Author: Joe Miller – Horizon Energy Group

Energy Central series on the Seven Principal Characteristics of the Modern Grid

[Article 2 of 7: ***Research on the Characteristics of a Modern Grid by the NETL Modern Grid Strategy Team***

Accommodates All Generation and Storage Options

Last month we presented the first Principal Characteristic of a Modern Grid, "Motivates and Includes the Consumer". This month we present a second characteristic, "Accommodates All Generation and Storage Options". This characteristic will fundamentally transition today's grid from a centralized model for generation to one that also has a more balanced contribution from decentralized generation and storage. This characteristic, along with the other six, define a Modern Grid that will power the 21st Century economy. For a more detailed discussion on "Accommodates All Generation and Storage Options", please see: http://www.netl.doe.gov/moderngrid/docs/Accommodates%20All%20Generation%20and%20Storage%20Options_Final_v2_0.pdf

Summary

One of the drivers that has enabled the U.S. economy to grow is the quality of our power generation and delivery system. Today, our electricity grid is powered primarily by large, centralized generation facilities with only a small amount provided by distributed energy resources.

The modern grid must accommodate not only large, centralized power plants but also the wide range of distributed energy resources (DER) that will enable many of the benefits expected in a modern grid. These distributed resources will be diverse and widespread, including renewables, distributed generation, and energy storage. And they will increase rapidly all along the value chain, from suppliers to marketers to consumers. This characteristic of the modern grid will enable the generation portfolio to move toward a more decentralized model yielding a balanced portfolio of large, centralized nuclear and fossil fuel plants and DER.[i] (See Figure 1)

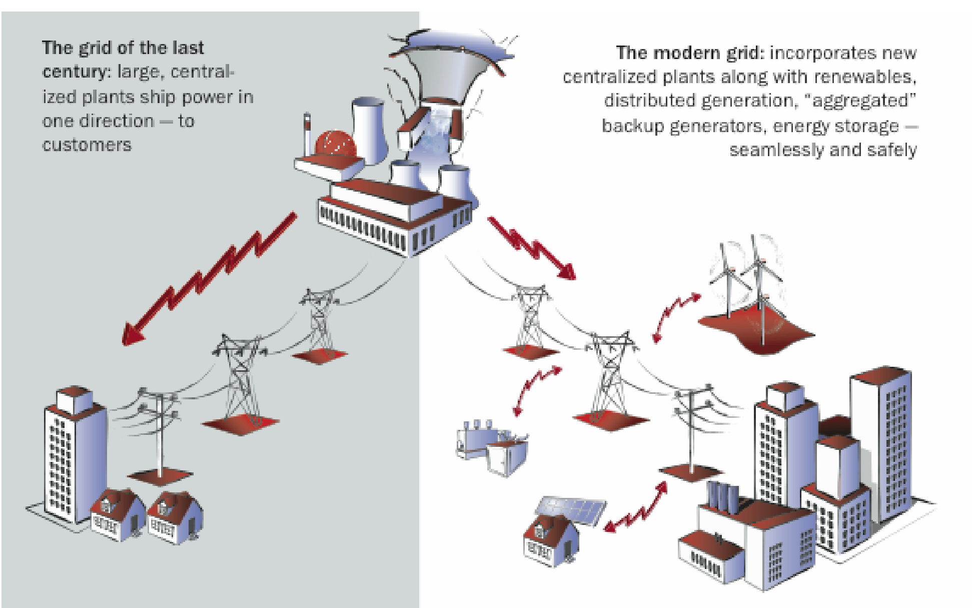

Figure 1: The modern grid accommodates all generation and storage options

Current State

Large generators (coal, nuclear, and hydro) made up over 75% of net generation in 2006. Only 2% of the energy generated was from renewables. (See Figure 2)

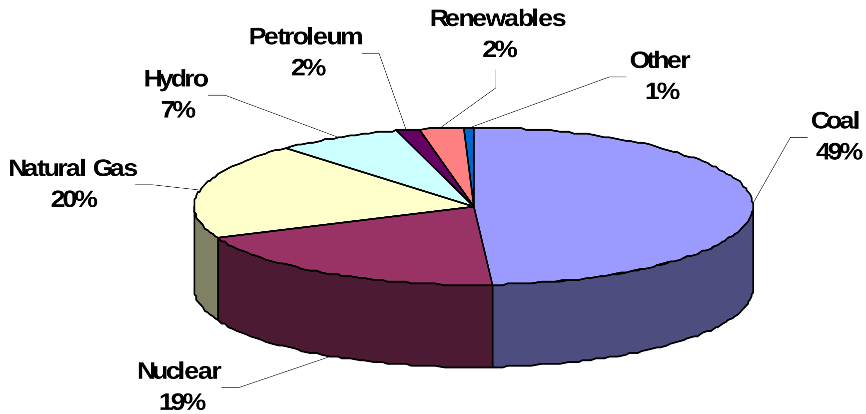

Figure 2: U.S. Net Generation by Energy Source[ii]

Distributed generation (DG) contributes only a small amount to our nation's electricity supply. As of 2005, approximately 12.3 million DG units were installed in the U.S. Collectively these units represented approximately 222 GW of capacity; however, less than 1% of them are connected to the grid.[iii] The majority of these units are small reciprocating engines used to supply emergency or standby power. The remainder is made up of combined heat and power units and combustion turbines.

Future State

The future offers several growth pathways for DER, depending on how technologies and markets evolve. A modernized grid should be prepared for at least five likely scenarios, as itemized below.

1. DER will increase dramatically. The modern grid must expect and enable a substantial increase in new energy sources. Renewable portfolio standard (RPS) programs require investor-owned utilities to provide a more significant portion of their electricity from renewable sources, many of which will be distributed. DER is also likely to grow rapidly among consumers as life cycle costs are reduced, more favorable regulations are created, and the desire to reduce the impact on the environment increases.

2. DER will be everywhere. Deployment will occur along the entire value chain. Suppliers will install it. Power marketers will embrace it. And all type of consumers – commercial, industrial, residential – will adopt it. DER will be located close to the consumers as well as aggregated into centralized farms where appropriate. The grid will be expected to enable the same widespread deployment of DER that occurred with personal computers, cell phones, and the Internet. Perhaps the plug-in hybrid electric vehicle (PHEV) will experience such widespread deployment.

3. DER will be grid-connected. Stand-alone generation will continue to be common. But in the future, more DER will be connected to the grid at many different points – at transmission voltages, at distribution voltages, and in AC and DC networks and micro-grids.

4. DER will be aggregated. Both the sources of power and the users of that power will often be aggregated. For instance, wind and solar units may be aggregated into energy "farms" and scattered backup generators into "peaking plants." In addition, virtual plants, in which many geographically diverse generators act as a single large unit, will be created through the utilization of advanced computer and communications technologies.

5. DER will be diverse. DER will not be dominated by any one size or type of generation or storage. Instead, it will include a wider variety, from those already available to those not yet invented and popularized.

As we turn our attention to what is required to reach DER goals, it is important to remember that the modern grid must also accommodate new centralized plants. We will need conventional, centralized power stations – coal, oil, nuclear, gas and hydro – to help meet the increase in demand.[iv]

Requirements

Accommodating all generation and storage options will impose a number of new requirements on the modern grid.

1. Time of Use/Real Time pricing is needed to set up the value proposition needed to encourage consumers to invest in DER. Consumers must see a benefit in investing in DER and time of use pricing schedules based on the dynamic wholesale price of electricity is a first step. Advanced metering infrastructure systems can provide the metering and communication infrastructure needed to enable consumer involvement in DER operation.

2. Smart sensors and controls are needed for integrating DER into the grid. Lower cost sensors, protective devices and controls will reduce DER installation costs; ensure stable operation of interconnected DER units, and safeguard line crews and the public during maintenance and restoration. On the customer side of the meter, home energy-management systems to monitor and control DER operations and demand-response requests from the utility are needed.

3. Operational and planning tools are needed to incorporate large numbers of generation sources that are smaller, decentralized, and often intermittent. Some of these tools include:

- New operating models and algorithms that address the transient and steady-state behavior of a grid with a deep penetration of DER.
- Improved operator visualization techniques and new training methodologies to enable system operators (both distribution and transmission) to work together to manage decentralized systems in both routine and emergency operations.
- Advanced simulation tools that can provide a more complete understanding of grid behavior, where a large number of diverse DER units are deployed.

- Methods for resolving the unique maintenance and operational challenges created by the interaction among DER, demand response, other new generation sources and advanced storage.
- Advanced system-planning tools that assess the benefits and challenges (and consider the uniqueness) of DER when locating optimal sites for new power stations.

4. Interconnection standards

Interconnection standards need to be adopted across the grid to support DER implementation. The development of these standards will enable DER to be easily integrated with the modern grid—similar to "plug and play"—allowing DER to be connected, recognized, and operated conveniently and quickly.[v]

Barriers

To achieve the level needed to support modern grid operations, DER deployment needs to be initiated by electric utilities, energy marketers, and consumers at all levels (residential, commercial, and industrial). Several barriers exist today that inhibit this level of deployment. Some of these barriers are addressed below:

1. Total cost of ownership is too high. Although improving, the lifetime cost (investment, operation, maintenance, fuel, etc.) is generally too high for existing DER devices to compete with traditional alternatives. Advances in R&D and commercialization are needed to make these costs more competitive with conventional generation. Very little of the U.S. distributed generation capacity (222 GW) is connected to the grid and dispatched by system operators because of environmental and cost considerations. Perhaps this existing fleet and PHEV's are good places to pursue a broader deployment of integrated DER at the consumer level.

2. Consumers are not motivated to invest. The value proposition to the consumer is not yet compelling. Favorable price signals coupled with a reduction in the cost of DER for consumer applications is needed to improve the "consumers' business case" for investing in and operating DER.

3. T&D system behavior with deep DER penetration is not well understood. Further study is needed on how various systems interact when DER of many types and designs are broadly deployed (particularly their behavior during upset conditions)[vi]. Experience in locations where deep DER penetrations exist, such as Hawaii or Germany, illustrates some of the stability concerns that can arise. The optimal application of renewable DER also requires complementary storage technologies to accommodate their intermittent nature. Proper integration of distributed generation and storage remains a technical issue.

Benefits

As we overcome the barriers to the modern grid, the seamless integration of diverse generation and storage options will deliver substantial benefits.

1. Improved reliability. Integration of DER can reduce the grid's dependency on the transmission system; increase operational flexibility during routine, emergency, and restoration activities; improve power quality; and reduce transmission losses and congestion due to the location of DER closer to the loads. These benefits put us "on the road" to a self healing grid.
2. Improved security. DER decentralizes generation and storage resources, reducing the grid's vulnerability to a single attack and gives operators more options in response to a security emergency.
3. Improved economics. DER deployment adds to the modern grid's economic advantages by allowing the deferral of capital investments in generation, substations, and lines; gives consumers additional options for participating in the electricity market; and reduces peak demand, transmission congestion and peak prices. In addition, smaller DER units can be placed in service relatively quickly, while large central plants pose more risk and require long approval, financing, and construction periods. Collectively, these benefits of DER can help reduce the upward pressure on electric rates for consumers.
4. Improved efficiency. DER gives system operators new options to improve the utilization of grid assets, gives system planners additional options to address future capacity issues, and reduces T&D losses by locating sources closer to the load centers. Significant gains in efficiency can be realized when DER provides both power and heat.
5. Less environmental impact. A modern grid that accommodates all generation and storage options is environmentally friendly because it encourages the deployment of smaller DER sources, many of which are renewables or employ combined heat and power technologies. DER also reduces system losses thereby reducing the overall amount of generation needed. Less generation results in fewer emissions produced.[vii]

Recommendations

Considering the barriers to meeting the modern grid requirements and the benefits to be obtained in overcoming these barriers, what are some of the steps that need to be taken?

1. Establish a clear vision. Stakeholders need a clear, consistent vision for the modern grid that identifies the role of generation, DER, and DR. The vision needs to explain why the new model is beneficial to all stakeholders and particularly to society in general.

2. Increase R&D. Additional research and development is needed to accomplish the items cited in the *Requirements* section.

3. Create financial incentives. Until the value proposition becomes compelling, financial incentives are needed to stimulate DER deployment. As overall demand for DER increases, production will increase, thereby allowing prices for DER to be reduced due to economies of scale.

4. State regulators should take a leadership role. They should create incentives that encourage utilities to invest in technologies that enable DER deployment. Also, disincentives that inhibit deployment should be identified and eliminated. Perhaps a new regulatory model is needed to achieve these outcomes.
5. Fund DER demonstration programs. State level and regional demonstrations are needed to prove the value and uses of DER. The Energy Independence and Security Act of 2007 has provided opportunities in this area.[viii]

More Information Available

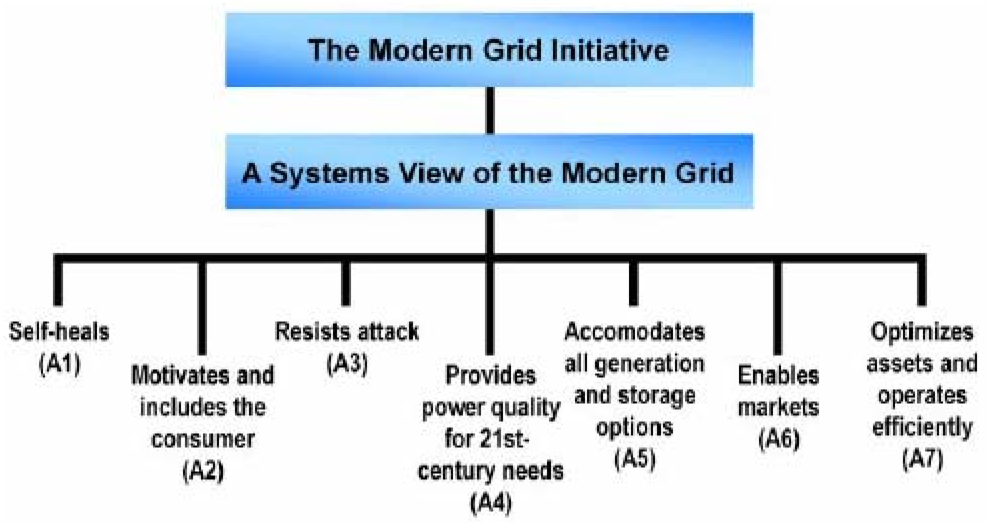

Figure 3: Principal Characteristics of a Modern Grid[ix]

Documents are available for free download form the Modern Grid website:

http://www.netl.doe.gov/moderngrid/

Email: moderngrid@netl.doe.gov

(304) 599-4273 x101

---

[i] A Systems View of the Modern Grid, Appendix A5: Accommodates All Generation and Storage Options, DOE/NETL Modern Grid Team, v2.0, January 2007, pgs A5-2, 3
[ii] Energy Information Administration, http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html
[iii] The Installed Base of U.S. Distributed Generation, 2005 Edition, Resource Dynamics Corporation
[iv] A Systems View of the Modern Grid, Appendix A5: Accommodates All Generation and Storage Options, DOE/NETL Modern Grid Team, v2.0, January 2007, pgs A5-5, 6
[v] Ibid, pgs A5-8, 9, 10
[vi] Ibid, pg A5-12
[vii] Ibid, pgs A5-13, 14
[viii] Ibid, pg A5-15
[ix] Ibid, pg A5-17