Study Committee C6

Active Distribution Systems and Distributed Energy Resources

Paper ID_10497

Case Study for Greening Island in Andaman

Dhirendra Joshi and Subir Karmakar

NTPC LIMITED, INDIA

Motivation

- Presently South Andaman demand is catered majorly through existing diesel generator (DG) capacity.
- Powering the island grid with renewable energy will reduce the overall electricity cost and be an energy ecosystem that relies on local resources to eliminate the dependence on imported fuels.

Method/Approach

- Simulation study was conducted taking historical actual solar PV plant data from an NTPC Ltd plant, and sizing of storage requirements with various fuel mixes was carried out.

Objects of investigation

- RE integration can be done with phase-manner, and the following are the Andaman future energy generation scenario:

(i) Optimum renewable energy (RE) plant (solar and wind) for better energy security.

(ii) Energy storage to cater to RE generation variability and peak shaving/energy time-shifting for optimum RE integration and mitigation of peak load demand.

(iii) Gas plant for based load during low RE generation and peak load requirement.

Experimental setup & test results

Software simulation is done based on Python, PVsyst, and Excel software.

Discussion

- Battery Energy Storage Systems (BESS) may prove to be very useful for power as well as energy application for the Andaman grid.
- Without the BESS system, the injected grid power from the solar plant is highly distorted/intermittent and causes the gas plant to operate with a high ramp rate, which may reduce the service life of the gas plant machine.
- With energy type BESS, the solar plant has the capability to absorb the surplus solar energy and supply the stored energy during evening peak hours.
- Different case studies with different fuel mix and energy storage and selection of optimal mixing based on techno-economical analysis are presented. Technical challenges for increasing renewable energy contribution and solutions to mitigate are presented.

Conclusion

- In the paper, a simulation study was conducted taking historical actual plant data from a NTPC plant, and sizing of storage requirement with various fuel mix was carried out and an optimal combination is proposed for future implementation.

- The following aspects are covered under this study and presented in detail with the one-year generation and meteorological data.

1) Renewable energy and energy storage configuration and detail of their major component.
2) Different case studies with different fuel mix and energy storage and selection of optimal mixing based on techno-economical analysis.
3) Technical challenges for increasing renewable energy contribution and solutions to mitigate.
4) Software simulation, mathematical computation, and techno-economical analysis.

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Andaman Load and Solar Generation Profile

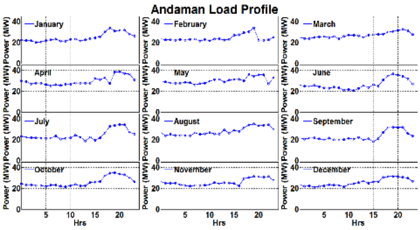


Figure: Typical month-wise load demand curve for south Andaman

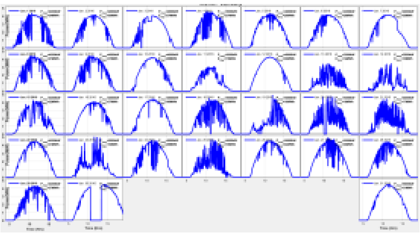
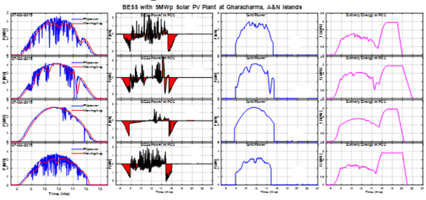


Figure: Generation variability of the existing 5MW solar plant of NTPC Ltd during monsoon season

Solar Power Generation Smoothening



Solar Power Generation Smoothening

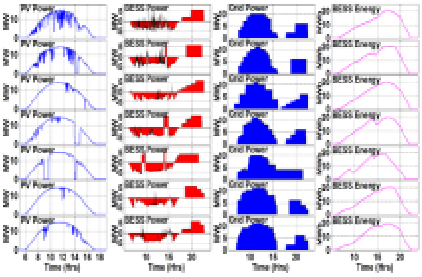


Figure: Simulated curve for solar generation peak shaving/peak shifting

Solar and Gas Plant Operation During Cloud Intermittence with BESS and without BESS Scenario

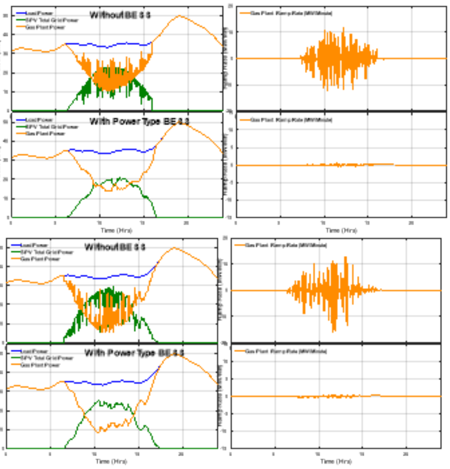


Figure: Simulated day generation curve for gas plant ramping requirement with and without BESS system during high solar intermittence

Figures show the simulated typical one-day load and solar and gas plant generation operation curve with and without the BESS system. It's clear from the figure that without the BESS system, the injected grid power from the solar plant is highly distorted/intermittent and causes the gas plant to operate with a high ramp rate, which may reduce the service life of the gas plant machine. With power type BESS the injected grid power from the solar plant is smooth, and the ramp rate requirement of the gas plant has significantly reduced. The total solar capacity considered in this case is 25MW and BESS of 12.5MW with one-hour backup.

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Solar and Gas Plant Operation During Cloud Intermittence with BESS and without BESS Scenario

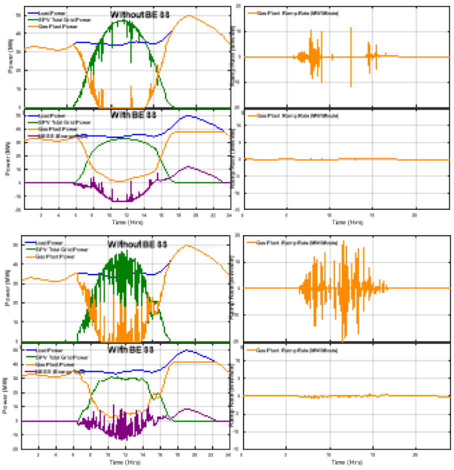

Figure: Simulated day generation curve for gas plant ramping requirement with and without Energy type BESS system

Figures shows the simulated typical one-day load and solar and gas plant generation operation curve with 55MW solar capacity and BESS capacity of 15MW with four hours of backup. From the figure, it's clear that without any battery storage system, the grid has surplus solar power even with zero power from the gas plant. In order to integrate the large solar power capacity during the daytime, the energy type BESS is a must. With energy type BESS, the solar plant has the capability to absorb the surplus solar energy and supply the stored energy during evening peak hours.

Simulation study suggests that without BESS (power or energy type BESS) the grid operation will be challenging as the gas plant requires a frequent start/stop and ramping up & down in order to offset the solar generation variability due to frequent cloud intermittence which leads to lowering of operating efficiency and higher maintenance. BESS system with solar plant shall significantly reduce the frequent start/stop and ramping up & down the requirement of the gas plant. Gas plant spinning reserve capacity requirement is also reduced, and a single machine can be sufficient to cater to the ramping up/down need. The gas plant unit can be operated at a minimum technical level, and the gas plant's ramp rate requirement would be considerably reduced due to BESS. Optimization of no running gas machine associated with the solar plant can be achieved as per grid requirements, thus significantly enhancing the engine average loading..

Analysis of Various Energy Mix Scenarios from Various Source

Different Cases	Case-1	Case-2	Case-3	Case-4	Case-5	Case-6
Load Range (MW)	30-50	30-50	30-50	30-50	30-50	30-50
Solar Capacity (MW)	25	55	55	55	55	55
Wind Capacity (MW)				35	35	55
BESS Capacity (MW/MWh)		15/ 60	30/ 120	15/ 60	20/ 100	30/120
Gas Plant Capacity (MW)	50	50	50	50	50	50
Load Annual Energy (MU)	322	322	322	322	322	322
RE Total Annual Energy (MU)	38.99	85.79	85.79	184.2	184.2	240.38
RE Direct Annual Energy (MU)	38.99	68.95	68.95	145	145	170.12
BESS Annual Energy (MU)		10.23	13.46	15.03	20.63	25.28
Gas Plant Annual Energy (MU)	283.1	242.9	239.7	162.1	156.5	126.69
RE Surplus Annual Energy (MU)		4.07	0.031	20.38	13.39	38.67
Gas Plant Annual (PLF) (%)	64.63	55.46	54.72	37.00	35.72	28.92
BESS Utilization Factor (%)		46.49	30.72	68.64	56.51	57.71
RE Contribution to Load (%)	12.11	24.58	25.59	49.68	51.42	60.67
Energy Tariff (kWh/INR)	13.67	13.92	14.26	14.19	14.10	13.51

Conclusion

- Comparative analysis of various energy mix scenarios has been carried out based on one-year hourly solar generation, wind generation, and load data.
- Load variation is considered 30MW during daytime and 50MW during evening peak time. 50MW (5x9.73 MW) LNG/gas plant is considered to cater to peak-load demand during low solar generation (monsoon season) and low windy periods. RE sources and load center will be located at the different parts of the A&N island. Due to RE generation's intermittency/variability nature, their generation must be smoothened before being dispatched into the grid; otherwise, they will create disturbances in the grid in terms of voltage and frequency fluctuations. Hence, a small size power-type battery is required and will be part of RE generating plants.