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**The Smart Grid – How do we get there?**

**One step at a time –** the path to the Smart Grid is a long and complex journey that needs to be broken down into manageable and understandable steps.

**Step 1: Understand what the Smart Grid is**

Some say the Smart Grid has not yet been defined, others say it is "too hard" to define. To help with this, the Modern Grid Strategy (MGS) team initiated a process to define the Smart Grid in terms of its most fundamental characteristics rather than in terms of the specific technologies it will employ – a process that included an extensive vetting process with interested stakeholders. By beginning with these fundamental elements a consistent vision emerges. *The Smart Grid will:*

- Enable active participation by consumers
- Accommodate all generation and storage options
- Enable new products, services and markets
- Provide power quality for the digital economy
- Optimize asset utilization and operate efficiently
- Anticipate & respond to system disturbances (self-heal)
- Operate resiliently against attack and natural disaster

These characteristics have been discussed in previous Smart Grid Newsletter (SGN) articles. Those contemplating Smart Grid investments should keep this set of characteristics in mind to ensure they are always aiming at the ultimate prize rather than just the next step along the way.

**Step 2: Break the Smart Grid down into intermediate milestones**

There are many ways to break down the implementation of the Smart Grid into manageable "chunks". The MGS team has defined the four milestones discussed below as one way to do that. The accomplishment of each milestone requires the deployment and integration of various processes, technologies and applications that both meet the immediate goals, and are compatible with the future milestones. Also, any barriers along the way must be resolved.

*Smart Grid Milestones*

1. *Advanced Metering Infrastructure (AMI)* **–** the AMI milestone is primarily aimed at the consumer side of the Smart Grid by providing them with information, control and options. AMI includes smart meters for advanced measurement, an integrated two-way communications infrastructure, an active interface to give consumers and their home area networks access to information, and a meter data management system to process the vast amount of new data. Additionally, AMI provides an interface to other utility enterprise systems that can benefit from its functionality. AMI's communication infrastructure, data, and interfaces with other enterprise systems are all critical links to the other three milestones.

2. *Advanced Distribution Operations (ADO)* **–** the ADO milestone is primarily aimed at the utility side of the Smart Grid providing the increased information and granularity of control needed for a self-healing grid. ADO includes a distribution management

system with advanced and ubiquitous sensors and distributed intelligence, advanced outage management capability, and distribution automation technologies. It enables effective and efficient operation of a grid that employs extensive distributed generation of all types and sizes (including perhaps millions of Plug-in Hybrid Electric Vehicles and various types of micro-grids), and it is deeply integrated with a distribution geographical information system (GIS). The ADO milestone supports the Advanced Transmission Operations milestone.

3. *Advanced Transmission Operations (ATO)* – the ATO milestone is primarily aimed at improving transmission reliability and efficiency, while managing congestion on the transmission system. ATO also integrates certain aspects of distribution system operations with transmission operations. It enables the security constrained economic dispatch models used by some regional transmission organizations (RTO) to more effectively utilize the distribution system as a "resource". ATO includes substation automation, advanced protection and control, modeling, simulation and visualization tools, advanced grid control devices and materials, and the integration of all these tools with markets and RTO operations and planning functions.

4. *Advanced Asset Management (AAM)* – the AAM milestone is primarily aimed at improving the utilization of T&D assets at the operational level and more effectively managing these assets from a life cycle perspective. AAM depends on the ubiquity of smart sensors that provide both operational and asset condition information that it acquires from the other three milestones. The deep integration of that information significantly improves the effectiveness of enterprise asset management systems such as T&D capacity planning, condition based maintenance, resource management, engineering design and construction and others.

**Step 3: Understand the barriers that need to be addressed for each milestone**
Each milestone's progress is impacted by a number of barriers. These barriers need to be identified and addressed up-front if progress is to be made. Some of the barriers are common to the industry while others may be unique to a utility or region and may depend on the current state of grid modernization there. They may come from various perspectives including change management, regulatory policy, consumer attitudes, financial, technical and others. Many of the barriers will impact multiple milestones. Metrics should be developed to monitor progress for each milestone to ensure the impacts of barriers are minimized.

**Step 4: Determine the best sequence**
One size doesn't fit all. Although the Smart Grid characteristics described above create a common vision for the Smart Grid, the pathway for building one can differ depending on many factors. The sequence for addressing these milestones may therefore vary – but the goal will always be to ensure that the benefits of each can be applied to the others where appropriate. While the AMI milestone is getting the most attention today some have chosen to address ADO first given their current state. Perhaps the finishing order is the most important consideration (e.g. ADO completion may depend on AMI being completed first). The MGS team offers the following sequence for consideration:

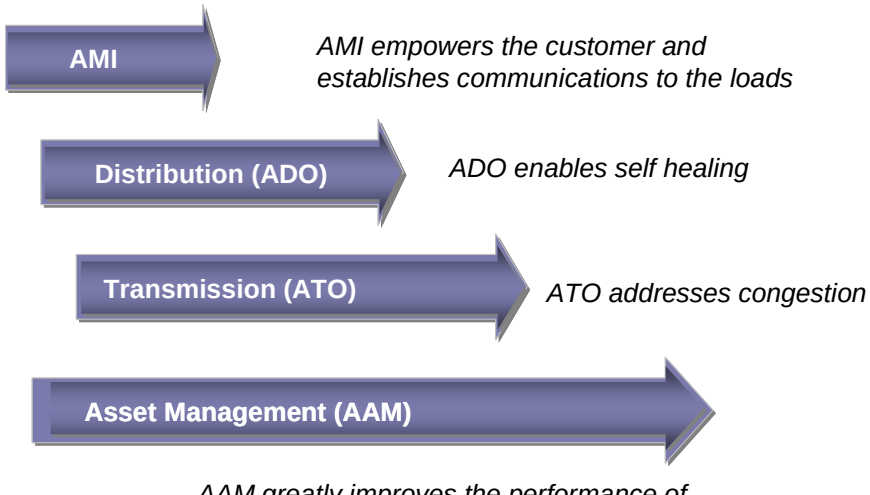

**Figure 1: Milestone Sequence**

**Step 5: Understand the business case**

Achieving the Smart Grid benefits our nation in many ways. In 2004, an EPRI study[1] concluded that the benefit to cost ratio for achieving what it then called the "future power delivery system" was in the range of 4 or 5 to 1. From a national perspective this is a good deal. But it takes individual stakeholders (consumers, vendors, utilities, regulators, and others) to build the Smart Grid and each of them needs to see a "positive" business case from their own perspective. Perhaps a new study should be done that includes all costs and all benefits for all stakeholders so we can not only see what the deal is from the national perspective but also from each of the stakeholders' viewpoints as well. This might help identify where changes are needed in policy, regulation and incentives to make the Smart Grid proposition a winner for all.

**Step 6: Keep the "end in mind"**

| *Characteristic* | *AMI* | *ADO* | *ATO* | *AAM* |
|---|---|---|---|---|
| Enables Consumer Participation | ✓ | ✓ | | |
| Accommodates All Generation & Storage Options | ✓ | ✓ | ✓ | |
| Enables New Markets | ✓ | ✓ | ✓ | |
| Meets PQ Needs for 21st Century | ✓ | ✓ | ✓ | ✓ |
| Optimizes Assets & Operates Efficiently | ✓ | ✓ | ✓ | ✓ |
| Self Heals | ✓ | ✓ | ✓ | ✓ |
| Resists Attack | ✓ | ✓ | ✓ | |

**Figure 2: Smart Grid Characteristic – Milestone Map**

To achieve the Smart Grid we must keep the end in mind. None of the Smart Grid fundamental characteristics can be achieved by just accomplishing a single milestone. Fully understanding how the milestones and their associated processes, applications and technologies depend on each other and how they contribute to the Smart Grid characteristics is very important - not only in achieving the Smart Grid but also in getting there most effectively and most efficiently.

A great deal of additional information is available on the NETL website (see link below):
Previous *SGN* article on NETL's Modern Grid Strategy
http://www.netl.doe.gov/moderngrid/

[1] Power Delivery System of the Future, A Preliminary Estimate of Cost and Benefits, Technical Report 1011001, Final Report, July 2004