USAID – FINAL REPORT
AID-OAA-F-13-00050

Contents

Executive summary

Key objectives

The overarching objective of the DIV grant was to help Gram Power figure out how to scale its technology for smart microgrids and smart meters to a larger audience to have maximal social and economic impact.

The project was initially designed to install up to 40 microgrids rural Rajasthan and impact up to 30,000 people. Through a randomized controlled trial (RCT) approach for site selection and distribution of power subsidies, along with high resolution data from the smart meters, J-PAL and UC-Berkeley (the research partners for this project) were to independently evaluate the social impact of the microgrids. Moreover, an analysis of the revenue recovery from microgrids was to determine the level of capital subsidy needed for microgrids to scale with private sector financing.

However, due to the challenges faced during the course of the project while installing microgrids, the microgrid installations were restricted to 10 sites and the goal was then changed to focus more on the installation of smart meters in grid connected sites. The impact of smart meters was then to be evaluated on parameters of loss reduction for distribution companies (DISCOMs), improvement in power supply availability for consumers, affordability enhancement for consumers due to introduction of prepayments, and figuring out how Gram Power's technology can scale. This was to be carried out for 3500 grid connected households.

Key results and lessons

We learned that the landscape for installing privately funded micro-grids in India is not conducive due to various socio-economic and political issues. Various challenges include 1) No clear mandate from the government on regions to be electrified using the national grid 2) No clear policy for private micro-grid businesses to exist with the overly subsidized grid and 3) Extremely challenging and expensive operations with no guarantee of revenues due to remote locations and high theft levels. This enabled us to decide that achieving scale in microgrids is possible by partnering with Indian Government rather than competing with the national grid. Gram Power has hence started focusing on Government funded contracts under the Decentralized and Distributed Generation (DDG) policy to install microgrids across India.

For smart meters, we realized that Gram Power is extremely well positioned in the industry to create widespread impact in resolving the $16B annual revenue loss problem in India's power sector, which is equal to 6 years of free electricity supply to all of Bangladesh. We managed to reduce losses for DISCOMs by over 90% by installing smart meters and are able to make power supply extremely reliable and affordable for end users. There is potential to scale to 250 Million connections in India over the next two decades and that is where Gram Power is strongly focusing its efforts.

Next steps

The next steps are to engage with the Government to participate in and get larger microgrid tenders for remote parts of rural India where the grid cannot reach. Also, we're scaling up our *'Metering as a Service (MaaS)'* business model to convert conventional meters into smart meters at scale without the Utilities incurring huge capital costs and getting a commitment on technology performance and loss reduction.

Background

Introduction and Project Overview

Over 400 million people in India today, lack access to basic energy as a result of the current power infrastructure of India not being adequate enough to provide sufficient and reliable power supply to all. (ET)[1]. In recent years, achieving universal access to modern energy has become a primary goal for policy makers, non-governmental organizations, and international donors. For example, the United Nations Sustainable Development Goals include, "access to affordable, reliable, sustainable and modern energy for all."[2] However, the extent to which energy access should be driven by private investments in large-scale infrastructure, such as grid connections, or smaller-scale decentralized approaches, such as microgrids, solar lanterns and solar home systems, remains contested.

Opponents of the centralized grid point to the high costs of extending the physical infrastructure to remote areas, as well as the poor historical performance of state-owned or state-controlled grid companies. For example, IEA (2011) projects that to achieve universal electricity access by 2030, 70 percent of the new household connections would be from solar microgrids or solar home systems.[3] At the same time, there is an emerging view that electrification is not a binary outcome, and, while small-scale technologies such as solar home systems can provide benefits to poor rural households, they provide different and less holistic services from a grid-scale connection. In turn, the reliability and performance of the grid can impact the development outcomes it delivers (ESMAP, 2015)[4].

In many ways, microgrids appear to offer the best of both worlds – private companies using scalable technologies that can almost provide full-scale grid services. Many microgrids can also be integrated with the national grid if and when it arrives. However, what microgrids lack is the economies of scale of that come with utility grid operations, while still having all the complexities of a full scale grid operation. This coupled with lack of policy support, and free grid extension by the State for remote households makes it even more difficult to scale microgrids with private sector investment for scattered remote and scanty populations.

This final report describes the experience of Gram Power, an energy technology company founded out of University of California - Berkeley, to provide solar microgrids in rural India. Gram Power used proprietary smart meters and off the shelf solar panels, batteries, inverters and other equipment to design and install their microgrids. As outlined in the following sections, Gram Power followed the vast majority of the best practices that have been articulated in the literature, and by the end of 2015, we had installed a total of 30 microgrids in Rajasthan and Uttar Pradesh in India, out of which 10 were funded under the $1M USAID-DIV grant. Yet, the company encountered unexpected challenges that threatened the viability of the systems. In particular, the company found it much more difficult than it had expected to convince villages to accept a microgrid when there was no clarity on grid extension,

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[1] India's looming power crisis - http://economictimes.indiatimes.com/toshiba/power-systems/thermal/indias-looming-power-crisis/articleshow/51051903.cms

[2] http://www.un.org/sustainabledevelopment/energy/

[3] http://www.worldenergyoutlook.org/media/weowebsite/energydevelopment/weo2011_energy_for_all.pdf

[4] http://www.worldbank.org/content/dam/Worldbank/Topics/Energy%20and%20Extract/Beyond_Connections_Energy_Access_Redefined_Exec_ESMAP_2015.pdf

which was supposedly free for these villages and funded by the State. This both drove up the company's customer acquisition costs and led it to reduce its projections on the potential market for its solution. In villages where the company installed microgrids, it experienced problems with persistent meter bypassing and other forms of theft. And, it was unable to address these problems even though the smart metering technology could detect and, in principle, redress these issues because once the technology issue was resolved in detecting and isolating theft, the issue that had to be addressed was changing consumer behavior and ensuring that they pay for what they consume. The company tried out a variety of business and operational models to try and ensure revenue and run the microgrids in a sustainable manner. However, a certain quantum of the sites did indeed get electrified by the State after getting a microgrid, which further hit its sustainability as people were getting grid power practically for free. Without sustained revenues, and due to high operational costs due to the remote location of sites, the company eventually adopted a community asset ownership model to run the sites. In the meantime, the Indian Government also revamped their national policy on microgrids under it funds microgrids 100% for those areas where it cannot extend the grid for the next 5 years. Gram Power then strategically decided to partner more closely with the government and execute turnkey contracts under this policy to scale up its microgrid business vertical.

However, Gram Power's core intervention had always been in providing the most advanced and lowest cost technology for managing power distribution. The company, during the course of the DIV grant, got an opportunity to bring its smart metering technology on the national grid with a Utility in Bihar, where it managed to reduce distribution losses in the pilot areas from 80% to 8% in under 3 months and provide a remote, online and centralized monitoring solution that helped the Utility enhance power availability by almost 2x in the areas where smart meters were installed. Upon realizing that India loses over $16B annually in revenue in the power sector and that these high losses are the main reason for low power availability in rural India and rapidly increasing power prices, Gram Power decided to focus its efforts in scaling its smart metering solution on the national grid as well. In under a year from then, Gram Power started working with 4 Utilities in India with total orders of 10,400 Smart Meters and a potential to scale to over 100,000 Smart Meters with these Utilities itself. 3,500 of these meters were included under the scope of the DIV project itself, the execution of which has made Gram Power realize that addressing energy lost is the most critical element in ensuring affordable energy access. Due to the large economies of scale on the Utility grid, Gram Power is now also providing its solution to other microgrid operators across the world to better manage their systems and experiment with various business models.

This final report outlines some of the broader lessons from Gram Power's experience. Because the project included a rigorous evaluation component and given the data collection capabilities of Gram Power's smart meters, we were able to collect detailed data on the households and their energy usage. The report thus also provides some of the first high-resolution data on first-time energy consumers.

This report proceeds as follows. It is divided into two sections - Gram Power's experiences, challenges, and future plans for (1) microgrids and similarly for (2) Smart Meters. The first section is on microgrids in which, we begin with an overview of the services Gram Power set out to provide in rural villages, comparing Gram Power's approach to best-practices. We next describe the village selection process, highlighting the unexpected difficulties the company experienced trying to convince villages to accept microgrids, and the implications these challenges had for Gram Power's financial model. Although the project originally planned to select a set of approximately 100 villages that were interested in the microgrids and then randomly allocate the microgrids to approximately 40 villages, we faced major challenges convincing villages to accept a microgrid with full probability, let alone a less than 50 percent chance of getting one. The report then describes the operations of the microgrids in their first several months, which includes profiles of the connected households. Post that, the report outlines the operational challenges that emerged in the first several months of microgrid operations. The most profound challenge was electricity theft, and we provide a detailed analysis of the evolution of theft in our villages. We also describe the challenges we faced addressing theft as well as other maintenance issues in remote, difficult-to-reach communities.

The report then concludes on microgrids by summarizing the main lessons and suggesting policy implications. We compare solar microgrids to other means of electrifying households in India, including grid connections.

In the next section on Smart Meters, we describe Gram Power's Smart Metering solution in detail and the approach that it had with Utilities for loss reduction. We share the impact that the technology had on loss reduction and power quality and the challenges that Gram Power and the Utility faced in getting smart meters installed at scale. Since the smart meters on the Utility grid have been supplied only recently and the Utility is responsible for the installation, Gram Power will periodically share data with USAID on the recurring impact of this technology on the national grid. The section then concludes with Gram Power's ambitious plans of scaling up its smart metering technology and bringing India's complete power infrastructure online.

Timeframe of execution and funding level

Initially, the project was designed to be completed within 2 years of the award date, i.e. by Sept 1, 2015. However, due to several challenges faced during execution, USAID approved a no cost extension for Gram Power and allowed the project to be completed by Sept 1, 2016 with a further 3 months of extra time for submission of any reports and completion of any pending tasks.

The total funding provided for this project was USD 999,961 as a grant from USAID.

Location of implementation and testing

The smart solar microgrids were all installed in Rajasthan after a very challenging process of site selection. A total of 124 villages were visited for selection over a period of 14 months. The first 26 sites were identified between March 2014 to July 2014, next 21 sites between July 2014 to October 2014 and the remaining 77 sites identified in the next 7 months as the installations for some of these sites had already begun. Although 40 sites out of these were finalized for installation, eventually only 10 sites with a total of 55 kWp of solar powered generation were installed in Rajasthan. The names and districts of these sites along with total number of households served are mentioned below:

S. No.	District	Village	PV Capacity (kW)	Battery	No. of connected Households
1	Baran	Khirkhiri	5 kW	96 VDC	21
2	Kota	Khanpuriya	7.5 kW	120 VDC	47
3	Kota	Keshopura	5 kW	96 VDC	30
4	Kota	Kolipura	7.5 kW	120 VDC	48
5	Baran	Gajron	5 kW	96 VDC	39
6	Baran	Kasba Thana	5 kW	96 VDC	28
7	Baran	Kunda	5 kW	96 VDC	42
8	Baran	Jawaipura	5 kW	96 VDC	38
9	Baran	Jeswa	5 kW	96 VDC	36
10	Kota	Damodarpura	5 kW	96 VDC	32

Table 1 - Details of the microgrid sites selected and successful installation completed

The Smart Meters were installed in Bihar and Andhra Pradesh. Over the course of the project, Gram Power developed relations with a total of 4 Utilities and supplied Smart Meters to all of them. 3500 of the total quantity was included under the modified USAID DIV Grant. The meters being manufactured by Gram Power are Utility grade and certified as per IS 13779, and recently also as per IS 15959. Our manufacturing is done at a facility in Jaipur, India, which has all the necessary test equipment to manufacture as per these standards and is also certified as per ISO 9001:2008 (all certificates included in ANNEXURE).

S. No.	DISCOM	City of Installation	Size of Installation (nodes)
1	Andhra Pradesh Eastern Power Distribution Corporation Ltd.	Visakhapatnam	2000
2	Essel Vidyut Vitaran (Muzaffarpur) Pvt. Ltd.	Muzaffarpur	4000
3	India Power Corporation Ltd.	Gaya	1400
4	Bhagalpur Electricity Distribution Company Private Limited	Bhagalpur	3000

Table 2 - Location and implementation of Smart meter installations

From initially manufacturing only a few hundred meters until 2015, the company today has a capacity to make over 30,000 meters a month, which can be scaled 10x within a span of 6 months based on market demand. Moreover, as a first step in Smart Metering, Gram Power digitally maps out the complete power infrastructure using our proprietary mobile application and a trained survey team. From having mapped out only a few thousand consumers until the end of 2015, we are today executing projects of mapping out complete cities and are able to digitally map over 500 households each day, creating direct employment for a large number of people.

Company profile

Gram Power is an energy technology company founded out of Berkeley, California in 2010. It started commercial operations in 2012 in India and since then has done pioneering work in the areas of energy access and radical loss reduction for power utilities in India. With technology and business model solutions ranging from Smart Metering to Minigrids to Prepaid Solar Home Systems, Gram Power's solution portfolio is designed to address energy problems for a large population and the company comes with sound experience of what it takes to implement and scale solutions in various demographics. To date Gram Power has successfully installed 30 solar powered minigrids in rural India, is completing over 10,000 Smart Meter installations for Utilities reducing loss levels by over 90%, and has also developed the industry's most cost effective prepaid solar home system to address energy needs of consumers that can neither be connected to a grid nor a minigrid. Currently Gram Power is working directly with 4 major utilities in the states of Andhra Pradesh and Bihar in India that serve close to 2 million connections combined. For these Utilities, Gram Power has also done large scale geospatial mapping of their infrastructure to visualize their infrastructure online and provide them advanced analytics to manage the infrastructure like never before. For our solar home systems, we partnered with our investors, Vestergaard Frandsen, in Kenya who serve over 1 million households with their products in the country. This gave us a lot of experience in understanding the kind of solutions that work in the Kenyan context and the challenges that exist in scaling electrification programs across the country.

Our work has been extensively recognized nationally and internationally. We were selected among the top 10 Cleantech Innovations around the world by the NASA LAUNCH Energy Challenge, have been covered by all the major publications around the world such as the New York Times, Economic Times, Guardian, Times of India and several more. The company won a wide range of business plan competitions in its early days and has secured multiple rounds of equity funding from investors in Silicon Valley and Switzerland. Our founder was awarded the Global Indian Award by the Indian Prime Minister and Gram Power was selected as a Climate Solver by the WWF. Gram Power's work, growth and recognition is a testimony to our commitment and vision in providing the most advanced and cost effective solutions to address the problems of the power sector across the world and achieving the goal of a sustainably and intelligently electrified planet.

Figure 1- Installations at micro-grids sites identified by Gram Power (India) Pvt. Ltd.

Figure 2 - Grid layout on Gram Power's online portline

Figure 3 - Gram power's smart meter installed in Baran district of Rajasthan

Figure 4 - Solar home lighting solution engineered by Gram Power

Figure 5 - Installation at site

Program Design, Implementation & Challenges

Goals of the project

The project was initially designed to install up to 40 microgrids rural Rajasthan and impact up to 30,000 people. Through a randomized controlled trial (RCT) approach for site selection and distribution of power subsidies, along with high resolution data from the smart meters, J-PAL and UC-Berkeley (the research partners for this project) were to independently evaluate the social impact of the microgrids. Moreover, an analysis of the revenue recovery from microgrids was to determine the level of capital funding needed for microgrids to scale with private sector financing.

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Baseline Data and Beneficiary Demographics

Off-grid beneficiaries

	Summary Statistics			Diff. p-Value	
	(1) Baseline: Full Sample	(2) Baseline: Microgrid Only	(3) Indian Census	(4) (1) vs. (3)	(5) (2) vs. (3)
Basic Characteristics					
Household Size	5.41	5.40	5.41	1.00	0.92
Household Members Age 18+	2.92	2.97			
Household Members under Age 18	2.50	2.43			
Metal Roof on Dwelling (=1)	0.08	0.12	0.13	0.10	0.87
No Toilet (=1)	0.95	0.96	0.74	0.00	0.00
Rooms in Dwelling	1.53	1.66			
Main Water Source: Handpump (=1)	0.79	0.77	0.36	0.00	0.00
Main Cooking Source: Firewood (=1)	0.99	0.99	0.90	0.00	0.00
Socioeconomic Characteristics					
BPL Status (1 = BPL)	0.52	0.48			
Land Ownership (Acres)	0.92	0.85			
HH Uses some Land for Agriculture (=1)	0.76	0.66			
HH Head is Farmer (=1)	0.56	0.47			
Yearly Income (1000 INR)	61.67	66.58			
Current Savings (1000 INR)	2.43	3.07			
Current Outstanding Loans (1000 INR)	27.84	40.33			
Energy Use					
Owns Solar Lamp (=1)	0.02	0.03			
Owns Solar Home System (=1)	0.26	0.34			
Owns Kerosene Lamp (=1)	0.92	0.88			
Uses Solar Home System (=1)	0.25	0.33			
No. of Solar Home Systems Used	0.29	0.38			
Uses Solar Lamp (=1)	0.01	0.02			
No. of Solar Lamps Used	0.02	0.03			
Main Light Source: Kerosene (=1)	0.71	0.63	0.86	0.00	0.00
Main Light Source: Solar (=1)	0.20	0.24	0.08	0.01	0.01
No. of Lights used Last Night	1.36	1.36			
Subsidized Kerosene Exp. (INR/Month)	43.66	40.56			
Unsubsidized Kerosene Exp. (INR/Month)	15.60	24.71			
Observations	582	346	33848		

Note: Households in the census sample are from the entire set of villages without electricity for domestic use as defined by the Indian Census in 2011 in the districts we initially surveyed. These districts are: Banswara, Baran, Barmer, Bundi, Chittaurgarh, Kota, Pratapgarh and Pali. Difference-in-means tests computed using standard errors clustered at the village level

Table 3 - Demographics of off-grid beneficiaries

Table 3 presents summary statistics on the connected households. Our survey team collected these data in the time period after the village had agreed to pay for a microgrid and before the microgrid was installed. For variables collected in the Indian Census, column (2) reports values from all un-electrified villages in the districts in Rajasthan that Gram Power initially surveyed.

Households in our villages have on average more than 5 members, roughly split between adults and children under the age of 18. In terms of basic socio-economic characteristics, our households are poor, with almost half reporting that they qualify for “Below Poverty Line (BPL)” status, average land holding less than an acre and very few having a metal roof and even fewer a toilet. On these metrics, our households look slightly less well off than other un-electrified villages in Rajasthan. This could reflect the fact that the wealthier, un-electrified villages were closer to existing grid connections and perhaps as a result less interested in the microgrid. This could also reflect suboptimal targeting on our part.

In terms of energy consumption, about a third of our households had solar home systems or solar lanterns. This is significantly higher than population averages, and may reflect a higher willingness to adopt a solar-based technology given previous experience with a related product. Figure 6 displays the electrical appliances owned by our households at baseline, including fans, TVs, light bulbs, and music systems. Other than solar, our households spend about 65 rupees per month on kerosene, primarily for lighting.

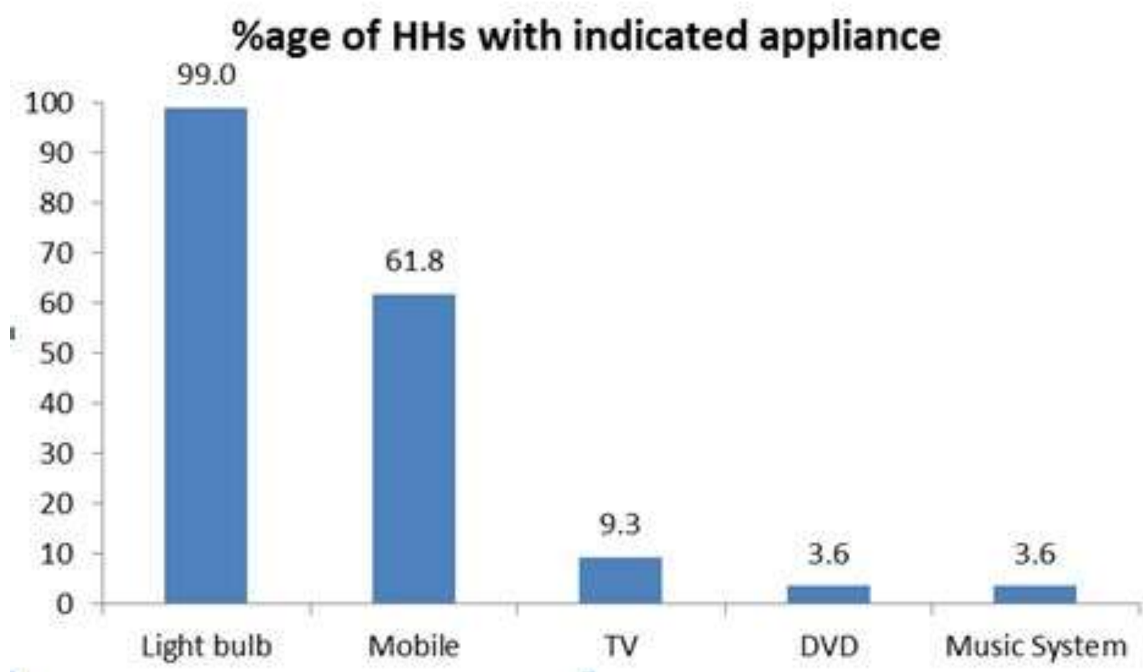

Figure 6 - Appliance census of off-grid beneficiaries

Grid-connected beneficiaries

Below are the results of the survey carried out by J-PAL in Muzaffarpur where the first 1000 smart meters were installed on the national grid as sub-meters in partnership with Essel Utilities.

Total sample	861 respondents (households) ~53% of the respondents are household heads themselves
Gender	Male (61%) Female (39%)
Religion	Hindu (86.5%) Islam (13.5%)
Social category	Extremely Backward Classes (41%) OBC (22%) General (13%) 75% households are on the government's list of BPL families
Highest level of education completed	No education (49%) Class 10 (10%)
Occupation	Farmer (13%) Unskilled construction laborer (13%) Own shop (10%) Mason (7%)
Land	58% of the households in our sample own land. Of these 45% own shared land
Income	Median highest income in a given month in 2015 was Rs. 6000

Table 4 - Demographics of grid-connected beneficiaries

Information on grid connectivity

- 97.7 % households were connected to the grid
    - 97% of the connections are single-phase in nature
    - 70.65% of the connections come under the Below Poverty Line (BPL) category and 27% are regular connections
- 2.3% households do not have grid electricity. One of the most commonly cited reasons was that they had applied but didn't get connection

Duration of being connected to the grid	%
Less than a year	9
1-2 years	32
3-5 years	35
Above 5 years	24

Table 5 - Duration since beneficiaries have been connected to the grid

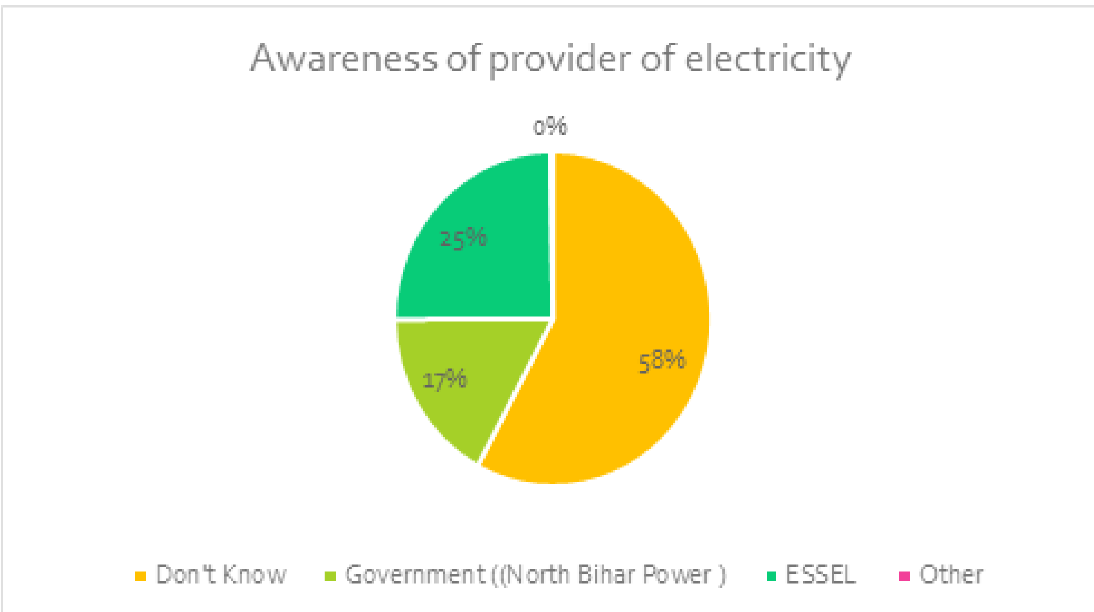

Figure 7 - Awareness of the organization which provides electricity to the household

From Figure 7, 75% of the consumers were not even aware that Essel Utilities was their electricity supplier. This indicates the level of engagement that people have with their Utility and the level of awareness created by the Utility for its customers. This poor public relations on the Utility's front, caused a lot of challenges during smart meter installations as is outlined in the challenges sections later in the report.

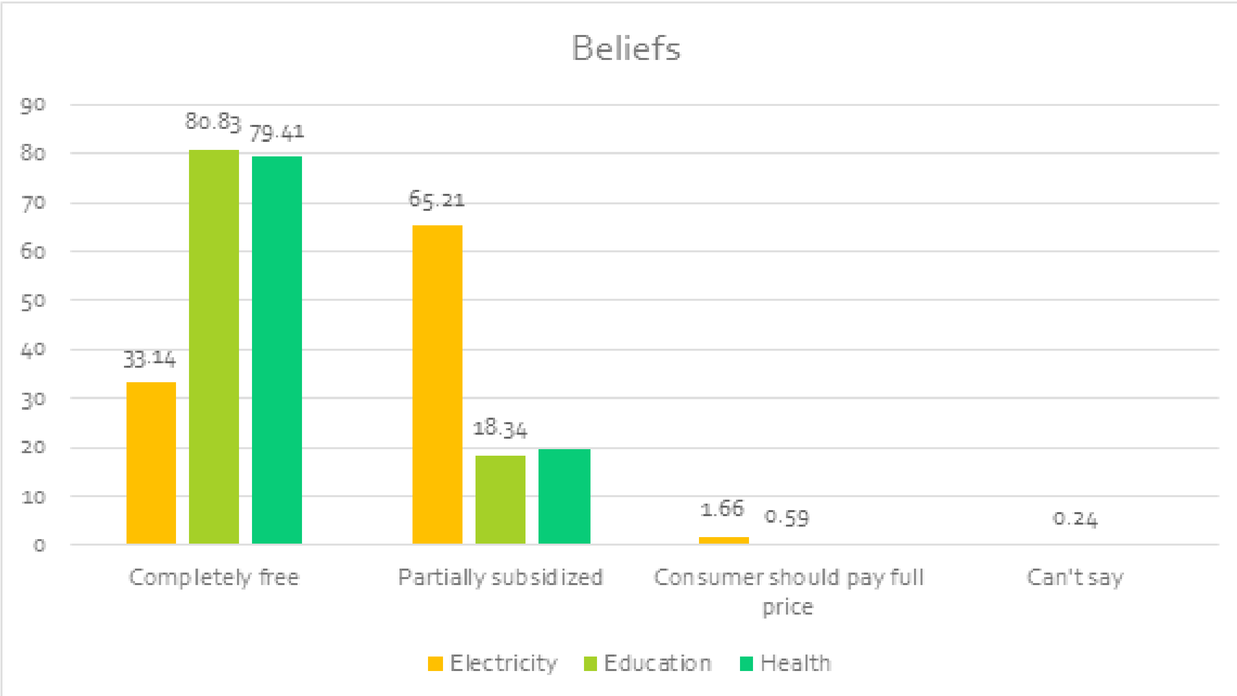

Figure 8 - Beliefs regarding costs for electricity access compared to other areas like health and education

Figure 8 is a stark reality of the mindset of the rural population in India, which makes sustainable electricity supply a very challenging industry to be in. As can be seen above, out of all the grid connected households surveyed, only 1.66% believed that consumers should pay full price for electricity. As high as 33.14% of the consumers believed that it should be completely free. This mindset is a result of decades of free electricity supply being given to rural areas, as power has always been a politically influenced sector and free electricity has been a vote-bank agenda for a lot of politicians. Fortunately, to ensure a better future for India, the Government is positively changing by privatizing the power sector and introducing a lot of technology for loss reduction. The process will take time as it's an industry where consumer behavior needs to change, but it will change nonetheless with interventions such as those of Gram Power's gaining momentum in India.

Figure 9 outlines the frequency with which consumers are delivered bills (%). As can be seen from this chart, almost 50% of the consumers received bills at intervals of one month or more.

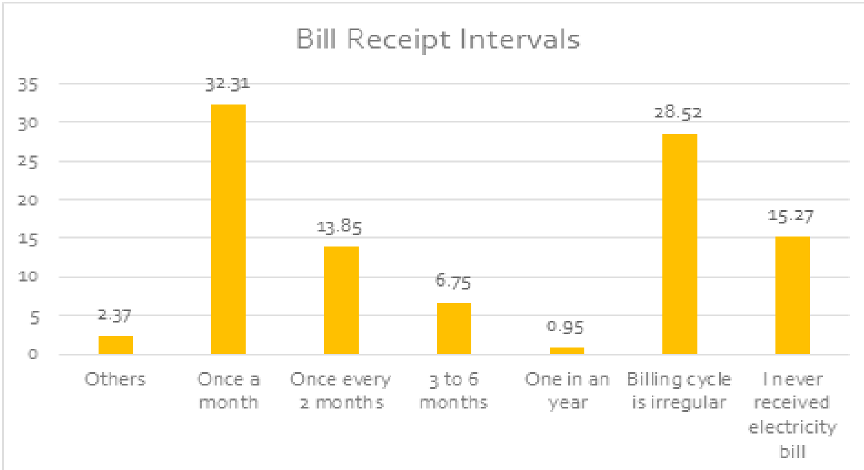

Figure 9 – Bill receipt intervals

- Nearly 50% of the households pay for their bills by visiting the ESSEL office in Turki. About 10% pay it by visiting the ESSEL office in Muzaffarpur. 17% of the households pay the bill to the ESSEL personnel who visits the village.
- 50% households were willing to shift to the pre-paid mode of payments and about 48% said no
    - Of those who said YES, one of the most commonly cited reason was "*It helps plan my finances better: flexibility in usage and payment*"
    - Of those who said NO, 75% did not want to shift since post-paid mode allowed them to make payments later without cutting their access to the service
- 90.5% of the households claimed that they have problems in paying their bills
- 37% of the households had concerns about the bills they receive
    - Of them, nearly 60% mentioned “incorrect billing” as the reason for their concern
- 4.62% of the households in our sample claimed that there had been occurrences of theft in their neighborhood
- Of these, 75% felt that up to 25% of the people in their village steal electricity. 5% felt that everyone in the village steals electricity

The data above outlines the potential that exists, with smart metering, for improvement in the lives of the poor rural populations that are connected to the grid. Making payments easier and more affordable, 100% transparency in billing, empowering people to control their expenses, radically reduce theft and losses, improving complaints redressal and most importantly the quality and quantity of power supply are only a few of the direct advantages that improve with the onset of smart metering that cause direct economic and social impact in the lives of the people. The baseline data and our work in both grid connected and off grid areas, helped us realize that it’s relatively easy to bring electricity in the lives of people, but what actually causes impact is reliable and adequate supply of power at an affordable price.

Microgrid Best Practices

While the technology is new and definitions are still evolving, a recent report describes a microgrid as, "[a]n electricity distribution system containing loads and distributed energy resources (such as generators, storage devices, or loads) that can be operated in a controlled, coordinated way while islanded from any utility grid, and is under the control of a single management entity" (Nordman 2016)[5].

Recent estimates suggest that fewer than 1 million people in India draw electricity from microgrids (Ferris 2015)[6], so understanding the extent to which the technology can scale to serve some of the nearly 300 million people who currently live without electricity is a key challenge.

Several reports have recommended best practices for operating microgrids and documented success stories. For example, Figure 10, reproduced from Schnitzer et al. (2014)[7], summarizes some of the suggestions for effective operations, emphasizing the distinction between a "virtuous cycle," in which the microgrid owner has good interactions with customers and customers continue to pay for and maintain the physical infrastructure, and a "vicious cycle," in which poor contractor performance and poor service quality lead to theft and low cost recovery for the operator. As the arrows entering each cycle emphasize, contractor performance, engagement with the local community, pricing policies and technical aspects of the system are important to success.

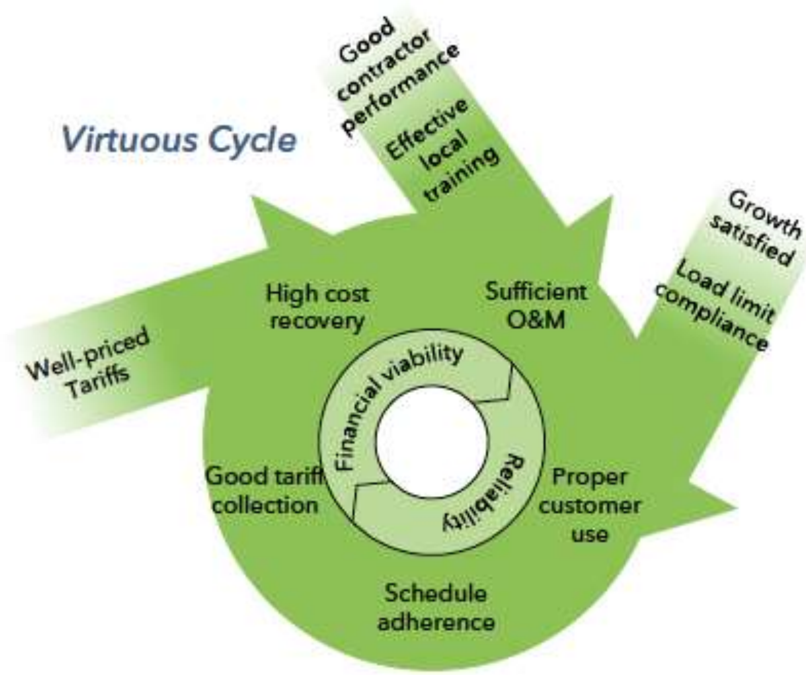

Figure 10 – Steps that lead a micro-grid owner into a virtuous cycle

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[5] http://nordman.lbl.gov/docs/SGIP_Local_Grid_Definition_2.pdf

[6] http://e360.yale.edu/content/print.msp?id=2729

[7] Microgrids for Rural Electrification: A critical review of best practices based on seven case studies - Daniel Schnitzer, Deepa Shinde Lounsbury, Juan Pablo Carvallo, Ranjit Deshmukh, Jay Apt, and Daniel M. Kammen

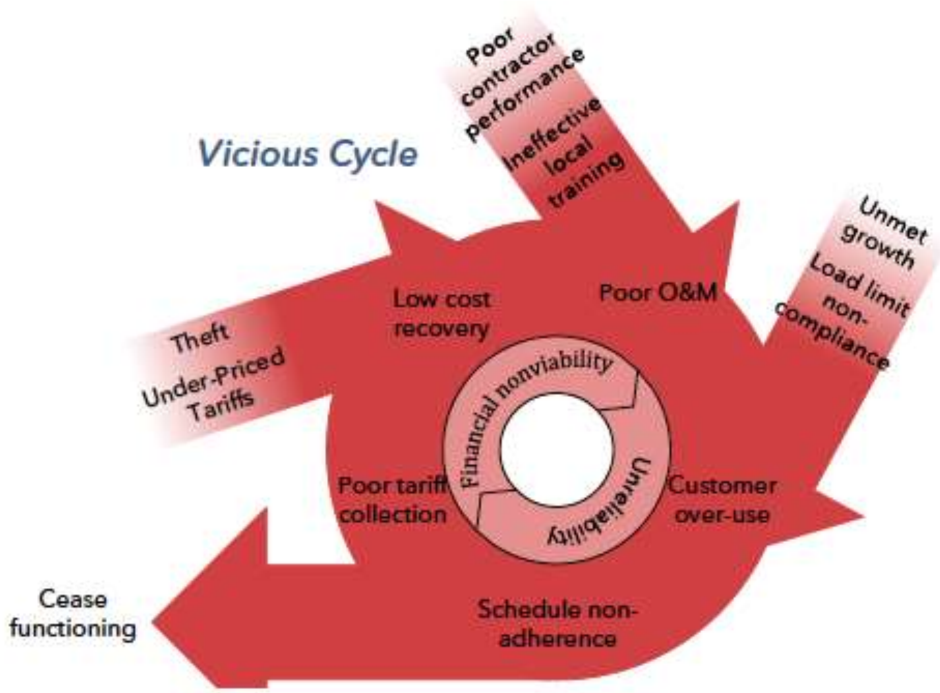


Figure 11 - Steps that lead a micro-grid owner into a vicious cycle

The first step on the virtuous cycle is to ensure timely and quality construction of the microgrid infrastructure. The contractors are responsible for effective vendor management, procurement of material, and facilitating construction of supporting structures. Contractor performance on these key tasks can shape communities' initial impressions around quality and timeliness.

Many observers note the importance of engaging with the local community. For example, the Alliance for Rural Electrification (2011) notes that, "developers should not design the system based on pure technological considerations, but instead adapt to the specific social and economic characteristics of the rural community." How this can be part of a profitable, scalable business is not discussed in as much detail.

The literature also links pricing policies to widespread community support. For example, prior work endorses the provision of a "lifeline" tariff sufficient for simple lighting so that even the poorest members of a community can have access to electricity. This can expand the social impact of the infrastructure and perhaps increase the acceptability of a project to communities, although again the impacts on profitability and scalability remain open questions.

On the technical side, microgrid systems are typically constrained by the total amount of power available. The best-practice literature therefore recommends several approaches to ensuring system reliability, including the use of load limiters, distributed intelligent load control, and advanced metering systems with centralized communication (Harper, 2013).

Theft mitigation is also an important component of any sustainable system. The literature generally recommends a zero-tolerance policy. For example, ESMAP (2000) suggests that, "it must be clear that if the consumer no longer has the wherewithal to pay, that household will be disconnected."

Finally, there is a general sense that rural electrification should ideally be coupled with development of commercial, income-generating activities.

Village Selection

The overarching goal of the project was to evaluate the effect of electrification using indicators such as improved health, improved literacy rates, and higher income levels. The team initially proposed running a randomized controlled trial (RCT) where they would recruit close to 100 villages interested in having a microgrid installed and then randomly select 40 of these to receive the microgrids. The team planned to conduct screening visits, conduct targeted technical assessment and install micro-grids in an organized fashion.

However, recruitment of the identified sites posed numerous challenges at each stage as described below. In the end, the team decided that it was unlikely to recruit enough villages within the given timeframe.

A. Site Selection

1. Identified unelectrified villages in Rajasthan from publicly available data

Gram Power prepared a list of villages and hamlets that were not targeted for grid extensions over the next 2 years. Since the Government of India has no clear mandate regarding the regions that will get grid extension, a wide variety of sources were used to prepare this list, including the Rural Electrification Corporation of India (see http://www.recindia.nic.in) and the state electricity board of Rajasthan (see http://energy.rajasthan.gov.in/rvunl#). In addition, Gram Power consulted with additional sources, including local NGOs, local real estate dealers, regional linemen and village panchayats (local self-government organizations) and ended up visiting a total of 176 villages.

2. Targeted subset for possible recruitment

During the first screening visit, Gram Power's field teams conducted survey of:

- the availability of undisputed land in a central location suitable for solar power generation
- total number of households ready to pay connection fees (or part of the connection fees)
- the willingness of the Panchayat to donate part of the connection fees to cover for households who themselves were unable or unwilling to pay the fees

In addition, Gram Power held Information sessions to explain the microgrid installations to the community. These sessions included details about the various tariff plans, the safe use of electricity, and the advantages of electrification.

If the response to the proposed microgrid seemed positive, the field team assessed parameters such as:

a) *Ease of access* – Most of the unelectrified villages in India are remotely located where grid extension is not feasible in the short-run. Hence, to install a microgrid, the procurement of the required material had to be facilitated with the availability of clear paths and proximity to local stations.

b) *Network availability* – The smart prepaid metering technology requires a minimum of 2G network to transfer the collected data and receive remote commands. Intermittent network availability posed difficulties in implementing remote monitoring systems.

c) *Land availability* – The solar panels require unshaded centrally located land where Gram Power could enter into an agreement with the landowner for mounting the generation infrastructure. Further agreements between the village community for housing the battery bank and balance of system equipment were also arranged.

d) *Distance between households* – Gram Power's technology required the households to be located on average 40m apart and within 40m of the central generation location to facilitate communication between the meters.

If a village cleared the aforementioned stages and if at least 50% of the interested households had paid their connection fees, the village was prioritized for installations.

3. Specific issues in following the protocol

Gram Power experienced several issues following the steps explained above. For example, sometimes the person who served as the communication link between Gram Power and the village would not inform the community of Gram Power's intention to visit, which made it more difficult to interact with the villagers and gain acceptance.

Often, local politicians would agree to cover the connection costs and would request a survey of surrounding villages under his/her jurisdiction. Gram Power saw this as an opportunity to scale. However, these politicians would usually later refuse to pay the connection fees on behalf of the village. Since Gram Power was relying on the local politician to cover the initial connection cost, the projects could not be implemented and new sites had to be identified.

The network connectivity at most of the sites was weak, unreliable or intermittent making the list of eligible sites smaller.

4. Influence of elections

The role of the election period -- leading up to the general election in April and May 2014 -- was profound. In many villages, politicians promised to extend the government grid with power supplied free of cost. This considerably dampened interest in microgrids.

In other cases, the election period worked to Gram Power's advantage. Since the head of the villages formed a crucial link between the village community and Gram Power, it was essential for Gram Power to convey the benefits of electricity and the setbacks of the government in extending the grid. Gram Power found some village heads to be receptive and adopt electrification as a part of their campaign. More often than not, convinced village heads would pay part connection fees out of their pockets to acquire a majority vote bank. In some cases, the election candidates would be convinced that the government grid extension would come at a lower cost and free to use service, leading to the communities disinterest in Gram Power's microgrids.

5. Example communities

i. Approached + Not Interested (e.g., Moulot)

The village communities that were approached but disinterested cited their poor past experience with other service providers, such as solar home systems or solar street lighting. This created a lack of trust between the communities and Gram Power.

ii. Approached + Interested + Installed (e.g., Kirkhiri)

Acceptance at sites where projects turned into reality came through Gram Power's persuasive interaction with the community. Gram Power built strong relations with the stakeholders to encourage the community to adopt micro-grids. The stakeholders were site relative and included the village panchayat head (sarpanch), local entrepreneurs/servicemen, and politicians.

Case 1: Khirkhiri was one of the first sites to adopt the micro-grid. Stakeholders included the sarpanch and a local linemen from a nearby hamlet (Devri Kasba). Upon strong persuasion, connection fees was collected from 11 households out of a total of 21 and the installation work began.

Case 2: Other sites were backed by financially strong regional political leaders who promised electrification for their people. The political leader of Keshavpura demanded the survey of surrounding villages which Gram Power saw as an opportunity. After the survey, however, the connection fees of only one village was paid through after strong persuasion from Gram Power.

iii. Approached + Interested + Not Installed (e.g., Mandirgarh)

In this case, financial hurdles disabled the village communities from availing the benefits that Gram Power's micro-grid had to offer. The upfront connection fees for each household was equivalent to the monthly allowance given by the government under the National Rural Employment Scheme. Beneficiaries who relied solely on this income found it hard to allocate funds towards the luxury of electricity. Other's allocated funds to the harvest season and could not pay upfront till the harvest season ended. Thus, in some cases, time of the year of approach influenced successful recruitment.

B. Value Proposition for Households

1. Explanation of service

This sections provides more detail on the information provided to potential customers about the microgrid. Initially, the rate plans were designed on the basis of the appliances that would be used by a household. The consumers could get a basic connection at Rs. 1000 which allowed them to charge their phones and use led light bulbs, Rs. 2500 which would allow them to use a fan and a tv additional to the basic connection and Rs. 15000 where a group of 3 people would be given permission to power a pump for irrigation purposes in addition to the Rs. 2500 plan each. The second and third options were deemed too high for a successful fee collection in any village, so Gram Power scrapped the different connection options and started providing connections at a basic rate of Rs. 1100 per connection for all.

Table 6 summarizes the basic pricing structure. In addition to the connection costs, households paid 20 rupees per kWh and 150 rupees per month.

Connection cost	Rs. 1100
Allowed appliances	2 LED bulbs + 1 mobile charging point + 1 fan
Monthly fixed charge	Rs. 150

Table 6 - Tariff structure

Pamphlets (Annexure) were provided with information on hours of service for recharge amounts to clarify expectations from Gram Power's micro-grid. Finally, customers were informed that they would receive two light bulbs (LED or CFL) and a switchboard that contained a light socket and two electrical outlets.

The selected site technicians were trained in detecting theft on ground. Details like contact numbers of a trustworthy authority was given to the villagers to follow up on the information provided to them

2. Reasons for lack of interest

Anecdotally, customers cited several reason for their disinterest in the microgrid. Some were unfamiliar with the product. Even households who understood solar microgrids were unfamiliar with Gram Power and were not willing to make the upfront payment if they did not trust that the company would return to install the microgrid equipment. Still other customers cited negative prior experiences with solar, such as government-supplied solar street lighting systems.

For some consumers, even an upfront cost of Rs.1100 seemed high as they completely relied on the rural employment guarantee program of the government or worked as laborers for other farmers. Moreover, several of the consumers knew that government funded programs provided free grid connections and extremely subsidized supply to BPL families, which created a priori for them and dis-incentivized them from paying for the connection.

In a large number of villages, grid connections were promised by politicians during their election campaigns. This would sporadically create hope amongst the villagers of getting free power and the message would spread to all nearby areas well, thereby removing all hope of the areas adopting a microgrid for months or years altogether.

Interestingly enough, in some villages political feuds existed within the communities itself. The communities would get split up based on their political preferences and they couldn't meet each eye to eye. In such a situation, the communities would demand independent systems to supply electricity to them as they did want to associate with the other section of the community. Since it wasn't possible for Gram Power to setup such small systems, these villages would also be dropped from the list.

C. 10 Study Communities

Gram Power and UC Berkeley were initially interested in randomly placing microgrids among interested villages. However, a combination of challenges with each site as outlined above made recruitment difficult. Each village was found to be a project on its own, which created serious doubts on the scalability of the process and practicality for operations and maintenance. One potential improvement would be if the government clearly delineated certain villages as unelectrifiable by the national grid. However, making such a list public is considered apolitical and is difficult to come by unless a guideline is issued by the Central Government on which type of areas will be earmarked for microgrids.

Consequently, upon discussions with USAID, the goal of electrifying 40 villages was modified, and among other things, Gram Power installed a total of 55 kWp capacity across 10 villages. (Table 7)

In the end, customer acquisition was more difficult and more time consuming than anyone on the team envisioned. The difficulties not only delayed the project, but increased the costs substantially.

Installation

Tables 7 summarizes the technical specifications and costs for the systems installed in the 10 study villages. Eight of the 10 systems included solar panels with 5 kilowatts of capacity, while 2 villages with larger and wealthier populations received 50 percent more capacity -- Khanpuriya and Kolipura. On average, 36 households per village connected to the systems.

Village	PV Capacity	Battery(Voltage in DC)	No. of connected Households
Khirkhiri	5 kW	96 VDC	21
Khanpuriya	7.5 kW	120 VDC	47
Keshopura	5 kW	96 VDC	30
Kolipura	7.5 kW	120 VDC	48
Gajron	5 kW	96 VDC	39
Kasba Thana	5 kW	96 VDC	28
Kunda	5 kW	96 VDC	42
Jawaipura	5 kW	96 VDC	38
Jeswa	5 kW	96 VDC	36
Damodarpura	5 kW	96 VDC	32

Table 7 - System specifications

On average, the installations took 30 days to complete.

The extensive recruiting process described above significantly added to the cost of installing the microgrids as it took much longer to identify and finalize the sites than what had initially been planned. For any new technology, it is important to recognize customer acquisition cost as a potentially substantial component of the cost of doing business. If customers are unfamiliar with the technology, it will take time to convince them to try something new, and many customers will decide not to switch, meaning the costs of marketing to them are spread over a smaller number of switchers. For microgrids, customer acquisition costs could decline if the Government of India were to issue clear, credible guidance on which villages would be connected by microgrids and which by the grid. Also, the very remoteness of the villages increases the costs of marketing to them.

Finally, administration and general costs, including the costs of operating and maintaining the systems, also significantly increased the cost of the system due to incessant delays and uncertainties that had to be handled as we went about the project execution. Some of these costs are fixed with respect to the scale of the company's operations (e.g., many of the costs of IT support or management overhead), so these may account for a smaller share of total costs at higher scale.

In general, the microgrid costs are not dramatically higher, and could be considerably cheaper than a grid connection in many situations, including where the village is more remote. It would be useful to detail the costs as a function of some measure of remoteness, such as distance from the nearest substation. Grid extension costs are certainly higher, although transportation and customer acquisition costs are also higher for a microgrid provider.

It should be noted that the microgrids provide a different service than the utility-scale grid. One commonly cited differences is reliability, with the common perception that microgrids can provide 24 hours of power 7 days a week. In many parts of India, the grid has high outage rates. This may partially be explained by the fact that, as reflected in the cost comparisons presented above, grid expansions are made without sufficient attention to the increases in required generation or without accounting for additional maintenance. On the other hand, it's important not to compare an ideal/theoretical micro grid to an actual grid. In fact, as we show below, micro grid systems are also prone to operational challenges, some of which can degrade performance.

In terms of power, microgrids are more limited by their scale. For instance, a household could not set up a welding shop without dramatically increasing the cost of the microgrid, whereas the ability to average across a much larger number of users allows consumers to power high-wattage appliances occasionally without huge cost implications for the macro grid.

Figure 12 - Comminity mobilization and site selection

Operations

A. Local Entrepreneurs

Gram Power's payment collection model was based on prepaid payments for the use of energy. This was analogous to prepaid telecom recharges familiar to most rural communities. Gram Power empowered local village entrepreneurs to collect these payments and administer recharges through a communication dongle and phone app. Village entrepreneurs were also trained to catch theft and report back to Gram Power for turning-off the defaulters' meter. However, the entrepreneur based faced various challenges.

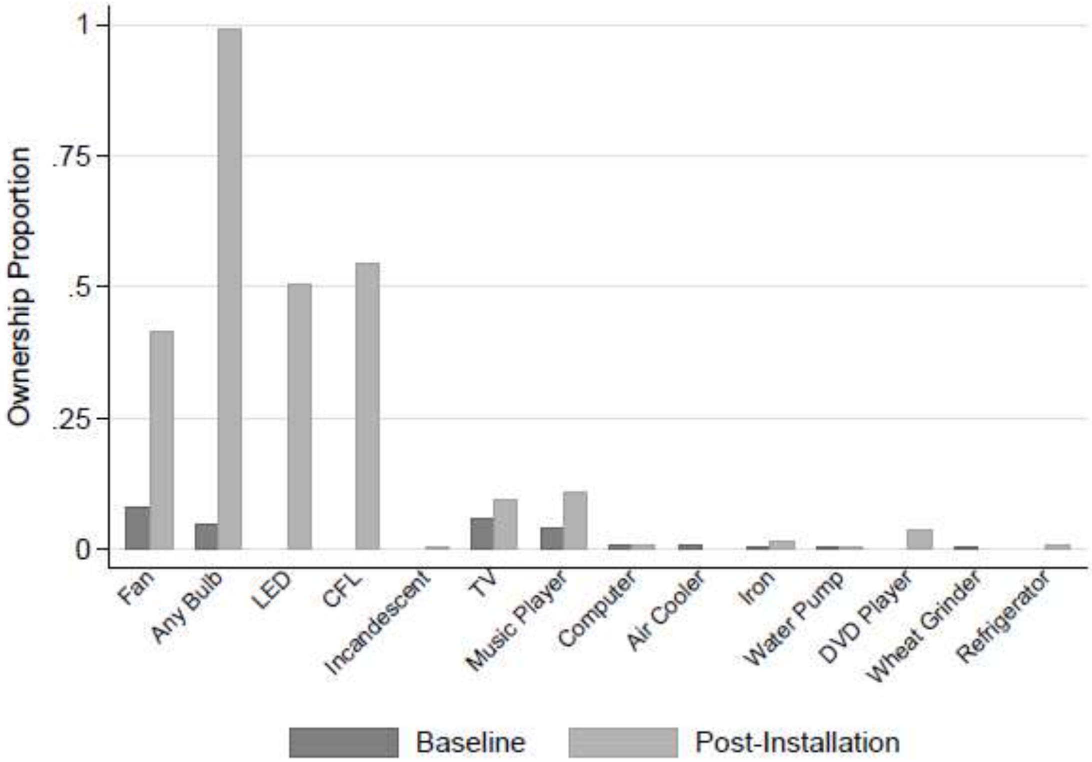
In an average village of 36 households, the typical monthly revenue, in the event of 100% collection, would be INR 14,400 or $215. Ideally, the entrepreneurs would have purchase this amount of recharge as credit from Gram Power and then sell to the consumers for a commission. We tried incentivizing them with 10%, 20% and even 30% commission levels. We realized however, that firstly due to theft the collection was never 100%. Secondly, since the quantum of revenue being dealt with is too small, the commission quantum was also quite small due to which the entrepreneurs would not be incentivized enough to collect the revenue, troubleshoot problems, and deal with theft cases in the village. In fact several entrepreneurs even refused to work since dealing with theft was making them unpopular in the village and they preferred not to have that responsibility.

We also tried providing a single entrepreneur a cluster of villages but due to cultural and political challenges across sites, and even to deal with maintenance issues in real time, the people demanded that they needed a representative from their village itself to run the system.

For Gram Power, a single visit to any of these sites would cost more than the monthly revenue, making it unviable for us to directly manage collections for such small villages.

Typical electricity consumption

Once connected to the microgrid, households' appliance holdings changed dramatically, as shown in Figure 13. The data depicted in this figure were collected approximately 6 months after the systems were installed.



Note: Shows proportion of onwership among households who eventually received access to a micro-grid at baseline and at post-installation ground truthing. N = 346 for baseline and N = 222 for post-installation. The post-installation survey occured in June and July of 2015, which is approximately two months after installation for all sites except Khirkiri. For Khirkiri, the post-installation period is approximately 8 months after installation.

Figure 13 - Appliance ownership before and after microgrid installation

Gram Power provided two light bulbs to households that paid the connection fee. In an attempt to learn about the "rebound effect," where households increase consumption of energy services when they have access to more energy efficient lighting, we randomly selected half the households to receive more energy efficient bulbs (LEDs, which consume 4 Watts). The remaining households were given compact fluorescent bulbs (which consumer 8 Watts) as was Gram Power's usual practice. Very few households appear to have procured their own incandescent bulbs.

The most popular additional appliance was a fan, which nearly one-third of our households purchased after the microgrid systems were installed. Several households also bought TVs and music systems.

With these appliances, households consumed approximately 1-30 kWh per month across various sites, indicating a significant variation across households, which is largely based on their income levels.

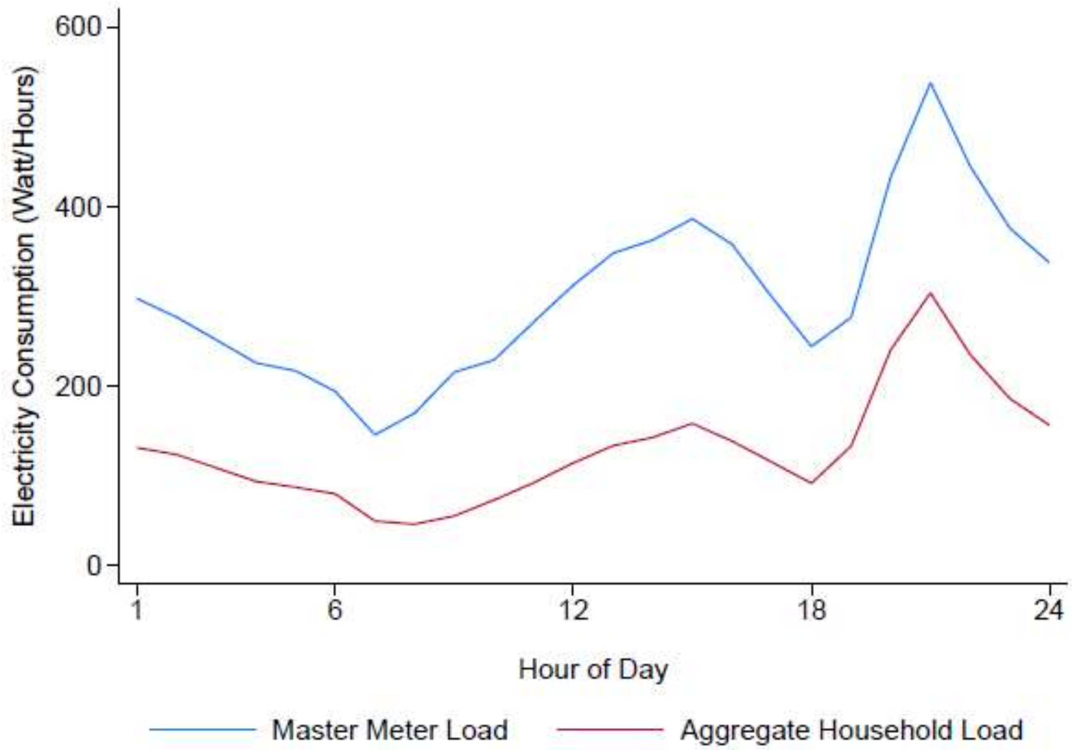
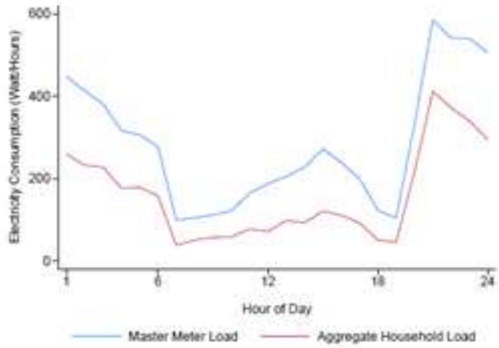
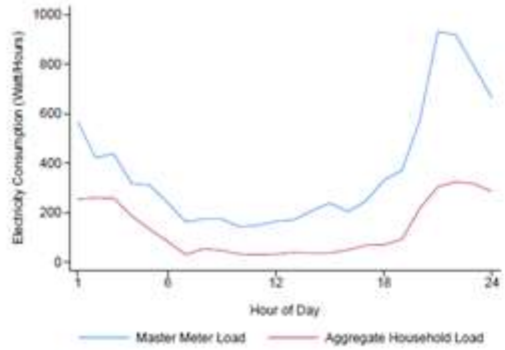


Figure 14 - Typical consumption profile over the day

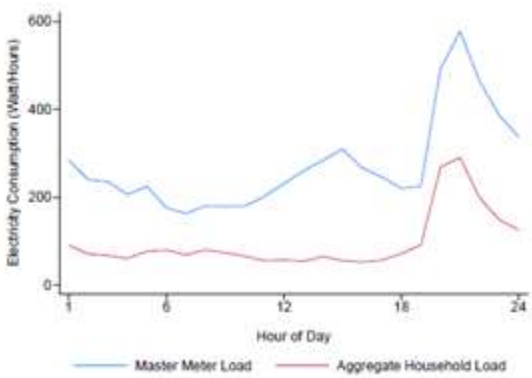
The blue line traces household consumption as measured at the centralized master meter averaged across all 10 microgrid systems, while the red line reflects the average across villages of the sum of all consumption metered at individual households. Focusing first on the shapes of the two lines, consumption peaks around 8PM, presumably based on lighting demand. Peak consumption is almost twice as large as average consumption throughout the day. Note that this profile is not optimally aligned with the production of solar electricity. Over time, when households purchase more and higher power appliances, those too add to the peak demand at night, which requires additional investment in batteries. In the wake of limited revenues from the existing system and poor willingness to pay high tariffs for higher demand, it becomes impossible to invest further into the system to meet the additional demand of consumers. This in turn starts the vicious cycle, as consumers start getting dissatisfied with the service and stop paying or start stealing, which in turn further affects even the operational viability of the system.



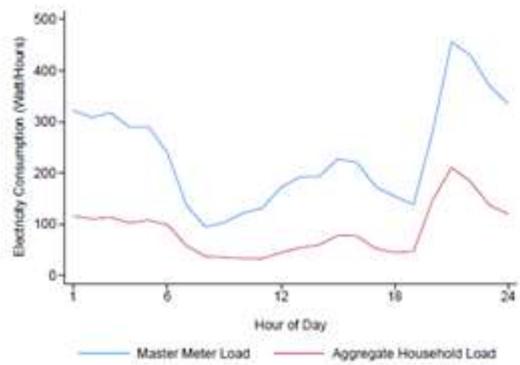
(a) Damodarpura



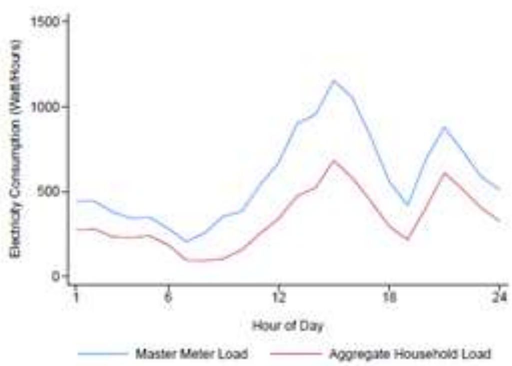
(b) Gajron



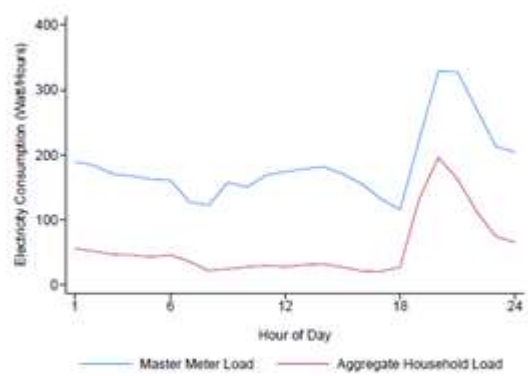
(c) Jeswa



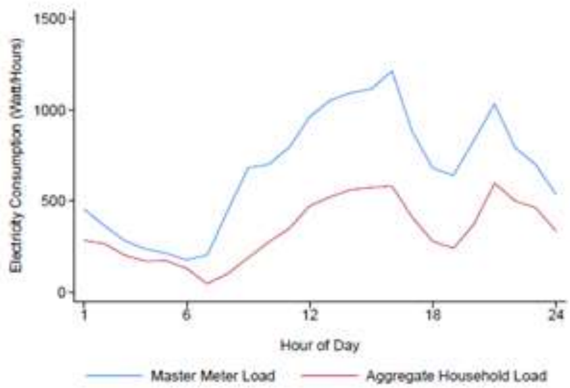
(d) Keshopura



(e) Khandpuriya



(f) Khirkhiri



(g) Kolipura

Figure 15 - Consumption patterns for a) Damodarpura; b) Gajron; c) Jeswa; d) Keshopura; e) Khanpuriya; f) Khirkhiri; g) Kolipura

Figure 15 displays consumption patterns for seven out of the ten villages. Five of the seven villages display peak consumption in the evening, while two -- Khanpuriya and Kolipura -- have system peaks in the late afternoon, which is more closely aligned with solar production. We surveyed households about the appliances they owned 6 months after the systems were installed. We recorded at least 1 household in each of these villages that wanted to own either a refrigerator or a chiller, compared to over 2 in the other four villages. Note that both Khanpuriya and Kolipura received larger systems and were found to own refrigerators in local shops upon our subsequent visits.

The cross-village differences in consumption profiles highlight important heterogeneity. Ideally, microgrid providers would be able to identify whether a village would have evening or midday peaks before sizing and installing the system as a villages with peaks in the daytime will require smaller batteries than villages with peaks in the evening.

In both Figures 14 and 15, the blue line lies consistently above the red line, suggesting that the consumption recorded at the master meter was higher than the consumption recorded at individual household meters. The master meter only measures electricity consumed by households, and does not include, for example, system power or electricity for community buildings. If none of the households were bypassing their meters, the red line would be on top of the blue line. We address the issue of theft in the next section.

Post Installation Challenges

Challenges with Revenue Collection

As noted in Figures 14 and 15, metered household consumption was often at least 30% less than the electricity generated by the system. By their very nature, illegal, or at least not-sanctioned, activities can be difficult to describe empirically as people do not want to be observed in the process. In this case, however, by using metering information from both the household and system levels and by triangulating across data sources, we are able to draw some inferences about the patterns of theft.

As summarized in Figure 10 above, theoretical descriptions of micro grid best practices suggest that theft may be caused by poor performance on the part of the micro grid provider, implying that the theft would not occur until after customers have a bad experience with the system. We can investigate whether the patterns of theft that we observe over time are consistent with these theories.

Figure 16 describes temporal patterns in reliability and theft from one of the microgrid villages, Khirkhiri. The figure shows that from the start of the system in October 2014, when the theft was low, it showed high reliability with power available for over 120 hours a week. The system peaked with 150 hours of supply per week along with simultaneous theft recorded by untraced power from the new year in 2015 for the next 5 months. This led to a high overload on the balance of systems, damaging the battery and the inverters till the system stopped functioning. The blue line records the share of the hours in each week when the microgrid was operating. After a few weeks of startup when the system operates for less than 80 percent of the hours, it operates for all hours by week 10 and is consistently doing so after week 15.

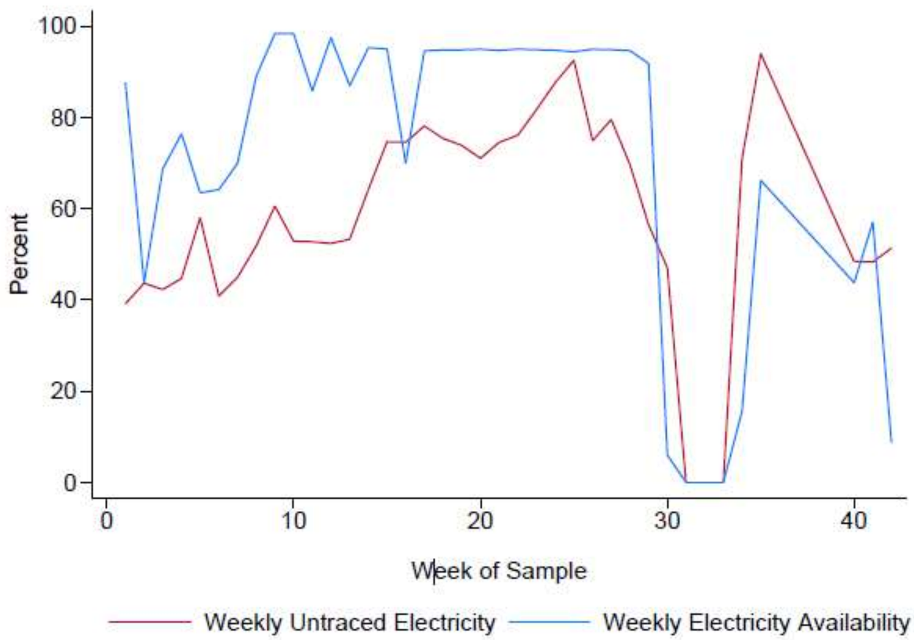
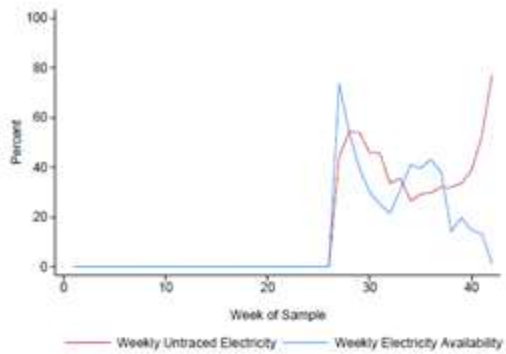
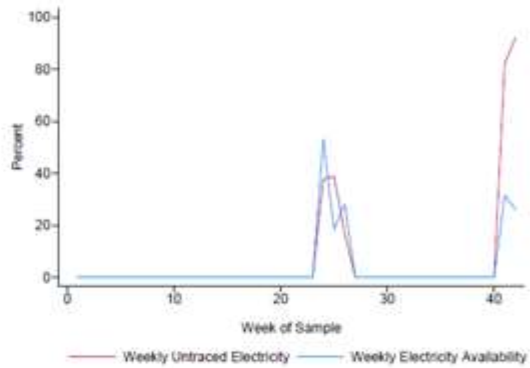


Figure 16 - Temporal patterns in reliability and theft

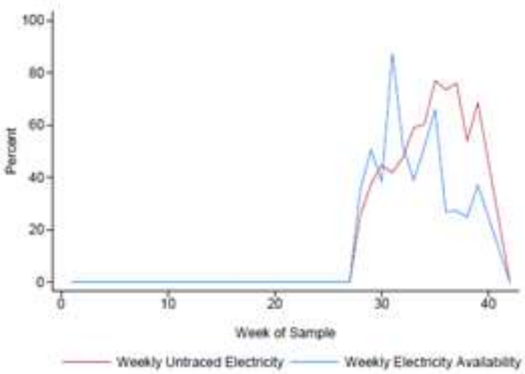
The red line describes the share of the electricity from the master meter that is not accounted for across the household meters. This is equivalent to the difference between the red and blue lines in Figure 14 divided by the blue line. For Khirkhiri, the theft levels exceeded 80 percent even during the weeks when the system was operating smoothly, contrary to the theory.



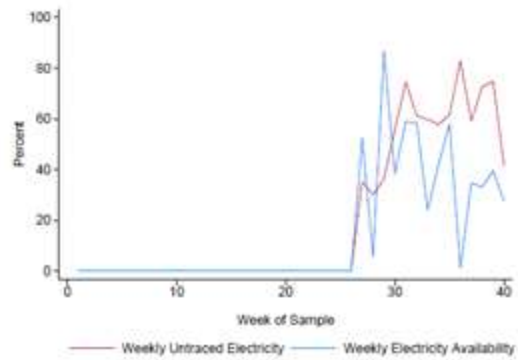
(a) Damodarpura



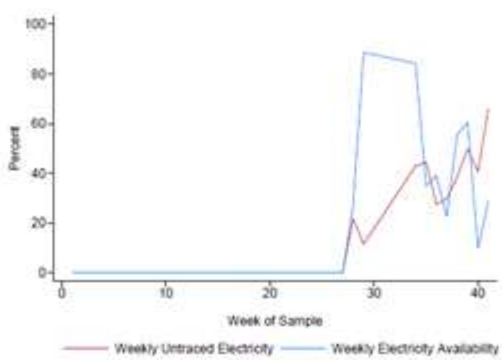
(b) Gajron



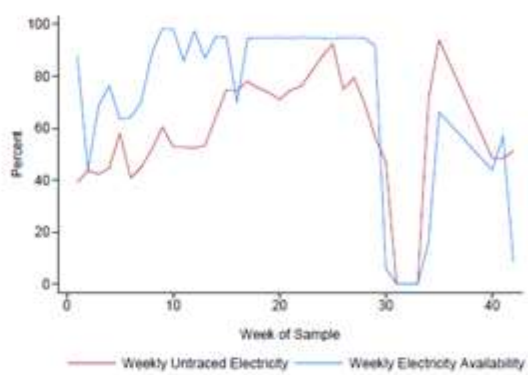
(c) Jeswa



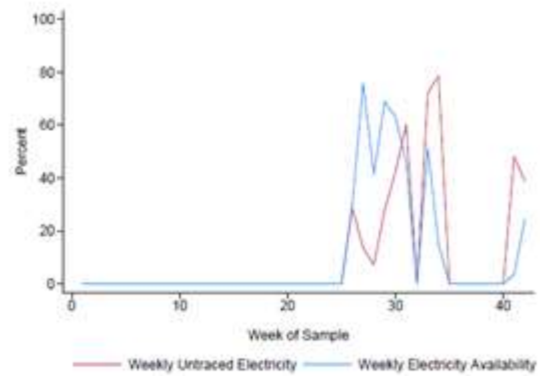
(d) Keshopura



(e) Khandpuriya



(f) Khirkhiri



(g) Kolipura

Figure 17 - Temportal patterns of reliability and theft in a) Damodarpura; b) Gajron; c) Jeswa; d) Keshopura; e) Khanpuriya; f) Khirkhiri; g) Kolipura

Also, there was a herd effect observed with power theft activities. Usually theft would start with a few households figuring an ingenious and minimally invasive way to steal power. For instance, in one of the sites, we observed that households used safety pins to pierce into the wires going into their meters. The pins would touch the phase and neutral wires inside the cable and become metallic contacts for the consumer. They would then use these contacts to power up any and every other appliance in their homes. Once this strategy was seen by others in the village, they quickly resorted to doing the same as they wouldn't want to pay for something that their neighbors were getting for free.

In future work, we will investigate household-level patterns and the core reasons behind theft. We will able to support this study with extremely rich data since our smart meters now are installed on the national grid as well where too theft is a huge menace that needs to be tackled. We believe the reasons for theft could be multifold as follows:

1. Cost related - When people are using just lighting, the total energy consumption is not high enough for the per kWh tariff to hurt the consumer's pocket. However, as access to grid electricity comes in, energy needs rapidly increase, due to which the bill increases significantly as well. Since consumers are aware that nearby villages that are connected to the grid receive highly subsidized power, they start resorting to theft to keep their electricity bills under check.
2. Load limit related - The connection type of consumers is based on the load demand that they sign up for. Gram Power's smart meters either turn off when the load limit increases beyond the prescribed limit or they charge the consumer a higher tariff/penalty for crossing the limit. Theft can occur to avoid both these situations
3. Peer pressure - As outlined earlier, stealing because others in the community are stealing can also be a major reason for theft.

Understanding the core reasons behind theft can inform us and power Utilities in general what strategies to adopt to address the problem.

Another implementation lesson was the difficulty of relying on the local village entrepreneur to deter theft. Village entrepreneurs were instructed to report theft to Gram Power. However, in the aim to protect his place in the community, the selected entrepreneurs would sometimes themselves indulge in malpractice. The ones who reported theft initially, would get beaten up by the rest of the community and had no other option but to stay quiet. In practice, we observed social pressures on the entrepreneurs not to punish their neighbors for stealing.

Maintenance Issues

Another practical lesson was the difficulty in maintaining systems in remote villages. While the system has no moving parts and doesn't require any recurring maintenance but if the system is abused, it takes only a few components to bring the whole system down.

A basic activity involved in regular maintenance is the cleaning of solar panels. In a funny incident, we noticed that in one of the sites, monkeys usually gathered around the solar panels and enjoyed sliding on them. Due to this, they would excrete on the panels as well which would dramatically bring down generation levels unless they were cleaned. Since the entrepreneur did not feel incentivized enough with the commission levels, panel cleaning was a recurring maintenance challenge and would prevent the batteries from getting charged adequately, which would reduce operational hours for the system.

Another requirement is the replenishment of distilled water in the batteries installed on ground. Due to untimely replenishment, the batteries would dry out and start degenerating. This would affect their charge retention capacity and eventually the operational hours of the system. This too was a responsibility of the local entrepreneur, which was not regularly carried out due to the same reasons as stated above.

One frequent reason why systems failed and required regular maintenance was overloading. Once the meters got bypassed, people started powering a whole range of appliances which the system was unable to handle. When the central circuit boards would trip to protect the batteries and inverters, people even started bypassing them. This eventually would cause the electronics inside the inverters to get damaged and even degenerated the batteries sooner than expected. Since these sites were extremely remote and the faults were being generated due to misuse of the system, the inverter suppliers would not provide recurring and timely service to address the problems. In such cases, the vicious cycle would also get initiated since lack of supply would annoy the villagers and eventually lead to non-payment.

In general the fundamental learning for us was that there are significant operational costs involved in running a microgrid and all the operational activities need to be closely monitored and executed in a timely manner for the system to function. Moreover, misuse of the system needs to be prevented at all cost either through periodic awareness programs and/or taking strict action against people carrying out such activities. However, this level of operations is difficult to sustain for remote and low population villages where our microgrids were installed. Also, power theft and fluctuations in revenue further worsens the problem to a level where the operational activities become unaffordable to sustain with operational revenues.

Political Issues

In addition to the challenges experienced during site selection, a lot of political challenges came up during and post installation as well. Our teams faced a lot of village level politics and interference from local leaders, and surrounding departments such as the forest department, which would keep stalling the progress of the project. For instance, despite an approval from the Village Panchayat Head, in one site the forest department official stalled the project work saying that the land on which the system was being installed was not registered so the forest department could uproot the system in the future if they wanted.

The capital subsidy policy from the Government too was unstable during the course of the project. Initially, when the project started, the subsidy level was $3/W, which within a few months was reduced to $2/W by the Ministry of New and Renewable Energy. Further, due to rapid devaluation of the Indian currency during the national elections, the value of the subsidy fell down to almost $1.5/W, which completely changed the economics for microgrids. On the other hand though, the State also had a policy under which they funded microgrids 100% through tendered contracts both for to cover their capital costs as well as the operational costs for 5 years. With this constantly changing policy environment and no clarity on which areas are earmarked for microgrids, it became almost impossible to invest in remote microgrids with private capital.

Community Asset Transfer

It was due to these challenges, that Gram Power finally decided, post approval from USAID to transfer the assets directly to the community and train them to operate and maintain the system. To promote better uptake, earn trust and ensure operational viability of the plant, we adopted a participatory community approach under which the ownership of the microgrids was given to the community. In each hamlet where the plant is set up, Gram Power formed a village energy committee and identified a village leader who was trained to administer recharges and carry out inspection of the balance of equipment to carry out preventive maintenance. We now provide maintenance support to the village community on a pay as you need basis for any faults that occur on the system. Hence operational sustainability is the critical success factor, which Gram Power believes can be achieved with the use of its technology and successfully buying in commitment from the community for the long run. It remains to be seen now how the community runs and manages the system over time and whether the revenues continue to be collected to take care of issues whenever they arise.

Figure 18 - Community Asset Transfer at the microgrid sites

Smart Metering

In 2015, Gram Power got an opportunity to get its smart metering technology on the national grid. We started working with Essel Utilities in Muzaffarpur where they had a license to privately distribute power in the district. The baseline situation of the Utility was extremely dismal as outlined below:

- Billing efficiency was as low as 25.57%, i.e. only 25.57% of the total input energy into Muzaffarpur was being billed. The primary reasons for this were theft, inaccurate billing, and poor infrastructure quality leading to a poor state of supply
- The average downtime hours as stated by the people was as high as 12 hours in rural parts of Muzaffarpur
- Supply voltage levels would go down to as low as 60V from the standard of 240V. This would damage appliances, let alone create any access to energy
- The Utility wasn't aware how many consumers were actually using the system as their customer information system was highly inaccurate and consumer indexing wasn't carried out. For instance, there were over 40,000 'ghost consumers' in their system. These were consumers who existed in their system but the Utility had no clue where these consumers actually were.

Gram Power was given transformers with a total of 1000 households to carry out a pilot project on how losses can be radically reduced. The initial set of transformers where we carried out the installation yielded extremely positive results:

Figure 19 - Images from the installation of Smart meters for grid-connected households

As can be seen from Figure 20, the commercial losses were reduced to as low as 8% from the 65% baseline losses found initially, a **<u>94% reduction</u>**

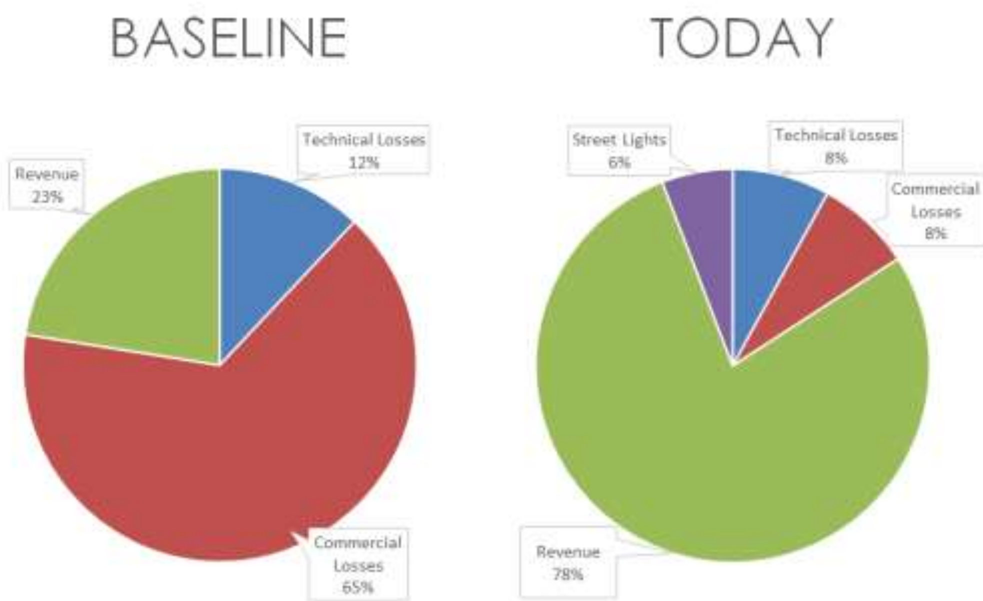


Figure 20 – Radical loss reduction in Kurhani New Tola

In addition, we were able to give the following analyses to Essel using the high resolution Smart Metering data:

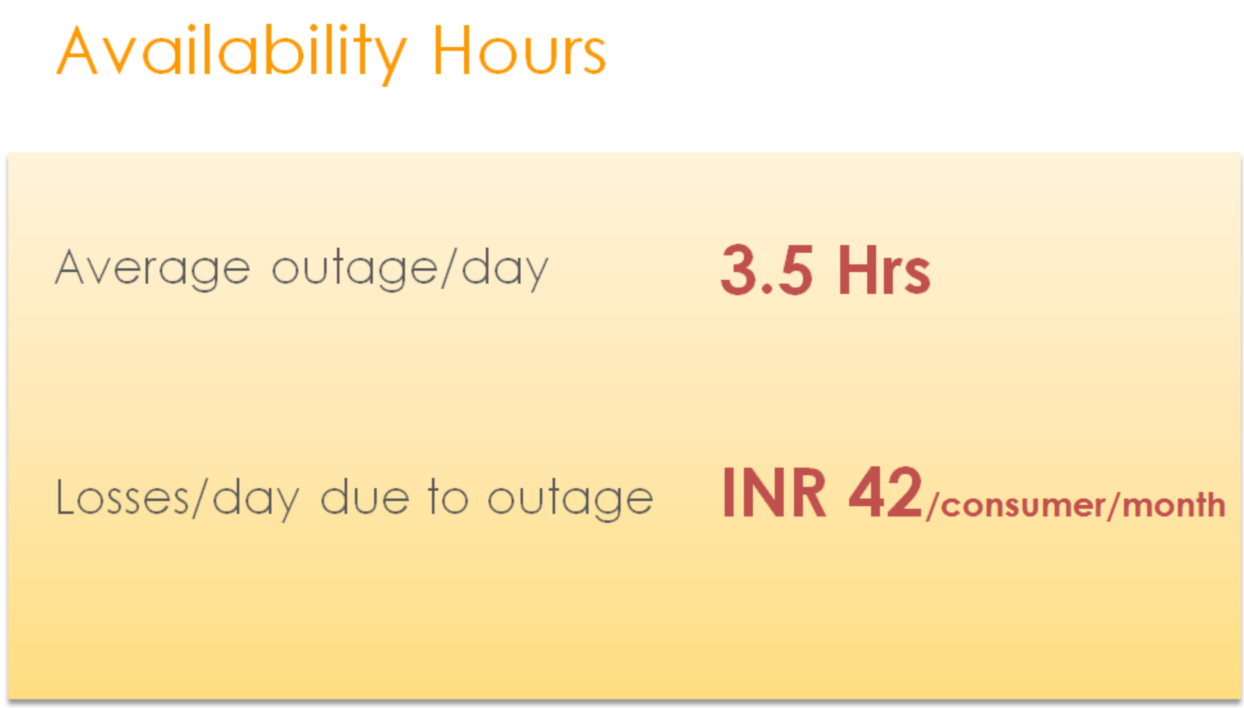


Figure 21 - Analysis provided to Essel from the Smart Metering data

The downtime hours was reduced to 3.5 hours and even that was costing them INR 42/consumer/month. Since our analyses converts every technical or commercial issue into a monetary value, it helps the Utility understand what investments they need to make where and with what priority.

Voltage Fluctuations

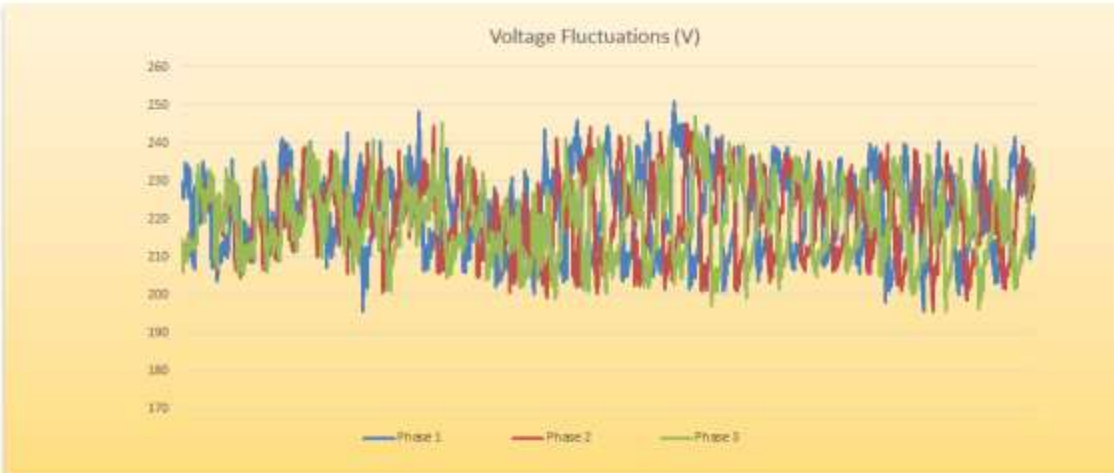


Figure 22 - Voltage fluctuations

Peak Load and Phase Imbalance

Figure 23 - Peak load and phase imbalance

As can be seen in Figure 22 & 23, the supply voltage values increased tremendously as we were able to ensure that the transformers for all our pilot areas were not overloaded. The analyses that our system was able to provide to Essel would not just outline the problem, but even the solution. For instance one of the transformers was imbalanced, i.e., the load on all three phases was not equal, which makes transformers more vulnerable to damage and reduces their lifetime. Our system not only identified the problem, but even pointed out that by switching which consumers from one phase to another, would the problem be resolved.

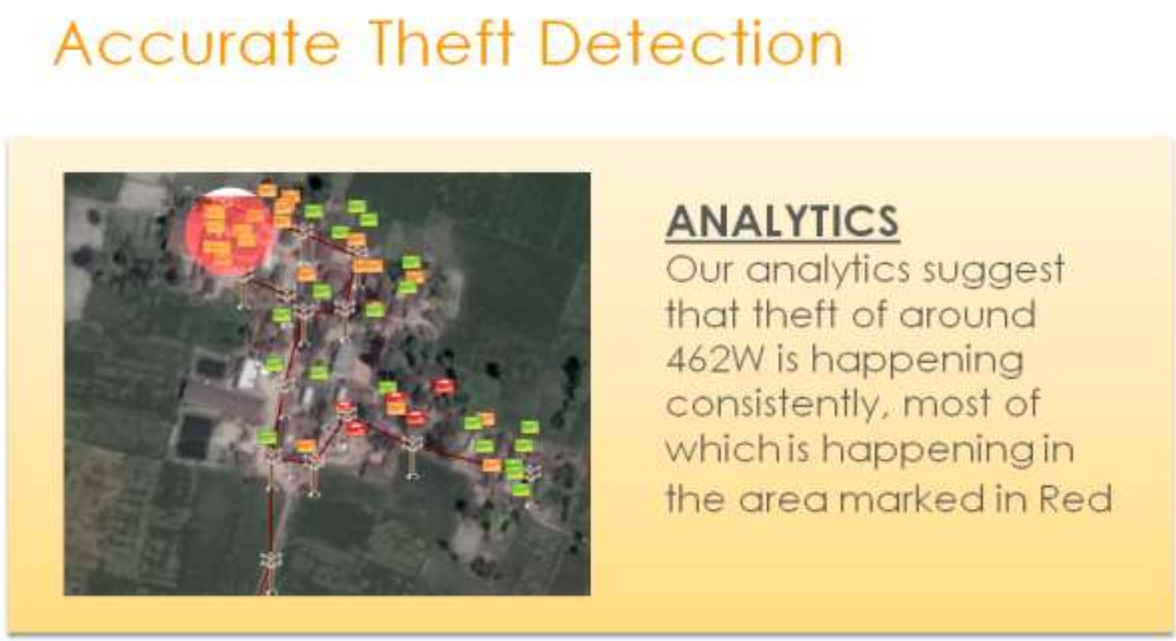


Figure 24 - Theft detection through our smart analytics

Finally, the most important and useful piece of information for Essel was accurate theft detection. With smart meters installed for every consumer on the transformer, we were able to locate the exact quantity and location of theft, which enables the Utility to focus their vigilance efforts, curb illegal activity on the grid, and ensure high distribution efficiency.

Benefits for Consumers

The points above only outline how our system benefitted the Utility. While the foremost precondition to energy access is that the distribution of power should be economically viable, it is also important that the consumer sees direct benefits of introduction of a new technology for easy and widespread adoption. Gram Power's technology benefits consumers in various ways as outlined below:

1. **Transparency** - As opposed to the conventional system, Gram Power's meters and mobile application inform the consumers in real time what their consumption levels are and what their bill is likely to be. Our analytics for consumers even helps them stick to their budgets and alerts them when their budgets are likely to be crossed. We're also working on a technology that will allow consumers to get information about their consumption, appliance-wise
2. **Affordable and easy payments** - When the smart meters are used in prepaid, consumers can recharge their meters from nearby shops for any amount that they would like. This helps them control their expenses and purchase power in increments that they can afford.
3. **Fault reporting and redressal** - Unlike the conventional system in which a consumer probably needs to personally know the lineman or someone from the Utility to get his/her complaint addressed, with Gram Power they can report any fault or complaint directly from their phones which gets recorded on our online fault portal with the fault's exact GPS location. This makes the Utility aware of all problems in real time and they are even able to monitor the efficiency of their field personnel
4. **Reliable power supply** - At the end of the day, what the consumer needs primarily is reliable supply. With smart meters, when the complete monitoring becomes autonomous and corrective

action is possible to take remotely, a lot of the problems such as overloading, fluctuations, power factor or frequency problems, and downtimes can be detected and avoided.

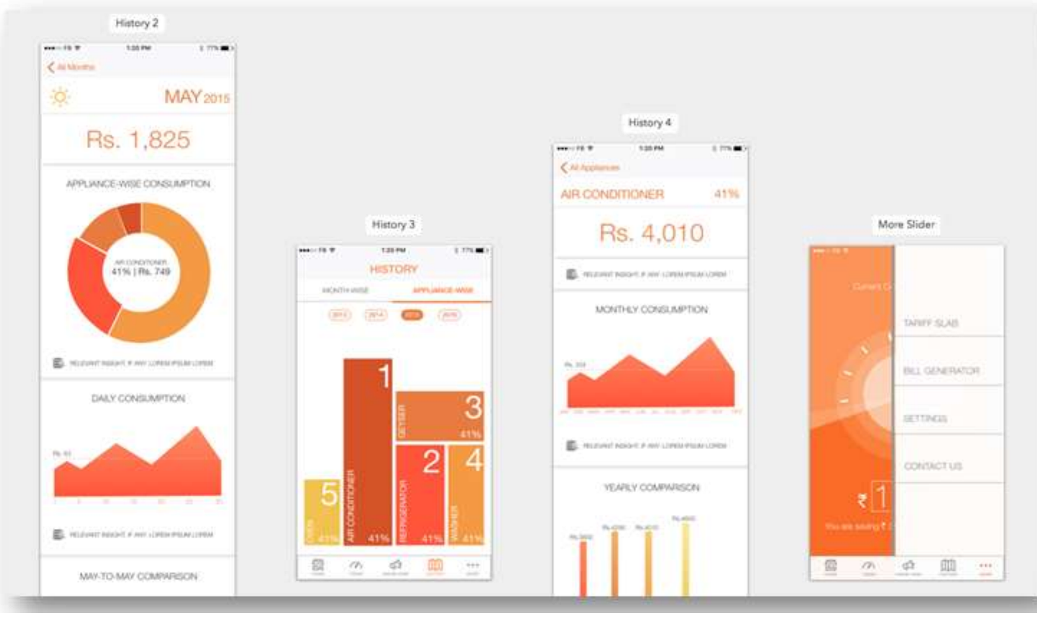
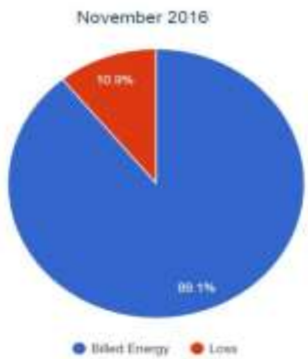


Figure 25 - Snippet of Gram Power's consumer mobile application

Further Projects

It was from the success of the project at Essel, that we identified that our technology's impact will be maximal on the national grid where $16B of revenue losses happen due to mismanagement of the infrastructure and these losses create strong disincentives for the Utility to supply adequate and quality power to rural areas. Due to this experience with Essel, Gram Power received larger scale projects from 3 other Utilities in India as outlined below:

1. **India Power Corporation Limited (IPCL)** - Just like Essel, IPCL is a private grid operator that is licensed to sell power in the city of Gaya in Bihar. They too have a very similar baseline situation with loss levels upwards of 60% across the district. Gram Power is doing a 1400 meter pilot project with them across 14 transformers in Gaya town. The results from the initial meter installation by the Utility have been very positive as can be seen from the graphs below:



November 2016	
Input Energy	5088.50 kWh
Billed Energy	4532.74 kWh
Losses	10% (555.76 kWh)

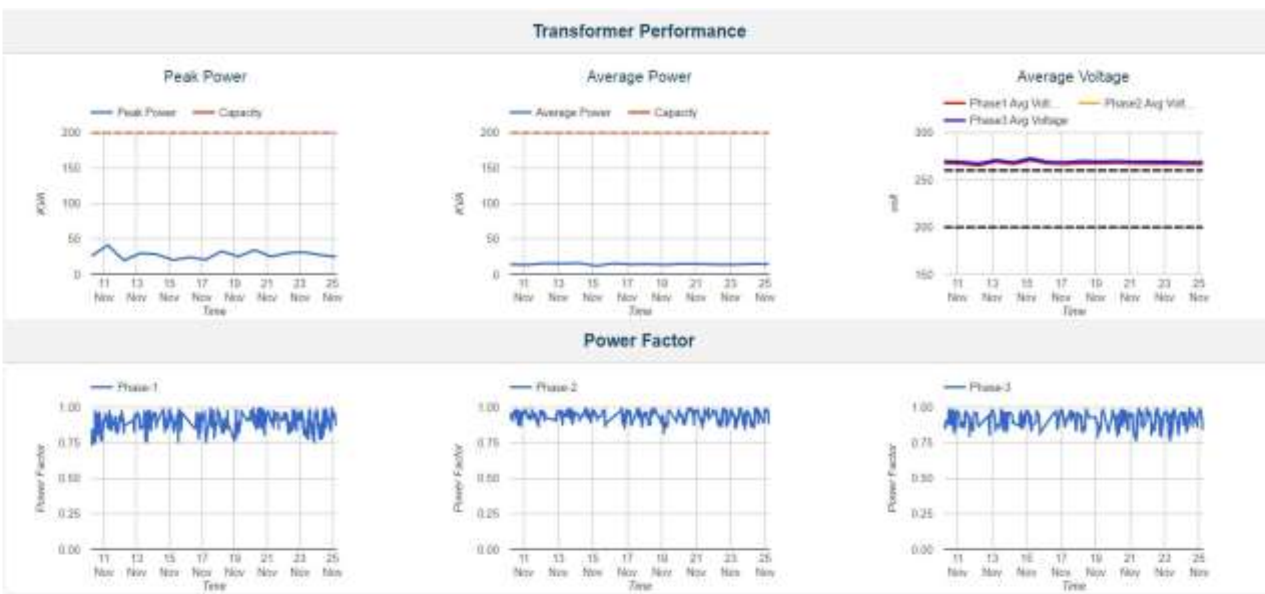


Figure 26 - Reports generated for IPCL

Due to the strong positive results with IPCL, Gram Power is currently in talks to expand the technology to 40,000 consumers within the next 12 months. This project would involve a complete digitization of the city and launch of all our technology platforms for all rural and urban citizens of Gaya.

2. **SPML** - SPML is the private Utility distributing power in the city of Bhagalpur in Bihar. With them too, Gram Power is carrying out a smart metering pilot of 3000 consumers across 30 transformers. In addition to this, we are also digitally mapping the complete city to help them understand where all their consumers are, where the infrastructure needs improvements, and where smart meters will have the maximal impact for them. A total team of 20 people are employed for this project who are able to map out and digitize over 500 consumers/day. Gram Power is currently in advanced discussions with SPML to scale up the project to 50,000 consumers in Bhagalpur with an innovative savings sharing business model.

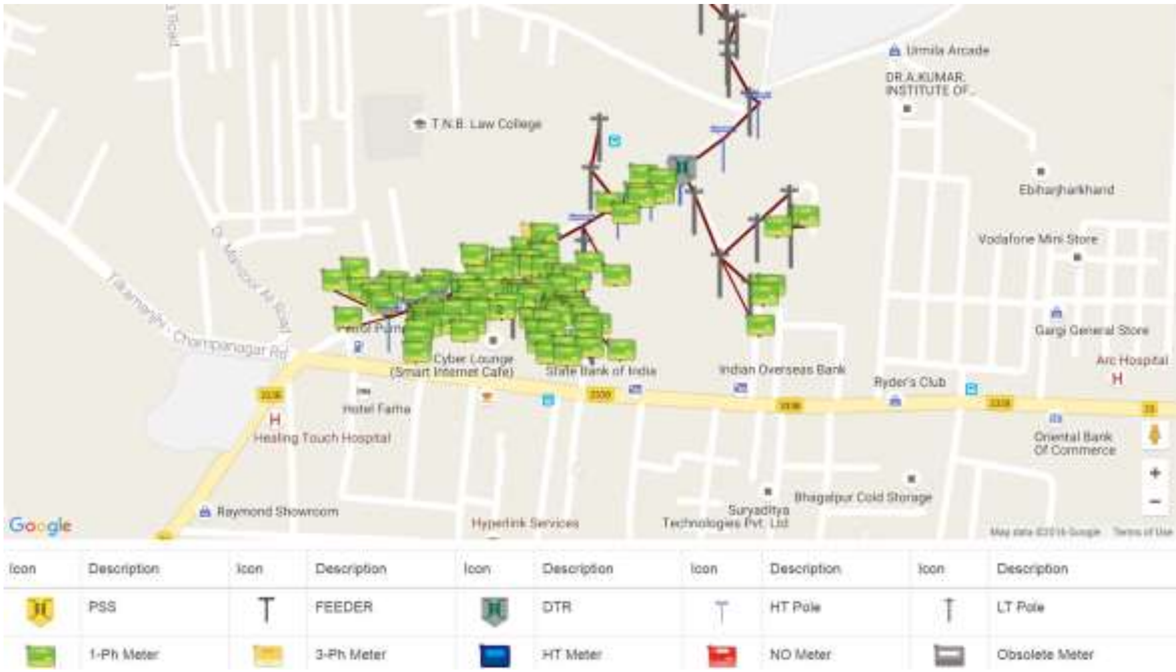


Figure 27 - Asset mapping for SPML in Bhagalpur

3. **Andhra Pradesh Eastern Power Distribution Company Limited (APEPDCL)** - One of the critical breakthroughs for Gram Power was getting a project from APEPDCL for the city of Vishakhapatnam for 2000 smart meters. This Utility is responsible for distributing power to nearly 1M households in Andhra Pradesh and is a State DISCOM. With the project being done with APEPDCL, Gram Power is in the league of all major meter suppliers and has a competitive edge above them by having the experience of executing a smart grid project in one of the selected Smart Cities in India.

Challenges with Smart Meter Installation

While Gram Power's smart metering solution holds tremendous potential to scale across India and the technology and business models are designed to be extremely scalable, the solution does come with it's fair bit of challenges, which curb the pace of achieving scale. Some of these that we experienced in our initial set of installations are outlined below:

Dilapidated Supporting Infrastructure

While smart meters can identify problems and to some extent prevent them, they need an operating fundamental infrastructure to function effectively. For instance, without adequately sized transformers the power supply quality to the area cannot be improved. If a transformer is overloaded, it needs to be adequately augmented to supply power at the desired load levels. If this is not done, the voltage levels in the area can drop to a level where even the smart meters would stop functioning, let alone any appliances.

With smart meters, a fundamental change that happens in the area is that it starts becoming very difficult for consumers to continue to not pay. As a result, if historically non-paying consumers are to change their behavior the first step that's needed is to improve the service quality and resolve issues of transparency and the whole experience of dealing with a Utility. While the smart meters takes care of the latter, the former must be taken care of by the Utility.

We faced a lot of challenges of delayed installation and revolts from the community to install smart meters because they demanded an upgrade of the supporting infrastructure as a prerequisite to changing their meters. While in the long run, this challenge will lead to an overall positive impact, it does increase the upfront capital outlay that the Utility needs to put in to do a holistic upgrade of the infrastructure.

Figure 28 - Low hanging AB cables (left); Disoriented distribution transformer in Bihar (right)

Lack of awareness for both Utility and Consumers

Due to the strong mistrust between consumers and the Utility, whenever a meter change happens, the immediate apprehension of the consumer is that the Utility is installing a meter that will run faster than normal and increase their bill. This hence, leads to community wide protests against installation of the meters. In some cases, a regionalized community is apprehensive to the installation of smart meters and demands that the installation take place in other areas before their own.

पच्छट्टी मुहल्ले में स्मार्ट मीटर लगाने का विरोध

■ इंडिया पावर की ओर से सभी घरों में स्मार्ट मीटर लगाने का काम किया जा रहा था शुरू

प्रतिनिधि ▸ बोधगया

बोधगया के पच्छट्टी मुहल्ले में बिजली सप्लाई का काम करने वाली कंपनी इंडिया पावर द्वारा स्मार्ट मीटर लगाये जाने का स्थानीय लोगों ने विरोध किया. स्थानीय लोगों ने सोमवार को गया-बोधगया रिवर साइड रोड में पच्छट्टी मोड़ के पास सड़क हंगामा भी मचाया. लोगों का कहना था कि कुछ महीने पहले ही पच्छट्टी मुहल्ले के सभी घरों में मीटर लगाये गये हैं, अब फिर से स्मार्ट मीटर (इलेक्ट्रॉनिक मीटर) लगाये जाने का क्या औचित्य है. लोगों ने यह भी कहा कि स्मार्ट मीटर लगाये जाने से उन्हें परहेज नहीं है, पर इसकी शुरुआत पच्छट्टी मुहल्ले से ही क्यों की जा रही है? इस सिलसिले में सोमवार को इंडिया पावर के डीजीएम राकेश रंजन व कंपनी के अन्य पदाधिकारियों ने मुहल्ले के लोगों को समझाने का प्रयास किया कि आगामी कालचक्र पूजा व बौद्ध महोत्सव को देखते हुए बोधगया के कई क्षेत्रों में स्मार्ट मीटर लगाया जाना है और साथ ही तार लगाने का काम भी किया जाना है. वहीं, लोगों ने मांग की कि स्मार्ट मीटर लगाने का काम पहले राजापुर गांव से शुरू किया जाये, इसके बाद पच्छट्टी मुहल्ले व गांव में स्मार्ट मीटर लगाने दिया जायेगा. राकेश रंजन ने बताया कि कालचक्र पूजा के मद्देनजर स्मार्ट मीटर लगाने का काम किया जा रहा है. उन्होंने बताया कि महाबोधि मंदिर व कालचक्र मैदान के आसपास के नौ क्षेत्रों में स्मार्ट मीटर लगाया जाना है, जिसकी संख्या 1500 है. उन्होंने बताया कि तार का काम करने के बाद स्मार्ट मीटर लगाने का काम शुरू किया जायेगा.

गया-बोधगया रिवर साइड रोड पर पच्छट्टी मोड़ के पास हंगामा करते लोग.

Figure 29 - Challenges faced with meter installation; Newspaper article reporting riots in Bihar due to smart meter installation; Gram Power's smart meter discarded to a sewage by a consumer (right)

We suspect however, that this is mainly a reaction of the society from the fear of coming under the radar for theft. Moreover, for the Utility staff who are extremely deprived of modern technologies in their everyday running of the business, switching to smart meters is a whole new way of doing things. Hence for a successful installation it is extremely important to adequately educate the Utility and carry out extensive awareness and marketing campaigns for consumers to prevent any problems associated with false myths about the technology.

100% metering

For smart meters to be effective and for the analyses to be accurate and useful, it is important that for any transformer 100% of the meters are replaced with smart meters. With Essel Utilities, the officials installed smart meters very sparsely for several of the transformers leading to them being ineffective for all those transformers. Replacement of 100% of the meters for any transformer turns out to be an operational challenge for the Utility as they need to do something with the meters that are being replaced and it also increases their adoption cost.

Invalid GIS data

Accurate GPS based mapping of the complete power infrastructure is a basic requirement for smart metering as the complete analytics on the data and the location of problems rests on these digital maps. This was the main reason that prior to installing any micrograds, Gram Power would first map out the entire infrastructure and visualize it on an online map. When we came to the national, we thought that such baseline work would have already been carried out by Utilities, but that was certainly not the situation.

In July 2008, the Ministry of Power, Government of India, launched a 2 part re-structured accelerated power development and reforms programme (R-APDRP http://www.apdrp.gov.in/Forms/Know_More.aspx) with a focus on establishment of baseline data. No granular information was collected in projects executed under this part of the programme. In fact, the GIS data collected under R-APDRP was more often than not, incorrect. At the time of our initial interactions with the DISCOMs, we were informed that the baseline data already existed, the ground reality was only found after the launch of the project. This led to a further delay in the timeline to execute. Gram power however, took this challenge as an opportunity to create its own proprietary app to collect of relevant data of the wires, poles, distribution transformers (DTs), consumers and create a comprehensive asset mapping support for utilities. Currently, Gram power has undertaken the biggest asset mapping project in the district of Bhagalpur, Bihar where the mapping of over 100,000 consumers is being undertaken. The data is being collected at the rate of over 500 consumers per day and overlaid aesthetically on a map online for virtual visualization.

Future Improvements and Plans to Scale

As outlined in the sections above, Gram Power has learned a great deal from this project and these learnings about the consumer, market, policy, and business challenges were possible only because we had a grant available from USAID. This project has helped us identify what we do best - provide cutting edge and cost effective technology for making power distribution affordable, efficient and intelligent - and has hence helped us identify our path to scale. In this section we outline how and what improvements we are making to scale in both microgrids and smart meter installations across India and the rest of the world.

Microgrids

Based on our learnings, we are looking to make the following improvements in our microgrid work in future:

Market Focus

Strategically, we have decided to work on tendered microgrid contracts under the Decentralized and Distributed Generation (DDG) scheme of the Ministry of Power, Government of India for setup of microgrids in remote rural areas that are focussed on meeting the domestic energy needs. We have now done enough projects to qualify for these tenders and since the source of revenue for these projects is guaranteed by the Government, the projects are economically viable to execute.

We are also looking to invest in microgrid projects in which 70% or more of the total load is being off taken by a commercial entity that is willing to sign a power purchase agreement with us. Such projects are bankable even without subsidies and provide 30% of the generation capacity as a buffer to improve energy access for domestic applications.

Finally, since our meters are getting the necessary economies of scale by supplying to the national grid, we are also launching the meters for microgrid operators across the world so that they can get a full feature solution at the same price points that we are able to offer to Utilities.

Operations

Since installation and ongoing operations and maintenance (O&M) are critical success factors for microgrids, we have started partnering with companies in every state in India wherever we are bidding for projects launched by the Government. We will be outsourcing several construction activities to these partners since we now have enough experience on what quality parameters need to be adhered to and how the systems must be designed. Moreover, since these partners will be local, it will be easier and more cost effective for them to offer ongoing maintenance services for the microgrids. Since the ongoing O&M of the plants is also funded in these tendered contracts, there will be no dependency on recurring revenues from the villagers to maintain the systems.

Training

We learned that detailed training and awareness creation of the locals is very important to ensure proper operations of the system and to reduce downtimes. Gram Power's training modules kept evolving during the course of the project as our business model for the microgrids kept changing. Due to this, the training of villagers might not have been as optimal as it should be. Since we are now clear on the business model moving ahead, the training can be standardized. Gram Power will also setup local O&M centers for clusters of villages, in addition to training a local technician within the village itself to ensure on time troubleshooting of systems.

Technology

By moving on the national grid, our technology has significantly evolved both for metering as well as our online portal for distribution management. We have built tools to digitize and monitor our installation activities, visualize the entire grid in real time, and monitor all performance parameters to ensure low downtime. In future, all this development for the smart meters on the national grid, will also be used for our microgrid projects, thereby making the installations far more efficient and of higher quality standards.

Smart Meters

Gram Power has very ambitious plans to scale its Smart Metering solution across India and very soon to other countries as well. Our future plans and improvements are outlined below:

Market Focus and Business Model

We are focussed on the Utility market for smart meters since that is where the scale is. There are 110 Utilities in India managing close over 200 Million meters, which is expected to increase to 300 Million within the next decade as every household in India gets electrified. Gram Power is initially targeting the Utilities that are experiencing end to end losses of 30% and above, which forms a bulk of the Indian Power Sector. To all these Utilities, we are offering a *'Metering as a Service (MaaS)'* business model in which Gram Power too invests in the upfront capital required to switch to Smart Metering. We then generate a positive return on this investment by charging for the recurring services being provided with the Smart Meter and a portion of the savings generated because of the technology's introduction. Gram Power is already in final discussions with two private Utilities (BEDCPL and IPCL) to execute this business model for a total of nearly 100,000 connections. We are also working with the Central Electricity Authority (CEA) (Govt. of India), which is the premier power sector think tank in India, to design guidelines for all DISCOMs on how a service based model should be executed for Smart Metering in India.

Technology

On the technology front, our immediate focus is to get our meters certified as per the new Indian Standard, IS16444, which has recently been launched for smart meters. There is no company in India at the moment which has this certification for their solution, and we believe that Gram Power can be the first company to get this certificate since our solution is compliant with it.

Besides this, we are building a whole set of new tools for consumers and the Utility to make the infrastructure management better. Some of them are as follows:

1. **Fault Reporting and Management** - With this development, consumers will be able to report faults with their exact GPS coordinates directly from their cell phones either through an SMS or through the Gram Power mobile application. Utilities would have an online portal to view and manage all faults in real time and take necessary action on it immediately, while also keeping the consumer aware of the problem's status. All of this will be managed digitally with minimal human intervention.
2. **Field Force Management** - With this tool, Utilities will be able to allocate and track the activities of their complete field force from our online portal. This will avoid any communication barriers and help the Utility evaluate the performance of all their work force.
3. **Consumer Mobile App** - The mobile app will be the single point of interaction between the Utility, the infrastructure and the consumers. Consumers will have complete transparency on

their billing and consumption on the app. They will also be able to make payments in any increment for prepaid or postpaid connections directly from the app. Finally, the app will allow them to rate the Utility, their services and any Utility worker to help constantly improve the service quality to them.

4. **Analytics** - Advanced analytics on asset performance, infrastructure expansion, preventive maintenance, and improving vigilance will all be a part of the online portal for Utilities to help organize and manage the complete infrastructure like never before

Operations

The scale of operations required to expand our work in Smart Metering is extremely huge. We have already started taking training and partnerships very seriously to make our operations very strong. Since we already have experience in almost every value chain needed to run a Utility, we are now building outsourcing partners for all the activities that are extremely human intensive. For example, GIS mapping of the infrastructure, installation of smart meters, regular O&M of the infrastructure, and even backend customer service. All these activities are closely monitored by Gram Power due to the technologies that we've built and we have our partners use for our work. For instance, our GIS mapping mobile application is supported with a back end digital QC portal on which the accuracy and correctness of the data is checked by our internal team. Moreover, the app monitors all the activities of each surveyor, such as the amount of time spent on each survey, the areas he/she travels to during the course of the day, etc. which our internal team then analyzes to ensure that the work being done and reported is as per our expectations and standards.

Cost-effectiveness

Gram Power is currently providing the most cost effective and advanced solution in the market both for microgrids as well as Smart Meters.

Competitive advantage over existing solutions

In India as per Ministry of New and Renewable Energy (MNRE) cost benchmarks the capital cost of a solar microgrid is stated as INR 300/W for systems over 10kWp and INR 350/W for systems under 10kWp. Gram Power is an accredited and empanelled member of MNRE as a Rural Energy Service Provider (RESP) and is able to provide our solution with Smart Metering for only INR 270/W for any capacity of the microgrid. The cost of the solution varies from case to case (both up or down) based on the project's technical and financial requirements.

As far as Smart Meters go, the Table 9 outlines the costs at which smart meter projects have been tendered in India in the last 12-18 months:

DISCOM	AWARDED TO	APPROVED COST (INR)	AWARDED COST (INR)	NO. OF CONSUMERS	COST PER NODE (INR/CONSUMER)
APDCL	Fluent Grid Ltd.	299400000	Data not available	15083	19850
UHBVN	Fuji Electric	207000000	Data not available	11000	18818
HPSEB	Alstom T&D	194500000	249900000	1251	199760
CESC	Enzen Global solutions	325900000	325600000	21824	14919
PSPCL	Kalkitech	101100000	81700000	2734	29883
TSSPDCL	ECIL, Hyderabad	418200000	376500000	11904	31628
PED	Dongfang electronics	461100000	439100000	34000	12915
				Average	57821

Table 8 - AMI tenders awarded in India as pwer www.indiasmartgrid.org

As per the table above, the average cost of the solution being offered in the market is $863/meter. Gram Power is offering this solution for $37/meter with monthly service charges of $1/meter and 15-30% of the incremental savings being generated by the DISCOM. **Hence against competition we are over 95% cheaper** and are able to offer a business model in which we inherently invested with the DISCOM to help make their infrastructure more efficient and reliable.

Scaling plan

Financial goals

Gram Power plans to install a minimum of 1M smart meters over the next 5 years and start generating revenues of over $100M annually within the next 10 years of operations. This revenue is going to come from the following sources:

1. Sale of microgrids through Government Tenders
2. Upfront capital revenue of smart meters ($37/meter)
3. Recurring service revenue from the smart meter (Up to $12/meter/year)

4. Recurring savings revenue from the DISCOM (Up to $25/meter/year)

The above figures are based on data collected from our existing DISCOM partners and the discussions being had with State and Private Utilities for partnering on large scale projects.

Equity/debt financing secured so far

Gram Power has till date received a total of $2.6M in equity funding and almost $1.1M in grants and awards. We are debt free at the moment but are looking to raise debt for all our large scale smart meter projects. The company is also looking to raise $10M in a Series B funding round which is targeted to be closed within the next 12 months.

Progress towards scaling

The company is currently negotiating India's largest smart metering project with BEDCPL for the city of Bhagalpur which if finalized will be completed by December 2017 and make Gram Power the largest smart meter player in India. The successful execution of this project will help us cross the inflexion point and bring exponential scale to our operations since we will be able to create significant barriers to entry through experience, technology and business model for the rest of the competition.

In addition to the above, we are also negotiating a project for 550,000 meters for the city of Kanpur in Uttar Pradesh with the Indian Government. This project will be executed over a 3 year period and involve the digitization of the complete power infrastructure in the city of Kanpur.

Gram Power has all the technology tools needed and an unmatchable price point to scale in this industry. This is just the beginning of the smart meter industry in India, which places us at a level playing field with the big guns of the industry since they too haven't done large scale smart meter installations in India and are not competitive on the pricing or solution offering. We are currently trying to secure debt financing and loan guarantees for our large scale projects to help us execute on all the available opportunities.

Differ from the scaling plan proposed at the beginning of implementation

The scaling plan proposed at the beginning of implementation was largely centered around microgrids and making private investments in microgrids in future. However, the policy environment and challenges outlined above made us decide the scaling in microgrids through the existing Government policy and tenders is a viable option and investing in smart meters for upgrading India's power infrastructure will provide a greater bang for the buck since the long term goal of the Indian Government is to bring the grid to every citizen of India. We continue to scale in microgrids in size and capacity as was initially planned, but have identified a greater scaling potential in smart meters both in India and the rest of the world.

USAID support needed in scaling this endeavor

Although there is tremendous potential to scale, securing financing is challenging since our business model hasn't been tried before and the financial health of most Utilities in India is quite poor. Despite this, we are very confident of our technology and business model and the returns it can generate through savings and recurring data revenue. In order to scale with this technology and business model, Gram Power is seeking a first loss guarantee (FLG) of about $2.5M on the debt that we would raise for our initial projects with BEDCPL and IPCL in Bhagalpur and Gaya respectively for a total of 100,000 connections. Demonstrating success of the project by paying back the debt on time without exercising the FLG, will open up doors for large scale and low cost financing for the balance 250M meters in India as well. And the FLG can then be used for larger scale or riskier investments in this sector.

Intended roadmap for the next 1 year

Our intended goal for the next 12 months is to successfully execute a single city wide project of at least 50,000 smart meters with our MaaS business model. For this, we already have the product, team and supply chain ready. We even have the clients with whom the project can be done. The final signature on the deal and securing financing are the only barriers for us to execute the project and closing that would be our goal for the next 3-4 months.

Feedback for USAID

Interactions with DIV that impacted the program

All in all, we strongly feel that USAID has been an very instrumental partner in helping us figure out our path to scale. The support, encouragement and most importantly, the flexibility that the program offered us over the last 3 years has been tremendous. For instance, if it was not for DIV's flexibility in helping us alter the project's goals, we would have never been able to switch from focusing on installing more microgrids to doing more smart meters. And installing more microgrids of similar capacity and for a similar target audience would not have resulted in any new learnings for USAID, UC-Berkeley (our knowledge partners) and us.

During one of our critical discussions with DIV, when we were revising the project's objectives we had a conversation with William Day, Scott Wu, and Jonathan Kirschner. Since there was a strong research component attached to the project with UC-Berkeley and J-PAL leading that effort, a change in the project's goals strongly influenced their research as well. There was a major dilemma in how we should go about the change and we were advised by all these three mentors from USAID to follow the path that would help Gram Power identify how to scale, because that was core objective from USAID's perspective for this project. Having that support from USAID, made it very clear to us on how to set the trajectory for the project and work with all the stakeholders. We even got support from William Day in having the discussion with our knowledge partners and successfully modifying the project, which at the end of it all, proved to be the most significant pivot point for the project and Gram Power.

Besides the above interaction, we got recurring mentoring from all the three people mentioned above during the past 3 years on business model discussions, dealing with investors and thinking through our challenges, which was extremely valuable for Gram Power.

How can DIV improve?

There are just a few core areas of improvement that we would like to suggest based on our experience thus far with DIV:

- **Manpower support** - To build a world class organization takes world class people and both access and affordability for these people is very difficult in the competitive work environment today. USAID however is connected to a very large international community that is extremely passionate about addressing world problems sustainably. It would be of immense value for DIV's portfolio companies to get connected to this community through a dedicated job portal. Moreover, it would also help if a certain % of the budget can be allocated towards recruitment of senior staff for the company.

- **Inherent flexibility in the grant** - As opposed to having very strictly set milestones and then going through a long process for any modification to the milestones, it would be useful if the project could have some overarching goals and then modifications could be made faster with direct interaction with the awardees AOR.
- **First loss guarantee** - It would be very useful for the grants to be structured as first loss guarantees against debt financing as that would remove the taboo that is associated with grant funded projects not being self sustaining or economically viable. Moreover, if successful, the guarantee will end us being used for larger projects and the project will have easy access to capital since the servicing of the debt would have been proven already.
- **Timeline** - Currently the project is limited to a period of 3 years. It would help if this timeline can be made flexible on a case to case basis depending on the project's requirements. Also, the timeline for the application going through all the processes is roughly 7-9 months long. In industry opportunities change very fast and 9 months to secure funding for any project risks losing the project or things changing significantly. It would help if the application process can work in a manner where a commitment to invest can come in within 2 months with pre-conditions and due diligence requirements and the money can come in after all the requirements are met. This will allow the applicant to work on project execution and deal closure on a faster timeline.

Environment Mitigation and Monitoring Plan

How Gram Power safeguards against the improper disposal of batteries?

Battery manufacturers in India set up individually or joint collection points for used and deteriorated/dried out batteries with the goal to prevent hazardous materials from entering landfills and to utilize the retrieved materials in the fabrication of new products. Gram Power ensures that the batteries are returned to an authorized recycler registered with the Ministry and assigned by the Manufacturer. These recyclers are responsible for collecting and recycling used batteries on behalf of Gram Power's battery manufacturer.

The Batteries (Management & Handling) Rules, 2001 was notified in May, 2001 to regulate the collection, characterization and recycling as well as import of used lead acid batteries in India. These rules inter-alia make it mandatory for consumers to return used batteries. All manufacture/assemblers/ reconditioners/importers of lead acid batteries are responsible for collecting used batteries against new ones sold as per a schedule defined in the rules. Such used lead acid batteries can be auctioned /sold only to recyclers registered with the Ministry on the basis of their possessing environmentally sound facilities for recycling/recovery. (http://envfor.nic.in/division/introduction-12)

How Gram Power safeguards against the improper disposal of Gram Power units?

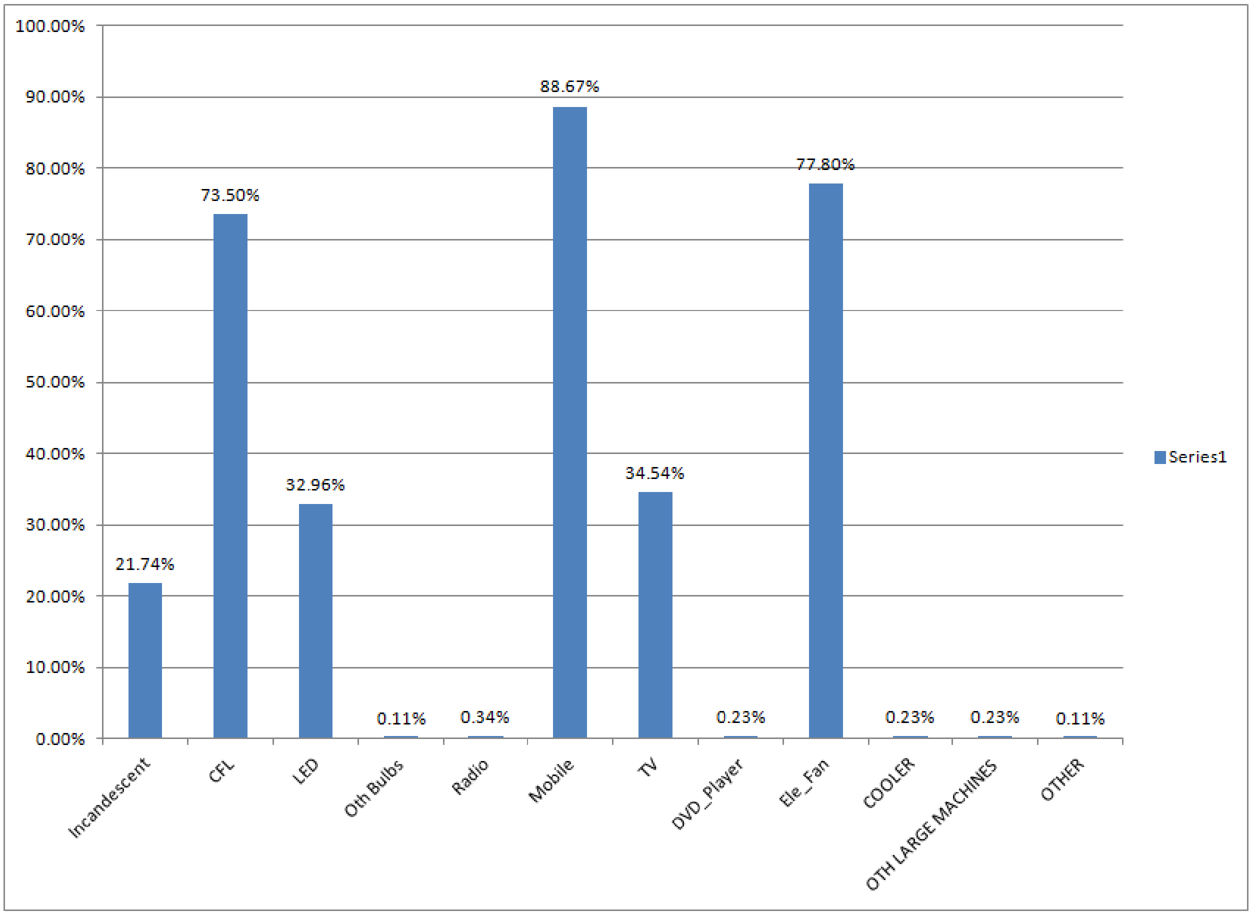
Gram Power ensures that the equipment at site is always under proper surveillance. The equipment is located in an enclosure which is designed in accordance with appropriate standards (See Annexure) and designs approved by a Senior Engineers for stability. The enclosure is further properly guarded by trusted locals and kept locked at all times to be kept safe from animals and other natural hazards. Gram Power is immediately notified of the meters and their respective co-ordinates that have stopped responding. Upon receiving this notification, a vigilance activity is further conducted to detect faults or if the meter has been illegal disposed off as in the figure x shown above and faulty meters thus refurbished or the components sold to authorize recyclers for recycling.

Provide evidence of conformity with local standards of satisfactory design and completed construction of microgrid, mounting frames, utility poles and transmission lines.

Gram Power delivers top quality products to the sites in compliance with the standards set by Ministry of New and Renewable Energy (MNRE). Gram Power ensures that the batteries, inverters, solar panels, wires, poles and mounting structures conform to the standards of satisfactory design. The evidence and standards followed are provided in Annexure.

Annexure

Appliance census for grid connected households



TEST CERTIFICATES AND CONSTRUCTION STANDARDS FOLLOWED FOR MICROGRID INSTALLATIONS

Figure 30 - Enclosures and battery racks

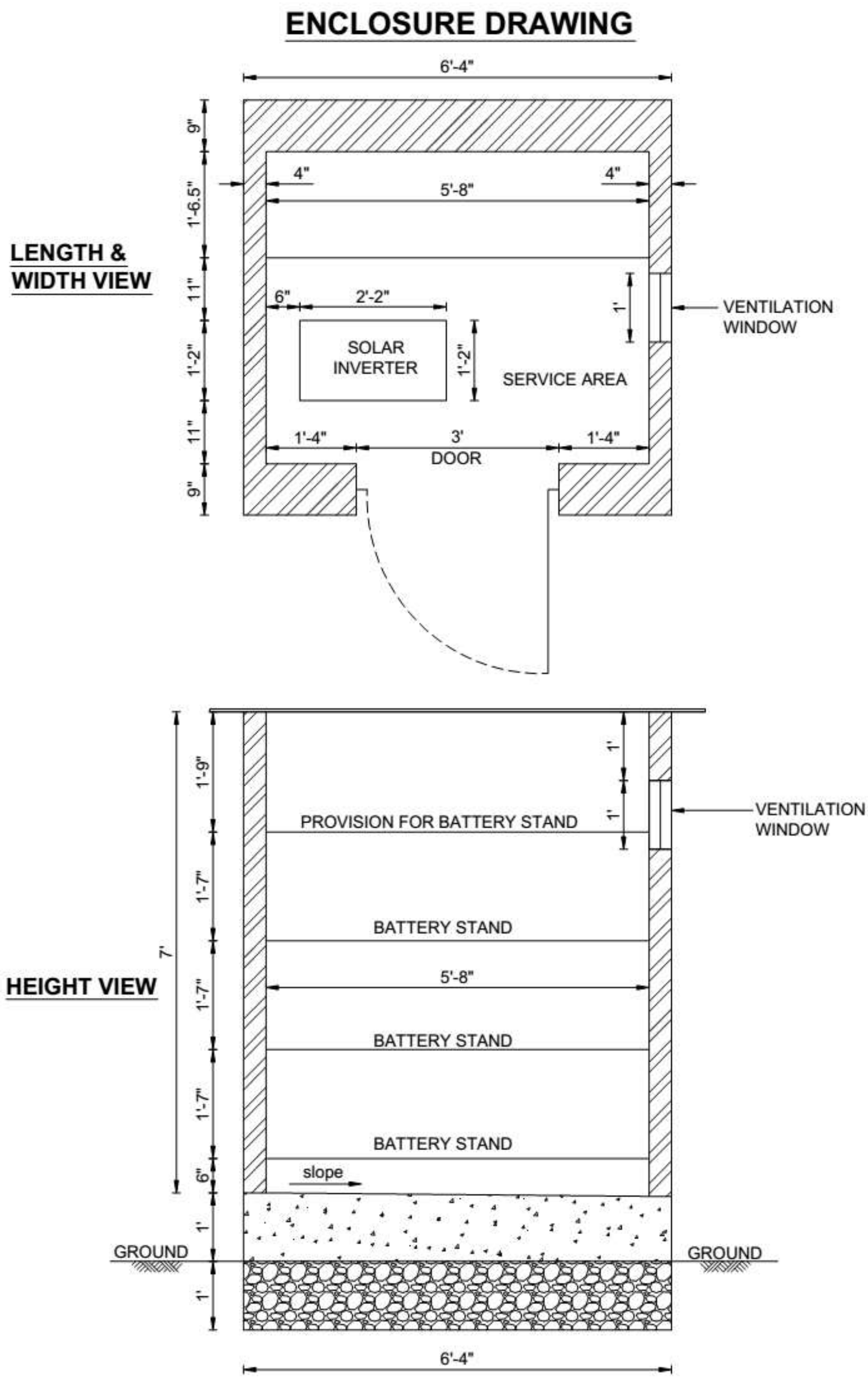


Figure 31 - Drawings for civil construction work as per standards

Mounting frames

Annexure VI: Mounting Structure

Expectations from our Mounting Structure Contracting Party.

Gram Power is committed to delivering top-quality products and services to its consumers. We expect the delivery to be punctual, the quality to be uniformly great and in compliance with the MNRE standards. We would also like the material to be directly shipped to our sites in rural Rajasthan/U.P and installed there. We would like to have a flexible warranty of 25 years from the time of delivery of the material to the site(s), the warranty should be valid for all load conditions.

Technical Specification

1. Detailed specifications for the mounting structure are given below:

Wind velocity withstanding capacity	150 km / hour
Structure material	Hot dip galvanised iron with a minimum galvanisation thickness of 80 microns or aluminium alloy.
Bolts, nuts, fasteners, panel mounting clamps	Stainless steel SS 304
Mounting arrangement for RCC-flat roofs	With removable concrete ballast made of pre-fabricated PCC (1:2:4), M15
Mounting arrangement for elevated structures	The elevated structure has to be securely anchored to the supporting surface. Concrete foundations of appropriate weight and depth for elevated structures mounted directly on the ground; Bolted with anchor bolts of appropriate strength for elevated structures mounted on RCC surfaces.
Mounting arrangement for ground installations	With removable concrete ballast made of pre-fabricated PCC (1:2:4), M15; assuring enough ground clearance to prevent damage of the module through water, animals and other environmental factors.
Installation	The structures shall be designed for simple mechanical on-site installation. There shall be no requirement of welding or complex machinery at the installation site.
Access for panel cleaning and maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the module junction box.
Panel tilt angle	We would like to have the flexibility of adjusting the tilt angle 4 times a year – specified as: 5deg, 10 deg, 23 deg and 43 deg.

Warranty Terms (Mounting Structures)

The contracting party shall provide a warranty for 25 years to cover the following -

1. Any manufacturing defects
2. Operational defects – in normal conditions of operations of any of the above conditions – in terms of durability / performance are not met.

If it is demonstrated that the technical quality is not met on site. The Contracting Party shall replace the damaged/under-performing pieces within 3 days of complaint registration

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Figure 32 - Mounting frames

Inverter

Figure 33 - Inverter housed inside the enclosure

Annexure V: Inverter

Expectations from our Contracting Party about Inverters.

Gram Power is committed to delivering top-quality products and services to its consumers. We expect the delivery to be punctual, the quality of inverters to be uniformly great and in compliance with the MNRE (Environmental EC 60068-2 (1,2,14,30) / Equivalent BIS Std. Efficiency - IEC 61683 / IS 61683, IEC 60068-2 (1, 2, 14, 30) / Equivalent BIS Std.) standards. We would also like the material to be directly shipped to our sites in rural Rajasthan/U.P and installed there. We would like to have a flexible warranty of 5 years from the time of delivery of the material to the site(s), the warranty should be valid for all load conditions.

Technical Specification

General Specifications

The Inverters should be capable of running stand-alone in an unattended SPV Power Plant unit. Inverters should be of very high quality having high efficiency (>85%) and microprocessor-controlled type. It shall be capable of monitoring its own parameters **The Inverter shall come in with a build in MPPT Charge Controller.** The inverter should have following features:

1. Reliable DC to AC energy conversion system.
2. The inverter shall be designed for continuous, reliable and prime power supply as specified.
3. The inverter shall have high conversion efficiency from 25% load to the 120% of the rated load. The conversion efficiency at 25% load shall not be less than 80% of that at full rated load. The efficiency of the inverter shall be more than 95% at full load.
4. The inverter shall have high overload capability. The overload capability of the inverter shall be a minimum of 200% at rated full load for minimum period of 10 sec. The output power factor of the inverter should be of suitable range to supply or sink reactive power.
5. The inverter shall have automatic restart facility after overload- triggered shutdown.
6. The output voltage of the inverter shall be sinusoidal with harmonic distortion less than 3% THD.
7. The dimension, weight, foundation details etc. of the inverter shall be clearly indicated in the detailed technical specification. The complete PCU should be compact & small in size.
8. The inverter shall have provision for input & output isolation (automatic & manual), Spare card (PCB) & other necessary parts as recommended by the manufacturer should be supplied compulsorily, with the PCU for any immediate requirement.
9. Each solid-state electronic device shall have to be protected to ensure long life of the inverter as well as smooth functioning of the inverter. **Inverter should have safety measures to protect inverter from reverse short circuit current due to lightening or line faults of distribution network.**
10. The no load power consumption < 1% of peak capacity.
11. The inverter should be able to charge the battery even if it is operating in low battery or deep discharge mode.
12. Communication through serial protocol to get in solar PV, battery & AC output currents and voltages. The communication protocol and data packet structure should be made available to Gram Power. The system should have a data storage capacity capable of storing 2 months' worth of data.

Detailed - Input Specifications

	1 kVA	2 kVA	3 kVA	5 kVA	7.5 kVA	10 kVA	15 kVA	20 kVA
Parameters								
DC Input Voltage	Input from PV 96 V to 260 VDC from Solar PV Array Output Voltage Suitable for charging 48/96/120/240V							
Minimum voltage	40 VDC	40 VDC	40 VDC	80 VDC	80 VDC	100 VDC	200 VDC	200 VDC
Maximum voltage	88 VDC	88 VDC	88 VDC	176 VDC	176 VDC	220 VDC	440 VDC	440 VDC
Solar Source Voltage	88 VDC	88 VDC	88 VDC	176 VDC	176 VDC	220 VDC	440 VDC	440 VDC
Battery Bank Voltage	48 VDC	48 VDC	48 VDC	96 VDC	96 VDC	120 VDC	240 VDC	240 VDC
Efficiency	95 %	95 %	95 %	95 %	95 %	95 %	91 %	91 %

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Start up Voltage	44 VDC	44 VDC	44 VDC	88 VDC	88 VDC	110 VDC	220 VDC	220 VDC
Tripping Voltage	79 VDC	79 VDC	79 VDC	158 VDC	158 VDC	198 VDC	396 VDC	396 VDC

Detailed - Output Specifications

	1 kVA	2 kVA	3 kVA	5 kVA	7.5 kVA	10 kVA
Parameters						
Output Voltage	230 V AC, Single Phase					
Output Frequency	50 Hz ± 6%					
Output kVA	1 kVA	2 kVA	3 kVA	5 kVA	7.5 kVA	10 kVA
Efficiency	87 %	87 %	87 %	90 %	90 %	91 %
Output Current	4.3 A	8.6 A	13.04 A	21.73 A	30.43 A	43.4 A
Output THD	<55dB @ 1 Meter	<55dB @ 1 Meter	<55dB @ 1 Meter	<55dB @ 1 Meter	<55dB @ 1 Meter	<55dB @ 1 Meter
Power Factor	0.8 %	0.8 %	0.8 %	0.8 %	0.8 %	0.8 %

Protections Desired:

- Panel under voltage and mains over voltage
- Output over load and output short circuit
- Over temperature
- Input Fuse
- High voltage in DC link
- Surge protection in mains input
- Lightning protection
- Deep discharge
- Input surge voltage
- Over current
- Battery reverse polarity
- Solar array reverse polarity
- Both AC & DC lines shall have suitable fuses and connectors to allow safe start up and shut down of the system.

General Temperature & Humidity Variance -

1. Cooling should be ensured with Temperature Sensitive Fan
2. Ambient temperature - 50 degree Celsius (Max) Operating
3. Humidity tolerance-95%

Warranty Terms (Inverters)

The contracting party shall provide a warranty for 5 years to cover the following -

1. Any manufacturing defects.
2. Operational defects – in normal conditions of operations of any of the above conditions – if the terms of durability / performance are not met the product needs to be replaced within the warranty terms.
3. Gram Power will conduct extensive tests to ensure that the features promised are met with, especially MPPT.
4. If it is demonstrated that the technical quality is not met on site. The Contracting Party shall replace the damaged/under-performing pieces. After deployment, when the inverter supplied is reported to be malfunctioning within the warranty period, it will should be replaced within 3 days of complaint registration in order to ensure maximum uptime to the consumers.

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Director

Batteries

Figure 34 - Batteries housed inside the enclosure control room

Annexure VII: Batteries

Expectations from our Contracting Party for **Batteries.**

Gram Power is committed to delivering top-quality products and services to its consumers. We expect the delivery to be punctual, the quality of batteries to be uniformly great and in compliance with the MNRE standards (BIS/IEC 61427 & IS: 13369& IS 1651:1991). We would also like the batteries to be directly shipped to our sites in rural Rajasthan/U.P. We would like to have a flexible warranty of 5 years from the time of delivery of the batteries to the site(s), the warranty should be valid for all load conditions

Technical Specification (Batteries)

The battery bank capacity shall be of different capacities as specified in the price schedule, of tubular lead acid type.

The general specifications shall be as under:

1. Each battery shall consist of 06 number of deep- discharge electrochemical storage cells (2V), suitably interconnected as required.
2. The cells shall be capable of deep discharge and frequent cycling with long maintenance intervals and high columbic efficiency.
3. The nominal voltage and capacity of **the battery will be 12V**
4. The self-discharge rate of the battery bank or individual cell shall not exceed three (03) percent per month at 30° C
5. Water top-up frequency – once in every 6-8 months – Low Maintenance.
6. The battery should be capable of withstanding partially charged state for up to six (06) months.
7. The Ampere-hour efficiency should be more than 90%
8. The Watt-hour efficiency should be more than 80%
9. The charging rate of 0.05% of normal current of the normal charging current should be adequate.
10. The permitted maximum depth of discharge (DOD) shall be as follows:

Depth of Discharge	Number of Cycles
70%	2000
40%	3500
20%	5000

11. Unless otherwise specified the cycle life of the battery shall not be less than 5000 DC discharge cycles between the fully charged state and the permitted maximum DOD at the rate of C/10. It should be able to deliver 90% of its rated capacity from fully charged position to DOD.
12. As per IS 1651:1991<u>Temperature Response</u> – the capacity may vary by 0.43% per °C at 10 hour rate.
13. The cells shall include explosion proof safety equipment and the make of the container, plates etc will be as per specifications mentioned below –

Container	Polypropylene
Cover	Protective Cover of Virgin / Filled Polypropylene against dirt and short circuit
Handles	Nylon or equivalent threads with rubber/plastic handles
Terminals	Lead Alloy
Vent Plugs	Microporous Ceramic
Covered Float	Present with level indicator
Separators	Microporous Polyethylene Envelope
Positive Plate	Tubular Type Cast of Highly Corrosion Resistant Low Antimony Special Alloy
Negative Plate	Flat Plate With Grids Cast of Corrosion Resistance Special Alloy

14. The cells shall include the required number or corrosion resistant inter-cell required chemicals electrolyte packed in separate containers.
15. A checklist of additional items/documentation required:
    1. Minimum specification with possible alternatives of the required battery charger for first time charging.
    2. Instruction of electrolyte filling, battery charging etc. and instructions on the transportation of charged batteries, if required.

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Nimit Agarwal

3. All technical and other details (with accompanying graphs) pertaining to the storage cells shall be supplied including but not limited to the following:
   a. Rated voltage and ampere-hour capacity of each storage cell as the rated discharge rate. b. Permitted maximum DOD.
   c. Self-discharge rate.
   d. Cycle life of the storage cell and the anticipated life (in years) of the battery.
   e. Total number of storage cells in use.
   f. Details on cell interconnections.
4. Every cell should have proper numbering marked clearly for its identification.
5. **Testing certificates confirming to the appropriate BIS/IS standards.**

Warranty Terms (Batteries)
The supplier/contracting party shall provide a warranty for 60 months to cover the following -

1. Any manufacturing defects.
2. Operational defects – in normal conditions of operations of any of the above conditions – in terms of efficiency / performance are not met.

If it is demonstrated that the technical quality is not met on site. The supplier/Contracting Party shall replace the damaged/under-performing pieces within 3 days of complaint registration. Gram Power will provide for adequate proof of battery malfunction on site.

Gram Power will be installing DC smart meters to monitor the performance of the batteries on field – the meters will provide information on the power pumped in, power drawn out and timestamps of meter readings and if the data indicates that the DOD (mentioned in point 10, Technical Specifications) is not met then the batteries need to be replaced within 3 days.

Depth of Discharge	Wattage Efficiency	Per discharge Wattage	Number of Cycles
70%	80%	1008 Wh	2000
40%	80%	576 Wh	3500
20%	80%	288 Wh	5000

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Director

TEST CERTIFICATES

ASSESSMENTS

CERTIFICATE

This is to Certify that the

Quality Management System

of

MAXWELL INDIA

F-946(D), Road No. 14, V.K.I.A., Jaipur-302013, Rajasthan, India.

has been independently assessed and is compliant with the requirements of

ISO 9001:2008

This Certificate is applicable to the following product or service ranges:

DESIGN, MANUFACTURE AND SUPPLY OF STATIC AND ELECTRO-MECHANICAL AC WATTHOUR (ENERGY) METERS.

:: Certificate No :: 104218-A01

Date of initial registration	24 July 2014
Date of this Certificate	24 July 2015
Certificate expiry	23 July 2016
Recertification Due	23 July 2017

This Certificate is property of LMS Certifications and remains valid subject to satisfactory surveillance audits.

Director

Accreditation

LMS Certifications Private Limited
1-Ananddham, Opp. Kukrail Picnic Spot Gate, Faridi Nagar, Lucknow - 226015, UP (INDIA).

Form No. QRF/2001-25

Government of India
Ministry of Communications and Information Technology
Department of Information Technology, Standardisation Testing & Quality Certification Directorate

ELECTRONICS REGIONAL TEST LABORATORY (EAST)

1.0 SCOPE

1.1 Service Request No. : TE/0182/02-15

1.2 Test Report No. : ERTL(E)/TES/M199/0166/02-15
Date : 20/05/2015

1.3 Requested by (Name & Address of the Organisation) : **MAXWELL INDIA**
B-210, VAISHALI MARG
VAISHALI NAGAR
JAIPUR 302021

1.4 Description, Identification of the item to be tested
Item : AC STATIC THREE PH 4 WIRE ENERGY METER (EXTERNAL CT OPERATED)
Make : MAXWELL
Model : RS-30
Sl.No. : 470115, 470116, 470117
Qty. : 3

1.4.1 Applicable Spec. of the item(s) tested:

3 Ph ; 3X(240Volt/-/5A) CT Operated ; 50 Hz ; CL-1 ;
1600 imp/kWh ; Polycarbonate Body ; LCD Display

1.4.2 Characterisation and condition of the item
Characterisation : Not applicable /
Condition : Satisfactory /

1.5 Date of receipt of item : 09/02/2015

1.6 Date of completion of testing : 20/05/2015

1.7 Location where testing performed : In house

1.8 Ambient condition during measurement : 25 +/- 1.5 Deg. C
70% RH. Max.

1.9 Spec. used for testing : IS:13779:1999 (with latest amendment), CBIP-304 & Additional Tests.

1.9.1 Details of non-standard method followed (if any) : NIL

For MAXWELL INDIA

Form No. QRF/2001-29, REV - 2

Government of India
Ministry of Communications and Information Technology
Department of Information Technology, Standardisation Testing & Quality Certification Directorate

ELECTRONICS REGIONAL TEST LABORATORY (EAST)

TEST REPORT ON : AC STATIC SINGLE PH 2 WIRE ENERGY METER   PAGE 01 OF 14

1.0 SCOPE

1.1	Service Request No.	:	TE/0129/10-13
1.2	Test Report No.	:	ERTL(E)/TES/M199/0094/10-13 Date : 18/02/2014
1.3	Requested by (Name & Address of the Organisation)	:	MAXWELL INDIA B-210, VAISHALI MARG VAISHALI NAGAR JAIPUR 302021.

1.4	Description, Identification of the item to be tested	Item	:	AC STATIC SINGLE PH 2 WIRE ENERGY METER
		Make	:	MAXWELL
		Model	:	TYPE RS-16
		Sl No.	:	889095, 889096, 889097
		Qty.	:	3

1.4.1 Applicable Spec. of the item(s) tested:

1 Phase, 240Volt, 5-30A, 50 Hz, Class 1, 3200 imp/kwh, Polycarbonate Body, LCD Display, Shunt in Phase and CT in Neutral Circuit.

1.4.2	Characterisation and condition of the item	Characterisation Condition	:	Not applicable Satisfactory
1.5	Date of receipt of item			04/10/2013
1.6	Date of completion of testing			18/02/2014
1.7	Location where testing performed		:	In house
1.8	Ambient condition during measurement			27 +/- 1.5 Deg. C 70% RH Max
1.9	Spec. used for testing			IS 13779:1999 (with latest amendment), CBIP-304 & Additional Tests.
1.9.1	Details of non-standard method followed (if any)		:	Nil.

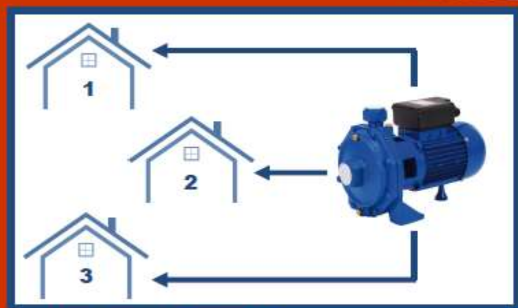
For MA[illegible]ELL INDIA

COPY OF THE PAMPHLETS

जगमगाएगा गाँव का हर आँगन
ग्राम पावर की उर्जा योजनाओं के संग

विशेष स्कीम

पम्प कनेक्शन



अब घर में पम्प चलाएँ
न्यूनतम ₹1100 प्रतिमाह प्रति घर

- तीन घरों पर एक पम्प
- कुल 3 घंटे प्रति दिन
- 3 HP का पम्प
- सिर्फ दिन मे ही चलेगा
- पम्प उपभोक्ताओं को घर में प्रति माह ₹500 का मुफ्त रिचार्ज
- एक घर को 10 घंटे प्रति माह, पम्प चलाने की सुविधा

जिस दिन पम्प ना चलाना हो, चलायें टी.वी. और पंखा 4 घंटे अतिरिक्त

"भविष्य में कम्पनी इस स्कीम में परिवर्तन कर सकती है"

"एक गाँव में अधिकतम दो पम्प चलाये जा सकते है

GRAMPOWER

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- 0141-2358178 (ऑफिस)
- 9571745675 (केदारी जी)
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- 9799404666 (संदीप जी)

कनेक्शन रकम
मात्र ₹5000/- *

*प्रति घर

हमारी सुविधाओं का लाभ उठाने के लिए

1. एग्रीमेंट पर दस्तखत करें
2. कनेक्शन रकम जमा करें
3. कनेक्शन लें

जगमगाएगा गाँव का हर आँगन
ग्राम पावर की उर्जा योजनाओं के संग

समस्त गाँव वासियों को यह खुश ख़बरी दी जाती है कि इस गाँव में ग्राम पावर की बिजली आने वाली है

GRAMPOWER

कनेक्शन रकम जमा कराने के लिए नीचे दिए गए नंबर पर संपर्क करें

120, विष्णु मार्ग, ऑफिसर्स कैम्पस एक्सटेंशन, संस्कार स्कूल के पास, जयपुर – 302012

0141-2358178 (ऑफिस)
9571999873 (अभय जी)
9799404666 (संदीप जी)

कनेक्शन रकम
मात्र ₹1000/- *

*प्रति घर

हमारी सुविधाओं का लाभ उठाने के लिए

1. एग्रीमेंट पर दस्तखत करें
2. कनेक्शन रकम जमा करें
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जगमगाएगा गाँव का हर आँगन
ग्राम पावर की उर्जा योजनाओं के संग

घरेलू कनेक्शन



- 2 सी.एफ.एल बल्ब
- 1 पंखा
- 1 टीवी + डिश
- अन्य छोटे उपकरण

कनेक्शन रकम मात्र ₹ 999/-

प्लांट में घरेलु कनेक्शन को सूर्यास्त के बाद कम से कम 6 घंटे चलाने की क्षमता है।

भविष्य में कम्पनी इस स्कीम में परिवर्तन कर सकती है

यह स्कीम कंपनी द्वारा निर्देशित मापदंड के उपकरणों के उपयोग के अनुसार बनी है

GRAMPOWER

120, विष्णु मार्ग, ऑफिसर्स कैम्पस एक्सटेंशन, संस्कार स्कूल के पास, जयपुर – 302012

- 0141-2358178 (ऑफिस)
- 9571999873 (अभय जी)
- 9799404666 (संदीप जी)

मासिक स्थाई शुल्क ₹150/-

इसके उपरान्त प्रीपेड सुविधा

हमारी सुविधाओं का लाभ उठाने के लिए

1. एग्रीमेंट पर दस्तखत करें
2. कनेक्शन रकम जमा करें
3. कनेक्शन लें

जगमगाएगा गाँव का हर आँगन
ग्राम पावर की उर्जा योजनाओं के संग




रिचार्ज रकम	2 सी.एफ.एल.	1 मोबाइल चार्जर		1 पंखा		1 टीवी + डिश
₹30/-	75 घंटे		या	20 घंटे	या	30 घंटे
₹50/-	150 घंटे		या	40 घंटे	या	60 घंटे
₹100/-	400 घंटे		या	110 घंटे	या	160 घंटे
₹200/-	1000 घंटे		या	270 घंटे	या	400 घंटे

नोट - प्लांट में घरेलु कनेक्शन को सूर्यास्त के बाद कम से कम 6 घंटे चलाने की क्षमता है।

भविष्य में कम्पनी इस स्कीम में परिवर्तन कर सकती है

यह स्कीम कंपनी द्वारा निर्देशित मापदंड के उपकरणों के उपयोग के अनुसार बनी है

GRAMPOWER

120, विष्णु मार्ग, ऑफिसर्स कैम्पस एक्सटेंशन, संस्कार स्कूल के पास, जयपुर – 302012

- 0141-2358178 (ऑफिस)
- 9571999873 (अभय जी)
- 9799404666 (संदीप जी)

मासिक स्थाई शुल्क ₹150/-

इसके उपरान्त प्रीपेड सुविधा

हमारी सुविधाओं का लाभ उठाने के लिए

1. एग्रीमेंट पर दस्तखत करें
2. कनेक्शन रकम जमा करें
3. कनेक्शन लें