clean.
He will be responsible for billings, the amount of which will be decided by the VO, and that funds are paid on time. If there are defaults by anyone in payments the VO will ascertain the reasons and a warning will be issue to the person. If further payments are not paid then the electric power will be cut off.

The VO will decide the amount each HH has to pay. The enterprise receiver will have a meter attached and will pay according to units used.
Each village will establish a "Village Bank" where all payments will be made. A register will be kept by the President and Treasurer of each VO.

Committee members to meet every month. Minutes will be taken by the VO and sent to IET. All community members will have a chance to make their voice heard at these meetings.
Power supply to HHs will be on a timing basis. To be decided by VO.

Enterprise electric supply will be allocated during day and in some situations at night. These timings to be decided by IET and VO.

All wring to be a minimum to be 1.5 ft below ground. This is essential as explained to the committee members. The depth is to prevent any one digging it up to illegally add another line and to keep wiring cool in the heat of the day.

A base line survey is to start immediately so that a clear picture can immerge of a before and after analysis.

There is no allocation for anyone to increase their electric supply or for any new enterprise at this stage. This is a pilot project that will be observed by donor to ascertain its impact on communities.
It was explained at some length that not only the donor but the whole province of Sindh has now been informed about this project via the media. All eyes are focused to observe the workability or otherwise of this programme. It is up to the communities to make it a success. Ownership is paramount. This is a unique opportunity which must be seized.
It is essential to keep children disciplined in not interfering in any way with the Mini Grid system. If anyone from the community deliberately damages any part of the Mini Grid, then they will be responsible for its replacement.

Project Committee members are as follows:

JAFFER JOKIO.
Shama
Rabia
Usman---elected operator.
Sultan----helper to operator.

BAJO KOLI.
Fatima.
Hoorbai.
Katu.
Paro-----elected operator.
Hamid---helper to operator.

HAMZO SAMO.
Amnath.
Sara.
Fazal Rehman.---elected operator.
Ali Azgar----------Helper to operator.

ISHAQ JOKIO.
Nuzrath.
Naseeba
Mehmood------elected operator.
Amir Bux--------Helper to operator.

Minutes written by Shahid Khan, CEO of Indus Earth Trust (8/March/16)

4.2 Solution Design

Closing the energy gap includes provision of electrical power for lighting, refrigeration, fans, enterprises as well as clean cooking fuels.

The Just Light is Not Enough project focusses on electricity supply, though IET has conducted cooking energy projects in the past.

The Sustainable Energy For All (SE4ALL) Initiative by the World Bank's Energy Sector Management Assistance Program (ESMAP) provides a goal for achieve 'universal access to modern energy services by 2030'. It also includes a Tier system providing a framework for energy access which can be used to guide solution design at specific villages.

Using the ESMAP approach, an energy supply for rural communities should have the following characteristics:

- Provide medium or high amounts of power in the context of the community
- Be available over 16 hours per day
- Provide reliable supply
- Be priced affordably
- Be legally accessible and usable
- Be convenient
- Be healthy and safe

These attributes are illustrated in the ESMAP presentation provided below:

Attributes of energy supply		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity	Household electricity	No electricity[a]	Very low power	Low power	Medium power	High power	
	Household cooking	Inadequate capacity of the primary cooking solution				Adequate capacity of the primary cooking solution	
Duration and availability	Household electricity	<4 hours	4–8 hours		8–16 hours	16–22 hours	>22 hours
	Household cooking	Inadequate availability of the primary cooking solution				Adequate availability of the primary cooking solution	
Reliability	Household electricity	Unreliable energy supply				Reliable energy supply	
Quality	Household electricity/cooking	Poor quality of energy supply			Good quality of energy supply		
Affordability	Household electricity	Unaffordable energy supply		Affordable energy supply			
	Household cooking	Unaffordable energy supply				Affordable energy supply	
Legality	Household electricity	Illegal energy supply			Legal energy supply		
Convenience	Household cooking	Time and effort spent sourcing energy cause inconvenience			Time and effort spent sourcing energy do not cause inconvenience		
Health and safety	Household electricity	Unhealthy and unsafe energy system				Healthy and safe energy system	
	Household cooking[b]	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5

Figure 4-2: ESMAP Multi tier approach to energy access

This is extracted from an ESMAP presentation [15]

[15] "Capturing the Multi-Dimensionality of Energy Access", 2014 by Nicolina Angelou, accessed from https://www.esmap.org/node/55526

MULTI-TIER MATRIX MEASURING ACCESS TO HOUSEHOLD ELECTRICITY

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity	No electricity	1-50W	50-500W	500-2000W	>2000W	
Duration	<4hrs	4-8hrs		8-16hrs	16-22hrs	>22hrs
Reliability	Unscheduled outages				No unscheduled outages	
Quality	Low quality			Good quality		
Affordability	Not affordable		Affordable			
Legality	Not legal			Legal		
Health & Safety	Not convenient				Convenient	

Figure 4-3: Measuring access to household electricity

A 15-20 year lifetime of the system is the design goal.

A high availability target exceeding 16 hours per day and 90% - 95% availability in demand periods is considered.

Consumption and demand management

The number of enterprises included in the design for power supply was refined to a shortlist of the most viable enterprises.

Generation System design goals

The scheme should be technically capable of providing power for the forecast village demand profile.

The system should generate sufficient electricity during all normal weather conditions, including August low solar yield scenario and during heat waves.

Demand management is important in the system especially during night time when battery capacity limitations may occur.

Meters should ideally be programmable to limit kW draw at night time and/or set daily quotas of kWh consumption. Also daytime vs night time tariff setting within meters is desirable where battery replacement costs are strongly impacted by night time electricity use.

Underground cables should be buried in locations where digging is unlikely to occur, and trench routes should be marked with clear above ground markers which remain permanently. Cables should be protected against future excavation through appropriate trench design and marker tape. Protective covers should be installed above cables at any road crossings.

Cables with heavy duty protection sheaths and UV resistance should be used throughout.

4.3 Technology Options

The technology options for a power supply for a village include:

- Centralised grid or household level systems
- Generation from renewable or non-renewable sources
- For renewable sources, use of solar PV, biogas, wind or hydro generation
- For hybrid generation, inclusion of multiple generation types e.g. wind and solar PV, diesel and solar etc

- Metered or unmetered supply
- Post paid or prepaid metering system
- Battery storage level of storage e.g. contingency for 1-4 days of low sunshine
- Battery storage above ground or below ground for temperature control
- Cables buried or overhead or combination

Solar photovoltaic and battery combinations were selected based on previous local success, low maintenance requirements, and ubiquitous availability of solar resource at all villages. Wind power was considered at Hamzo Samo where a reasonable wind resource exists, but was ruled out due to maintenance difficulty associated with a wind turbine in coastal humid conditions compared to solar PV. Biogas is an option where livestock wastes are available and some villages was considered as a cooking fuel replacement, however this program focussed on electrical power solutions hence gas creation was not prioritised.

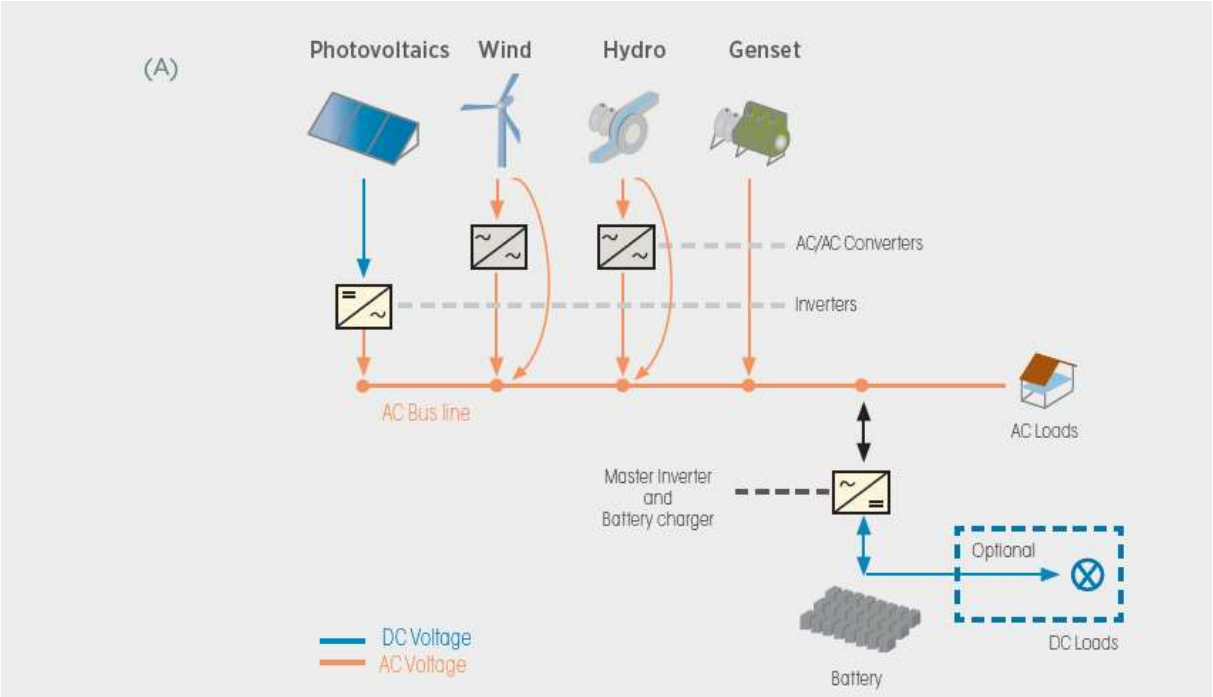


Figure 4-4: Technology of hybrid mini grids for AC coupling, Source: IOREC, 2012[16]

Fully renewable generation was selected, with power coming 100% from solar PV. While small diesel generators were considered for reduction of night time battery usage, and maximising system availability, the additional fuel cost and maintenance cost was a factor against the inclusion of diesel generators in these pilot projects.

The ready availability of solar PV, inverter and battery products in stock in the Karachi region was a factor in favour of the final solution.

[16] See reference [14], this was adapted from ARE, 20011

4.4 Demand, Generation and Storage modelling

The electricity demand of each village was calculated based on forecast LED lighting power requirement and usage hours at households and street lights.

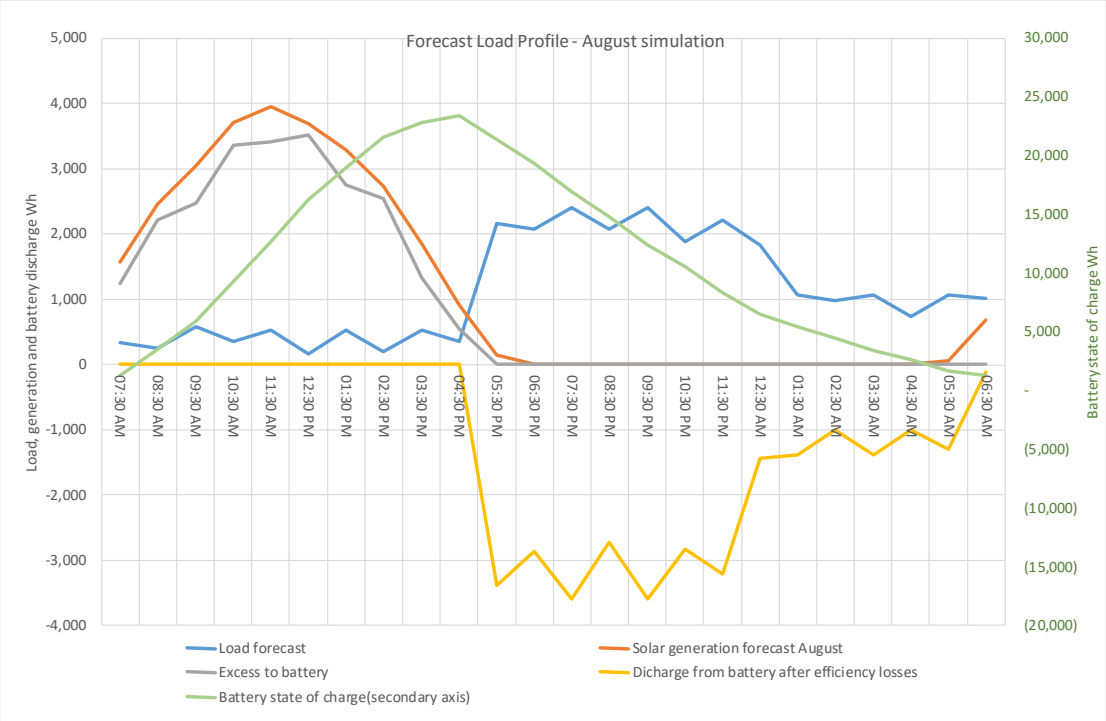


Figure 4-5: Hamzo Samo load forecast (August weather scenario)

This village is spread over a large distance, hence the system was designed to be installed in three separate systems, to significantly reduce cable costs.

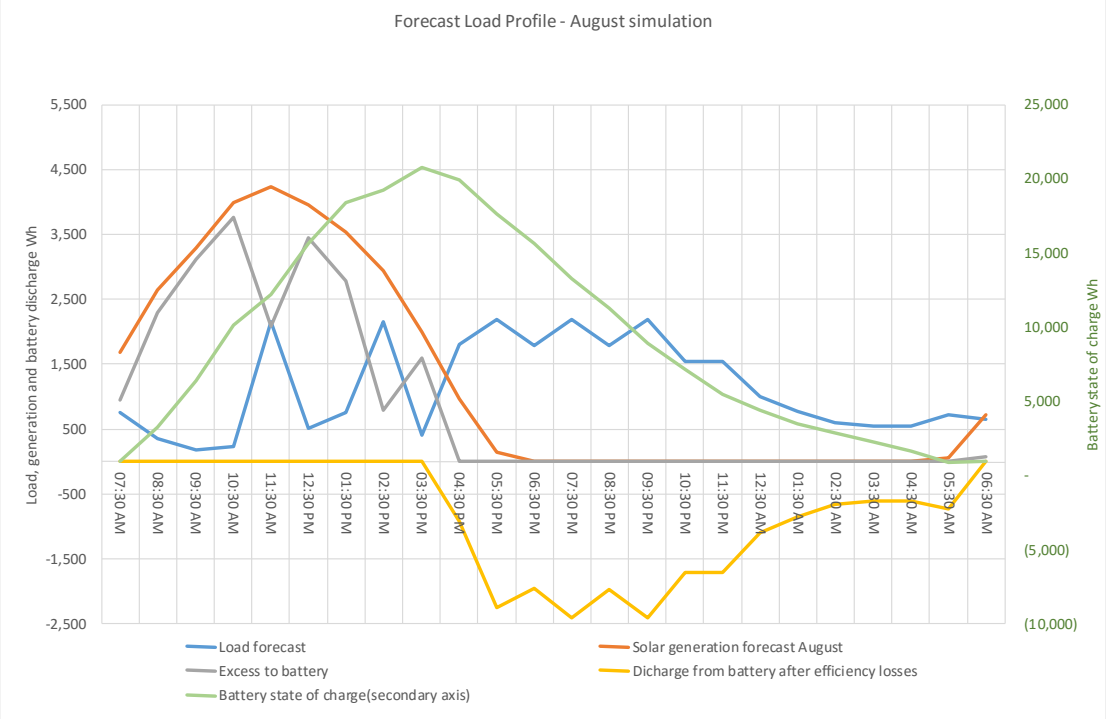


Figure 4-6: Bacho Kohli power forecast (August weather scenario)

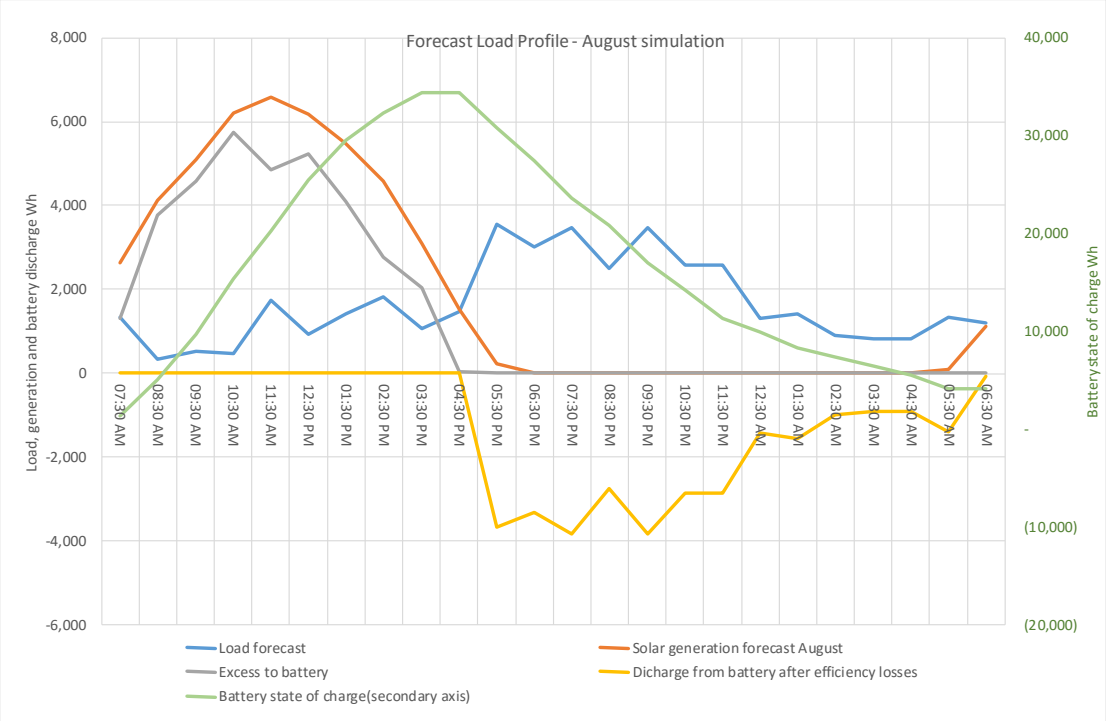


Figure 4-7: Jaffar Jokhio power forecast (August weather scenario)

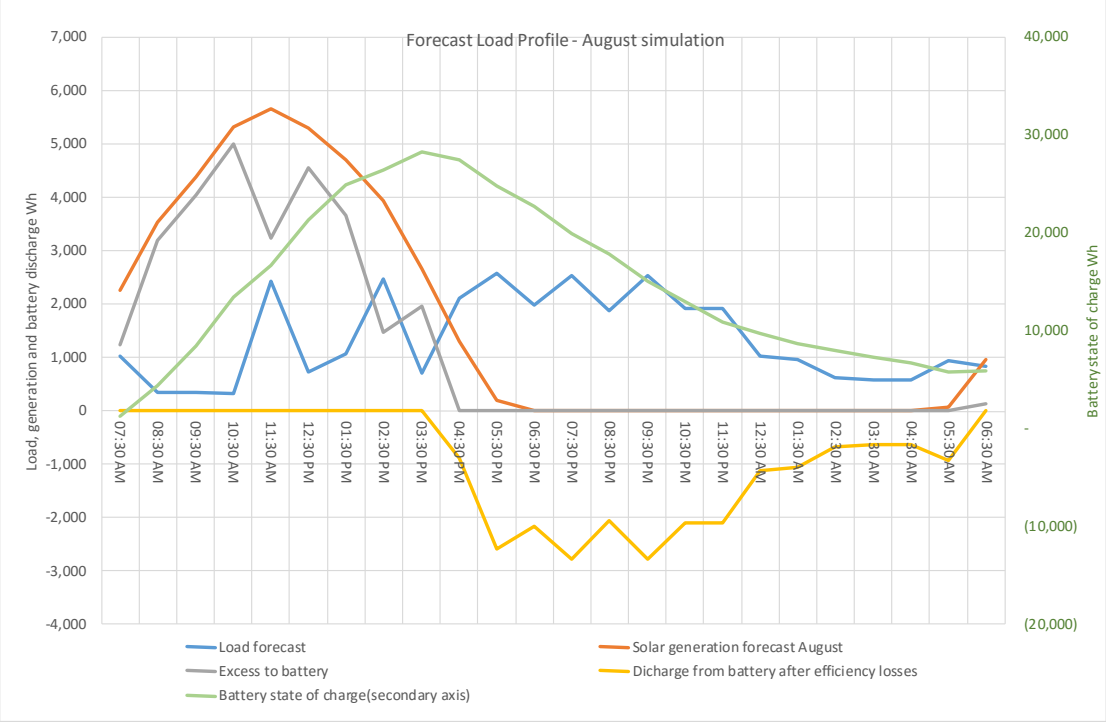


Figure 4-8: Ishaque Jokhio power forecast (August weather scenario)

4.5 Summary of system designs

The system specifications designed at 4 villages are shown below.

Table 4-2: Hamzo Samo specifications

Village/Community Organisation Name:	**District:**	**Union Council:**
Hamzo Samo	Thatta	Tehsil MirPurSakro
Latitude:	**Longitude:**	
24°42'41.00"N	67°36'9.27"E	
Total No. Households:	**Total No. Rooms**	
64	91	
Total No. LED lights 9W	**Total no LED lights kitchen 4W**	**No of mobile phone charge sockets**
171	45	64
No of power sockets for businesses	**No. of electricity meters required**	**No of street lights 12W with poles**
2	9	7
Solar PV capacity (kW) required	**12V Battery storage capacity Amp hours**	**Capacity of inverter required kW**
9.62 kW Divided into 3 systems. Main (6.3KW) Cluster 7 (1.8KW) Cluster 8 (1.5KW)	24 x 800Ah, 2V 4 x 200Ah, 12V 4 x 200Ah, 12V	5.5 Plus 2 smaller inverters
Approx total cable length for AC transmission system (m)	**Approx cable length required for AC distribution system (m)**	**No of distribution control points**
800-900 Reduced from 1500	1,280	7

Table 4-3: Bacho Kohli specifications

Village/Community Organisation Name:	**District:**	**Union Council:**
BachoKohli	Thatta	Tehsil MirPurSakro
Latitude:	**Longitude:**	
24°46'45.42"N	67°29'5.52"E	
Total No. Households:	**Total No. Rooms**	
53	58	
Total No. LED lights 9W	**Total no LED lights kitchen 4W**	**No of mobile phone charge sockets**
120	53	53
No of power sockets for businesses	**No. of electricity meters required**	**No of street lights 12W with poles**
5	8	5
Solar PV capacity (kW) required	**12V Battery storage capacity Amp hours**	**Capacity of inverter required kW**
12.5 No. 310W panels: 41	24 x 800Ah 38,400	5.5
Approx total cable length for AC transmission system (m)	**Approx cable length required for AC distribution system (m)**	**No of distribution control points**

400	1,060	5

Table 4-4: Jaffar Jokhio specification

Village/Community Organisation Name:	**District:**	**Union Council:**
Jaffar Jokhio	Thatta	Tehsil MirPur Sakro
Latitude:	**Longitude:**	
24°47'34.57"N	67°36'10.00"E	
Total No. Households:	**Total No. Rooms**	
80	108	
Total No. LED lights 9W	**Total no LED lights kitchen 4W**	**No of mobile phone charge sockets**
195	62	62
No of business appliances to be powered	**No. of electricity meters required**	**No of street lights 12W with poles**
5	10	5
Solar PV capacity (kW) required	**2V Battery storage capacity Amp hours**	**Capacity of inverter required kW**
14 No. 310W panels: 46	24 x 1200Ah 57,600	5.5
Approx total cable length for AC transmission system (m)	**Approx cable length required for AC distribution system (m)**	**No of distribution control points**
500	1,600	5

Table 4-5: Ishaque Jokhio specification

Village/Community Organisation Name:	**District:**	**Union Council:**
Ishaque Jokhio	Thatta	Tehsil Mir PurSakro
Latitude:	**Longitude:**	
24°45'1.95"N	67°33'45.00"E	
Total No. Households:	**Total No. Rooms**	
78	116	
Total No. LED lights 9W	**Total no LED lights kitchen 4W**	**No of mobile phone charge sockets**
203	56	56
No of business appliances to be powered	**No. of electricity meters required**	**No of street lights 12W with poles**
7	6	5
Solar PV capacity (kW) required	**2V Battery storage capacity Amp hours**	**Capacity of inverter required kW**
19.5 No. 310W panels: 63	28 x 1500Ah 72,000	5.5
Approx total cable length for AC transmission system (m)	**Approx cable length required for AC distribution system (m)**	**No of distribution control points**
338	1,120	3

Cable lengths are approximate only and are confirmed through ground measurements by the installer. A star formation of cable laying is utilised with meters located at the control building.

4.6 Capital and Operational Costs

Appendix C provides detailed capital and operational cost data for a sample village: Jaffar Jokhio.

These are summarised below:

Village/Community Organisation Name:	**District:**	**Union Council:**
Jaffar Jokhio	Thatta	Tehsil MirPur Sakro
Total No. Households:	**Total No. Enterprises**	
80	5	
Capital Cost for installation of system	**Solar PV capacity**	**Battery capacity**
Rs 5,639,010 / USD $53,705	14 kW	58 kWh

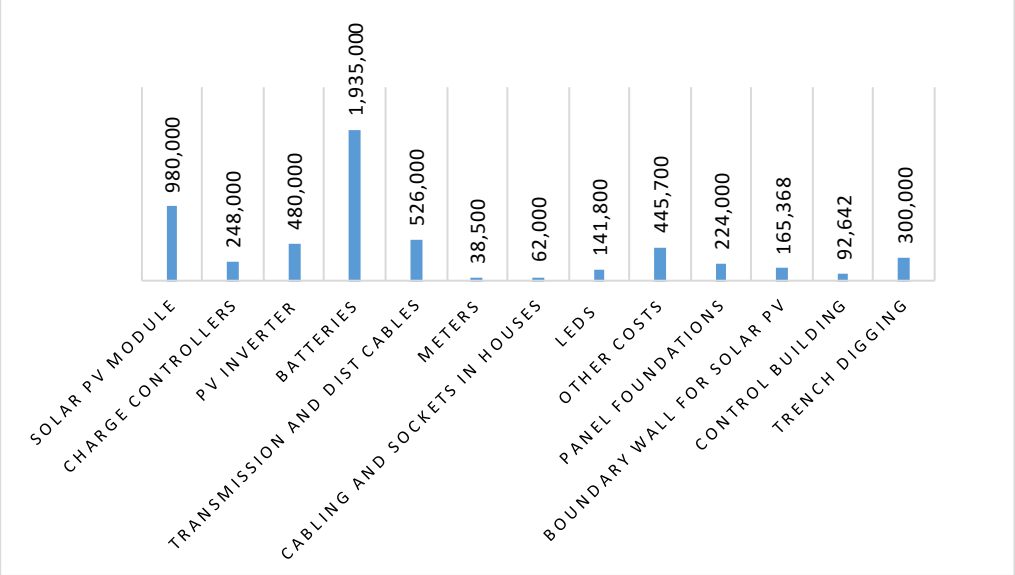


Figure 4-9: Capital cost example by for village minigrid Jaffar Jokhio

Table 4-6: Operational and maintenance costs

Description of routine annual Opex item	Annual Opex PKR	Annual USD
First 2 years maintenance by Nizam included	0	-
Cleaning panel, 2 days per month, Rs 300/day	7,200	69
Year 2 onwards: scheduled maintenance - PV/inverter	22,050	210
Year 2 onwards: scheduled maintenance - batteries	30,000	286
Year 2 onwards: scheduled maintenance - control building & frames	30,000	286
Billing reading and bill admin	33,000	314
Debt collection from clusters and businesses	13,200	126
Internet subscription	5,000	48
Other admin/overheads	20,000	190
Total (excluding equipment replacement)	160,450	1,528

Equipment replacement costs are itemised below.

Table 4-7: Equipment replacement costs

Description of Equipment Replacement cost over 20 years	20 yr cost PKR	20 yr cost USD
Replacement of batteries (3 times)	- 3,356,016	- 31,962
Replacement of inverter (once)	- 432,000	- 4,114
Replacement of charge controllers (3 times)	- 496,000	- 4,724
Replacement of meters (once)	- 38,500	- 367
Replacement of LEDs (every 2 years)	- 1,276,200	- 12,154
Replacement of sundry equipment	- 1,337,100	- 12,734
Total	**- 6,935,816**	**- 66,055**

Capital and Operational costs are detailed further in Appendix C below.

5. Energy Policies

This section discusses Energy Policy creation including management strategies, institutional models to manage the power system, maintenance responsibilities and social sustainability.

A common approach to energy policies is required as a template which can be widely adopted in other regions in rural Pakistan.

In light of the 20 specific villages assessed, and the 4 villages where implementation has been undertaken, an approach to local energy policy creation can be developed.

From a starting point of very low energy access, e.g. no access to electrical power, a village energy policy aims to:

- Create a 'map' of how to enhance energy access to a level which enables livelihood creation as well as basic lighting to reach a satisfactory level
- Provide a step by step approach which will lead to a successful energy supply being established
- Inform the village which external organisations and stakeholders to approach
- Guide the village on what internal organisational structures and responsibilities will be required
- Minimise reliance on government subsidy while still moving swiftly towards universal energy access
- Provide financial models which are affordable to the village organisation
- Where the village is not able to raise the whole capital investment up front, guidance on finding micro credit or alternative loans to fund the construction phase.

5.1 Business Models to be adopted by Energy Policy

Pakistan currently has no national or regional government funded program to provide off-grid energy access to rural areas. Therefore a strategic goal of this project is to enable Mini Grids to be financed and managed by communities with minimal government interventions.

Information from other countries with similar challenges include the GNES India publication[17] .

The GNES report states:

> "**Service delivery models**
> The operational artefacts of mini-grids reveal that they operate under various delivery models. Most of the publicly supported mini-grids in India are structured around community-based models, albeit with different names, such as Village Energy Committee (VEC), Village Development Committee (VDC) and Rural Electricity Co-operatives (REC). A majority of publicly supported mini-grid projects promoted by Ministry of New and Renewable Energy (MNRE)… follow the VEC structure with some variations. Here, the VEC or the REC play the pivotal role as a power producer, distributor and supplier of electricity. The service delivery approach of the model involves the formation of a VEC by the Project Implementing Agency (PIA) – usually the state renewable energy development agency or a non-governmental organisation (NGO) – with representations from villagers and the local governing bodies (known as Gram Panchayat). The VEC usually consists of nine to 13 members, with 50 percent representation from women members and elected village Panchayat members being ex-officio members of the VEC. The PIA sets up the energy production systems and hands over the facility to the VEC for day-to-day operation and management. The VEC thus acts as custodian of the energy production system and is responsible for its operation and management. The electricity generated is distributed to the community through local mini-grids.
> In line with the provisions of the Rural Electrification Policy, often the tariff is set by the PIA in consultation with the VEC. As the capital cost is almost entirely subsidised, the tariff is set such that the revenue can take care of the fuel, operation and maintenance costs including remuneration of the system operator."

[17] GNESD 2014 'Renewable energy based rural electrification: The Mini-Grid experience from India, accessed from www.gnesd.org

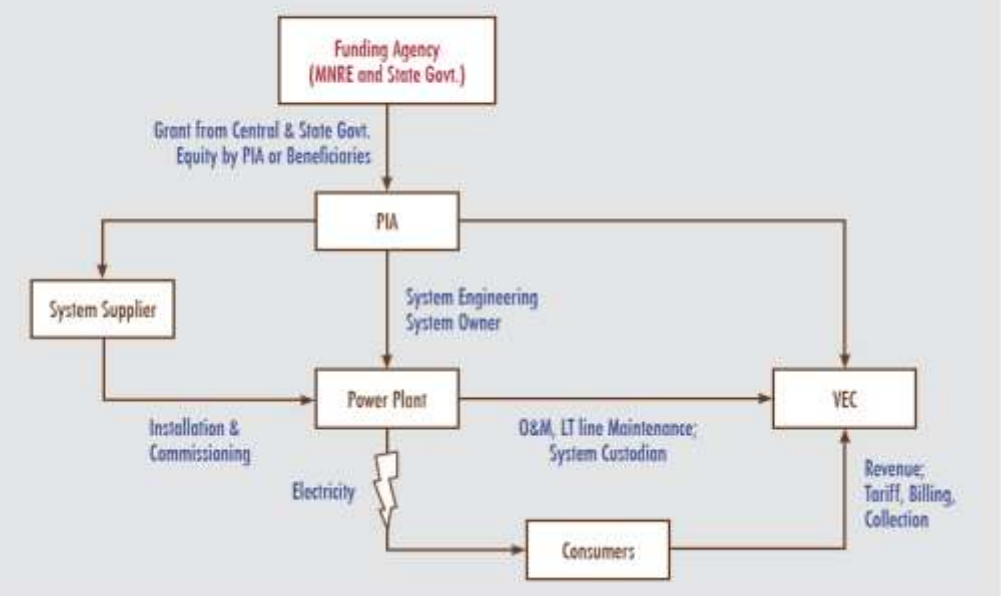


Figure 5-1: Service Delivery models presented in [9]

Other service delivery models involve greater ongoing role for the state government, or alternatively private company development and ownership of the minigrid.

The following are some alternative models that are discussed in the India report [9]:

1. Business models promoted by private companies:
BOOM: Build, own, operate, maintain.
BOM: Build, operate, maintain.
BM: Built, maintain. (Owned and operated by a local entrepreneur).

2. A-B-C. (advocated by the World bank).
Anchor: Predictable base load offers a guaranteed source of revenue for the developer.
Business Group: Customers for the project.
Community members. Customers for Project.

Mini Power business-in-a-box where community entrepreneurs are engaged in village electrification.

Prepaid system based on subscription: The customer is charged a monthly fixed rental for use of the energy. A well designed energy efficient system is essential in this scenario.

3. Pay as you go.
A pre-paid credit model to provide electricity and also to create village-level entrepreneurship. This is a metered system in which local entrepreneurs purchase prepaid bulk energy credits from the developer and wirelessly transfer the prepaid recharge into consumers meter, again as a prepaid basis from consumers.

The meter also indicates quantum of load that can operate for certain hours. Customers are charged on an hourly basis. Local entrepreneurs could earn 10% on every power sale for example.

In the case of Just Light is not Enough, the strategic goal is to empower village communities themselves to fund the construction of minigrid solutions.

"IET has extensive experience with renewable projects. Thus, the organization has already implemented project with solar lanterns, individual SHS (16 systems installed), community solar systems (installed in more than 50 villages, 10-50 houses each), solar water pumping (installed in 14 villages), and started first projects with hybrid (solar and wind power) community systems (2 villages)." [MEI, 2014, reference 7]

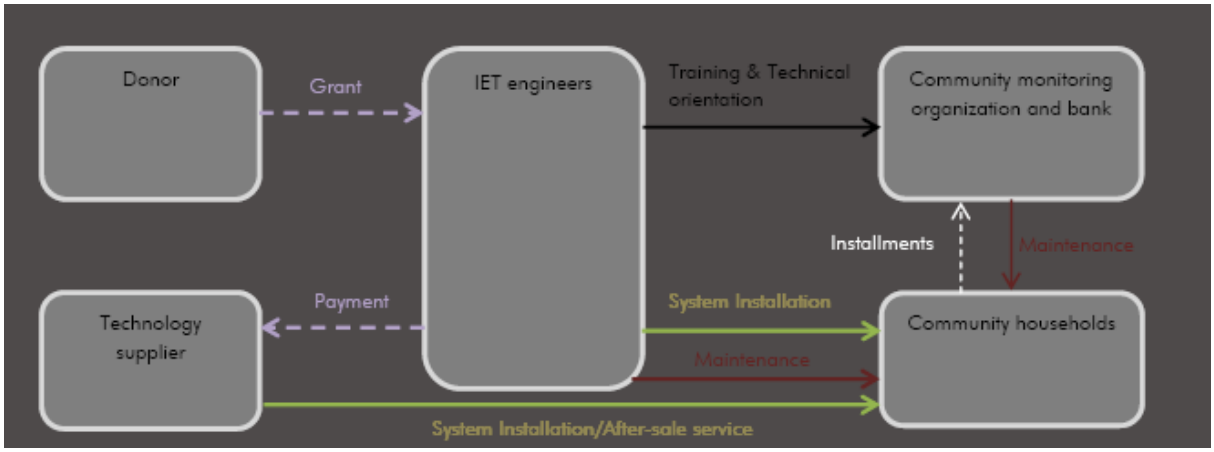


Figure 5-2: Business model adopted by IET for community solar projects

The figure above is taken from the Micro Energy International report [7].

5.2 Investment planning, micro finance and social investment

PPAF and Partner Organisations can play an important role to partner with village/union councils to overcome issues surrounding community capacities including finance/management/technical.

5.2.1 Micro Finance

The initial capital cost of a solar-battery minigrid system is aprox USD 50,000-60,000 for villages with 60-80 households. By contrast the operational costs are much lower therefore the largest capital investment required is at commencement.

If government or donor subsidy is not available, then the village organisation must turn to alternatives for raising capital. Significant capital can be raised within a village through pre-payment of connection fees for all households. In some cases, the village may be able to afford the full initial capital cost through this means, plus providing in-kind labour towards the civil construction aspects, removing the need for any loan or subsidy. This has not been observed yet in Pakistan and all minigrid examples known to date have been subject of donor funding. Some corporate funded rural electrification has been observed for workers villages.

In many cases it is likely that the local capital raising from within the VO would not reach the full capital costs of a minigrid installation. In these cases, a loan to the VO may be a solution if suitable loans can be identified.

The proportion of commercial loan funds would be likely to be linked to the recoverable value of the equipment. In the event of default, the minigrid can be switched off by the lender, and if payment defaults continue the final recourse would be to retrieve the equipment which has a second hand value. Given that solar panels have a 20 year lifespan and inverter and battery equipment also have a second hand value, a ball park of 50% of the total capital cost of the project could be recoverable through second hand value of retrievable equipment.

'Micro finance' in Pakistan is available to low income borrowers. The terms are generally full repayment within 1 – 1.5 years and interest rates at 25%-35%. MEI have provided a detailed report on micro credit for solar home systems in Pakistan [7]. Presently the lending limits from Micro Credit lenders go from about Rs 20,000 per household rising to Rs 50,000 per household with some institutions.

To enable village organisations to invest in their own energy solution without government subsidy, a micro credit loan for 1 year at 25-30% interest will do little to assist the village overcome the initial hurdle of capital cost. While the ongoing energy bills enable a village to collect funds for ongoing repayment of a loan, this process should be spread over several years rather than 1 year, so that the initial year of bills are affordable.

To significantly assist rural energy access developments at a grassroots level, a loan of at least 3 years repayment term and interest rates of 10-15% would be beneficial.

The supplier/installer of the minigrid hardware could be approached to provide credit terms on the up front cost, with customer repayments over 3 years.

The source of capital loans could include entrepreneurship organisations such as Karandaaz Pakistan or Akhuwat.

"Karandaaz Pakistan is a private company established in August 2014 which promotes access to finance for small businesses through a commercially directed investment platform, and financial inclusion for individuals. The Company has financial and institutional support from leading international development finance institutions; principally the United Kingdom Department for International Development (UKAid) and the Bill & Melinda Gates Foundation. The Consultative Group to Assist the Poor (CGAP), a member of the World Bank Group, has managed the start-up phase of the Company and will continue to provide technical support."

"Karandaaz offers financial and technical help to mobile money providers, start-ups, and innovators to experiment with unproven approaches. It supports cutting-edge public-good research to encourage pro-poor and consumer-smart digital financial services".[18]

5.2.2 Social Investment model

An alternative source of loan could be a social investment model. This is a system where a philanthropic organisation facilitates a loan on favourable terms, such as a 2-5 year repayment and interest rates between 8 – 12%.

The philanthropic organisation, or corporate social responsibility section of a corporation, could act as guarantor to enable a bank to lend funds at bank rates and longer terms, to a rural energy access project.

IET has previously spoken to organisations such as i-Care about the possibility of providing loans to village communities to establish mini grids.

In addition to social entrepreneurship, i-Care also works with organizations that provide loans to individuals who intend to start small businesses of their own.[19]

A natural extension of the micro loans for entrepreneurs is to provide a loan to a village organisation to establish their mini grid.

For the purpose of our modelling an unsubsidised scenario for villages to establish mini grids, we have used the following parameters:

- Social investment loan is available at 50% of the total capital cost
    - The recoverable value of the installed assets will amount to at least 50% of total capital costs
- Loan term is 3 years
- Interest rate of 13%

To bridge the gap between the market rates for micro credit and the likely required rates to enable communities to establish their own minigrids, communities and partner organisations should look at some or all of the following:

A).Some credit from the suppliers of the solar equipment
B).Tapping into some subsidized segment like the interest free loans proposed by the government, or from entities like Akhuwat
C). A grant covering part of the cost from donor institutions supporting either livelihoods or such energy. The UN's Green Climate Fund is a possible source of funding.

It is likely that energy systems may need to be subsidized in some way either through upfront grants, interest rate subsidies or guarantees for the longer tenors i.e years 4,5.

[18] Description taken from http://karandaaz.com.pk/content/digital-financial-services
[19] http://i-care-pakistan.org

5.2.3 Philanthropic Crowd Funding

More and more examples are becoming evident in the use of Crowd Funding, especially for developing countries. This source should be seriously considered. If 500 persons contributed USD$80-100 each the target of $ 40,000-50,000 would be easily reached. Alternatively a target could be 2000 persons giving $20-25 each.

5.3 Setting Tariffs

The goal of tariff setting is to find the right balance between affordability and economic cost of electricity generation.

FIGURE 10 TARIFF COMPONENTS FOR MINI-GRID INSTALLATIONS (BASED ON ARE, 2011B)

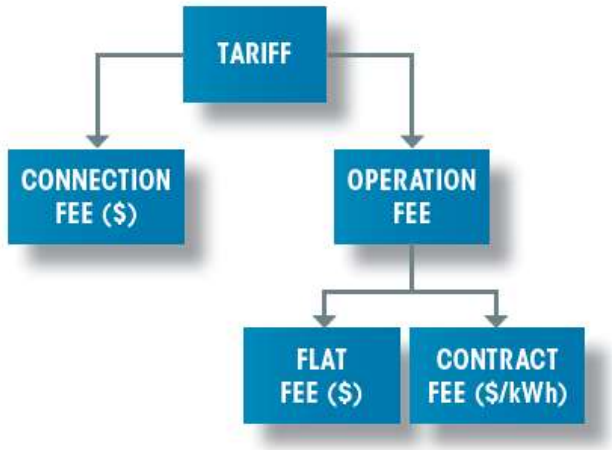


Figure 5-3: Tariff structure proposed for minigrids [source: IOREC 2012]

Local involvement in setting up and agreeing tariffs is essential.

Tariff setting can be based on principles such as:

- Based on wealth ranking of village community.
- Also based on the length of equipment guarantees. By the time that battery warranties expire for example (e.g. 4 years in the case of the four villages implemented in this project), community tariff collection should be able to fund the cost of spares and replacements.
- Each community should open a village bank (cash) and link it to a bank account. Records must be kept to income and expenditure.
- Establishing a system which gives notice to anyone who does not pay regularly. After 2 notices and ascertaining reasons why payments are not made, electric supply is cut off from mains. These records are kept in a register by the Operator and checked by the PO every 3 months. This system should be kept simple as anything too complex is liable not to understood and therefore not trusted by communities.
- Prepay systems with prepay meters are advantageous as there is no need for payment collection and debt accumulation or defaults cannot occur. There is also no need to intervene to cut off a customer who is in default because the pre-pay meter will automatically cut off the customer if there is no credit in the meter.
- Availability of prepay meter systems in Pakistan is limited and suppliers are therefore encouraged to identify suitable low cost pre-pay energy meter products for rapid deployment.

Questions which might be typically asked to a village community households include:

- Is Rs. 218 (USD 2.08) per month for 100 watts of connected load acceptable?
- Or Rs. 231 (USD 2.20) per month for 120 watts of connected load?
- Or Rs. 131 (USD 1.25) per month for 60 watt connected load?
- Can a charge of Rs. 178 (USD 1.7) per month be levied for connection charges to those below poverty line and Rs. 346 (USD 3,3) per month for others?
- Is equity and fairness important in the context of neighbouring villages being charged the same monthly rates?

The baseline energy audits identified that households are currently paying an average of Rs500-Rs2,000 per month for lighting from kerosene and candles. The monthly bills arising from a minigrid providing solar-battery LED lighting is lower than current expenditure on kerosene and candles in most cases as shown below.

5.3.1 Subsidised scenario examples

Some examples of tariff calculations for the four implementation villages are now discussed.

Table 5-1: Recommended tariffs for the subsidised (actual) scenario at Jaffar Jokhio

Customer	Initial Connection Fee	Monthly flat fee	Usage charge per kWh	Average total monthly bill	Metering system
Household	**None**	**Rs 200 per HH** USD$1.90	**Rs 16/ kWh** USD$0.15/kWh	**Rs 340/ month**	metered by cluster of HHs, VO to apportion HH payments per cluster
Enterprise	**None**	**Rs 600 per enterprise** USD$5.71	**Rs 16/ kWh** USD$0.15/kWh	**Rs 1,720 / month**	metered by each enterprise

The recommended monthly total bill is comprised of 2 parts, as per Figure 5-2 above: a flat fee plus a usage charge. The flat fee is fixed and unchanged each month, and ensures that even if a household is empty for a period there is still a contribution to covering the cost of maintenance of the minigrid.

The usage charge is based on a measured kWh usage, read by the system operator on the installed meters, similar to a KElectric utility bill. The usage charge encourages efficient usage e.g. increasing the likelihood that households will turn the lights off during the daytime, in order to save money on their energy bill. The total monthly bill average amounts shown above are estimates based on the forecast usage at household and enterprise level. The actual bills for enterprises in particular will vary widely depending on actual kWh usage by each enterprise.

Detailed financial calculations were undertaken to develop these recommendations which are provided in Appendix C below, including 20 year cashflow model for the minigrid system.

5.3.2 Unsubsidised scenarios

Analysis of the tariff and connection fees needed for unsubsidised solar minigrids was also performed. This considers a 3 year loan at 13% interest granted to the Village Organisation by a micro finance institution, and the Village Organisation providing the rest of the initial investment with a focus on connection charges:

Table 5-2: Recommended tariffs for the unsubsidised scenario at Jaffar Jokhio

Customer	Initial Connection Fee	Monthly fixed fee	Usage charge per kWh	Average total monthly bill	Metering system
Household	**Rs 26,000**	**Rs 200 per HH**	**Rs 60/ kWh**	**Rs 770/ month**	metered by cluster of HHs, VO to apportion HH payments per cluster
Enterprise	**Rs 63,000**	**Rs 800 per enterprise**	**Rs 60/ kWh**	**Rs 5,500 / month**	metered by each enterprise

Assumptions:

- Micro credit* up to recoverable value of panels, inverters, batteries
- Assume micro credit loan for 50% of Capex, 3 year term, 13% interest
- Average bill household Rs770/month, for enterprises Rs5,500/month
- Loan paid back after 3 years, then system enters profit for 17 years
- Energy Tariffs could be reduced from year 4 onwards after loan is repaid

* Consultation regarding micro credit was undertaken in Karachi with Mr Zubyr Soomro, chairman of PPAF

5.3.1 Comparison to other tariffs

The research project revealed that metered electricity customers in the target villages are typically paying Rs2000-5000/month/household and unmetered 'Kunda' users are paying Rs500-1000/month/household to use electricity for ~10 hours per day or in other cases Rs250/month/household to use electricity 4 hours per day. Unofficial tariff escalation has been applied in some cases, increasing the cost of supply sometimes to the point of unaffordability and disconnection. Installation and connection of meters when grid line extension is available, is charged by KElectric at rates up to Rs100,000 according to community representatives at Ismael Arti Jokhio.

Some villages, such as Ayub Khashkeli, are faced with defunct electricity supply which has been disconnected due to price escalation, expressed a willingness to pay Rs 4,000/month/household for a reliable electricity supply system.

The financial attractiveness of a solar minigrid can be considered in light of the following:

- metered electricity usage is unavailable in most villages
- charges to install meters from the main grid are up to Rs100,000 per meter
- when supplied, the main grid provides a maximum of 10 hours power per day, and costs between Rs2,000-Rs5,000/month/household
- Kunda supplies are available in some villages but cost Rs250/month/household for 4 hours power per day or Rs500/month/household for 10 hours power per day
- monthly charges for electricity from both metered supply and Kunda are subject to indiscriminate price escalation

On this basis, it can be concluded that a solar minigrid at the current market prices can provide :

- more reliable power: providing daytime power all day every day to businesses and night time power every night all night to households
- cheaper connection charges than metered grid electricity
- monthly costs similar or cheaper than Kunda customers
- monthly costs significantly cheaper than metered customer costs

Previous and current projects in Pakistan funded by PPAF programs include hydro and solar minigrids in KPK Province. The KPK hydro projects are adopting a Rs 4/kWh tariff and the solar PV minigrids adopt a Rs10/kWh tariff. These tariffs are set to fund operation and maintenance costs but not to recover the capital cost of the system. No documented feasibility analysis of tariff setting process at these projects was available. Typical KElectric rates for Karachi residences are Rs 16/kWh

5.3.2 Social Factors

In the case of highly subsidised pilot projects, it may be advantageous to establish tariffs which are higher than the minimum required level, in order to ensure economic value is perceived by the users.

The ability to pay at a village should be assessed by the PO through interview and questionnaire approach. On consideration the PO's recommendation may be that the villagers can afford to pay a higher amount than strictly required for maintenance and operation purposes. For example, Rs 500 / household/month.

The social advantages to increasing the tariff for a subsidised village to e.g. Rs 500/HH/month include:

- Greater value will be attributed to a system which costs a little more, conversely lower tariffs would promote a perception of lower value in the minigrid, reducing the chance of long term success. To "cheap" a product will not provide the same "respect" as something more expensive but within financial range.
- Ability to pay gauged against current expenditure on Kerosene and Candles, which is ~Rs500-2,000 / month/household according to IET questionnaire survey results.

- Inculcate that sustainability in the mind set of communities, means saving as much as possible. This has worked well where the PO (IET) has enforced this.

SUSTAINABILTY. "What happens after 10 years".

It is with great hope that a Mini Grid system installed in 4 villages of Sindh, will eventually achieve its objective to improve the living standards of its communities.

Communities have to understand the essence of 'energy on tap'. This will be a long process and continuous monitoring by social mobilisers is absolutely necessary. After all it is the communities that will make this programme a success. They will have to learn to look after the Mini Grid as a 'life source' for their sustainability.

Rural communities in Sindh, have over time, developed their own perceptions and fears of living, in some situations, on the edge of survival. They are used to hand outs, given with good intentions by philanthropists from time to time, but with drastic long term, "sustainable" repercussions.

They begin to depend on others; mostly government, and not themselves to provide their own solutions. This is, unfortunately, a mind-set that is hard to break.

So now four communities have been given an energy supply, not only for their houses to provide light at night, but also to create their own enterprises where they are masters of their 'destiny'.

This energy supply is of the highest standard technologically with the best available invertor- perhaps the most important element in the system- and long lasting batteries (at least 10-12 years).

What then happens after say 10 years. Some equipment and batteries may have to be replaced. Can these communities, who have received 90% of the hardware free, be able to replace from their resources?

It is appreciated that this is a pilot programme and many aspects will be studied, both social and technological and it is being kept in mind. Nevertheless there is an issue that needs to be addressed at this early stage of development.

Communities are used to paying small amounts of monies at a time. They can afford to do so and seems within their reach. Multi Nationals have gotten on to this. They sell small portions of shampoo, in sachets that eventually cost more than the large bottles, but is easily sold because of the acceptable 'cheap' cost.

There has to be a balance with the most "expensive", that lasts long, and the "cheaper", that lasts a shorter period of time. Would communities prefer to pay small amounts more often to replace equipment, than wait for a longer period and have to make a much higher financial commitment? Yes there is a saving scheme in place for all community members using this electric supply.

For example a village of 100 HHs having a Mini Grid costing Rs.4 million will entail a saving of Rs.350 per month per HH over 10 years to able to replace the system. Is this possible for the poorest of the poor? They will also pay a monthly usage cost as per meter installed for each cluster and for each enterprise.

Previous projects by PPAF have used a unit cost of Rs.10/kWh. However in reality for these projects, this unit cost could be closer to Rs.50/kWh.

The Energy Policy must come up with a realistic tariff. And if necessary to suggest a subsidy by Government or other source for those unable to pay suggested tariff.

Shahid Khan, CEO of Indus Earth Trust, March 2016

5.4 Operational Responsibilities

Indus Earth Trust has developed Operational Plans which are presented below. These were developed in the context of subsidised systems where 88% of the total capital costs were provided by a government agency (PPAF).

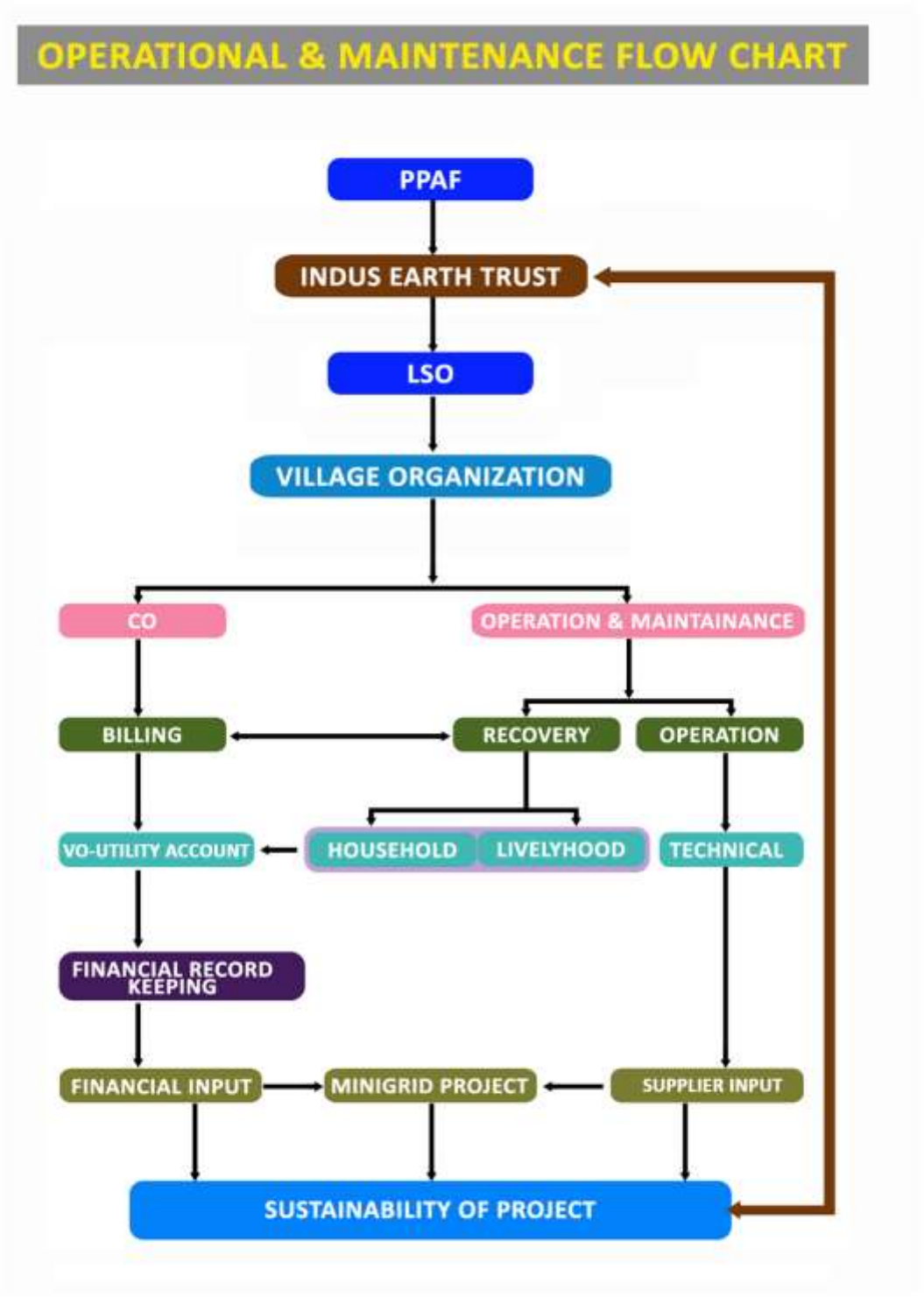


Figure 5-4: Operational and Maintenance responsibilities flow chart by IET

5.4.1 Operation & Maintenance

This is the post installation phase of the project, which is a very important and decisive stage that will lead towards sustainability of the project. A Solar Mini-grid is an exceptional project in terms of investment, technology and productivity regarding the provision of electricity for the homes, kitchens and local livelihoods. A Solar Mini-Grid (SMGP) project requires special attention and dedicated mechanisms to operate and maintain by the village organization with the conjunction of the PO and LSO.

5.4.2 Operation & Maintenance Committee

Village organization (VO) to select a five person committee: 2 female & 3 male members. With consultation of the respective Community Organisations (COs), the committee will be responsible for looking after the overall operation and maintenance of the project. The VO will review weekly progress related to the operation and maintenance. The O & M committee will responsible for reporting the current status to the VO and VO will make decisions if necessary.
The VO will recruit two young members among the community for the following tasks, they will be paid by the community organizations from their savings or O & M funds:

- SMGP Operator
- Recovery Assistant

SMGP Operator will be responsible for looking after the Mini-Grid System on daily basis, and to provide a daily report to VO representative and committee. He will focus on the system operations and he will also report to the VO as soon as possible, if he identifies any unusual technical or social issue with system. He must attend weekly meeting of the O & M committee. He can contact the Supplier and PO field engineer, if desired. He will assist the VO in O & M record keeping.

Operator Selection Criteria
Qualification Minimum: Matric, Renewable Energy Sector CRP & electrician skills will be preferred
Salary. Rs 7 ,000 / month
Workload: Part Time on daily basis.

Recovery Assistant will be responsible for collecting all monthly bills from the VO office and distribute among the household and Entrepreneurs. He will also be responsible for collecting bill charges from consumers and submit to respective COs & copy to VO. He must ensure the paid funds go to the VO and the VO then deposits the funds in the dedicated SMGP bank account.

Recovery Assistant Selection Criteria
Qualification Minimum: Matric, Financial Literacy Institutional CRP will be preferred
Salary. Rs 4,000 / month
Workload: Ten days in a month

These salary rates are based on Minimum Govt. salary structure of Rs.12,000/month

5.4.3 O & M Fund

Sufficient funds must be deposited in the CO account to cover O & M cost for the system, and also accumulate sufficient savings to pay for equipment replacement including battery replacement after warranty period. A financial model should be prepared, as illustrated in Appendix C. A system utility account will be opened separately, where monthly bill charges and Saving are deposited in CO account on monthly basis. This will enable proper financial record keeping by the CO who will publish a summary of funds to the VO on monthly basis.

The collected funds will be used for the Solar Mini-Grid System maintenance, parts replacement and operator & recovery assistant salaries. The PO will monitor and audit the financial records from time to time.

5.4.4 Sustainability

This is a community owned project - the community will operate and maintain the Mini-grid system with help of O & M committee, SMGP operator and recovery assistant. All stakeholders have to play their role which is described in O & M flow chart below and necessary input in terms of supervision, monitoring, technical, social & financial input towards sustainability of the innovative project '' Light is Not Enough'' Solar Mini-Grid System.
LSO will supervise the VO process of operation and maintenance. The VO will stay informed about the system on monthly basis.
The Tariff will be different for Domestic use and commercial use. Electricity for Commercial activities will be allowed in day time only, to preserve night time use for households and reduce wear and tear on batteries.

5.4.5 Training

SMGP operators will be trained by the solar contractors. This is on the job training at the village during the project system Installation.

Recovery Assistant will be trained by the Project Organisation, e.g. Indus Earth Trust

5.5 Payment Technology for energy microgrids

The advancement of mobile phone based payment systems such as EasyPaisa, using platforms from Mobicash and Telenor present major opportunities in Pakistan.

In an article in the Dawn Newspaper on 18th March 2016, Nadeem Hussain writes about four disruptions changing the nature of payments in Pakistan. Chairman of the Pakistan Microfinance Network, Nadeem highlights that the number of smartphones in Pakistan will reach nearly 60 Million by the end of 2017*: "These $50 devices are the mobile point of sale solutions of the future".*

Minigrids in various countries are already using mobile phone based payment systems to benefit the customers. Nadeem writes: "The customer wants convenience, security and transparency". Mobile phone payment systems offer just that, and offer wider access to the rural communities who cannot readily open bank accounts but can access mobile plans. *"Non card payments are a strong contender to cash, and we will see conversion out of cash given the convenience of this payment method",* notes Nadeem.

In Pakistan, companies such as Nizam are launching smart energy meter products which provide convenience, security and transparency. These platforms include Solarpaygo software and Nizambijli devices which enable the customer to pay monthly repayments via their mobile phone.

Internationally, the SparkMeter microgrid metering system is an example of a low-cost system consists of four hardware components, a cloud-based operator interface, and a mobile money or cash-based pre-payment system. It gives operators flexibility to choose and create unique billing structures to suit their application. Tariffs and service levels are customizable, and billing can be conducted on a pre- or post-paid basis for energy consumption, hourly consumption, or with flat monthly fees. Operators can also create "credit" accounts for customers to pay back fixed cost expenses, such as connection fees or appliances, out of their tariff payments.[20]

Benefits of such systems for village based minigrid systems include:
- Greater convenience to customers in how to pay bills
- Greater convenience when collecting payments and avoidance of bad debts and debt collection difficulties
- Where pre-payment is used, avoids need to cut off customers as payment defaults cannot occur

[20] http://www.sparkmeter.io/

- Customer payments can be directed directly into a village bank account, avoiding handling of cash and risks of corruption
- Higher security than cash based post payment systems due to high security mobile / internet systems

The standard electricity meter technology currently available in Pakistan is digital meters which are manually read for post-payment and paper billing. Due to large volume these meters are available at around USD40 per meter. These are the default option for minigrids and will utilise manual reading and paper bill payment system.

In some minigrids, no meters are used as customers are charged fixed amounts based on wattage. Such a system is already underway in a village project implemented by Indus Earth Trust where customers pay a fixed rate per month. An example electricity bill at this village is shown in Figure 5-5 below:

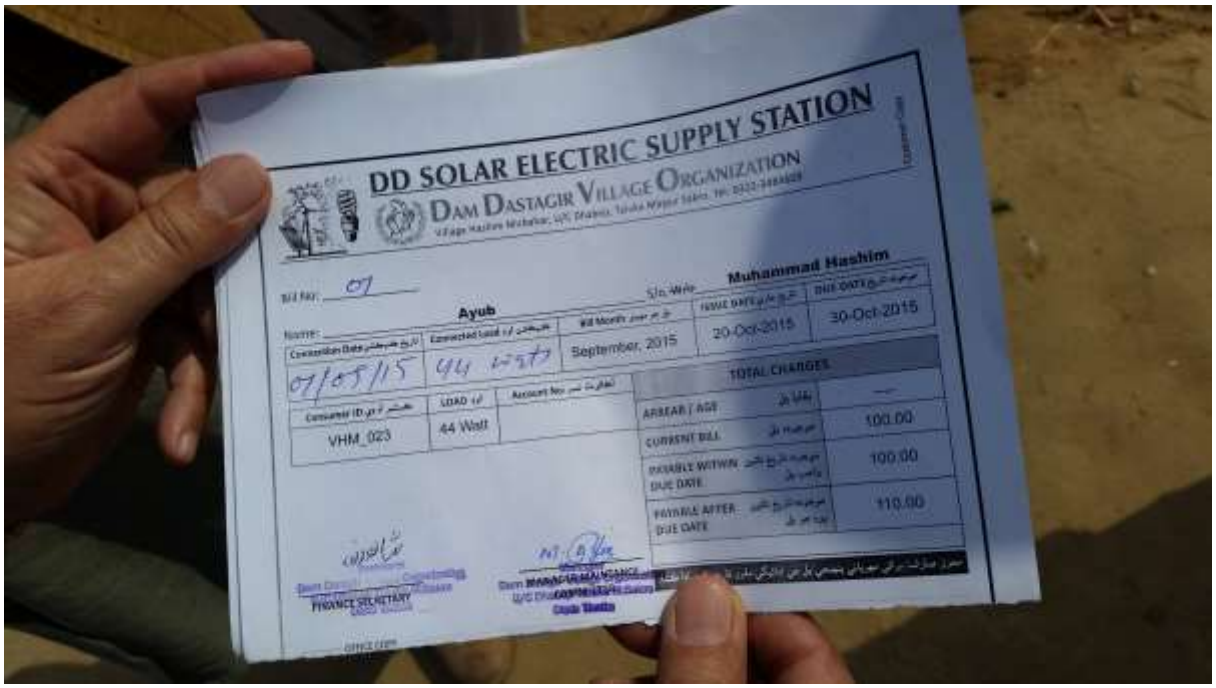


Figure 5-5: Electricity bill in Hashim Mirbahar, fixed price per month based on wattage

For the Just Light is not Enough project, the availability of mobile-based modern meter systems was investigated.

The supplier had limited access to pre-pay meter technology however agreed to establish pre-paid meters in one village out of the four.

Previous PPAF experience with metering and payment systems in KP are that each household is charged a flat rate monthly basis. Further details of the billing and metering system at other minigrid projects in Pakistan was not available.

6. Case Studies

6.1 Hamzo Samo

The photo below shows the solar array foundations at completion, security wall and gate, control building to house batteries and inverter plus cable trench digging:

Figure 6-1: Solar array foundations at completion, Hamzo Samo

Panel frame and panel installation is shown below:

Figure 6-2: Solar array being installed, Hamzo Samo

Figure 6-3: Completion of installation of Solar panels

6.2 Jaffar Jokhio

Figure 6-4 Jaffar Jokhio solar enclosure, control building and cable trenches, April 2016

6.3 Bacho Kohli

Figure 6-5: Bacho Kohli solar enclosure ender construction, April 2016

6.4 Ishaq Jokhio

Figure 6-6: Ishaque Jokhio solar PV enclosure wall and control building under construction

Layout plans of the solar Minigrids and other drawings are provided in Appendix D below.

7. Risks and System safety for Residents and Enterprises

Electric shock risk exists and should be managed and minimised.

This section outlines some key safety risks in the operation of solar PV minigrids and recommended risk mitigation measures.

It also considers project risks including time and quality issues.

The risks to success of the project have been grouped in 3 chronological periods through the project timeline: planning (project design phase, pre-construction), installation (construction and commissioning phase), and operational (after commissioning through the 25 year project lifespan).

7.1 Planning Risks

Table 7-1: Planning risks

Issue	Risk	Impact	Mitigation
Shading	Excessive shading	Reduced solar yield reducing to poor financial performance	Conduct a detailed onsite quantitative shading assessment to identify suitable PV locations and shading loss
Equipment	Poor quality equipment installed	Low solar generation, early equipment failure, warranty issues with suppliers	Ensure that detailed quality specifications are included in tender documents
Contractor requirements	Poor quality contractor selected	Poor quality installation, safety and communication by tenderer. Possible warranty and performance issues	Ensure quality detailed specifications for the tendering parties to include in-house electrical team, 5 years minimum experience in the solar industry and locally based employees and office
Installation requirements	Inadequate site information leading to variations	Higher cost of installation above budgeted amounts	Provide detailed site information during the tender phase. Conduct an on-site tenders meetings
Structural	Poor structural capacity of frames	Proposed panel layout not suitable due to structural limitations of foundtations/frames	Engage structural engineer in early stages to provide assessment of the frame and foundation structure
	Coastal winds and salt air corrosion	Corrosion on components, strong gusts dislodging panels	By using suitable Wind Load code for coastal zones, appropriate structural strength is assured. Stainless steel and galvanised components will be specified where appropriate.

7.2 Installation Risks

Table 7-2: Installation risks

Issue	Risk	Impact	Mitigation
OH&S	Workers falling from roof	Death of contractor and/or of council employee	- Ensure site specific safety issues are addressed in the tender response by the contractor, and signoff of safe work method statements prior to on site works. - Regulate that all appropriate safety hardware, safety barriers and fall restraint systems must be used
Electrical	Electrocution	Death	Ensure that only experienced electricians manage the solar installation and AC electrical connections.
Timing of installation	Installation delays	Loss of generation	Minimum weekly meetings during the installation phase

7.3 Operation Risks

Table 7-3: Operation risks

Issue	Risk	Impact	Mitigation
Equipment failure	Early failure of equipment	Loss of solar generation and replacement costs	Ensure a minimum 10 year warranty period is provided for all items of plant
Vandalism of system	Children playing near panels break panels	Loss of generation, replacement costs,	Wall to be constructed around panel array, gate kept locked Children and all residents to be educated about importance of system
Theft of power	Unauthorised connections made to network	Loss of power, loss of revenue, safety impacts	Bury cables throughout village To facilitate repair of cables when needed, bury cables with buried marker tape above
Livestock animal impacts on system	Animals, cows, goats, enter panel array area and eat/break connections	Loss of generation, replacement costs,	Wall to be constructed around panel array, gate kept locked
Warranty issues	Equipment supply company not in business	Equipment replacement costs, loss of solar generation	Ensure technical specifications include requirements regarding financial performance of the manufactures, minimum history in the industry
Contractor warranty issues	Contractor goes out of business during warranty period	Additional costs if there is a failure	- Ensure the technical specifications require the contractor has adequate experience in the industry - Ensure that the head contractor is responsible for the warranty, installation and design.
Soiling of panels	Excessive dirt on the panels	Loss of performance and hot spots developing on panels	- Ensure minimum 10^0 tilt on panels, to enable rain cleaning - Ensure routine cleaning is provided with a minimum of 6 cleans per year. - Include a maintenance contract in the tender specification - Plant area under panels with grass to minimise dust
Routine maintenance	Maintenance not undertaken	System failure, generation reduction, cost for replacement parts earlier than necessary	Ensure a maintenance plan is in place. Enter into a maintenance contract with a competent local individual from the outset of the project, include a 2-5 year maintenance contract in the initial tender.

Table 7-4: Minigrid Operation Safety risks

Issue	Risk	Impact	Mitigation
Household electrical safety	Electrocution of householder	Loss of solar generation and replacement costs	Lay cable in channel ducts to prevent from alteration & false connections. Use appropriate circuit breakers.
Enterprise electrical safety	Short circuiting	Fire due to short circuit or damage to appliances. Cost of replacement.	Use appropriate cable size as per ampacity of cable. Lay cable in channel ducts to prevent from alteration & false connections. Use appropriate circuit breakers.

Issue	Risk	Impact	Mitigation
Transmission Cable electrical safety	Electric Shock & disconnection of power supply	Casualty due to high power electrical shock & power failure.	- Bury transmission cable properly with all buried cable protocols specified by NEC. - Use XLPE type cable to prevent short circuiting & loss of power due to high temperature.
Control building electrical safety	Electric shock & short circuit.	Fire due to short circuit AC/DC. Casualty due to high power electrical shock & total power failure.	- Earth all equipment properly. - Tag all power cables and control cables. - Use cable tray with separation for AC/DC connections. - Include circuit breakers on input & output power. - Use MCCBs for high power circuits.
Panel array electrical safety	Short circuit and disconnection	Loss of fire & permanent damage to PV panel.	- Earth all solar panels & mounting structures. - Use MC4 connectors for interconnection of solar panels to provide IP65 protection at interconnections. - Use weather proof combiner boxes with proper earthing.

7.1 Weather contingencies and other risks

El nino and other factors cause heat waves, with a heat wave predicted in 2016 in Pakistan.

Battery survival temperatures may be exceeded in these conditions and insurance is required to mitigate against this risk.

Insurance should cover theft, extreme weather and fire incidents.

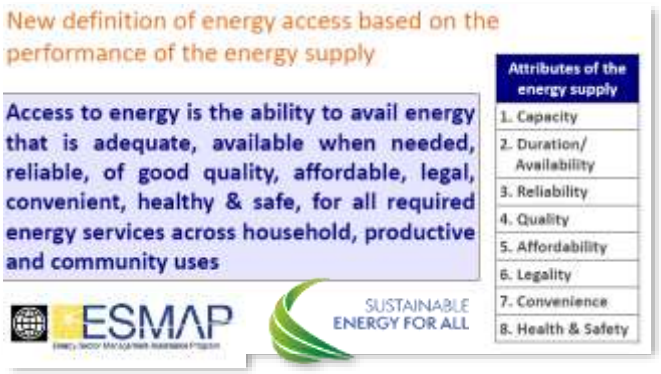
In flood prone areas, the design of systems should include elevated platform for panels and control rooms, to a sufficient height to mitigate the risk of flooding.

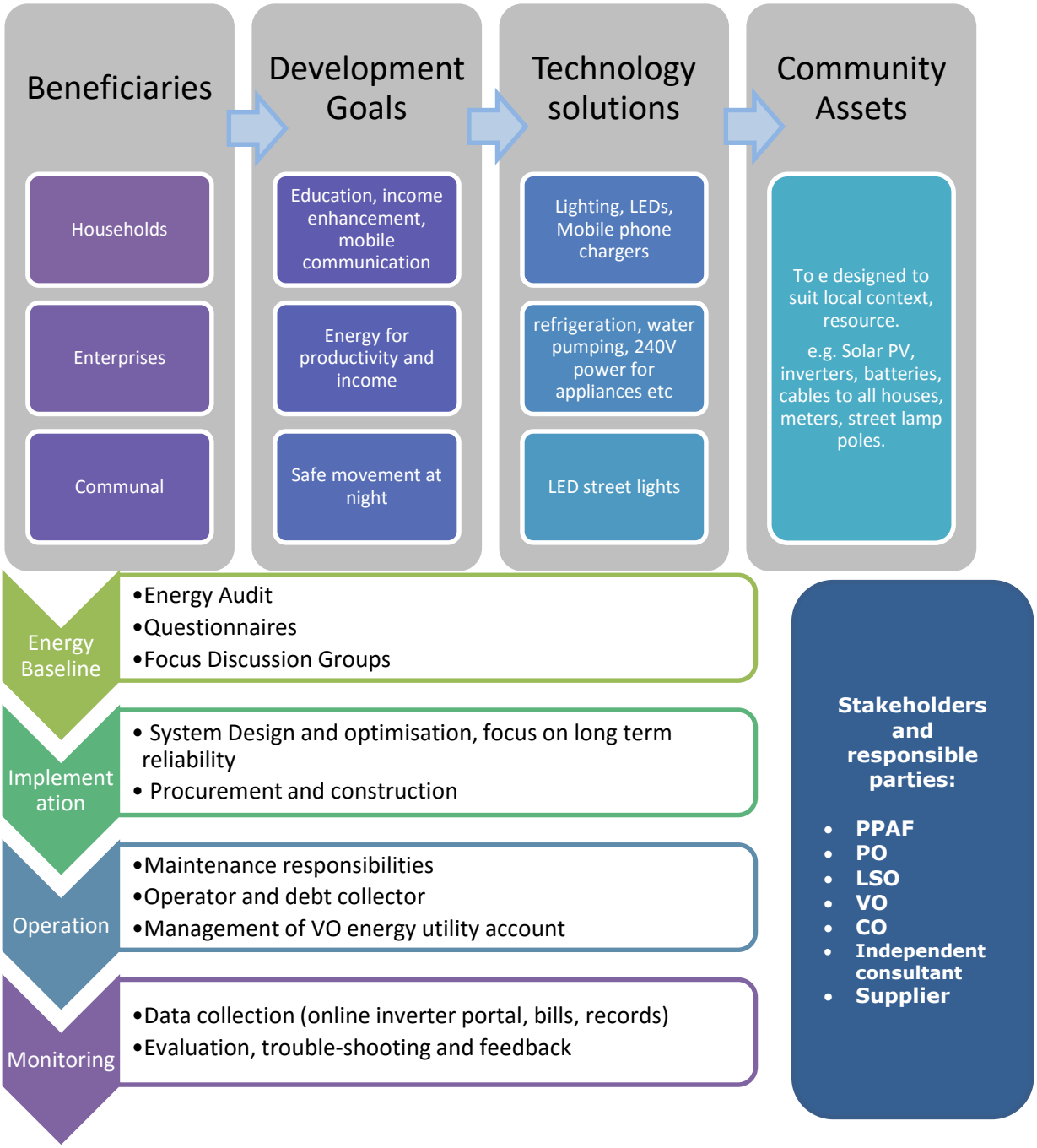
Earthquake risk must also be considered in system design and civil engineering design.

8. Template approach and recommendations

Using the international ESMAP approach, an energy supply for rural communities should have the following characteristics:

- Provide medium or high amounts of power in the context of the community
- Be available over 16 hours per day
- Provide reliable supply
- Be priced affordably
- Be legally accessible and usable
- Be convenient
- Be healthy and safe





8.1 Sector Development through phased subsidies

A Semi Subsidised program of energy access could be considered to be the next phase for sector development by PPAF, with the subsidy scheme ramping down over time.

The following figure from the IOREC Key Findings report [14] illustrates the change in grant level provided per installation and average interest rate for loans (based on IDCOL, 2012). This was in Bangladesh for a solar home system (SHS) scheme.

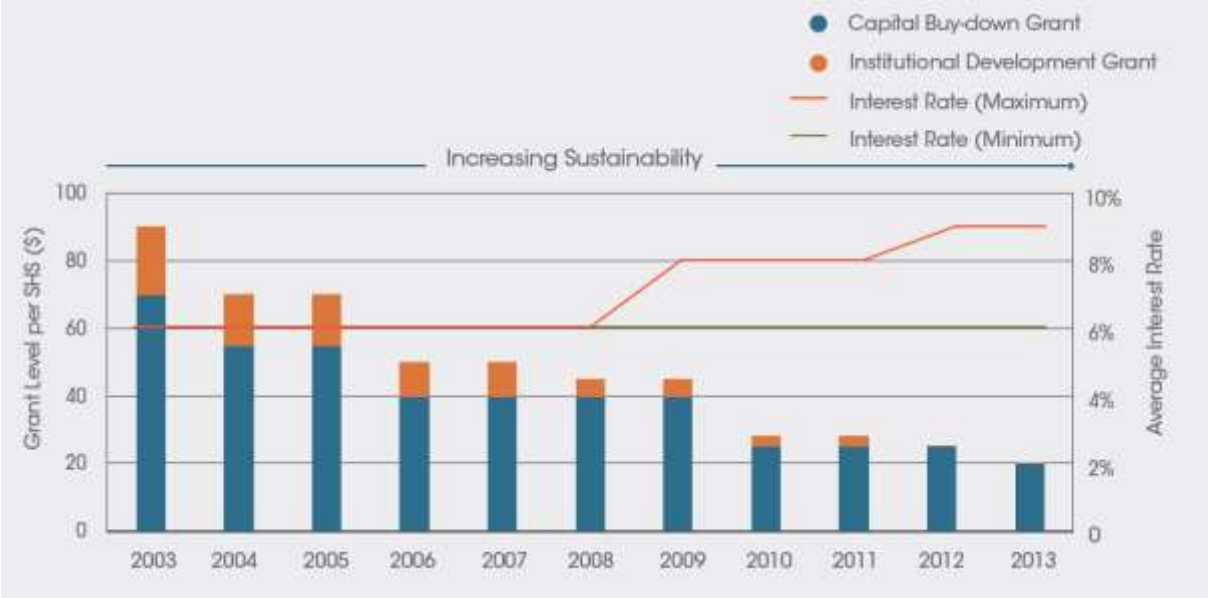


Figure 8-1: Change in grant level in Bangladesh solar subsidy scheme [14]

The IOREC report [14] notes:

> *"There is a perceptible shift in the use of donor funding sourced, for instance, from public financing or development agencies. It is moving away from partly or wholly subsidising off-grid RE systems towards supporting the creation of a sustainable market for them. In this context, donor funding can play an important role in supporting rural electrification programmes, especially in the early stages. Experience shows that the role of donor funding can be reduced as the programme reaches scale and the local off-grid market matures - as seen in the case of Bangladesh. The major financial components of the IDCOL SHS programme - grants and concessional finance - are designed in such a way that dependence on external finance gradually recedes (Figure 5-3)"*

An analysis of possible subsidy scenarios has been conducted for the Just Light is Not Enough project. This illustrates the impact on energy costs for a range of subsidy levels.

The analysis has been performed using two case studies from the implemented sites: a ~90% subsidised (actual) scenario for Jaffar Jokhio and an unsubsidised scenario for Jaffar Jokhio. A linear interpolation between these two end points provides the following graph:

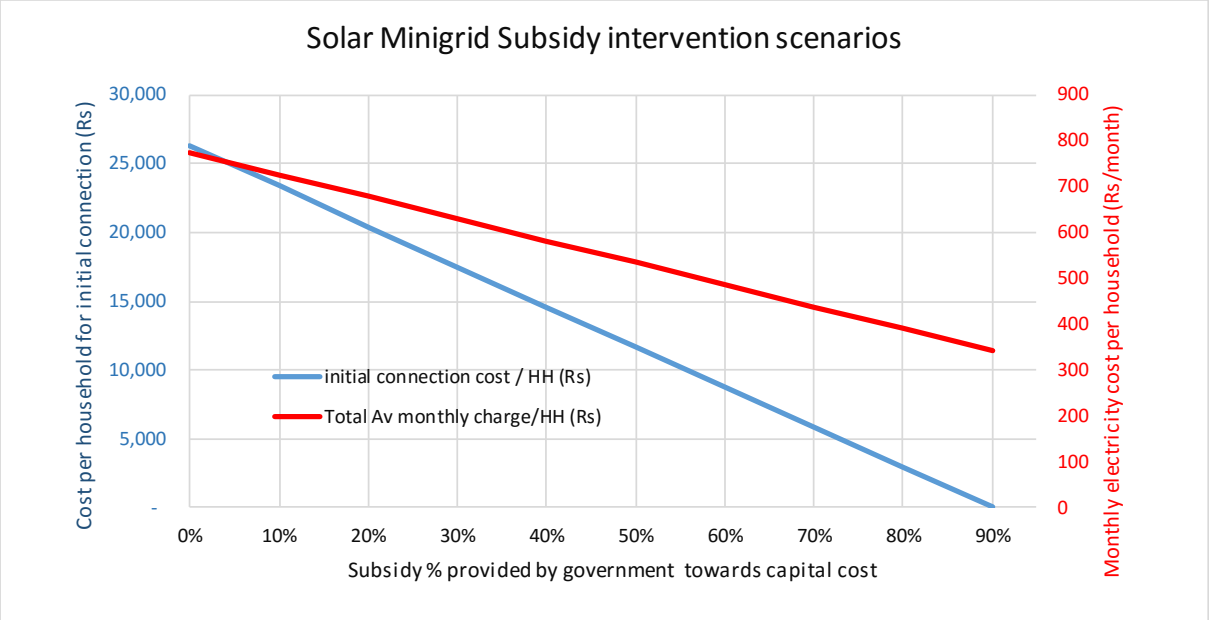


Figure 8-2: Solar minigrid subsidy intervention scenarios

This shows that scaled subsidy can provide a significant impact on the cost of energy. A subsidy scheme could be developed through either means testing ability to pay, or a universal grant percentage available to any village to apply for. The subsidy amount could be ramped down over time as per the Bangladesh example.

In addition, the existence of an advertised grant subsidy could provide incentive and higher engagement in rural regions where organised energy access initiatives may otherwise be unlikely to occur.

9. Conclusions

The demand for reliable power is widespread and it is estimated that over 140 million people in Pakistan have no access or inadequate access to power.

Rural communities in many areas are likely to have more success from island minigrid solutions than waiting for grid connection and affordable meters to be provided. The economic advantages of island minigrids compared to unreliable main grid supply are considerable, and establishment costs can be cheaper than the cost of grid connection meters.

Solar PV and battery solutions in the Sindh region offer low maintenance solutions. Capital cost amounts for minigrids are likely to be affordable to some villages without subsidy, however subsidy and capacity support interventions are important to stimulate the sector in the coming years.

Local bottom-up growth of rural energy access solutions is also likely to continue through commercial enterprises providing household and minigrid level solar solutions. This is a rapidly expanding commercial market.

Coordination between grid electrification departments, PPAF and NGOs is encouraged, in order to prioritise off grid minigrid solution activities in areas least likely to receive affordable grid connections in the medium to long term.

Strategic investigation of energy access throughout rural regions is recommended to ascertain lowest energy access locations, and where greatest savings can be obtained through avoidance of grid line extension through minigrid development.

Regulatory mechanisms to promote minigrid customer safety and consumer choice are recommended at regional and national levels.

9.1 Social Implications of intervention

It is important to understand what affect light for each home and, especially electric supply for enterprise development will have on the communities and villages in the region.

Not having had access to electrical energy for many generations for generations, it becomes important to educate, individually and collectively, the immediate and long term benefits. This is required to create real community ownership and leadership of the minigrids; and achieve long term sustainability of the energy access enhancement. There is a risk that a subsidised minigrid could be treated just as a new novelty and not given the seriousness it deserves, and community engagement in the project is paramount to its long term success.

Naturally this comprehension by communities will take time and they may have to be guided as to the full implications of this type of energy provision. It is important that a proper social mobilisation programme be continued wherever a Mini Grid proposal is to be implemented.

Literacy in the villages without a reliable electrical energy supply is very low, and in some cases literacy among women and children is non-existent.

However, it is has been noted how eager communities are willing to learn as they can appreciate that this type of intervention is for their benefit. It has been observed that in several villages' energy efficient wood burning stoves are being used for cooking. This is a positive indicator that communities are becoming aware that using less fire wood wherever possible results a reduction in health issues, deforestation and workload; in addition it indicates a positive attitude to energy efficiency and behavioural change.

Given a strong community desire for improved energy access, improvements in technology efficiency and reductions in capital cost, the opportunity for improving energy access in rural Pakistan is very large.

With a ramp up of government subsidy intervention and capacity building program, plus private sector initiatives, significant energy access enhancement can be achieved in rural Pakistan on a wide and far reaching scale.

10. References

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[4] Energy Sector Management Assistance Program, ESMAP: The Energy Sector Management Assistance Program is a global knowledge and technical assistance program administered by the World Bank. The Pakistan resources are accessible at https://www.esmap.org/re_mapping_pakistan

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[12] A New Multi-Tier Approach to Measuring Energy Access, Feb 2014, Nicolina Angelou, accessed via www.esmap.org

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[15] Pakistan 2025 – One Nation, One Vision, published 2014

Appendix A – Questionnaire survey sample and energy audit results

About the energy usage and costs pie charts:

The pie charts of energy consumption are the aggregate data from the individual household surveys.

About the Poverty Score Cards

"The Poverty Scorecard for Pakistan has been developed by the World Bank as a tool to measure change in poverty in an effective way and to support the management of development programmes that focus on alleviating poverty. It is also a useful tool for social investors that need to measure results according to the triple bottom line objectives i.e. financial, social and environmental results.

By ranking targeted households relative poverty, it helps managers target the poor, track changes in poverty, and manage depth of outreach. Because the scorecard is based on an expenditure survey, it can also provide the clients' comparative poverty. The scorecard uses 0/100 weights and 12 inexpensive-to-collect indicators. Statistically optimal weights improve its predictive power. The Scorecard uses the 2005/06 Pakistan Socio-economic Living Standard Measurement Survey (PSLM) to construct an easy-to-use, objective poverty scorecard.

In order to target particular groups for specific intervention, it is important to decide a cut-off point and label potential programme participants with score at or below a targeting cut-off in respective categories. Based on World Bank guidelines and PPAF's experience of implementing the poverty scorecard, the following cut-offs are being used to identify people in different categories."

Poverty score-ranges matrix and cut-offs

Cutoff Ranges	Score Ranges	Categories
1	0 – 11	Extremely poor/ Ultra poor
2	12 – 18	Chronically poor
3	19 – 23	Transitory poor
4	24 – 34	Transitory vulnerable
5	35 – 50	Transitory non-poor
6	51 – 100	Non-poor

Source: "Assessment of Measuring Impact of PPAF Interventions using Pakistan Poverty Scorecard", 2014 accessed from www.ppaf.org.pk/Research/ReportOnPSC.pdf

Appendix B- Meeting Minutes

Minutes of meetings attached include:

1. 9th October 2015: Expansion of the PPAF Renewable Energy program
2. 2016 meetings: IET and VO meetings

Appendix C- Tariff recommendations and financial model

Appendix D – Village Layouts and system drawings