Jnana Prabodhini–Harali

HARNESSING THE SUN FOR A NOBLE CAUSE

—Shrinivas Kulkarni, Project In Charge

BACKDROP:

Jnana Prabodhini (JP) is a well-known educational/social organization in India and also known abroad for its innovative approach as well as its concern for the last man on the ladder. A branch of JP is active in the earthquake and draught prone District of Maharashtra State. In the village Harali, JP has a rural residential school and an Agricultural Polytechnic. As the grid supply is short and very unreliable, JP constructed off-grid photovoltaic power plant of 48 kW with two sets of 24 kW each. As the electrical loads are spread over the campus, it was convenient to install two separate PV power plants.

GRID AND LOAD PROFILE:

The available grid power on this site is quite short. Moreover, unscheduled frequent supply shutdowns and interruptions worsen the reliability. Scheduled three phase grid power is available just for 6 to 8 hours a day and single phase supply for 8 more hours. The three phase supply voltage frequently drops down to 340 VAC phase to phase. The JP school here has about 300 residents, school buildings, laboratories, well equipped computer lab and many support centers, consuming large amount of electrical power. JP is also running an Agricultural Polytechnic, nearly 56 acres of horticulture, agriculture cultivation, Fruit processing unit, animal husbandry and allied activities. All these drain additional power. It was really a challenge to run all activities. Total connected load is around 100 kW. The average energy consumption of the campus is approx. 4000 kWh per month. To overcome this difficulty, JP has started many small activities to generate non-conventional energy. Bio-gas plant, Scheffler solar concentrators for cooking steam generation, wind-solar hybrid power generation, solar street lamps, solar lanterns, solar water heaters, solar driers, are some of these to name. However, this was just a first step. The final aim is to become self sufficient for energy demand. Now harnessing the Sun is a bigger leap towards our ultimate goal.

PROJECT CONCEPT:

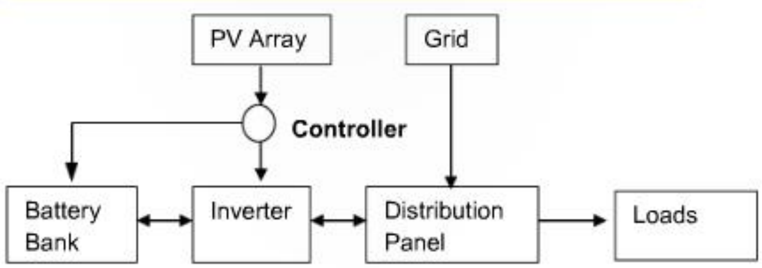
As stated earlier, this project is split into two equal size plants with almost similar specifications. Since the generated power has to be utilized without a specific schedule, it was mandatory to provide sufficient power storage. The most common way, of course, is to use lead-acid battery bank for storage. The solar PV panels have a life expectancy of 25 plus years. The support structure life expectancy requirement should go hand in hand. An intelligent power control unit (PCU) is required to efficiently share load between Solar PV, battery bank and grid. The existing motive power load should run to fulfill its purpose. A smart load management is also needed.

PROJECT DESIGN:

Normally it is customary to apply AMG rule, which denotes the hierarchy of consideration. A stands for AVOID the power use if possible, M for MINIMIZE the consumption, and G stands for GENERATE the remaining energy. It was difficult to apply this thumb rule here as some of the connected load had to be considered although it was not on the priority list. Secondly, JP at Harali undergoes continual expansion. The open land here is under cultivation, hence all the PV panels are required to be mounted on rooftops.

PV panels Installed

We have used grid-support solar PV system for our application



Schematic arrangement of the system

Since the life span of the PV panel is around 25 plus years, it was absolutely essential to use the support structure material with matching life span. MS angles/channels with GI plating are very widely used. However, its corrosion in exposed condition can be a concern after some years. Mechanical strength to withstand heavy storms is also required. We therefore used fiberglass section. It is a type of Fiber Reinforced Plastic (FRP). This was a novel concept which was being used for the first time. The strength at the junction point could be a weak link. To address this, we used rivets with alloy aluminium cap and SS pin. Both of these materials are long lasting and also provide expected mechanical strength. Electrically it is completely a bad conductor. Moreover it is absolutely rustproof and has a permanent natural color. Mr. N. C. Kanade has taken lot of pains to develop the FRP structure.

The concrete pedestal was used as foundation to counteract the uplift caused by wind. The FRP structure members were secured with foundation plate and anchors were provided to make the structure stronger. The FRP structure is 3.6 times lighter as compared to GI structure and yet provides comparable strength. The PV array is mounted on the terrace at a height of 10 m from the ground. The support structure is expected to withstand high wind speeds in the range of 300 kmph. The PV panels we used are 300 Wp 160 Nos. We used two huge battery banks of 120 numbers of 2V, 800 Ah cells and 120 numbers of 2V, 600 Ah cells respectively. This was absolutely essential to maintain one day autonomy and also to control DOD during normal use. The life expectancy of battery bank thereby is also taken care of. The battery bank is expected to last for up to 5 years (warranted) and extendable to 7-8 years.

The main brain of the system is of course the charge controller (CC) and the inverter or the power control unit (PCU). We used 30 kVA PCU. The CC for each system has all the features to control the battery bank charging like MPPT, constant current bulk charge, float and equalizing charge system. There is also a provision to charge the batteries through single phase grid power which is unique. But the output has always a three phase, four wire supply. The system voltage selected is 240 VDC, 10 modules in one string and 8 strings connected to PCU.

INTEGRATION CHALLENGES:

It was a real challenge to get work done from untrained, unskilled and illiterate work force. Availability of grid power was very feeble. Every alternate week, supply was unavailable during day time. Therefore, to achieve time line, we were left with the alternative to work with the supply from an alternator driven by a tractor. A 30 kW generator had to be run for many hours during construction of battery rooms and was very expensive. Since the PV structure was required to be mounted on rooftops, about 12 cubic meter of concrete blocks were used. A total of 20,000 kg raw material was required to be lifted. This was done manually with the help of a pulley at a height of 10 m from the ground. This was not an easy job.

Solar panel wiring

Use of automated fork lift or any other mechanism was not possible. All the residents here were motivated to contribute voluntarily their time and efforts for this noble cause. The support structure installation was done with utmost care to ensure that all panels in a row were dressed in one line. This could be achieved by meticulous planning in fabrication and installation of support structure. The day and night time load profiling, battery bank charge and discharge profiling, minimization of inter-row shadows, optimization of PCU function and heat dissipation, PV-Battery-Grid-Load Power and Energy Balance are some of the challenges ahead. The individual components and systems efficiency also need to be established.

PLANT PERFORMANCE:

On a good sunny day, the output of PV array is approx. 44 kW and the energy generated is approx. 180-200 kWh. We plan to monitor DC energy generated by PV, DC energy supplied to and from Battery Bank, AC energy drawn from Grid and AC energy supplied to load. This will establish PV, Battery and Inverter efficiency as well as overall system efficiency.

SAFETY AND MAINTENANCE SYSTEM:

As the PV string voltage is approx. 370 VDC and string current approx. 80 Amps, it is highly dangerous and even fatal if not handled properly. Safety measures are required to be followed while handling, maintaining, and cleaning the battery bank, PV modules, AJB, PCU, ACDB etc. We have developed SOPs and safety instructions and also created a system to keep a close watch on their implementation. We have installed two separate grounding electrodes for DC and AC circuits for safety reasons. All module frames are connected to DC ground. Also, we have used DC string fuses and DC Surge Protection Devices in the Array Junction Box (AJB). Two separate lightning arresters are installed as safety devices. All DC and AC cables are laid in trays/trenches. Battery Bank is installed little above the flooring on neoprene rubber mats laid on concrete floor to minimize leakages. Maintenance of all the system components and the distribution system is also of utmost importance. Although seems trivial, cleanliness of PV modules can provide better generation. A close eye on the Battery State of Charge (SOC) and Depth of Discharge (DOD) is required to enhance its life. We plan to monitor both open circuit voltage and specific gravity of individual battery cells. On load consumption side, we have used VFDs for all the motive loads, to reduce the high inrush current at the start up and conserve power.

FUTURE PLANS

- We plan to install BLDC ceiling fans, LED lighting and energy efficient equipment in place of the conventional ones.
- A smart SCADA system for monitoring the plant performance and also for smart management of load will be required. Time sharing of load on priority basis with this SCADA system would take care of AMG rule mentioned earlier.
- JP at Harali is following its objective to strengthen the weakest link in the chain. A short-term course to develop micro level household solar system is taking shape. A dedicated team of social workers is inducting the importance of such micro-scale solar system in five nearby villages. Some solar technicians are also being trained to handle maintenance of these systems.
- The readers are most welcome to share their views, visit the village and contribute in their own way for enhancing the noble cause.

Facts & Figures at Glance – 48.0 kWp

No	Description	Remarks
1	Total Load off-set During Day Time (kW)	25.0
2	Solar Cell Technology	Polycrystalline Silicon
3	Inverter Configuration	Off-Grid
4	Area Required (Sq. Mtr.)	511.0
5	Power Evacuation Level (VAC)	415.0
6	Estimated Power Generation per Year (kWh)	65,000.0
7	Time for Implementation (Days)	90
8	Cost of the System (Rs.) Lakhs	56.7
9	Estimated Savings on Electricity Bills per Year averaged over 25 Years of Plant Life & increase in Tariff by modest 5 % per Year (Rs.) Lakhs.	09.45
10	Estimated Savings on Electricity Bills in 25 Years of plant life & increase in Power Tariff by modest 5 % per Year (Rs.) Lakhs	236.36
11	Total CO2 Emissions reduced per Year (Kg)	51,000.0

Savings on Energy Bills –

The combined (MSEB + Generator) average rate of Energy is about Rs. 10.00/kWh. Also we have considered a modest increase in rate by 5 % per year to make the projection of savings on Energy Bills more realistic.

Year	kWh	Rate (Rs./kWh)	Total (Rs.)
1	65,000.6	10.00	6,50,006.00
2	64,399.1	10.50	6,76,191.00
3	63,803.1	11.02	7,03,110.00
4	63,212.6	11.76	7,43,380.00
5	62,627.6	12.35	7,73,451.00
6	62,048.1	12.97	8,04,764.00
7	61,473.8	13.62	8,37,273.00
8	60,904.9	14.30	8,71,001.00
9	60,341.3	15.02	9,06,326.00
10	59,782.8	15.77	9,42,835.00
11	59,229.6	15.56	9,80842.00
12	58,681.4	16.34	9,58,854.00
13	58,138.4	17.16	9,97,655.00
14	57,600.3	18.02	10,37,957.00
15	57,067.3	18.92	10,79,770.00
16	56,539.1	19.87	11,19,458.00
17	56,015.9	20.86	11,68,492.00
18	55,497.5	21.90	12,15,395.00
19	54,983.9	23.00	12,64,630.00
20	54,475.1	24.15	13,15,574.00
21	53,970.9	25.36	13,68,702.00
22	53,471.4	26.63	14,23,943.00
23	52,976.6	27.96	14,81,226.00
24	52,486.3	29.36	15,40,998.00
25	52,000.6	30.83	16,03,178.00
		Total	**2,36,36,890.96**

SOLAR PV SYSTEM A – SPECIFICATIONS

1. Capacity of Solar PV Modules : 24.0 kWp
2. Capacity of Solar Inverter : 30.0 kVA - 240 VDC
3. Capacity of Battery Bank : 240 VDC, 800 Ah
4. Estimate of Energy Generation : 90.0 kWh / Day

SOLAR PV SYSTEM B – SPECIFICATIONS

1. Capacity of Solar PV Modules : 24.0 kWp
2. Capacity of Solar Inverter : 30.0 kVA - 240 VDC
3. Capacity of Battery Bank : 240 VDC , 600 Ah
4. Estimate of Energy Generation : 90.0 kWh / Day

CREDENTIALS

1. System design
: Jnana Prabhdhini, Harali
2. System integration
: Jnana Prabhdhini, Harali
3. Civil work execution
: Jnana Prabhdhini, Harali
4. PV support structure
: Shri N. C. Kanade, Pune