Insights From Optimizing Energy Storage Sizing and Dispatch

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Customized Energy Solutions

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Established in 1998, **Customized Energy Solutions (CES)** is a consulting and services company that assists clients in managing and staying ahead of the changes in the wholesale and retail electricity and natural gas markets. Serving hundreds of clients, Customized Energy Solutions offers best-in-class hosted energy market operations platforms and a wide spectrum of consulting services. CES is committed to promoting economic development through the advancement of transparent, efficient, and non-discriminatory wholesale and retail electricity and natural gas markets.

Presence

Headquartered

Philadelphia, PA

Over 200 Associates across 9 Regional offices in United States, Canada, India, Japan & Mexico. We support clients in all US 7 ISOs and RTO's

Resources

14,000 MW assets under Active Management

400 MW Energy Storage assets under Management

Awards and Recognitions

Inc. 5000 – Eleven Time Honoree, Philadelphia 100 - 2001, 2004 – 2012,2019

Best Places to work: 2014, 2016

2016 Energy Storage Association Brad Roberts Award Winner

Clients

500+ Clients Worldwide

Our consulting services enables competitive suppliers, technology providers, marketers, utilities and customers to prosper through change, by turning knowledge into value

Market Operations and Optimization

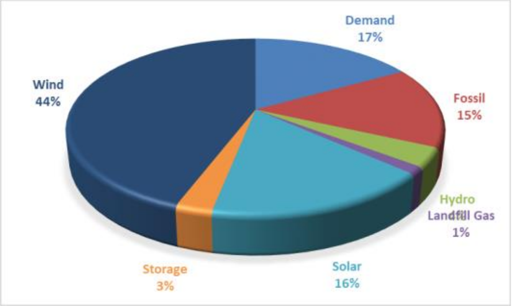
Our 24 hour Market Operations Center (MOC) and Operations Control Center (OCC) provides full spectrum market scheduling and dispatch services to energy market participants. Our services include: Real Time Markets, Operations Strategy, RT Dispatch, Curtailment Management, Outage Coordination, Wind Turbine Monitoring, Wind Generation Forecasting, Optimization Strategies, and Solar Monitoring.

MOC

The MOC performs day-ahead offering, real-time generation scheduling, curtailment management, reserve and regulation offering and monitoring, and daily meter verification

OCC

The OCC monitors plant status through our in-house generation management system, communicates plant status changes to RTOs, dispatch to maximize revenue minimize risk, and pass telemetry information to ISOs

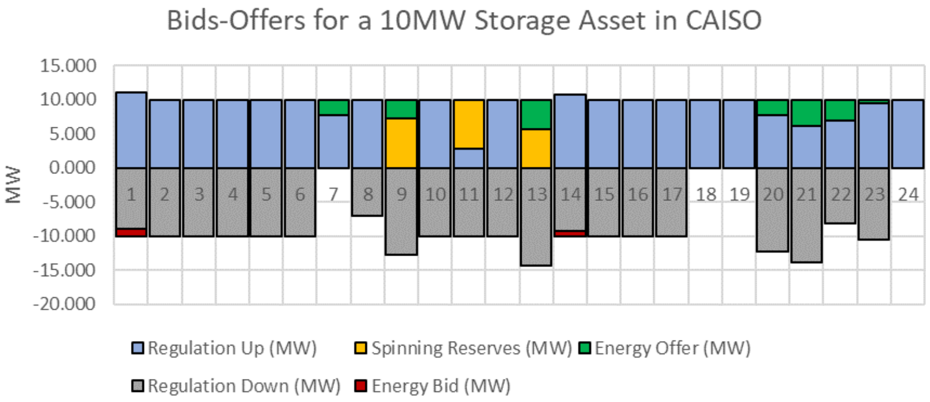


CES Portfolio 2020 – 14 GW+

CES currently manages over 400 MW of advanced energy storage resources in various wholesale markets through North America

GridBOOST: Bid-Offer Optimization Platform

- Energy Storage Asset Scheduling and Optimization platform provides multi-stack revenue optimization
- Optimizer accounts for market participation rules, storage technical constraints as well as degradation costs
- Platform optimizes revenue for grid-scale energy storage and RE integrated hybrid projects



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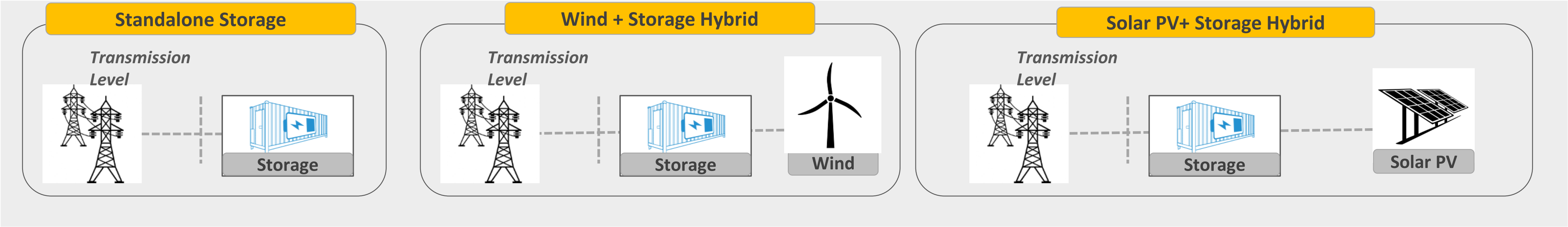
CES - CoMETS

Financial Decision Making Tool

Comprehensive Markets Evaluation Tools for Storage
In-front-of-the-meter Module

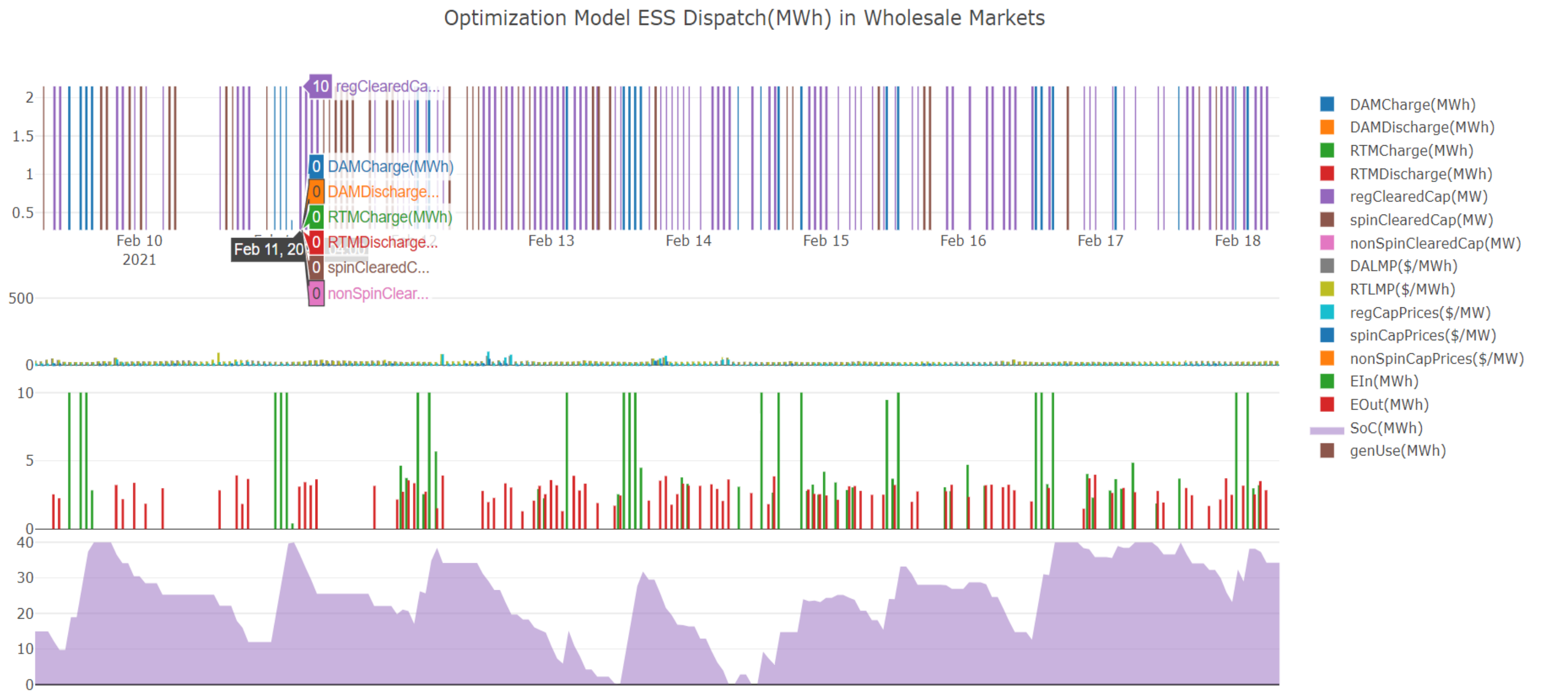


Inputs

Project Inputs	Generation/Dispatch	Strategy	Commercial
Asset Power/Energy Ratings/Efficiencies	Transmission - Available Transfer Capability	Power Purchase Agreement/Merchant Parameters	Incentives – PTC, ITC, Accelerated Depreciation
Charge-Discharge Constraints	Wind Speed Data/ Solar Irradiance	Time of Production Multiplier	Financing and Taxation
Capital Expenditures	Wind Turbine Power Curves		
Operating Expenditures	Wind/ Solar Forecasting Error		
Project Lifetime/Investment Term	Storage Degradation/Self Discharge		

CoMETS: In-front-of-the-meter Module

CoMETS uses a mixed integer linear programming (MILP) based optimization engine to determine optimal hourly dispatch of the ESS in order to maximize potential market revenues subject to participation in various market segments and under relevant operating constraints.



Key Features

- Market Services Selection
- RE Charging Limits
- Operational Restrictions
- Control DoD Cycles
- Enforce Market Rules
- Multi-Stack Hourly Dispatch
- Long Term Revenues

* Charts are for representative purpose only

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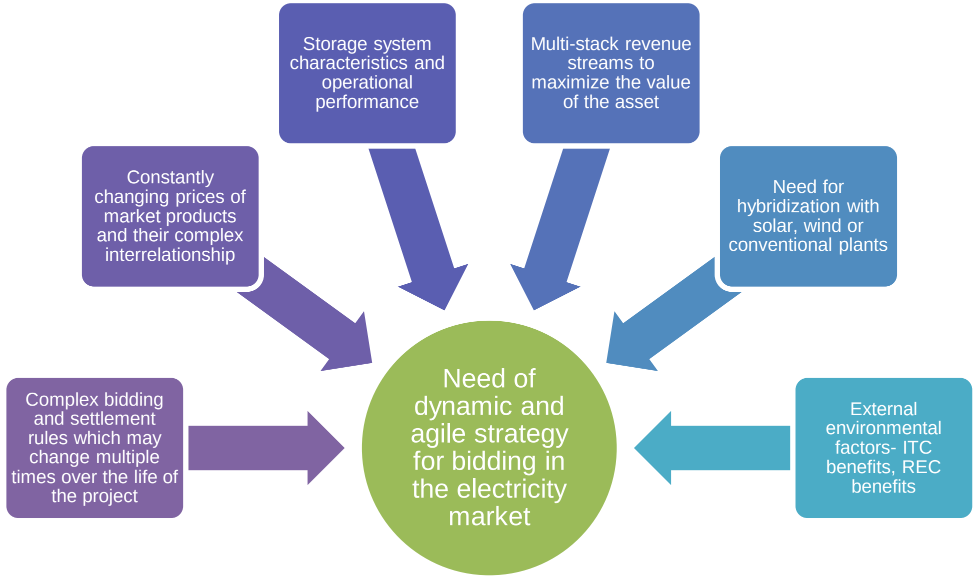
CES - GridBOOST

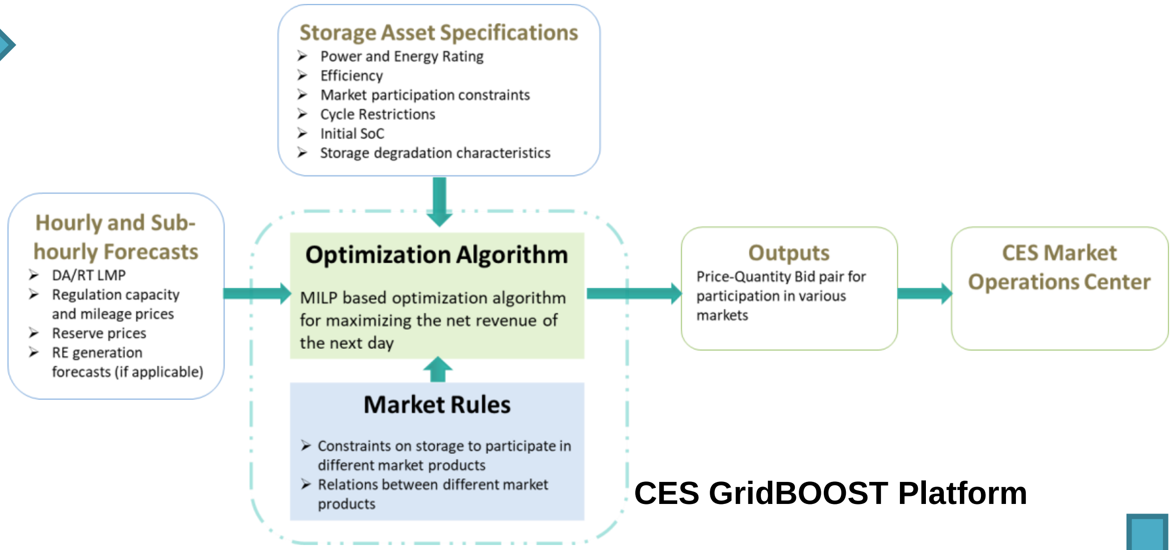
Operational Platform to Maximize the Value

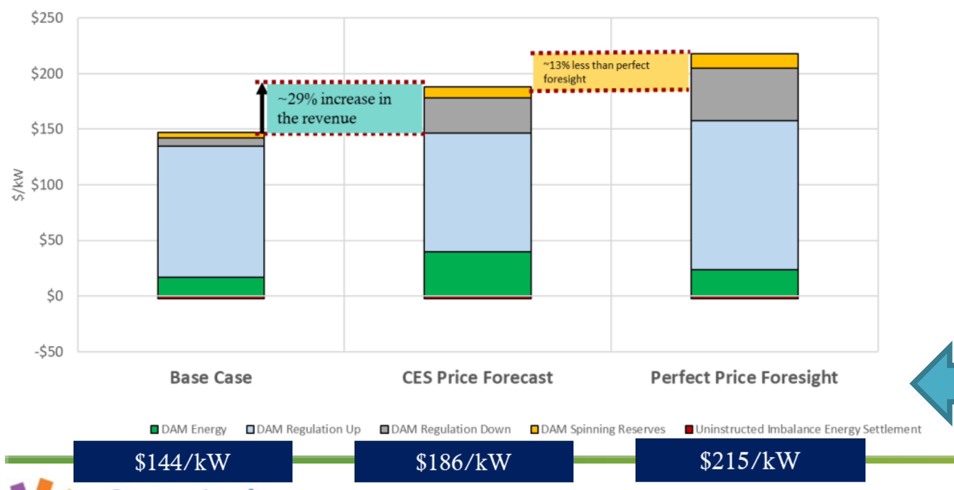
GridBOOST - Operational Platform to Maximize Value of Storage

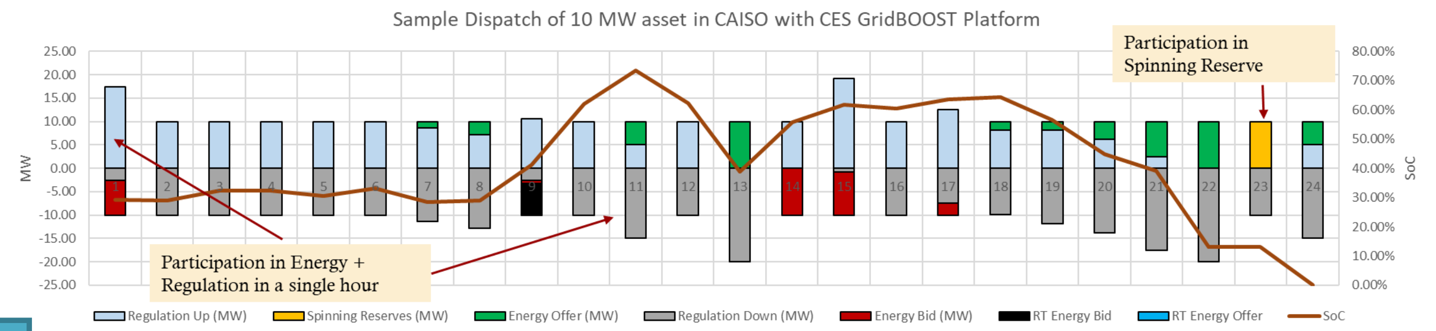
Why Optimization is Needed?



Bid Offer Optimization







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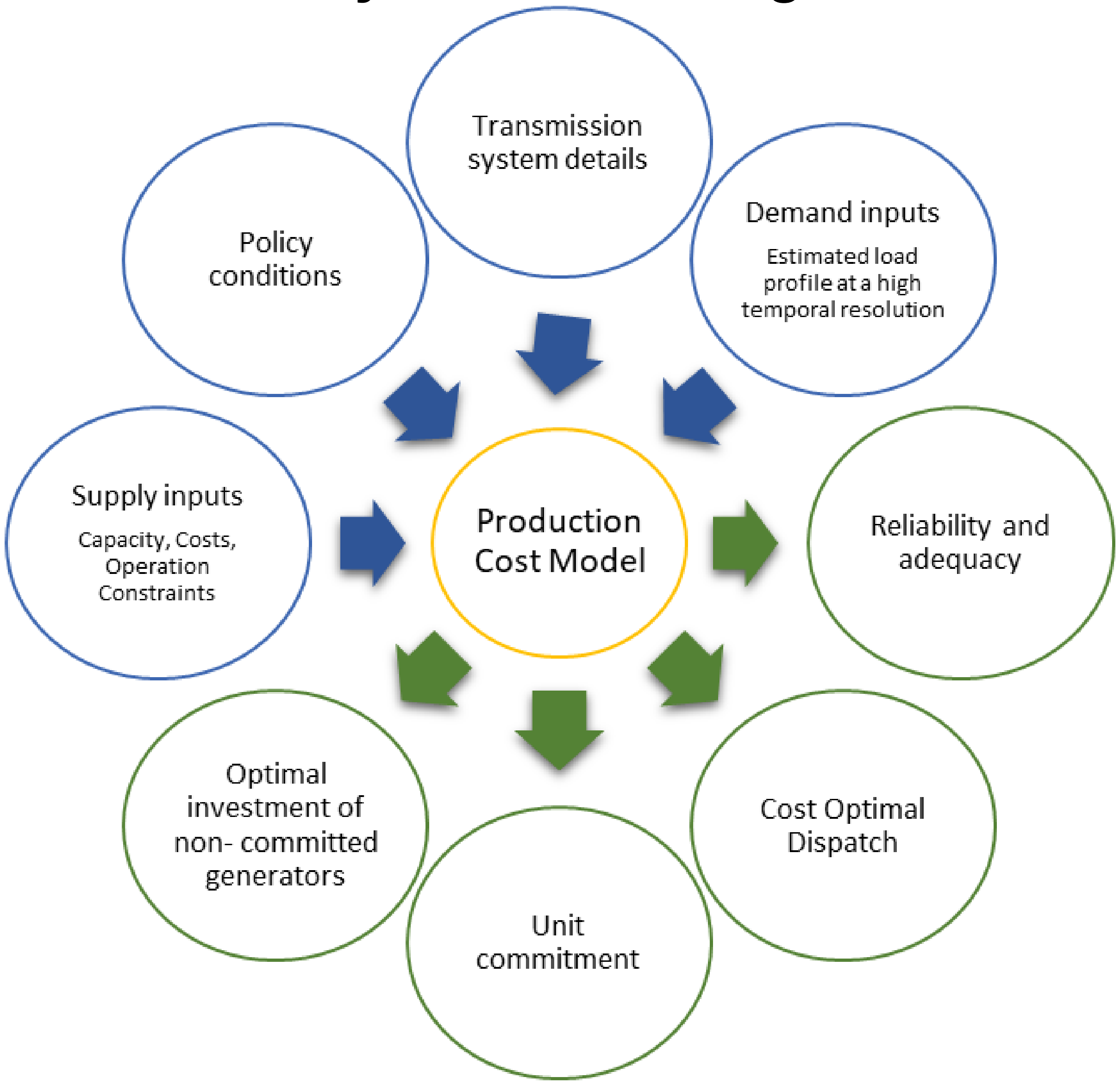
Production Cost Modeling

System Level Analysis

Power System Modeling Framework to Optimize System Level Aspects



Production cost models

- are **Constrained Optimization models**
- **capture** various **costs** incurred during system operation
- both **fixed and variable** costs are considered
- adhere to **operational constraints**
- take **DC** transmission
- can operate at **high** temporal and spatial **resolution**
- output economic dispatch
- extends to security constrained unit commitment, capacity expansion or economic dispatch model

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Case Study 1

Optimal Sizing for Solar-integrated Storage

Optimal Sizing of Solar Integrated Storage Project

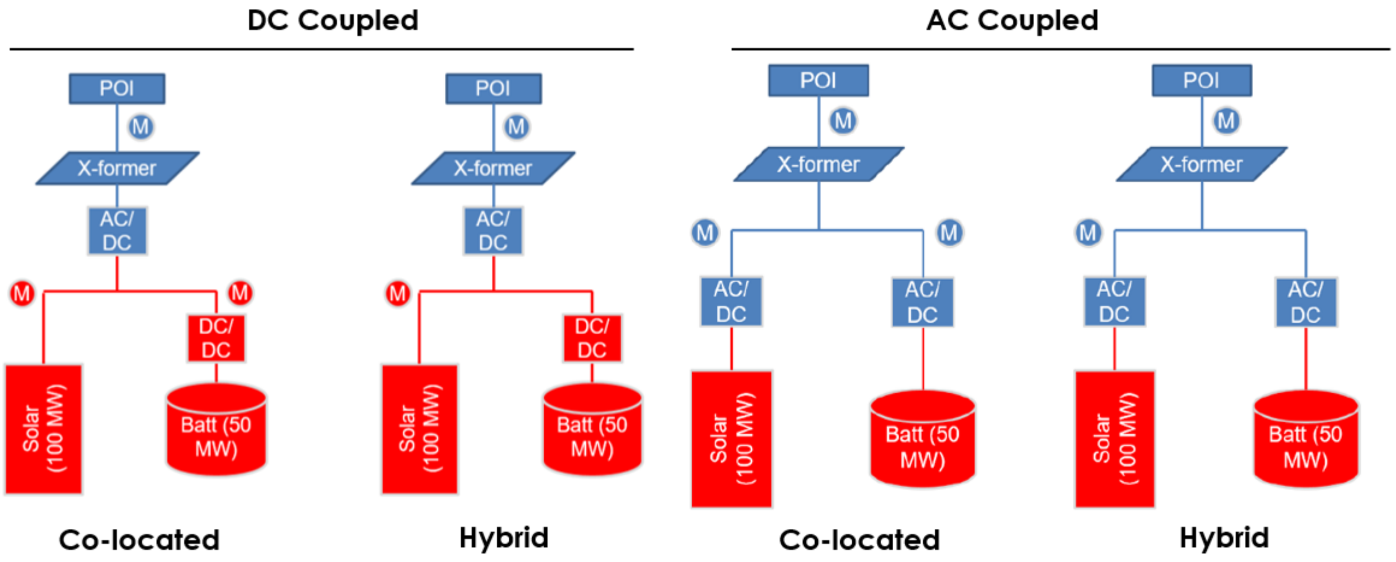
Comprehensive Project Financial Analysis

Objective

Analyze various solar – storage configurations in terms of risks and returns and determine optimal size

Analysis Details

- For a location in Midwest USA – analyzed various storage sizes with 600 MW ac solar
- Determined long term contract price for solar-storage hybrid
- Analyzed both AC and DC coupled configurations with multiple DC/AC ratios
- Risk analysis with P50 and P90 solar output from PV System
- Debt sizing based on the contracted revenue



Outcomes

- NPV and IRR for multiple configurations and sizes
- Hourly optimal dispatch
- Determination of right DC/AC ratio
- Determination of right coupling

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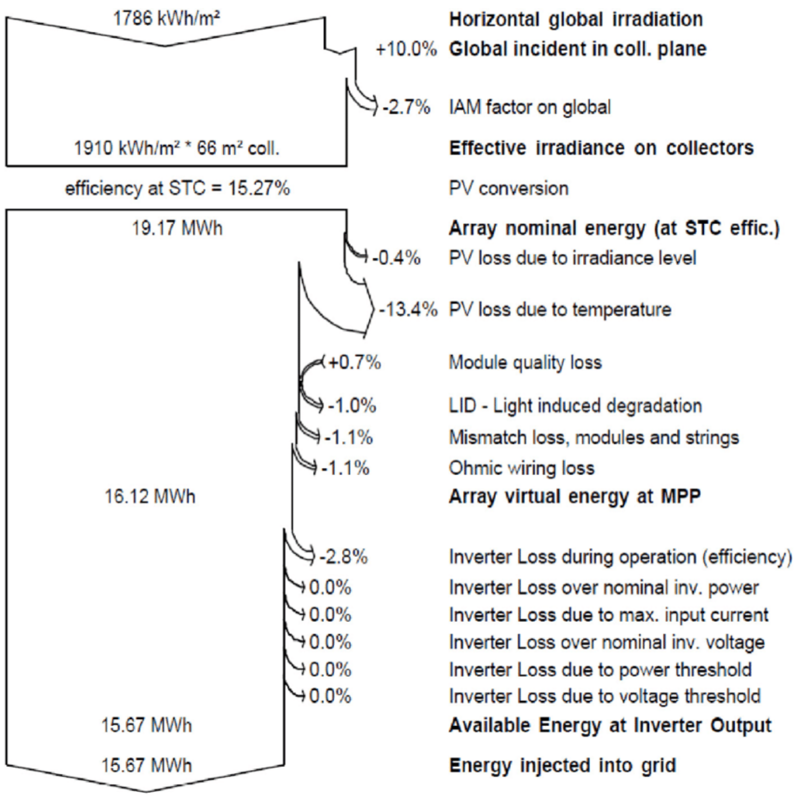
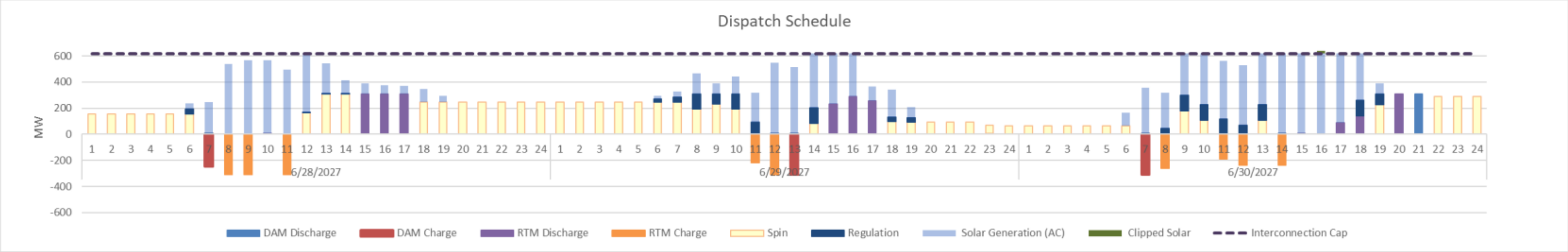
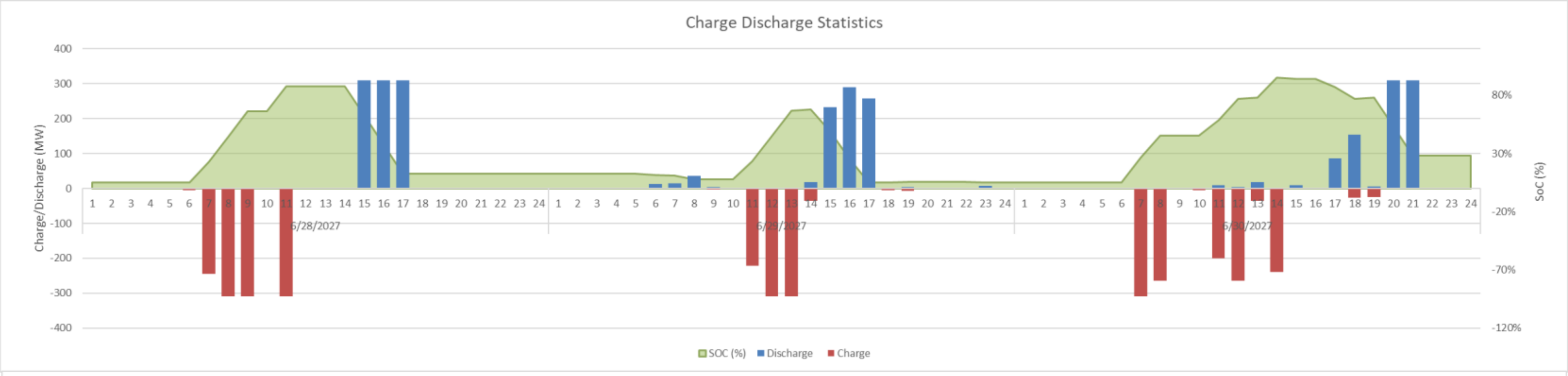
Key parameters for modeling



PV System – Loss Diagram

- **Solar Output:** It is critical to understand the solar output available for charging and solar output injected into the grid
- **DC/AC Ratio**: Solar is often oversized than inverter rating to increase the utilization of interconnection and to account for degradation in solar output for future years. Storage is oversized by 20 to 80%.
- **DC vs AC Coupling**: Battery utilizes clipped solar in DC coupling. DC coupling thus shows better economics but controllers for DC coupling might be expensive. AC coupling doesn't utilize clipped solar but adds flexibility to market participation.



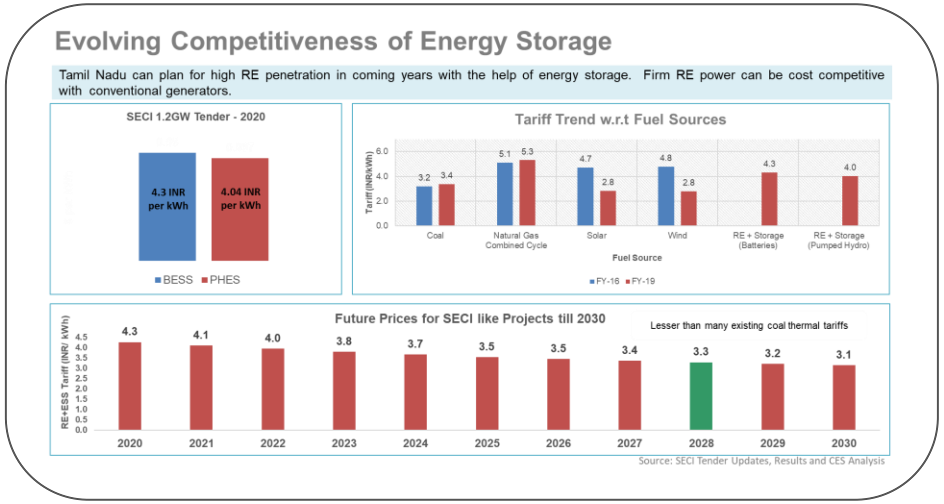


Case Study 2

Estimating Energy Storage Requirements for Tamil Nadu Grid

Optimal RE Integration in TN Grid by 2025 and 2030

ESS Requirement Analysis and Techno-Commercial Viability Study



Objective

The project objective was to make an optimum renewable energy (RE) integration plan for 2025 and 2030 with the support of Energy Storage Systems (ESS) and create Energy Storage Policy Roadmap for Tamil Nadu.

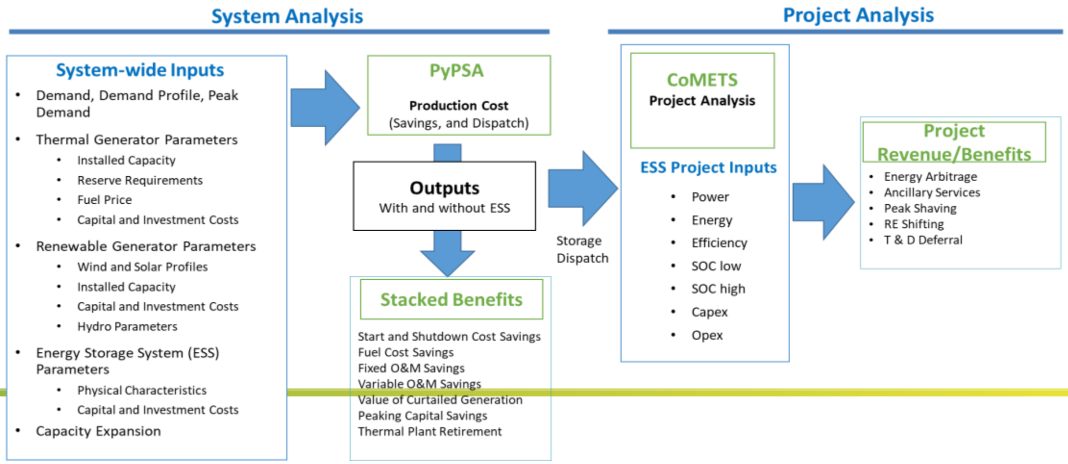
Analysis Details

- Considering the increasing competitiveness of Energy storage options, a preliminary market analysis was done
- The analysis consisted two time-frames viz. 2025 and 2030, for different renewable penetration scenarios.
- Modelling consisted of two levels, an initial system level production cost analysis and then a project level study
- The economic dispatch simulation was conducted including capacity expansion of storage
- Storage plays significant role in shifting of the excess solar energy from day to evening in all seasons
- Moreover, short term variations are effectively absorbed by either charging or discharging
- Excess wind availability during monsoon and summer is used productively for nighttime or peak time supply.

Outcomes

- Suitable energy mix for better RE integration with addition of storage
- Storage capacity requirements for in high and low RE scenarios
- System level benefits due to addition of storage
- Performance of existing assets after RE and storage

Modeling Approach



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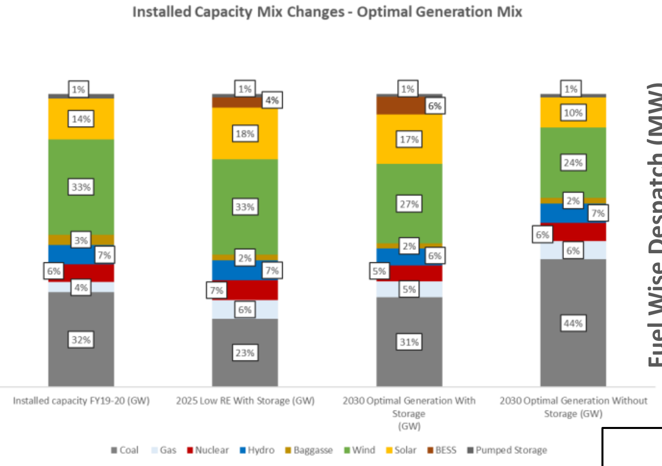
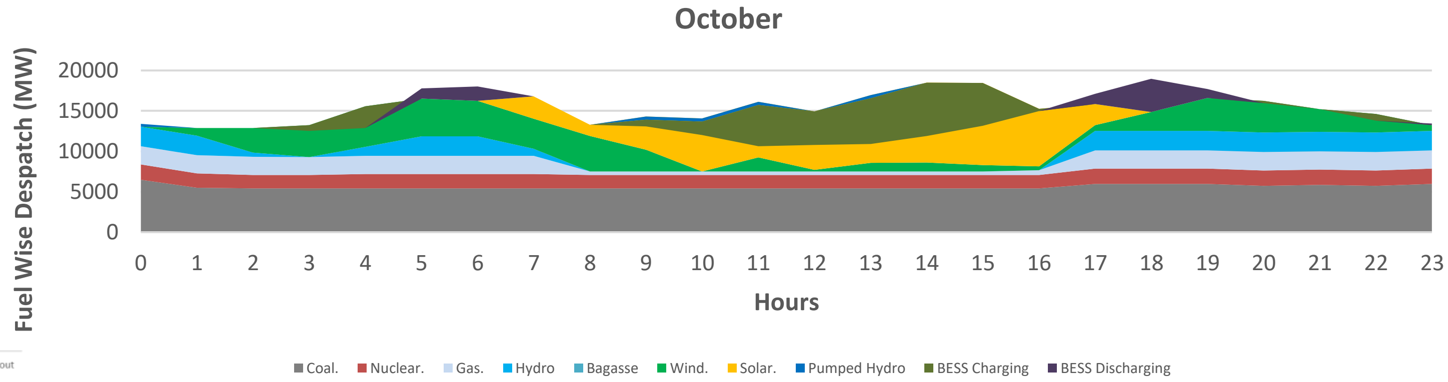
Optimal RE Integration in TN Grid by 2025 and 2030

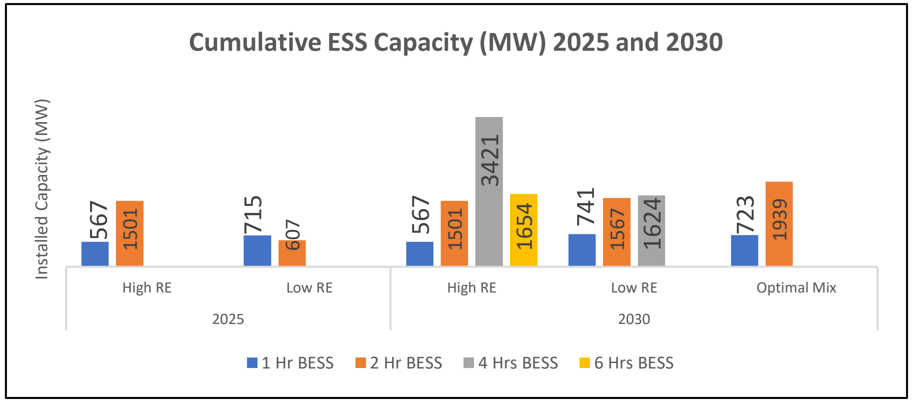
Optimal Generation Mix 2030

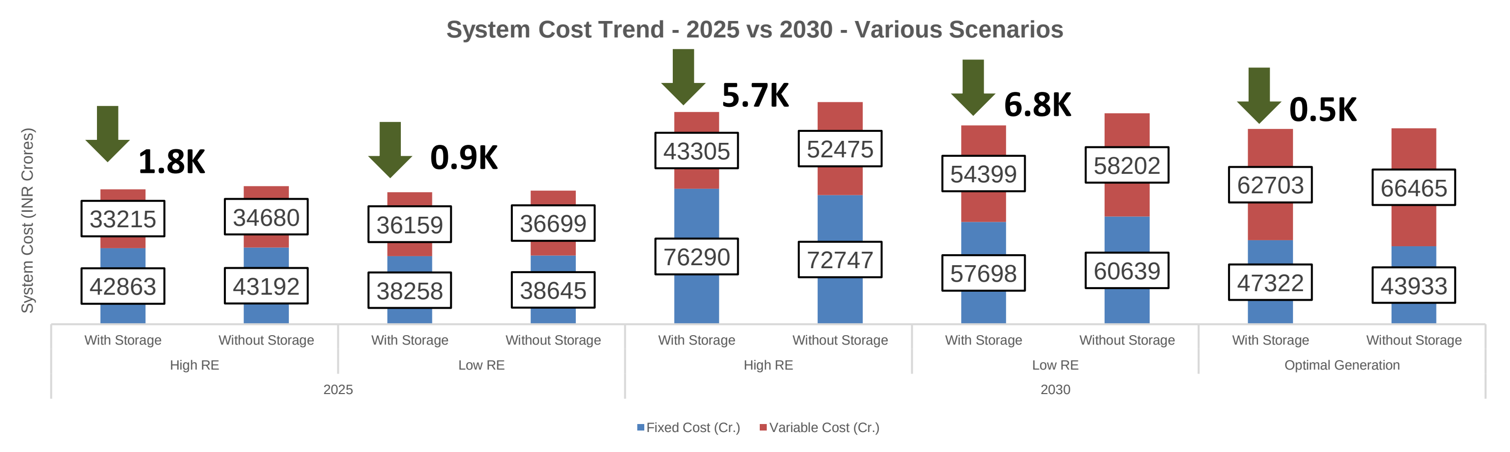
- In the Optimal Generation Mix simulation, the Model takes the least cost of generation as a criteria to decide on generation Mix while keeping the RE spillage minimal.
- We see that with small addition of storage 4% of total capacity in 2025 and 6% in 2030 the level of RE integration increases from 34% to 44% in 2030.
- Also, decreases the coal share in capacity by 13%



Model based example of economic dispatch showing the shifting and smoothing application of storage







Recommendations

- Storage penetration in the Grid is prescribed to be Gradual
- The storage duration during the initial years are of 1 to 2 hours and the same increases to 6 hours for High RE case and 4 Hours for Low RE Case by 2030
- As per cost benefit analysis it is observed that BESS at Grid level brings maximum benefits in the 4 to 6 hours duration
- By 2030, with decrease in battery costs and improvement in technological performance, BESS will be highly competitive with new coal or gas additions

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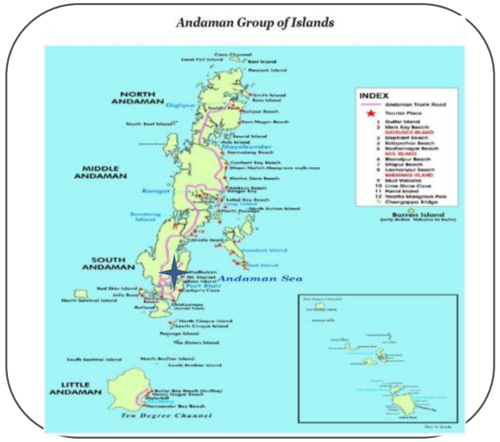
Case Study 3

Analysis of BESS Integration for South Andaman Electricity Grid

Analysis of BESS Integration for South Andaman Electricity Grid

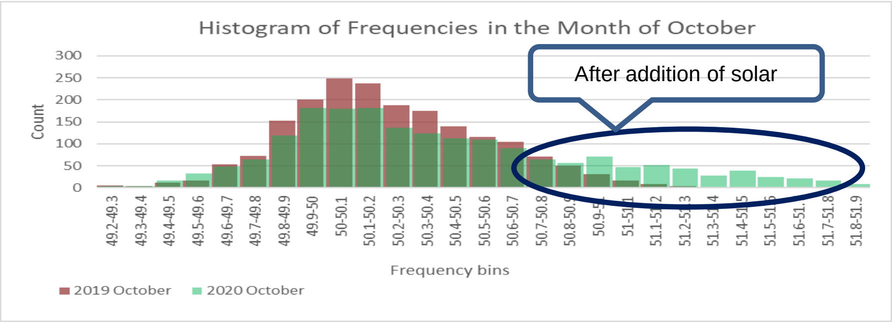


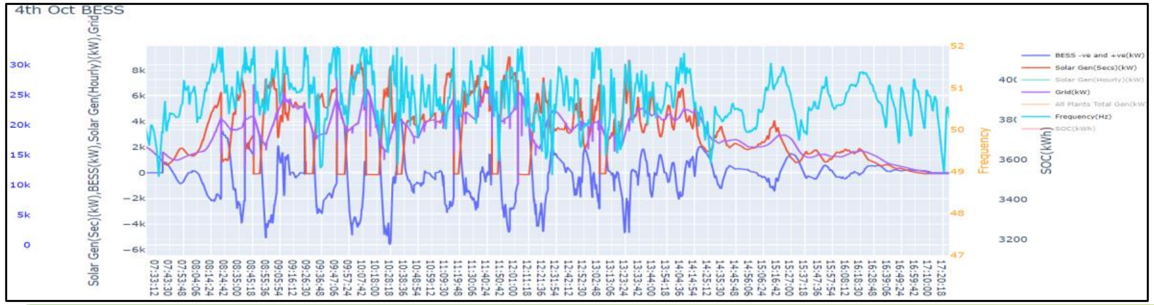
Objective

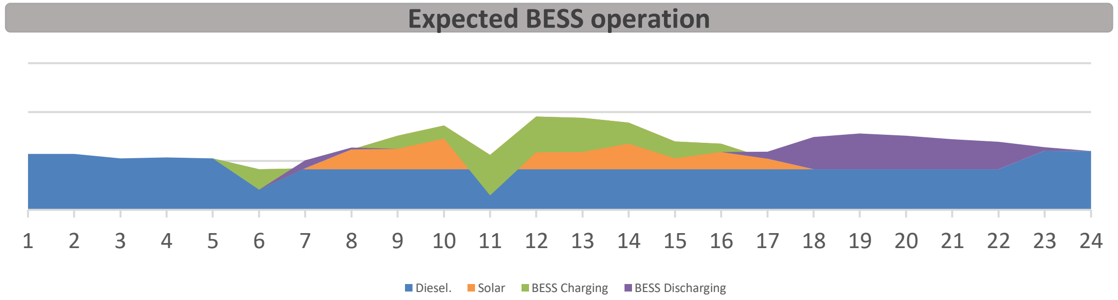
Carry out feasibility study for setting up a standalone Battery Energy Storage System (BESS) in South Andaman to arrive at an optimal solution for addressing current as well as forthcoming frequency management issues pertinent to RE integration and RE shifting for evening hours.

Analysis Details

- Production cost model was developed to assess the capacity requirements for both the purposes
- The economic dispatch was obtained at minute-level resolution
- To make the objective more tractable, days of the year were clustered based on weather volatility and were correlated with occurrence of grid interruptions
- The simulation performed capacity expansion of storage to reliably balance load at high resolution while minimizing the overall system level cost for each type of day
- Cost Savings due to addition of storage was calculated at system level, along with savings due to reduced diesel consumptions and avoided solar curtailment were also found out
- With the costs and benefits, a complete financial analysis was carried out
- Suggestions on placement and operation of the standalone BESS was also provided







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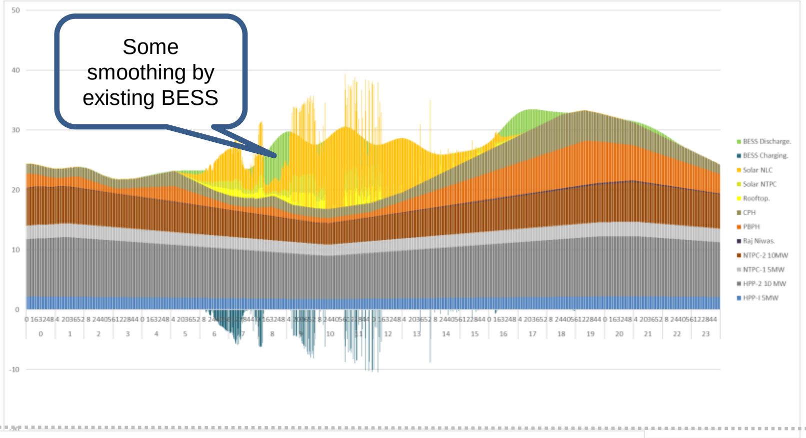
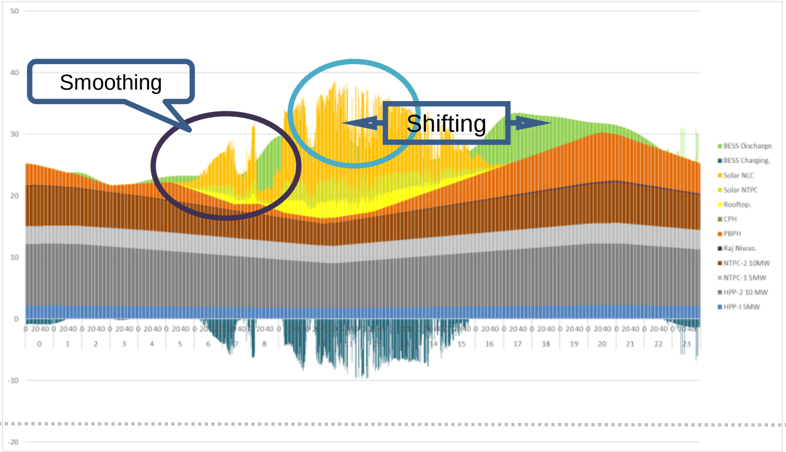
Analysis of BESS Integration for South Andaman Electricity Grid

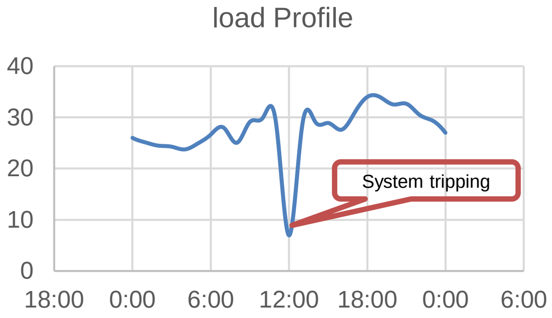
Solar Availability

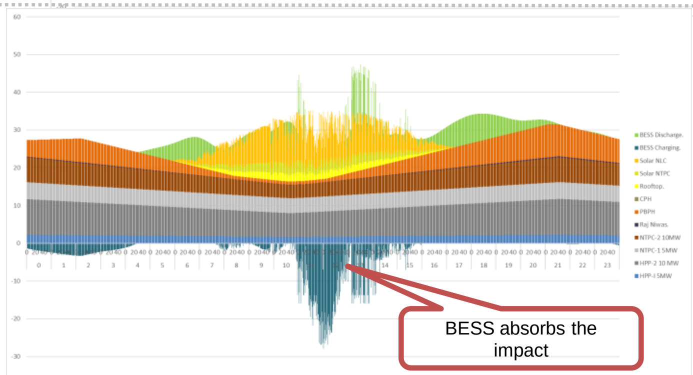
Dispatch WITHOUT storage addition



Dispatch WITH storage addition







Multiple denominations of storage type size and rating which provide the best economics, limited curtailment and diesel savings were estimated so that it can be considered as the optimal solution for South Andaman's present power system

Recommendations

- Power and Energy rating of storage along with type (1-hour, 4-hour etc)
- System level benefits obtained from, with and without storage scenario comparison
- Diesel saving was reported both as liters and INR; Avoided curtailment was also reported in MWh and INR
- For the recommended sizes of storage, the possible pricing, payback period, IRR, DSCR and 10-year Net Benefits were reported
- Inputs regarding Placement and Operation of BESS were provided
- Detailed report regarding risk, safety and standards of BESS

Questions & Comments

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