Written by Editor
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Recently the *Journal of Energy Security* had an opportunity to have a conversation with Mr. Terry Boston, who in 2013 was elected president of GO 15 group which is a voluntary initiative of the world's 16 largest Power Grid Operators representing more than 70% of the world's electricity demand and providing electricity to 3.4 billion consumers on the 6 continents. Who better to ask about the challenges facing the energy industry in delivering on the exponential demand for power, on the investment requirements needed to ensure continued and reliable electricity transmission to end-users, and in the challenges this industry faces in integrating renewably generated power into the world's electricity grids? The JES would like to explicitly thank Mr. Alain P. Steven, Secretary General of GO15, for facilitating this exchange of Q&As with Mr. Boston.

I understand that one of GO15's main areas of interest, understood as an industry challenge, are the technical challenges to integrating generated renewable power into the grid? Could you talk a little bit about these challenges and what you hope to achieve through cooperative action among grid operators?

Boston: Grid operators must be able to accurately forecast the load, the amount of power customers are expected to use, and schedule generation resources to be available. We have to consider transmission constraints and the costs of generation. In addition, grid operators must handle unexpected shutdowns of generation and transmission, weather-related events and so forth.

Renewable generation can introduce several new challenges:

• Much renewable generation, like wind and solar, is intermittent, non-dispatchable and weather dependent. That adds uncertainty to the forecast of how much generation will be available.

• In addition, renewable generation is not necessarily available at the time it is needed. For example, wind generally blows more strongly at night, when people are using less power.

• The location of renewable generation does not necessarily coincide with location of the population centers. The best places to build wind power often are farther from urban load centers. For example, in Germany 41% of wind generation is located in the north, while the main load centers are situated in the south, which makes having an adequate, resilient transmission system even more important.

• Building the necessary transmission lines take time. On average, it takes our members seven years to add new transmission lines due to the lengthy administrative process associated with the permits and rights-of-way. It can be challenging to have adequate transmission capacity available in time to accommodate new generation.

• You can also think of demand management programs as a kind of flexible resource. While they provide a valuable tool for grid operators, they also can add the uncertainty of new load patterns. Similarly, the integration of electric vehicles, and more particularly fast charging stations, also is expected to change load patterns.

Despite these challenges, renewable generation is coming online in record amounts in many nations, and grid operators are working hard to enable them to demonstrate their value.

The energy transition to incorporating new power generation from renewable resources must necessitate some rather hefty investment on the part of grid operators. What kind of numbers are we talking about? How do they vary, if they do, from country to country and region to region? In particular I'm interested in how these challenges are to be met in emerging and developing economies such as in Brazil and South Africa?

Boston: GO 15 members share a conviction that the rapidly changing nature of electric power supplies around the world requires the strengthening and expansion of the transmission grids as well as an increase in the interconnections between countries. This will require unprecedented investments, estimated last year by the members at 700 billion USD over the next 10 years.
Key drivers include:
• A substantial increase in the electricity consumption resulting from population increases and economic development in large countries such as India, China, Brazil, South Africa and Russia;
• Integrating renewable energies, primarily in Europe, North America and China, while more traditional forms of electricity generation, primarily older coal-fired units, are being retired as a result of environmental regulations and reduced profitability;
• Aging of current infrastructure and adaptation to new standards;
• Developing energy sources in new locations that are not as well served by major transmission lines compared to the traditional areas, necessitating the construction of new lines. In the face of this evolution, power grid operators must proceed, or encourage the asset owners to proceed, with three types of investments:
• Upgrades and replacements for aging assets
• Increased transmission capacity through the construction of new transmission lines
• Advanced technologies and computer systems to support increasingly complex and uncertain power flows. In order to do this, it is necessary to encourage investment in grid assets through regulation and tariffs.

What are the chief obstacles to grid reliability today? To what extent has your group focused on cyber challenges to grid operations and reliability?

Boston: For many of the GO 15 members, challenges to grid reliability include:
• Increases in the number of grid interconnections that must be managed. As power grids become more complex and interconnected, grid operators must manage increasingly complex interactions, for example, in the area of transient stability and voltage stability. Instabilities are a cause of blackouts and involve extremely complex phenomena. There are major cooperative

efforts occurring in this area among our members. GO 15 members have dealt with these challenges through investments in new technologies such as synchrophasors and the development of advanced algorithms for early detection and mitigation of instabilities.
• Integration of intermittent and non-dispatchable renewable resources which may be located far from existing transmission lines or existing population and load centers. The result can be new power flow patterns across the grid that were not part of the original grid design. This is another major area of joint activity and information exchange for GO 15 members
• Uncertainties from changes in customers' usage behavior and consumption patterns that can result from demand-side management and demand response programs that aren't integrated into the grid operator's planning and operations. Again, our members are working together on these issues and are studying ways to incent consumers and distributed assets to synchronize with power grid needs, Other threats to grid reliability obviously include the extreme weather events, such as Hurricane Sandy. The solutions require increased grid resiliency. The members are studying lessons learned from recent events like the blackout in India. In terms of cyber threats, grid operators must deal with the issue on a regional basis in coordination with their respective governments.

How does energy storage fit in with your mission in providing reliable power delivery? I'm most interested in what technologies you find most promising and where they are at in the supply chain towards bringing them online in a way they will have significant impact on the reliability of delivered power?

Boston: Energy storage has the potential to become a key contributor to reliability in future power grids. In particular, energy storage provides grid operators with a way to react more quickly and economically than traditional resources for short-term variations in system load and changes in intermittent generation. In addition to the traditional solution of pumped hydro storage, there are many new forms of energy storage such as electric batteries, flywheels and compressed air energy storage, to name a few. You can take technology as old as electric water heaters, add data communications and real-time rates and pricing and turn it into a grid storage device that can provide regulation service or level demand by heating water at off-peak times. The challenge that many are working on with energy storage is how to fairly compensate it because it's different from traditional resources. You can think of electric vehicles as storage devices, too. The vehicles and their charging stations can also become a reliability asset to the power grid operator by participating in frequency regulation markets in response to a real-time signal from the grid operator. The electric vehicle can charge or discharge according to the grid operator's signal. For the vehicle owner, it provides a source of revenue for essentially doing nothing beyond plugging in.

To what extent does GO15 promote trans-boundary power markets? Earlier in 2013 we covered the development of the SIEPAC grid and power market in Central America. Was your group or *its members involved in this decades long project development? Do you actively promote international power markets? What is your opinion, if any, of the success that Nord Pool has had in Scandinavia/Northern Europe?*

Boston: Although none of our members were involved in the development of the power market in Central America, our members are exchanging knowledge and experience with different market designs and structures, such as modal and nodal market designs. More specifically, members are now studying incentive structures and market mechanisms that would encourage investment in new distributed assets, which could contribute to grid reliability by responding to signals produced by the system and/or the market operator.

Speaking personally, PJM is having significant success with a forward capacity market that obligates capacity resources three years in advance of their delivery. A well-developed capacity market can do a lot to improve planning and ensure reliability while helping to make it possible for demand-side management and renewable energy resources to compete.

Hydropower is the world's largest and most stable source of renewable power and energy storage for that matter. Are GO15 members involved in transmitting electricity generated from hydro? If so, where and what has been your experience with this?

Boston: Yes, and to various degrees. For example, a key generation asset connected to State Grid Corporation of China is the Yangtzee Three Gorges Dam, which produces up to 22,500 MW. Other members that are transmitting substantial amounts of electricity generated from hydro sources include China Southern Grid, ONS (Brazil), RTE (France), SO UPS (Russia) and Terna (Italy).

Going back to grid-related security concerns, could you talk a little bit about these concerns maybe providing some insight into what you are worried about and by implication what we as the end-user community should be knowledgeable about?

Boston: As I mentioned previously, the extreme weather events that we've experienced increasingly threaten damage to transmission systems that can disrupt service and require extensive time to repair. Many grid operators are concerned about the uncertainty of the location of new generation and its impact on power flow patterns. For them, this presents not only a substantial investment risk but also the risk of not being able to reinforce or expand the power grid to interconnect new energy sources. Others must adapt their systems to a changing fuel mix of generators and can face a rapid retirement of traditional power plants, such as coal and nuclear, and uncertainties about replacement power.

What's on the horizon for GO15 members in terms of emerging issues and new areas of interest and perhaps concern?

Boston: As it always has been, grid operators' primary focus is ensuring reliability. That has to be the starting point. We've already discussed some of the challenges that various GO 15 members have to meet to ensure reliability: the intermittency of expanding renewable generation, the potential effects of recharging electric vehicles without coordination with grid conditions, the changing use patterns and the uncertainty of new generation location and the need for unprecedented investments and associated investment risks. All of us are seeing new and increasing demands, challenges and needs for the grid. They come to each member in slightly different ways. One challenge, for example, facing all of our countries is how to pay for grid improvements and who ultimately pays for them.
Some other emerging areas of interest among the GO 15 members include:
• early detection and mitigation of grid disturbances;
• getting the most out of existing transmission assets; and
• developing incentives, tariff structures and/or market designs that promote the use of the most effective and economic resources to provide the services and response necessary to maintain or improve grid stability and reliability. Communication also is an important area of interest. GO 15 members want governments, regulators, decision makers, the public, the media and other stakeholders to know and understand the implications of decisions and choices on the power grid. Members want a constructive dialogue among the various stakeholders to ensure success as the industry transitions through the challenges we've discussed. For example, last year the GO 15 signed a memorandum of understanding with the International Confederation of Energy Regulators. As a result, GO 15 and ICER held a workshop in which their respective members and others discussed the issues facing the power grids including, for example, the investment risks associated with new generation location.

In closing, as part of the 'energy transition' many concerns have been raised regarding the issue of smart meters? How does/will this technology make your members' job easier and to what extent, as has been suggested in many publications, does this technology open up to new security threats if any?

Boston: In general, grid operators deal primarily with the transport of electricity at the mediumto high-voltage level and not with distribution of electricity to individual consumers, who are the customers of the electric distribution companies. Smart meters are associated with those distribution customers. However, some form of smart meters help to optimize demand response through allowing end-use customers' devices to respond to real-time price signals from the grid operator that reflects real-time conditions on the grid and to record and document the response. Consumer rates and prices that are aligned with grid conditions empower consumers to control their costs and, when they respond to price signals, to help promote electric system reliability.

Thank you for your time Mr. Boston

Boston: Thank you for the opportunity.