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

[Article 4 of 7]: ***Research on the Characteristics of a Modern Grid by the NETL Modern Grid Strategy team***

Optimizes Asset Utilization and Operates Efficiently

Last month we presented the third principal characteristic of a Smart Grid, "Enables New Products, Services, and Markets." This month we present the fourth characteristic, "Optimizes Asset Utilization and Operates Efficiently." This characteristic is aimed at improving the overall efficiency of the grid by getting more out of its existing assets, reducing losses, and optimizing the value of the investments that will be needed to support future growth. This characteristic, along with the other six, define a Smart Grid that will power the 21st Century economy. For a more detailed discussion on "Optimizes Asset Utilization and Operates Efficiently, please see: http://www.netl.doe.gov/moderngrid/docs/Optimizes%20Assets%20and%20Operates%20Efficiently_Final_v2_0.pdf.

Summary

The Smart Grid will utilize the latest technologies to optimize the use of its assets over two different time horizons – short term in how it is operated day-to-day and over the longer term through dramatically improved asset management processes. Operationally, the Smart Grid will improve load factors, lower system losses, and dramatically improve system reliability and outage management. Real time information from advanced sensors will also give operators sophisticated risk assessment capabilities to better understand the state and condition of the system. Planners and engineers will have the knowledge they need to build what is needed when it is needed, extend the life of assets, repair equipment before it fails unexpectedly and more effectively manage the work force. Advances in technologies and materials will allow the "power density" of system assets to increase. Operational and maintenance expenses and the cost for capital investments will yield more effective results for the dollar spent, creating "more bang for the buck" – resulting in downward pressure on increasing electricity prices.

Current State

Asset Utilization

In today's grid, the data and information systems needed to understand real-time asset utilization are not typically available. Even with the needed information, the ability to adjust individual asset loadings is limited given the relatively limited penetration of distribution Supervisory Control and Data Acquisition systems (SCADA) and demand response into today's grid. The current utilization rate of assets within a utility, if it is measured at all, is mostly limited to station transformers and transmission lines. Both assets use an average load divided by capacity calculation for percent loading. The utilization of transformers at distribution substations is currently about 40%. At transmission substations, utilization of transformers is around 50%.[1]

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System Losses

Today's grid suffers losses in the range of 5-10% due to unbalanced loads on the three phase system, transformer losses, and line losses. Reducing these losses would result in a corresponding reduction in generation – making the grid more efficient, reducing costs, and reducing environmental emissions. Today's grid lacks the information, control, and resource options to effectively reduce these losses.

Another dimension to losses is the fact that today's outage management systems are generally ineffective at minimizing the time consumers are "out of service," with outages representing a lost opportunity to deliver electricity. Unexpected outages create a deviation to the planned delivery of electricity which leads to unexpected re-dispatch of generating resources.

Asset Management

Asset management processes include system planning, maintenance, engineering, and work management processes among others. Each of these processes is limited in their effectiveness because the information on which they depend is limited.

System planners make decisions on capacity improvement projects using load forecasts with less than complete data. Often, this leads to conservative decisions which sometimes are viewed after the fact as overbuilding.

Maintenance engineers struggle with the implementation of condition based maintenance (CBM) programs. They are hampered by the lack of asset condition information needed to implement an optimal CBM program that extends asset life and minimizes reactive maintenance. Monitoring of equipment health in near real time is limited, resulting in maintenance practices that are primarily time-based rather than condition-based. Reactive maintenance is common.

Today's engineering, design, and work force management processes also lack the operating information and communication capabilities needed to leverage these processes to the level of performance that can be achieved with a Smart Grid. Optimized capacity, optimized condition, and optimized operations will result in substantial cost reductions.

Improving asset efficiency is certainly of interest today. Much work is being done in the area of superconductivity, more efficient transformers, and dynamic line ratings. The penetration of these technologies, however, is still limited due to their cost and lack of the appropriate intelligent electronic sensors and communications needed to support their deployment.

Future State

The deep penetration of intelligent electronic sensors, the ability to control essentially all assets (including the smart loads of willing consumers), the integration of communication systems that connect them, and the advanced algorithms that analyze and diagnose asset condition, will enable this Smart Grid characteristic to be achieved. The good news is much of this functionality will be provided by the technologies and processes that support the other principal characteristics of the Smart Grid. The sharing of this information allows operators, planners, and engineers to greatly improve operational and asset management processes for a relatively minimal incremental cost.

1. Asset utilization will improve. Advanced Distribution Management Systems (DMS) and enhanced transmission flow control will give grid operators the information and control needed to adjust system flows to increase the loading of under-utilized assets. Loading of assets under stress will be reduced to lower their probability of failure and extend their life. Improved power quality will further extend equipment life as damaging surges and harmonics are reduced. And, improved load curves will allow more energy to be delivered per KVA of installed capacity.

2. System losses and congestion will be reduced. Widespread deployment of distributed generation, storage, and demand response will give grid operators additional resources to reduce losses. Two-way power flow, and the participation of willing consumers to offer their resources to the market, will allow the distribution system to become an asset to Regional Transmission Organizations (RTO's), giving them additional tools for managing transmission congestion and improving their economic dispatch process. In addition, improved reactive power management will allow transmission lines to operate near unity power factor, thereby reducing losses associated with reactive power flow.

3. Capacity planning processes will improve. Detailed and accurate load forecasts will enable system planners to better predict asset loading and more accurately determine what we need to build and when it needs to be built. Complete, historical, time-stamped information will be available at all planning nodes leading to a more accurate projection of future peak loads. Future overloads and voltage constraints will be more accurately identified, leading to more effective solutions and a more accurate timeframe on when the solution is needed. And, the use of distributed resources (generation, storage, and demand response) represents a new set of tools for system planners.

4. Maintenance programs will move from reactive to predictive. Utilizing asset condition information for all critical assets, maintenance programs will predict when failures can be expected to occur. Armed with this understanding, equipment can be taken out of service for repair or replacement before failure. The lifetimes of critical assets will be extended and the costs, dangers, and inconveniences of failures and the associated reactive maintenance will be reduced. CBM will also provide the capability to extend the lifetime of existing assets by predicting when assets should be relocated to a less stressful electrical environment. The result will be lower maintenance costs, safer maintenance practices, and fewer equipment failures.

5. Advanced Outage Management Systems (OMS) will greatly reduce outage duration. Extended outages are inconvenient and costly to consumers and represent a loss of revenue to generators and delivery companies. Advanced OMS will virtually eliminate the time to detect, locate, and diagnose outages allowing system dispatchers to focus on getting the needed resources in the field to correct the problem and restore service more quickly. And, OMS will complement OMS by dynamically reconfiguring system feeders and branches to reduce the number of customers affected by an outage.

6. Engineering, customer service, and work management processes will also benefit. The availability of operating and asset condition information gives engineers the ability to improve their design standards and provides customer service staff with the information they need to better satisfy customers. Access to the distribution communication system and its interface with existing Geographical Information systems (GIS) will also enable a more efficient mobile work force management program.

7. Modeling and simulation tools will enable operators to better manage operating risk. The availability of operating and asset condition information coupled with modeling and simulation tools, will allow both distribution and transmission operators to improve their risk management capabilities. Understanding how the grid might be affected as conditions on it change, and the implementation of the corresponding corrective actions, can prevent unexpected disturbances, thus making grid operation more efficient over time. New monitoring tools, such as wide area monitoring systems (WAMS) using phasor measurements, will allow transmission operators to anticipate emerging problems and take corrective actions.

8. The "power density" of assets will increase. Advanced materials will allow higher capacity ratings on new assets. New intelligent electronic sensors and communication methods will support accurate dynamic ratings for transmission lines and other assets.

Requirements

1. Deep penetration of intelligent electronic sensors that measure both operating and asset condition parameters is needed. These sensors must be capable of monitoring at the consumer level (e.g. smart meters), distribution level, and transmission level (e.g. phasor measurement units).

2. Deployment of automated switching devices and systems controlled by grid operators, and where appropriate, by autonomous distributed grid automation software is needed. Distribution management systems need to give operators the ability to switch consumers (remote connect/disconnect), distribution, and transmission assets as needed. Intelligent controls that enable automatic grid reconfiguration and microgrid operation are also needed to address rapidly-changing events.

3. An integrated communication system to communicate the needed information to the users and systems responsible for optimizing the operation and management of the assets is needed. These communication systems should also be interoperable with other enterprise wide processes such as GIS, mobile work force management, engineering, and records management.

4. Process integration among all applicable users and systems is needed so that the operating and asset condition information can be leveraged. In particular, an interface with the RTO is needed to ensure the optimization of operations and asset management is not limited to just the distribution system.

5. Advanced applications and algorithms are needed to take advantage of the vast amount of new information and control options. Real time dynamic rating applications, condition-based maintenance applications, advanced protection and control systems, and more sophisticated modeling and simulation tools are examples that can greatly enhance efficiency and reduce operating risks. Methods are also needed to convert the huge amount of new data to information so that system operators can comprehend grid status "at a glance." Situational awareness, enabling a rapid conversion of information to action, will be greatly improved.

Barriers

In general, the following fundamental elements are needed to create a Smart Grid that meets this characteristic. Barriers to achieving each of these elements are also noted:

1. **Measurement of operating and asset condition data.** Advances are needed to greatly simplify these sensing devices so they are small in size, low in cost, easy to install, interoperable, and communicating.
2. **Integrated communications systems.** Communications that enable "plug and play" convenience with the above sensors are not yet widely deployed at the needed penetration levels: consumer, distribution system, and transmission system. Also, the interoperability of these communication systems should allow integration with existing enterprise-wide technologies and processes. Standards are the key to this interoperability.
3. **Applications and analysis tools.** Applications designed around the expected higher level of information, provided by a Smart Grid, are needed. Development should be done now so that when the needed information is available, the applications can be immediately deployed.
4. **Methods to increase the power density of assets.** New materials are needed that increase the capacity per unit volume of assets. Also, new approaches for calculating dynamic ratings of lines and other assets using advanced sensors are needed.
5. **Effective change management processes.** The change process in utility organizations is often difficult to execute. Utility processes that need to change in order to achieve this characteristic have been developed over many years. Often the "siloed" nature of utility organizations makes the change process difficult without executive level sponsorship. Changes to state regulatory policies will also be needed and will require substantial effort to achieve.
6. **Asset transition process.** A strategy is needed that supports a timely and low cost upgrading of existing assets so they can be integrated with new Smart Grid technologies and processes.

Benefits

Overall, the benefits of this characteristic come at a relatively low cost in that much of the information, communications, and control technologies that are needed to achieve the other six principal characteristics enable this one. More specifically:

- As we overcome the barriers to this characteristic, the optimization of assets and more efficient grid operation will lead to an increase in the value of each dollar spent on the grid – creating "more bang for the buck".

- The improved utilization of assets and the understanding of asset health will reduce reactive maintenance, and hence, improve reliability.
- The knowledge to build what is needed, when it is needed, will result in the deferral of large capital investments.
- Reduced losses will enable a reduction in generation for a given load, thereby reducing environmental emissions that would otherwise have occurred.
- Reduced reactive maintenance reduces the exposure of grid workers to hazards thereby improving the safety of the grid.
- Improved efficiency of the grid will put downward pressure on electricity prices.

Recommendations

What are some of the steps that need to be taken to achieve this characteristic?

1. Align around a clear vision. The seven principal characteristics of the Smart Grid have been widely communicated, but more work is needed to share this vision with stakeholders. The value proposition for all stakeholders requires further refinement and communication to provide the momentum for change.

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

3. Develop Smart Grid deployment plans. The seven principal characteristics form a common vision for the Smart Grid. However, the technologies and processes needed to achieve it are different depending on many factors – clearly “one size does not fit all.” Specific Smart Grid deployment plans that consider the entire vision should be developed to ensure the benefits of this characteristic are achieved in the most efficient way.

4. **Fund DER demonstration programs.** State and regional level demonstrations are needed to identify integrated solutions for optimizing grid assets and improving operating efficiency. The Energy Independence and Security Act of 2007 has provided opportunities in this area.

More Information Available

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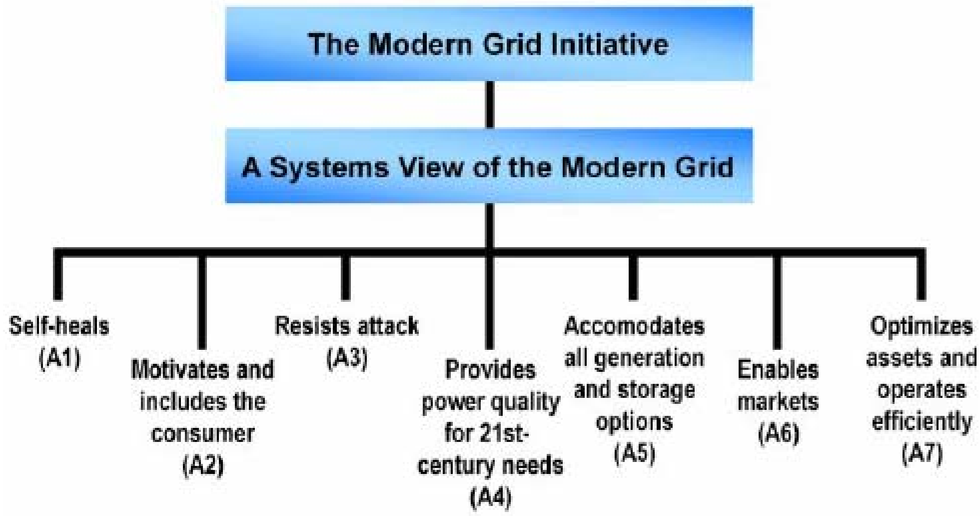

Figure 3: Principal Characteristics of a Modern Grid

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

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

Email: moderngrid@netl.doe.gov

(304) 599-4273 x101

[1] A Systems View of the Modern Grid, Appendix A7: Optimizes Assets and Operates Efficiently, DOE/NETL Modern Grid Team, v2.0, January, 2007, pgs A7-4