
# Energy storage integration

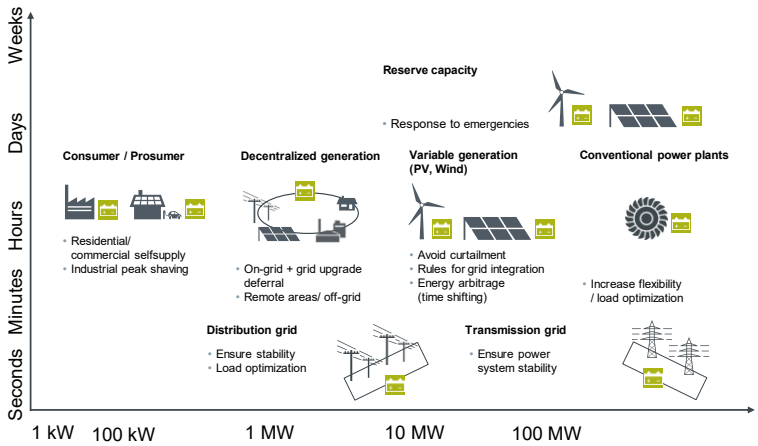
## Leveraging the full potential of storage solutions in transforming energy systems

### At a glance

The increasing share of intermittent - time-of-day dependent renewable energy resources, both at the utility level connecting to transmission and distribution (DER), is posing new challenges for the economic operation, stability and reliability of supply. Electrical energy storage systems (ESS) and in particular Battery Energy Storage System (BESS), can provide solutions to several of these challenges and – if properly designed –maximize the economic revenue.

As trusted consultants in the design of reliable, economic and resilient power systems and backed by Siemens's technology expertise, Siemens PTI supports clients in evaluating the potential of energy storage solutions within the specific framework conditions of all types of storage applications, such as:

- Energy storage systems for economic integration of renewable resources; energy shifting, curtailment minimization, energy arbitrage
- Application of battery storage systems to provide fast and/or regulating reserves
- Providing spinning reserve for frequency control and improve system reliability, e.g. to protect sensitive processes and operations
- Increasing grid capacity and efficiency by optimizing network equipment utilization and investment deferral, i.e. use of Non-Wires- Alternatives
- Enabling island operation of networks in microgrids for resiliency
- Generating additional revenue by participating in energy trading.




### The challenge

The renewable power output from solar or wind is highly dependent on the time-of-day and the fluctuating character of solar radiation or wind speed. One possible solution to overcome this intermittence is to use energy storage systems. Batteries and flywheel storage systems are existing examples used to store energy for periods ranging from minutes to hours and have a wide range of applications. As energy systems are more and more impacted by volatile power generation from wind turbines and solar power, energy storage helps balance fluctuations in supply and manage the rigid temporal connection between the supply and demand of energy, in addition to providing the ancillary services formerly supplied by conventional synchronous generation. However, the technical feasibility and economic value of storage solutions needs to be thoroughly evaluated considering the individual application, market response, regulatory framework and network conditions.

### Our solution

Siemens PTI provides independent technical consulting services for utilities, independent system operators (ISO) and the industrial sector worldwide. We offer a unique combination of industry leading energy business advisory, power system planning expertise and grid simulation software (e.g. PSS®SINCAL or PSS®E) to support utilities, grid operators, industrial customer and power producers to find solutions to the challenges resulting from the transforming energy landscape.

Our experts evaluate the impact of storage solutions by means of simulation-based technical and economic analyses. With these results, we provide valuable decision support for investments to enhance grid performance, resource optimization or leverage new business cases in energy trade.

Learn more about the services we offer with regards to the various applications of storage solutions in power grids.

### Increasing the profitability of RES

Wind and solar power plants generate electrical energy independently of demand and energy prices. Besides causing voltage fluctuations, this also has an economic impact on electricity prices (e.g. merit order effect) and can lead to curtailment of the resource to manage transmission and/or generation limitations. To manage intermittency, energy storage solutions capture surplus energy from renewable energy systems (RES) which can be discharged to cover the load in times of RES shortages or higher market prices.

This optimizes the contribution of the local energy system to energy supply and saves costs. Our offering includes:

- Assessment of storage applications via cost-benefit-analysis, e.g. considering the reduction of fuels and GHG emission, growing share of renewables and the degree of independency
- Technical-economical (pre-) feasibility study of load and generation profile leading towards optimal storage dimensioning and dispatch
- Identify optimal connection points to the grid to minimize and/or postpone grid investments

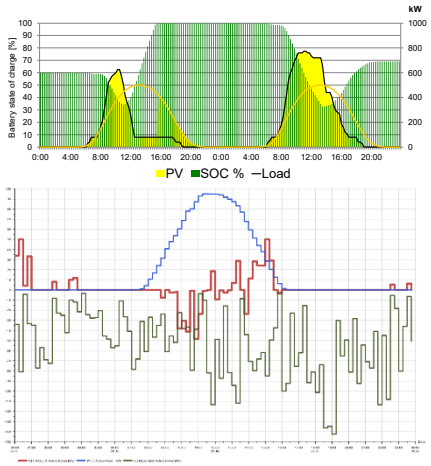



Figure 2: Storage operation with renewables (lower fig: simulation results in PSS®SINCAL)

- Ensure grid code compliance with a grid impact study considering latest standards and regulations
- Dynamic stability analyses for balancing of fluctuating feed-in caused by variation of wind speed or solar irradiation
- Optimization of storage controller and state of charge.

### Integration with microgrids

Storage solutions are an important element of cost-efficient and resilient microgrids. They enable island operation to seamlessly switch between the grid and its own reserves. Our offering includes:

- Microgrid studies for the dimensioning of storage and generation units and the analysis of the grid structure with respect to optimized levelized cost of energy (LCOE), network tariffs and sustainability

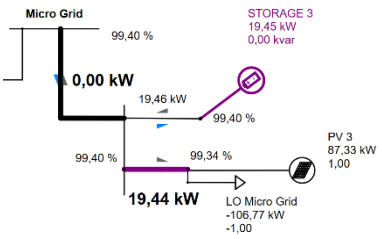



Figure 3: Microgrid simulation in PSS®SINCAL provides detailed results on grid impact

- Dynamic stability analyses, investigating the reaction of the microgrid regarding stability, voltage recovery and frequency, as well as optimization of generation patterns
- Determination of parameters for the decoupling, load shedding and protection in the event of falling into isolated operation
- Identifying mandatory and optional measures and development of an implementation roadmap with breakdowns of prospective cost structure, saving potentials and additional sources of income.

### Improve system reliability

Storage solutions can be applied to provide power output as spinning reserve to meet unexpected imbalance on the grid and provide network response to improve the system's reliability. This is particularly important for power systems as the level of inverter based and inertia less generation increases, as well as industrial applications with sensitive processes which need to be protected to outages and resulting costs.

Our offering includes:

- Simulations of potential faults and outages, investigating the reaction of the system regarding angular and voltage stability, as well as frequency response
- Definition of capacity, energy content and controls of ESS (e.g. voltage control, frequency control, charge/discharge cycles)
- Evaluation for optimization and/or avoidance of load shedding
- Assessment and feasibility study of battery black start capability and grid booster
- Evaluation of primary frequency control and rate of change of frequency (RoCoF).

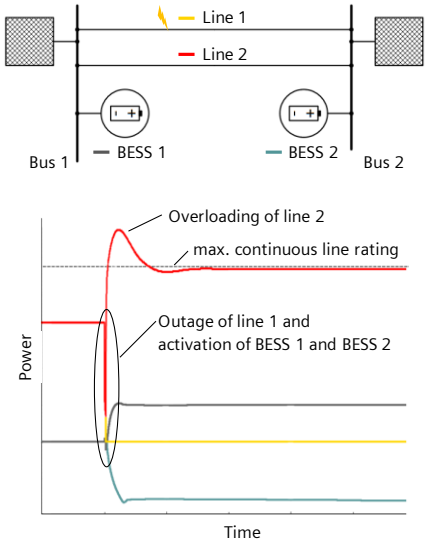



Figure 4: Activation of grid booster after line outage to reduce overloading

### Increasing grid efficiency and stability

With the increase in renewable energy resources and in particulate DER, transmission and distribution systems are expected to be brought close to their technical limits, leading to contingency overloads and voltage violations. Instead of adding voltage regulation equipment and/or building new lines to increase grid capacity, alternative operating strategies with controllable renewable energy resources in combination with storage systems can be an alternative solution.

Our offering includes:

- Evaluation of storage dimensioning and operational aspects to postpone or entirely avoid grid equipment investments.
- Grid planning and design including steady-state assessment of existing grid and forecasted performance and reliability
- Identification of optimal connection points and analysis of short-circuit current changes and resulting impact on equipment/ connected grids
- Define individual optimum between technical and economic aspects (e.g. reliability vs. CapEx)
- Dynamic stability analyses for improvement of voltage recovery and frequency response after faults, generation trips, renewable generation ramps or load changes, e.g. induction machine start-up.

**Engaging in energy trade**

Besides the market for reserve and control energy, electricity can be traded via bilateral contracts on future- or spot-markets. With our energy storage market studies, we support customers seeking new revenue streams to increase the potential from their renewables by evaluating their business cases for engaging in energy trade.

Our services include:

- Nodal congestion and locational marginal price analysis
- Pricing and revenue evaluation for participation in both energy and capacity markets
- Optimal location and sizing of storage and energy resources (co-location vs. different locations).

**How you can benefit**

With our consulting services for energy storage solutions, we can help evaluate the potential of applying energy storage solutions on your grid to:

- Optimize network and equipment utilization
- Postpone investments on the grid by the use on non-wire alternatives.
- Increase system resilience by enabling island operation from the grid
- Ensure system availability, e.g. to protect sensitive production processes
- Increase utilization of RES
- Generate new revenue streams by engaging in energy trade

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