Smart Grid in North America

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OVERVIEW: Smart Grid is a challenge to achieve a secure and efficient electricity supply system and a low carbon society. This paper reports the current status of Smart Grid in North America, role of stakeholders, and Smart Grid technologies, products, and services.

SMART GRID IN NORTH AMERICA

SMART Grid is in fact a modernization of the electricity system by implementing an intelligence and communications layer onto the conventional grid.

The concept of Smart Grid is that of intelligent interactive communications facilitated by interoperability between the conventional grid and the Smart Grid through a series of devices beginning with smart meters, switches, and transformers.

Drivers and Objectives

The drivers and objectives of Smart Grid are summarized as follows:

(1) Empowerment of electricity users through information exchange and the demand response tools to make a positive impact on issues of conservation and energy efficiency (system performance) using dynamic pricing options

(2) Integration of renewable energy information across commercial boundaries to deliver more market options to wholesale, industrial and consumer energy users

Benefits

Benefits of Smart Grid are:

- Increase in service reliability (i.e. grid stability)
- Optimized asset utilization through better system transparency
- Accommodating the use of innovative and emerging energy-saving technologies
- Integration of renewable energy resources and DER (distributed energy resources).

With these benefits followings can be expected:

(1) Engagement for consumers of energy to make the best choices for conservation and efficiency based on real-time information

(2) Effective demand response program based on “behind the meter” addressable options enabled by built-in controls in all appliances and home network access

CURRENT STATUS OF SMART GRID

Canada

The Green Energy Act passed by the Ontario Legislature in 2009 mandates the framework to develop Smart Grid through regulation and policy tools such as Feed-in-Tariff for renewable energy along the following roadmap:

(1) Establishing an AMI (advanced metering infrastructure)

Smart metering facilitates communication and necessitates the development of standards and protocols by Canadian Standards Association for interoperability.

(a) Approximately 3.6 million meters installed to date
(b) 350 thousand customers on TOU (time of use)
(c) 3.6 million expected to be on TOU by 2011

(2) Network management integration (MDI)

MDI acts as a repository for data that can be distributed automatically to various stakeholders, including consumers, to be harvested for the development of CDM (conservation demand management) programs.

(3) Customer empowerment through demand response programs and dynamic pricing alternatives

Average spending in Ontario will be in excess of two to three billion US dollars over the next five years if grid expansion, grid refurbishment as well as smart meters costs are included. If only information spending is considered, then approximately 1.5 billion dollars over the next five years is the target spending.

This will increase as the requirements for the Smart Grid are further defined and implemented.

USA

The National Institute of Standards and Technology (NIST) serves as the coordinating body for the development of a framework for protocols and model standards to achieve interoperability of Smart Grid devices and systems.

The US DOE (Department of Energy) and the ARRA (American Recovery and Reinvestment Act) committed 4.5 billion dollars in initial base funding to promote the development of Smart Grid technologies and solutions.

The size of smart meter deployment underway is 40 to 50 billion dollars.

ROLE OF STAKEHOLDERS

ISO

ISOs (independent system operators) consist of: AESO (Alberta Electric System Operator), CAISO (California ISO), ERCOT (Electric Reliability Council of Texas), Ontario IESO (Independent Electricity System Operator), ISO-NE (ISO New England), MISO (Midwest ISO), NBSO (New Brunswick System Operator), NYISO (New York ISO), PJM (PJM Interconnection), and SPP (Southwest Power Pool). The 10 ISOs' priorities are grid reliability and generation sustainability for reduction in green house gas footprint.

In the NIST generic Smart Grid framework, there are overlapping functionalities in transmission and distribution domains. In a similar way operating regions within the ISO share physical transmission networks with overlapping domains within an interconnected grid. However the future developed Smart Grid will utilize communication technology to de-silo any domain barriers to achieve competitive and reliable electricity supply in an efficient and robust market.

Enhanced reliability is achieved through:

(1) Efficient grid dispatch
(2) Addition of green power reliably to the grid
(3) Pricing transparency/signals
(4) DRD (demand response development) / CDM

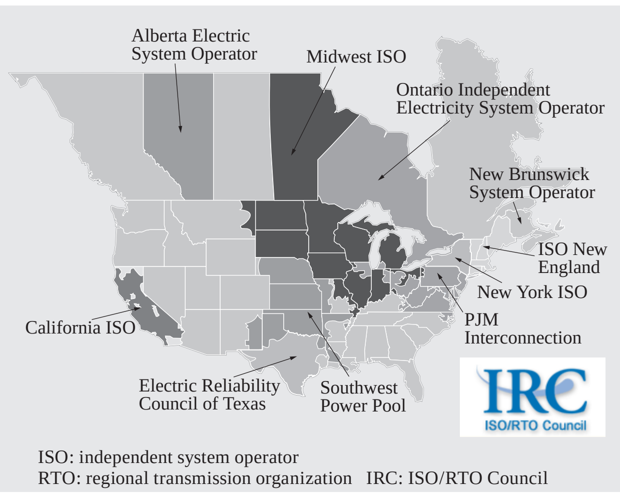

Fig. 1—ISO/RTO Operating Regions.

Utilities/Power Generators

Generation companies integrate new sources of fuel to generate competitive and reliable electricity while achieving green house gas / lower carbon emissions footprint.

Regional Transmission Operator

Regional transmission operator delivers electricity over various transmission lines from station to station.

LDC

LDC (local distribution company) delivers electricity to industrial / commercial sectors and consumers, maintains and operates electricity distribution infrastructure.

The LDC remains the front line in the delivery of CDM programs.

Retail Energy Service Providers

Retailers remain a critical enabler for creating a competitive market by offering financial options to energy users.

Manufacturers/Technology Partners

Technology providers such as Hitachi as a stakeholder with leading edge research and development, information systems, and manufacturing capabilities play a key role in creating the solutions to realize the Smart Grid.

SMART GRID TECHNOLOGIES, PRODUCTS, AND SERVICES

New and Improved Technologies to Meet Smart Grid Challenges

9,000 MW of renewables were added to the USA grid in 2009, with another 9,000 MW addition expected in 2010 with greater increments in 2011 and beyond while in Canada approximately 15,000 MW are slated to be introduced by 2020.

This expansion of renewable energy will increase the need to balance supply and demand against a somewhat predictable load but an uncertain and variable supply.

In support of integrating renewable energy into the grid a multitude of new technologies and approaches if successfully developed could significantly impact the power flows and hence costs to consumers.

Storage technology such as batteries, CAES (compressed air energy storage), and pumped hydro generators increase off-peak usage and optimize asset utilization.

For example these technologies will support variable renewable energy, smooth out intermittent generation, and provide ancillary services such as load following, area regulation as well as black start capability.

It is estimated by the US DOE that grid parity for renewable energy will be achieved during 2015 to 2020 as market penetration of renewable energy increases. This will significantly increase the need for on-line TSC (transient stability control) to enhance grid stability while saving on infrastructure investments in transmission systems.

Necessary Consumer Technologies

Behind the meter application devices have to accommodate bi-directional or reverse power flow from small scale DER. This means home energy management systems to control customer-owned resources to facilitate automatic dynamic pricing response through smart appliances.

Communication

USA and Canada are currently awaiting NIST standards and protocols to achieve interoperability.

Canada has recently concluded its plan of using a dedicated spectrum for electric utility communications.

A communications system for Smart Grid must be scalable to allow for the addition of new devices as technology evolves against the uncertain pace of Smart Grid implementation.

In addition, the MTBF (mean time between failures) requirements of communications equipment versus Smart Grid power systems must be matched for service and reliability.

Most importantly, the potential access points from the deployment of Smart Grid devices create unknown risks to cyber security and mitigating such risks will be mandatory. While this will result in increased costs, it also creates the opportunity for further security solutions, which are within the development capabilities of Hitachi.

DA

Two-way communications and enhanced sensor capabilities on TOU meters enable utilities to better understand conditions throughout the distribution system.

Automatic grid reconfiguration function in DA (distribution automation) detects faults and restores blackout areas.

DER

Visibility to monitor DER as well as control of electricity production is almost non-existent and may impact upstream transmission reliability, public safety or service to customers. Smart Grid technology with its components for enhanced monitoring when combined with future load-shedding capabilities will facilitate greater reliability on distribution lines.

EV

EV (electric vehicle) presents multiple challenges due to infrastructure inadequacy and vehicle battery charging time. EV impacts on regional transmission stability and infrastructure due to mobile load. Optimization of generation options during off-peak hours could be a huge benefit when renewable energy is taken into consideration.

Projections of EV or PHEV (plug-in hybrid electric vehicle) market penetration in North America are 20% by 2020.

The lithium-ion battery technology is evolving as the preferred option.

The Smart Grid is critical to successful deployment of electric vehicles. In the future, batteries taking on a role as an energy supplier to the grid are very probable.

Microgrids

In this concept of an integrated energy solution serving a group of consumers such as the MUSH (municipalities, universities, school boards, hospitals) sector, including nursing homes and long-term care facilities, police, and children's aid societies, a neighborhood or remote town cannot operate independent of the larger electricity system. Putting aside the vast legal and regulatory hurdles to be overcome, it is of interest to note that technical solutions to challenges (connection to existing distribution systems, safety, equipment protection) which such a concept presents are already under pilot testing evaluation in Denmark (Energinet.dk) using cell structure as a controller to integrate renewable and DER into the transmission grid reliably, overcoming connection limitations.

Transmission

Massive investments will be needed to refurbish existing infrastructure as well as enable the new connections required to facilitate renewable energy and DER. This will also allow the implementation of Smart Grid technologies during this renewal phase as old equipment is replaced and could very well be one of the largest infrastructure projects to be undertaken in North America.

Beyond the wider visibility afforded by phasor measurement, advanced phasor visualization and decision support tools, investment will flow into technologies for transmission efficiency and control of the transmission systems.

Congestion removal using Smart Grid technology will also increase reliability while making the systems more flexible and accommodating of larger amounts of generation from variable DER.

Ultimately large scale demand response, storage, and technologies such as FACTS (Flexible Alternating Current Transmission Systems) will also bring more efficiency to the grid.

CONCLUSIONS

Smart Grids will provide solution opportunities in the following areas:

(1) Communications
(2) Consumer Energy Management
(3) Meter Data Management Repository
(4) Active Distribution Network Management and
(5) Transmission and Distribution.

For the most part, technologies to achieve the Smart Grid's promise still remain at the pure research level and must be commercialized on an urgent basis. The private sector utilizing its vast research and development capability must focus its researchers to develop the products that will brand its solutions within the nexus of "power systems and communication network layer convergence."

Smart Grid product development roadmap matched to expected Smart Grid deployment milestone must establish product development priorities and form the basis for collaborative development with external partners such as utility system integrators, consumer mobile application providers, and smart meter manufacturers. This must be undertaken on an urgent basis to meet market deadlines.

Involvement with NIST as open standards and protocols is critical to achieve interoperability which is a mandatory market requirement of the future Smart Grid solutions.

The drive for information integration across commercial boundaries will demand innovative solutions to integrate renewable energy and DER as a greater percentage of the electricity supply mix, thereby providing global product opportunities for companies such as Hitachi.

REFERENCE

(1) Report of the Ontario Smart Grid Forum: "Enabling Tomorrow's Electricity System," (Feb. 2009).

ABOUT THE AUTHOR

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Howard Lincoln Shearer is the President and Chief Executive Officer of Hitachi Canada Ltd (HCL), having joined Hitachi in October 1984. He is also a member of HCL's Board of Directors, a position to which he was appointed in 1999, and a Board Member of GE-Hitachi Nuclear Energy Canada Ltd. Prior to this, he served as Vice-President & General Manager of HCL's semiconductor division. Prior to joining Hitachi, Mr. Shearer was employed in the high-tech industry by Texas Instruments as well as Murata Erie. Mr. Shearer holds a bachelor's degree in electrical engineering from McMaster University, Hamilton, Ontario and is currently a member of McMaster University's Board of Governors. He serves on the boards of the following non-profit organizations: Responsible Gambling Council of Canada (RGCC), Japan Society and the Canadian Nurse Foundation. He is one of board of directors of the Independent Electricity System Operator (IESO) in Ontario, Canada. He is also a member of the Principal's Advisory Council (PAC) at the University of Toronto as well as a member of other professional organizations including the Energy Council of Canada and the Canadian Nuclear Association.