DIV Project: "Electrifying India Intelligently: Bringing Smart Grids to Rural India"
Partners: Gram Power, J-PAL South Asia, and UC Berkeley
Milestone 1 Deadline: October 1st, 2013

Updated Implementation Plan

Our current implementation plan is detailed below, and accompanied by the attached Gantt charts.

- *Preparation for data collection.* By November 1st, 2013, the UCB and J-PAL team will have hired and trained a Research Associate, and begun to train a team of 2 survey enumerators and 1 supervisor.

- *Site identification.* Using lists of unelectrified villages, and other available administrative and spacial data, we will select clusters of villages with low electrification rates that are relatively close to Jaipur (where J-PAL South Asia has an office). A local NGO, that we are considering hiring for an initial round of site visits, will confirm that 1) each village is not currently electrified; 2) there are no plans for the village to be electrified in the next 2 years; 3) there is centrally located, unshaded land available for a microgrid site; 4) the local Panchayat is willing to donate, lease, or sell this land to Gram Power for the purpose of installing a microgrid; 5) there are at least 50 households located within an average distance of 30-40m of one another and the central site; and 6) there are no other "red flags" that might prevent Gram Power from installing a microgrid.

  JPAL will work closely with the NGO to ensure the integrity of the site identification process and research design. Once these data are collected from 10-14 sites, Gram Power and J-PAL (with input from UCB) will confirm the eligibility of each village by analyzing digital maps of the village and performing technical calculations to ensure site feasibility. Site identification will be done in approximately 8 rounds, with 10-14 sites identified and randomized in each round, so as to minimize the amount of time that passes between our initial contact and microgrid installation (this minimizes the risk of contamination by another off-grid power source, and helps to maintain local political will).

  To maximize efficiency, we may wish to over-sample at the beginning of the site selection process (in other words, enroll more than the target 10 villages in a single round), so that we can get a sense of what attrition will look like in our study area. If attrition is low or nonexistent (i.e., most or all of our treatment villages end up accepting a microgrid), then we can reduce the number of villages we enroll in each round accordingly.

- *Baseline survey administration.* Once a round of 10-14 villages has been selected, the J-PAL survey team will conduct up to 20 household baseline surveys in each village. Households will be selected based on a set of basic criteria, including: no electricity connection; proximity to the previously identified microgrid site; house (building) size; number of livestock; household made of durable material (a proxy for standard of living); more than five permanent household

members; and likely interest in connecting to the microgrid. Specific outcomes to be measured during baseline survey administration are detailed below.

- *Randomizing villages into treatment and control.* Randomization will be done in one of two ways: 1) once 10-14 eligible villages have been identified in a single round, J-PAL will convene local leaders from each village, and hold a public lottery in which exactly 50% of the villages are selected to receive a microgrid; or 2) once 10-14 eligible villages have been identified, J-PAL will create matched pairs of villages based on characteristics collected at baseline (including mean income, population density, proximity to a main road or town), then randomly (using a random number generator) assign one village from each pair to be in the control group. If for whatever reason it does not work to install a microgrid in a given village, *both* villages in the matched pair will be excluded from the study (though we will make every effort to ensure maximum take-up in the villages that are selected). This will help us minimize any bias or loss of statistical power that may result from attrition. The decision about how to randomize will depend on our budget (it will cost more to use matched pairs, since we will have to identify more villages than are ultimately needed) and how important we feel a public lottery is to village leaders in Rajasthan, which we will learn as we do additional piloting over the coming month. We may end up with a combination of the two approaches (doing a public lottery which results in several sets of matched pairs).

- *Preparation for microgrid installation.* Once villages have been randomized into treatment and control groups, Gram Power will begin its in-depth negotiation with local leadership in the treatment villages, to finalize land contracts and prepare for installation. A detailed distribution map providing GPS coordinates of each house and electricity pole along with the location of the solar generation station will be prepared. This will help in evaluating the reliability of the wireless network of meters. A land agreement will be done with the land owner for installation of solar panels and an agreement will be done with the operator who will maintain the microgrid. The same NGO we hire to do the initial site selection will conduct mobilization activities to boost take-up within the community and collect connection fees from interested households. The NGO, assisted by Gram Power, will carry out a training session of all the entrepreneurs. Gram Power will limit the variation in connection fees to a range of 2000-3000 INR. This way, the difference between the most expensive and the cheapest connection fees across sites does not distort the types of households that connect in different villages.

- *Microgrid installation.* Once a minimum of 50% of households buy into the system, demonstrated by deposit of at least 50% of connection fees as advance, Gram Power will start installation in microgrids in each treatment village, barring any unforeseen obstacles. The pace of installation will depend on cash flow, as equipment is expensive and must be procured in advance. The partnering NGO may accompany Gram Power to the field at this stage, and handle the collection of connection fees, as the majority of households prefer to connect after the equipment has arrived in the village (and not before). Budget permitting, J-PAL may pay an

additional visit to households enrolled in our study to ensure the highest take-up possible among this group, and to offer free appliances to randomly selected households.

- *Ongoing encouragement.* After the microgrids are installed, community mobilization will continue as funding permits, or until 100% take-up is reached. J-PAL may pay additional visits during this period as well to collect midline data.

- *Endline survey administration.* J-PAL will collect endline survey data in all households enrolled in the study (treatment and control). Note that because microgrid installation is spread out over 16 months, and data collection is condensed into 10 months, there will be some variation in the amount of time that passes between baseline data collection, microgrid installation, and endline data collection. However, we consider the implications of this variation to be negligible, as the outcome that will be most affected by "time since microgrid installation" – quantity of electricity consumed – will be collected in real time by the smart meters. Seasonally affected outcomes – including reliance on alternative power sources, income generation, schooling, etc. – are more dependent on seasonal variation, which we account for by maintaining consistency of month surveyed between treatment and control households.

  Note: Given funding constraints, Gram Power can only install microgrids at the rate represented in the attached Gantt chart. Installing all 40 microgrids will take a full 16 months, from March of 2014 to July 2015. Within the current timeline outlined in our USAID DIV award document, we will be limited to a three-month window between treatment and follow-up data collection for several of our study sites. As a result, our research team may eventually wish to explore a no-cost extension with USAID, allowing us to delay the collection of endline survey data by a few months. For some of the outcomes listed below – especially household income generation and school performance for children – more time is needed between microgrid installation and endline data collection to see significant impacts. This adjustment would add substantial value to the study, while maintaining the same general approach and targets in terms of microgrid capacity installed and beneficiaries reached.

<u>Progress to Date</u>

Since the start date of the award, Gram Power, along with the UC Berkeley research team and J-PAL SA have made significant progress in terms of discussing the research design and finalizing an MOU (attached). The J-PAL SA Research Manager assigned to this project has spent time in Jaipur with the CEO of Gram Power, and is making plans to meet with the NGO we are considering hiring to conduct the site selection and community mobilization exercises.

Technical Progress

1. Gram Power has been extensively field testing its new wireless smart prepaid meters for the past 3 months.
2. By November, 1000 of these meters will be installed

3. Gram Power has also developed an advanced mapping tool that allows them to digitally map out every village that is surveyed with GPS coordinates of individual households. The tool allows their ground staff to collect household survey data digitally as well, which is uploaded to their servers. The data and distribution map is then cross verified by their team using Satellite Images on Google Earth.
4. There is further going on to automate the distribution map creation and simulating power losses across the grid at different power supply levels.
5. Gram Power has further refined its long distance communication technology to make data transfer on power consumption from remote hamlets to become significantly more reliable. At this point, even if there is 24 hours of no solar power generation, their communication and grid monitoring systems keep running and sending data to ensure that there is reliable control that Gram Power has on the entire infrastructure

Site Selection

We are currently in the process of collecting lists of sufficient number of unelectrified villages and hamlets in rural Rajasthan that are located in clusters. About 70 villages have already been identified in one district of Rajasthan and we're planning to locate another 200. The 80 treatment and control sites will then be chosen from this list using our advanced mapping tools.

Discussions with MNRE

Gram Power has already spoken to MNRE about this award and MNRE has agreed in principle to give their support under the Jawaharlal Nehru National Solar Mission. Up to Rs.105/Wp of capital subsidy support can be provided by MNRE. In addition MNRE will also allow Gram Power to avail of certain import duty exemptions that it has in the past allowed only for grid-connected renewable energy projects. Gram Power will submit a formal proposal to MNRE for this project within October for sanction of the subsidy amount.

Plans to engage solar distributors, dealers and other stakeholders

Gram Power already has working relations with suppliers for all the major components of the microgrid such as batteries, solar panels, inverters, mounting structures, and wires. They have contract manufacturers for their smart meters and their own facility to assemble, program and test them. For all civil and electrical work required for site installation, Gram Power has been working with local contractors. These contractors belong to villages near the potential sites itself and historically have been quite unreliable with time commitments. Hence, Gram Power is now identifying and training more civil contractors to have multiple options during installation and to ensure smooth execution of this project.

For this project, the material sourcing will work as follows:

1. Gram Power will standardize the sizing of batteries, solar panels and mounting structures to be used in the project and enter into contracts with the suppliers to supply necessary equipment at least 1 month prior to the planned installation timelines. Gram Power will place these orders 4-8 weeks prior to the desired delivery date.

2. The components for the smart meters will be ordered soon after milestone 2 is completed and it will be manufactured in batches of 1000 meters.

The plan to engage with national utilities is as follows:

1. A list of all villages shortlisted by Gram Power will be submitted to the State Utility and Rural Electrification Corporation to inform them of the project's activities. This should ensure that similar microgrid projects are not sanctioned for these areas under any other electrification scheme of the government. Gram Power will also try to get a letter from the utilities or REC confirming that no other microgrid project is planned in the selected sites.
2. Gram Power will propose to the State Utility to sanction them a Distribution Franchisee for power supply in neighboring grid-connected villages. Having this will make easier any future grid integration with the microgrids.
3. The State Utilities and Ministry of Power also implement various programs for rural electrification that include microgrids. Historically, these programs have been unsuccessful because of the lack of a sustainable business model. Gram Power will have the state utilities well informed about this work and the results in these 40 microgrids to demonstrate how these systems can be made sustainable and what policy changes need to be done to scale the sector. The Chairman of Rural Electrification Corporation and Joint Secretary of the Ministry of Power recently visited Gram Power's work in Rajasthan and have expressed very keen interest to alter the rural electrification policies to scale such projects and initiatives

Updated Monitoring & Evaluation Plan

The monitoring and evaluation of demand and impact for this project will be highly data intensive. The data to support these activities will be collected in a variety of ways:

Household-level Baseline Surveys

Surveys will be conducted in 40 treatment and 40 control villages; in up to 20 households in each village. J-PAL will begin administering this survey in January 2014. Survey instruments will be designed to collect information about the following:

- Household size and demographics
- Household appliance holdings (e.g. solar lanterns)
- Appliance utilization (e.g. hours of lighting)
- Local costs of appliances
- Household energy consumption and expenditures
- Household income
- Income generating activities
- Estimated value of household assets
- Time use log
- Student school attendance and performance
- Mental and physical health

Smart Meters (treated households only)

Gram Power metering technology monitors energy use (and expenditures) at a sub-hourly level. These very high frequency data can be used to measure the following:

- Hourly household energy consumption
- Daily/seasonal household energy expenditure
- Disaggregated (by end use) energy consumption (i.e. lighting and cooling)
- Household pre-payments (dollar value and frequency)
- Technical losses

Administrative Data from Gram Power

The following data will be collected from Gram Power (Note: Gram Power reserves the right to prevent the publication of system and O&M costs as these are confidential figures of the company. Since the company works with competitively bid projects, public disclosure of these costs will be harmful to their activities). Administrative data shared with the research team will include:

- Total installed cost per microgrid system
- Total installed power supply
- Households/microgrid system
- Operations and maintenance costs
- Cost per kWh supplied

Household-level Endline Surveys

J-PAL will conduct a follow up survey with all 1,600 households participating in the study (as both treated and control units). If grid installation proceeds as planned, this end-line survey will begin in either January of 2015 or later, according to our note on page 6, above. End-line survey instruments will be designed to collect information about the following:

- Household appliance holdings (e.g. solar lanterns).
- Appliance utilization (e.g. hours of lighting).
- Local costs of appliances.
- Household energy consumption and expenditures.
- Household income
- Income generating activities
- Estimated value of household assets
- Time use log
- Student school attendance and performance
- Mental and physical health

Objectives for Evaluating Outcomes

- Estimating the impacts of grid access on a range of household-level outcomes: Random assignment of micro-grid technology across villages will allow us to compare outcomes across households that gain access to electricity and those that do not. With such a small sample size, it will be important to control for pre-existing differences in order to increase precision. Outcomes we will focus on include: kerosene expenditures, types of appliances used, time use. Although our study period will likely be too short to assess long-run outcomes (such as improved school performance), we can estimate impacts on behavioral changes that can lead to long run outcomes (more time devoted to reading).
- Assessing rural Indian households' usage of – and possibly willingness to pay for more and less energy efficient appliances. Random variation in appliance holdings across newly connected households will allow us to estimate the effect of improved appliance efficiency on appliance utilization, energy expenditures, and non-energy related expenditures. We will test for a direct "rebound" effect (i.e. a relative increase in demand for lighting services among households assigned more efficient lighting appliances) and indirect rebound (i.e. a relative increase in demand for other energy-consuming end uses among households assigned more efficient lighting appliances).
- Assessing the financial viability of the pre-paid smart micro grid model. We will compare the costs of building and maintaining the microgrid systems against the revenue generated through the sale of electricity. We will project future revenue generating potential under a range of assumptions. When comparing these costs and benefits, it is important to keep in mind that these remote locations are very costly to serve in general. To do a balanced and fair comparison, the researchers will compare the net costs of the Gram Power approach to the cost of grid extension to these villages. It will then be determined to what extent is the grid infrastructure subsidized for the end consumer or paid for using tax dollars, and in the event that this infrastructure was not subsidized at all how would the cost of supply compare with that of Gram Power's.

Power calculations

Please note that the data we need to inform power calculations (i.e. energy consumption data form newly connected households, time use data from rural Indian households, etc.) is very difficult to find. A research associate has conducted a short household survey in one of the first villages that received a Gram Power microgrid. We are in the process of gaining access to electricity consumption data from recently connected villages. Once we have the data in hand, we will carry out more detailed power calculations will inform the design the household-level appliance intervention.

MILESTONES

Note: September 1, 2013 is the award date.

Milestone	Estimated Completion Day	Deliverable	Amount
1	Award date + 1 month	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Updated implementation plan (including a Gantt chart) that includes all key planned project implementation activities, and summarizes progress to date. The plan should discuss plans to engage solar distributors, dealers and other stakeholders including private investors and national utilities. • Update project monitoring and evaluation plan. This should include a statement delineating the roles of the M&E partner (JPAL) and of Gram Power in evaluation activities, and a statement from the M&E partner that they endorse the plan. The anticipated statistical power of the evaluation should be provided. The evaluation plan should include the following major categories of analysis: (1) estimating the socioeconomic impact of the Gram Power microgrids; (2) assessing rural Indian households' willingness to pay for, and usage of, more and less energy efficient appliances; and, (3) evaluating the financial viability of the prepaid smart microgrid model by assessing financial returns, cost-effectiveness and scalability in comparison to existing, alternative solutions. • Updated list of indicators necessary to track progress of the project and measure impact. Also include a timeframe for data collection and the source of the data - at a minimum, all indicators listed should be collected at baseline, and endline, but some indicators should be collected as appropriate. Gram Power must report information for all indicators for each milestone. It is understood that new information from Gram Power will not be available for every indicator during every reporting period. It is appropriate to report "N/A" for indicators that have not been collected yet or are not reporting new information. The list of indicators should include but need not be limited to the following: o Development Impact indicators: ▪ household energy use (kWh/household) ▪ total $ value of displaced kerosene purchases ▪ household income ▪ value of household assets (est.) ▪ Average household energy use per night	$ 199,992.20

		(kWh/household) ▪ lighting hours available ▪ student school attendance and performance ▪ household fires due to lighting ▪ technical losses (expressed as stolen power/overall power supplied) ▪ Types of appliances used ▪ local costs of appliances o Cost Effectiveness Indicators ▪ direct beneficiaries/$ spent ▪ households/microgrid system ▪ cost/microgrid installation ▪ O&M costs/microgrid ▪ consumer price ($/kWh) o Sustainability/Scalability Indicators ▪ total direct beneficiaries ▪ total installed power supply ▪ # of systems installed ▪ average prepaid power purchase frequency ▪ average prepaid power purchase amount ▪ microgrids sold to investors (as stated on the project income statement)	
2	Award date + 8~~5~~ months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities include indicators listed in milestone 1 • Quarterly Income Statement • Identify an initial wave of 28 potential Gram Power microgrid sites. • JPAL to collect baseline survey data in 14 sites, and r~~R~~andomly assign these 14 sites to treatment and control groups. • JPAL to conduct data cleaning of collected data • ~~Secure government approval for project subsidies~~ • ~~Ministry of New and Renewable Energy (MNRE) sanctions project.~~	$199,992.20
3	Award date + 10~~7~~ months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities including indicators listed in milestone 1 • Quarterly Income Statements • Identify a second wave of 24 potential Gram Power microgrid sites (52 running total) • JPAL to collect baseline survey data in 26 sites (40 running total), and randomly assign these 26 sites to treatment and control groups (40 running total).	$49,998.05

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		• ~~J-PAL to collect baseline survey data from 20 treatment and control sites.~~ • ~~-~~Material ordered for 20 microgrid sites and received for 10 microgrid sites. • 2 Microgrid sites setup, and NGO/GP to promote take up of microgrids in these treatment sites • Connected HHs in 2 treatment villages (2 running total) are provided with high energy efficiency/low energy efficiency appliances • JPAL to conduct data cleaning of collected data	
4	Award date + 1 year, 4~~1~~ month	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities including indicators listed in milestone 1. • Quarterly Income Statements • Identify a third wave of 42 potential Gram Power microgrid sites (94 running total) • J-PAL to collect baseline survey data in 54 sites (94 running total), and randomly assign these 54 sites to treatment and control groups (94 running total). ~~data from 20 treatment and control sites (40 Total)~~ • 8 microgrids installed in treatment sites (10 running total), and NGO/GP to promote take up of microgrids in these treatment sites • Connected HHs in 8 treatment villages (10 running total) are provided with high energy efficiency/low energy efficiency appliances • JPAL to conduct data cleaning of collected data • Material ordered for balance 20 microgrid sites • Submit an Environmental Mitigation and Monitoring Report (EMMR) that summarizes compliance with mitigation requirements. EMMR should describe: o How Gram Power safeguards against the improper disposal of batteries o How Gram Power safeguards against the improper disposal of Gram Power units; and o Status of The Government of India's Ministry of Environment and Forests and other local laws and rules for battery collection and disposal and how Gram Power ensures that batteries used in Gram Power units are disposed of in accordance with such rules. o Provide evidence of conformity with local standards of satisfactory design and completed construction of microgrids, mounting frames, utility poles and transmission lines.	$349,986.35
5	Award date + 1 year, 7~~4~~ months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence:	$99,996.10

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		• Update of project implementation and evaluation activities including indicators listed in milestone 1 • Quarterly income statements • ~~J-PAL to collect baseline survey data from 20 treatment and control sites~~ • 10 microgrids installed in treatment sites (20 running total), and NGO/GP to promote take up of microgrids in these treatment sites • Connected HHs in 10 treatment villages (20 running total) are provided with high energy efficiency/low energy efficiency appliances • JPAL to conduct data cleaning of collected data • Material received for balance 20 microgrid sites	
6	Award date + 1 year, 10~~7~~ months	This milestone requirements is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities including indicators listed in milestone 1 • Quarterly income statements • ~~J-PAL to collect baseline survey data from 20 treatment and control sites (80 total)~~ • ~~Efficiency information provided to all connected households and invited to participate in lottery treatment~~ • 10 microgrids installed in treatment sites (30 running total), and NGO/GP to promote take up of microgrids in these treatment sites • Connected HHs in 10 treatment villages (30 running total) are provided with high energy efficiency/low energy efficiency appliances • JPAL to conduct data cleaning of collected data	$39,998.44
7	Award date + 2~~1~~ years, 1~~0~~ month~~s~~	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities including indicators listed in milestone 1 • Quarterly income statements • 10 microgrids installed in treatment sites (40 running total), and NGO/GP to promote take up of microgrids in these treatment sites • Connected HHs in 10 treatment villages (40 running total) are provided with high energy efficiency/low energy efficiency appliances • JPAL to conduct data cleaning of collected data	$19,999.22
8	Award date + 2 years, 5~~1~~ months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities including indicators listed in milestone 1 • Quarterly income statements	$19,999.22

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		• GP to continuously promote take up of microgrids in treatment sites • JPAL to collect endline survey in 40 sites (40 running total) • ~~Endline survey data collected from 40 treatment and 40 control sites~~JPAL to conduct data cleaning of collected data • ~~Deliver a draft of the final evaluation (including lessons for project improvement) and scaling report, addressing:~~ ~~o **Impact Evaluation:** The report should describe evaluation methods and preliminary results, using the plans approved in Milestone 1.~~ ~~o **Project Improvement:** The report should discuss lessons learned and action steps regarding improving the product. Topics must include (but need not be limited to) technical issues, progress engaging business partners, and success reaching base of the pyramid customers.~~ ~~o **Cost-effectiveness:** Using the methods and indicators in Milestone 1, assesses whether Gram Power provides 1) a cost-effective investment for the public sector if the project requires additional public support and 2) a cost-effective investment for customers. Provide a breakdown of all sources of revenue (including from other public or private funders). Differentiate between funding for research activities (e.g. data collection) and funding for business activities.~~ ~~o **Scaling:** Discuss progress towards scaling, including finances to date and the potential for financial viability at scale. If the project is successful enough to merit ongoing efforts, the report should provide an update on anticipated demand for the product; prospects for financial sustainability, and next steps to scale the product, including engaging stakeholders. The report should also discuss plans to disseminate results of the impact evaluation.~~ • Submit an Environmental Mitigation and Monitoring Report (EMMR) that summarizes compliance with mitigation requirements. EMMR should describe: o How Gram Power safeguards against the improper disposal of batteries o How Gram Power safeguards against the improper disposal of Gram Power units; and o Status of The Government of India's Ministry of Environment and Forests and other local laws and rules for battery collection and disposal and how Gram Power ensures that batteries used in Gram Power units are disposed of in accordance with such rules. • Provide evidence of conformity with local standards of satisfactory design and completed construction of microgrids, mounting frames, utility poles and	

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		transmission lines.	
9	Award date + 3~~2~~ years~~4~~	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative has been submitted to the AOR for review/concurrence: • Update of project implementation and evaluation activities including indicators listed in milestone 1. • Quarterly Income Statements and a revised 5-year projected income and cash flow statement. This revised projected income and cash flow statement should explain any difference from the projections included in Gram Power's original application. • GP to continuously promote take up of microgrids in treatment sites • JPAL to collect endline survey in 40 sites (80 running total • JPAL to conduct cleaning of collected data • Deliver a draft of the final evaluation (including lessons for project improvement) and scaling report, addressing: o **Impact Evaluation:** The report should describe evaluation methods and preliminary results, using the plans approved in Milestone 1. o **Project Improvement:** The report should discuss lessons learned and action steps regarding improving the product. Topics must include (but need not be limited to) technical issues, progress engaging business partners, and success reaching base of the pyramid customers. o **Cost-effectiveness:** Using the methods and indicators in Milestone 1, assesses whether Gram Power provides 1) a cost-effective investment for the public sector if the project requires additional public support and 2) a cost-effective investment for customers. Provide a breakdown of all sources of revenue (including from other public or private funders). Differentiate between funding for research activities (e.g. data collection) and funding for business activities. o **Scaling:** Discuss progress towards scaling, including finances to date and the potential for financial viability at scale. If the project is successful enough to merit ongoing efforts, the report should provide an update on anticipated demand for the product; prospects for financial sustainability, and next steps to scale the product, including engaging stakeholders. The report should also discuss plans to disseminate results of the impact evaluation. • ~~Deliver the final evaluation (including lessons for project improvement) and scaling report.~~	$19,999.22
		Total Fixed Obligation	**$999,961**

USAID DIV Timeline: Electrifying India Intelligently - Bringing Smart Grids to Rural India

Proposed no-cost extension

			YEAR 1 (Sept 1 2013 - Aug 31 2014)												YEAR 2 (Sept 1 2014 - Aug 31 2015)												YEAR 3 (Sept 1 2015 - Aug 31 2016)											
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Milestone	**Start**	**End**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
GP, UCB and J-PAL to finalize implementation plans, MOU	1-Sep-13	1-Oct-13																																				
J-PAL to hire and train Research Associate	1-Sep-13	1-Oct-13																																				
GP, UCB and J-PAL to finalize division of labor between the three part	1-Oct-13	31-Jan-14																																				
GP and UCB to finalize protocols for site selection and community mo	1-Dec-13	31-Jan-14																																				
GP to secure contract with NGO	1-Jan-14	28-Feb-14																																				
GP and J-PAL to train NGO on site selection	1-Feb-14	28-Feb-14																																				
NGO to identify eligible villages	1-Mar-14	31-Oct-14							14	14	12	12	12	10	10	10																						
GP and UCB to confirm eligibility of villages	1-Mar-14	31-Oct-14							14	14	12	12	12	10	10	10																						
J-PAL to conduct baseline survey in treatment and control villages	1-Apr-14	30-Nov-14								14	14	12	12	12	10	10	10																					
J-PAL to randomly assign villages to treatment and control groups	1-Apr-14	30-Nov-14								14	14	12	12	12	10	10	10																					
GP and NGO to conduct community mobilization activities (i.e., villag	1-Jun-14	30-Sep-15																									4											
GP to install microgrids in treatment villages	1-Jun-14	30-Sep-15										2	1	1	2	1	2	1	3	3	4	3	3	4	3	3												
Connected HHs in treatment villages are provided with high energy/lo	1-Jun-14	30-Sep-15																																				
GP to continuously promote takeup in treatment villages	1-Jun-14	31-May-16																																				
J-PAL to conduct endline survey	1-Oct-15	31-May-16																										10	10	10	10	10	10	10	10			
J-PAL data cleaning and analysis	1-Apr-14	31-Aug-16																																				
			Milestone 1							Milestone 2		Milestone 3						Milestone 4			Milestone 5			Milestone 6			Milestone 7				Milestone 8						Milestone 9	

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DIV Project: "Electrifying India Intelligently: Bringing Smart Grids to Rural India"
Partners: Gram Power, J-PAL South Asia, and UC Berkeley

Update on the Project Status and indicators outlined in Milestones 3 and 4:

The following update outlines the activities done so far concerning various aspects of the project and the planned activities in the near future.

- **Preparation for data collection-** Site survey and community mobilization forms were designed and developed together by J-PAL, UC Berkeley and Gram Power. Using these forms and the survey CTO server/application Gram Power is administering site selection and community mobilization activities on the field.

- **Site Identification-** Gram Power had hired a team for site identification and community mobilization activities. The team is responsible for bringing in un-electrified sites, which suits Gram Power's site selection criteria and sensitizes/mobilizes the community about the electrification plan. So far, Gram Power's site identification team has identified 124 sites out of which 40 have currently made it to the final list of microgrid sites. The identified sites are in Banswara District located in South Rajasthan, Baran District located in South East Rajasthan, Kota and Chittorgarh District located in West Rajasthan. 26 sites had been identified in Ghatol Tehsil in Banswara District from March 2014 to July 2014. A list of these sites is mentioned below:

    1. Bhom Pada-I
    2. Bhom Pada-II
    3. Her Pada-I
    4. Her Pada-II
    5. Lamba Ghata Pada-I
    6. Lamba Ghata Pada-II
    7. Aamli Pada-I
    8. Aamli Pada-II
    9. Gada Pada-I
    10. Gada Pada-II
    11. Gada Pada-III
    12. Sarpota Pada-I
    13. Sarpota Pada-II
    14. Agajiriya Pada-I
    15. Agajiriya Pada-II

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16. Hanuman Pura Pada-I
17. Hanuman Pura Pada-II
18. Gulab Pura Pada
19. Suna Khora Pada-I
20. Suna Khora Pada-II
21. Panchalwas Nayi Basti
22. Mohrukha Pura
23. Hijudi Pada
24. Timba Pada
25. Roan Pada
26. Umra Pada

21 sites had been identified from July 2014 to October 2014 in Shahbad and Kishanganj Tehsil in Baran District. A list of these sites with the survey details is summarized below:

S No	District	Block	Gram Panchayat	Hamlet	HH
1	Baran	Kishanganj	Vastoni	Git Pada	30
2	Baran	Kishanganj	Ghati	Borda I	30
3	Baran	Kishanganj	Ghati	Borda II	25
4	Baran	Kishanganj	Ghati	Boren I	126
5	Baran	Kishanganj	Ghati	Boren II	45
6	Baran	Shahbad	Sanwada	Sanwada	70
7	Baran	Shahbad	Sanwada	Matiya Khara	56
8	Baran	Shahbad	Sanwada	Pathari Shahriya Colony	61
9	Baran	Shahbad	Sanwada	Pathari Aahir Yadav	50
10	Baran	Shahbad	Sanwada	Basai	38
11	Baran	Shahbad	Sanwada	Sadhri Colony I	58
12	Baran	Shahbad	Sanwada	Sadhri Shahriya Colony II	75
13	Baran	Shahbad	Sanwada	Mandi Saavar Singha	32
14	Baran	Shahbad	Sanwada	Sandhri	80
15	**Baran**	**Shahbad**	**Sanwada**	**Khirkhiri**	**21**
16	Baran	Shahbad	Beel Kheda Daang	Chora Khadi I (Nayi Basti)	60
17	Baran	Shahbad	Beel Kheda Daang	Chora Khadi II (Purani Basti)	45
18	Baran	Shahbad	Beel Kheda Daang	Hari Nagar (Nayi Basti)	70
19	Baran	Shahbad	Beel Kheda Daang	Hari Nagar	65
20	Baran	Shahbad	Sanwada	Rijhol	18
21	Baran	Shahbad	Sanwada	Patan	39

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77 sites have been identified since October 2014 in the Districts of Banswara, Baran, Kota and Chittorgarh. A list of these sites is provided below:

1. Jaitpura
2. Pandeya Por
3. Borpi Kareng-I
4. Borpi Kareng-II
5. Devli Aada
6. Chundai
7. Chandiya
8. Timu Tapra
9. Badeta
10. Jhapa Pada
11. Sooraji Kheda
12. Bawri Kheda
13. Siya Talayi
14. Taraka Pada
15. Aamli Pada
16. Kakra Pada
17. Chimrolgad
18. Siyaliya Pada
19. Sor Vadala
20. Katha Pada
21. Sangama
22. Jatov Colony
23. Mahori Colony
24. Manka Kheda
25. Karaliya
26. Anjani
27. Sandokra
28. Kasba Nunera
29. Majhari Colony
30. Devri Colony
31. Boheyl Colony
32. Kali Mati
33. Kunda
34. Kasba Thana Colony
35. Gajron

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36. Raj Khera
37. Koti Khera
38. Jaitpura
39. Kherua Basti
40. Naya Gaon
41. Binjoliya Banjaran Basti
42. Sehriya Basti Nahargad
43. Jeswa
44. Jawaipura
45. Sunda
46. Dikoniya
47. Bamanda
48. Gareda Pura Colony
49. Joga Colony
50. Thakur Baba Colony
51. Mohdari Bhilan
52. Nathan Mohdari-I
53. Nathan Mohdari-II
54. Moheda
55. Kherua Mohdari
56. Aor basti
57. Iklera Danda
58. Sodana ka Danda
59. Akawa
60. Kolipura
61. Khanpuriya
62. Damodarpura
63. Keshopura
64. Mandirgarh
65. Kasar Station
66. Talab Gaon
67. Molath-I
68. Molath-II
69. Baga Ka Jhopda
70. Borkui
71. Dhuva Dhop
72. Khati Kheda Badya
73. Jed Phala

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74. Sobaniya
75. Ghati Pada
76. Nava Tapra
77. Samla Pada

Of the 77 sites listed above, 40 have been finalized for installation of microgrids. Of the 40 sites listed above Gram Power has already set up microgrids in 10 sites. A list of these sites with the survey details is summarized below:

S.No	Site	District	HH's
1	Khirkhiri	Baran	21
2	Kolipura	Kota	48
3	Khanpuriya	Kota	47
4	Gajron	Baran	39
5	Jeswa	Baran	36
6	Damodarpura	Kota	32
7	Jawaipura	Baran	38
8	Kunda	Baran	42
9	Kasba Thana colony	Baran	28
10	Keshopura	Kota	30

- **Baseline survey administration-** J-PAL has hired a Project Associate and a project assistant for administering baseline survey. J-PAL has also hired a survey team for assisting the project Associate in administering the baseline. The baseline instrument is finalized, field tested and already in use. J-PAL has already completed baseline in 22 villages covering 715 households. A list of these sites is given below:

S. No	Site	District
1	Khirkhiri	Baran
2	Kolipura	Kota
3	Khanpuriya	Kota
4	Gajron	Baran

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5	Jeswa	Baran
6	Damodarpura	Kota
7	Jawaipura	Baran
8	Kunda	Baran
9	Kasba Thana colony	Baran
10	Keshopura	Kota
11	Mandirgarh –I	Kota
12	Mandirgarh- II	Kota
13	Jaitpura	Banswara
14	Pandeya Por	Banswara
15	Badeta	Banswara
16	Chundai- I	Banswara
17	Chundai- II	Banswara
18	Jhapa pada	Banswara
19	Dhuva Dhop	Kota
20	Khati Khera Badya	Kota
21	Sandhri -I	Baran
22	Sandhri –II	Baran

Meanwhile, keeping the modified research design in mind, J-PAL is starting to work closely with the state utility to gather baseline data from the already electrified villages where Gram Power will be installing smart meters.

- **Appliance Distribution-** J-PAL has completed the distribution of high and low efficiency appliances in a total of 10 sites. This covers 361 households where the microgrids have been installed and are operational. The list of these sites is given below:

S.No	Site	District
1	Khirkhiri	Baran
2	Kolipura	Kota
3	Khanpuriya	Kota
4	Gajron	Baran
5	Jeswa	Baran
6	Damodarpura	Kota
7	Jawaipura	Baran
8	Kunda	Baran

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9	Kasba Thana colony	Baran
10	Keshopura	Kota

- **Preparation for microgrid installation-** Gram Power had entered into a contract with Rays Power Experts for installing the microgrid in Khirkhiri. For the rest of the microgrid sites Gram Power has entered into contract with Aubade Solar Private Limited for commissioning the generation unit. Gram Power has released an order of 110 kWp to the contractor. Gram Power has completed installation of a total of 55 kWp worth of generation capacity in 10 sites and the plants are now operational.

- **Microgrid installation**- For the remaining villages, once a minimum of 75% of households buy into the system, demonstrated by deposit of full connection fee as advance, Gram Power will install microgrids in each treatment village, barring any unforeseen obstacles.

- **Ongoing encouragement-** To promote better uptake, earn trust and ensure operational viability of the plant, Gram Power has adopted a participatory community approach under which the ownership of the microgrids will be with the community. In each hamlet where the plant is set up, Gram Power will form a committee or identify a village leader to set up a joint account for depositing the payments collected from the village. The village committee/leader and Gram Power will jointly hold the payments collected from consumers. The committee has to pay Gram Power for any maintenance visit done by its technical staff to the village in addition to a nominal fixed monthly charge. Gram Power will train the representatives of the committee on the necessary technical skills required for preventive maintenance of the micro grid. This model is being experimented because Gram Power plans to scale up its microgrid work in India through projects that are funded by the Government. 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. Having a joint bank account for plant operations will keep all transactions completely transparent to the village and ensure the consumers that their payments are being used only for the upkeep, maintenance and/or expansion of this asset.

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Update on delay and other Milestone Activities.

Reasons of Project Delay: From March to July 2014, Gram Power had identified 26 hamlets in Banswara district in Southern Rajasthan. While the community mobilization activities were going on, the distribution utility announced a plan to electrify a few of the villages that were listed in the 26 hamlets that we had identified as potential Gram Power microgrid sites. The information, though dubious, about the Government's plan to extend the grid spread even in villages that were not included in the state's electrification plan. This gave rise to false expectations in these communities who then lost interest in Gram Power's microgrids in the hope that they would be getting electricity from the local distribution utility. Hence Gram Power and its local partner had to face difficulties on the field to ensure the financial buy in from the community. This led to a 3-month delay in the project as we had to identify a completely new cluster to implement our project.

By September 2014, Gram Power had identified a new wave of 21 sites in Baran district. Gram Power faced a further obstacle in theses villages. A senior politician from the government announced in his campaign speech that these villages would be getting grid connectivity as early as October 2014. In Baran district, the villages largely fall under the forest areas, where grid extension is legally not allowed. This announcement although deceitful gave rise to false expectations in these communities causing further delay in the project. Since there is no clear policy from the state government on grid extension to microgrid sites, it was difficult to convince the hamlets to pay up for Gram Power's microgrids. In the month of October 2014, Gram Power managed to convince the community of Khirkhiri in Baran district and install Gram Power's microgrid believing that the installation of one plant in one of the villages will have a herd effect and promote take up in the remaining villages. For achieving the same Gram Power sought the help of the senior politician who convinced the community for the microgrid and inaugurated the plant in the month of December.

Gram Power is still in touch with the local leaders from these hamlets but the villages have been currently de-prioritized. Gram Power intends to revisit these sites once the community has better clarity on state's electrification plan and we have implemented our project in the villages identified in Baran district.

Since October 2014, Gram Power has identified 77 potential hamlets in the districts of Banswara, Baran, Kota and Chittorgarh for installing microgrids. Of the 77 sites 40 sites had been finalized for installing microgrids. 10 microgrids have already been installed. Gram Power has been facing issues with financial pay up in the rest 30 sites.

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Updated Monitoring & Evaluation Plan

The research design had been modified after consultation with the project partners and with the consent of USAID. Which is outlined below:

The overarching goal of this project is to evaluate the impacts of Gram Power (GP) micro-grid technology, placing particular emphasis on how this technology performs vis-a-vis the more standard government-provided electricity connections. To this end, in addition to the 40 villages wherein GP microgrids will be installed, GP and UCB-MDT propose to evaluate villages connected to the government grid. These government-connected villages are being proposed to be finalized in Bihar where Gram Power has entered into a partnership with India's biggest private utility. A total of 1101 households in 4 villages have been identified in these areas where loss levels are as high as 80% and hours of power availability are as low as 8hrs/day. Despite the fact that these sites have electricity, the poverty levels are either similar or worse off than our microgrid sites. We have carried out a first wave of surveys in these households and are currently in talks with the utility to increase the scope of the project to 5000 smart meters. If Gram Power is able to validate our technology on the ground and prove the financial viability of installing smart meters, the utility is committed to getting into a partnership with Gram Power to make us their exclusive suppliers of smart metering technology.

Including government sites in the evaluation will allow GP and UCB-MDT to compare outcomes such as energy use and theft (described in more detail below) between GP microgrid systems and grid-connected villages. Note that this comparison is potentially confounded by difference in unobservable factors, since assignment to the GP system/government grid is non-random. Nevertheless, the results will provide information that may help GP scale up its operations, as well as understand and communicate the value of its Smart Grid technology.

While the research questions are being finalized with the utility, the following sections describe two possible directions for the evaluation based on discussions between GP and UCB-MDT and initial discussions with the utility. In particular, we describe two questions that the evaluation may be able to answer by comparing the GP microgrid villages and government-connected sites.

Evaluation Question 1: How do newly connected households use electricity? Does the GP technology facilitate more informed and efficient electricity demand? If so, how is this accomplished?

We will first examine basic energy usage patterns of households in GP microgrid sites using the high-frequency energy consumption data from GP's smart meters. We will also conduct a detailed baseline survey in the GP sites to gather information on use of alternative energy sources, appliance holdings,

etc. This combination of smart meter and survey data will allow us to examine how newly connected households consume energy. For example, by how much does electricity substitute for kerosene consumption? What is the load factor of a typical household's consumption? How much consumption is at night versus during the day? This analysis will not only inform energy policies in developing countries, but it will also demonstrate the value of GP's smart meter technology for data collection.

In addition, we will conduct an experiment where we will distribute appliances to households in both GP microgrid and government regime, allocating high efficiency versions of the appliances to a randomly selected subset of households. We will also install GP meters in households in the government regime, for high-frequency data collection on energy consumption similar to the microgrid sites. Then, we will compare electricity consumption patterns across households with/without efficient appliances. Within each regime, this comparison yields unbiased estimates of how household demand will respond to policies that promote accelerated diffusion of more efficient appliances. In particular, we will be able to examine whether the demand responses to energy efficiency improvements are more pronounced in households in GP microgrid sites. If so, this would suggest that GP's technology facilitates more sophisticated and informed energy consumption choices.

To complement the appliance experiment, we will also conduct an information experiment involving the government-connected sites using a randomized phase-in design. Specifically, when the meters are first installed in these sites, they will show no information on energy consumption. Then, we will randomly roll-out this meter feature across households over time. Doing so will allow us to examine whether the provision of information mitigates the difference in energy consumption responses between GP microgrid and on-grid villages. That is, how important is pre-payment versus information in explaining differences in demand response across GP/government systems?

Evaluation Question 2: Does the GP system reduce electricity theft vis-a-vis a normal grid-connected government setting?

We will conduct a careful comparison of measures of theft at the GP microgrid sites relative to villages with grid connections. Since government data on power flowing through the grid may be unreliable, GP and UCB-MDT are currently exploring ways to monitor and measure theft that are accurate and technically feasible. One important challenge is to reduce biases arising from Hawthorne-type effects (e.g., individuals change their behavior because they know they are being monitored). Possibilities for overcoming this challenge include monitoring at the system- or transformer-level.

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Environment Mitigation and Monitoring

How Gram Power safeguards against the improper disposal of batteries?

The manufacturer of the batteries in India set up collection points, either individually or jointly, for used batteries from consumers or dealers. These batteries are collected at collection points on scrap value wherein the rate is set per kilogram of dried out weight of the battery (i.e. after the used acid is removed from the batteries).

In the case of Gram Power's battery supplier, the batteries are collected by Lead Battery Recycling Plants (or collection points) who later provide waste battery recycling process for the battery manufacturer. These companies provide solutions from Lead battery breaking & separation to Lead refining & alloying. This ensures that the toxic substance Lead Sulphate which is formed while a battery discharges is carefully disposed. The Lead Sulphate can be reprocessed to form Lead and Sulphuric acid and they are used as raw material by the manufacturer.

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 standards *(See Annexure)*. The design has been approved by a Senior Civil Engineer for stability. The enclosure is properly guarded by trusted locals. The enclosure is kept locked at all times to keep them safe from animals and other natural hazards.

Status of The Government of India's Ministry of Environment, Forests and Climate Change and other local laws and rules for battery collection and disposal and how Gram Power ensures that batteries used in Gram Power units are disposed of in accordance with such rules.

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

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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)

Gram Power returns the batteries to and authorized recycler registered with the Ministry and assigned by the Manufacturer. They are responsible for collecting and recycling used batteries on behalf of Gram Power's battery manufacturer.

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.

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ANNEXURE

ENCLOSURE FOR INVERTERS, BATTERIES AND COMMUNICATION EQUIPMENT

Figure 1: Enclosure at site

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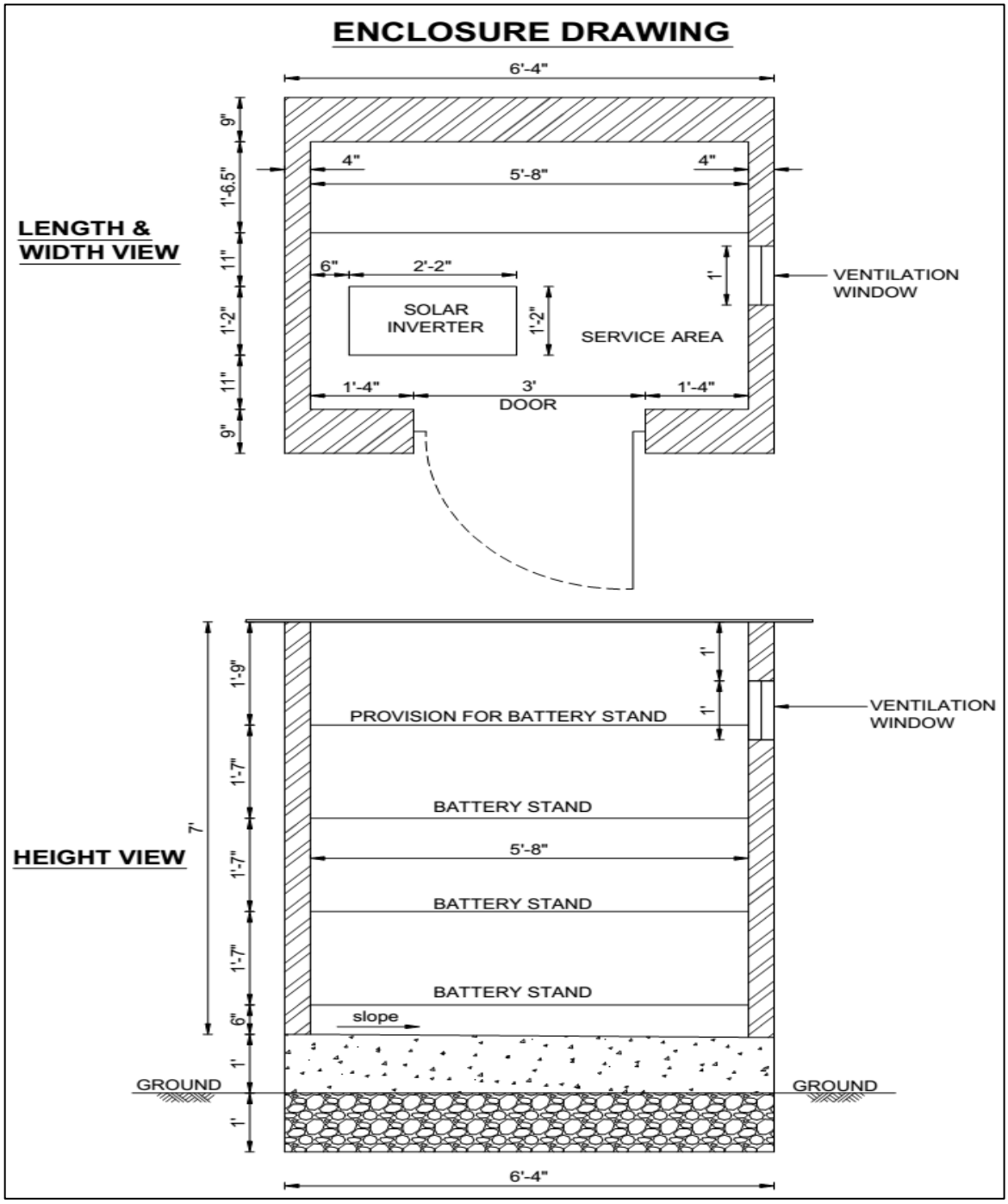

Figure 2: Enclosure Drawing (approved by Civil Engineer)

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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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Director

Gram Power India Private Limited & Aubade Solar (Sign & Stamp here)

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Figure 3: Mounting Structure in Keshopura

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Figure 4: Mounting Structure in Khirkhiri

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INVERTERS

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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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BATTERIES

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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 1651:1991Temperature Response – 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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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