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CIGRE US National Committee
2022 Grid of the Future Symposium

Energy Storage Planning Tool (ESPT-T)
Reliability and Resilience Grid Planning with Storage

R. ANILKUMAR, H. OTHMAN
Quanta Technology LLC
USA

SUMMARY

Energy storage is increasingly attracting the interest of policymakers, regulators, project developers, and electric utilities. A properly sized and sited energy storage solution can provide several grid reliability, resiliency, and efficiency services while facilitating public policy initiatives. The conversations around non-wire solutions (NWS) including energy storage are gaining momentum in light of recent FERC Notices of Proposed Rulemaking (NOPR) for Grid enhancing technologies, Climate Change considerations in transmission planning, and improvements to current planning processes.

Energy storage can add strategic value to existing systems by 1.) Improving utilization of existing T&D lines, 2.) Provide flexibility to address reliability and resilience needs in the system 3.) Leverage the modularity of energy storage to de-risk grid investments, especially in the face of growing planning uncertainties and permitting processes.

The application of energy storage within transmission grids as NWS is hindered by the lack of readily available tools, standardized planning processes, and practical know-how. The objective of this paper is to present methods of analysis to help transmission planners examine the technical and economical efficacy of energy storage as an NWS to address grid reliability and grid performance. This paper will highlight the capabilities of the Energy Storage Planning Tool (ESPT-T), designed specifically for transmission planners to understand the value of energy storage solutions.

KEYWORDS

Non-Wire Solutions, Energy Storage, time-series analysis, siting, sizing, techno-economic evaluations, software, planning tool, transmission planning,

RAnilkumar@Quanta-Technology.com

1. Introduction

Transmission grids are operated under strict reliability standards that address operating criteria not only under normal or intact (i.e., N-0) conditions but also under potential contingencies (N-1, N-1–1) that take one or multiple grid elements out of service. The reliability standards ensure robustness and security of the extra-high voltage grid to avoid the risk of cascading outages and widespread loss of load. Traditional reliability planning that takes into consideration extreme events driven by climate change, cyber-security, and natural disasters is the first step towards resilience planning [1].

Within a typical planning horizon that spans 5–20 years, system planners update the demand forecast and consider the impact of the planned retirements of generation assets, the interconnection queue of resources, and the health of existing T&D assets on grid reliability and the need for T&D upgrades and reinforcements. The menu of conventional upgrades includes enhancements to existing assets and building new ones such as substations, lines, transformers, reclosers, shunt reactive compensation, and dynamic technologies such as Flexible AC (FACTS) and smart wires. Utilities are increasingly evaluating energy storage as a non-wire alternative (NWA) to address grid capacity, reliability, resilience, market efficiency, and renewable integration needs. A properly sized and sited storage system can provide several grid reliability and resilience services while facilitating public policy initiatives, as summarized in Figure 1.

Energy storage rapidly injects and absorbs electric power at its point of interconnection (POI) and alters the power flow on T&D lines. The flow can increase on some line segments and decrease on other line segments. Similarly, when equipped with four-quadrant inverters, energy storage is capable of injecting and absorbing reactive power and consequently can increase or decrease bus/node voltages. If the storage systems are located within the grid where they can reduce the flow on overloaded lines and/or bring bus/node voltages within acceptable operating bands, then they can provide grid reliability services and be utilized as grid assets (either to replace or to complement conventional assets). However, an important distinction should be made between the reactive power provided by inverter-based sources compared to those provided by conventional rotating equipment during low voltage or short circuit situations - due to the limited overcurrent ratings of inverters[2].

Currently, energy storage evaluations are limited to the available suite of transmission planning and economic planning software. Common transmission planning software includes GE PSLF, Siemens PSS/E or PowerGem TARA. The common suite of economic planning software includes Hitachi GridView and Hitachi PROMOD. In addition to these commercial tools, there are a suite of publically available tools including EPRI-Storage VET, QuEST, System Advisor Model (SAM), and Energy Storage Evaluation tool (ESET), that are more focussed on the techno-economic elements of storage evaluations. While these tools are extremely valuable for storage valuation and design, they are decoupled and do not operate in an integrated manner [3].

Energy Storage Planning Tool (ESPT) [4] has been designed as a dedicated tool for storage applications. It has a broad set of use cases and can interact with commercial software. Further, ESPT follows a stacked application logic, where the primary application is used to size the storage in terms of power and energy, and the slack is contributed to secondary applications, like market participation. In terms of the optimization logic, ESPT is a network-aware model with a constrained time-series-based Optimal Power Flow (OPF) mathematical optimization.

This results in several benefits being co-optimized: battery charging does not create additional violations and solutions capable of solving multiple violations at once are in the feasible set. Financial considerations like revenue requirement and upfront installation costs are also inputs to the co-optimization.

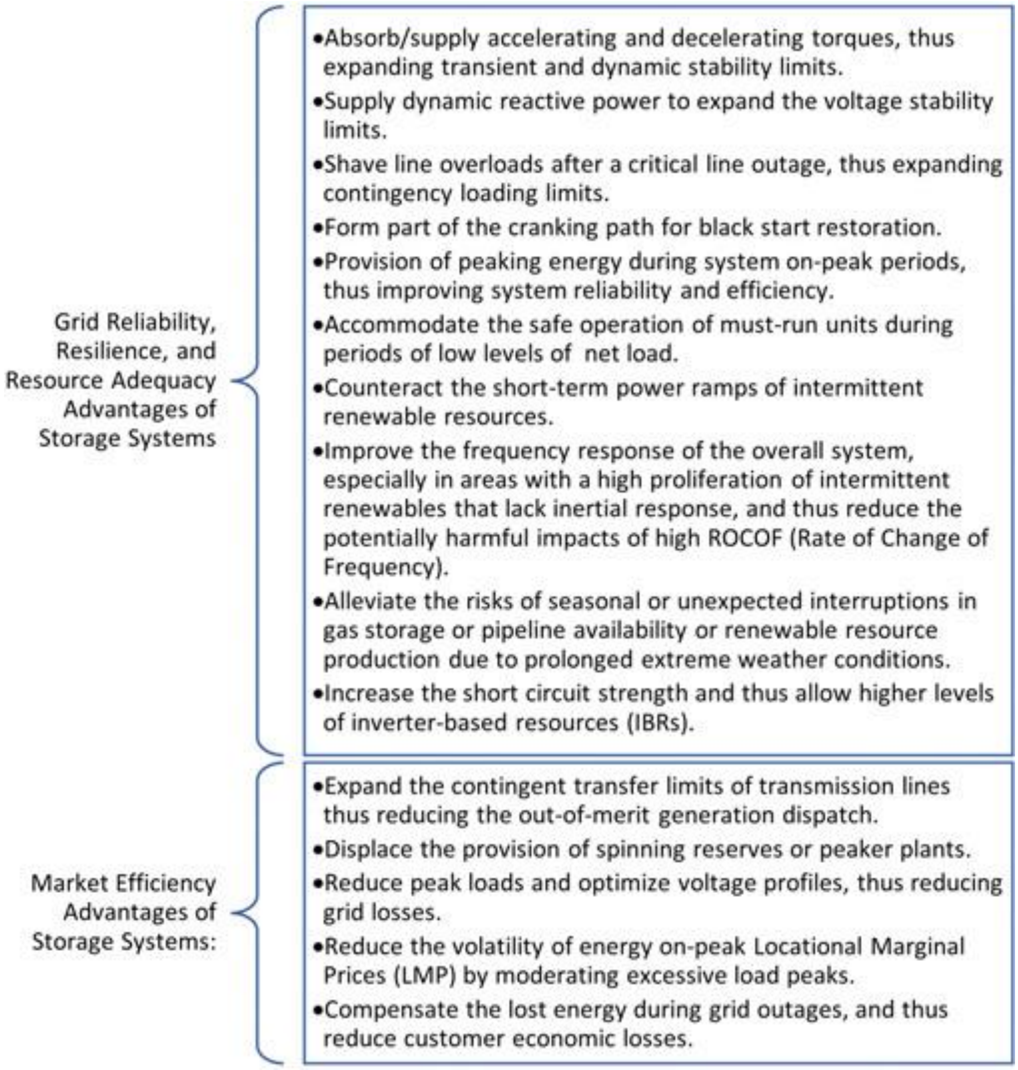

Figure 1 : Storage System Reliability and Resilience Benefits[2]

2. Analysis Techniques When Planning Energy Storage

The increasing variability and unpredictability of power flows in T&D grids, instigated by the proliferation of distributed energy resources (DERs) and variable renewable resources (VERs), increases the complexity of grid planning and necessitates the development of more advanced analysis tools and processes.

The traditional capacity planning that assumed dispatchable centralized resources and unidirectional flows on distribution grids is giving way to performance planning that seeks to assure successful integration of DERs and VERs while adhering to reliability standards. The traditional practice of examining grid performance at a limited number of operating snapshots (e.g., summer-peak or spring off-peak) is no longer adequate, and in many cases, a more complex hourly (e.g., 8760) series power flow and contingency analysis is required. The variability of renewable profiles and load profiles and their uncertain alignment may require probabilistic analysis such as Monte Carlo simulations wrapped around the 8760 time-series analyses. Furthermore, the dynamic interactions between inverter-based resources (IBR) on the transmission and distribution grids following a system event on either side are increasingly driving the need for integrated T&D analysis.

Typically, planners would utilize transmission planning or economic planning models to design the technical solution and assess its benefits, respectively. The transmission planning tools largely restrict visibility into a single snapshot of the system, typically useful for capacity (MW) storage sizing. This is coupled with excel based load curve analysis to estimate the storage energy (MWh) sizes. The technical solution is introduced into an economic planning model to assess the impact on electricity markets and production costs. While these tools do not directly generate ESS valuation results, the outputs – such as operation cost, prices, and dispatch results – could be used to estimate ESS economic benefits utilizing the suite of publically available techno-economic tools.

Unlike traditional T&D lines, which work passively without time limits and without active controls to increase transfer capacity, energy storage provides similar core functionality, but for a limited time window, and requires active monitoring and control to coordinate and manage its real and reactive outputs and state of charge. On the other hand, the footprint, modularity, and potential movability of energy storage is a significant advantage, especially when deployed in the vicinity of load centres and for edge-of-grid applications.

The proper analysis of energy storage as an alternative or a complement to traditional wire solutions should explore not only the core functionality but also the flexibilities and vulnerabilities inherent in each technology and supporting system and their ability to de-risk capital investments in the face of increasing levels of uncertainty. Six key aspects are critical to the successful planning of energy storage as grid assets:

- Siting
- Sizing
- Revenue stacking
- Techno-economic lifetime comparative analysis
- Control system signals and relay tuning
- Protection System Design and Settings

The ESPT software as a storage toolkit is capable of performing Siting, Sizing, Revenue Stacking and Techno-economic lifetime analysis. Additional details regarding these features are described in this paper along with several case studies.

3. Siting Analysis Methodology

The siting analysis aims to find the best locations within a grid where storage systems can be most effective at reducing the lifetime cost of grid congestion while ensuring secure operation of the power system. The analysis is influenced by the grid structure (topology and equipment ratings), loading profile, renewable energy profile, and the critical contingency list.

The congestion cost of a transmission grid with a set of injection (generation and load) nodes denoted as i, a set of congested lines denoted as k, and a contingency list of equipment outages denoted as j, can be calculated using a security-constrained optimal power flow and can be expressed in a linearized format as:

$$Congestion\ Cost = MAX_j \{ \sum_k \mu_k \left(\sum_i h_{ki}.P_i + L_{kj}.F_j \right) \})$$

Where,

Pre-outage power flow on line j is $F_j = \sum_i h_{ji} P_i$

μ_k is the marginal cost of congestion of line k

$L_{kj} = \frac{\partial F_k}{\partial F_j}$ is line the outage distribution factor, or, specifically, the change in power f low on line k due to outage of line j

$h_{ki} = \frac{\partial F_k}{\partial P_i}$ is the power transfer distribution factor, or, specifically, the change in power flow on line k due to injection at bus i

The sensitivity index of the system congestion cost to a power injection at bus i can be derived as:

$$\frac{\partial Congestion}{\partial P_i} = MAX_j \{ \sum_k \mu_k (h_{ki} + L_{kj} . h_{ji}) \})$$

A variation on the formula directly above is to consider the probability of each contingency in lieu of the worst-case embodied by the MAX function. Another variation is to set μ_k as a function of the overload of the monitored line.

For technologies such as generators, loads, and energy storage, the locations with the largest negative (or positive) sensitivity index are the most influential in reducing the congestion cost when the battery is operated in a discharge (or charge) mode. The analysis can either be repeated for each chronological hour or performed on a select set of snapshots of loading profiles. The optimal sites are ranked by sorting the annualized congestion cost sensitivities for each of the potential sites as calculated using the formula above, in ascending order, with the highest being the best site for locating an energy storage system. The above formulation does not require any optimization method to calculate. The marginal costs are relative and can be taken as uniform for all lines. They can also be skewed to reflect the level of line loading or, if available, the marginal congestion cost of each line.

4. Sizing Analysis Methodology

The objective of adding energy storage systems to relieve grid congestion is to allow the dispatcher to load the transmission grid, during normal operation, up to its N-0 limits, and for the storage to remain ready to offset any potential overloads on congested lines that may result after a contingency event.

If the flow on a path k is denoted by F_k^{post} during a post-contingency event and F_k^{pre} prior to the contingency event, and if the injection at bus i is denoted by P_i^{post} during post contingency and P_i^{pre} prior to the contingency event, then:

$$F_k^{post} = \sum_i h_{ki} . P_i^{post} + L_{kj}. \sum_i h_{ji} . P_i^{post}$$

and, the change in line k flow resulting from a line j outage is:

$$\Delta F_k^j = F_k^{post} - F_k^{pre} = \sum_i h_{ki} . (P_i^{post} - P_i^{pre}) + L_{kj}. \sum_i h_{ji} . P_i^{post}$$

The energy storage sizing problem can be formulated as a linear program (LP) – the aim of which is to minimize the largest increase in congestion cost resulting from all contingency events – as follows:

$$\min \left(\max_{j} \sum_{k} (\mu_k . \Delta F_k^j) + \sum_i \propto_i \left(P_i^{post} - P_i^{pre} \right) \right)$$

Subject to:

$$P_i^{min} \leq \left(P_i^{post} - P_i^{pre} \right) \leq P_i^{max}$$

for all buses i where energy storage is contemplated, where P_i^{max} and P_i^{min} are the discharge and charge power rating limits of a storage system at bus i (in part due to substation capacity limits).

$\sum_i P_i^{post} = 0$, to preserve the power balance in the post contingency state (optional).

$\propto_i$ is the marginal cost of power generation or storage at node i.

This is a general formulation that allows the grid planner to optimize the size of a single or a set of coordinated energy storage systems. It also allows balanced or unbalanced storage solution strategies, where a balanced strategy will require that the storage systems charge and discharge in a manner that has a zero net injection into the power system, and thus, avoid any interaction with the energy market even during a brief period after the occurrence of a rare contingency. The solution of the LP is very fast (seconds). The above formulation can be modified to consider reliability violations with a few additional constraints in the LP formulation.

5. Revenue Stacking

Revenue stacking describes a situation where the energy storage system (ESS) is used for more than one domain of applications. Revenue stacking attempts to find secondary sources of revenue for the ESS resource when available to the market and not limited by its primary function.

T&D reliability applications always takes priority to wholesale market participation. This means, ESS always ensures safe operation of the T&D system. Needed capacity and required dispatch levels must be considered as constraints to market participation. Once the T&D constraints are available, the ESS capacities available for market purposes must be modified on an hourly / daily basis so that the market valuation can respect the T&D application requirements. During the period of the year when the ESS is not required for the primary application, it can time shift the energy by participating in wholesale energy markets. This service results in ratepayer savings when the asset is assumed to be utility owned with all energy cost savings passed on to ratepayers.

The revenue stacking function typically optimizes the various applicable market participation services including energy and ancillary service, while respecting primary reliability functions to estimate revenue for stacking market services. Certain operating constraints are applied to ensure ESS can always meet the reliability application considered. For instance, circuit loading mitigation thresholds are used to ensure enough capacity to serve customer loads if outage occurs. The market analysis is on an hourly basis for 8760 hours a year.

6. Techno-Economic Analysis Methodology

A solution that includes an energy storage asset should be evaluated on the same basis as a conventional solution. However, there are differences between the attributes of the two categories of solutions, including the permitting duration, the expected life, the asset management strategy and costs, the operational risk, and the ability to provide additional services beyond the primary reliability function, which should be quantified and evaluated equitably.

The proposed economic analysis methodology considers the lifetime costs of each solution including initial capital, operations and maintenance, capacity augmentation, asset replacement and renewal, and asset retirement. The analysis considers the revenue requirements of each solution as a regulated asset, and thus, focuses on the cost to the utility customer. The evaluated cost can be adjusted up or down to account for additional value or revenue streams that a solution may provide.

The economic evaluation of the storage solutions as compared to the conventional T&D solutions requires the following:

- Lifetime modeling of the cost of each project from inception to retirement inclusive of project development activities and timeline, EPC (Engineering, Procurement, Construction), O&M (Operations and Maintenance), capacity management, replacement, disassembly, and recycling.
- Modeling of utility capital structure including debt and equity ratios, costs, and tax rate.
- Proper regulated-asset-base (RAB) accounting including treatment of asset depreciation.
- Useful asset life estimates: The conventional T&D solutions have an assumed book life of 40 to 60 years, while the energy storage technology has a typical useful calendar life of 10 to 15 years for lithium-ion technology and is further restricted by the usage profile and its impact on the life cycles.

The following methodology is adopted to compare the economics of the various solution alternatives:

- The initial installed capacity of the energy storage part of a solution is upsized to mitigate the anticipated capacity fading throughout the asset life. For a nominal 2% annual degradation of storage capacity [5], the installed storage MWh capacity can be upsized by 16% from the level required to address the system needs in order to have one augmentation at mid-life.
- A straight-line depreciation of each asset is adopted for book accounting and tax purposes. The tax depreciation methodology can vary depending on applicable rules. In the U.S., accelerated depreciation is used for tax depreciation.
- Due to the differences in asset life between the conventional asset (40–60 years) and the storage asset (10–15 years), the analysis is carried out over a 45-year horizon, and multiple battery investment/replacement cycles are considered. Two approaches are considered for the comparative analysis; the first calculates the present value of each solution cost over the 45-year horizon, while the second focuses on the first life of the storage system (e.g., 15 years) and calculates the levelized real cost of the conventional solution over that period of time utilizing a real economic carrying cost taking into account the utility's weighted average cost of capital and the inflation rate.
- The present value of the revenue requirement for each solution is calculated.
- The ratio of a storage solution's revenue requirements to that of the conventional solution is taken as the key metric of evaluation. When the ratio is below 1, the storage solution is deemed less expensive for the ratepayers than the conventional solution.

7. Energy Storage Planning Tool (ESPT)

Quanta Technology has developed a software tool to help planners site, size, cost estimate, stack revenues, and perform techno-economic analysis of Energy Storage solutions. The tool is capable of handling short-duration and long-duration storage analytics with the following features:

- Calculate a siting index for each bus in the study area, based on the locations ability to reduce line overloads after contingencies. The resulting heatmap guides developers and utility planners to find suitable locations.
- The MW rating of single or multiple storage systems are optimized to ensure lowest storage cost while meeting system security constraints.
- Time-Series power flows (8760 hours) is utilized to size the energy capacity requirement taking into account not only the relief of the grid constraints but also the ability to recharge (or discharge) the storage system to be ready to serve its function the next time it is needed.
- Robust method and software tool to develop a total cost of the storage system and its bill of material and cost breakdown.
- Storage extra capacity, beyond its primary function, is optimized in the wholesale energy and ancillary markets
- Compares the revenue requirements of a regulated storage asset against a conventional solution, while accounting for the differences in asset life and O&M practices. Calculates investment metrics of IRRs, NPVs, and breakeven analysis for market assets.
- Valuation of the optionality value embedded in energy storage to deal with uncertainty in load forecast and market prices. Rolling incremental investment decisions are triggered to address near to mid-term forecasts. Monte Carlo simulations show the envelope of financial outcomes.
- Designed to integrate directly with commercial planning software including PSS/E, PSLF and TARA.

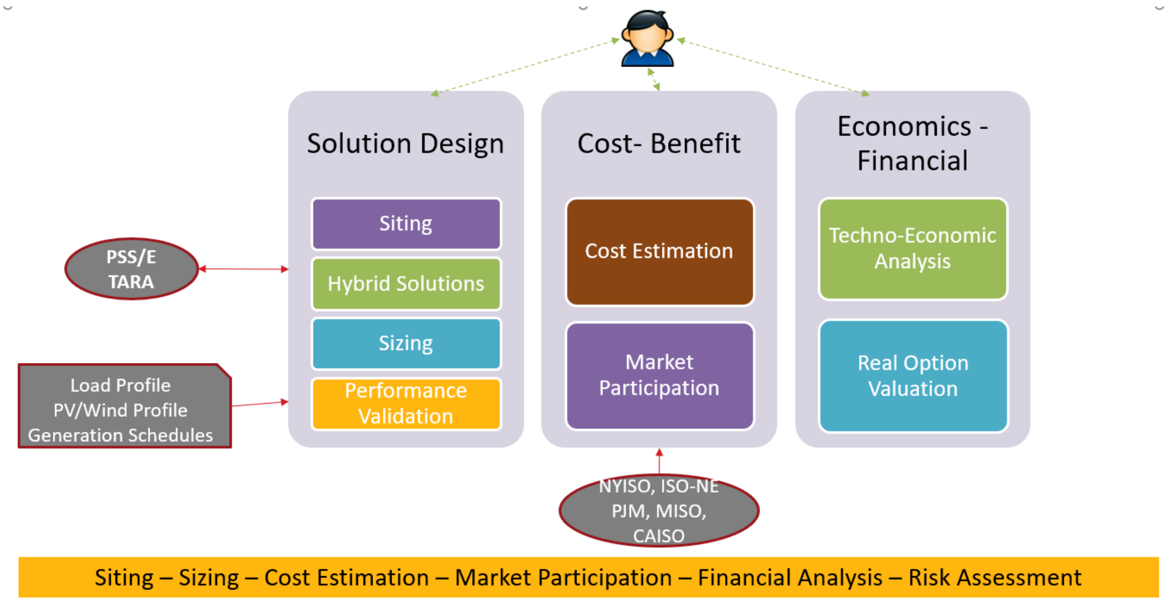

Figure 2 : Building blocks of the ESPT Tool

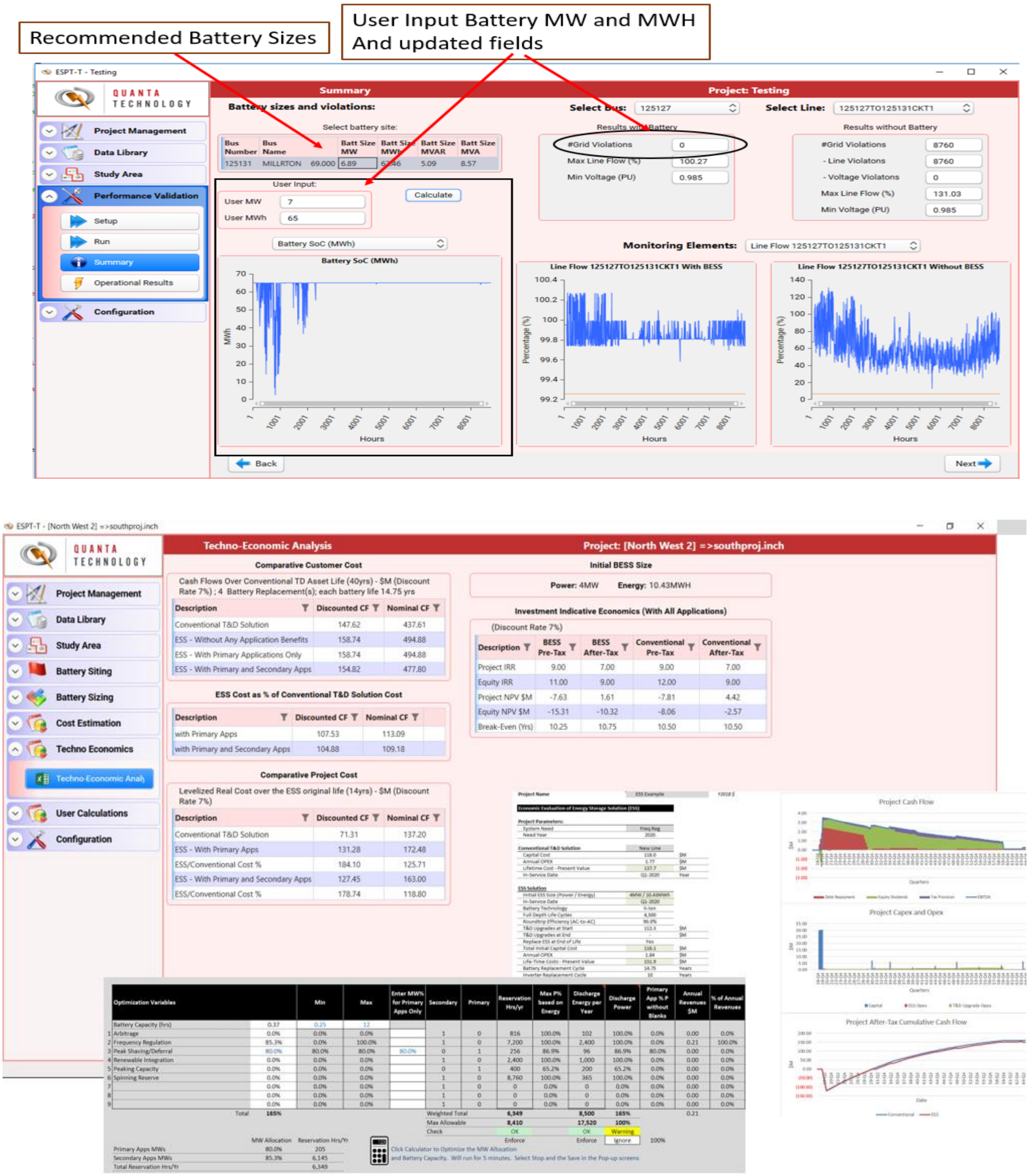

Figure 3 : ESPT GUI and Key outputs

8. Case Study 1: American Transmission Company (ATC) – Waupaca Project

The Waupaca area (Figure 4) of the ATC service territory in Wisconsin is supplied through two 69-kV sources (Wautoma to the south and Whitcomb to the north), one 115-kV source (Hoover to the west), and one 138-kV source (White Lake to the east). The peak load in the area reaches 200MWand exceeds 155 MW during 6% of the days.

The area can potentially experience reliability concerns that involve thermal overloads and low-voltage conditions under scenarios involving multiple outages (i.e., NERC Category P6 or maintenance + P1 outages). Depending on the load level in the Waupaca area, thermal overloads, emergency low voltages, or unsolved contingencies may occur for the loss of a second line (i.e., loss of the remaining 115-kV or 138-kV source in the area). The most constraining outage in the area was observed to be the loss (planned or forced) of the 115-kV source at Hoover and the 138-kV source at White Lake. Under these multiple outages, the local loads cannot be sustained if the area load exceeds 120 MW.

The existing solution is to utilize an operating guide after the first outage to sectionalize the 69-kV system at certain load levels, creating radially served loads. This allows the loads to be served after the second contingency but places many loads at risk of loss for a subsequent single failure. This operating guide reduces maintenance opportunities and increases the amount of load at risk in the area.

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This wire solution will require an expansion of the right-of-way (ROW). ATC proposed a hybrid storage solution that aims to increase local area reliability and to provide operational flexibility in the Waupaca area. The hybrid storage solution consists of a 2.5 MW/5 MWh battery to be installed at the Harrison North 138-kV substation, 14 MVAR shunt capacitors (8 at Arnott and 6 at Harrison North), and an upgrade to the 69-kV source bus in the south. The estimated total capital cost of the solution is $9.1 M (in 2019$). This hybrid solution will have fewer public impacts on the right-of-way (ROW).

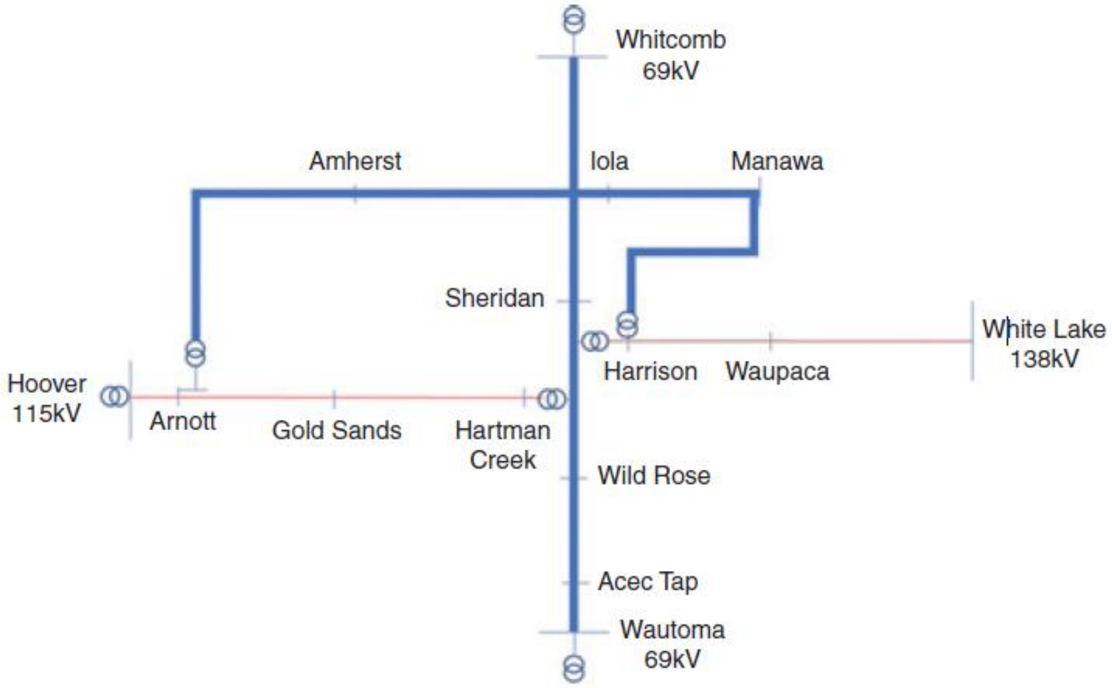

Figure 4 : Waupaca Study area

The ability to relieve the thermal and voltage violations through real and reactive power injections respectively is assessed at each bus in the study area using ESPT tool. The minimum reactive power injection to relieve voltage violations and the minimum real power injection to relieve thermal overloads from each candidate bus are quantified and compared. Sites with the least amount of power injections are deemed more suitable than others.

Additionally, the sites are further analysed based on their topology to remain networked and not be isolated following the first critical contingency. A power flow program is used to calculate the minimum reactive power injection to maintain system voltages above 0.9 p.u. following the first contingency, and distribution factors are utilized to calculate the minimum MW injections to mitigate thermal overloads. The overload on the Wautoma-ACEC Wautoma Tap can be mitigated by upgrading the bus rating to 94 MVA emergency rating and was excluded from the storage siting and sizing analysis. Figure 5 presents the level of reactive and real power injections that are required to mitigate overloads and voltage violations if the solution is placed at one of the system buses. The proposed hybrid project will mitigate the thermal overload and voltage violations in the system.

There are three operating modes that should be recognized and parametrized in the battery control system:

1. In the base (or intact) system, the battery will either be off-line during periods of the year when the forecasted load level does not trigger a reliability concern, or it can be used to regulate voltage using its dynamic reactive capability.
2. After the first contingency in the target area, the shunt capacitors will be switched on, and the battery will be online but without injecting any real power. It can, however, regulate voltage if needed.
3. Following the second outage, the battery will automatically sense the line power flow and bus voltage and will discharge real power and regulate voltage to mitigate the thermal overloads and voltage violations.

Map #	Bus Station Name	MVAR Need	MW Need Harrison Tap – Wild Rose Tap 69 kV	MW Need Harrison – Harrison Tap 69 kV
1	Harrison 69 kV	16	5.5	3.4
2	Harrison North 69 kV	16	5.5	3.4
3	White Lake 138 kV	16	5.9	3.6
4	Harrison 138 kV	16	5.9	3.6
5	Waupaca 138 kV	16	5.9	3.6
6	Hartman Creek 138 kV	16	6	3.6
7	Golden Sands 138	16	6.2	3.7
8	Hoover 138 kV	16	6.3	3.8
9	Hoover 115 kV	16	6.3	3.8
10	Arnott 138 kV	16	6.3	3.8
11	Arnott 69 kV	17	7.1	4.3
12	Iola 69 kV	19	8.4	5.1

Figure 5 : Breakdown of Substation Screening

9. Case Study 2: Offshore Wind Integration into New York

New York state has significantly large Offshore Wind (OSW) targets of 9 GW by the year 2035. This case study describes an evaluation of the role of energy storage to support the integration of 6 GW of Offshore Wind into NY Load centres (Zones J and K).

The 6 GW is distributed among common interconnection points identified through the New York ISO interconnection queue, primarily at voltage levels between 138kV and 345kV. The most common challenges observed with offshore wind integration into large load centres are coupled to the interactions between OSW and load profiles. During periods of peak demand, all energy from the OSW is readily consumed, with limited risk of congestion or reliability concerns. However, during light loading periods, majority of the offshore wind is being exported to the rest of NY state. During these times, significant congestion and system transmission security risks are observable. The primary use case for storage applications is to consume the excess offshore wind energy and make it available during less congested hours of the day.

To capture the most critical contingencies that limit offshore wind production, a detailed contingency analysis was performed. A combination of 26 facility violations were identified attributed to lines or transformers loaded above reliability criteria, wherein system dispatch was unable to mitigate the overload. Figure 6 identifies the overloaded facilities and relative location of offshore wind POIs.

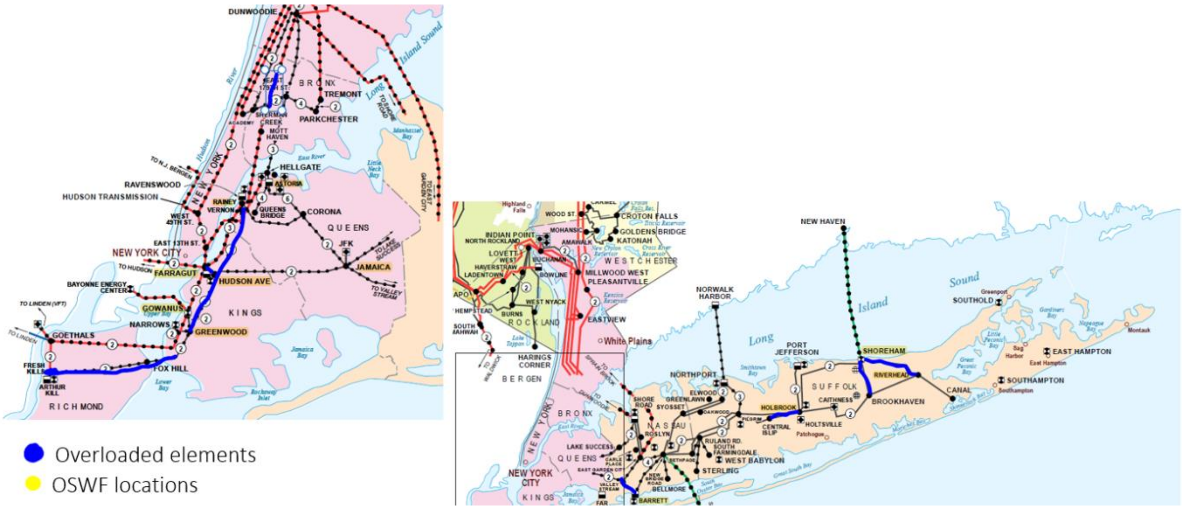

Figure 6 : NY Zone J and K [6]

The conventional solutions were evaluated on the basis of reconductoring the least amount of facilities that would result in addressing all violations. The cost of conventional solutions were $1B. Table below summarizes the circuits selected for conventional solutions.

Circuit	$M
Varnon W-Greenwood	322.59
Vernon E- Greenwood	294.10
Shoreham-Wildwood	143.24
Holbrook- Ronkonkoma	87.48

Circuit	$M
2 x 345/138Kv TRANSFORMER (Fresh Kills and Farragut)	33.51
Barrett to Valley Stream OH	43.48
E179 TO Sherman Creek	142.21
Total	**1,066.60**

ESPT tool was used to site and size the storage solutions that could provide comparative performance to conventional solutions and address all reliability violations. ESPT identified a combination of charging and discharging solutions to address the needs. The total size of the storage device, distributed among three locations is 158 MW and 1043 MWh. Figure 7 below identifies the location of storage sites relative to the constraints and offshore wind facilities.

Alternatively, hybrid solutions were investigated to look at a combination of reconductoring specific line segments and utilizing storage. Figure 8 presents the hybrid portfolio wherein the change in storage size with each conventional solution is reported. Figure 9 presents the 8760 MWh duration sizing of the storage device while tracking flows on overloaded facilities and accounting for battery charging opportunities.

The cost of the storage solution was $309M, which shows that the storage solution cost to ratepayers is 66% of a conventional solution.

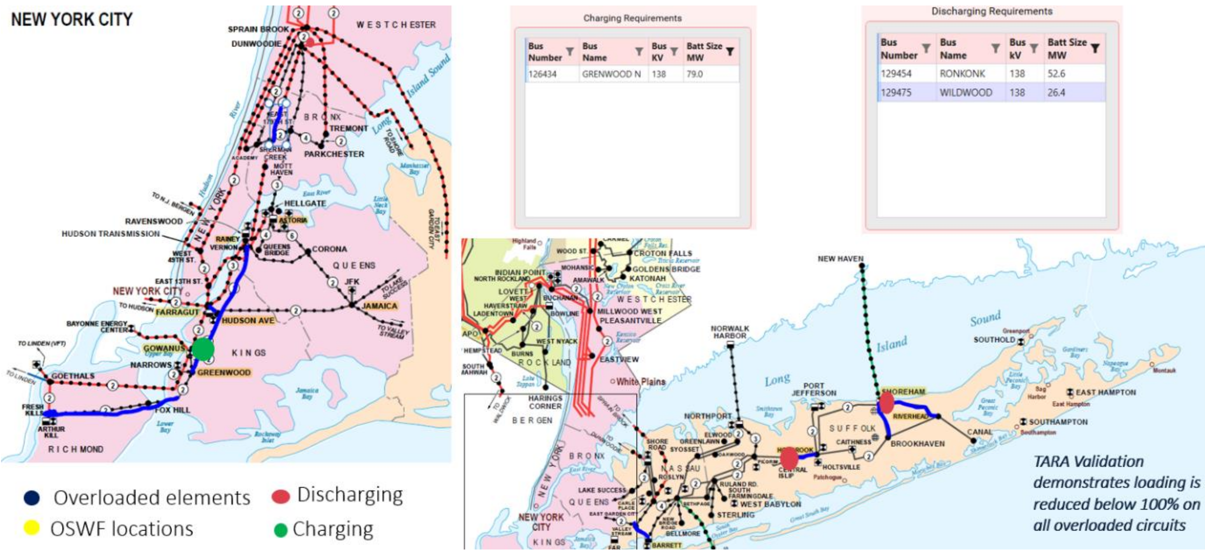

Figure 7 : Storage sites in Zones J and K [6]

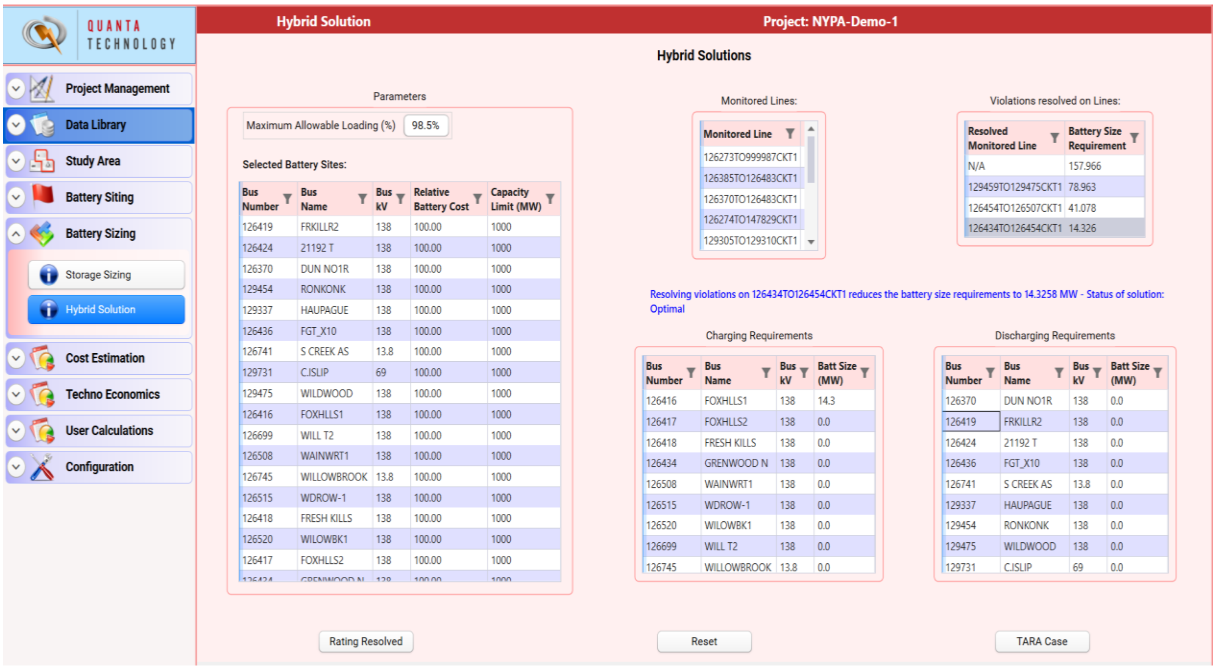

Figure 8 : Hybrid Portfolio evaluation using ESPT

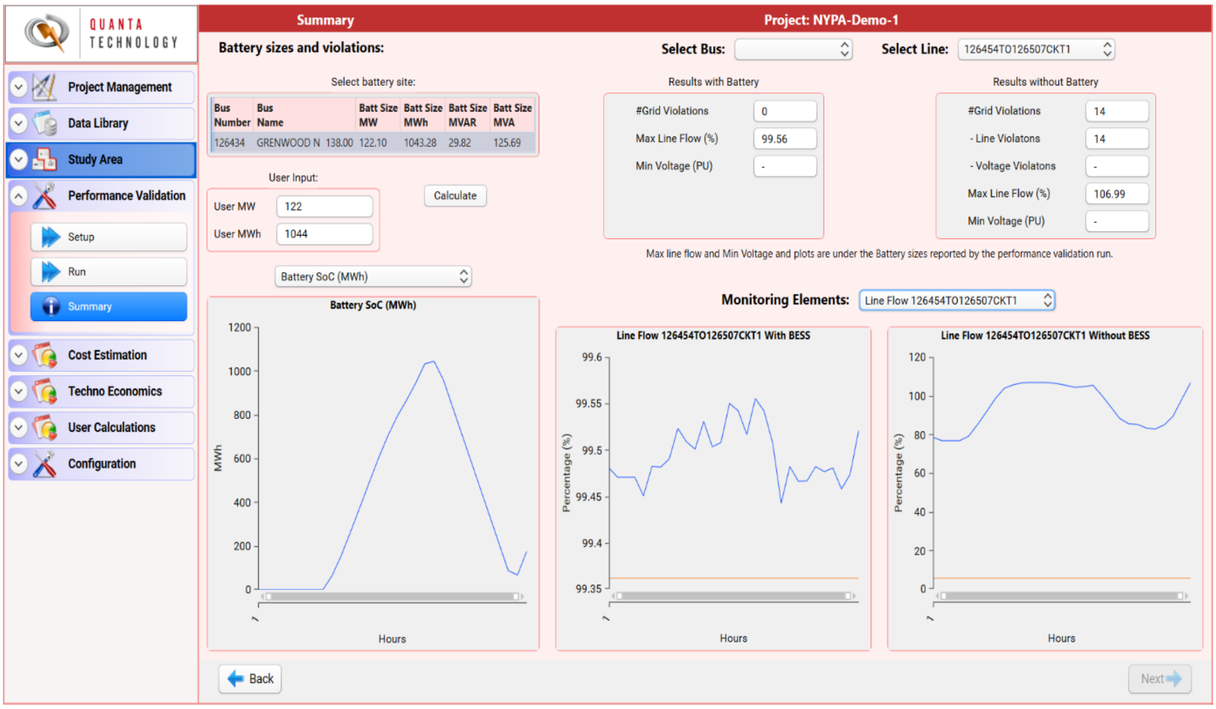

Figure 9 : MWh Energy sizing using ESPT

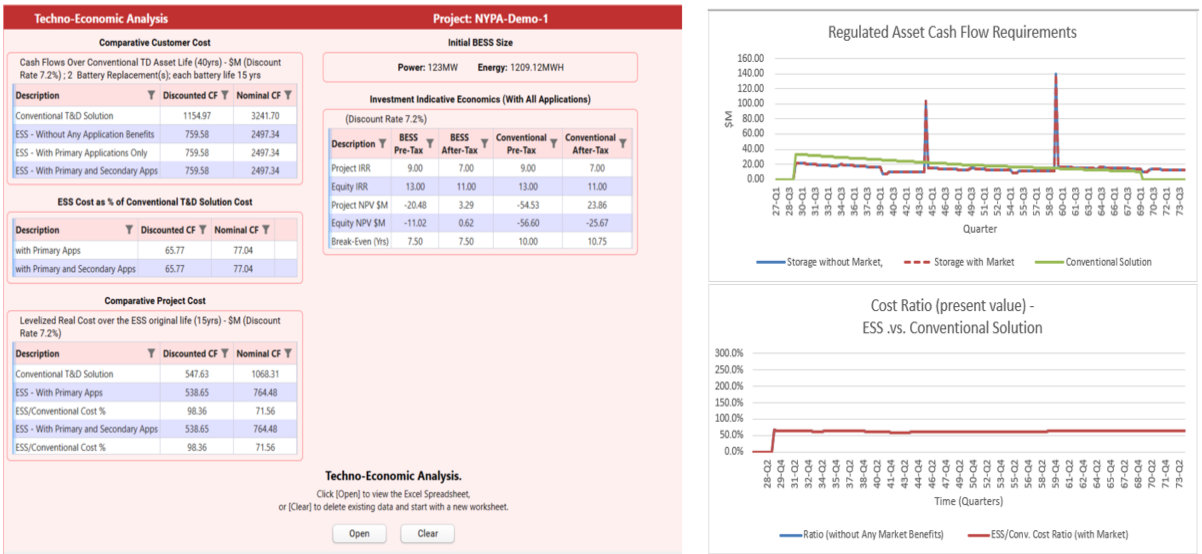

Figure 10 : Techno-Economic Analysis using ESPT

10. Conclusion

Energy storage is increasingly attracting the interest of project developers and electric utilities. These modular assets have the capability to rapidly inject and absorb not only reactive power but also real power making them essential elements of the electricity value chain from generation plants to consumers. A properly sized and sited storage system can provide several grid reliability and market efficiency services while facilitating public policy initiatives.

Other Non-Wire Alternative (NWA) technologies can also affect transmission system thermal loading and voltage limits. They can be used alone or in combination with energy storage and conventional solutions such as shunt compensation to bring a competitive hybrid solution. In short, energy storage is a valuable tool in the planning process, and its importance will grow over time.

Tools like ESPT offer planners the flexibility to evaluate energy storage as a non-wires solution to address grid needs. Some of the key features of tools like ESPT include-

1. Multi-application functionality – Load Backup, Peak shaving, Congestion relief, Capacity Deferral, Renewable Integration, Merchant Market Participation
2. Key functions – Siting and Sizing optimization, Performance Validation, Battery Energy Storage System Cost Estimation, Techno-Economic Lifetime analysis, Optimization of Market Participation.
3. Key features – Time series power flow analysis (8760 hours), Monte-Carlo capabilities, use of industry tools (PSS/E, TARA, PSLF), Regulated and Merchant Asset accounting, Market participation considering system reliability needs, lifetime analysis considering battery fading and lifecycle utilization.
4. Design features – Object Database to store multiple projects and underlying cases. User configurable Library, Modern multi-tier platform, Intuitive HMI.

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