**Our Energy Future**

**Energy Efficiency and Smart Grid**

The grid has always been smart to a certain degree; there has always been embedded intelligence in how it operates and its protection systems. However, with advances in technologies in telecommunications and computing, the grid has the opportunity to become even smarter.

The benefits of a smart(er) grid are:

* Improved operational efficiency
* Reduced environmental impact
* More consumer choice

In the past, the power grid was operated in a highly *centralized* fashion. There was a power plant that generated most/all electricity, and this electricity was transported to end consumers through distribution circuits. Any problems would be detected manually (e.g., consumers calling the power company to report loss of service), and maintenance trucks/workers dispatched to the problem area.

Contrast that with how the power system will be designed and operated into the future. There will be centralized power stations, but these will be comprised of more wind and solar parks in addition to traditional fossil fuel-based power plants. There will be additional *distributed* power generation with residential and commercial PV solar panels integrated into the grid. A large increase in the amount of automation will be needed to handle the variability of the power generation of the renewable sources, as well as energy storage integration to smooth out this variability of renewable sources. All of this will result in increased reliability and efficiency of operations of the power grid.

The different work needed to achieve a smart grid falls into five different categories:

* Renewable Integration

Enable and accommodate higher levels of renewable generation, both distributed and centralized renewable power plants

* Adoption of EV

Enable adoption of new EV loads (one EV equals roughly the electricity consumption of one household) while minimizing impact to electric system operations and T&D (transmission and distribution) facilities

* Improved System Reliability

Through automated response and advanced communications control, maintain and improve reliability and safety in response to challenges associated with renewable generation and PEVs. Improved operational visibility

* Resource Adequacy

Ensure sufficient resources are available to meet customer load demand requirements. Over time, fewer *baseload* generation plants (centralized power plants that provide the minimum amount of power to meet demand at any given time) will be deployed. This puts more of an emphasis on balancing load and generation from variable renewable sources, especially considering that renewables would be responsible for providing a *spinning reserve* for emergencies (instantaneous power available in case of outages)

* Customer Choice

Provide more opportunity for customers to have choice for energy management, efficiency improvements, and cost savings

*Challenges with integration of renewables into the grid*

* Increased supply volatility associated with the variability of the renewable sources
* Less predictable load patterns because of integration of rooftop solar, EV
* Changing revenue patterns. Because of the changing load patterns, the price of electricity will fluctuate at different times of the day/year

The smart grid is helping with some of these challenges, including advanced forecasting techniques to predict the upcoming power generation from renewables, energy storages for fast ramping and smoothing of intermittency.

*Resource mix of energy usage*

The resource mix required for the smart grid of the future will successfully and automatically balance *generation*, *storage*, and *demand response* associated with delivering electricity to customers. To make this happen, the consumer will play a more participative role than in the past.

The consumer will

* Be responsible for electricity generation
* Be responsible for energy storage
* Have visibility and control over consumption and costs associated with that consumption
* Have automated appliances which optimize consumption depending on rates

Much of the above relates to the fact that electricity will cost different amounts at different times of time, aka electricity will cost different amounts at different times of time, aka *dynamic rates* of electricity.

*Microgrid*

A microgrid balances load and generation on a small scale within a community. Implementing microgrids more commonly would support the integration of renewable resources, improve reliability and power quality, and provide the capability to “ride through” outages on the larger scale grid. Additionally, it would optimize energy usage, enable participation in new markets to a wider spectrum of generators (e.g., consumers), and encourage self-sufficiency within communities.

*Energy Storage*

Because of variability/intermittency of renewable sources, a big breakthrough is needed in the area of energy storage to help smooth out this variability. There is a ton of research going on all over the world looking at different battery chemistries, control strategies of batteries to automate how each battery charges and discharges energy