The Importance of Smart Grid to Our Nation's Energy Future

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Today's Electricity Grid

The U.S. electricity grid is an aging infrastructure based largely on designs of the 1950s before the era of the microprocessor and it was mostly constructed in the 1960s and 1970s. Since the 1970s, the U.S. grid has been expanded as needed to meet load growth using the same vintage technologies. The U.S. Department of Energy estimates that 70% of the transmission lines and transformers are over 25 years old and 60% of the circuit breakers are over 30 years old (Lightner, DOE, Jan 2005). The nation's electricity grid is under increasing stress and is being asked to perform functions that it was not designed to perform. This has resulted in some disturbing trends:

- Transmission Loading Relief actions have increased dramatically to relieve transmission congestion (i.e., 10-fold since 1997).
- U.S. businesses have experienced financial losses up to $150 million per year due to outages and power quality events.
- The frequency and duration of power outages have risen 4% per year and 3% per year, respectively.
- Cost of electricity is rising due to increases in fuel and plant construction costs and inefficiency of grid operation (e.g. the cost of new baseload generation has doubled since 2003).
- Asset utilization has decreased 8% over the last decade as reflected by widening gap between the amount of electrical generation capacity and the amount of electricity delivered .
- Customers are disconnecting from the traditional grid at a rate increasing by 33% every year. Most of these customers have their own source of electricity generation that is not connected to the grid At this rate, half the electric consumers in the US could be off-grid by 2026.

Without a strong and resilient electricity grid, we become increasingly vulnerable to natural disasters, acts of terrorism, losing jobs to foreign competition, escalating costs, and widespread and frequent blackouts and brownouts.

Much of Europe, the Middle East, China, and India have upgraded or are upgrading their electrical grids to meet the demands of the 21st century global economy and its customers. The U.S. is lagging these other parts of the world since the last major buildout and upgrade to the U.S. electricity grid was 40 to 50 years ago.

In the U.S., we are just beginning to see the cusp of upgrading our electric grid with some major investments in Advanced Metering Infrastructure, distributed generation, wind turbine farms, and a few Demand Response programs.

Value of the Electricity Grid

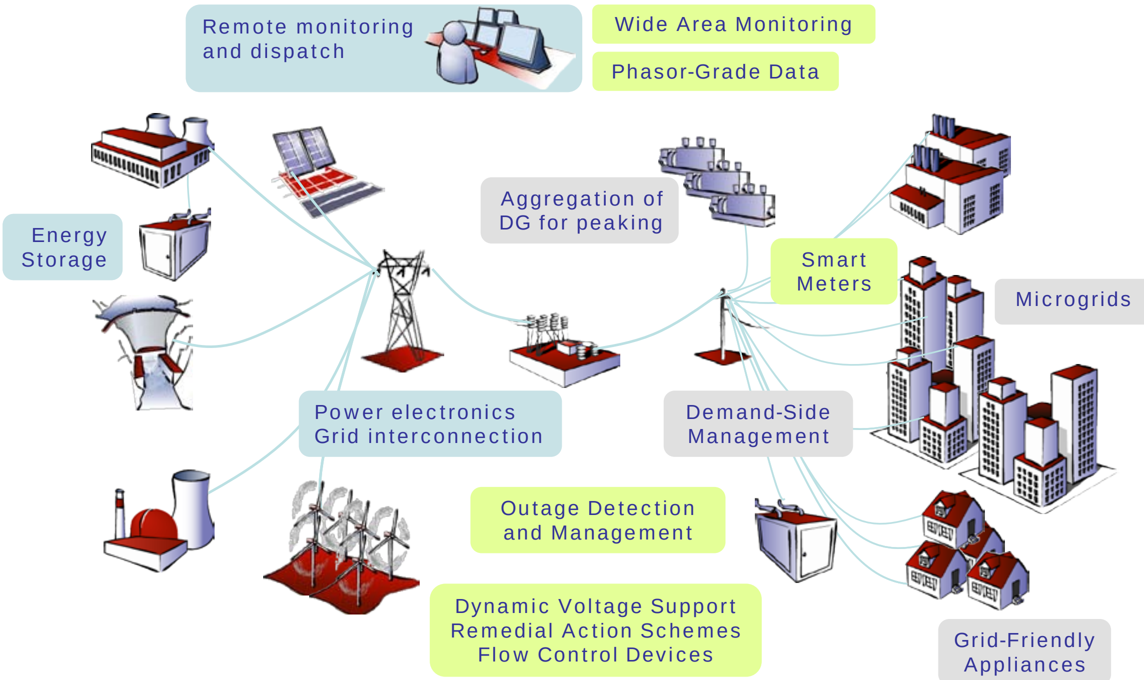
The electric grid plays an important part in maintaining our nation's economic prosperity, lifestyle, and security. An affordable and reliable electric grid is critical for U.S. businesses to compete in the global marketplace. For some businesses, it is the cost of not having electricity that drives business decisions as much as the cost of electricity indicating that electricity reliability is critical to their operations. Business executives have shared stories about momentary disruptions to their electric service that have shutdown sensitive digital automation equipment causing production lines to go idle for three weeks while the equipment is repaired and the product is jack-hammered out of the production line. An increase in our nation's consumption of electricity is directly related to an increase in our gross national product (William Brier, June, 2008, Edison Electric Institute)

The electricity load in our society is becoming more digital with industry transforming to more automation and more computers, televisions, and digital devices in homes. The digital load requires a higher level of power quality and is projected to increase from 20% in 2005 to 60% by 2015. The electric grid can also transform the transportation sector through the use of plug-in hybrid electric vehicles (PHEV) and all-electric vehicles largely powered from electricity produced from coal and nuclear plants and renewable resources, thus reducing foreign imports of crude oil for transportation fuels by over 50%. (Michael Kinter-Meyer, Scheider K. and Pratt R., Impacts Assessement of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, Part I: Technical Analysis, PNNL)

NETL Modern Grid Strategy Project

In support of the DOE Office of Electricity Delivery and Energy Reliability, the National Energy Technology Laboratory launched a Modern Grid Strategy (MGS) project in 2005 to assist the nation in modernizing the electricity grid by confronting the barriers that slow progress. Some of the key initiatives of the MGS team are to (1) align the power industry and its stakeholders in reaching a consensus on the values, functional characteristics, key technology areas, and metrics of a Smart Grid; (2) participate in large-scale field demonstrations of integrated suites of Smart Grid technologies to validate the business case of moving to a Smart Grid considering benefits to utilities, consumers, and society; (3) assist state regulators as requested to enable them to implement the regulatory and policy changes that are absolutely necessary to move to a Smart Grid; (4) assist all stakeholder groups (e.g., utilities, consumers, researchers, vendors, government) by sharing information on Smart Grid and (5) share successes of Smart Grid implementation to encourage further deployment.

The MGS team has engaged the stakeholders of the electric power industry through many workshops and other correspondence. For a national Smart Grid to be achieved, all stakeholders need to have a common understanding of the values, functional characteristics, and technologies that comprise a "Smart Grid." In addition, stakeholders need to have a consistent approach to achieve the Smart Grid and to be able to measure progress in achieving it. Primary stakeholders include Federal, state, and local regulators and government; utilities; residential, commercial and industrial consumers; electric power industry vendors and service providers; and various advocacy groups such as environmental groups and electricity consumer groups. As a result of MGS engaging electric power industry stakeholders, there is a growing general consensus



on Smart Grid values, functionality, and key technologies (see Figure 1).

Figure 1: Smart Grid Vision

The Smart Grid "values" are the goals to be realized through achievement of a national Smart Grid. These goals include:

- Increase in reliability through reductions in the number, duration, and extent of blackouts and brownouts
- Reductions in failure to meet the high power quality criteria demanded by some customers.
- Improved security and resiliency from cyber attacks, physical attacks, and natural disasters.
- Delivery of electricity to customers at an affordable price.
- Efficient generation and delivery of electricity
- Reductions in losses associated with transporting electricity through transmission and distribution substations and interconnecting lines.
- Reductions in environmental impact impact through electricity generation from green, renewable sources (e.g,. solar , wind) and through improved efficiencies.
- Enhanced safety to workers and the public due to reductions in routine field maintenance and emergency work by utility crews, and public safety issues during electrical outages (e.g., traffic signals, climate control)

The seven functional characteristics of the Smart Grid that enable the values to be achieved include:

- Motivates and includes the consumer by enabling the consumer to beneficially participate in grid operations through consumer-owned generation and demand response programs
- Accommodates all generation and storage options including large central generating stations and smaller distributed generation
- Enables new products, services, and markets including real-time prices for electricity
- Provides power quality needed by 21st century customers with pricing options at various power quality needs
- Optimizes grids assets and operates efficiently by increasing load factors, reducing losses in transmission and distribution systems, improving planning, and adopting condition-based maintenance programs
- Self-heals by continually assessing the condition of the grid; anticipating problems before they occur; and automating responses to avoid problems or quickly correct them.
- Operates resiliently despite adverse physical and cyber events including natural disasters

The key technology areas (Figure 2) of the Smart Grid are Integrated Communications, Sensing and Measurement, Advanced Control Methods, Improved Interfaces and Decision Support, and Advanced Components. The Integrated Communications provides the high-speed, integrated, two-way communication backbone that enables the condition of the grid to be monitored and grid technologies to be controlled and interact with each other. Sensing and Measurement provides the real-time data to assess the condition of the grid and support real-time pricing markets for electricity. Advanced Control Methods makes use of the data from Sensing and Measurements to implement an appropriate response to any event. Advanced Components enables improvements to efficiency, reliability, and power quality and includes devices such as superconductors, energy storage, and power electronics. Improved Interfaces and Decision Support provides an array of tools to operators to assist in their decision making including advanced visualization and simulation methods to enable operators to quickly assess viable responses to events.

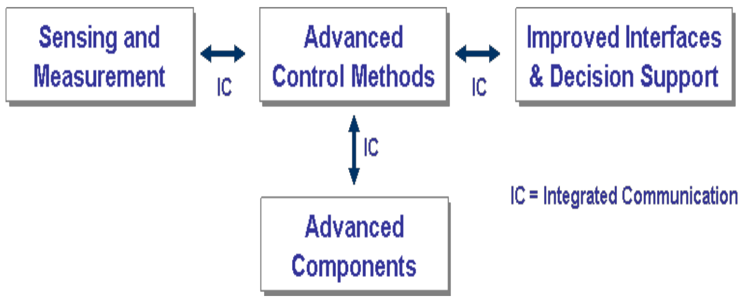


Figure 2: Smart Grid Key Technology Areas

Smart Grid Role in National Priorities

The Smart Grid plays an important role in our nation's current priorities namely affordable and secure energy supplies and climate change. The MGS team has become increasingly aware of the importance of energy independence for the nation, as this affects economic strength, global competitiveness, and geopolitical risk as can be seen in Eastern Europe. While the news today is centered on gasoline prices and oil independence, the MGS team sees the same issues in the electric and natural gas industry. While the issues are developing slower in the electric and natural gas industry, it has the potential to be even more devastating than the current oil independency issue.

Affordability. The Smart Grid accommodates all sources of electricity generation and storage options including domestic resources such as coal, natural gas, biofuels, wind, hydro, solar, and geothermal. Each state and region of the country possesses or has access to unique resources for its electricity supply. The Smart Grid enables each state and region to use the optimal mix of generation resources considering cost, environmental impact, reliability, consumer preference, and other factors.

Security. The Smart Grid enables more domestic resources to be used to generate electricity which reduces our nation's dependency on foreign sources of fuels such as liquefied natural gas (LNG). In addition, the Smart Grid operates more efficiently which reduces consumption of fuels for generation of electricity. Demand side programs such as Demand Response programs, Dispatchable Distributed Generation, and Energy Efficiency programs also reduce the need for foreign sources of fuels.

Reliability. The Smart Grid can improve resiliency from natural disasters and manmade events due to improved communications, connectivity, and controls and increase number of generation sources, particularly local generation sources, providing more options for recovery. The self-healing nature of the Smart Grid makes it resistant to long and widespread outages and most problems can be detected and corrected without interruption of service.

Climate Change. Coal will continue to be a domestic baseload resource for electricity generation by employing clean coal technologies with carbon capture and sequestration. In addition, renewable resources such as wind, hydropower, biopower, geothermal and solar will be vital in regions where they are available. The improved efficiency offered by the Smart Grid, Demand Response and Energy Efficiency programs reduces environmental emissions by reducing the generation of electricity to meet peak demand.

Value Proposition of Smart Grid

In 2004, the Electric Power Research Institute released a report on the benefit and costs of implementing a national Smart Grid. The report concludes that the cost over 20 years is about $165 billion and the benefits to utilities, consumers, and society ranges from $638 to $802 billion indicating that the benefits of Smart Grid outweigh its costs by a 4:1 to 5:1.

The current investment in maintaining and expanding the nation's electricity transmission and distribution grid using conventional technologies is about $18 billion per year.

This investment is necessary to replace existing aging electrical infrastructure and to meet the growing demand for electricity. Implementation of a national Smart Grid over 20 years would require an additional investment of about $8.3 billion per year, but would accrue far more benefits than continuing to install conventional T&D technologies. For example, the MGS team studies have shown the possibility that transitioning to the Smart Grid may cost less over the next 20 years than the currently planned building of more central, traditional generation and its associated transmission lines.

Conclusion

There is great benefit to implementation of a Smart Grid nationwide since it beneficially addresses key energy issues of our nation, namely energy independency, climate change, electricity reliability, and how we use our assets. The Smart Grid will provide benefit to the electric power industry and the transportation industry through the introduction of electric-powered vehicles and associated infrastructure. However, there are some major change management, regulatory and policy, and to a lesser extent, technical barriers that must be overcome for the Smart Grid to become a reality. As a nation, it is critical that we overcome these barriers and implement a Smart Grid as part of the solution to our nation's energy issues.