

# Performance and Economic Evaluation of Storage Technologies

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## ABSTRACT

In the last decade there has been a drastic increase in the penetration of variable generation (VG) such as wind and solar. VG increases the MW variability that must be met in the regulation and reserve markets. If VG penetration levels are allowed to increase without providing additional flexibility in the form of fast response regulation, reserves, and capacity, then the required capabilities will be provided by the existing conventional generation fleet. This “do-nothing” approach will lead to increased cycling of the existing plants and thus weaken the health of the current grid. The increase VG capacity penetration will also necessitate increased transmission capability in the grid in order to facilitate increased VG energy penetration. All these boils down to endowing the grid with the capability to be flexible by investigating the various options such as transmission expansion, demand control, fast responding generation, VG MW output control, expanding the balancing areas and/or investing in storage technology.

In this dissertation, the primary focus is on storage technologies, which is one of the attractive means to meet VG variability due to their fast response. With sufficient energy storage capability, they also promise many other valuable grid services such as peak shaving, load leveling, relieving congestion, increasing VG energy penetration, and deferring generation and transmission expansion plans. The objective and contribution of the dissertation is hinged on developing tools and assessment methodologies to perform economic assessment of storage.

The work develops a high-fidelity technology adaptive storage dispatch model for production costing study within a co-optimized energy and ancillary market. This tool is used to

investigate the grid benefits and economic viability of different class of storage under various wind penetration scenarios, compare them with other competing solutions, and devise appropriate monetizing schemes for their services. This work also proposes an integrated approach involving production costing and automatic generation control simulation tools to assess short-term storages. Based on the application in IEEE 24 bus system, many conclusions and indicators on storage venture's profitability and risks are drawn.