QER East, Newark, September 8th

Distribution - How Do We Cope With New Challenges and Opportunities?

Damir Novosel, IEEE PES President Elect

The US DOE QER leadership has requested from IEEE to provide insights on a specific set of QER priority issues. IEEE, the world's largest professional organization dedicated to advancing technology for humanity, utilizes synergies among private and public sectors (e.g., utilities, vendors, academia, national labs, regulatory organizations, and other industry participants) to provide unbiased and independent technical leadership to electrical power and energy industry worldwide. IEEE Joint Task Force leaders engaged a large IEEE volunteer community to help write and review the report that was delivered to DOE in support of the QER initiative.

The National Academy of Engineering considers electrification as the first of twenty engineering achievements that have had the greatest impact on quality of life in the 20th century. Presidential Policy Directive 21 identifies the Energy Sector as uniquely critical because it provides an "enabling function" across all critical infrastructure sectors. Modern society has reached a point where virtually every crucial economic and social function depends on the secure, reliable operation of the power and energy infrastructures. These infrastructures provide huge societal benefits but also face big challenges. International energy industry has been experiencing significant changes caused by new technology trends, environmental drivers and weather patterns, changing consumer needs, and regulatory requirements. The electrical power and energy sector will continue evolving as consumer expectations and options will change, technology breakthroughs will happen, and energy sources and their usage will be transformed. Use of electricity is expected to grow even with improvements in energy efficiency as it is expected that electrical energy will replace other forms of energy (e.g. transportation}.

There was a dramatic expansion of the electric infrastructure that lasted for a number of decades. Similar expansions occurred in other infrastructures, such as the interstate highway system. However, this period of great expansions has largely ended. The age of the infrastructure (particularly underground city networks) is an issue, but it should not be treated on its own merit. Instead, industry focus should be on the holistic asset management approach to address grid resilience and efficiency. A holistic asset management approach requires viewing the entire equipment fleet as critical strategic assets impacted by key inter-related areas in support of business goals: Aging Infrastructure (including use of condition monitoring and assessment tools), Grid Hardening (weather related response, physical vulnerability and cyber security initiatives), and improving System Reliability and Capabilities.

Business models of the energy industry have evolved substantially since restructuring and the adoption of new technologies and grid configurations such as distributed energy resources and microgrids, along with energy efficiency programs and demand response. In addition, consumer interest in increased resiliency and differentiated levels of service (consumers pay for reliability, power quality, and overall service) are creating new opportunities and challenges.

Some believe that microgrids will be the grid of the future and while others that there is no business case for large proliferation of microgrids. Today's interconnected grid has started as a microgrid and interconnected grids were originally created to improve grid cost-effectiveness, reliability, and service quality. Although technology advancements made it easier to deploy controllable and more efficient microgrids, the fundamental benefits of a connected grid still hold.

Some questions that could help us address the grid of the future:

- How best to deliver renewable energy from remote areas to load centers – One could envision building cities where renewable energy resources are. Is this the realistic?
- Is it more reliable and cost efficient for each house to have a generator or is it better for community to have two (one for a backup)?
- Is it more reliable and cost efficient that each microgrid operates independently or is it important to integrate microgrids and rely on a utility grid as a backup? Is it cost-effective and appropriate to treat the grid as a "free storage"?

We are at a crossroads of making business and technical decisions that will allow us to optimally and cost-effectively manage the grid. It is expected that the energy delivery business and technical delivery models will change. However, traditional grids and microgrids should be purposefully integrated as hybrid grids to fulfill all the consumer needs (e.g. resilience and cost-efficiency), with transmission as an enabler to support integration of renewable resources. The microgrid business case depends on benefits achieved, including required level of service, and continued decrease in pricing of technologies such as PV panels and storage. Key aspects include costs, efficiency, reliability, safety, and resilience -- all supported by and coordinated with the balance of the grid in a manner that enables the utility or energy company to defer more expensive investment or to manage its grid in a less costly manner. To optimally address all those aspects, it is necessary to optimize the use of microgrids and reduce costs for end users while assuring required levels of safety and reliability. Policy should support value creation, with results-based rewards, and not unduly favor either incumbent utilities or non-utility microgrid sponsors.

An important question is how renewable generation intermittency affects the electric power grid and the role of storage. The variability and uncertainty can be tolerated at the grid level if traditional power system planning and operations are updated, even at higher penetration levels of around 30%. It is necessary to address technical aspects (such as voltage and reactive power management, frequency regulation, and transient behavior of the system). Energy storage is a beneficial resource but its absence is neither a barrier to nor is its availability per se an enabler for penetration of renewable energy. On the distribution system, high penetration levels of intermittent renewable resource may include significant technical challenges that may be mitigated using a combination of conventional and advanced solutions, such as distributed energy storage, advanced power electronics-based technologies (e.g. smart inverters), and increased real-time monitoring, control and automation.

Another aspect to address is the technical implications of electric vehicle integration. It differs substantially between the Plug-In Hybrid Electric Vehicles/Extended Range and Battery Electric-only Vehicles, depending on the size of the on board battery and the owners driving patterns and charging strategy. While 8 to 12 million vehicles would not require any additional generation or transmission capacity, for the existing distribution infrastructure some rework may need to be done. For example, as most charging would occur off-peak, considering that equipment needs the over-night off-peak time to cool, the equipment may fail if it is not upgraded to deal with this new load requirement. It is recommended to promote the development of PEV charging infrastructure and modeling tools, the battery research, and the efforts on improving cost and efficiency of various converters.

The grid complexity requires development and deployment of a "smarter" solutions using advanced technology. As the "Smarter Grid" requires integrated solutions, development of standards is necessary to support interoperability among Smart Grid components and the use of best practices. IEEE's Standards Association, other Standards Developing Organizations, and the stakeholder community should improve the timely development of Smart Grid standards and promote widespread deployment by putting selected standard development on “fast-track”.

There is no progress and ability to address industry changes and challenges above without skilled workforce. Unfortunately, there has been a decrease in the number of employees in critical job categories: Engineers by 3.2%, Plant Operators by 2.3%, Linemen and Technicians by 1.4%. However, there is an increase in employees under the age of 37, indicating a steady increase in hiring. It is required to continue education partnerships, to be viewed together with research and policy initiatives, to develop new curricula, enhance workforce training programs, apprenticeships and best practices.

Observations common to many of the topics above are:

- Institutional challenges can be serious barriers to engineering solutions.
- More emphasis on accelerated development of industry consensus standards.

In conclusion, the electrical power and energy industry is in a crucial transition phase as initiatives we take today will affect how the grid is operated for years to come. The IEEE industry leadership is critical in addressing that transition. IEEE plans to continue supporting DOE and other government agencies on important initiatives such as the QER.