`CASE STUDY: APPLICATION OF ENERGY STORAGE SYSTEM (ESS) TO REDUCE DIESEL POWER CONSUMPTION AND IMPROVE GRID STABILITY IN PORT BLAIR

Objective

To reduce diesel power consumptions and improve grid stability issues due to solar ramping in Port Blair.

Background

The island operates Diesel Generators (DGs) for source of power. In 2013 Port Blair authorities installed solar PV to reduce diesel consumption, but have not achieved expected savings as diesel generators also need to act as reserve due to sudden changes of solar output.

Solutions

CES helped TERI to explore potential solution with solar and energy storage system (ESS) hybrid to minimize diesel consumption for Port Blair.

Analysis

Port Blair has a 35 MW peak and about 19 MW off-peak load. The system peak is driven by evening residential loads. Table 1 summarizes the generators stack for Port Blair

Power House	Installed Capacity *(MW)*	Continous Capacity *(MW)*	Present Loading *(MW)*
Chatam	15.00	9.00	8.40
Phoenix Bay	8.00	5.40	4.80
Hired Power House-I (NBEW)	5.00	1.65	1.30
Hired Power House-II (SRGS)	10.00	10.00	10.00
IPP(SPCL)	20.00	15.00	15.00
Solar Power Plant	5.00	5.00	4.00
Raj Niwas, Medical, Secreteriat	1.05	1.05	1.05
Total	64.05	47.10	44.55

Table 1: Port Blair generators supply stack

Typically the solar output lasts from 6 AM to about 5 PM on a daily basis. Figure 1 shows the daily solar output pattern during the solar output hours of 6 AM to 5 PM.

Load %	kWh/liter
100%	3.56
75%	3.53
50%	3.34
25%	2.72

Table 2: Assumed DG Load % and efficiency. Source: Energy Development in Island Nations

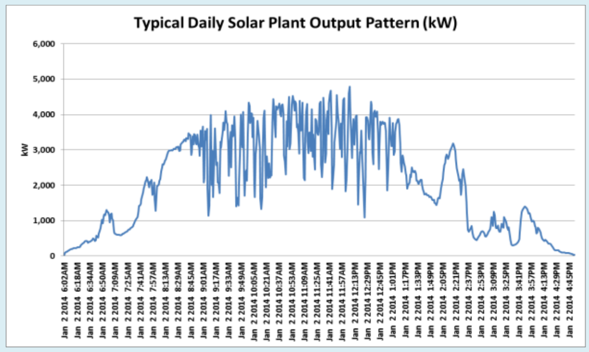

Figure 1: Typical solar output pattern during the day.

During Jan-Feb the maximum ramp up/down range observed is about 3,700 kW which is about 75% of the maximum solar plant output of 5,000 kW observed during certain time intervals. The mean for the ramp up/down observed for Jan-Feb is about 200 kW and the average solar plant output during this period is about 2,300 kW.

Based on the above observations and metrics for solar output data, we analyzed ESS based solution to

1. Reduce the number of solar plant output ramps above **assumed tolerance threshold of 100 kW for 1-minute interval and 500 kW for 5-minutes interval**.
2. **Reduce diesel consumption** by optimally operating the Chatham, Phoenix Bay and Hired Power House-I (New Bharat Engg. Works) DGs while smoothening solar output.

DIESEL SAVINGS

With ESS the need to run DGs at part load and keep reserves reduces significantly. Now DGs can be run more efficiently. One such combination is to:

1. Operate Chatham DG at 80% load (12MW)
2. Operate Hired Power House-I (New Bharat Engg. Works) at ~ 80% load (4 MW) and
3. Shut down Phoenix Bay DG during the daily solar output hours (7 hours)

It will save 2,95,592 liter of diesel (worth INR 1.68 crores) annually at Port Blair.

APPLICATION OF ESS

Based on the assumed ramp tolerance threshold 100 kW for 1-minute interval the ESS would be charged whenever the difference in solar plant output is greater than 100 kW within permissible constraints of ESS power rating, state of charge (SOC), charge efficiency, upper SOC limit.

Figure 2 shows solar plant output for a day without and with ESS for 1-minute interval 100 kW ramp tolerance thresholds.

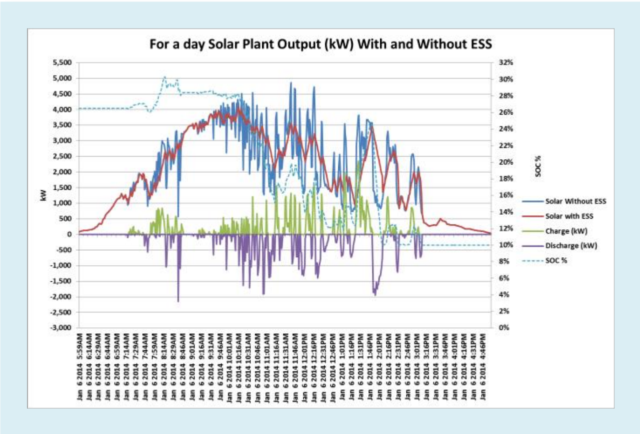

Figure 2: Typical solar plant output for a day without and with ESS (3,000 kW, 3,000 kWh).

For example for 100kW threshold, during 1-minute interval the solar plant output varies from 1000 kW to 1700 kW, the ESS would be charged using the additional 600 kW above the 100 kW assumed tolerance. Similarly whenever the difference in solar plant output is below the tolerable ramp threshold 100kW the ESS would be discharged. Within permissible constraints of ESS power rating, state of charge (SOC), discharge efficiency, lower SOC limit. The above method of smoothening solar output is considered during the observed 7 hours of solar plant output.

ESS TECHNOLOGY (LI-ION AND ADV LEAD ACID)

We considered application of Li-Ion and advanced Lead Acid based ESS. For both the technology 3000 KW and 1 hour duration storage shows optimum configuration for the project.

Table 3 has the Li-Ion and advance lead acid ESS summary tables for ramps reductions.

For Li-Ion	# of 1-min interval ramps	
Ramp Range (kW)	W/o ESS	With ESS
0 to 500	32537	36997
500 to 1000	2893	91
1000 to 1500	1108	32
1500 to 2000	423	8
2000 to 2500	129	2
2500 to 3000	31	0
3000 to 3500	6	0
3500 to 4000	3	0
Total	37130	37130

for Adv. Lead Acid	# of 1-min interval ramps	
Ramp Range (kW)	W/o ESS	With ESS
0 to 500	32537	36981
500 to 1000	2893	98
1000 to 1500	1108	37
1500 to 2000	423	13
2000 to 2500	129	1
2500 to 3000	31	0
3000 to 3500	6	0
3500 to 4000	3	0
Total	37130	37130

Table 3: summary tables

Project Economics

Project Economics			
Technology used	Li-Ion	Adv Lead Acid	
Technology Configuration			
Power Rating	3,000	3,000	*kW*
Duration	1	1	*hr*
Energy Rating	3,000	3,000	*kWh*
Capex (INR Crore)	17.10	8.10	*INR Crores*
Outcomes			
Reduction in 1-min interval ramps above 100kW	12,046 to 317	12,046 to 374	
Reduction in 5-min interval ramps above 500 kW	8,400 to 643	8,400 to 753	
Annual full depth DOD Cycle used	121	119	
Annual Diesel Consumption Savings	2,95,592	2,95,593	*Liters*
Potential Revenue			
Annual Diesel Savings	1.68	1.68	*INR Crores*
Investment Matrix			
Return on Capital (ROC)	10%	21%	
Simple Payback Period	10	5	*years*

On projects economics advanced lead acid shows a better ROC and IRR than Li-Ion technology due to lower capital cost. Following points need to be considered on project implementation.

- Lower Annual equivalent of full depth of discharge (DOD) cycles for both the technology signifies that battery will last for several years.
- Here we have not considered state of charge (SOC) management. If SOC is managed by providing more charging opportunities versus discharging the battery life can be increased further.

(Initially prepared for TERI)