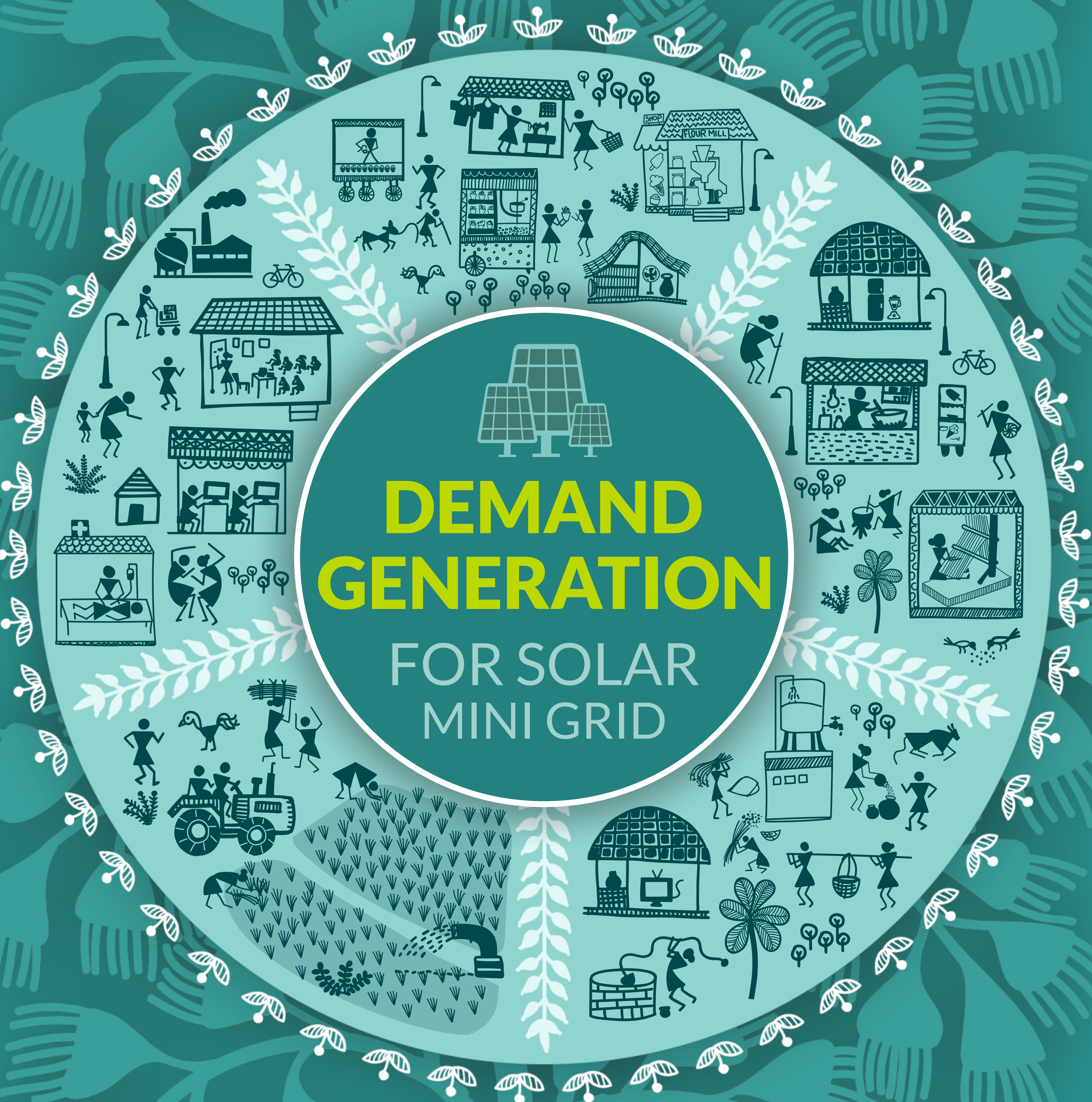
SmartPowerIndia

DEMAND GENERATION

FOR SOLAR MINI GRID



SmartPowerIndia

DEMAND GENERATION

FOR SOLAR MINI GRID

Acknowledgements

Leadership
Jaideep Mukherji, CEO, Smart Power India

Guide & Advisor
Samit Mitra, Senior Director, Smart Power India

Authors
Satya Prakash Choubey, Associate Director, Smart Power India
Piyush Kumar Prasoon, Partner, Samavit
Soumya harsh Pandey, Partner, Samavit
Sachin Kumar, CEO, Samavit
Prodyut Mukherjee, Partner, En-genuity

Publications Team
Vaishali Mishra, Associate Director, Smart Power India
Himani Gupta, Chip Munks
Karmendra Singh Negi, New Edge Communications Pvt. Ltd.

Special Thanks
All our Mini Grid developers/ESCOs, Micro Enterprise Development and Program Implementation partners, members of Smart Power India Program Implementation & Demand Generation team and specifically to all Village Level Entrepreneurs who were an integral part of SPI's journey.

Foreword

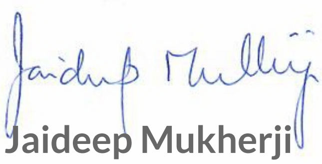
India has made phenomenal strides in achieving universal electrification. It is indeed a welcome development that due to the government's persistent efforts, all villages in India have been electrified and today, almost 100% households have received electricity connections. Now that the government has achieved this commendable feat, it is time to shift attention to the next electrification challenge of providing effective, quality electricity supply and service not just for lighting purposes but also for productive use. It has been well established that electricity is a change agent that improves quality of life and promotes economic activities.

However, in order for it to work as an effective catalyst, it is essential to ensure sufficient and affordable electricity supply, delivered with good quality, and supported by good services. While there has been tremendous progress made in rural electrification with respect to household electrification, challenges remain in even ensuring basic connections to rural businesses and micro-enterprises.

It is with this overarching objective, Smart Power India (SPI) established in the year 2015, embarked on a journey with a vision to drive socio-economic progress of rural customers by ensuring access to reliable and quality electricity. As of September 2020, we have supported 12 developers in building a portfolio of over 330 mini-grids in the states of Uttar Pradesh, Bihar, and Jharkhand. These mini-grids cumulatively serve over 2,80,000 customers – from households and shops requiring simple lighting, to commercial enterprises, telecom towers, agri-processing, and schools.

The mini-grid sector has proved that reliability is key to unlocking latent demand and achieving the full economic potential of energy access in under-served regions. Only with access to reliable power are enterprises likely to employ relatively expensive and sophiscated appliances for productive purposes. When this happens, we observe a triple-win of improved household incomes, increased enterprise productivity and higher revenue for mini-grid operators.

The Demand Generation Manual for Solar Mini Grid that SPI has put together aims to address the importance of electricity for productive use by creating adequate demand among customers. The focus of this manual is to thus guide practitioners on how to generate demand, impacting the mini-grid sustainability, supporting micro-enterprises, and the well-being of the rural community. Even though the described context is predominantly of the Indian mini-grid set up, we do believe that the manual will be useful for the larger global audience who can replicate the outlined value chain customizing it to their respective situations.



Jaideep Mukherji
CEO, Smart Power India

Foreword

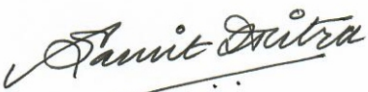
"Electricity coming to the village is really a good thing to happen, but the biggest challenge is how to make the villagers use it for their own benefit". This is what I was told by a village Sarpanch (local elected representative) of Gumla in the Indian state of Jharkhand during one of my initial visits to a mini grid site. With time, I have realised how prophetic this statement has been. Electricity is just not only a mean for the development of a village, but how it's utilised by the inhabitants defines the overall socio-economic well-being of the community.

Over the past five years, we have witnessed how villages have transformed themselves from being sleepy hamlets to vibrant commercial hubs. From distress migration to becoming self-sufficient by taking up farming on their own pieces of land, women from being housewives to thriving entrepreneurs, villages getting regular supply of safe drinking water, well-lit roads, access to news and entertainment, accessible health support systems, but above all the presence of a certain level of confidence, these villages are replete with examples of community achievement and success stories.

During this journey, the most important thing that we learned, as a team, is not to underestimate the ambition and ability of rural India. If we are able to understand their needs and also where their strength lies, and design the programs addressing these aspects, the chances for these programs to succeed are very high. We usually try to develop a programme sitting in our ivory towers (based on our best judgement) and then try to parachute it down to the village setting without considering the local socio-economic conditions or the skill sets prevalent in the local area. In most such cases, the implemented programmes fizzle out with time.

I have come across the rhetoric of developing successful pilots and proof of concepts for DRE based productive uses in a lot of conferences, webinars and seminars time and again. We at SPI have been walking the talk for the past 5 years. We have not only been able to create through our program implementation team and partners, able proof of concepts for productive use but have also successfully demonstrated scaling up of profitable and sustainable rural micro enterprises. We strongly believe that on ground and real-life success stories are the best form of evidences of sustainable projects that can inspire others to replicate similar activities.

Through this handbook, we have shared our learnings, both successes and failures, so that the need to reinvent the wheel is reduced for interested practitioners in the field of DRE and livelihood. We do hope that this handbook proves to be useful for Mini Grid developers, Livelihood development practitioners, Multilateral Organisations and Investors and above all the rural community who need a little bit of encouragement and guidance to achieve their dreams. We, at SPI, look forward to provide support and guidance to all such stakeholders.



Samit Mitra
Sr. Director, Smart Power India

Table of Contents

1 THE RATIONALE FOR MINI-GRIDS

1.1
History of Rural Electrification in India

With the understanding that access to electricity is a vital input in socio-economic development, policymakers have been focusing on rural electrification since the past many decades. Food shortages marked the decades after Independence due to weak agriculture production. To increase production, the Government of India (GoI) in 1969 established Rural Electrification Corporation (REC) to promote grid-connected irrigation pump sets and bring in more area under irrigation. Then in 1974, the Minimum Needs Program (MNP) was launched to enhance access to electricity services to rur al areas. All subsequent programs since then had focused on universalizing access to electricity, like the Kutir Jyoti Program (KJP). KJP, launched in 1988-89, aimed at improving the quality of life of the poorest households through the provision of single-point connections[1].

During[2] all this time till 1997, the definition of an electrified village was "A village should be classified as electrified if electricity is being used within its revenue area for any purpose whatsoever." After 1997 and till 2004, the definition of an electrified village was enlarged to "A village is deemed to be electrified if the electricity is used in the inhabited locality, within the revenue boundary of the village for any purpose whatsoever." In 2000-01, GoI launched the Pradhan Mantri Gramodaya Yojana and added a rural electrification component to it the next year. In 2003-04 the Accelerated Rural Electrification Program was launched. The following year, this program was merged with the KJP to form Accelerated Electrification of one lakh villages and one crore households. The merger brought into focus the importance of 'household electrification.'

To deepen village electrification, GoI in 2004 e xpanded the definition of an electrified village and, in 2005, merged all ongoing schemes/programs to launch the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY). Now, the village is considered electrified if:

(a) necessary infrastructure such as distribution transformers and distribution lines are provided in the inhabited locality;

(b) electricity is provided to public places like schools, Panchayat office, health centers, community centers;

(c) the number of households electrified should be at least 10% of the total number of households in the village.

The focus of RGGVY was to create a backbone of rural electricity supply, however, at the risk of being extensive (number of villages electrified) rather than intensive (% of households covered)[3]. Interestingly, RGGVY had a component on Decentralized Distributed Generation (DDG) for remote villages where grid connectivity was either not feasible or not cost-effective. All un-electrified villages and hamlets having a population of more than 100 were eligible under the scheme, and identification of eligible villages was to be done by the State Nodal Agencies (SNAs) in consultation

[1] A brief history of rural electrification in India. https://www.engenuity.co.in/file/Rural%20electrification%20-%20a%20brief%20history%20and%20context%20for%20the%20future.docx
[2] Dakshinanchal Vidhyut Vitran Nigam Ltd:: DVVNL. https://dvvnl.org/RGGVY_def_electrified_village.aspx
[3] Modi, Vijay, 2005. Improving Electricity Services in Rural India, CGSD Working Paper No.30, pp. 30

with State utilities/Distribution companies (DISCOMs) and MNRE. The Ministry of Power, which has always been anchoring rural electrification programs through Rural Electrification Company (REC), and the Ministry of Renewable Energy (MNRE) jointly assumed responsibility of providing electricity to remote hamlets/villages through Renewable Energy Technologies (RET). MNRE had also been running Remote Village Electrification Program (RVEP) and Village Energy Security Program (VESP) through the SNAs. In 2014, GoI launched the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), which in addition to the rural electrification component of RGGVY, had additional components on the separation of agriculture and non-agriculture feeder. It further strengthened/augmented transmission and distribution infrastructure in rural areas. RGGVY was thus subsumed into DDUGJY[4].

While the country was on its course for 100% village electrification, which happed in April 2018, GoI in September 2017 launched the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) targeting 100% household electrification of all interested households, estimated at 3 crore[5]. To date, 99.99% of all interested households have been electrified, and the remaining households will be pro vided with basic electricity services shortly.

1.2

The Paradox of Demand-Supply Gap

Despite such significant strides in the universal village and household electrification, studies consistently reflect that this more comprehensive electricity coverage, especially in rural areas, does not automatically result in increased and sustained consumption of electricity resulting in improvements in incomes and quality of life. The gap is a result of mismatches between characteristics of demand and supply.

1.2.1

Supply-Side Issues

Rural electricity distribution is primarily the responsibility of the state-owned DISCOMs. They do not prioritize the quality supply of power to rural areas primarily because of the following challenges:

- **High capital investments:** creating the necessary infrastructure of sub-stations and feeders and providing connections to individual connections is a capital-intensive exercise that acts as a deterrent for the DISCOMs.

- **Higher losses:** a large number of distributed loads increase the distribution losses for the DISCOMs.

[4]http://www.swaniti.com/wp-content/uploads/2017/07/DDUGJY-Brief_Schemes-Compendium.pdf
[5]http://pib.nic.in/newsite/mbErel.aspx?relid=171148

- **Lesser returns:** typically, rural consumers have lesser paying capacities as compared to their urban counterparts. This issue, coupled with lesser per capita consumption of electricity (at least in the domestic category due to lesser use of electrical appliances), results in lesser returns for the DISCOMs per unit of electricity supplied to a rural consumer as compared to an urban one.

- **Operational inefficiency:** per unit cost of billing and collection for a rural consumer is comparatively higher as compared to urban ones. Billing and collection in rural areas are not economical without automation or computerization of electricity distribution. It should also be noted that a significant component of this operational inefficiency of DISCOMs is hidden in the 'pilferage' component of their financial statements.

- **Higher pilferage:** though this is not specifically a rural phenomenon, coupled with the above issues, the theft of electricity in rural areas through by-passing of meters, hooking (katiya), and bribing of DISCOM agents further aggravate the supply challenges.

Technological interventions like pre-paid metering, load limiters, use of armored cables, remote monitoring can help address some of the above challenges of pilferage, and operational inefficiency. Institutional models like input-based franchisees have also been explored in different parts of the country, though with mixed results, to address collection and operational issues. Also, government programs like APDRP carry out the augmentation of distribution infrastructure. However, low returns from investments have been a consistent challenge for the DISCOMs.

1.2.2 Demand-Side Issues

Rural consumers have comparatively much lesser demand for electricity as compared to their urban counterparts, at least at the household level and excluding the energy consumed for irrigation water pumping. The low demand is primarily due to:

- **Lower ability to pay:** rural households have much less per capita income as compared to urban households, and thus the amount of disposable income is also lesser impacting their ability to pay for electricity and electrical appliances. Also, incomes of rural households are from a mix of livelihood options, the returns from which are not assured and in control, thereby impacting their ability to pay for electricity and electrical appliances.

- **Poor quality of supply:** there is a muted demand for electricity services due to the poor quality of supply characterized by frequent, unscheduled, and prolonged power cuts, voltage fluctuations, and tail-end voltage drops.

- **Lower willingness to pay:** the above two reasons result in the lower willingness of villagers to pay for electricity services.

- **State focus on household electrification:** in the 1990s, the State focused on pump-set energization and village electrification for improving rural energy access. Since the last couple of decades, the focus has primarily been on household electrification, with commendable achievements. The provision of electricity services for micro industries and off-farm based livelihood activities have never been the focus.

- **Characteristics of rural markets:** the availability of electrical appliances and their servicing support is limited, resulting in unmet demands.

1.3

Emergence of Mini-Grids

Small local grids operating in parallel to the distribution network have been in vogue in urban and peri-urban settings in energy deficit regions since decades[6]. Diesel Genset (DG) operators selling power in the evenings based on light, fan, and TV points in energy-deficient habitations were quite common in the 1980s until the early 90s. With the improvement of the power supply scenario in the 1990s, these local grids went out of business. However, the rural power supply scenario did not improve. Private players came up in many rural areas to meet household electricity needs, especially through renewable energy-based mini-grids in rural areas[7]. Bad quality of grid supply, unavailability of supply, fall in RET costs, knowhow on RETs and their implementation, support from donors, and acknowledgment of the State on the difficulty (financial and technical) of extending the grid to remote locations and non-remunerative loads have been the drivers for mini-grids[8]. The poor financial condition of the erstwhile State Electricity Boards (SEBs) and later the DISCOMs coupled with increased levels of disposable income in villages and fulfilling the aspirational needs of the rural population also contributed to the emergence of this sector.

[6] Living with Load Shedding, Vol 15, Issue No. 24-25, Economic and Political Weekly, 14 June 1980
[7] Bhattacharyya, S.C., 2012a. Energy Access programs and sustainable development: a critical review and analysis, Energy for Sustainable Development, Energy for sustainable development, Volume 163, pp. 260-271
[8] Tongia, Rahul. 2018. Microgrids in India: Myths, Misunderstandings, and the Need for Proper Accounting, Brookings India, pp 5

1.4

What is a Mini-Grid?

Mini-grids are electricity distribution systems comprising generation sources (e.g., solar panels, biogas plant), and a distribution network to deliver power to customers. A typical rural mini-grid (figure 1.1) distribution network extends 1-2 km from the plant, allowing it to service 100-140 households, 50-60 shops, and a mix of productive users.

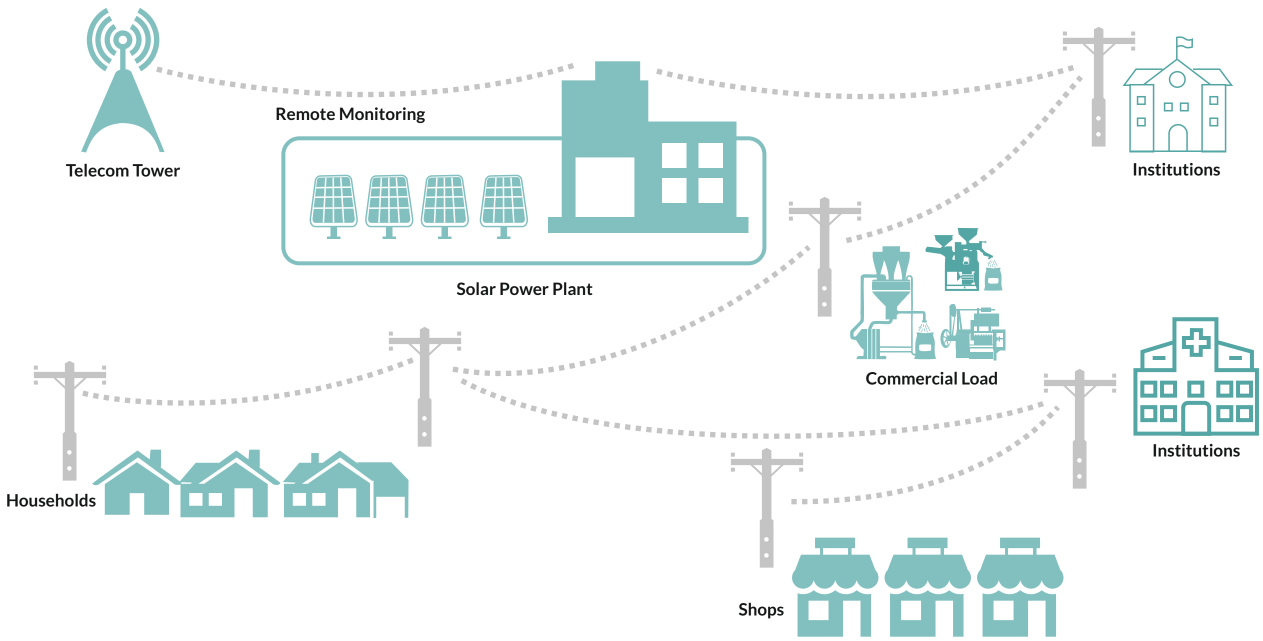


Figure 1.1C : A typical solar mini-grid

1.4.1

Benefits and Constraints of Mini-Grids

Mini-grids provide capacity for both domestic appliances and local businesses and have the potential to become the most potent technological approach for accelerated rural electrification. Mini-grids also offer an optimal solution for utilizing localized renewable energy resources. Many locations offer excellent natural conditions for the use of solar photovoltaic (PV), wind, or small hydropower. In recent years, RETs have evolved dramatically in terms of prices, efficiency, and reliability. Today, conservative calculations of life-cycle costs show that RE based mini-grids are usually the most competitive technical solution.

[9]https://www.ruralelec.org/sites/default/files/hybrid_mini-grids_for_rural_electrification_2014.pdf

Mini-grids have to demonstrate to existing and prospective electricity consumers that they offer above mentioned tangible benefits over alternatives (possibly cheaper) energy sources such as kerosene lamps, diesel generators, solar home systems, rechargeable batteries, and the government grid. The drivers of customer satisfaction—and hence their willingness to pay for a mini-grid connection—are described in Box 1, which constitutes the "customer service mantra" for mini-grid developers[10].

Box 1: Why customers choose mini-grids ?

- **Quality and reliability of power :** mini-grids must ensure dependable, uninterrupted service, at a voltage sufficient to run customers' appliances
- **Packages tailored to local needs:** a variety of package options with a range of tariffs, load levels, and timings satisfy customers that they are paying for what they need
- **Responsive customer service:** agents available to resolve technical problems, assist with package changes, and spread information about promotions with high customer engagement and perceptions of dependability
- **Investment in the local community:** ESCOs invest for supporting access of energy efficient appliances for customers—both household and commercial.

Regarding the limitations of mini-grids, technical constraints of technologies like loads and their usage patterns are a significant limitation. Also, per-unit rates of electricity are generally higher than what the grid offers, which acts as a barrier for communities to pay for the services. Finally, mini-grids, like other electricity initiatives in the power sector, have to function in the existing regulatory framework, and this sometimes limits the extent of benefits that they can offer to communities.

1.5

Business Models for Mini-Grids

Business models of mini-grids vary according to their ownership, which also is dependent on existing regulatory frameworks. In the context of rural electrification in India, DISCOMs, or entrepreneurs or village institutions can own, manage, operate, or maintain the systems. Based on ownership, business models[11] could be:

[10]http://www.smartpowerindia.org/Media/1140/MGH%20Hand%20Book_V3%2022%20Nov%20FInal%20Edited%20For%20web%20use%201.pdf
[11]https://www.usaid.gov/energy/mini-grids/ownership/models

1.5.1
Community-Based Business Model

In this model, local communities own, manage, operate, and maintain mini-grids through an institution that they develop (figure 1.2). Such projects usually receive external funding and assistance in design and installation. Once the mini-grid is installed, the community institution collects tariffs and runs the project.

Community-based ownership models are standard in developing countries where private companies and utilities lack the capacity or incentive to electrify remote communities. In remote rural areas, where tariffs won't cover investment costs, community-based ownership may be the only option.

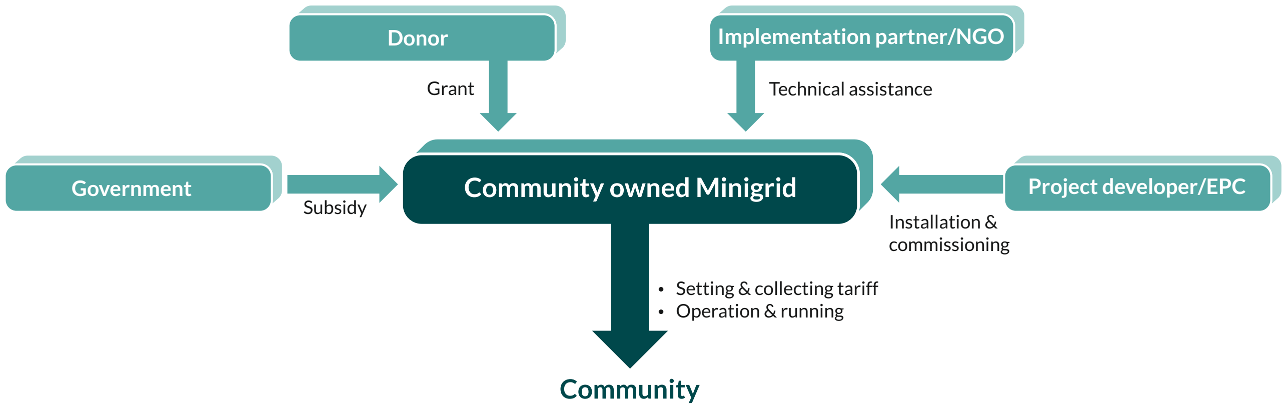


Figure 1.2: Simplified community-owned business model

1.5.2
Private Sector Based Business Model

In this model, a private investor pays to construct, operate, and maintain the mini-grid (figure 1.3). Funding often comes from private equity and commercial loans. Involving the private sector in mini-grid development can be challenging since small-scale, remote projects are not usually profitable. Creative approaches, however, can make the mini-grid investment financially attractive. Entrepreneurs use the anchor load approach, community clustering approach, and private-private partnerships to implement successful projects.

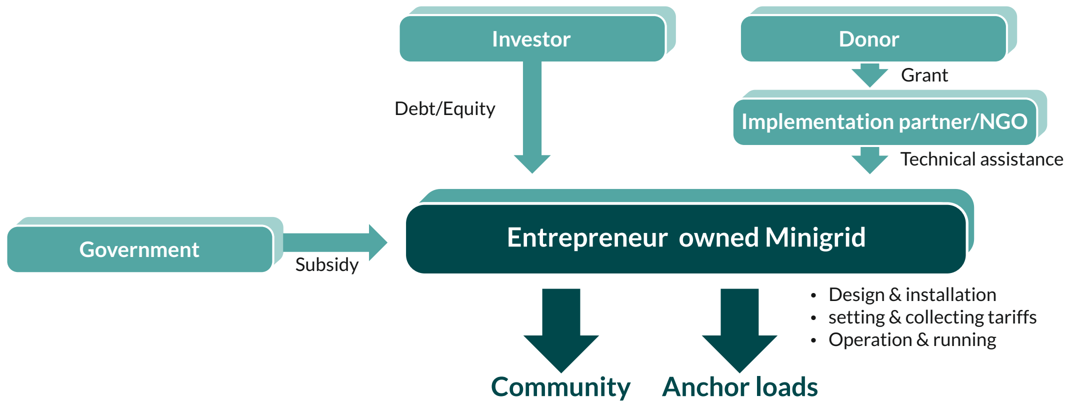


Figure 1.3: Private sector based business model

1.5.3
DISCOM Based Business Model

DISCOMs can also own mini-grids in much the same way as their distribution network but on a smaller scale (figure 1.4). In some such models, the DISCOM contracts with local firms to manage parts of the project, say like billing and collection[12]. DISCOM based mini-grid projects often use subsidies to keep tariffs affordable in remote communities.

Figure 1.4: DISCOM based business model

1.5.4
Hybrid Business Model

Hybrid business models[13] combine different aspects of the models given above. Different entities could be involved in investment, ownership, and operation of a mini-grid. There is a division of labour between the responsibilities of various actors involved in the mini-grids through joint ventures or other contractual arrangements. The generation and distribution of electricity can be divided between government companies, private firms or local communities in the form of small power producers (SPPs) and small power distributors (SPDs). The success of these models is dependent on the regulatory framework and clarity of property rights.

Examples of contractual arrangements that are a part of hybrid models are:

- Public-private partnerships: public sector could build, operate and manage the mini-grid with the private firm responsible for maintaining the system
- Renewable energy service companies (RESCOs): assets are owned by the government and the machinery is operated and maintained by RESCOs. They are also responsible for tariff collection.

[12]Similar models called franchisee has mixed success in India.
[13]https://e4sv.org/wp-content/uploads/2017/05/TR9.pdf

- Concessions: beneficial terms are given to the concessionaire to provide electricity to rural areas. These terms could be in the form of geographic monopolies or preferential tariffs.

- Power purchase agreements: distribution and generation assets are owned and controlled by different entities and a power purchase agreement is signed for providing electricity

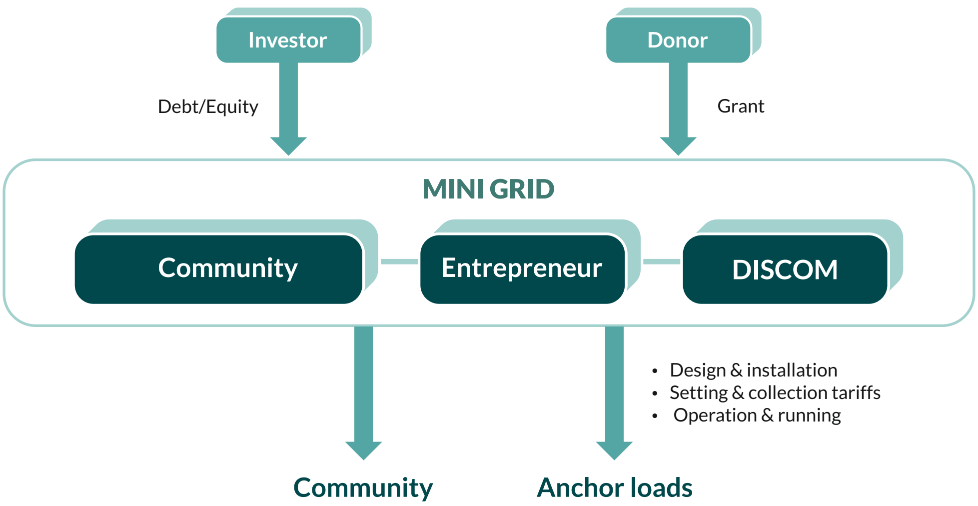


Figure 1.5: Hybrid business model

1.6

The Need for Demand Generation

To be financially sustainable in the long run, the energy service companies (ESCOs) running the mini-grids need to focus on meeting the village's existing power demand along with building additional demand for power by supporting the development of local micro-enterprises. Such a strategy is a win-win for both the ESCO and the community as the development of micro-enterprises translates into the higher economic development of the village and increased demand for electricity from the mini-grids resulting in higher revenues and profit.

The objective of this manual is to guide practitioners on how to generate demand, impacting the mini-grid sustainability, supporting micro-enterprises, and the well-being of the rural community.

Points to remember

- REC was established in 1969 to promote grid connected irrigation pump sets and bring in more area under irrigation

- Till date different initiatives were taken by the Government of India to deepen the grid connectivity in the rural areas.

- Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) was pivotal in achieving 100% rural electrification while Pradhan Mantri Sahaj Bijli Har Ghar Yojana led to the 100% household electrification.

- Despite achieving such a remarkable feat there remains supply side and demand side issues.

- Some of the supply side issues are high capital investments, higher transmission losses, lesser return, operational inefficiency, and high pilferage leading to loss making DISCOMS

- Demand side issues affecting electricity consumptions are lower ability to pa y combined with low willingness to pay, poor quality of supply and state focus on household electrification while neglecting micro-enterprise.

- The mismatch between demand and supply side has resulted in solar mini-grids

- Mini-grids are electricity distribution systems comprising generation sources (e.g., solar panels, biogas plant), and a distribution network to deliver power to customers. A typical rural mini-grid distribution network extends 1-2 km from the plant, allowing it to service 100-140 households, 50-60 shops, and a mix of productive users.

- There are various business models for mini-grid depending on ownership of the generation and distribution – community-based business model, private sector-based business model, DISCOM based business model, and hybrid business model.

2

DEMAND GENERATION STRATEGY FOR MINI-GRIDS

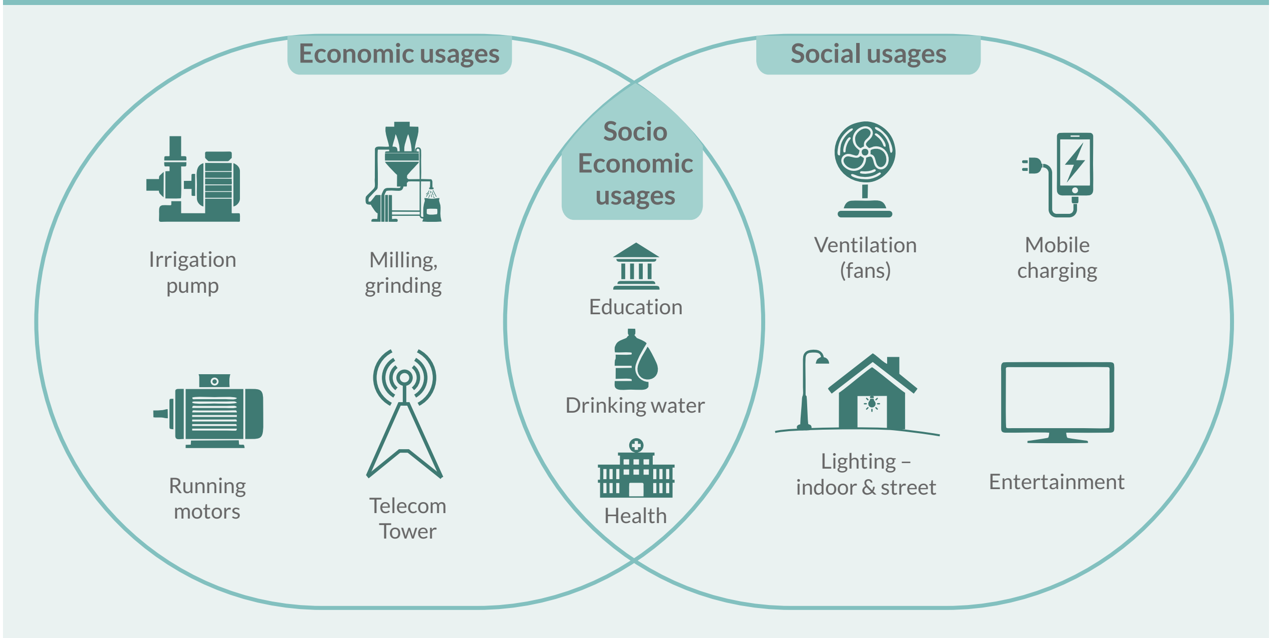
2.1

Usage of Electricity in a Village

Electricity usage can be social and economic. Economic usage of electricity enhances incomes while social usage improves the quality of life of the household. Use of electricity for income-generating activities like running appliances or motor in shops and micro enterprises, water pumping for irrigation are examples of economic usage of electricity (Figure 2.1). In contrast, electricity for common usage resulting in better indoor air quality, better lighting, ventilation, and entertainment is a social usage.

Often there is an overlap between the two, and it is a matter of valuation of the benefits that become important in identifying impact of mini-grid. For example, adequate health, education, and drinking water services need energy provision and are social usages, but their sub-optimal performance due to lack of energy results in losses in productivity and hence the linkage with commercial usage.

Figure 2.1 : Examples of economic and social usage of electricity



For demand generation, an ESCO needs to identify the electricity usage in a village where the mini-grid will be set up and classify the usages into the above two categories to impute the value of electricity services.

Post identification of electricity usage, the next step for the ESCO is the estimation of demand arising from the use of various appliances and equipment. Studying the 'motor specification details' and description of the appliances/equipment reveal their loads.

2.2

Segments of Rural Demand and Usage Patterns

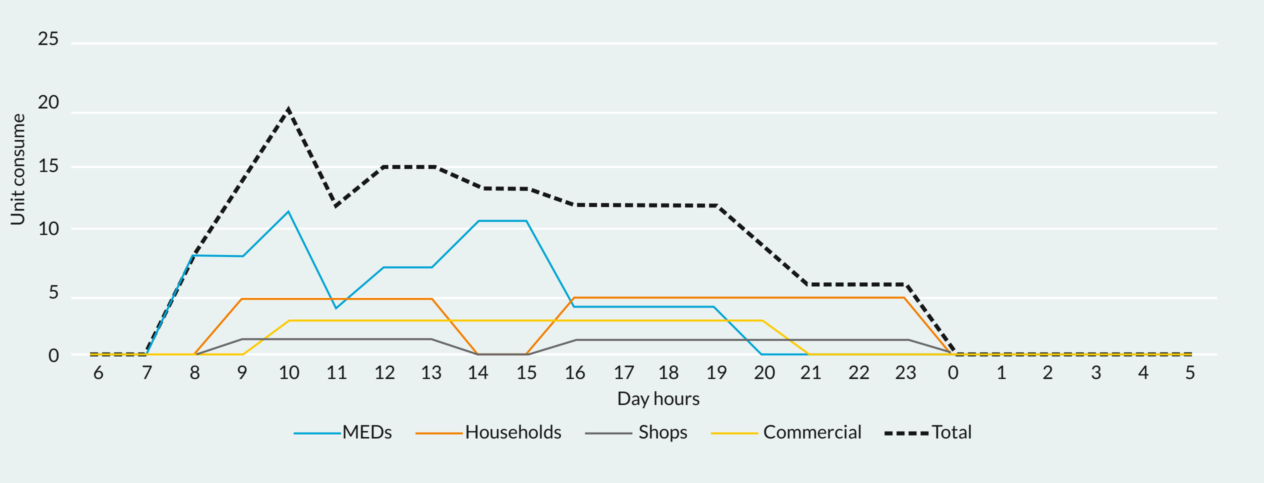
The ESCO also needs to identify the various segments of the demand that exists and that can be developed in a village which will be catered to by the mini-grid. Broadly there are five customer segments in a rural context. Table 2.1 shows the different customer segments and their average daily load utilization and pattern of electricity consumption.

Table 2.1: Customer segments and usage patterns

Customer segment	User example	Load (kW/ day)	Electricity usage pattern	Type of load	Challenges for ESCO	Opportunity for ESCO
Domestic	Houses	0.1 – 0.3	Night	Lighting, fan, mobile charger, television	Not enough device or conventional device	Meeting immediate demand, promoting Energy Efficient Appliances (EEAs)
Shops	Small, large or medium shops	0.1 – 0.3	Day			
Commercial Motors (Industrial/ agriculture)	Flour mill, irrigation	2 – 5	Day	Motors, Refrigerators, Machines	Manual; not enough enterprise	Introduction of motors, finance, market linkage
Institutional	School, bank, ATMs, health center	1-4	Day	Light, fan, mobile charger, laptop, printer	Conventional device	EEA
New Demand Generation	Oil Expeller WTU and Flour Mill	10-15	Day	Motor	Not enough enterprise	Introduction of motors, finance, market linkage

When we plot the loads as mentioned above of each segment (expressed in kW) against time intervals on a graph, we get a Load Curve (figure 2.2). A load curve is useful to understand the distribution of segment-wise and overall load over a twenty-four-hour period. The smoother this curve, i.e., with few spikes, the easier it is for the ESCO to design its generating unit with minimum energy storage resulting in lesser per unit generation cost and hence tariff for customers. In the case of solar-powered mini-grids, the closer the load curve matches the solar generation curve, the more manageable it is for the ESCO to service the loads, with lesser energy storage. Also, in the case of spikes, the load curve provides the ESCO a basis to design packages for different customer segments.

Figure 2.2: A typical load curve of a mini-grid site



It should be kept in mind that load curves change over seasons, and the ESCO needs to develop them for different seasons so that an appropriate strategy for servicing customers can be designed.

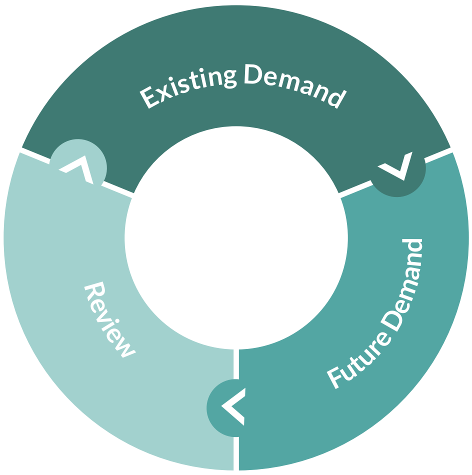


Figure 2.3: Cyclical nature of demand estimation

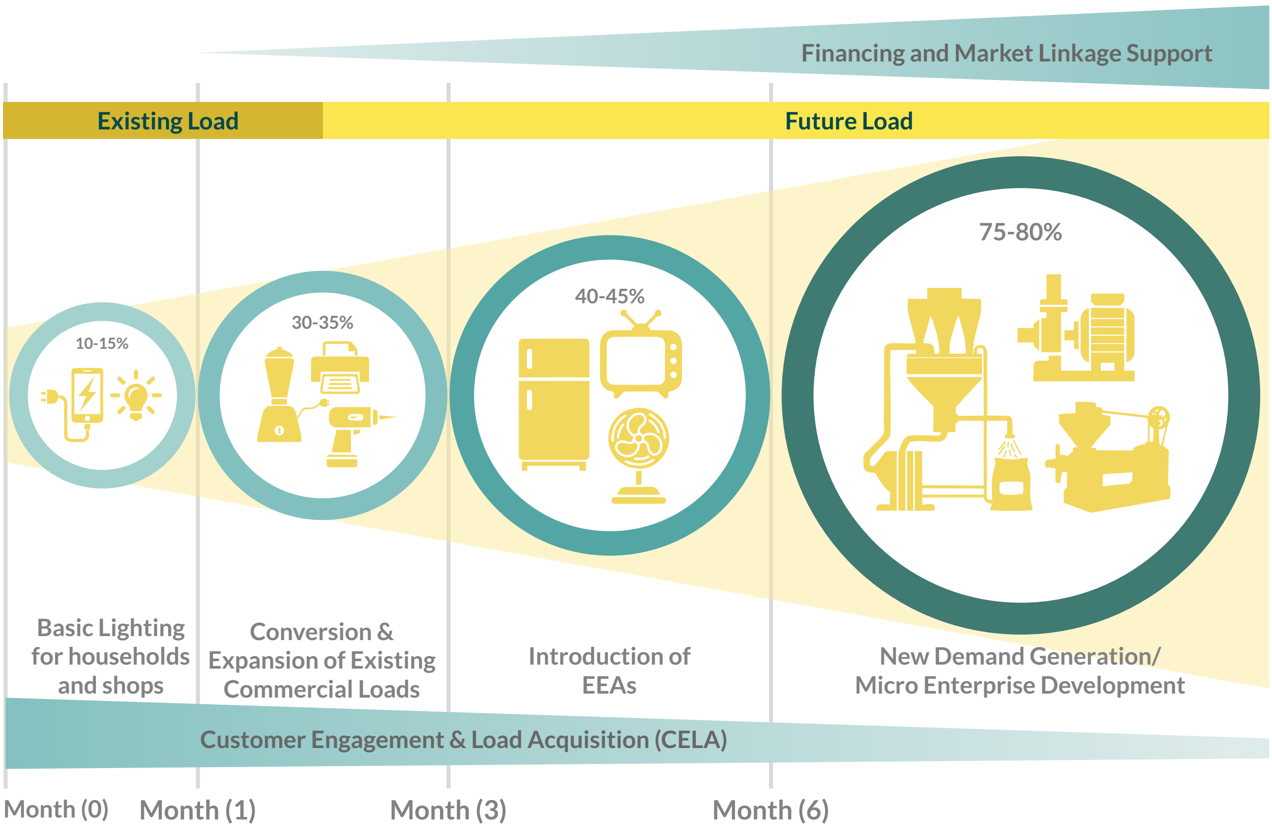
For each segment, the electricity demand changes over a time post setting up a mini-grid (figure 3). The existing electricity demand changes with the introduction of Energy Efficient Appliances (EEAs), efficient motors, and more opportunities in the form of new microenterprise development. Over some time, the electricity consumption scenario may again change due to higher aspiration of the customers or new usage of electricity by customers or the establishment of new enterprises or the introduction of a new customer segment. Therefore, the ESCO should periodically revisit the electricity demand for each of their mini-grid customer segments and conduct a review of the electricity demand in a village using the Detailed Energy Survey (DES) Tool (discussed in chapter 3 in detail). It improves the load acquisition by an ESCO and contributes to improving their revenue.

2.3

Demand Progression at Mini-Grid Site

Not all demand comes into the fold of a mini-grid at the outset but gradually increases when the customers realize its benefits. Initially, the ESCO targets customer segments like domestic and commercial establishments to meet their existing electricity demand of essential lighting, entertainment, ventilation, and running a few small capacity appliances by providing reliable and continuous electricity supply. Servicing existing load helps the ESCO in building trust with its customers.

Figure 2.4: Demand progression at a mini-grid site



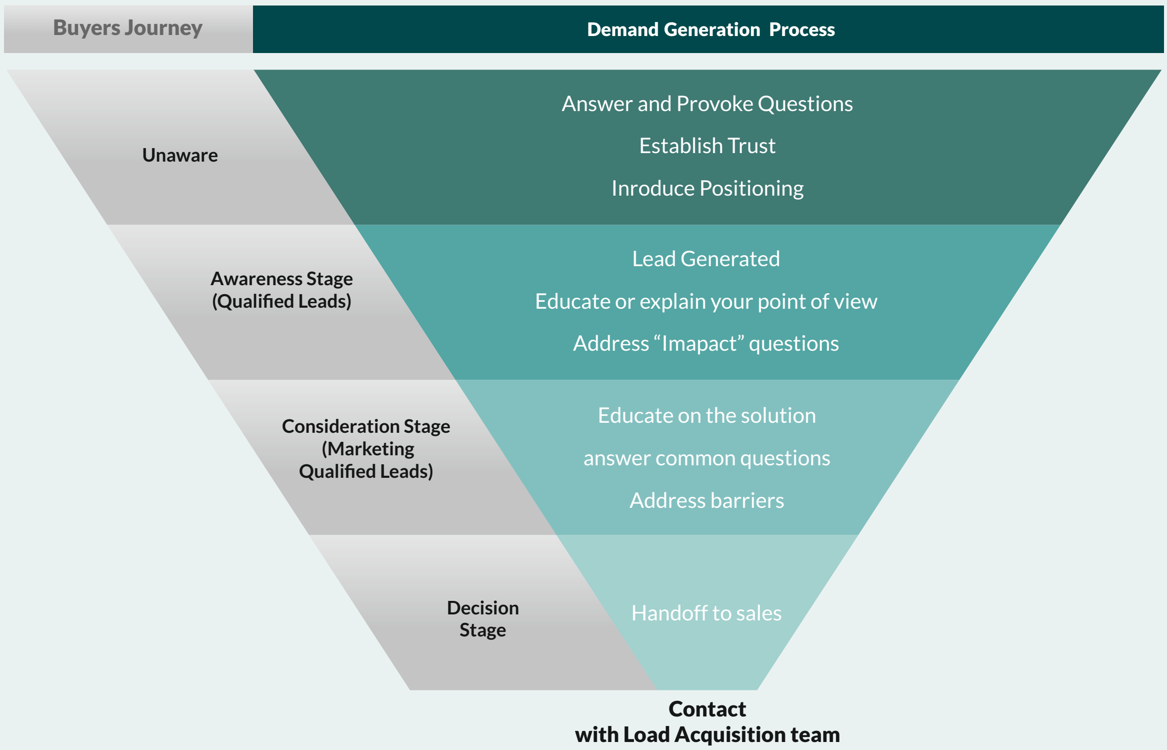
Additionally, it helps the ESCO to increase electricity demand through the introduction of EEA and efficient electric motors. Over some time, based on the economic potential of the area, the ESCO initiates activities like microenterprise development to create new electricity demand opportunities. The following figure sums up the demand progression. Once an ESCO understands the demand progression, they can identify appropriate Customer Engagement and Load Acquisition (CELA) activities like awareness campaign and financial support. In the initial stages, CELA activities are high, but later its requirement tapers but never ends. It is a continuous process throughout the life cycle of a mini-grid. The financial support is required to facilitate the adoption of newer and efficient technologies which can substantially reduce the electricity consumption at the same or higher level of output. In the long run, the benefits of these efficient technologies outrun the financial cost. To increase the electricity demand, ESCO should undertake the development of new microenterprise, which requires both financial and market linkage support. Figure 2.4 sums up the entire demand progression at a mini-grid site along with CELA activities and the requirement of financial and market linkage support.

2.4

Demand Generation Strategy

Based on the demand from different users, the ESCO prefers the demand curve to overlap as much as possible with the solar generation curve to minimize the energy storage (battery) capacity, which is a substantial (and generally the most expensive) component of the system. In this context, the generation of appropriate demand that provides additional revenues to the ESCO against its capital investments is crucial, and hence the need for a Demand Generation Strategy.

Figure 2.5: Demand generation strategy



Demand generation strategy is a means to make aware potential customers about the mini-grid and related product leading to Load Acquisition (LA), thus, driving revenue. We can simply say that demand generation strategy links sales with revenue, which typically follows a buyer's journey from being unaware to becoming a customer or champion of a product, as described in Figure 2.5[14].

[14] The model is adopted from a blog written by Doug Davidoff titled "The Difference Between Demand Generation & Lead Generation" and available at https://blog.imaginellc.com/demand-generation-vs-lead-generation and sourced on 15th September 2019.

The potential customer in an area might not be aware of the benefits of the mini-grid or related products. Also, the ESCO cannot convert all leads into sales at the very outset of the project. A village has different customer segments, each with its demand characteristics, which need to be assessed by the ESCO to develop its demand generation strategy. Communication is the key to making a demand generation strategy effective, and interventions like advertisements, awareness programs, groups, and one to one meeting may be employed.

Customers can be grouped based on their adoption of the mini-grid services as:

- Early adopters - who adopt the mini-grid or related products immediately
- Reluctant adopters - who are aware but are hesitant to adopt the mini-grid
- Non-Adopters - who do not see any benefit from the mini-grid and hence do not participate

The ESCO should have a different demand generation strategy for each set of customers. The early adopters readily participate, and the immediate benefits of the mini-grid are apparent to them. The benefits, however, need to be communicated to the reluctant adopters. Table 2.2 provides an indicative list of benefits vis-à-vis other competing technologies that may be communicated to the reluctant and non-adopters.

Table 2.2: Comparing of mini-grid over other available sources of electricity

Parameter	Mini-grid	Solar home lighting systems (SHLS)	Grid	Diesel generator
Cost of electricity	High due to high CAPEX	Medium	Low due to economies of scale and sector structure	Very high due to increasing cost of diesel
Reliability	High	Medium. Faults need to be locally rectified	Low with frequent outages	The medium as long-running is difficult
Quality of supply	High	Average	Low, tail-end voltage drops	Medium, tail-end problems
Pollution	Low	Low	At generation point	Very high
Social Benefit	High	High	Average	Low

2.5

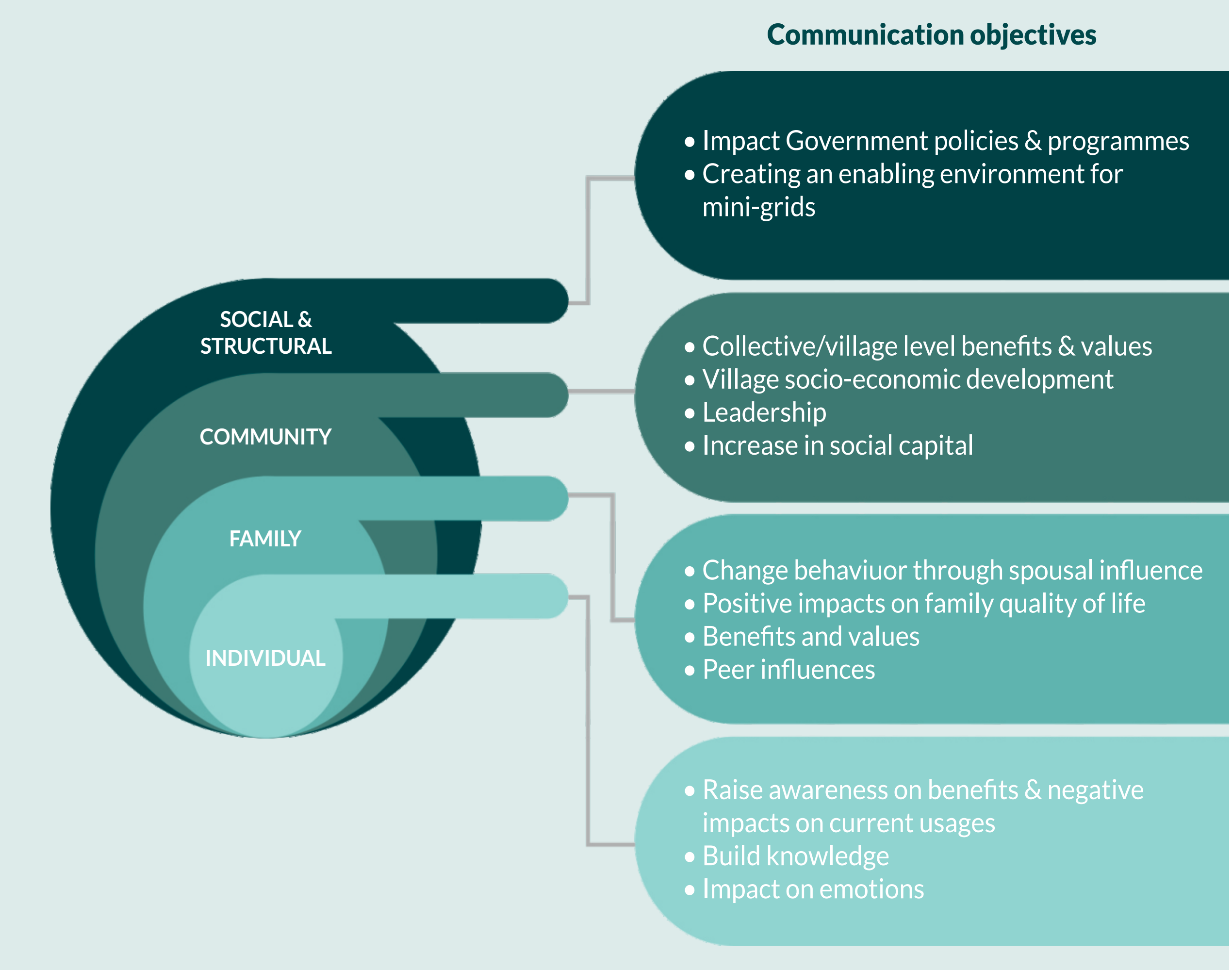
Designing an Effective Communication Strategy

Communication plays a dominant role in shaping demand - addressing barriers, communicating benefits, and acquiring consumers – for mini-grids. In recent years effective communication has evolved from sporadic awareness-raising information, education, and communication (IEC) activities to strategic, evidence-based behavior change communication (BCC) strategies. The change has come about with the realization that as socio-cultural and gender norms influence individual behavior, the need to mobilize communities in support of recommended behaviors is imperative, along with integrating advocacy at the policy level.

For mini-grid projects, the ESCO needs to design a communication str ategy that targets individuals, households, and the community separately so that behavior changes can be stimulated. The strategy should also keep in consideration that as one goes up from the individual to the community, the messages should be reinforcing in nature.

The overall framework for the communication strategy is represented in figure 2.6 .

Figure 2.6: Behavioral change communication framework and objectives



At the level of the individual, the communication strategy may focus on increasing the level of awareness of individuals on the negative impacts of the current energy usage patterns on both the economic and social aspects and the benefits of adoption of mini-grids and how the negative impacts can be addressed. Lack of knowledge of mini-grids and the opportunities that they offer is one of the primary reasons for lack of participation of communities, and the ESCO needs to focus on building this knowledge-based of the community.

At the family level, the communication strategy should focus on trying to change the behavior of families by using spousal influence. It should build an understanding of families on the benefits and values that they can realize by adopting mini-grids and the positive impact that such adoption can have on the quality of life of the family members. At this level, peer influence – a neighbor having adopted – can have a significant role in the change in behavior of the target family.

At the community or village level, the overall socio-economic development contributions of mini-grids may be communicated and how the village can play a leadership role in their area. Successful mini-grids can build the social capital of the community that can be tapped for other development interventions, and this should be kept in mind by the ESCO.

Communication at the social and structural level focuses on creating an enabling environment for large scale adoption of mini-grids and working with governments and donors to impact policies and programs to that effect positively. A policy advocacy team or agency may best lead communication targeted at this with evidence-based inputs from the ESCOs.

Specific points of communication for consumers at various stages of the Demand Progression are detailed out in the relevant subsequent sections.

Points to remember

- **Understanding different energy usages:** it is important to assess different energy usages to monetize supply for usages
- **Demand patterns guide customer acquisition strategy:** sub-segmentation of demand forms the base for arriving at an acquisition strategy and designing packages. ESCOs must invest focused effort to understand these demand patterns
- **Understanding customer journeys:** mini-grid customer needs are not static; they change over time. The demand generation process should be flexible enough to meet these changing needs over time. Thus, mini-grid practitioners should develop close relationships with their customers and be a part of their journey
- **Communication of benefits:** different levels of service generate different benefits; sometimes, these benefits are intangible (improvement in the quality of life, convenience); in other cases, they are tangible (increase in production and productivity, increase in profits). Identifying these benefits for each sub-segment and communicating the same to potential customers forms the essence of a Demand Generation Strategy.

3

SITE SELECTION

3.1

Site Selection Framework

Site selection is a precursor to the building of a mini-grid and demand generation activities. A robust site selection framework should be able to estimate the potential demand of the village as well as provide inputs to the demand generation strategy.

The critical factor for the success of any solar mini-grid is its reliability in meeting consumer demand cost-effectively. At the core of the framework (figure 3.1) is the generation of electricity demand to ensure that the mini-grid is sustainable, scalable, and attractive for an ESCO.

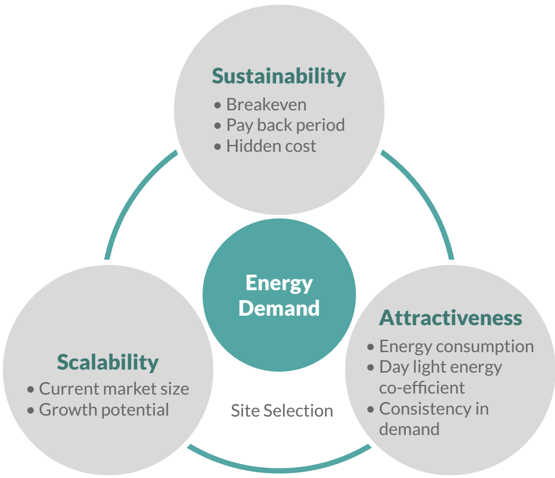


Figure 3.1: Site selection framework

- **Scalability:** the site selected for mini-grid installation should have sufficient electricity demand nearby.

- **Attractiveness:** a good site should have high electricity generation potential, sufficient day time demand, and the paying capacity of the consumers.

- **Sustainability:** mini-grid is a capital-intensive business. Targeting shorter payback leads to higher consumer tariff making mini-grid less attractive to the consumers. However, a more extended payback period increases the risk of the mini-grid. A suitable site should ha ve long term potential.

3.2

The Site Selection Process for Demand Generation Strategy

The site selection process has been developed based on the site selection framework. The process for comprises of five key steps (figure 3.2):

Figure 3.2: Site selection process

Steps	Site profiling survey	Detailed electricity survey	Load Assessment	Load curve study	Assessment of enterprise opportunity
Task	Site profiling results in short listing of states, districts and villages/ clusters	Detailed survey results to estimate demand potential of the village/cluster	Load assessment for each segment to understand demand pattern	24 hour load study to estimate basic configuration of generation unit	Assessment of enterprise opportunities for potential future upscale demand
Data source	Primary and secondary research	Primary research	Inputs from detailed electricity survey	Inputs from load assessment	Inputs from detailed electricity survey

3.2.1

Site Profiling Survey

Site profiling is done to identify tentative energy-deficient villages and clusters with paying capacity. It is done through secondary research and interviews with local stakeholders like government officials and grassroots level organizations. Table 3.1 lists down indicative parameters for site profiling.

Table 3.1: Indicative parameters for site profiling

Focus Area	Parameters	Remarks
Electrification Status	• Electrification status - Grid-connected or Off-grid a.If electrified, grid availability duration and timings • % of customers having a grid connection • Quality and reliability of electricity	• A village, suitable for mini-grid deployment, should be energy deficit, with a supply of grid electricity of fewer than 8 hours in a day and less than 2 hours from 5 pm to 10 pm • % of customers having a grid connection should be few • Low quality and reliability of electricity supply from the grid

Focus Area	Parameters	Remarks
Electrification Status	• Degree of use of alternate sources for electrification e.g., dependence on kerosene, presence of standalone solar home systems	• Availability and use of alternate electricity sources should be carefully analyzed • Electrification information can be obtained from the power department, regulator and telecom operators
	In case of the site has a telecom tower, the electricity supply data can be obtained from the tower operator. Preferably, electricity data of the past one year should be used for analysis to understand seasonality, political environment, etc. *In case the site has no telecom tower, the information as mentioned above may be obtained from state electricity department/ villages (on best possible estimate)*	
Demographics	• No. of households, population, population density, and population growth	• A higher number of households improves the viability of mini-grids. • High population density and growth are preferable • Individual hamlets should have high population density and are at proximity to each other
Solar potential	• High solar irradiation and low number of rainy days • Biomass availability	• A higher number of sunny days improve generation from the solar PV plant • Biomass-based generation technology can be deployed as a back up to the solar reducing need for energy storage
Paying capacity of customers	• Source of income; occupation; the presence of enterprises; the level of industrialization; the presence of a DG operator	• Paying capacity is critical to understand the profitability of mini-grid and as well as design suitable service packages • Higher non-agriculture economic activity is a good indicator for higher income level and demand for electricity
Status of 'Rural' notification	• State of 'Rural' notification of the village	• Mini-grids are safeguarded in rural areas from extension and strengthening of central grids in India
Presence of anchor load	• Status of the presence of any anchor load such as telecom tower.	• An anchor load within 1 to 2 km distance from village increases the viability of a mini-grid operation
Clustering potential	• The selected sites should be analyzed for potential clustering opportunities.	• Clustering helps in sharing fixed overheads like a manager, accountant, engineer, etc. among several mini-grids thus reducing cost per mini-grid • The grouping is driven by the distance between villages and distribution of load. Typically, 6 to 10 villages within 30 to 40 km radius can be clustered for mini-grid development.

The above parameters are indicative, and ESCOs may develop their own set of parameters depending on their requirements and business model.

3.2.2
Detailed Electricity Survey

Detailed Electricity Survey (DES) is an extensive on-ground survey to validate desk research information and obtain additional information required for estimating the economic viability of the mini-grid (Box 1). The objective of this step is to assess the existing as well as future demand potential, time of day usage, and seasonality of demand.

Box 1: About DES Tool

The DES tool helps in capturing information to generate village energy usage profiles for a variety of purposes, like identifying an appropriate location for setting up of a mini-grid or assessing the electricity demand of the site. Information required for the DES tool is gathered through door-to-door surveys, focused group discussions, selected influential person's interview. DES Tool is a detailed questionnaire designed to capture:

- **General information of the village:** general information of a village helps understand the availability of necessary infrastructure available, demographics, and economic activity of a village/cluster. Public information includes the name of the village, panchayat, block, co-ordinates, infrastructure available, number of households, and income range.

- **Mapping of a village:** mapping of a village helps in identifying village clusters, the distance between them (aerial and road distance), and location with a high household density as well as enterprise. A map should clearly show the aerial as well as road distance between different clusters/villages or significant loads like telecom towers (figure 3). GIS tools may be used for mapping.

- **Load Mix:** This helps understand the existing demand from different customer segments within a village. It captures information related to the number of various appliances used and their usage in detail.

- **Electricity supply information:** electricity supply information help in estimating the gaps in electricity supply and should capture a current level of electrification, reliability, and timing of supply an alternate source of electricity lik e solar home systems, kerosene, and diesel generators.

The tool should be as detailed as possible to capture the variations during day and night demand as well as the seasonality.

The existing demand is usually from households, shops, and existing enterprises or institutions. Future demand potential is from the addition of appliances b y existing consumers or the addition of new enterprises. ESCO would need to develop a DES tool to carry out the exercise.

DES involves gathering a large number of data points from all households, shops, and other establishments in a village. Collecting such extensive data has a high chance of errors, which can lead to inadequate design of the mini-grid system leading to its failure. Thus, ESCOs should engage highly specialized agencies for carrying out DES and should review the survey for any errors, missing information, biased opinions.

Figure 3.3: Snapshot of DES of a hamlet

MINI - GRID PROJECT DETAILED ENERGY SURVEY

Google earth map of the village at Hamlet level with location of towers (exact coordinates)

Distance between hamlets identified and telecom towers

Tower / Hamlet	CERT1 (Path distance)	CERT1 (Arial distance)
H1 (biggest hamlet) Gaurekhera	1 km	0.73km
H2 Badhar	1.22 km	1.07km
H3 Jinual	0.13 km	0.20km
H4 Jinwa	1.27 km	1.03km
H5 Nangla	0.46 km	0.25km

*Table is indicative-number of towers and hamlets may vary
*In addition to distance, also mention any other details

Aerial Distance Between the hamlets

Hamlets	H1	H2	H3	H4	H5
H1		1.69km	0.57km	1.36km	0.62km
H2	1.69km		1.16km	0.71km	1.30km
H3	0.57km	1.16km		1km	0.27km
H4	1.3km	0.73km	1km		1.26km
H5	0.62km	1.30km	0.27km	1.26km	

1.6 Information Related to Alternate Sources of electricity/Lighting

Source	Parameter	H1 Gaurekhera	H2 Badhar	H3 Jinaul	H4 Jinwa	H5 Nangla
Diesel Powered Generator (DG) Self Owned	No. of users	2*	None	None	None	None
	Duration and hours of Operation per day	-	NA	NA	NA	NA
	Average Monthly Expense	-	NA	NA	NA	NA
Kerosene Powered Generator (KG)	No. of users	None	None	None	None	None
	Hours of Operation	NA	NA	NA	NA	NA
	Average Monthly Expense	NA	NA	NA	NA	NA
Battery & Inverter	No. of users	205	7-10	7-10	15	2-3
	Hours of Operation	8-10hrs	8-10hrs	8-10hrs	8-10hrs	4-5hrs
	Average Monthly Expense	Rs.20000/ On purchase	Rs.20000/ On purchase	Rs.20000/ On purchase	Rs.21000/ On purchase	Rs.10000/ On purchase
Standalone solar system	No. of users	199	7-10	7-10	15	3
	Hours of Operation	6-7 hrs	5-6 hrs	5-6 hrs	6-7hrs	5-6 hrs
	Average Monthly Expense	One time Investment	One time Investment	One time Investment	One time Investment	One time Investment
Local DG/KG mini-grid structure	No. of users	None	None	None	None	None
	Hours of Operation					
	Average Monthly Expense					
Any other technology– Biofuel, Husk	No. of users	None	None	None	None	None
	Hours of Operation					
	Average Monthly Expense					

* Used for household/village function occasionally

INFORMATION TO BE CAPTURED FOR ALL HAMLETS SEPARATELY

1.8 Existing electricity consumers (For each hamlet) GAUREKHERA (H1)

No	Category of consumer	Nos.	Estimated load (kW or kVA – label unit)	1Ø or 3 Ø	Number of Hours of Operation	Duration and timings of Operation	Monthly Expense	Mention Hamlet Code	Contact Details
1.	Households								
	Basic (1 LED + Mobile charging)	Nil							
	Advanced 1 (2 LEDs + Mobile charging)	Nil							
	Advanced 2 (LEDs + Mobile charging + Fan)	Nil							
	Advanced 3 (LEDs + Mobile charging + TV)	Nil							
	Advanced 4 (LEDs + Mobile charging + Fan + TV + other appliances)	10	2 kW	1Ø	14 hrs	(11:45pm-8:00am) (1:30pm-7:00pm) changes weekly	Rs. 226	H1	**Pradhan-** Seema Devi W/O Rajbeer Singh (M)7376136991 **Line man** Mahender (M) 9415667569 **Teacher** Harbhajan Sharma (M) 9452437093
2.	Shops								
	Basic (1 LED + Mobile charging)	20 (Solar light)	100 W	1Ø	16 hrs	7:00-22:00	Invested Rs.12000-15000 for solar PV panel	H1	**Sh. Kumarpal Singh (M) +91-7080573268**
	Advanced 1 (2 LEDs + Mobile charging)	Nil							
	Advanced 2 (LEDs + Mobile charging + Fan)	Nil							
	Advanced 3 (LEDs + Mobile charging + TV)	Nil							

1.5 Specific information of the Hamlets within the village's survey area

No.	Particulars		H1	H2	H3	H4	H5
1.	Hamlet code		H1	H2	H3	H4	H5
2.	Co-ordinates		N 27°40.277' E 79° 09.664'	N 27° 0.524' E 79° 08.326'	N 27° 40.498' E 79° 08.600'	N 27° 40.240' E 79° 08.952'	N 27° 40'42.09' E 79° 09'01.55'
3.	Name of Hamlets		Gaurekhera	Badhar	Jinaul	Jinwa	Nangla
4.	Number of households		APL 318, BPL 24	APL 120, BPL 30	APL 62, BPL 18	APL 65, BPL 15	APL 0, BPL 35
5.	Population		2800	2000	800	750	140
6.	Number of Shops		26	5	4	4	0
7.	Occupation (Provide Number of HHs and range of income)						
	Agriculture	Number	306	150	78	78	2
		Income	Rs.50000 yearly	Rs.50000 yearly	Rs.10000 yearly	Rs. 10000 yearly	Rs.8000 yearly
	Labour	Number	40-45	10	25	10	40
		Income	Rs 10,000-25,000 monthly	Rs.9000 Monthly	Rs.9000 Monthly	Rs.9000 Monthly	Rs.2000 monthly
	Service	Number	6	7	2	None	None
		Income	More than 3Lacs p.a.	More than 3Lacs p.a.	More than 3Lacs p.a.	Not applicable	Not applicable
	Business Labour	Number	20	5	4	4	None
		Income	Rs. 5000-10000 monthly	Rs. 5000-10000 monthly	Rs. 5000-10000 monthly	Rs. 5000-10000 monthly	Not applicable
	Others (Families having members working outside the village)	Number	Not Present	Not Present	Not Present	Not Present	
		Income	Not Present	Not Present	Not Present	Not Present Not Present	
	Migrant Labor	0-3 Months / 3-6 Months / 6-12 Months	86+	Not Present	10	20	
		Income	Rs.9000 Monthly		Rs.9000 Monthly	Rs.9000 month	

3.2.3

Load Assessment for Different Customer Segments

Through DES, ESCO has complete information on the number of consumers under each segment, kind of appliances currently used, existing infrastructure, clusters/ hamlets, electrification status, quality and reliability of electricity supply, and paying capacity of potential customers (figure 3.3). Based on this information, the daily electricity demand for each segment can be assessed. The ESCO can also calculate the size of the solar generation unit and its possible capacity utilization from this study. High capacity utilization is desired as it is directly proportional to the mini-grids revenue and hence its sustainability. A sample load assessment for three villages is shown below in table 3.2. The analysis of table 3.2 clearly shows that village C is best suited for the location of solar mini-grid as it has the highest existing load as well as the future load. Also, the majority of the load is day time load.

Table 3.2: Sample Load Assessment										
Demand Type	Load Type	Villages/Clusters								
		A			B			C		
		No. of units	Cumulative Load Usage/ Day (KW)	Time of day usage	No. of units	Cumulative Load Usage/ Day (KW)	Time of day usage	No. of units	Cumulative Load Usage/ Day (KW)	Time of day usage
Existing	Households/ shops	100	10	Night	200	20	Night	250	25	Night
	Institutional	3	1.5	Day	5	2.5	Day	7	3.5	Day
	Commercial Loads	8	8	Day	10	10	Day	12	12	Day
Total Existing Load			19.5			32.5			41.5	
Future	Households/ shops	100	15	Day/Night	200	30	Day/Night	250	37.5	Day/Night
	Institutional	3	3	Day	5	5	Day	7	7	Day
	Commercial Loads	8	12	Day	10	15	Day	12	18	Day
	New Demand Generation	3	30	Day	3	30	Day	3	30	Day
Estimated Future Load			60			80			92.5	

3.2.4
Load Curve Study

For solar mini-grids lowest generation cost is achieved when demand pattern matches that of the generation profile. However, in reality, this is never the case. An analysis of the load curves of each customer segment as well as the cumulative load curve, juxtaposing them with the generation curve, and calculating the energy generated and demanded helps the ESCO to arrive at the energy storage capacity. Also, such an analysis enables the ESCO to 'manage' the load curves by trying to shift demands by playing with tariffs.

3.2.4.1
Day-Night Variation

The flatter the demand curve, the easier it is for the ESCO to set up capacity and service loads. However, the demand for electricity in a village is not constant throughout the day. Commercial and micro-enterprise loads are generally in the day time, and household loads come up in the night. For solar mini-grids, the challenge is compounded due to the nature of the generation curve, making energy storage compulsory, thus raising the cost of electricity as energy storage typically is the most expensive component of a mini-grid. This day-night variation has to be kept in mind by the ESCO in designing the mini-grid.

3.2.4.2 Seasonal Variation

Seasonal variation is an essential factor that needs to be factored while analyzing demand. Demands for electricity vary across seasons in a y ear due to the difference in usage of appliances, agricultur al pump sets, and economic activities. Usually, the demand for electricity is significantly reduced during the winter season in rural areas – for households and shops, it is due to decreased usage of appliances like fans and refrigerators, and in the case of agriculture, it is due to less irrigation. Similarly, enterprise activities like oil expeller, water treatment unit, bulk milk chiller, etc. also show significant variation in demand over seasons.

3.2.5 Assessing Opportunities for New Demand Generation

While conducting DES, ESCO should analyze data to arrive at future opportunities of new demand through micro-enterprise work. Micro-enterprises have following advantages for mini-grids:

a) Micro-enterprises generally use heavy motors (>2 hp) which require three-phase electricity and can potentially contribute about 70% to 80% of the total load

b) As the demand from enterprises is usually during the daytime need for energy storage is lower

This assessment, as a part of the site selection process, helps ESCOs in deciding on the actual size of the mini-grid and also prepare for the future scale-up opportunity. Based on the characteristics of the site, potential micro-enterprises can be identified. Data requirements for assessing the potential need to be identified and integrated with the DES tool and data need to be collected through DES. Following are a few pointers for potential micro-enterprise development:

- Demand for processed products in surrounding areas for which raw material is commonly grown in the identified village. Processing can be done at the village from the crop produced and sold in the nearby markets, e.g., mustard, a commonly grown crop in northern parts of India, can be used for producing mustard oil consumed across northern and eastern parts of India.

- Small and micro-enterprises commonly present in nearby areas. Such new demand generation or micro-enterprises can be developed within the mini grid catchment.
  Identification and analysis of new demand generation are discussed in Chapter 7.

Points to remember

- **Scalability, attractiveness, and sustainability:** chosen sites should be such that they offer sufficient electricity demand within proximity, high electricity generation potential, sufficient day time demand, and high paying capacity of consumers, with shorter payback periods for investments.

- **Importance of DES:** designing of the system capacity depends on the DES, and the ESCO should undertake this exercise with utmost diligence. In-depth understanding of customer segments, segment-wise demand, demand curves for each segment, and generation curve from solar at the particular site forms the basis for designing the mini-grid.

- **Understanding existing micro-enterprises:** micro-enterprises generate more revenue per unit of electricity (and hence surplus/profits) for the ESCO; serving these micro-enterprises contributes to the financial viability of a mini-grid.

- **Understanding local livelihoods:** post-arrival of the mini-grid, other micro-enterprises can come up depending on the livelihoods of the village. Thus, ESCO needs to understand the livelihood pattern at the selected site so that it can develop new micro-enterprises that uses electricity from the mini-grid, ensuring mini-grid financial viability and also contributing to the socio-economic development of the village.

4

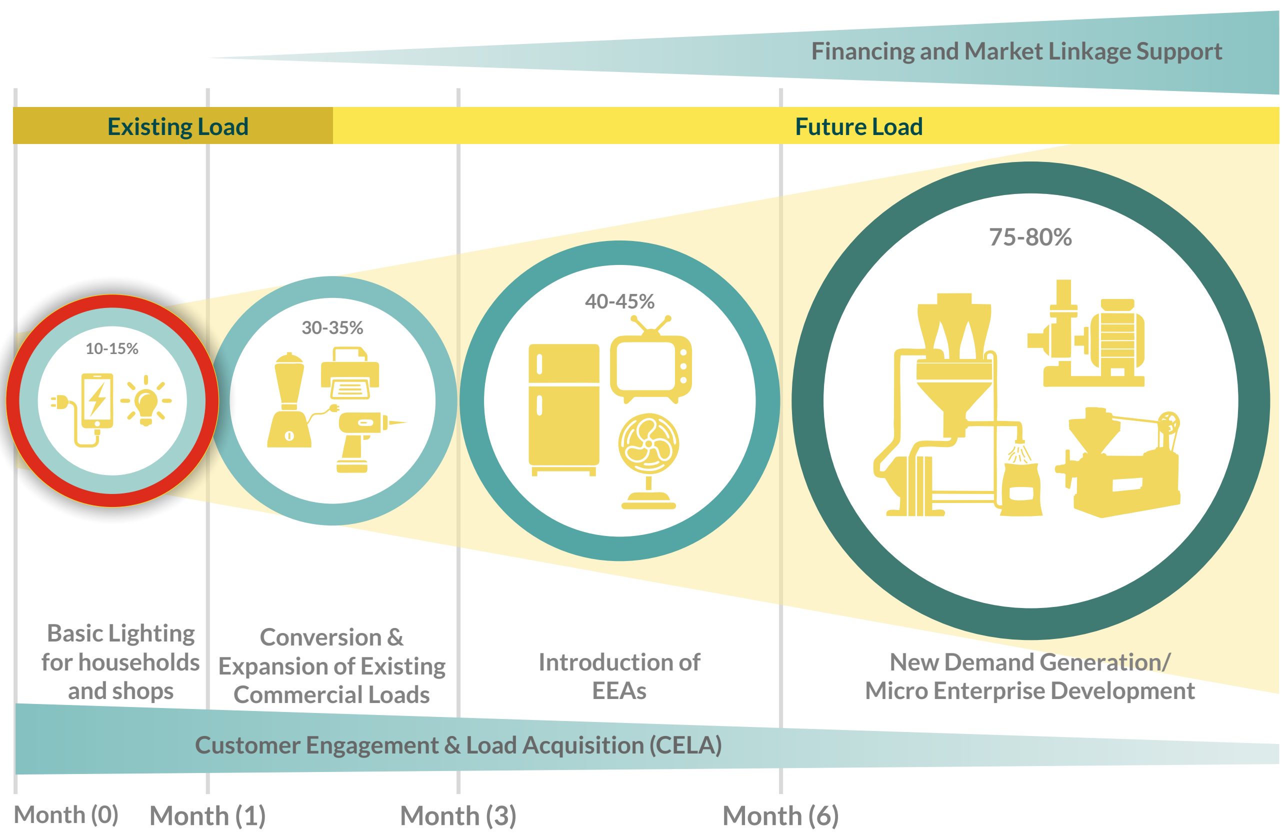
DEMAND GENERATION FOR EXISTING LOADS

4.1

Background

Existing energy users meet their needs from sources like kerosene, solar home systems, diesel generator sets, and government grid. The electric appliances used by existing energy users are defined as existing loads. Most of the households, shops, commercial establishments, and institutions can be classified as an existing load (figure 4.1). A significant consumption is from lighting, fans, and mobile charging. Well-to-do households and bigger shops may use other electric appliances like television, computers, refrigerator, mixer grinders, and geysers. Meeting energy needs of existing loads are for two customer segments: (a) households and (b) shops. The types of loads are typically lighting, fans, TV, and mobile charging. Targeting the existing load is an entry point activity for the ESCO and can be done quickly. Tapping these loads is essential because of the following reasons:

Figure 4.1: Demand progression



- The customers of these loads suffer due to the quality of supply, and hence the prompt resolution of their energy problem and service can build the trust of the ESCO and the mini-grid in the village

- Meeting these loads are the easiest as convincing the customers of the financial benefits of the mini-grid is not required as the benefits that these customers realize are intangible one – convenience, quality of life, positive effects on education, indoor air quality, etc.

However, it should be kept in mind that for this category of customer, quality of service is paramount.

Consumers with essential electricity requirements, i.e., for lighting, fans, and mobile charging, are usually the first movers to mini-grids. Consumers with large loads like motors and large loads with steady demand like telecom towers often adopt mini-grids after demonstration of the reliability of services. This section covers the demand and acquisition of early movers.

4.2

Identifying Potential Customers

There is a positive correlation between income and energy consumption of households. Progressing from the customer segmentation outlined in Chapter 3, at this stage, the ESCO needs to further segment the customers for a deeper understanding of their energy needs. Each of the consumer segments can be further sub-segmented into:

1. Households – Small, medium and large based on their income
2. Shops - Small, medium and large based on their turnover
3. Commercial establishment – Small, medium and large based on their turnover
4. Institutions – Small and large based on number of employees
5. Anchor –Telecom tower or new demand generation (micro-enterprises)

Detailed load and demand pattern analysis of the sub-segments helps the ESCO in designing and pricing packages so that they meet the requirements and is affordable for the particular sub-segments. Different pricing for different segments helps ESCO to increase the customer base.

An unreliable or limited supply of energy and a lack of reliable and affordable alternatives make households and shops the early movers. Other consumers usually rely on diesel generators for meeting their demand and often adopt mini-grids after the demonstration of the reliability of supply. Though the electricity demand of households and shops is lower in comparison to others, they help in kick-starting and providing revenue for a mini-grid in the short term.

4.3

Load Acquisition (LA) for Mini-Grid

An ESCO needs to identify customer segments while approaching them, and the best-suited strategy should be adopted to bring them in their fold. To acquire existing loads, the ESCO needs to understand consumer behaviors vis-à-vis their level of income, which can be explained through the concept of 'Energy Ladder.'

4.3.1
The Concept of the Energy Ladder

The behavior of customers depends on where they are in the 'energy ladder.' The energy ladder theory (figure 4.2) posits that in response to higher income and other factors, households shifts from traditional biomass and other solid fuels to more modern and efficient cooking fuels such as LPG, kerosene, natural gas, or even electricity. This process is usually termed 'fuel-switching' or 'inter-fuel substitution'[14]. In the case of mini-grids, load acquisition by the ESCO also follows the energy ladder concept, as illustrated in the following figure.

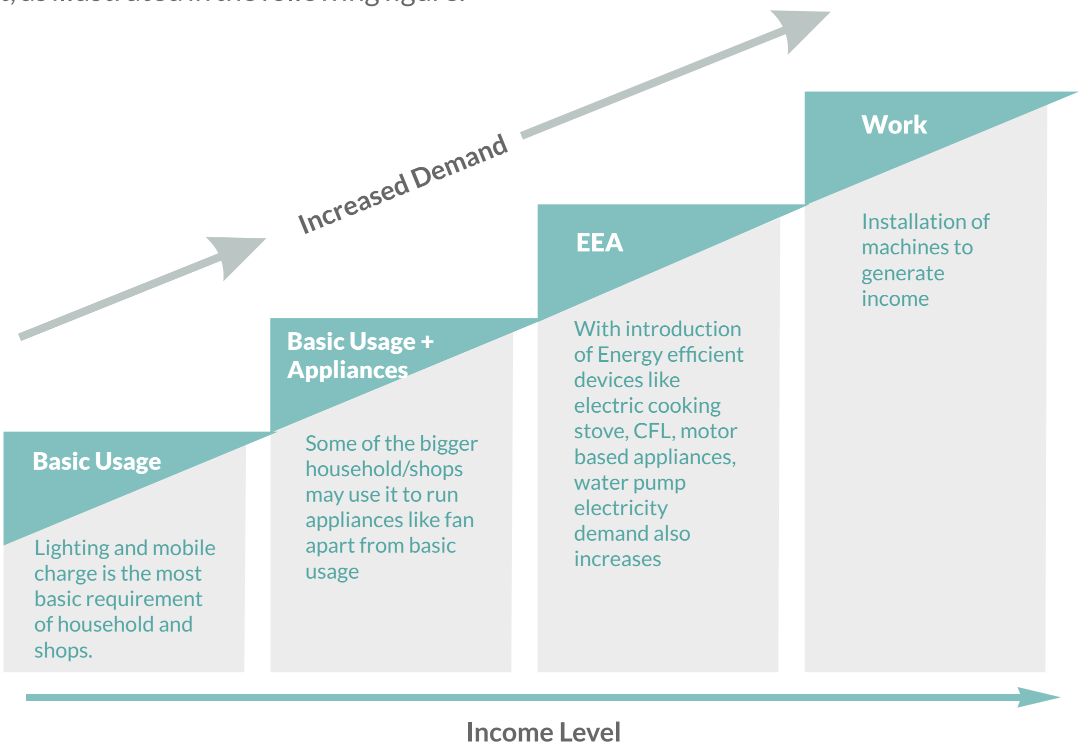


Figure 4.2: Progression of mini-grid customers on the Energy Ladder

Once reliable and consistent electricity is available, people's aspiration increases, and accordingly, the consumption of electricity also increases. In the long run, this means that electricity demand increases over time in the same population, which means that there is the opportunity for the ESCO to introduce EEA and other non-lighting appliances like television, mixer grinder, etc. Access to finance helps speed up this process when they can purchase devices and equipment they aspire. Moreover, there is an opportunity to add new economic activities at the household level due to the availability of electricity. Different consumers are at different levels of the electricity ladder, and with an increase in income, move up the ladder, thus increasing the consumption of electricity produced.

[14] Barnes, Douglas F., and Uu Qian. 1992. "Urban Interfuel Substitution, Energy Use, and Equity in Developing Countries." World Bank Industry and Energy Department Working Paper, Energy Series Paper 53, Washington, DC.Hosier, R, and W. Kipondya. 1993. "Urban household energy use in Tanzania: prices, substitutes, and poverty." Energy Policy 21: 453-73 MayLeach, Gerald. 1992. "The energy transition" Energy Policy, February: 116-123.

4.3.2
Communication for Meeting Existing Loads

After understanding the position of different consumers in the energy ladder, the ESCO needs to execute its communication strategy as developed through the framework outlined in Chapter 2. A possible plan for creating awareness among different types of customer segments need to be designed as per the level of awareness level of the target segments is provided in table 4.1.

Table 4.1: Strategies vis-a-vis customers' awareness

Awareness Level	Connection Status	Proposed Strategy
High - medium	Existing customer	Need to continue sharing benefits and sell deeper i.e., move them up the electricity ladder
High – medium	Not existing customer	Need to communicate benefits and convert the customers actively; also understand the rationale for not taking the solar mini-grid electricity
Low – unaware	Not existing customer	Need to provide necessary awareness, communicate benefits and convert customers

A well-designed strategy for these consumers should consider their behavior, awareness levels, and suitable awareness channels. The strategy should include:

1. Message to be delivered to potential customers
2. Partners to deliver the message
3. Communication channels to deliver the message to the potential customers

4.3.2.1
Message to be Delivered to Potential Customers

The social and economic benefits of the mini-grid need to be communicated to potential customers. Also, the benefits need to be compared with their current sources of energy, helping potential customers quicken the process of decision making (table 4.2).

Table 4.2: Benefits of Mini-Grid over other available sources of electricity

Services	• Reliable supply of electricity for lighting, fan and mobile charging
Comparison	• Provides better light vis-a-vis kerosene lamps • Provides a more reliable supply of power compared to the central grid • Flexible services and multiple service packages to select from
Economic Benefit	• Extended productive hours • Start new economic activities at home due to extended productive hours
Social Benefit	• Access to lighting means more time for the children to study • Enhanced safety and security

4.3.2.2

Partners for Delivering the Message

To effectively deliver the message, it needs to be achieved through stakeholders thoroughly embedded in the community. Some of these stakeholders are:

- **Forming local partnerships with local NGOs:** many NGOs are engaged with rural communities to implement various social projects at the grass-root level. These NGOs have a good rapport with the local community and can help the ESCO in getting introduced to the communities, which is vital for making inroads in the market. They can help in creating awareness and also last mile load distribution.

- **Local influencers:** local influencers act as a link between ESCO and the community. They create a conducive environment for a social meeting for running a campaign. The local influencers can be a teacher, health worker, social worker, village head, or even an existing customer. They are persuasive in their approach and can help the ESCO is customer acquisition.

- **Other stakeholders:** there are several service providers visiting villages like roving merchants. These service providers can be used to spearhead the campaign by meeting the local community or distributing pamphlets or doing a small survey for the ESCO. They can provide information to the ESCO related to the economic activities in a village, household density, route planning, etc.

4.3.2.3

Communication Channels

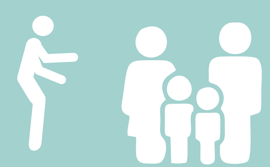
The ESCO should devise its communication strategy to bring them into their fold to increase the customer base. A sustained campaign should be designed to create awareness, increase adoption, and engage with the community for the approval of solar mini-grid. Possible communication channels that the ESCO can explore are shown in figure 4.3.

Figure 4.3: Communication channels for customer messaging

Individual

- Door step meeting
- One-to-one meetings
- Use local partner organisation

Family



- Group discussion
- Community level awareness generation
- Use peer cross learning

Points to remember

While engaging with customer segment with existing load, one should remember:

- **Gaining of trust:** for a mini-grid to be successful, the ESCO needs to build the trust of the community, and meeting the energy problems of the early adopters can build that trust.
- **Knowledge about the problem:** it is crucial to assess the existing pain points of the community and its willingness to adopt a change
- **Belief in the importance of the problem:** besides understanding the real pain points and needs of the community, the community itself must realize the necessity of reliable electricity. Moreover, they should be proactive in wanting to find solutions and overcome challenges to fulfill this need
- **Desire to change:** the willingness to adopt the change is as essential as being aware of one's needs
- **Belief in one's ability to change:** it is vital to make the community realize its own ability to adapt the change and see the desired outcome
- **Ability to take action:** after understanding the need and showing a willingness to be part of the initiative to bring about the desired change, it is essential to make them know how to go ahead and take relevant action

5

CONVERSION AND EXPANSION

5.1

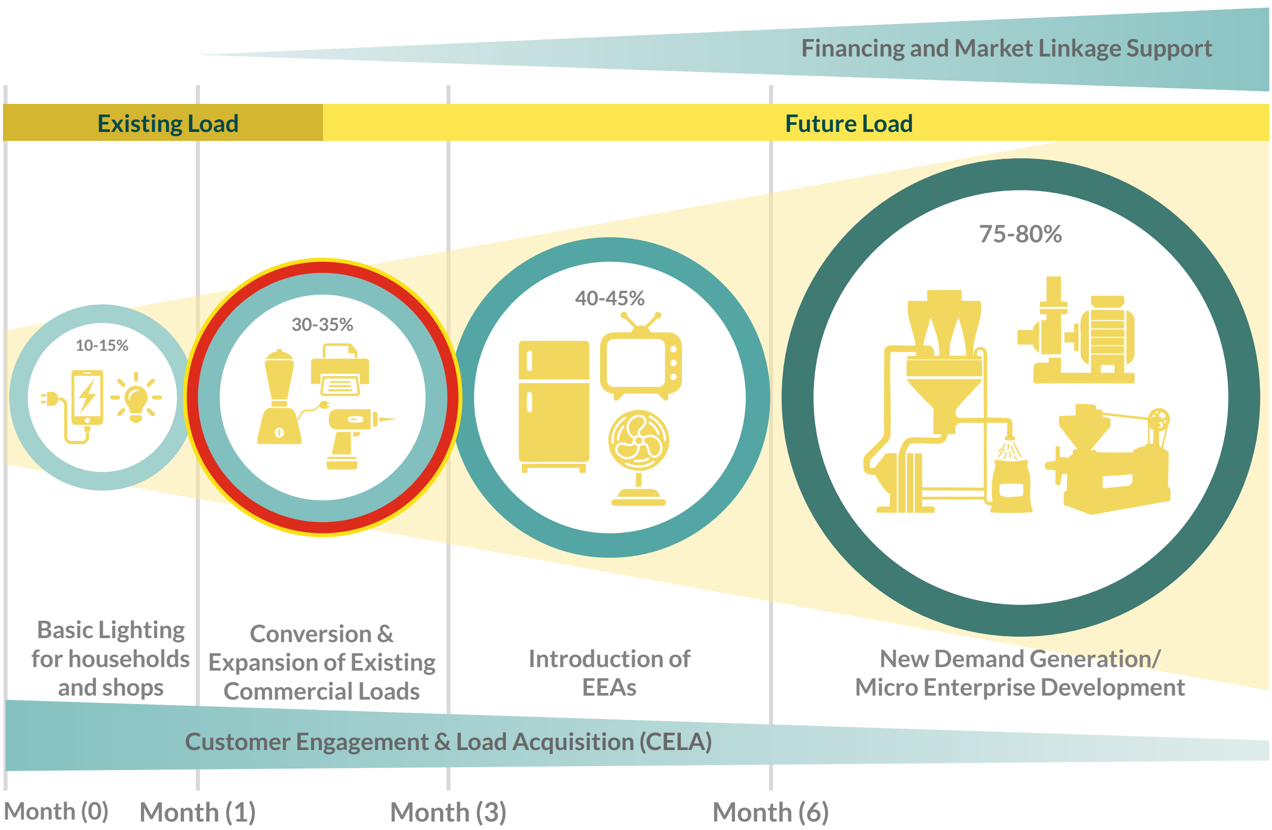
Background

The earlier chapter discussed the demand generation strategy for existing consumers. This chapter deals with the increasing demand through the adoption and expansion of existing commercial motors (figure 5.1). In rural areas, micro-enterprise like flour mill, oil expeller, small dairies, and farmers use commercial motors. High energy costs limit micro-enterprises from expanding their operations because:

1. It makes their products/services less competitive to products/services imported from outside of the village

2. It increases the cost of production requiring more capital outlay of the entrepreneur/ owner

Figure 5.1: Demand progression



5.2

Importance of Commercial Motors for a Mini-Grid Site

Commercial motor loads have the following advantages:

1. They are usually during day time and would require less or no battery backup.
2. They are larger loads compared to household and shop loads. The addition of motor loads can improve capacity utilization.

Due to the above two reasons, the addition of these loads reduces the average cost of electricity and makes it more attractive for the customers.

Existing commercial motors are generally single-phase motors or are powered by diesel engines. They are inefficient, leading to high energy costs and generate local air and noise pollution. Lack of a reliable supply of electricity is one of the primary reasons for using these motors.

Ensuring a reliable supply of electricity can enable the usage of efficient commercial motors. Using efficient motors reduces energy consumption and pollution. However, the high upfront costs of such commercial motors act as a barrier for micro-enterprises and farmers in adoption. ESCOs can play an essential role in enabling micro-enterprises to deploy efficient motors by:

- Providing a reliable supply of electricity
- Promotion and facilitation of adoption.

5.3

Defining Conversion and Expansion

To gain from the improved supply, existing motors, i.e., single-phase and diesel engine based, need to be replaced with three-phase motors. Since the current motors need to be replaced with efficient three-phase motors, the inclusion of these loads into mini-grids is referred to as 'conversion.' With improved supply, micro-enterprises can deploy additional machinery to expand their business and enhance their income regarded; this is regarded as 'expansion.'

Conversion and expansion require the purchase of new machinery. Micro-enterprises and farmers may have limited technical and financial capacity to invest in new machinery. ESCOs addressing limited capacity can potentially lead to the addition of loads to mini-grids improving the capacity utilization of the mini-grids.

5.4

Segmentation

Commercial motors loads can be segmented on their power rating, as shown in table 5.1.

Table 5.1: Showing segmentation of commercial motors

Segments	Definition	Example
Commercial appliance-based customers	Commercial appliance-based loads <1kW	Photocopy machine, photo studio, etc.
Commercial motor -based customers	Commercial motor-based loads >1kW	Refrigerators, irrigation pumps, flour mill, oil expeller, etc.

Though small in number, commercial motor based customers have the potential to create a high demand for a mini-grid, for example, the addition of a flour mill and an oil expeller can add substantial loads of up to five times or more as compared to commercial appliance-based customers. By adding more commercial motor based customers, ESCOs would need a lesser number of other consumers.

5.5

Customer Acquisition Strategy

The ESCO has to put in the effort to acquire commercial loads and convince clients to go either for conversion or expansion. The staff of ESCO should visit each microenterprise and farmer and inform them about the benefit of the mini-grid and how it can transform their business by reducing cost and enhancing income. The first category of customers comprises of clients who are aware of the benefits and easily participate in the mini-grid and go for conversion/ expansion. The second category includes customers who are aware of the benefits, but they do not have enough finances for conversion/ expansion. The third category is of customers who are not aware of the benefits of mini-grids and conversion/ expansion. The customer acquisition strategy that can be adopted is as follows:

- For the first and third categories of customers, ESCOs need to run awareness campaigns, though the messaging has to be different.
- The second set of customers, in addition to awareness campaigns, requires financial support for conversion/ expansion. ESCOs can explore partnerships with MFIs and banks for meeting the financing needs.

5.6

Importance of Financing

The conversion of existing motors with efficient motors or expanding the current capacity of a micro-enterprise using motors requires upfront investments, which is a challenge for micro-enterprise owners or farmers. Therefore, providing financing facilities to such customers increases the adoption of conversion and expansion strategy. The ESCO can arrange finance in the following ways:

- Provide efficient motors and building its cost in the package
- Partnership with microfinance institutions (MFIs) or other lending agencies to make credit available to the micro-enterprise owners and farmers to purchase efficient motors.

Points to remember

While engaging with customer segment with commercial motor load, one should remember:

- **Smoothens demand curve:** conversion of existing inefficient motors and diesel engines give ESCOs loads that overlap with solar generation and hence smoothens the load curve.
- **Clean energy use:** replacing diesel engines not only reduces energy costs of micro-enterprises but reduces local air pollution.
- **Communication of benefits:** the thrust of the ESCO should be to convey the financial benefits of conversion to the micro-enterprises. Improvement in working conditions is another benefit that needs to be communicated.
- **Addressing financing needs:** high upfront costs of efficient motors act as a barrier to adoption, and the ESCO may enter into partnerships with MFIs and banks for financing these.

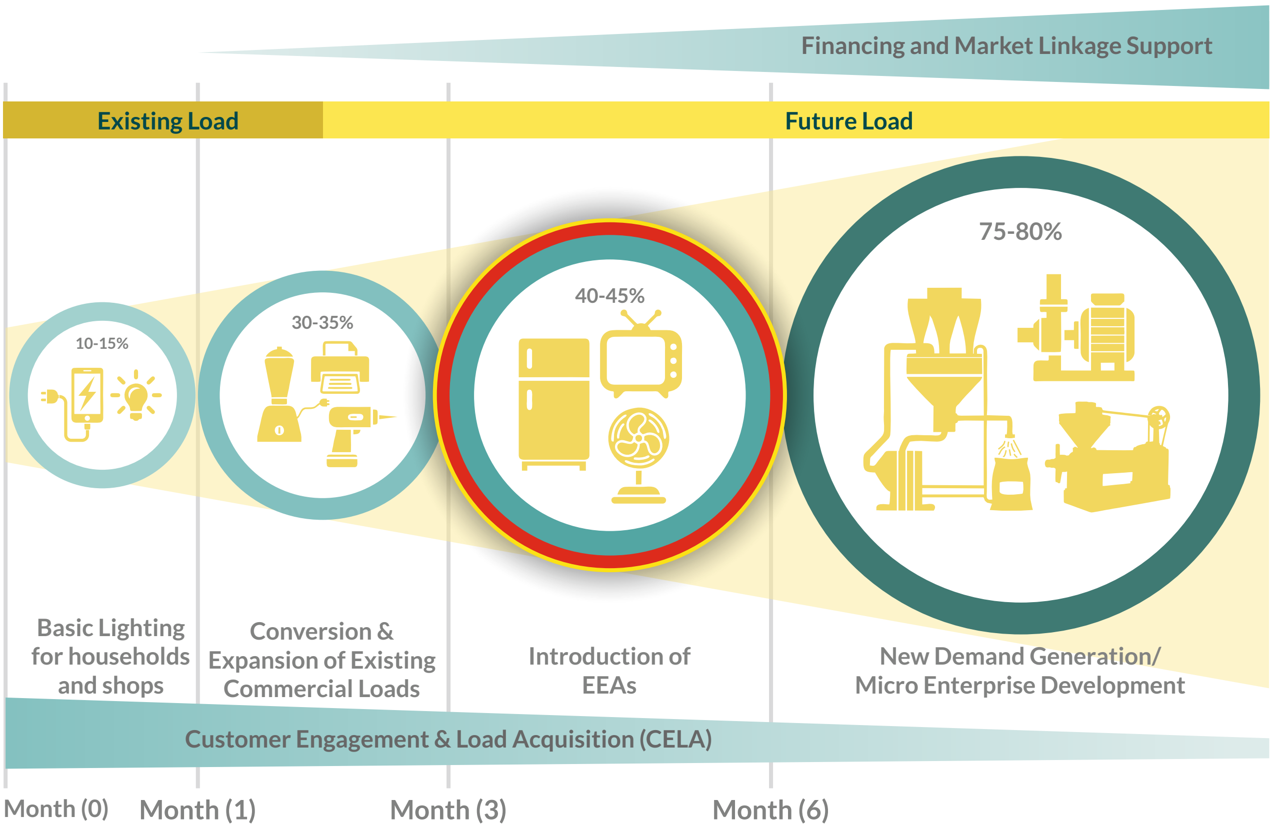
6

DEMAND ENHANCEMENT THROUGH ENERGY EFFICIENT APPLIANCES

6.1
Background

The targeting of basic lighting and conversion and expansion of commercial motors helps ESCO to achieve 30%-35% of the targeted load to make the solar mini-grid sustainable. An additional 5%-10% increase in utilization can be achieved through energy-efficient appliances (figure 6.1). Meeting the energy needs of such appliances can contribute up to 40 to 45% of the total demand for electricity of the mini-grid and hence is quite essential. The introduction of energy-efficient appliances (EEAs) creates numerous additional benefits for both the consumers as well the ESCO, and this is detailed in subsequent sections.

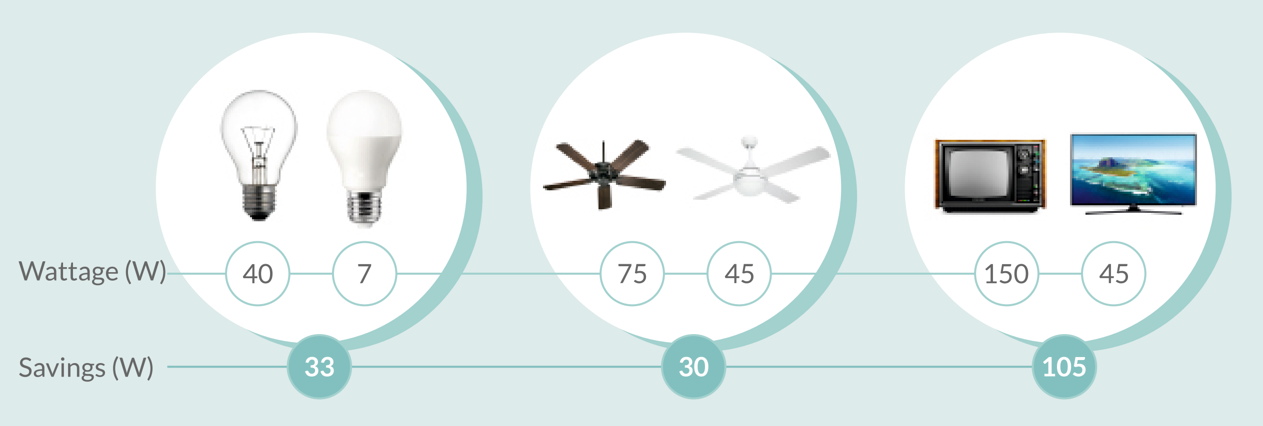
Figure 6.1: Demand progression



6.2
What are Energy Efficient Appliances?

Energy-efficient appliances (EEAs) are designed to utilize minimum energy to complete the required task. Small and medium households, shops and commercial establishments have low demand for electricity due to limited paying capacity. EEAs help increases the demand for electricity affordably. EEAs consume considerably less energy as compared to the appliances that they replace and help consumers to use more appliances with the same amount of energy (figure 6.2).

Figure 6.2: Savings in electricity usage using EEAs



6.3

Economics of EEA

It is imperative to understand the economics of EEAs to design the promotion strategy, be it generating awareness, developing new packages, or tying up MFIs. To understand the economics, let us take an example of a commonly used incandescent bulb of 40 W and 7 W LED bulb with similar lumen outputs.

Table 6.1: Savings in energy bill using EEAs

Parameter	60 W incandescent bulb	7 W LED bulb
Electricity consumed/ day assuming 6 hours/day usage	40 X 6 = 240Wh or 0.24 units	7X6 = 42Wh or 0.042 units
Electricity Cost @ INR 20[15]/unit	0.24 X 20 = Rs 4.80	0.042 X 20 = Rs 0.84
Monthly expense assuming	4.80 X 30 = Rs 144	0.84X 30 = Rs 25.20
Cost of bulb	Rs 10	Rs 60
Savings after replacement/ month	144 – 25.2 = Rs 119.8	
Payback for replacement	Less than one month	

The calculation in table 1 clearly shows that the replacement of the existing inefficient incandescent bulb with an energy-efficient LED bulb can pay back the additional investment within the first month. It also generates continuous savings over a much longer duration as the life of LED bulbs is at least 25

[15]Energy tariff as charged by ESCOs under SPRD Programme

times that of an incandescent bulb. The same is the case for other appliances. If customers are made aware of such savings, the rate of adoption of such devices is bound to increase.

6.4
Importance of Promoting EEAs

In the context of solar mini-grid where the cost of electricity is higher than the central grid, EEAs becomes very important in reducing the cost of consumption and reduces generation pressure on the ESCO. Promoting EEAs in a mini-grid is essential because it generates several benefits to both the consumers and the ESCO, as enumerated below.

6.4.1
Benefits of EEAs to Mini-Grid Consumers

Adoption of EEAs by households can generate the following benefits:

- **Efficient usage:** with the same amount of energy consumption, a household can derive more benefits from the electricity that it consumes. For example, more than five LED bulbs can replace an existing incandescent bulb thereby providing the household with more light across the household post replacement

- **Generating savings:** a household can reduce its electricity bill by replacing energy-inefficient appliances with efficient ones.

- **Increasing demand:** once the above two benefits are realized, the household starts to move up the energy ladder, which creates a strong need for new uses of electricity. During this stage, consumers begin to use appliances that they would not have used otherwise, which translates into an improvement in the quality of life and an increase in household incomes.

6.4.2
Benefits of EEAs to ESCOs

Promotion of EEAs is also beneficial to the ESCOs through:

- **Higher capacity utilization of mini-grid:** EEAs cuts across the customer segments – households, commercials, and institutional, therefore, can significantly contribute towards the capacity utilization of the solar mini-grid.

- **Decreases demand:** though counter-intuitive, this is a positive development for the ESCO as with reduced demand from existing consumers, ESCO can now focus on promoting MEDs, which are financially more rewarding, matches the generation curve, and contributes to the long-term sustainability of the mini-grid.

- **Avoiding demand peaks:** supplying electricity to meet spikes in demand is a big challenge for mini-grids. Inefficient loads coming online create power surge requirements that are difficult to serve. The ESCO needs to build up new generation and energy storage capacities, which have low capacity utilization and contribute negatively to the financial viability of the mini-grid. Large scale adoption of EEAs helps avoid this challenge.

- **Retaining consumers:** it has been observed that consumers who adopt EEAs tend to stick with the mini-grid and have much less tendency to drop off. It provides the ESCO with assured revenues over longer durations.

At the village level, the benefits of large-scale adoption of EEAs are immense. For example, let us take a village of around 300 households and having eight shops. The daily electricity consumption and overall expenditure of such a village pre and post-adoption of EEAs (specifically LED bulbs, fans, and TVs) are shown below.

Table 6.2: Cost Savings after the adoption of EEA by 30% household in a village

Household/Shops Load assessment			Wattage (W)	No. of Appliances	Daily usage (h)	Daily Consumption (kWh)	Electricity cost perday @ INR 20/unit (Rs)
Pre EEA adoption	Households/ Shops	Bulb	40	200	6	48	960
		Fan	75	50	8	30	600
		TV	150	20	4	12	240
Total						90	1,800
30% EEA adoption	Households/ Shops	LED	40	140	6	33.6	672
		Fan	75	35	8	21	420
		TV	150	14	4	8.4	168
	30% conversion	LED	7	60	6	2.52	50.4
		Fan	40	15	8	4.8	96
		TV	45	6	4	1.08	21.6
Total						71.4	1,428

From the above table, we can see that if all the households and shops replace their existing incandescent bulbs, fans, and CRT TVs with LED bulbs, energy-efficient fans, and LED TVs, respectively, the village overall can save 21% electricity usage (and hence expenditure). As mentioned earlier, when households realize the savings that EEAs generate, they tend to use more of such appliances at the village level.

6.5

Factors Affecting the Adoption of EEAs

We can observe that the large-scale adoption of EEAs in a mini-grid has apparent benefits (Box 1). Still, at the village level, this does not happen as expected. Lack of awareness, high upfront costs, poor marketing/ sales, and after-sales network of manufacturers, and lack of financing are the significant reasons (figure 6.3).

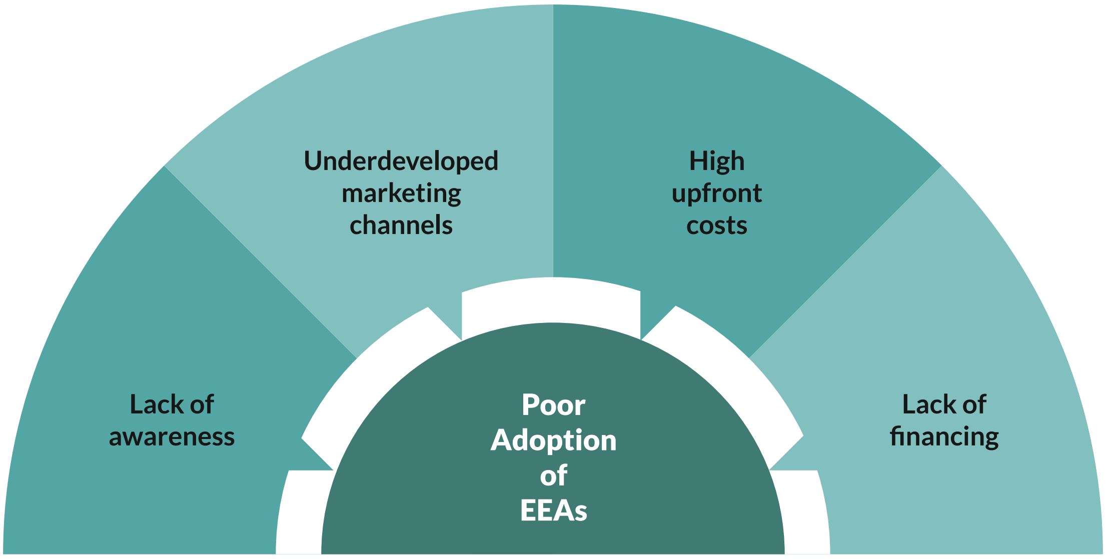


Figure 6.3: Reasons for poor adoption of EEAs

a) **Awareness of customers:** the customers in rural areas have limited knowledge of EEAs about:

   I. Overall net savings despite high upfront costs

   ii. Differentiation of EEAs with conventional appliances as well as other EEAs, i.e., star rating

   iii. Quality standards and credible manufacturers/vendors of EEAs

b) **The high upfront cost of EEAs:** one of the significant challenges in the adoption of EEAs is their high upfront costs as compared to conventional appliances.

c) **Underdeveloped marketing channels:** lack of availability of ground-level information like consumer preference, their paying capacity, usage often lead to poor marketing of EEAs. Manufacturers typically ignore these customers who are at the bottom of the p yramid citing higher customer acquisition and servicing costs.

d) **Lack of financing:** as the upfront costs of EEAs are comparatively higher than existing appliances, and rural consumers find it challenging to purchase them without financing support, which is generally lacking.

6.6
Load Acquisition Strategy by Promoting EEAs

Against the above background, ESCOs can adopt a passive role and wait a more extended time for the uptake of demand from households, shops, and small commercial customers. Alternativ ely, they can adopt an active role in accelerating an increase in demand by promoting EEAs. A successful EEA promotional strategy should include the following initiatives individually or in combination:

- **Increase in awareness:** ESCOs should educate their customers with savings on electricity bills, quality of EEAs, and credible vendors.
- **Reduction in prices of EEAs:** ESCOs can purchase EEAs in bulk from vendors resulting in better rates for ESCOs.
- **Introduction of new packages:** ESCOs can introduce packages which include both EEAs and electricity.
- **Partnering with financial institutions:** ESCOs can partner with financial institutions like microfinance institutions to provide EEAs, especially big-ticket appliances like television sets and refrigerators, to customers through monthly installments. MFIs, with the support of ESCOs, can sell EEAs and collect the payment through monthly installments. ESCOs might have to build the capacity of MFIs in selecting EEAs, vendors, and estimating monthly installments.
- **Partnering with distributors:** ESCOs can enter into partnerships with reliable brands and bring their products to their consumers.
- **Incentivizing EEAs:** ESCOs can incentive their customers to adopt EEAs through a discount on a bill or provide free/ discounted EEA items like bulbs or fans.

Increase in energy consumption post EEA adoption

Studies conducted by SPI have shown that the adoption of EEAs has increased when supported with focused distribution and deeper ground-level engagement. Wherever ESCOs have distributed EEAs, the adoption of consumers to the mini-grid has also been higher. It has also been found that per capita consumption of electricity has increased wherever EEAs have been introduced, as shown in the figure 6.4.

The reasons for increased consumptions are:

1. Improved reliability of services due to mini-grid increased consumption.
2. Change in consumer behavior due to the reduction in electricity expenses.

A pilot test by SPI also demonstrated that average revenue per user (ARPU) increased by 90%, i.e., INR 228 per user for EEA customers. Hence the adoption of EEA's by customers means higher revenue for ESCOs.

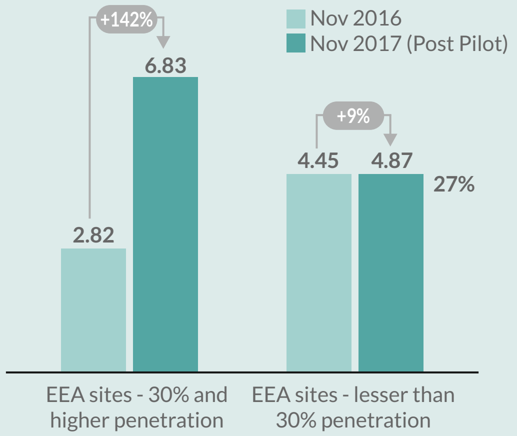


Figure 6.4: Change in average energy consumption

6.7

Need for Marketing and Finance

EEAs are generally costly, and their marketing channels, along with after-sales, is limited to urban and peri-urban areas. It limits the adoption of EEA devices. Therefore, marketing of EEAs coupled with service support increase the adoption of EEAs[16]. While designing the marketing strategy, the ESCO may consider the following:

- ESCO can be a distributor of the EEA device and can actively promote the products among the rural population.
- ESCO can also bundle various EEA devices in a package that can be sold to different population segments.
- While the manufacturing companies can sell their EEAs, ESCO can provide service support. The customer or manufacturing can pay the cost of service.

Financing support is an enabling factor, which ensures that household adopts EEA devices. The initial upfront cost is recovered in the form of accrued benefits in the form of savings in the energy bill. There could be a different model to provide access to finance for EEAs depending on –

[16]The State of The Off-Grid Appliance Market published by Global Leap; page no.8-10

- **Direct selling:** the ESCO themselves becomes distributor of the EEA product and recover the cost of the product by building them in the regular energy bill.

- **CSR activities:** providing simple EEA device like LED bulbs at zero cost as a part of CSR product of corporates

- Partnership with lending agencies and EEA manufacturing companies: ESCO can partner with lending institutions like microfinance institutions, banks, and other NBFCs and EEA manufacturing companies where the lending companies provide credit to the individuals on purchase of EEA device from the manufacturing companies.

The adoption of EEAs by the customer and the promotion of the EEA market in the rural areas by ESCOs is a win-win strategy where the customer gains by reducing energy consumption with similar output. At the same time, the ESCO increases their depth of outreach. Some factors limit their adoption by rural customers. Therefore, ESCO should devise strategies like pricing, partnership with financial institutions, and improving marketing channels to overcome these challenges and help in the promotion of EEAs.

Points to remember

While promoting EEAs, one should remember:

- **Win-win intervention:** adoption of EEAs by consumers and promotion of the same by ESCOs is a win-win intervention and should be a significant focus of the ESCO setting up and running the mini-grid

- **Communication of benefits:** the initial thrust of the ESCO should be to convey the financial benefits of different EEAs. The early adopters go for replacements when they get to know about these benefits.

- **Need to build partnerships:** encouraging large scale adoption of EEAs is not the primary line function of an ESCO, and it needs to develop partnerships with manufacturers/ suppliers in making products available at the village level.

- **Addressing financing needs:** being comparatively expensive, the ESCO has to take the lead in working with MFIs to develop financial products for EEA purchases by consumers.

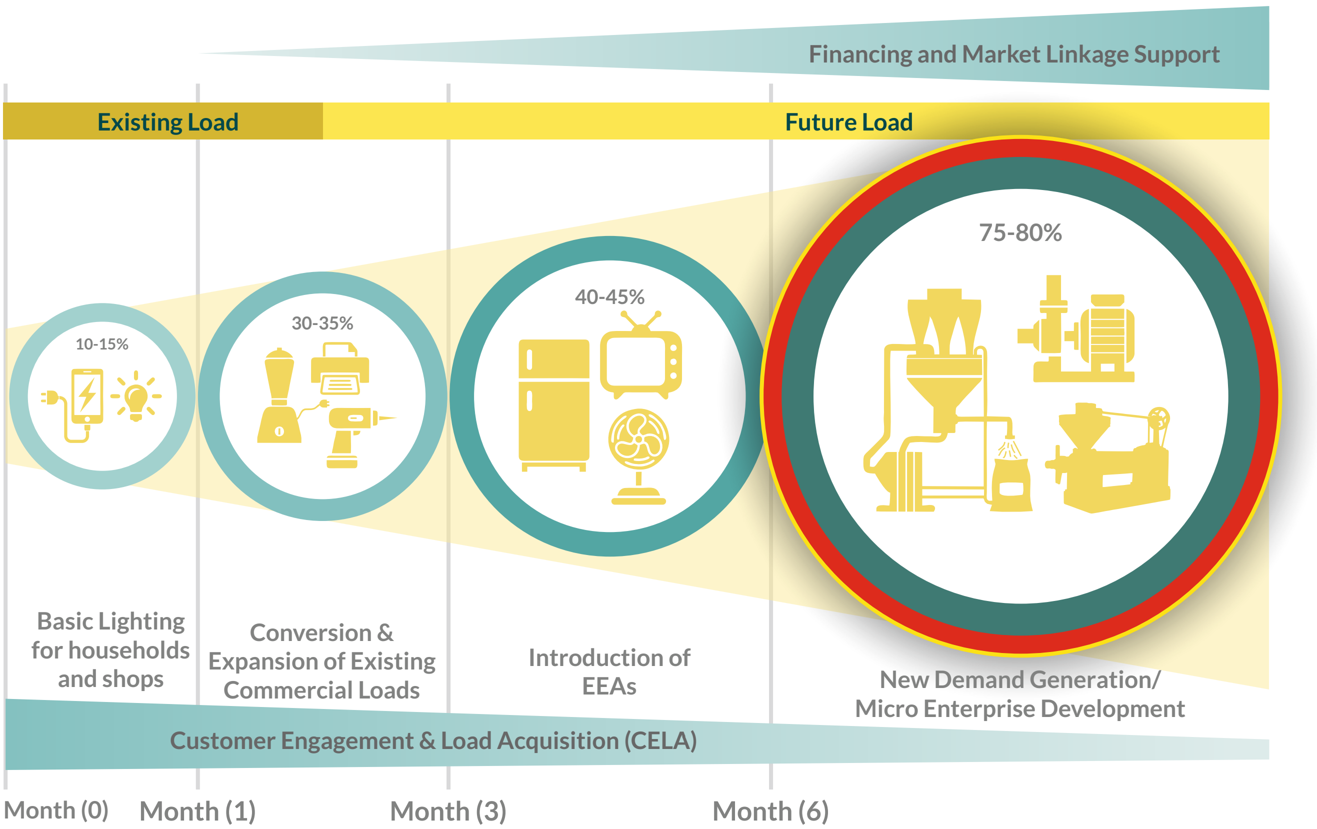
7

NEW DEMAND GENERATION

7.1 Background

As mentioned earlier, higher capacity utilization of mini-grid positively contributes to its financial sustainability. The cost of a mini-grid is sometimes only justified when productive loads—especially daytime loads—are large enough to supplement the night-time household loads. ESCOs need to put in additional efforts in developing new electricity demand through village level micro-enterprises, which may depend on the mini-grid to ensure the usage of electricity for productive purposes. ESCOs need to invest resources in screening such micro enterprises, mark et linkages, training and capacity building of the local community to stimulate the creation of micro-enterprises (figure 7.1). The key consideration that the ESCO needs to keep in mind is that micro-enterprises are likely to come up or existing micro-enterprises may subscribe to the mini-grid sooner than later.

Figure 7.1: Demand progression



Identifying the likely micro-enterprises early on, assisting them in developing robust business plans, and identifying financing modalities is very important. Development of new demand also helps in:

1. Adding new services other than electricity where micro-enterprise has become available to the local community
2. Creating a social impact on livelihood/health/education of the local community, which results in higher acceptance and use of the mini-grid.

Making the right selection for micro-enterprise is a complex task because of the number of factors to consider. The decision becomes even more intricate when there are competing factors and activities for determining a micro-enterprise for new demand. It calls for a structured approach to new demand generation. Assessing this need, SPI has developed the '5S' framework as an approach to the selection of micro-enterprise for new demand. This chapter details the process of exploring new demand generation using SPI's '5S' framework.

Subsequently, this chapter also describes the steps in using the framework to follow the right sequence of filters to select potential micro-enterprise.

7.2

Defining a Micro-Enterprise

According to the World Bank's SME department[17], a micro-enterprise is defined as an enterprise that has one to nine employees. However, this definition is context-specific. For example, in India[18] micro-enterprise is defined as an enterprise where investment in plant and machinery does not exceed Rs 25 lakh. Whatever be the definition, micro-enterprises have three elements:

- A small amount of capital used
- A small number of people employed
- Specialization in providing goods and services to the local area.

For new demand generation, a micro-enterprise can be defined as any business activity that act as an anchor load in the context of mini-grid

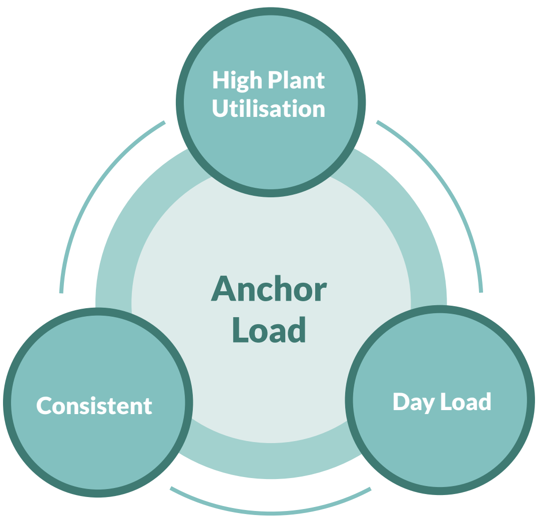


Figure 7.2: Anchor Load

[17]http://web.worldbank.org/archive/website00504/WEB/DOC/CIS_7_SM.DOC, viewed on 1/10/2019
[18]https://msme.gov.in/faqs/q1-what-definition-msme, viewed on 1/10/2019

An anchor load is an activity or enterprise which has a contribution towards high capacity utilization of 30 to 60% of the total electricity generated by the mini-grid consistently and mainly as a day load (figure 2). Anchor load stabilizes the income of mini-grid and increases its profitability; however, the risk then, of course, depends on the performance of the anchor load's business activity.

7.3

Data Collection for New Demand Generation

Data collected during the site selection stage forms the basis for new demand generation as well. However, data points, level of analysis, and the process of finalizing new demand are different. The mini-grid demand generation team of the ESCO should analyze the following data from the site selection process:

a) **Site profiling survey:** this covers both desk and primary research of the major economic activities existing in the potential mini-grid site.

b) **Detailed electricity survey for demand generation:** it provides the data points on existing MED activities, associated motor loads, alternate sources of electricity and demand for the mini-grid.

c) **Assessing opportunities for micro enterprise development:** initially designed detailed survey capturing site-specific information to bring out the opportunities for potential micro enterprises for scaling up in a geography such as water treatment unit, flour mill, oil expeller etc. The survey should include standard items in the study like cropping pattern, agricultural produce, raw material availability, local consumption pattern, quality of water, groundwater level, skill set available with the community etc.

7.4
SPI's '5S' Framework for New Demand Generation

SPI has developed '5S' framework for new demand generation to help a practitioner to select micro-enterprise focusing on five broad components and their subcomponents represented as a key as it acts as a key or guide for an ESCO. The following figure describes the '5S'framework and its components.

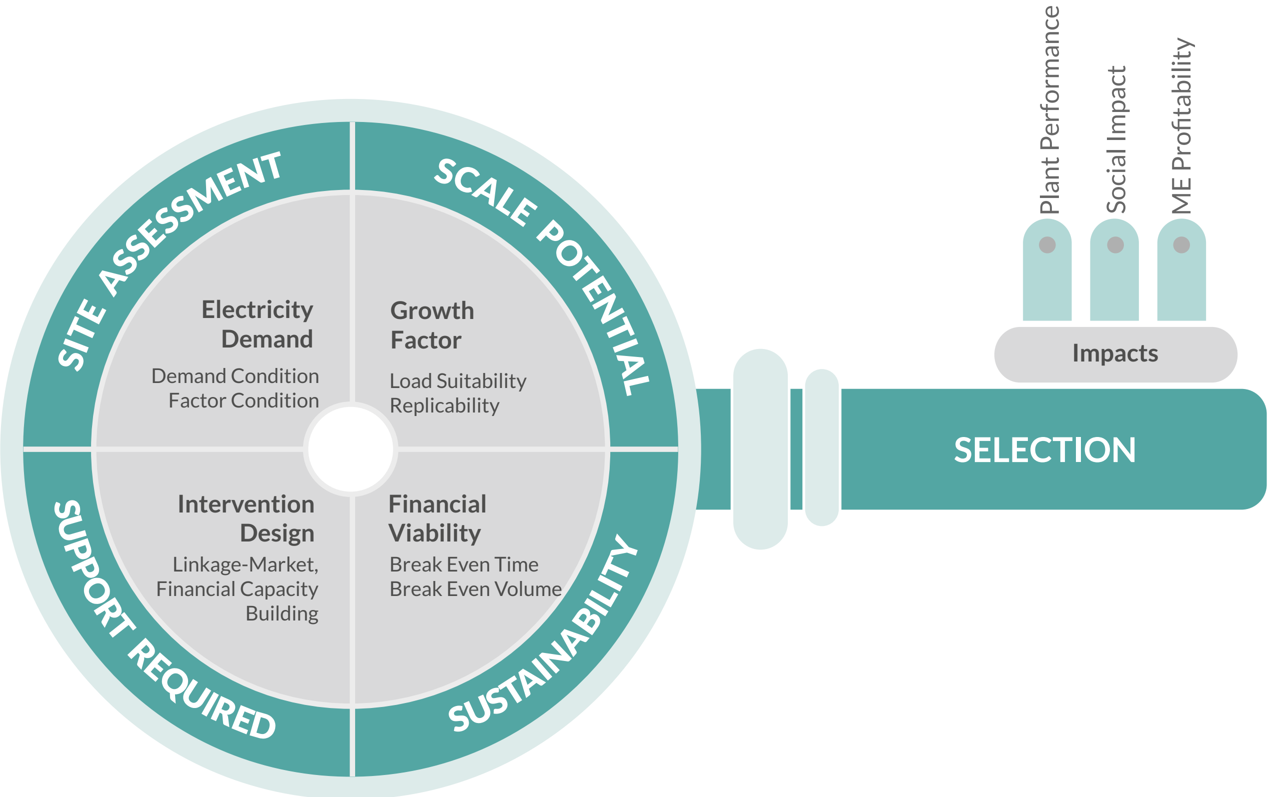


Figure 7.3: SPI's '5S' framework for new demand generation

Figure 3 represents the '5S' framework of SPI and has 5 major components each depicted by an 'S' – Site identification, Scale potential, Support required, Sustainability, and Selection. These factors are discussed in details in the following section.

7.4.1
Site Assessment

This is the first component, and comprises two sub-components- Demand Conditions and Factor Conditions. The site assessment is part of the site selection process as explained in Chapter 3. Economic activities or sub-activities are identified based on the data collected at the time of site selection. Site assessment gives a list of possible economic activities and has following components.

a) **Demand Conditions:** it refers to local demand, external demand, mild competition, cost competitiveness, and presence of alternative. Analysis of the activities is done on these parameters to assess their suitability.

b) **Factor Conditions:** it refers to the presence of surplus raw material and current source of electricity suited to the micro-enterprise as necessary factor conditions. These are conditions that are advantageous to a particular type of enterprise in a given area therefore their presence is necessary to achieve scale and build business around them.

7.4.2
Scale Potential

This is second component of the '5S' framework and refers to the potential to scale for the micro-enterprise in a mini grid cluster. It is measured through load suitability and replicability of the activity, as explained below:

a) **Load suitability:** it refers to identification of an activity that fits as an anchor load. Further, the requirement for a single-phase or three-phase connection, electricity surge motor efficiency and voltage by the specific load should also be considered.

b) **Replicability:** this helps us to understand the probability of such business activities in close cluster of mini grids with similar site conditions. ESCOs may build their expertise for the most replicable new demand generation. The water treatment unit can be taken as an example, which shows the potential to scale as more and more villages are adopting RO filtered water with an increase in awareness.

7.4.3
Support Required

A micro-enterprise identified may requires external support to be sustainable in the long run and thus generate long term revenues for the ESCO. The assistance that a micro-enterprise may require:

a) **Market linkages:** initially, the village level enterprises may require support to establish linkages to any stakeholders in the value chain for the sustaining their business. This may be financial linkages for capital investment or market linkages for business growth.

b) **Capacity building:** most of the new demand generation activity will be established by village level entrepreneur and will require handholding support from the ESCO or any livelihood agency. ESCOs need to evaluate the time and resources required to providing such facilitation for successful enterprise.

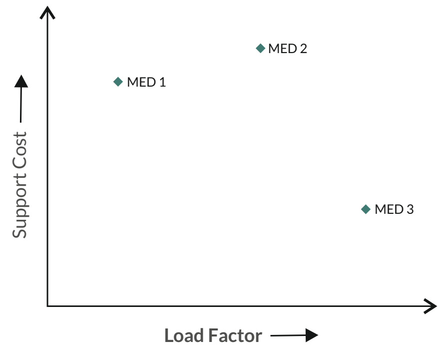


Figure 7.4: Support cost and electricity utilization comparison

However, extending support is resource-intensive, and the ESCO needs to assess the expected returns from its efforts. Long term sustainability of performance for the ESCO is directly proportional to the load factor and inversely proportional to the amount of support cost of the micro-enterprise. The ESCO should undertake an analysis of these parameters before finalizing on the micro-enterprise. As illustrated in figure 4, if there are three plausible activities, which can be shortlisted, then MED 3 should be selected because this activity will yield maximum electricity utilization of the mini grid for every unit of investment made.

7.4.4 Sustainability

Sustainability forms the core of a micro-enterprise and refers to assessing the financial viability of the micro-enterprise Form the perspective of new demand generation financial sustainability refers to an activity which generates surplus/profit to keep the business running for a long time. Financial viability is analyzed on two key parameters:

a) **Length of payback:** it is the point in time from the start of operations of a micro-enterprise until it becomes profitable. That is when the cumulative capital expenditure and operational expenditure are fully met from the cumulative net operational profit. There are two related concepts to the length of payback:

   i. When the variable expense is reduced to such a level of production where the operations become profitable. This is known as operational break even.

   ii. When variable expense and capital invested becomes fully met cumulatively from the cumulative net operational income. This is known as full break even.

b) **Payback volume:** it is the cumulative amount of profit over a period of time from the start of operations of the micro-enterprise. This financial analysis is assumption based and takes into account all costs involved, and the future cash flows from the micro-enterprise. This is important from the point of view of comparing profitability for the investment to be made.

By the time financial analysis starts, ESCO will have a more specific list of viable micro enterprises and more detailed information to help build the assumptions for the business models leading to more realistic projection and analysis.

7.4.5 Selection

Selection is the final step for choosing a micro-enterprise aligned with the impact an ESCO wants to achieve as per its organizational objective. Depending on the objective of the organization – social, commercial, or mixed, the final selection of the micro-enterprise takes place. Key components of selection refer to the following:

1. **Profitability:** the selection of an enterprise based on the sole criteria of profitability. It refers to micro-enterprises with higher profit margins and low gestation period.

2. **Social impact:** those enterprises which are high on social impact in terms of livelihood generation, well-being of women and children, reduction in carbon emission, or improving the lives of people in the catchment area of the mini-grid.

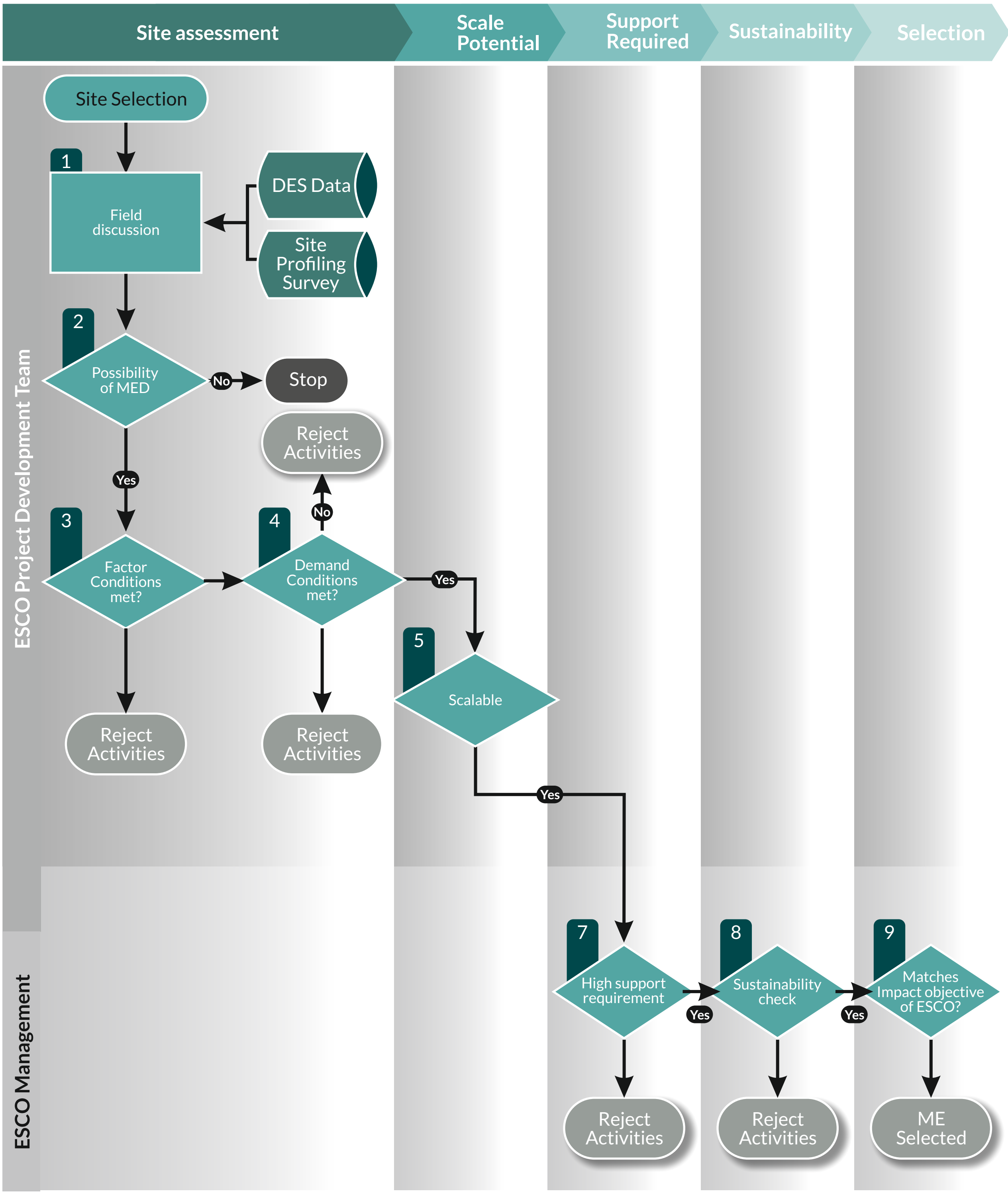
3. **Plant Performance:** it refers to selection of an enterprise on the criteria of utilization of electricity produced by the mini-grid. There are ESCO who follow this as their primary criteria and often set up a mini grid in an area where they have already identified anchor load e.g. telecom tower and electricity supply to the local population comes only as secondary priority.

7.5

Steps for Executing the ‘5S’ Framework

While analyzing the approach for selection of micro-enterprise following steps emerge.

Figure 7.5: Steps for executing the '5S' framework



The steps given in the above figure are illustrated through the following example – the case of Rampur village (box 1).

Box 1: Rampur village

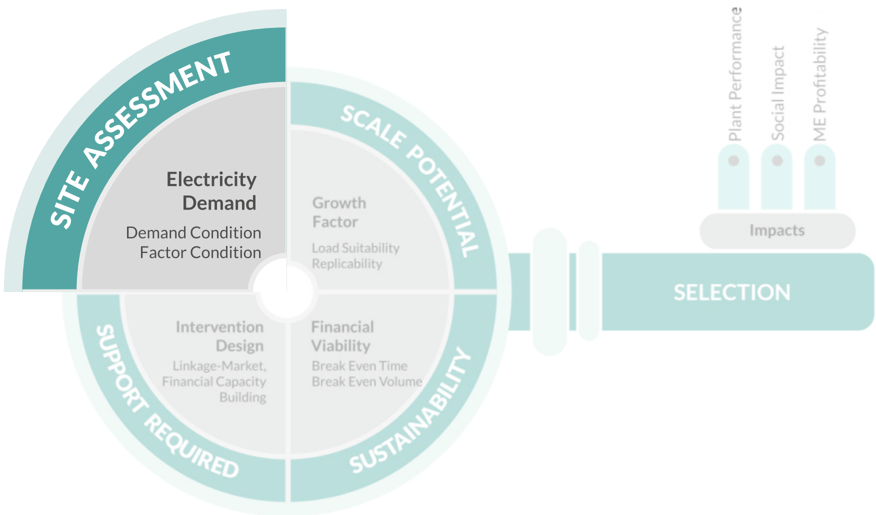
Rampur village is located around 20 km from the state highway. The development block headquarter is 10 km away from the village. The block has a population of 1,00,000 and has schools, colleges, and other government offices. The number of households in the village is 570 and the total population is 3,000. There is a small market in the village with 50 small shops and 4-5 micro enterprises. The grid supply of electricity is inconsistent and power outages are very common and for long durations. The situation during the summers is even worse and electricity supply is usually not available during daytime. Single phase connection makes running of commercial motors a difficult task.

The cropping pattern in the area is good, and usually, two crops are grown in a year – paddy in kharif and wheat in rabi - with intervening vegetable growing season. The village in the region are mostly dependent on diesel pump sets for irrigation as the grid electricity supply is inadequate. Animal husbandry is only for sustenance. However, organizations are working in the area in the promotion of back yard poultry and apiculture. The region is also rich in mustard seed production, which is processed and consumed locally. Since the place is also near to the sea, fishing is a common occupation, and fishes are sold in the local marketplace. Seasonal variations in temperature are not high with mild winters and long summers.

Considering Rampur village as an example where an ESCO plans to set up mini-grid let us now analyze it for selecting a potential micro-enterprise. Analysis is done as per the steps mentioned in figure 5.

Site Assessment

Site assessment covers step 1 to 4 of executing the '5S' frameowrk. These steps are detailed as below:



Step 1: Field discussions

Given the background and the regional characteristics as mentioned above, the demand generation team first analyzes the site data to find out the existing potential micro-enterprises (ME). Then s/he goes to the operational area of the site and talks to the local people and entrepreneurs and lists different new demand generation activities.

Step 2: Possibility of MED

After the initial discussion and analysis of data it is assessed whether a micro-enterprise can be setup in the area or not.

Table 7.1: List of potential micro-enterprise		
S.N.	Activities	Electricity Demand
1	Water Treatment Unit	✓
2	Oil Expeller	✓
3	Flour mill/Pulverizer	✓
4	Irrigation pump	✓
5	Bulk Milk Chiller	✓
6	Honey Processing Unit	✓
7	Rice Huller	✓
8	Seed business	✗
9	Fish processing/Cold Storage	✓
10	Chicken Rearing	✓

Once the activities have been listed, then they are shortlisted based on electricity demand. As observed, out of the activities like Seed Business and Processing of mustard seed though lucrative livelihood options in the agricultural belt are irrelevant from a mini-grid perspective. So, for the next step, we eliminate this activity.

Step 3: Factor conditions check

In this step, we eliminate the activities based on whether existing grid supply is suited to production and secondly on whether there is an availability surplus of raw material. We find out that since the grid supply is inadequate, it is not suited for any of the activities. It means that all the activities selected qualify.

Table 7.2: Demand Conditions Check			
S.N.	Activities	Grid supply for ME?	Surplus local raw material?
1	Water Treatment Unit	✓	✓
2	Oil Expeller	✓	✗
3	Flour mill/Pulverizer	✓	✓
4	Irrigation pump	✓	✓
5	Bulk Milk Chiller	✓	✓
6	Honey Processing Unit	✓	✗
7	Rice Huller	✓	✓
8	Fish processing/Cold Storage	✓	✓
9	Chicken Rearing	✓	✗

On the other parameter, we find that the 'Honey Processing Unit' and 'Chicken Rearing' do not have a local surplus. Still, people can be motivated to rearing chicken, and there is already a local organization which is supporting this activity. However, production is not regular, and consumption is primarily outside the area. Setting up an apiary and motivating people to take up this activity, therefore, is a long-drawn process. As a result, this activity gets rejected at this stage.

Step 4: Demand conditions check

The next step is to filter out the activities based on 'Demand Condition,' which covers factors like – local demand, external demand, mild competition, cost competitiveness, presence of alternatives. The following table summarizes the activities based on these parameters.

Table 7.3 analyzes Demand Conditions for the production of these micro-enterprises. For example, for Water Treatment Unit (WTU), the demand for purified water that is being analyzed, and for Bulk Milk Chiller, it is the demand for milk from local dairy units. Micro-enterprises such as flour mill and irrigation pump will always bank on local demand. 'Presence of Alternative' is an important parameter to note here. A negative result on the presence of alternatives is good for the proposed micro-enterprise.

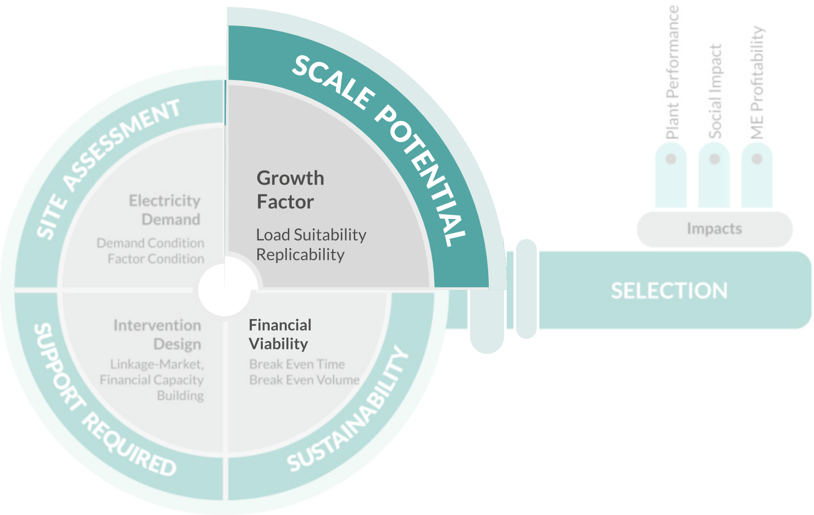
Table 7.3: Demand Conditions Check

S.N.	Activities	Local Demand	External Demand	Mild Competition	Cost Competitiveness	Presence of Alternatives
1	Water Treatment Unit	■■■■■	■■■■■	■■□□□	■■■■□	■■□□□
2	Oil Expeller	■■■■■	■■■■■	■■■□□	■■■■□	■■■■■
3	Flour mill/Pulverizer	■■■■■	■■□□□	■■■■□	■■■■■	■■□□□
4	Irrigation pump	■■■■■	■□□□□	■■□□□	■■■■□	■■■■□
5	Bulk Milk Chiller	■■■■□	■■■■□	■■□□□	■■■■□	■■■■□
6	Rice Huller	■■■■■	■■■■□	■■□□□	■■■■□	■■■■□
7	Fish processing/Cold Storage	■■■■□	■■□□□	■□□□□	■■■□□	■■■□□
8	Chicken Rearing	■■■■□	■■■■□	■■■■□	■■■□□	■■□□□

The table above gives mixed results. However, based on cost competitiveness and the presence of alternatives, we can eliminate bulk milk chiller and chicken rearing from the list of activities because the product is not competitive and options to the product already exist.

Scale Potential

The next stage in the process is to filter out activities depending on the possibility that they offer in scaling up. Each micro-enterprise is measured against their load suitability and replicability; this is elaborated in Step 6.



Step 5: Scalable

This is measured as suitability as an anchor load and on the potential to scale in the future. Let us understand this from Table 7.4 given below. We see that except for chicken rearing, which requires electricity for lighting and ventilation during the night, all other activities qualify for load suitability and scalability. The list of activities is now sent to the management of the ESCO for further analysis.

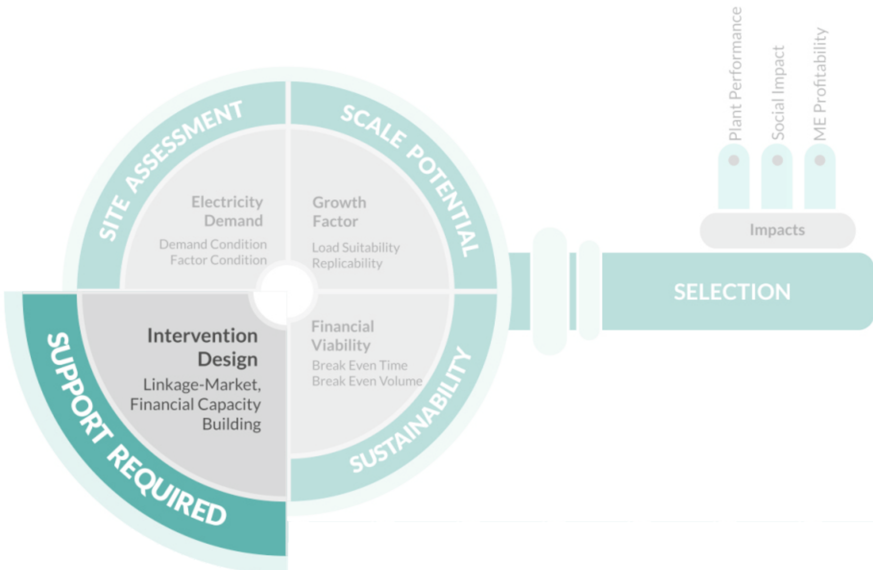
Table 7.4: Growth Potential Check

S.N.	Activities	30-60% electricity utilization	Consistent demand	Day load	Potential to scale
1	Water Treatment Unit				
2	Flour mill/Pulverizer				
3	Irrigation pump				
4	Oil expeller				
5	Fish Processing/Cold Storage				
6	Rice Huller				

Based on analysis in table 4 we can eliminate fish processing/cold storage activity due to its localized demand and dependence upon fishing as livelihood activities.

Support Required

The next process in implementing the 5S Framework is to assess each micro-enterprise on the extent of support required (figure 6). The amount of time and associated costs involved in capacity building, awareness creation, creating financial and market linkages for the enterprise is assessed based on the cost involved.



Step 6: High support requirement

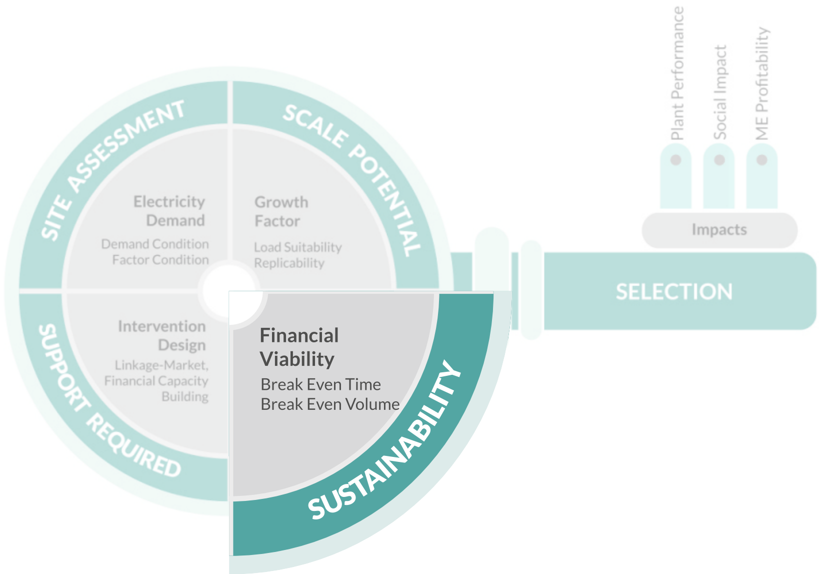
At this stage level of support required is checked for different activities. Associated costs, as relevant for various activities, are then factored in doing the financial analysis in the next step. Table 7.5 given below depicts the costs involved in support required across various parameters. It can be observed that micro enterprise like water treatment unit, irrigation pump and oil expeller required comparatively higher support and need to facilitate by expert agency.

Table 7.5: Support Required Check

S.N.	Activities	Financial Linkage	Market Linkage	Marketing/ Branding	Capacity Building
1	Water Treatment Unit				
2	Flour mill/Pulverizer				
3	Irrigation pump				
4	Oil Expeller				
5	Rice Huller				

Sustainability

Based on the input of the field team, and data collected during the site survey, the financial analysis of the shortlisted micro-enterprises is carried out. The financial viability of each enterprise is checked mainly on two parameters – the payback period and payback volume.



Step 7: Sustainability check

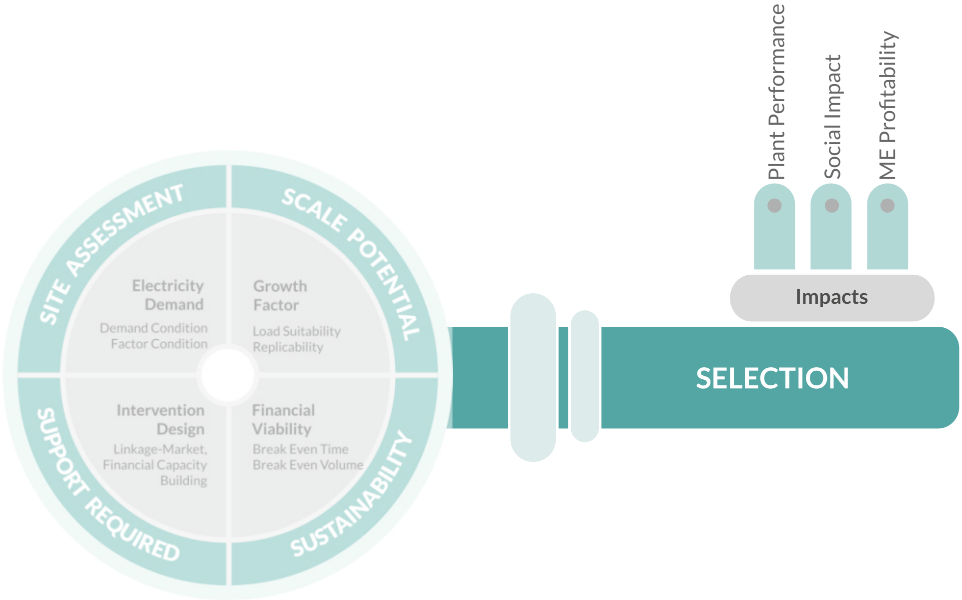
Comparison of results of different activities on these two parameters is given in Table 7.6. However, it is to be noted that other costs like maintenance cost, storage requirement, branding and packaging cost, and quality control cost should also be factored as per different new demand activity to assess the financial viability and payback period. In this case, financial analysis reveals that rice huller, can be eliminated as it is not financially viable.

Table 7.6: Financial Viability Check

S.N.	Activities	Payback Volume	Payback Period
1	Water Treatment Unit		
2	Flour mill/Pulverizer		
3	Irrigation pump		
4	Oil Expeller		
5	Fish processing/Cold Storage		

Selection

It is the final stage in implementing the '5S' framework to take decision on new demand generation activity influenced by objective of the ESCOs.



Step 8: Match impact objective of ESCO

By this time of the analysis, only four enterprises have passed all the filters. The decision now rests with the management to select the activity based on the objective of the organization. Depending on the objective of the organization – social, commercial, or mixed, the final selection of the micro-enterprise takes place.

Table 7.7: Selection

S.N.	Activities	Profitability	Social impact	Plant performance
1	Water treatment unit	■■■■■	■■■■■	■■■■□
2	Irrigation pump	■■■□□	■■■■■	■■■□□
3	Flour mill/Pulverizer	■■□□□	■■■□□	■■■■□
4	Oil expeller	■■■□□	■■■■□	■■■■■

A comparison between these three activities, as shown in Table 7.7, is based on the micro enterprise profitability, social impact and plant electricity utilization. Water treatment units and irrigation pumps have higher immediate social and economic effects, respectively, and the electricity from the mini-grid can be utilized relatively quickly as compared to rice huller, which has a longer gestation. However, in the long run, it has more significant potential to utilize mini-grid electricity. Therefore, the final selection of the micro-enterprise is to be done based on the organizational objective. Some organizations focus on high social impact while others may focus on early break-even. There may also be organizations that look for higher returns, even if the break-even period is extended. Therefore, the final selection is heavily weighted on the organizational objectives and alignment of micro-enterprise with that.

The '5S'framework highlights the key factors to consider and also tells about the sequence in which the factors are to be considered. An ESCO staff who is leading the field level operations and working on a strategy to establish a mini-grid '5 S' framework acts as a guide. However, while using the framework, it is essential to be objective in the assessment of activity. as it easy to get biased based on our past experience.

A detailed illustration to the eight different micro-enterprises is given in annexure covering their operational model, key success factors, and analysis on the '5S' framework. These case studies are based on the experience of field implementations by SPI and are a great resource for learning to apply the '5S' framework.

Points to remember

While conducting the new demand generation for mini grid, one should remember:

- **Follow the order of steps:** while following the framework, it is always good to follow the sequence of steps of the '5S' framework as it helps in eliminating any decision bias.
- **All elements of the framework may not be applicable:** some of the factors mentioned in the framework may not apply to certain areas, so they should be left out in the analysis.
- **Data gaps lead to a wrong decision:** there should not be data gaps while analyzing as it leads to a wrong decision. All field-level data should be appropriately collected using the tools, and multiple visits to the location should be made to build understanding before starting the analysis.
- **The objective analysis leads to better selection:** objective analysis of the activities should be done to remove any individual bias. It leads to better decision making.

8

MEASURING THE IMPACT

8.1

Background

Mini-grid and it services has the potential to be a significant driver of rural development, unlocking latent economic potential and livelihoods, while simultaneously enabling aspirations for improved quality of life. A mini-grid execution follows an input-output-outcome-impact cycle, as shown in figure 8.1.

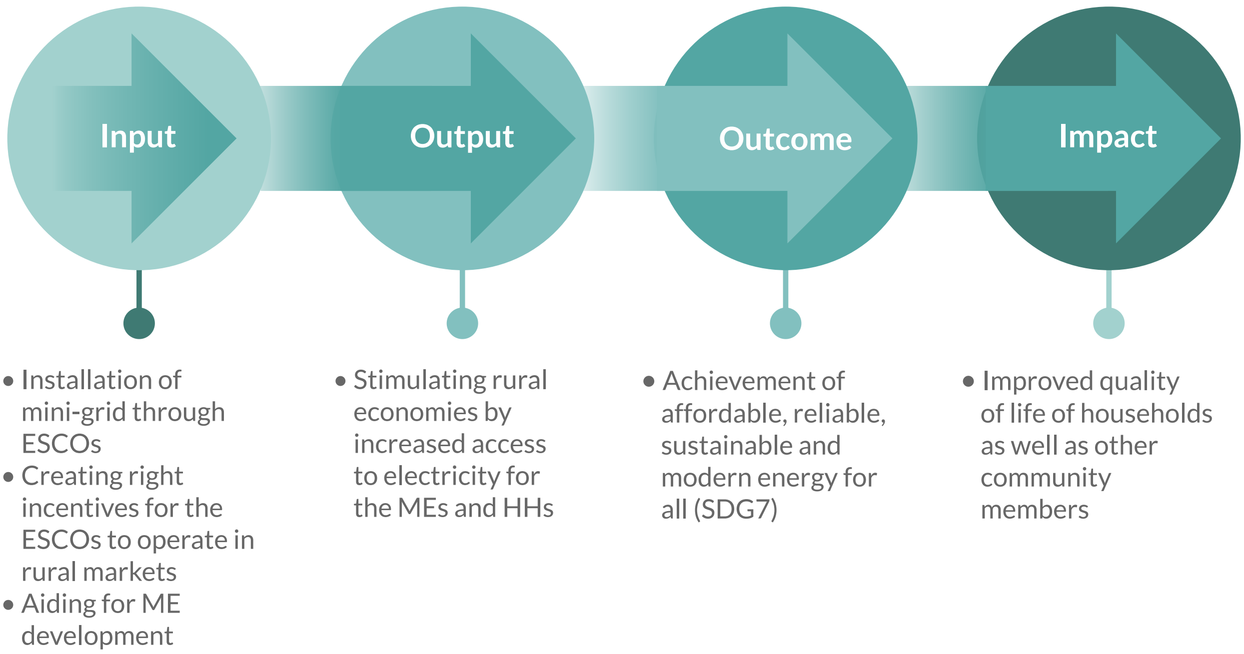


Figure 8.1: Input-output-outcome-impact cycle for impact assessment

Existing mini-grid have already worked to realize many of these benefits like:

- Economic benefits in terms of growth in number of micro-enterprise establishment and increase in incremental incomes due to livelihood creation, business expansion, and improved irrigation facility.

- Social benefits like improved education indicators through access to reliable household lighting, school power supply, and other information services

- Reduced air and noise pollution due to less usage of diesel-based generators for electricity. This has also resulted in improved health indicators for women and children from the replacement of polluting energy sources such as kerosene lamps, as well as specific health initiatives taken by ESCOs

8.2

Why do we Need to Measure Impacts?

The above benefits are substantial and very relevant in the rural context. In addition to capturing these impacts, assessment for mini-grid interventions thus needs to be carried out in a structured manner to determine how it works, where to extend the level of efforts, how it can be refined, etc. An impact assessment for solar mini-grid projects is thus crucial for the following reasons:

- It enables ESCOs to learn and better decision-making about improving services and achieving maximum impact.
- It facilitates a better understanding or comparison with alternatives for investment when making decisions on options for sustainable energy services.
- It increases the value derived to customers via a more efficient and tailored service by increasing willingness to pay for services and further increasing the financial viability of business models.
- It demonstrates accountability to customers, partners, and donors.
- It allows for lessons learned to be communicated. It can help to improve the quality of mini-grid implementation through adaptations and innovation in mini-grid business models for the base of the pyramid customers.

8.3

Approach for Impact Assessment

Approach for impact assessmentThere is a need to develop an evidence-based approach for a practical impact assessment with clear identification of expected impacts, impact indicators, data required to study the effects and procedures for evaluating the effect. A solar min-grid project has social, economic, and environmental effects at the household and community levels. Table 8.1 guides the measurement framework that can be adopted.

Table 8.1: Indicative approach for measuring the impact

Impact category	Indicator	Data set	Methodology
		Social	
Usage of electricity at the household level	Applications for which electricity is used	• Number of electric appliances used in the households • How many households used electrical appliances • Frequency of usage	Household survey on electricity consumption

Impact category	Indicator	Data set	Methodology
Usage of electricity for common facilities such as community centers, schools, and health facilities	People benefitting from the common facility	• Number of hours for which electricity is used for common facilities • Number of people using the same	• Analysis of the logbooks of common facilities • Surveys and personal interaction with the community
Economic			
Entrepreneur development	Setting up new businesses in the area	A number of people set up a new business after the electricity supply in the area What to measure?	• Market based survey • Analysing load usage patterns
Change in business practices	Adaptation of electric appliances such as electric motors for business	Number of entrepreneurs using electricity in their business	
	Changes associated with operating hours, production and revenue	• Number of operating hours • Increase in production capacity • Increased sales	Primary survey with local entrepreneurs
Environmental			
Reduce usage of conventional fuels (diesel and kerosene)	Households using kerosene	Number of households stop using kerosene for electricity	Household survey on electricity consumption
	Entrepreneurs using diesel for running motors and other appliances	Number of entrepreneurs stop using diesel-based systems	Primary survey with local entrepreneurs
	Diesel based generators operative in the area	Change or reduction in the number of diesel based generators	Primary survey in the area

It is advised that the ESCO develops its assessment framework at the start of the project and captures the baseline information so that against the same indicators, an assessment can be undertaken after the project is executed.

8.4
Data Collection Processes

To measure the impact listed down in the above table, ESCO should ensure timely data collection. There is a need to collect baseline data, i.e., before the start of the project and post-implementation data at regular intervals through primary survey, focused group discussions, personal interviews at household and community levels. The ESCO should keep the following aspects in mind:

8.4.1
Establish Roles and Responsibilities

Establishing roles and responsibilities for undertaking each stage of these processes is essential for accurate and timely data collection. If it is not clear who is responsible, for what and when it won't happen!

8.4.2
Setting Baselines and Targets

Once the indicators are defined and tools to collect the data developed, it is useful to establish the baseline values of these indicators. The baseline information is essential to measure the relative changes that take place with the implementation of the project.

8.4.3
Technical and Non-technical Data Collection Processes

Study of load characteristics, demand growth, etc. are linked to the operation of mini-grid. Regular monitoring of data highlights consumption patterns at the domestic and commercial le vel, variation in time of a day, weekly/ monthly variations, etc. Non-technical data collection processes can include, for example, demand assessment surveys, entrepreneur surveys, and household satisfaction surveys. Examples of possible data collection processes are provided in the table 8.2.

Table 8.2: Data collection processes		
Data collection method	**Time of collection**	**Frequency**
Electrification status of the area, load pattern, type of conventional fuel used and applications	During the start of the project	Baseline
Household satisfaction survey	Within 3 to 6 months of project implementation	Bi-annually
Entrepreneur survey	Within 3 to 6 months of project implementation	Bi-annually
Focused group discussion	During the start of the project Post-implementation	Baseline End-line

8.5

Challenges with Data Collection

While assessing impacts, the ESCO should keep in mind the following problems in the data collection process, like:

- Biased information about the income data as people don't want to discuss their incomes and don't track their spending. Non-cash income is particularly difficult to track, as are estimates of quantities and time in general.

- The data can be biased because of the non-participation of the woman at the household level. Inaccurate answers can also arise if there are language differences

- The data can be incorrect in the absence of trained surveyors. The trained team, with the presence of a local person, is better because they become specialized and efficient. The presence of a known person creates trust within the community.

Points to remember

Input-output-outcome-impact cycle is used for measuring impact assessment by ESCOs. Following points are useful while conducting impact assessment:

- A mini grid has both social, economic, and environmental impact on the users and the community.
- These impacts are substantial and needs to be measured so that the ESCO can provide better service to their customers.
- An evidence-based approach to measure the impact with clear identification of expected impacts, impact indicators, data required, and methodology is ideal for solar mini-grid.
- Data for measuring impact is collected at various touch points while technical data is captured through the systems.

ANNEXURES

Annexure 1: Water Treatment Unit

Wherever there is treatable groundwater , decentralized Water Treatment Units (WTUs) powered by mini-grids can be set up to provide clean drinking water to village communities in a financially viable manner. A typical such WTU comprises a reverse osmosis (RO) plant and a chilling unit. A WTU of 4 kW load and has a capacity of about 1,000 liters per hour (lph) is being considered for this case study.

WTU operational model

The demand for filtered water is created by households and shops in the catchment area that can range from 5 to 10 km. Each WTU sells water in campers/jars of typically 15-20 litres capacity at price ranging from INR 20 to 30/camper and distributed by rickshaws or vans (see Figure 1). WTU having 1000 liters per hour capacity takes two hours to filter and three hours to chill up to 2000 liters enough to supply 100 campers/jars. With a 4-5 hour/day operation, a WTU output is approximately 2-3,000 liters/day. A WTU unit employs an entrepreneur/operator and two other individuals to provide operational support as a helper and delivery person.

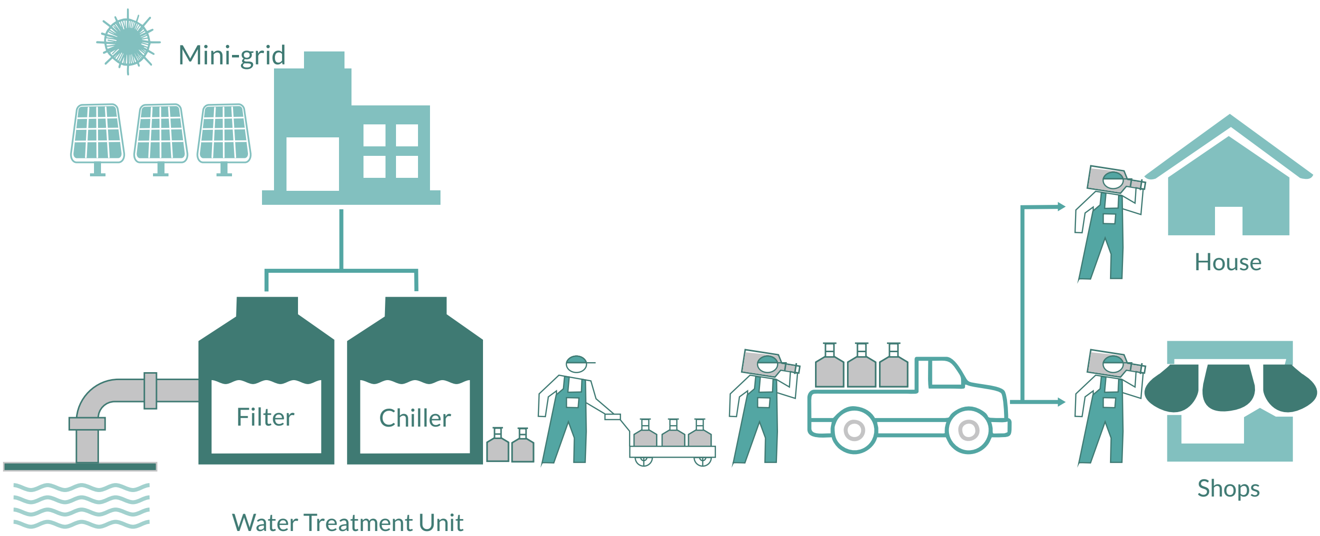


Figure 1: Operatinal model of a WTU unit

The average electricity consumption of a WTU is 14 kWh/day with a peak of 17 kWh/day in summer and 12 kWh/day in winter. The variation is due to a reduction in water demand and the need for chilled water in winter season. During its peak months, the WTU can act as an anchor load for the mini-grid and draw up to 20-30% of electricity produced by the mini-grid.

[19]Water without concentrations of heavy metals/minerals like Arsenic

Key success factors

Four main factors determine the commercial viability of a WTU:

Figure 2: Key success factors

1. **Treatable groundwater**: groundwater having total dissolved solids (TDS) of more than 500 ppm and free of heavy metal pollution

2. **Household density**: high number of households (typically >500 HHs) close to the WTU

3. **Consumer willingness to pay**: success of a WTU is directly related to willingness of consumers to pay for clean drinking water. It has been observed that commercial set-ups like shops have higher willingness to pay as compared to households

4. **Competition**: the absence of a competitor in the broader catchment increases the chances of success of the venture. However, it has been observed that the presence of more than two competitors negatively impacts scalability.

Analyzing WTU based on the '5S' framework

Site assessment

Identification of WTU as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand of the WTU suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the WTU are analyzed, and it was found that:

- The current source of electricity: lack of alternate sources or poor grid supply makes it attractive for the mini-grid

- Availability of raw material: the site has treatable groundwater with high TDS

In Step 5, the demand conditions for the WTU are analyzed, and it was found that:

- High local demand: the household density in the immediate vicinity was found to be high, and there is a small town near the village
- Mild competition: the nearby town has drinking water suppliers, and villagers are accustomed to using drinking water in campers during various social occasions
- Cost competitiveness: enjoying the right factor conditions and demand, the WTU can produce clean and cool water at competitive prices
- Presence of alternatives: hand pumps and dug wells are alternatives but provide unhygienic water.

Scale potential

In Step 6, an analysis of the growth potential of the WTU is undertaken, with the following results:

- High load utilization: with average electricity consumption of 14 kWh/ day, the WTU can utilize a high share of the mini-grid generation
- Constant demand: overall demand for electricity of the WTU is constant throughout the year
- Day load: operation of the WTU is a daytime activity which puts less pressure on the mini-grid
- Potential for upscaling: increase in awareness amongst the community and proximity to the town, there is lots of scope for the enterprise to upscale in similar mini grid clusters.

Support required

In Step 7, an analysis of the support that the WTU requires in making it sustainable is undertaken, and it was found that the ME needed market linkage, marketing, and branding inputs in the initial year through community awareness generation initiatives is required.

Sustainability

In Step 8, the financial viability of the WTU is analyzed, focusing on the pa yback period and payback volume. Typical capital investment for a WTU of the said capacity is around Rs 5 lakh, and the average operating expense is around Rs 4 lakh/year. The share of different components of the CAPEX and OPEX is shown in Figure 3. With this investment, the operating breakeven point for such a unit is within first year, and the payback period of investment is 2-3 years.

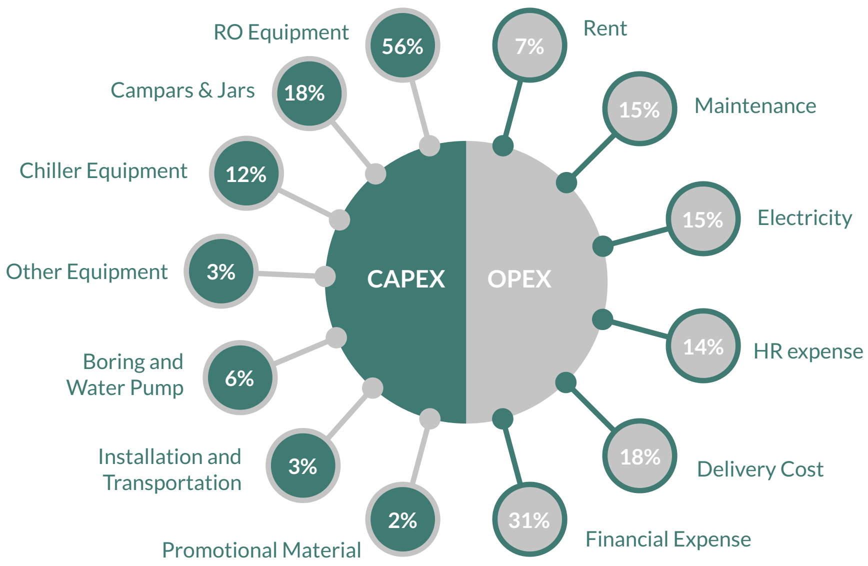


Figure 3: CAPEX and OPEX components

There are two kinds of levers that affect the financial viability of a WTU – cost and revenue levers. Cost levers are the delivery cost of the water campers and the electricity tariff of the mini-grid. The profitability of the WTU is inversely related to the cost levers. Revenue levers are the camper price and demand penetration; higher these parameters, better is the profitability of the venture.

Impact of WTU as micro-enterprise

WTUs powered by ESCOs are a financially viable model that achieves two-fold objectives:

1. Providing access to clean, safe drinking water to people in rural areas
2. Contributing to the growth of sustainable electricity solutions

They can also act as a catalyst for developing the local economy by providing investible opportunities to people while improving the quality of life of people. Some of the benefits directly linked with WTU are the following:

- WTU provides safe drinking water in rural households
- A significant drop in the number of cases of water-borne diseases in these areas
- Sustained employment of two to four persons from the local community
- Avoidance of carbon dioxide emissions to the tune of 25.55 tons per year[20].

[20]Assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not take into account CO_2 from other parts of the value chain Read more at http://www.solarmango.com/in/tools/ CO_2 -emission-reduction-results/

Annexure 2: Flour Mill

A flour mill (FM) unit is a commercial entity where wheat, rice, and spices are milled and is a common micro-enterprise in rural areas catering to domestic demands. Households bring their grains and spices and pay a fee to get it milled. An FM once set up can serve two markets: (a) primary – village community against extraction fee and (b) secondary – processing for forward selling in local and regional markets. For this case study, an FM of 7.5 hp motor capacity and 80 kg/hour milling efficiency is being considered.

FM operational model

Households bring their stored wheat for milling as per their needs. FM units also stock some wheat to cater to the demand of customers who come to buy flour from them directly. Some FMs also sell wheat flour to wholesalers and retailers in their area (Figure 1). Currently, operational units are milling wheat at INR 2/kg, whereas wheat flour is sold at INR 20 to 23/kg. An FM employs one person who handles feeding grains, monitoring output and handling flour.

Figure 1: Operational model of Flour Mill

Although wheat is harvested once a year, people get their wheat milled as per their needs, usually in batches of 5 to 10 kg. Therefore, there is consistent electricity consumption by the FM throughout the year. Each unit consumes an average of 15 kWh/ day.

Key success factors

The success of an FM depends on the following factors:

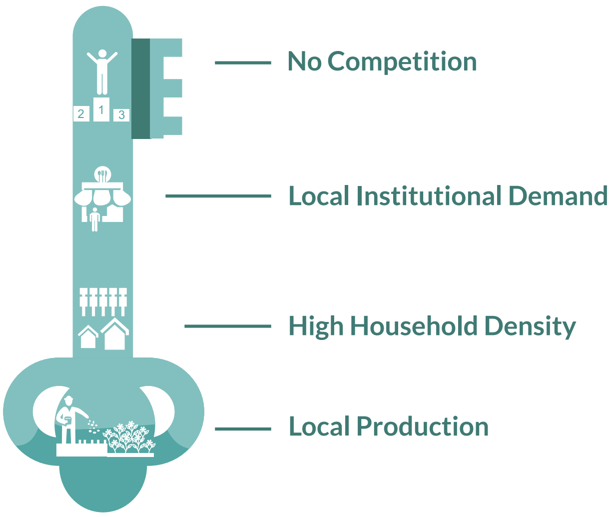


Figure 2: Key success factors

1. **Local production:** the raw material for an FM has to available in sufficient quantities for higher capacity utilisation of the FM. The area has high local production of wheat, fulfilling this factor

2. **Household density:** high household density resulting in consistent demand for milling and hence utilization

3. **Local institutional demand:** presence of local wholesalers and retailers to buy flour increases contributes to the success of an FM

4. **Competition:** presence of local competitors adversely affects the success of an FM.

Analyzing FM based on the '5S'framework

Site assessment

Identification of FM as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand (15 kWh/day) of the FM suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the OE are analyzed, and it was found that:

- Current source of electricity: power supply in the area is inconsistent and thus an FM relying on the grid cannot serve its clients whenever they come for milling

- Availability of raw material: wheat is the major crop in the village and is the staple grain for the local population, thereby assuring continuous supply of raw material to the FM in required quantities.

In Step 5, the demand conditions for the FM are analyzed, and it was found that:

- Local and inherent external demand: since both production and consumption of wheat are endemic, there is always a demand for flour. The household density is also high in the area resulting in concentrated demand that can be met easily

- Mild competition: there are other flour mills in the area which are mainly run on diesel generators

- Cost competitiveness: running cost for solar-powered FM is lower than a diesel one. Also, the maintenance cost of diesel engines is higher than that of electric motors

- Presence of alternatives: other mills are operating in nearby villages where people take their wheat for milling. However, the FM at the site offers many conveniences to the local population.

Scale potential

In Step 6, an analysis of the growth potential of the FM is undertaken, with the following results:

- High load utilization: with average electricity consumption of approximately 15 kWh/day, the FM can utilize around 20-30% of the mini-grid generation

- Constant demand: demand for wheat milling shows little fluctuation and is generally consistent through the year

- Day load: FM operation is a day time activity putting less pressure on the mini-grid

- Potential for upscaling: steady demand, higher efficiency, and quick service make the FM a high potential micro-enterprise.

Support Required

In Step 7, an analysis of the support that the FM business requires in making it sustainable is undertaken, and it was found that the micro-enterprise need support is creating awareness among the community on its availability and quality of service. Further, market linkages can be established for supplying more substantial quantities of flour to retailers and wholesalers.

Sustainability

In Step 8, the financial viability of the FM is analyzed, focusing on the payback period and payback volume. Typical capital investment for an FM of the said capacity is around Rs 50,000, and the average operating expense is around Rs 1.1 lakh/year. The share of different components of the CAPEX and OPEX is shown in Figure 3.

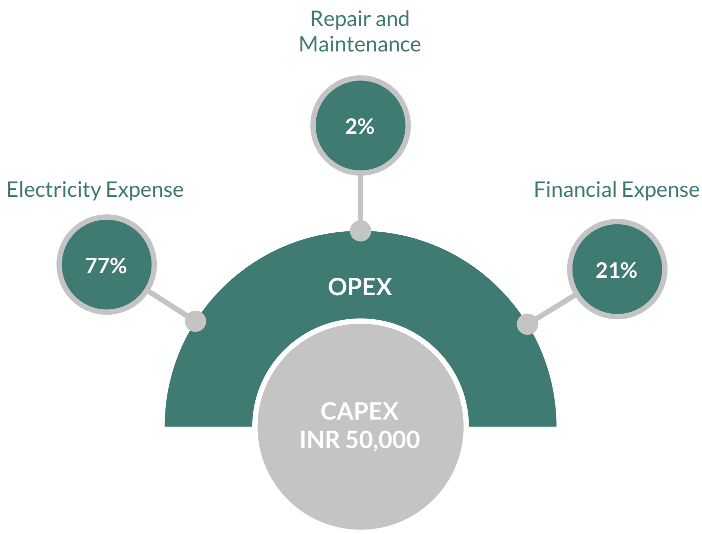


Figure 3: Key success factors

With this investment, the operating breakeven point comes in the first year itself, and the payback period of investment is less than a year. Cost lever for the FM is the electricity tariff, which is pre-determined between the FM and the ESCO. The profit margin of the FM is highly sensitive to the electricity tariff and is inversely related. Revenue lever of the FM is the milling charges, which is generally constant in a particular region, and there is little possibility of the FM charging higher rates to increase its margins.

Impact of FM as micro-enterprise

Flour milling in rural communities has been an unorganized sector, and the entry barriers are low. An FM can generate the following impacts:

- Reduce travel and procurement cost for customers
- Women SHGs can start FMs generating substantial socio-economic benefits
- Create meaningful employment for one person as an operator. Besides, another person can be employed for delivery when the business expands
- Avoidance of carbon dioxide emissions to the tune of 12.8 tons per year[21].

[21]assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO_2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not consider CO_2 from other parts of the value chain.

Annexure 3: Oil Expeller

Small scale manual/animal powered oil expellers have been in existence in oil-producing areas for ages. Villagers bring their oilseeds and pay a fee for oil extraction primarily for domestic consumption. In such villages where substantial cultivation of oilseed crops like mustard, rapeseed, sesame, sunflower, karanj, etc. are undertaken, setting up an oil expeller (OE) can be explored. Such a unit once set up can serve two markets:(a) primary– village community against extraction fee and (b) secondary – packed oil in local and domestic markets. For this case study, an OE of 7.5 hp motor load and 70 kg/hour processing capacity on mustard seed is being considered.

OE operational model

OE units buy and stock oilseeds (for continuous production) during the harvest season, which is compressed to extract oil and sold to wholesalers who further sell it to primary and secondary markets (Figure 1). Also, local households bring their oilseeds and get the extracted oil paying an extraction fee. Currently, operational OE units are processing oilseeds for a fee of INR 5/kg and sell oil at INR 100 to 120/l in the market. The residual oil cake also carries value and is used as cattle feed and fertilizer.

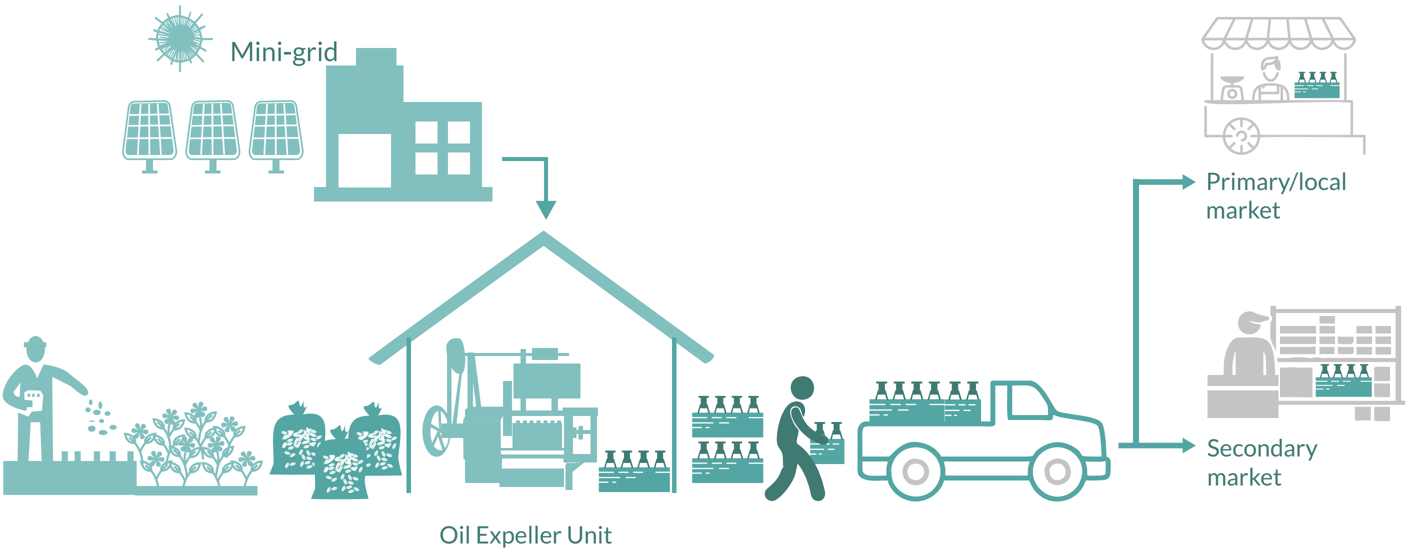


Figure 1: Operational model of Oil Expeller

An OE unit employs two persons who feed oilseeds, monitor operations, and pack the oil. The average electricity consumption of an OE unit is 36 kWh/day, and it varies little once a steady state of operations is achieved. The OE can act as an anchor load for the mini-grid and draw up to 60 to 70% of electricity produced by the mini-grid.

Key success factors

Four main pre-conditions need to be in place for the success of an OE:

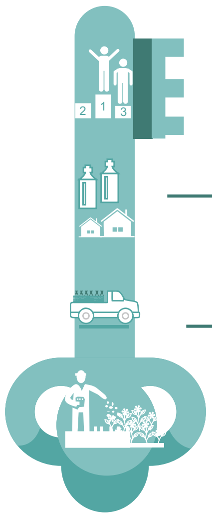


Figure 2: Key success factors

1. **Local production and its quality**: high local oilseed production and high oil content increases the production and productivity of the unit

2. **Local demand**: high local demand helps reach operational stability quickly

3. **Physical connectivity**: presence of a road connectivity infrastructure for transportation of oil seeds from farms to the unit and packed oils from the unit to the market dramatically improve operations

4. **Local institutional demand**: presence of wholesalers and retailers in the primary market for offtake of packed oils

Analyzing OE based on the '5S' framework

Site assessment

Identification of OE as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand (36 kWh/day) of the OE suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the OE are analyzed, and it was found that:

- Current Source of electricity: electricity supply in the area is infrequent, thereby making it difficult for the OE to rely on it

- Availability of raw material: mustard cultivation is carried out in a large scale in the village and the area thus ensuring adequate supply of raw material to the OE

In Step 5, the demand conditions for the OE are analyzed, and it was found that:

- Local and inherent external demand: high local household density, the proximity of neighboring villages and a small town and dependence of the population on mustard oil for cooking

- Mild competition: there is only one OE unit within 5 km radius

- Cost competitiveness: due to favorable factor conditions and demand, the OE unit can produce oil at competitive market rates

- Presence of alternatives: although there are alternatives to mustard oil, the latter has been traditionally used, making it difficult to replace.

Scale potential

In Step 6, an analysis of the growth potential of the OE is undertaken, with the following results:

- High load utilization: with average electricity consumption of 36 kWh/day, the OE can utilize 60 to 70% of the mini-grid generation

- Constant demand: driven by the constant demand for oil, overall demand for electricity of the OE is constant throughout the year

- Day load: OE operation is a daytime activity which puts less pressure on the mini-grid

- Potential for upscaling: with the increase in market linkages with restaurants and shops dealing in the trade of oil, there is a tremendous potential to scale the production.

Support required

In Step 7, an analysis of the support that the OE requires in making it sustainable is undertaken, and it was found that the OE needs market linkage, marketing and branding inputs. Also, improving the production and productivity of mustard cultivation are other options.

Sustainability

In Step 8, the financial viability of the OE is analyzed, refocusing on the pa yback period and payback volume. Typical capital investment for an OE of the said capacity is around Rs 4.5 lakh, and the average operating expense is around Rs 7 lakh/year (excluding the cost of mustard seeds). The share of different components of the CAPEX and OPEX is shown in Figure 3. The cost of mustard seeds is around Rs 38 lakh/year. With this investment, the operating breakeven point comes in the first year itself, and the payback period of investment is 2-3 years.

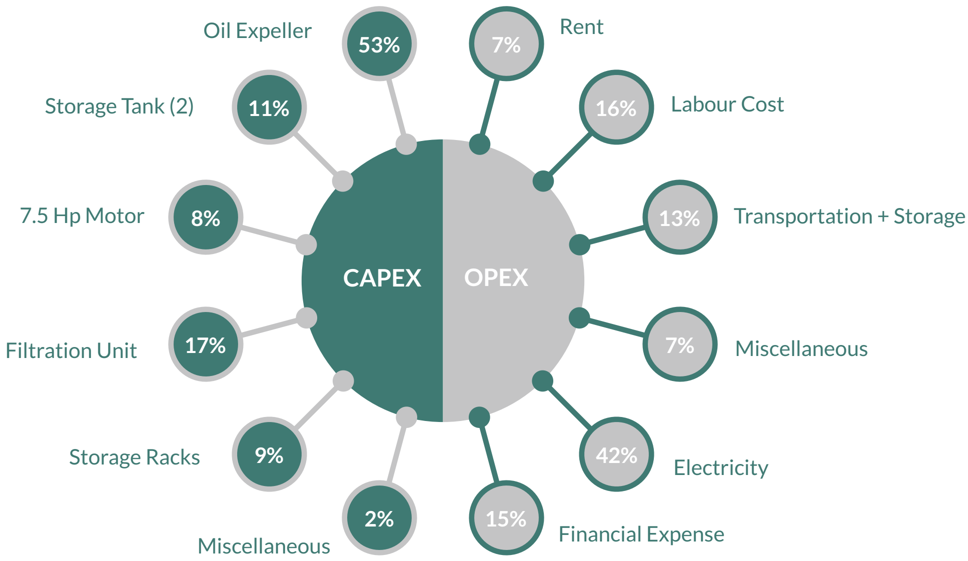


Figure 3: CAPEX and OPEX components

Cost levers are the procurement price of mustard seeds, which depends on the procurement timing and transportation cost from the farms to the unit, and electricity tariff of the mini-grid. The profitability of the OE is inversely related to the cost levers. Revenue lever is the selling price of oil; the higher the price better is the profitability of the venture. The selling price of oil depends on:

- **Quality of oil:** fat content, viscosity, and smoking point are some parameters determining the quality of the oil. For mustard oil, the smell is a significant determinant of its price. Some markets, however, do not prefer the raw pungent smell and OEs catering to such markets need to invest in deodorization

- **Brand differentiation:** branding enables product differentiation and differential pricing

- **The regularity of supply:** retailers/wholesalers tend to enter into higher price contracts with OEs which can guarantee a steady supply

- **The purity of oil:** being an edible commodity, marks of quality/purity leads to better price.

Impact of OE as micro-enterprise

Some of the potential impacts that local level oil extraction can create are:

- Many OEs can come together as a single organized commercial enterprise leading to economies of scale. It could also lead to the creation of commercial hubs in rural areas, which can further spur the development of other industries

- Decentralization of oil extraction can help improve efficiency in the supply chain by reducing travel and procurement cost for secondary markets

- Women SHGs can start OEs generating substantial socio-economic benefits.

- Sustained employment for at least two other persons

- Avoidance of carbon dioxide emissions to the tune of 22.8 tons per year[22].

[22]assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO_2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not consider CO_2 from other parts of the value chain.

Annexure 4: Rice Huller

Traditionally in rural India, paddy is de-husked manually. With increase in paddy production and advancement in technology, motorized rice hulling units have come up across rice producing areas. At a village level, Rice Hullers (RH) can be established with a secure and consistent source of power produced by the mini-grids to cater to local rice milling demands. For this case, RH of 400 kg/hour capacity is considered with a 7.5 hp motor load.

RH operational model

Generally, household consumption of paddy is processed in batches and stored; the surplus is sold to local traders or in local wholesale markets. With access to RH in the area, farmers or local entrepreneurs can get their paddy de-husked, store the rice and sell it in the market, for better earning. An entrepreneur owns the RH and provides hulling service at a fee. The operating model proposed is that a collective of women SHGs acts as an aggregator, procures paddy from the village and nearby areas, gets them processed, and sells the rice to wholesalers or retailers. If women come as a collective to start this enterprise, ESCO would need the support of local NGOs to mobilize the women.

Figure 1: Operational model of Rice Huller

The processed rice can be sold either to retailers or intermediaries—the latter fetch a lesser price as compared to the former. As paddy production is generally in the kharif season, utilization of the RH is also seasonal, typically 8-10 months a year after harvesting and comparatively less running during the rest of the year. The average daily electricity consumption is mainly for 10 months and in the range of 10-12kWh per day.

Key success factors

The necessary pre-conditions that can enable the success of an RH are as follow:

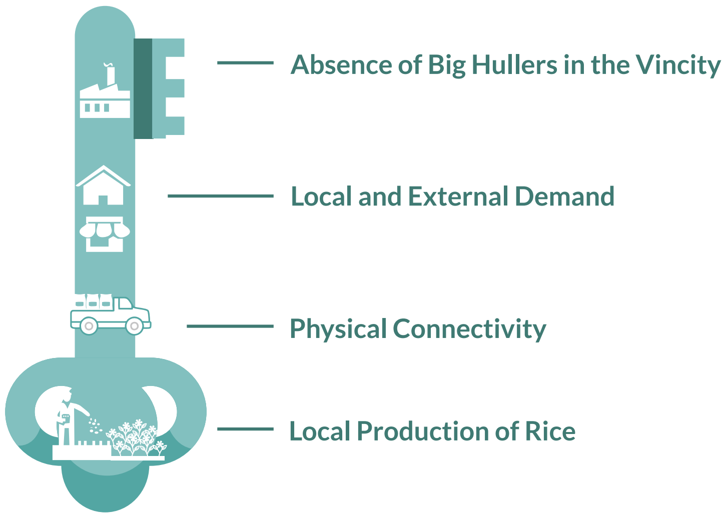


Figure 2: Key success factors

1. **Local production of rice:** production of a marketable variety of rice at the location of the site is a must as locally procured rice can be procured at much lower transportation cost as well as storage requirement.

2. **Local and external demand:** rice is a highly standardized commodity with standardized guidelines on quality and 'grades.' There has to be both local and external demand for the hulled rice

3. **Absence of big hullers in the vicinity:** bigger rice hullers are very sophisticated and have much larger capacities in terms of processing as well as for sorting and grading of rice. They also get the advantage of scale with their size of production and have established backward and forward market linkages.

4. **Physical Connectivity:** rice hullers that are close to the market/ households enjoy an advantage as people prefer to get their rice hulled locally, given its daily consumptions.

Analyzing RH based on the '5S' framework

Site assessment

Identification of RH as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand of the RH suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the RH are analyzed, and it was found that:

- The current source of electricity: the current grid supply is inconsistent and power cuts ma y result in a reduced level of utilization of the RH depending on the grid

- Availability of raw material: site selection data shows that paddy is the major crop in the village and is the staple cereal.

In Step 5, the demand conditions for the RH are analyzed, and it was found that:

- Local and inherent external demand: there is a local demand for rice as well as market linkages with local level retailers, and intermediaries can be established.

- Mild competition: local level competition with other small RH units in the area is low, which makes setting up RH viable.

- Cost competitiveness: cost is determined by the market and is mainly dominated by established players.

- Presence of alternatives and replacement cost: not relevant in this case

Scale Potential

In Step 6, an analysis of the growth potential of the RH is undertaken, with the following results:

- High load utilization: average consumption in RH is around 10-12 kWh which means it can utilize up to 20% of electricity generated from the mini-grid

- Constant demand: overall demand for electricity of the RH is mainly for 8-10 months in a year

- Day load: most of the paddy processing is done during the daytime.

- Potential for up scaling: given that there is no other RH in the area, there is potential to expand operations beyond the village.

Support Required

In Step 7, an analysis of the support that the RH requires in making it sustainable is undertaken, and it was found that the ME needs intensive support in terms of mobilizing people and linking them to the RH. There are costs involved in forward linkages and motivating women SHGs to take up this activity as a collective.

Sustainability

In Step 8, the financial viability of the RH is analyzed, focusing on the payback period and payback volume. Typical CAPEX for an RH of the said capacity is around Rs 84,500/- and average OPEX is around Rs 70,000/year from the third year of operations. The share of different components of CAPEX and OPEX is shown in Figure 3.

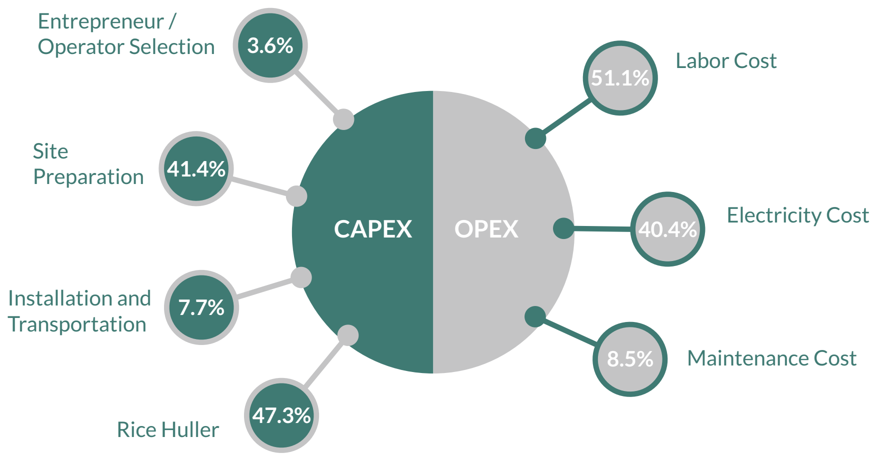


Figure 3: CAPEX and OPEX components

With this investment, the operating breakeven point for such a unit is around 1.6 years, and the payback period of investment is 3-4 years. Cost lever for the RH is the electricity tariff of the mini-grid, which is pre-determined between the RH and the ESCO. The profitability of the RH is inversely related to the cost levers. Revenue lever of the RH is the de-husking charges, which is generally constant in a particular region, and there is little possibility of the RH charging higher rates to increase its margins. Other revenue levers are capacity utilization of the unit and the amount of production of paddy in the area.

Impact of RH as micro-enterprise

Some of the potential positive impacts that an RH can create at the village are as follows:

- Development of local entrepreneurship for owning and running the RH
- Generating direct employment of at least one person at the unit
- If this micro-enterprise is taken up by an SHG, their members' income increases, creating positive socio-economic changes.
- RH operating on renewable electricity from the ESCO mini-grid can also lead to a carbon dioxide savings that can help in offsetting the emissions from fossil fuel. The electricity consumed from the renewable electricity mini-grid leads to a carbon dioxide offset of 3 to 4 tons per year[23] Per RH unit.

[23]assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO_2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not take into account CO_2 from other parts of the value chain.

Annexure 5: Irrigation Pump

Except for high-value cash crops, diesel-based irrigation makes agriculture less remunerative. Getting grid connections for irrigation pump sets (IP sets) is expensive, and due to lack of focus of the DISCOMs in farm electrification, this remains a challenge for small scale farmers. Besides suppressed tariffs and over-exploitation of groundwater compounds the problems of the DISCOMs and the State. Keeping this in mind, the promotion of solar pumping has been a focus of the Government. With the availability of electricity from the mini-grid, instead of standalone solar pumps, electrical IP sets can be set up as a micro-enterprise, thus bringing down the in vestment required by the farmers and simultaneously helping them enjoy the benefits of cheaper power from solar. For this case study, an IP set of 5 hp capacity with a command area of around 30 acres is being considered.

IP operational model

The electric IP set distributes/pumps water from either underground or surface source and distributes it to farms through a network of pipes. Supply to farms is according to a pre-decided schedule and rate[24] (Figure 31). The IP sets can be run by an entrepreneur or be run in a Company-Owned and Company-Operated (COCO) model, where the ESCO takes the lead. In the latter model, ESCO funds and runs the system and employs an operator to carry out daily operations. ESCO makes profits, and electricity costs are internalized.

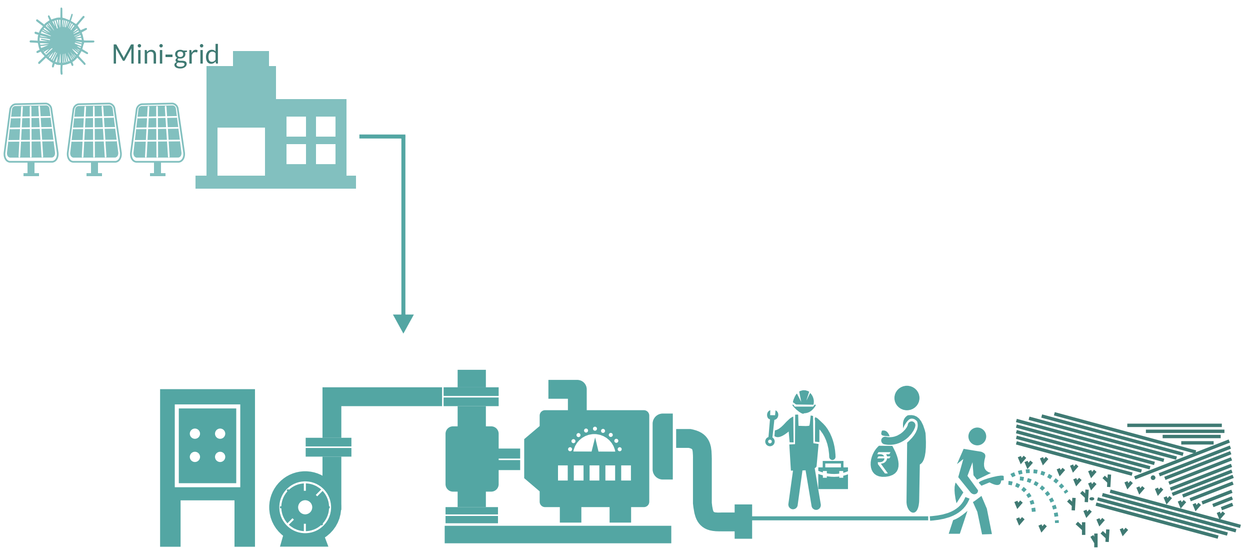


Figure 1: Operating model of an Irrigation Pump

The average annual electricity consumption of an IP set is 17 kWh/ day, with seasonal fluctuations, higher in rabi (winter) and lesser in kharif (monsoon) which potentially can be increased by scheduling and working on changing the cropping pattern in the village. Electricity consumption is expected to be lower in the case of the entrepreneur-led model due to the possible prevalence of alternatives and 100% from the mini-grid in the COCO model.

[24] The rate may be volumetric or hourly based.

Factors determining IP success

The success of an IP depends on the following factors:

Figure 2: Key success factors

1. **Prevalence of irrigated agriculture:** presence of irrigated (preferable) or arable land in the vicinity of the mini-grid site (typically > 20 acres/pump)

2. **Land holding of farmers:** farmers in the proposed command area should have some minimum land holding, preferably > 0.5 acre/farmer

3. **Cropping intensity:** high cropping intensity (typically >= 2) indicating the practice of irrigated agriculture

4. **Availability of water:** the raw material (if one can say so) for an IP is water, and that should not be a constraint

Analyzing IP on the '5S' framework

Site assessment

Identification of IP as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand (17 kWh/day) of the IP suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the IP are analyzed, and it was found that:

- **Current source of electricity:** running of 5 hp (and above) IP need 3 phase electricity supply at the farm level, is almost absent. Diesel-powered irrigation is practiced but is financially not rewarding to the farmers

- Availability of raw material: site selection data shows high groundwater availability in the catchment area.

In Step 5, the demand conditions for the IP are analyzed, and it was found that:

- Local and inherent external demand: rich agricultural belt at the site location and qualifies for more than 30 acres of agricultural land in the catchment area of the site
- Mild competition: high dependence on diesel-based pumps which is very costly
- Cost competitiveness: with a continuous rise in diesel prices and increasing maintenance cost of diesel pumps, running electric IP sets is cost-effective for the farmers. Also, maintenance costs are comparatively less for electric IP sets
- Presence of alternatives: grid-based IP sets connections are difficult to access. Also, the supply of power is erratic.

Scale Potential

In Step 6, an analysis of the growth potential of the IP is undertaken, with the following results:

- High load utilization: with average electricity consumption of 15 kWh/day, the IP can utilize around 30% of the mini-grid generation
- Constant demand: demand for irrigation is throughout the y ear, with small variations, which can be smoothened by working on cropping pattern changes
- Day load: demand for irrigation is during the day putting less pressure on the mini-grid
- Potential for upscaling: electric IP sets have the potential to replace all existing diesel IP sets because of lower cost and very low maintenance.

Support Required

In Step 7, an analysis of the support that the IP requires in making it sustainable is undertaken, and it was found that this micro-enterprise needs support in creating awareness among the farmers on its quality of service and benefits. Support is required to work on changing the cropping pattern and improving the cropping intensity to more remunerative and round the year crops.

Sustainability

In Step 8, the financial viability of the IP is analyzed, focusing on the payback period and payback volume. Typical capital investment for an IP of the said capacity is around Rs 1,25,000/-, and the average operating expense is around Rs 2.8 lakh/year. The share of different components of the CAPEX and OPEX is shown in Figure 3.

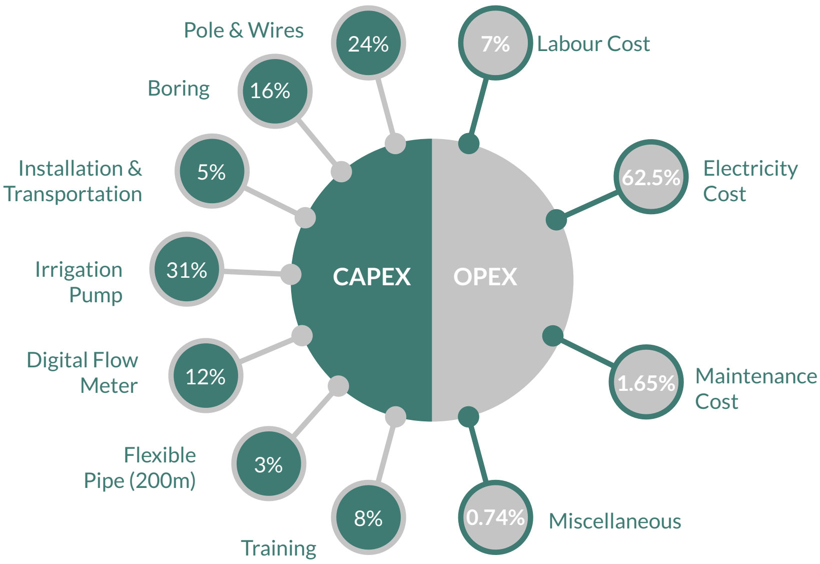


Figure 3: CAPEX and OPEX components

With this investment, the operating breakeven point comes in the first year itself, and the payback period of investment is one and a half years. Cost lever for the IP is the electricity tariff of the mini-grid, which can be set by the ESCO, which depends on the willingness of the ESCO and distance of the IP from the mini-grid generation. The price of pumped water and pump utilization factor is the critical revenue levers that affect the financial viability of an irrigation pump. IP services fail to command customer loyalty, and as a result, 'stickiness' to one service is low, with farmers changing service providers for slight differences in price. Price of alternates, number of competitors, and depth of water table in case of groundwater-based pumping determine the price charged.

Impact of IP as micro-enterprise

Mini grid intigrated irrigation pumps operating as a microenterprise has the potential to improve the irrigation services in rural areas, particularly those of small scale farmers. Without this, farmers depend on the rains (risky) or diesel IPsets (expensive), making agriculture risk-prone and non-remunerative. Thus, the potential impact of solar-based IP can be summarised as:

- Reducing risks of crop failures
- Increase area under irrigation
- Increase in cropping intensity
- Encourage farmers to shift to high-value crops (change in cropping pattern)
- With volumetric based payment, improve the water use efficiency
- Savings in costs and hence increase in profits of farmers
- Reduction in local level pollution from diesel-based IP sets
- Avoidance of carbon dioxide emissions to the tune of 27.2 tons per year[25].

[25]assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO_2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not take into account CO_2 from other parts of the value chain Read more at http://www.solarmango.com/in/tools/CO_2-emission-reduction-results/te may be volumetric or hourly based.

Annexure 7: Honey Processing Unit

A Honey Processing Unit (HPU) can increase the shelf life of honey before it is packaged and sold in the market. Setting up of an HPU makes beekeeping (apiary) an attractive livelihood option and can help increase incomes of families. For this case study, an HPU of 4 kW motor load and 50kg/hr processing capacity is being considered.

HPU operational model

While setting up an HPU, its ecosystem also needs to be created either through the third party or directly, the ESCO mobilizes and incentivizes groups of bee-keepers (both new and existing) to supply honey to the HPU. Once procured, honey is processed and sold to wholesalers and retailers. Establishment of marketing linkages, marketing, and sales is best handled by an expert third party to eventually transition these responsibilities and overall unit operations to the beekeepers who may be organized as a cooperative or producers' company. Operational expenses are met through a combination of HPU revenues and support from ESCO. HPU of the said capacity consumes an average of 34 kWh/day in a steady-state year. This is a conservative estimate given that the steady-state sales target is 80% of the unit's processing capacity. The electricity consumption could be lesser, depending on the availability of the grid and the HPU using both sources of electricity.

Figure 1: Operational model for Honey Processing Unit

Key success factors

The necessary pre-conditions that can enable the success of a HPU are as follow:

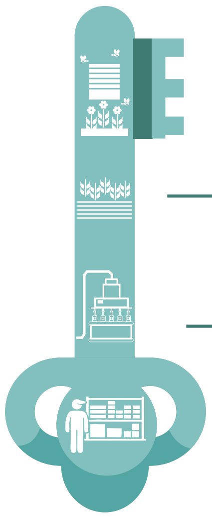


Figure 2: Key success factors

1. **Abundance of nectar-rich flowers close to apiaries:** high density of nectar-rich flowers such as sunflowers, lavender, salvia, etc. close to the apiary

2. **Presence of water source in farms:** the presence of water source close to the flower farms/areas

3. **The proximity of apiaries to HPU:** apiaries within 15 to 20 km from the HPU to ensure that the costs of transporting raw honey to the HPU are not high

4. **The proximity of HPU to primary regional market:** to keep costs of transporting honey to retailers and distributors under check.

Analyzing HPU based on the '5S'framework

Site assessment

Identification of HPU as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand (34 kWh/day) of the HPU suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the HPU are analyzed, and it was found that:

- Current source of electricity: inconsistent power supply risking the quality of the honey that is processed, hence the need for the mini-grid

- Availability of raw material: the presence of the natural source of water and neighboring nectar-rich flower fields.

In Step 5, the demand conditions for the HPU are analyzed, and it was found that:

- Local and inherent external demand: this refers to the consumption of honey in local and nearby regions to estimate the sales potential.
- Mild competition: there are several brands at the national level, but there is always a demand for local honey from bulk purchasers
- Cost competitiveness: price of honey is determined by the market, which is dominated by big players, whose scale of operations is manifold. Keeping costs low by the HPU to meet market prices is a challenge
- Presence of alternatives: honey is a specific commodity and there are not alternatives

Scale Potential

In Step 6, an analysis of the growth potential of the HPU is undertaken, with the following results:

- High load utilization: with average electricity consumption of 34 kWh/day, the HPU can utilize more than 30—40% of the mini-grid generation
- Constant demand: demand for processed honey is throughout the year
- Day load: processing and packing are daytime activities putting less pressure on the mini-grid
- Potential for upscaling: the HPU can act as the primary electricity consumer in the mini-grid.

Support Required

In Step 7, an analysis of the support that the HPU requires in making it sustainable is undertaken. It was found that the micro-enterprise needs intensive support for mobilizing people, training and capacity building of beekeepers, investment in branding and marketing of processed honey, getting Government certifications, transportation, and storage.

Sustainability

In Step 8, the financial viability of the HPU is analyzed, focusing on the payback period and payback volume. Typical capital investment (CAPEX) for HPU of the said capacity is around Rs 45 lakh, and the average operating expense (OPEX) is around Rs 55 lakh. In addition, there are some other expenses which are one time in nature like (i) company registration ;(ii) FSSAI license (iii) brand design and development (iv) brand registration or trademark (v) staff selection and training. With the wholesale rate of Rs 150/kg and retail rates of Rs 250 to 300/kg, the operating breakeven is achieved in 1.5 years, and payback for investments is less than seven years. Cost levers for the HPU are the electricity tariff of the mini-grid, which is a fixed cost and is pre-determined between the HPU and the ESCO and purchasing price of raw honey from the beekeepers. It is dependent on the following:

- Number of competing aggregators/processors in the area
- Relative bargaining power of beekeepers
- Quality of honey
- Regularity of procurement
- Providing technical assistance

Revenue levers include:

- **Selling price:** primarily dictated by the market and depends on the price of honey from other producers, number of competitors, quality of honey and product and brand differentiation
- **Sales:** this depends on the intensity of sales/marketing efforts, market/forward linkages and relationships established and product quality and brand differentiation

Impact of HPU as micro-enterprise

The potential positive impacts that an HPU generate at the village level are:

- Increase in incomes of beekeepers/farmers
- Helping in diversification of livelihoods of farmers thereby reducing their risks.
- Provide direct employment of two to three staff at the unit.
- An HPU operating on renewable energy-based mini-grid can lead to an offset of 30 to 34 tons of CO2/year[26].

[26]assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO_2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not take into account CO_2 from other parts of the value chain.

Annexure 8: Mini Cold Storage

Mini Cold Storage (MCS) can be set up in areas with high production of fruits and vegetables with short shelf life. For this case study, MCS of the configuration of 4kW, 5 tons, 20x10x8 ft^3 size is considered. The capacity of MCS (usable volume) is considered to be 936 ft^3 after accounting for aisle and racks.

MCS operational model

There could be two business models – entrepreneur-led and ESCO led. In the entrepreneur-led model, one or two big farmers take the cold storage on rent from the ESCO/supplier and earn revenues by renting out space to small farmers. (S)he can also buy the cold storage on loan, repaying in EMIs. In addition to rent/ EMI, the entrepreneur also incurs electricity costs.

In the company-owned model, the ESCO owns and deploys the mini cold storage either near the farms or at the market (mandi), and employs staff (e.g., an operator) to manage the day to day operations. Revenue of the ESCO is from renting out space by volume by day; electricity costs are internalized.

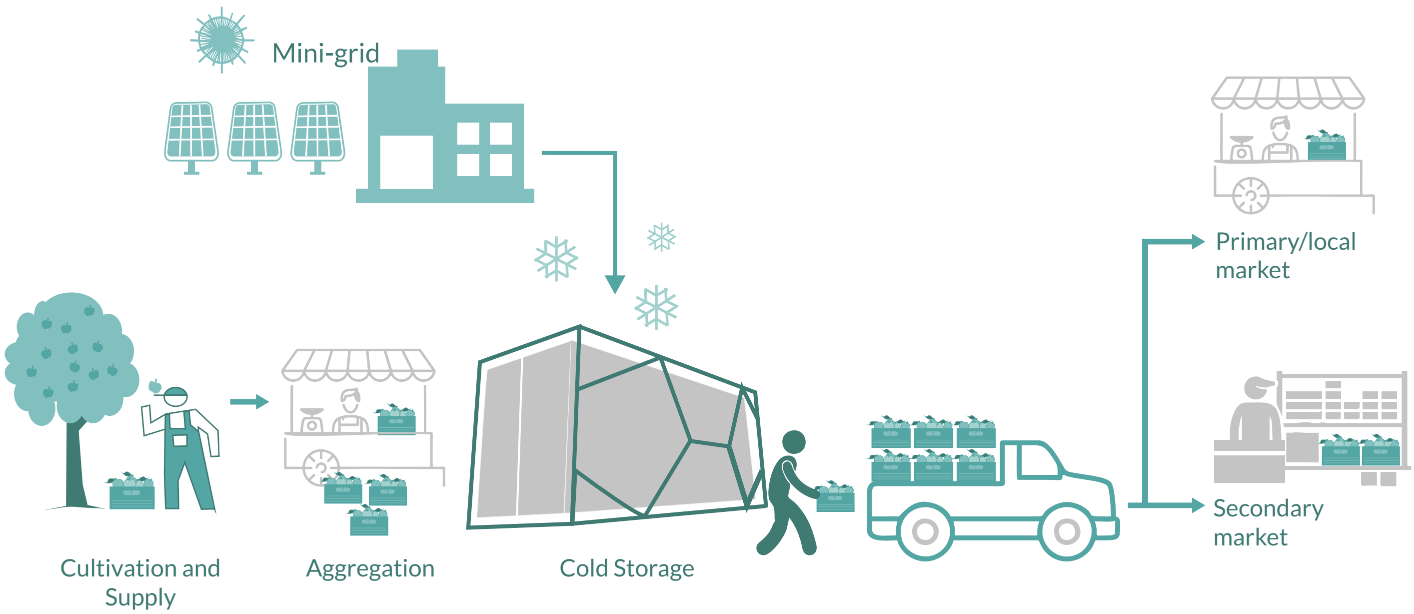


Figure 8.1: Operational model of Mini Cold Storage

Although the cold storage is operational 24x7, the compressor needs to run only during daylight hours, and the time for compressor operation depends on operation and kinds of produced stored in it. During winter months, there is a lesser need for a compressor to be operational. An operational MCS running at 80% capacity utilization consumes up to 18kWh of electricity, and therefore it acts as an anchor load.

Key success factors

Several factors determine the commercial viability of an MCS:

Figure 2: Key success factors

1. **Availability of suitable commodities:** availability of suitable agri-produce at a scale having short shelf life yield high margins with cold storage facility.
2. **Organized marginal farmers/vendors:** smallholder farmers or fruit vendors in organized groups to ease the storage of their produce for better margins.

3. **Presence of a mandi:** were farmers from other villages come for trading the products and prefer using micro cold storage to store surplus produce

Analyzing MCS based on the '5S' framewrok

Site assessment

Identification of MCS as a micro-enterprise is an outcome of Steps 1 to 3. Analyzing the potential electricity demand of the MCS suggests that it can act as an anchor load for the mini-grid. In Step 4, factor conditions of the MCS are analyzed, and it was found that:

- Current Source of electricity: the current electricity supply in the area is plagued by frequent power cuts, especially during the day may risk the stored commodity.

- Availability of raw material: selection of sites depends on availability of different types of fruits and vegetables during the different seasons of the year.

In Step 5, the demand conditions for the MCS are analyzed, and it was found that:

- Local and inherent external demand: MCS mainly caters to external demand, and there is existing unmet demand from nearby urban areas
- Mild competition: there are no small -scale cold storages in the area, and hence competition for the MCS is absent
- Cost competitiveness: the MCS can provide critical service of extending the life of high-value perishable produce, thereby reducing losses and ensure higher returns to farmers. It is expected that and hence can charge for this service
- Presence of alternative and Replacement Cost: No alternatives are present in the area.

In Step 6, an analysis of the growth potential of the MCS is unde rtaken, with the following results:

- High load utilization: as me ntioned earlier, MCS can act as an anchor load for the mini-grid unit.
- Constant demand: electricity demand is consistent demanding on the availability of the commodities throughout the year.
- Day load: MCS required mostly electricity supply during day time or operational hours. Night time load is significantly very low once the desired temperature is set by the compressor.
- Potential for upscaling: MCS can act as an anchor load itself and has a high demand for mini-grid electricity.

Support Required

In Step 7, an analysis of the support that the MCS requires intensive support is required in terms of mobilizing farmers/fruit vendors and linking them to the MCS. Also, the benefits that the MCS needs to be communicated to them in the initial days. There are costs involved in forward linkages as well.

Sustainability

In Step 8, the financial viability of the MCS is analyzed, focusing on the payback period and payback volume. Typical capital investment for an MCS of the said capacity is around Rs 14.10 lakh, and the average operating expense is around Rs 3 lakh/year from the second year of operations. The share of different components of the CAPEX and OPEX is shown in figure 3. With this investment, the operating breakeven point for such a unit is around 2.8 years, and the payback period of investment is 12-15 years depending upon the business model adopted and kind of produce stored in it.

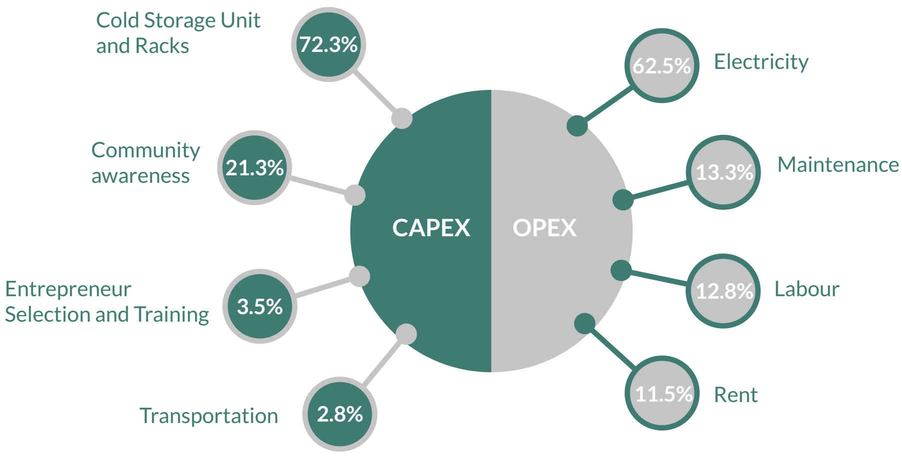


Figure 3: CAPEX and OPEX components

There are two kinds of levers that affect the financial viability of an MCS – cost and revenue levers. Key cost levers are electricity tariffs and the labor cost of the mini-grid. Revenue levers are capacity utilization of MCS units and fees charged for different commodities.

Impact of MCS Micro-enterprise

MCSs powered by ESCOs can be financially viable micro-enterprises and can generate the following positive impacts:

- Reduces distress sale by the farmer and therefore realize better price
- Sustained employment of one to two persons from the local community
- Avoidance of carbon dioxide emissions to the tune of 33 tons per year[27].

[27]Assumptions: Reduction of CO_2 emission per 1 kWh of solar power = 1 kg of CO_2. Please note that the above calculation considers only the reduction in CO_2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not take into account CO_2 from other parts of the value chain read more at http://www.solarmango.com/in/tools/CO2-emission-reduction-results/

Glossary

List of Figures

Glossary

List of Tables

Contact

Smart Power India
706, Time Tower, MG Road,
Gurgaon, Haryana – 122002, India

www.smartpowerindia.org
contact@smartpowerindia.org