DEVELOPMENT OF
"SOLAR PV BASED MICRO GRIDS"
IN
ANDHRA PRADESH

(VILLAGE ELECTRIFICATION)

Final Report

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ACKNOWLEDGMENT

We are sincerely thankful to "Godrej Consumer Products Limited (GCPL)" for their everlasting support in implementation of the Solar PV based micro grids in the state of Andhra Pradesh.

We express our gratitude to "Godrej Consumer Products Limited (GCPL)" for giving us the opportunity to be a part of this first of its kind large scale initiative in the "Village Eectrification". We also acknowledge the support and guidance provided by the GCPL team during the feasibility study, Training support, implementation of the solar PV based micro grids for village electrification. We are also thankful to the Forest Department, ITDC and Government of Andhra Pradesh for their immense support.

The implementation would not have been completed on time without GCPL team's interaction and timely support. We are grateful for their cooperation during the in the project area.

EXECUTIVE SUMMARY

Agricultural and Social Development Society (ASDS) is implementing the Village Electrification projects by developing Solar PV based micro grids in East and West Godavari Districts of Andhra Pradesh. The project is developed under Corporate Social Responsibility (CSR) scheme of Godrej Consumer Products Limited (GCPL). In the first phase, first phase 18 numbers of villages covering 460 households were electrified. The detailed list of villages and the projects is discussed in the next chapters. A total of 22 kWp was installed in the first phase, the last system was commissioned in Pusugumpuvillage on 7 May 2017.

1 INTRODUCTION

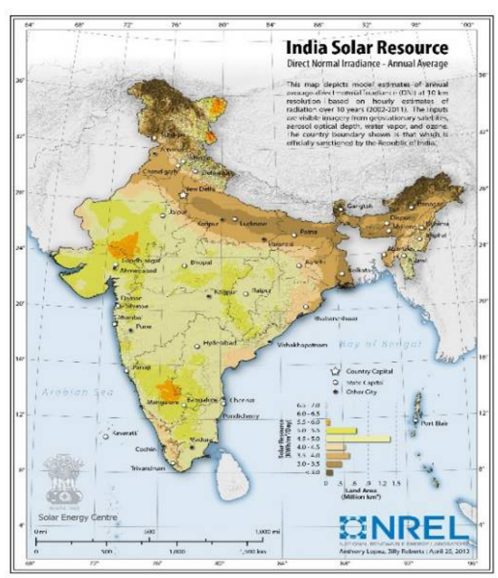
The Ministry of New and Renewable Energy (MNRE) aims to attain a sustainable growth in the country by securing the energy needs through Renewable Energy (RE) sources such as Solar, Wind, Biomass, Hydro etc. Along with the support to large scale RE generators, the Ministry also promotes the Decentralized Energy Generation solutions based on sources such as Solar, Wind, Biomass, Hydro etc for meeting the Electrical and Thermal energy requirements especially in rural areas.

<u>Renewable Energy in India:</u>

India has set an ambitious target of reaching 175 GW of installed capacity from renewable energy sources including 100 GW from solar and 60 GW from wind by the year 2022. Various policy initiatives have been taken to achieve this target.

Solar and wind power being infirm in nature impose certain challenges on grid security and stability. Studies revealed that solar and winds are almost complementary to each other and hybridization of two technologies would help in minimizing the variability apart from optimally utilizing the infrastructure including land and transmission system.

2 SOLAR POTENTIAL IN INDIA



India, with its large population and rapidly growing economy, needs access to clean, cheap and reliable sources of energy. India lies in the high solar insolation region, endowed with huge solar energy potential with most of the country having about 300 days of sunshine per year with annual mean daily global solar radiation in the range of 4 - 7 kWh/m^2/day. Solar power can also help meet energy requirements for both grid connected as well as off-grid applications such as solar powered agricultural pump sets.

3 PRESENT SCENARIO

Agriculture and Social Development Society (ASDS) is actively working in developmental activities in East and West Godavari districts of Andhra Pradesh State, India. ASDS identified 25 villages for electrification in the first phase. In the first phase 460 houses were electrified in 18 villages. At present, the identified villages do not have any electricity supply. The main source of revenue to the villagers is by way of daily labour to nearby towns. The identified villages do not have any educational institutions, community centres, etc. The villagers walk for at least 3 kms for purchasing any grocery items etc. The villagers return back to their houses and complete their daily activities before sunset. Some of the households lit the houses with kerosene lamps while most of the houses cannot afford. There is a good potential for installation of micro grids and electrify the villages.

4 MICRO GRIDS

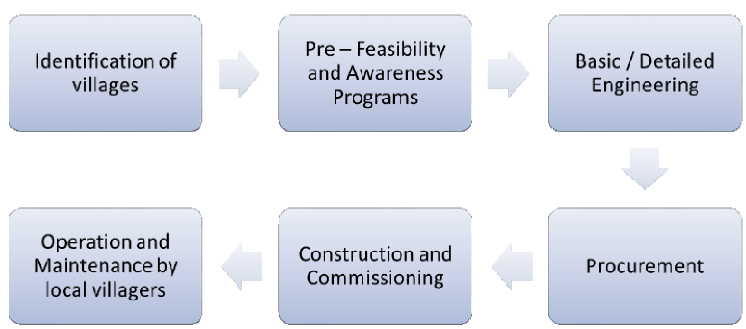
A 'Micro Grid' system is similar to a mini grid but having a RE based generation capacity of below 10 kW. Micro and mini gridsgenerally operate in isolation to the electricity networks of the DISCOM grid (standalone), but can also interconnect with the grid to exchange power. If connected to grid they are termed as grid connected mini/ micro grid.

5 ROAD MAP

PROJECT DEVELOPMENT PROCESS

The team of experienced people will be working on Renewable Energy based projects from conception to commissioning. The systematic approach will enable for reliable project development in this specialized market with maximum involvement in decision making by the stakeholders.

For any project, it is proposed to follow the following procedure for development of the project. The following phases, carefully concluded at the end of each phase with the Owner, Operator and Stakeholders:



S No	Activity	Description
1	Pre – Feasibility	A top-Line Evaluation of the possibilities, requirements and objectives for a specific site. The pre-feasibility includes financial cost and revenue estimation and is intended as a bases for strategic decision making.
2	Awareness programs	Conduct Awareness programs and Training Programs about the proposed projects
3	Basic Engineering	During basic engineering, final technical decisions are made and the documentation for procurement is generated
4	Detailed Engineering / Design	All engineering documentation, Layout drawings, Electrical schemes, Civil and Structural drawings, instructions in 'good for construction' status
5	Procurement	Procurement of all the Equipment as per Bill of Material (BOM)
6	Construction	To carry out the supervision of construction activity and quality of the works as per the standards
7	Commissioning and Start up	Commissioning and operation of wide range of Power Projects

6 EMPLOYMENT GENERATION

Installation and commissioning of micro grids generates the employment both for unskilled and skilled labour. The unskilled people can be used for Mechanical and Civil works such as erection of module mounting structures, solar modules, civil foundation, etc. During the construction of the micro grids, local villagers were employed.

Three people were shortlisted at the district level for providing the rigorous training on the installation and commissioning, O&M of the Solar PV based micro grids. The trained professions will be responsible for carrying out the maintenance and also train the youth. The trained youth on Solar PV micro grids can get placed in Solar PV power plants in India and abroad.

7 SKILL SET REQUIRED AND CHALLENGES

Installation of renewable energy power project is a step in the right direction, it poses few challenges and at the same time provides a plethora of opportunities. One of the major challenges is to meet the growing need for skilled manpower, both in terms of quality and quantity.

Some of the key issues related to manpower are:

Availability of adequate skilled manpower

The sector is facing challenges in sourcing skilled manpower in many functional areas like manufacturing, production, installation, operation & maintenance, marketing and research & development. As the sector is relatively new and fast growing, there is a shortage of experienced or skilled manpower. It is also important to note that the renewable energy sector is more manpower-intensive than the conventional energy sector.

Attracting talent

There is a general lack of awareness amongst the student community on the challenging career and entrepreneurial opportunities that exist in this sector. There is an opportunity to attract students, enthusiastic young entrepreneurs, and experienced professions in this sector.

Training and capacity building

The installation, operation and maintenance of renewable energy systems need specific skills and knowledge. To impart this skill and knowledge to those entering the sector as well as continuously upgrading them, there is a need for training and capacity building. Currently there is a shortage of renewable energy trainers or training centres, who can offer this service to the industry. Also, there is a need to setup institutional mechanisms to offer intensive and comprehensive training in all aspects of renewable energy.

8 COMMUNITY OWNERSHIP

Apart from creating improved access to electricity, the plan is to generate a sense of ownership to the project from the community by ensuring their participation from the very beginning. This enables long term ownership of the system and hence its sustainability. Essentially the idea is that each household contributes a certain amount per month as decided by the Gram Sabhas to contribute towards basic maintenance of the system even though in practise this might pose as a challenge particularly with regards to regularity in contribution.

It is in this context, that we propose a metering system along with the solar system (at least one per village, which is not considered at this stage) so that the community can be made aware of their consumption patterns and accordingly be willing to make corresponding contribution towards maintenance.

In addition, in the long term the government's policy on net metering (when installed) policy may facilitate the community to augment their contribution towards maintenance of the solar project by contributing to grid electricity.

WOMEN SUPPORT:

In the first phase, the local villages cooperated in installation and commissioning of the projects at different villages. Women of the local villages actively supported in Civil and Mechanical works while installation of the project. The involvement of women during the project construction phase shows the need of electricity for the villages.

Photographs: Women helping in installation and commissioning of the project

8.1 Community Organization and Exposure

Since the community is quite unaware of the efficacy of such a solar system, capacity building programs with the community before and after the installation is imperative. Several meetings were organized with representatives of the villages that will receive power from the project.

The initial attempt was to explain how the Solar system works and will power the village along with its limitations. One person from each village was identified to create awareness about the solar powered systems. Eventually we envisage informal committees in each village to emerge to carry out the responsibilities related to running and maintaining the system.

8.2 Operational committee

Youth normally come forward to learn how to run the system. One youth from each village invited to take responsibility to ensure collections every month and take care of basic issues that may arise in the electricity distribution. The youth will also be responsible for training the fellow villagers. The idea is that he is given basic training in the precautions necessary to run the system and take care of minor repair issues. Additionally, when there is a major problem they could get in touch with implementing agency and seek consultation from qualified engineers to make the necessary repairs.

Each household contributed a onetime amount of Rs 150 towards the project. Village level committee will be responsible for managing the corpus fund for any repair and maintenance of the system.

9 CAPACITY BUILDING

During the implementation of the Solar PV based micro grids, the local villagers were also trained on the installation of the systems. The following people were trained both class room as well as onsite.

S No	Name of the villager	Village Name	Mandal	Nature of work
1	NupaChukkaiah	Yedugurallapalle	Chintooru	Installation of BoS – House wiring, installation of boards, Micro Grids, holders etc
2	PallalaSomraju	Rekhapally	Rekhapalle	
3	NallarapuPavan Kumar	Suddagudem	Chintooru	

The identified trainers were given training in the following areas

- Electrical circuits
- Installation of Micro Grids
- Household electric connections
- Connecting the Solar PV systems
- Installation of Solar PV systems
- Maintenance of Solar PV systems

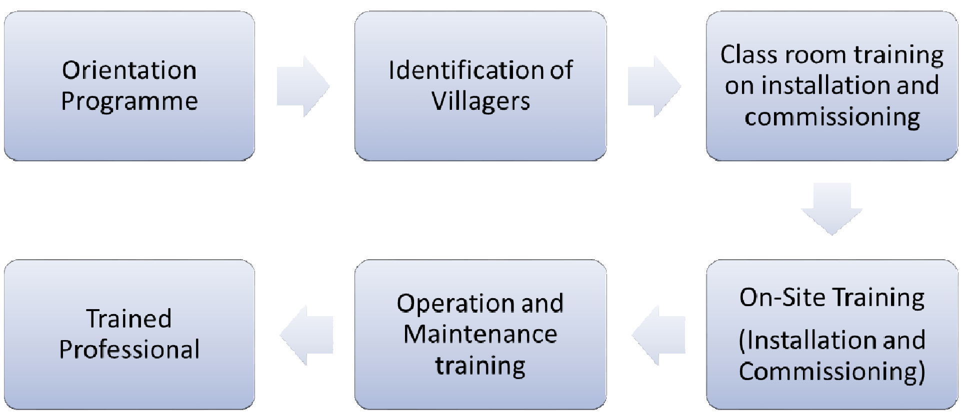
The above local villagers are now familiar about the micro grids installation and commissioning. The team is also familiar with general Operation and Maintenance (O&M) of the micro grids.

The three member team was trained on installation and commissioning training from 19th March 2017 to 7th May 2017. The tree member team was also given stipend for their support towards the installation and commissioning.

<u>Awareness programme:</u>

Orientation training programme was conducted in ASDS office on the village electrification.

Details of the Solar PV micro grid systems and the operation and maintenance requirements were discussed in detail with all the villagers. The load limitations and the system configuration was also discussed in detail. Villagers actively participated in the discussion and showed interest in installation of the micro grids for villages.



10 PROJECT BACKGROUND

The programme intends to establishment of mini grids in the state of Andhra Pradesh. The micro grids will be established in East Godavari and West Godavari districts. It was proposed to electrify the identified villages in four phases.

A total of 18 villages were identified for electrification in the first phase. The details of the houses:

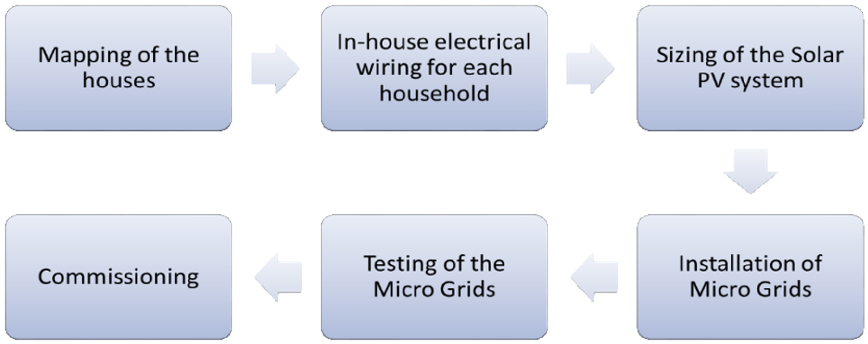
S No	Name of the Village	Total H/H	In house wiring and Micro Grid connected Nos (No of H/H)
1	Mallavaram	14	14
2	Gollaguppa	44	44
3	Bandirevu	21	21
4	ThatiGondi	18	18
5	Chukkalapadu	30	30
6	NarsingPadu	23	23
7	ChimulaVagu	26	26
8	Chandranna camp	9	9
9	Ramachandrapuram	39	39
10	Rajiv Camp	9	9
11	Venkatapuram	21	21
12	Allivagu	35	35
13	Errabore	16	16
14	ChupuruChilaka	31	31
15	Regula Cheruvu	34	34
16	Reddy Gudem	43	44
17	Jaggaram	41	41
18	Pusugumpu	6	6
	Total	**460**	**460**

In the Phase – 1, a total of 18 numbers of villages are electrified using a Solar PV based system. 460 households were given electrical connections and fully electrified.

11 INSTALLATION AND COMMISSIONING

Installation and Commissioning of the project was divided in to different phases.

1. Mapping of the houses
2. Electrical wiring for households
3. Sizing of the systems
4. Installation of Micro Grids
5. Testing
6. Commissioning



Installation of micro grids and electrical BOS started on 19thMarch 2017. The first village was commissioned on 3rd April 2017 and the last micro grid was commissioned on 7th May 2017. The details:

S No	Name of the Village	Total H/H	No of PV Systems Commissioned	Commissioning Date
1	Mallavaram	14	1	04-Apr-17
2	Gollaguppa	44	2	03-Apr-17
3	Bandirevu	21	1	06-Apr-17
4	ThatiGondi	18	1	06-Apr-17
5	Chukkalapadu	30	1	19-Apr-17
6	NarsingPadu	23	1	02-May-17
7	ChimulaVagu	26	1	26-Apr-17
8	Chandranna camp	9	1	17-Apr-17
9	Ramachandrapuram	39	2	19-Apr-17, 1-May-17
10	Rajiv Camp	9	1	17-Apr-17
11	Venkatapuram	21	1	03-May-17
12	Allivagu	35	1	03-May-17
13	Errabore	16	1	02-May-17
14	ChupuruChilaka	31	1	21-Apr-17
15	Regula Cheruvu	34	2	22-Apr-17
16	Reddy Gudem	43	1	23-Apr-17
17	Jaggaram	41	2	06-May-17
18	Pusugumpu	6	1	07-May-17

The commissioning of the micro grids was done only after complete testing of the system. Some of the photographs:





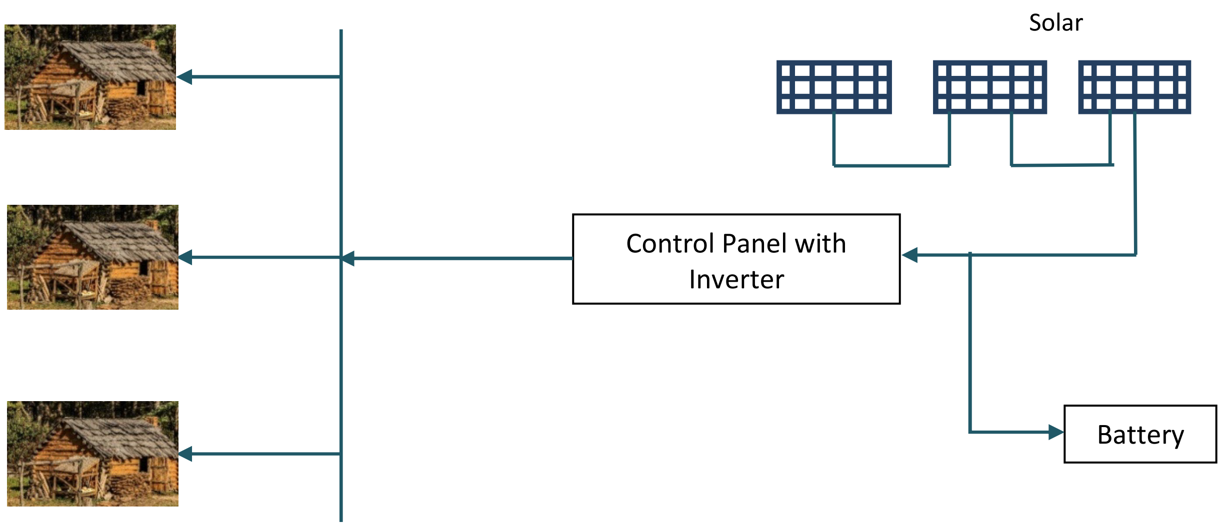
12 SYSTEM MAPPING

System mapping was carried out for all the villages. All the households are marked with house numbers. The distance between the houses was measured and recorded. Based on the mapping study, the optimal sizing of the system design was carried out. The details are annexed as an annexure to this report.

13 MICRO GRID PROJECT

Details of the each equipment:

The key components of a solar photovoltaic power system are the photovoltaic cells (solar cells) interconnected and encapsulated to form a photovoltaic module (the commercial product), the mounting structure for the module or array, the inverter and a battery system for storage. The typical line diagram is given below:



Solar PV technologies:

Crystalline silicon technologies currently account for most of the overall cell production. Single crystal PV cells are manufactured using a single-crystal growth method and have commercial efficiencies between 15 % and 20%.

Thin film cells, constructed by depositing extremely thin layers of photovoltaic semi-conductor materials onto a backing material such as glass, stainless steel or plastic, show stable efficiencies in the range of 7 % to 15 %. Thin film materials commercially used are amorphous silicon (a-Si), cadmium telluride (CdTe), and copper-indium-gallium-diselenide (CIGS) and Copper Indium Selenium (CIS).

The PV modules must confirm to IEC 61215 or equivalent BIS Standards, IS14286, for PV module design Qualification and type approval.

The crystalline technology is chosen for the proposed project due to its advantages in terms of technology, efficiency, ease of production / availability etc. For the proposed project it is proposed to deploy 250 Wp. For a building a 1,000 Wp system 4 numbers of 250 Wp solar PV modules will be utilized. The modules will be

Inverter:

Inverters are used for DC voltage to AC voltage conversion. According to output voltage form they could be rectangle, trapezoid or sine shaped. The most expensive, yet at the same time the best quality inverters, output voltage in sine wave. Inverters connecting a PV system and the public grid are purposefully designed, allowing energy transfers to and from the public grid. Inverters connected to module strings are used in wide power range applications allowing for more reliable operation.

MNRE empanelled inverters, MPPT type of capacity to be installed for any project.

For the project it is proposed to deploy 1,250 VA inverter, the modules connected in series and parallel will connected to the inverter for converting DC to AC. The output voltage of the inverter is connected to the LT side (~ 230 V) for domestic applications.

Module Mounting Structures:

The module mounting structure is designed for holding suitable number of modules in series. The frames and leg assembles of the array structures is made of mild steel hot dip galvanized of suitable sections of Angle, Channel, Tubes or any other sections for steel structure to meet the design criteria. All nuts and bolts considered for fastening modules with this structure are of very good quality of Stainless Steel. The array structure is designed in such a way that it will occupy minimum space without sacrificing the output from SPV panels at the same time.

Standards: Modules shall be mounted on a non-corrosive support structures towards due south and at a suitable inclination to maximize annual energy output. Mounting structure should be withstand for 180 Kmph wind speed with sustainability certificate. Support structures shall be manufactured with steel angles and channels; hot dip galvanization to IS 1416.716.7 Part -1. Structure shall be designed for mounting of offered Solar Modules with angle adjustment facility from 5° to 45° with an interval of 5°. All fasteners shall be of Stainless steel - SS 304.

Batteries:

Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode to which cations (positively charged ions) migrate. Cations are reduced (electrons are added) at the cathode during charging, while anions are oxidized (electrons are removed) at the anode during charging. During discharge, the process is reversed. The electrodes do not touch each other, but are electrically connected by the electrolyte. Some cells use different electrolytes for each half-cell. A separator allows ions to flow between half-cells, but prevents mixing of the electrolytes.

MNRE Empanelled Batteries shall be Flooded Electrolyte Type, Positive Tubular Plate; low maintenance or Tubular gel Valve Regulated Lead Acid (VRLA) type batteries of 2 or 12 Volts cell of capacity as indicated in the scope of works of the system to be installed.

For the project it is proposed to deploy four numbers of 150 AH batteries for each 1000 Wp system to make sure that the battery provides necessary power backup. The DC energy generated from the Solar PV panels will be used for charging the battery during the sunny hours. The batteries will supply power during the night time or when required based on the energy demand.

Cables and Connectors:

The size of the cables between array interconnections, array to junction boxes, junction boxes to inverters etc shall be so selected to keep the voltage drop and losses to the minimum. Our effort will be to source the bright annealed 99.97% pure bare copper conductors that offer low conductor resistance, they result in lower heating thereby increase in life and savings in power consumption. These wires are insulated with a special grade PVC compound formulated. The skin coloration offers high insulation resistance and long life. Cables are flexible and of annealed electrolytic grade copper conductor and shall confirm to standards and are extremely robust and resist high mechanical load and abrasion.

Civil works:

The civil engineering works shall include the design, detailing, and construction of all foundations, structures, installation and service of facilities required for the installation, commissioning, operation and maintenance of all equipment associated with the Power Plant.

The civil works includes the following: preliminaries, additional survey, soil exploration, piling if needed, ground improvement, foundations, and all necessary site investigation associated with the operations. Site leveling and grading with boundary fences, and gates (if required). In order to avoid flooding, rain water drainage system may be considered while designing the plant layout.

Other Accessories:

The energy generated from the solar PV modules is directed to the central inverters through the DC combiner boxes and from the inverters it is routed though the Low voltage panel / loads.

The BoS items / components of the Solar PV Power Plants/ systems must conform to the latest edition of IEC/ equivalent BIS Standards as specified:

BoS item/component	**Applicable IEC/equivalent BIS Standard**	
	Standard Description	**Standard Number**
Power Conditioners/ Inverters	Efficiency Measurements Environmental Testing	IEC 61683 IEC 60068 2 (6,21,217,30,778)
Charge controller/ MPPT units	Design Qualification Environmental Testing	IEC 62093 IEC 60068 2 (6,21,27,30,75,78)
Cables	General Test and Measuring Methods PVC insulated cables for working Voltages up to and including 1100 V-Do-, UV resistant for outdoor installation	IEC 60189 IS 694/ IS 1554 IS/IEC 69947
Switches/Circuit Breakers / Connectors	General Requirements Connectors – safety	IS/IEC 60947 part I,II,III EN 50521
Junction Boxes/	General Requirements	IP 65 IP 21 IEC 62208

Enclosures		
SPV System Design	PV Stand-alone System design verification	IEC 62124
Installation Practices	Elect. installation of building requirements for SPV power supply systems	IEC 60364-7-712

14 PROPOSED PROJECT CAPACITY

The sizing of the project was carried out based on the number of households and also the connected load. The electrical appliances supplied to each household is tabulated below

S No	Particulars	Wattage	No of equipment
1	LED Bulbs	5 W	2 Nos
2	Mobile phone Charging Point	5 W	1 No
3	TV Charging Point (village level)	50 W	1 No
4	Losses (T&D and others)	25%	-

Sample Calculation for Sizing the Project

Particulars	Value	Unit
No of LED Bulbs	2	Nos
Each LED bulb Wattage	5	W
Charging point	5	W
Total Load	**17**	**W**
No of houses	34	
Total load for 40 households	510	W
Losses (T&D and Conversion)	25%	
Gross load	**638**	**W**
Inverter Voltage	24	V
Inverter size	1200	VA
Battery Voltage	12	V
Operating hours (Autonomy)	10	hrs
Minimum battery Capacity required	266	Ah
Battery capacity considered	150	Ah
No of Batteries in Series	2	Nos
No of Batteries in Parallel	2	Nos
Total No of Batteries required	4	Nos

Hence a 1 kW system will have a minimum of 4 Nos of 150 Ah /24V batteries and the 1.2 kW inverter for providing 10 hours backup.

15 BILL OF MATERIAL

Bill of Material and make of each equipment is tabulated below:

S No	Particulars	Description	Quantity	Make
1	Solar PV Modules	1000 Wp, Poly Crystalline, MNRE approved specifications	1	HBL / equivalent with 250Wp or above as per MNRE standard specifications
2	Solar Inverter	1.2 kVA/24V Solar PCU with MPPT feature and accessories	1	Photolite / equivalent
3	Batteries	12 V, 150 Ah of 4 Nos	1	HBL / equivalent
4	Mounting Structure	Hot dipped Galvanized Iron structure more than 70 Microns	Lot	Reputed local made
5	Cables	MC4 Connectors, 2.5 sq.mm Copper cables with associated pipes	Lot	Reputed local made
6	Accessories	Installation materials including Array Junction Boxes (AJBs), boxes, stands etc	Lot	Reputed local made

16 TECHNICAL SPECIFICATIONS

The technical specifications of each equipment are tabulated.

SOLAR PV MODULES:

S No	Particulars	Value
1	Make	HBL Power Systems Limited
2	Pmax	250 Wp
3	Voc	36 Volts
4	Isc	8.57 Amps
5	Vmpp	31.14 Volts
6	Impp	8.04 Amps
7	No of cells in series	60 No's
8	Max system voltage	1000 V_{DC}
9	Mechanical Specifications	1660 mm x 990 mm x 42 mm

- All modules are made with POLY CRYSTALLINE SOLAR CELLS
- All measured tolerances on electrical parameters lies within ± 5%
- All electrical parameters specified above are measured at STC conditions (Cell0 2 temperature 25 C, 1000W/ m irradiance and 1.5 AM spectrum)
- Modules are supplied with 3 bypass diodes, 1 meter length Cables and MC4connectors

<u>Certifications for solar PV panels:</u>

- IEC : 61215
- IEC : 61730 - 1 & 2
- IEC : 61701
- RDSO : upto 100 W

<u>BATTERY:</u>

S No	**Particulars**	**Value**
1	Make	HBL Power Systems Limited
2	Model	PL 150 (C10 Tubular Batteries)
3	Voltage	12 V
4	Capacity	150 AH
5	Dimensions	522 mm x 281 mm x 317 mm
6	Weight (Wet)	60.8 kg
7	Weight (Dry)	38 kg
	Electrolyte volume (approx.)	18.2 ltr

<u>INVERTERS:</u>

S No	**Particulars**	**Value**
1	Make	HBL Power Systems Limited
2	Type	1.2 kVA MPPT based solar inverter / PCU
3	Rating	1200 VA
4	Battery	24 V_{DC}
5	SPV VOC	90 Vmax
6	SPV Current	30 A max
7	SPV charger type	MPPT
8	Model	HBL_1.2KVA_24VDC_MPPT

17 IDENTIFICATION OF PROJECT MATERIAL

The 22 numbers of systems are installed in 18 villages. The each and every equipment has a serial number on it so that in case of any service maintenance, the equipment can be easily traced. The name of the village and the serial number of the solar panels, batteries and inverters are tabulated.

18 IMPACT ON LOCAL ECONOMY INCLUDING CO_2e REDUCTION

Renewable Energy projects are cleaner energy generation options in comparison to other technologies. The zero dependence on fossil fuels makes it a preferred choice in comparison to non-renewable energy options.

Social benefits:

The following social benefits are

(i) Improved health,
(ii) Consumer choice,
(iii) Greater self-reliance,
(iv) Work opportunities and
(v) Technological advances

Environmental benefits:

Environmental aspects and quality of life indicate that environmental pollution is largely linked to the increasing use of energy, presently the climate changes due to heavy use of fossil fuel with emissions in to the atmosphere.

Water pollution is another aspect of environmental problem. Water pollution includes any detrimental alteration of surface waters, underground waters or the marine environment with a thermal or material pollution. Water pollution occurs primarily from:

1. Effluents such as water discharges from households, industries, trade or polluted rain,
2. Discharge of used oils,
3. Discharge of liquid substances containing poisonous chemicals including heavy metals (mercury, lead, etc.), also products like arsenic, zinc, copper nickel, cadmium, etc., and
4. Pollution by acid rain precipitation.

The following environmental benefits are

(i) Reduced air pollution,
(ii) Lower greenhouse gas emissions,
(iii) Lower impacts on watersheds,
(iv) Reduced transportation of energy resource and
(v) Maintaining natural resources for the long term

Economic benefits:

Using renewable energy generates a wide variety of economic benefits like

(i) Job creation:

It is a key part of economic development activity and for healthy economies. With the new and innovative projects coming in the villages, results in increased job creation. This will stop the migration of villagers to nearby towns or cities.

(ii) Increased agricultural produce:

With the sustainable power supply to local villages, three crops can be cultivated in the identified villages resulting in increased revenue to the villages.

(iii) Entrepreneurial initiatives:

Entrepreneurship can lead to poverty reduction. Benefits occur when workers spend part of their income in the local economy, generating spin-off benefits known as the ‘‘multiplier effect.’’ This increased spending creates economic activity in other sectors such as agro, retail, restaurant, entertainment, eco-tourism etc.

(iv) Skilled manpower:

With the increased number of industries being setup in the nearby villages, the skill set of man power may be enhanced by way of establishing industrial training centers, workshops, etc. This will not only reduce the migration of the villagers to nearby towns but also increase the skill set of the manpower of villagers.

Carbon Dioxide emissions:

By implementing a 22 kWpSolar power plant, it is estimated that the project will reduce 30 tCO_2e per annum.