

## Optimization and Control of Energy Storage and Demand Response

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The deployment of large amounts of intermittent and stochastic renewable energy sources, such as wind and solar, increases the need for more “flexibility” in the operation of the grid to handle rapid and often hard to predict changes in the net load, i.e. the power that has to be provided by conventional generating units. At the same time, these conventional generating units are being displaced by these renewable energy sources and the flexibility that they were providing to the system is dwindling. Maintaining the reliability of the system may therefore require the large-scale use of demand response and energy storage devices.

However, compared to the traditional ways of controlling the system, demand response and energy storage remain quite expensive. Justifying their deployment therefore requires that they be utilized for various purposes, either simultaneously or separately. Harnessing these resources in an economic fashion will therefore require the deployment of a cyber infrastructure that will perform the following functions:

- Optimize the scheduling of storage devices to take advantage not only of arbitrage opportunities and their ability to provide ancillary services but also of their ability to enhance the existing transmission capacity through congestion reduction and the implementation of post-contingency corrective actions.
- Optimize the use of demand response through a negotiation between the system operator and the consumers that allows all parties to maximize their benefit.
- Manage the risks associated with the uncertainty on the net load caused by the stochasticity of wind and solar and the occasional major equipment failures.
- Support the reliable and economically efficient operation of the electricity markets.

This cyber infrastructure will require some components that can take a system-wide perspective (to manage the overall risk of outages and blackouts and take advantage of the natural diversity of renewable energy sources and loads). On the other hand, it will also require components working at a highly distributed level (to look after the interests of individual participants and to optimize the operation of millions of appliances).