Science Pages

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Smart Grids

Smart Grids are electricity transmission systems that offer many potential improvements over the existing grid system, including increased reliability and reduced energy consumption. It is estimated that the Smart Grid market will be worth $100 billion in 2030. This edition of SciencePages focuses on how Smart Grids differ from our existing grid system and examines regional, national and international policies, as well as privacy and pricing issues.

What is a Smart Grid?

The present North American power grid includes nearly 3200 utility companies. It allows a one-way flow of electricity from centralized generators to consumers and a limited exchange of real-time information. A Smart Grid uses advanced digital communication to enable a two-way flow of both electricity and information. This allows electricity generation, delivery and load to be adjusted for optimal performance. Changes in the way customers record, pay for and manage energy consumption can help reduce the power system's peak load – the period of time during the day when energy demand is highest.

Integrating Renewable Energy

Although it varies by province, Canada's energy mix is dominated by hydroelectric power, followed by coal and nuclear power. A Smart Grid can accommodate intermittent power sources such as wind turbines and solar arrays, whose output may not coincide with demand. Wind turbines generate more energy at night, when demand is lowest. To meet demand, a Smart Grid would not only switch from one generation source to another, but also rely on demand-response – consumers changing their usage to different times of the day - and energy storage, often driven by price differentials.

Demand-response also plays a role in the use of plug-in hybrid electric vehicles. When recharging, these vehicles draw more electricity than a typical household, but their batteries can act as significant energy storage devices. Smart charging devices can be designed to communicate with utility companies and adjust recharging cycles to coincide with low prices, low grid impact and make use of low-emission periods - when renewable energy sources are available to recharge the vehicle. Dealing with surplus electricity is a concern with the present grid as electricity must be consumed the moment it is generated. Research is examining the benefits of distributed storage facilities that could decrease energy waste and make the grid system more efficient. Using two-way communication, consumers would be able to sell surplus electricity from wind turbines, roof-top solar panels or energy stored in plug-in electric vehicles, back to utility companies.

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Communication

Two-way high-speed information flow is the back-bone of Smart Grids. Part of the required communication infrastructure already exists in long-distance optical, wireless and cellular networks. In Canada, a 1.8 GHz radio spectrum has been reserved for the utility industry, including Smart Grid development. Advanced computing hardware and software allows grid operators to see electricity networks functioning at various scales, from an individual building to an international grid. However, the addition of such devices may increase potential entry points to the electricity network and could make the grid more vulnerable to cyber-attack.

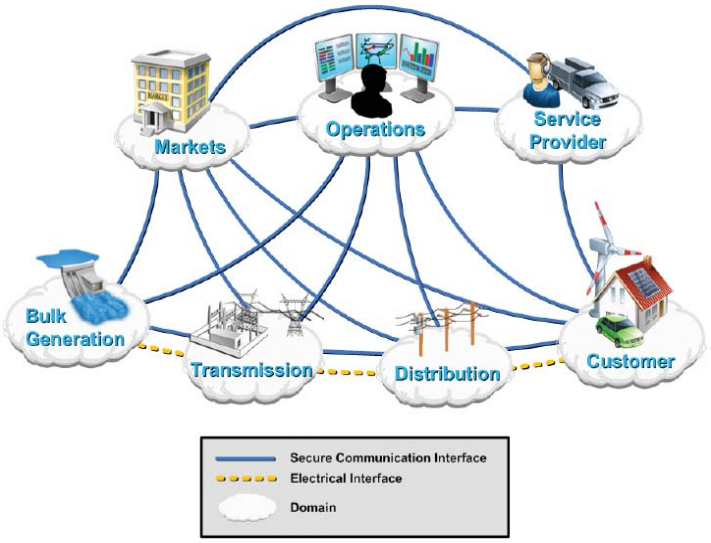

Figure 1: The different actors involved in a Smart Grid

Source: NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, (NIST Special Publication 1108); January 2010.

Canadian Smart Grid Policy

Energy in Canada is regulated at the provincial and territorial level. Most provinces have a single dominant publicly-owned electrical utility company responsible for the development and delivery of electricity as well as Smart Grid development. Two provinces, Ontario and British Columbia, have introduced legislation which support elements of Smart Grid development. Ontario's *Green Energy and Green Economy Act*, for example, introduced the Feed-In-Tariff (FIT) program, the first guaranteed pricing structure for renewable energy generation in North America. At the federal level, the Canadian government supports the development of Smart Grids through Industry Canada and Natural Resources Canada (NRCan). Industry Canada is responsible for spectrum allocation and the development of industrial strategies related to the digital economy, of which Smart Grids are a key component. NRCan undertakes public-interest research such as development and pilot projects related to Smart Grids. NRCan, together with the Standards Council of Canada convened a National Smart Grid Technology and Standardization Task Force which manages various aspects of Smart Grid development and contributes to the U.S Smart Grid standardization efforts. The Canadian Standards Association takes an active role in harmonizing Canadian and international standards.

Smart Meters

Smart Meters are the Smart Grid component most visible to consumers. They facilitate a closer relationship between consumer demand and supply management by measuring energy consumption every 1-5 minutes. Information is then supplied to the grid operators. This allows for time-of-use billing – different electricity rates at different times of the day – the aim being to reduce electricity use at peak times. Ontario is one of a handful of jurisdictions world wide with plans to install Smart Meters in all households by June 2011. In 2006, the Ontario Energy Board initiated the first pilot project in North America, to examine changes in customers' electricity consumption in response to three different types of electricity pricing. British Columbia aims to install Smart Meters in all households by 2012. Internationally, Sweden was the first country with mandatory Smart Meters in 2009. Italy estimates their 40 million Smart Meters will provide annual savings of $750 million.

Integrated Smart Grids for North America

Canada and the United States are close electrical allies sharing 33 major transmission lines and other infrastructure (see Figure 2). Even a minor fault in this tight interconnection can lead to grid failure with cascading outages like the one that occurred in August 2003. Smart Grids can circumvent these types of events by locally disconnecting the defective system instantaneously. This is one of the benefits motivating the adoption of Smart Grids in North America

In February 2009, Canada and the United States began the *Clean Energy Dialogue* (CED) to develop clean energy technologies to address climate change, expand clean energy research and build a more efficient energy grid. The CED Action Plan has 20 recommendations, including demonstration projects, development of regulatory standards, research and increased public awareness of clean energy technologies. In the US, the National Institute of Standards and Technology (NIST) is working on the Smart Grid interoperability standards to ensure Smart Grid cyber security. In 2010, NIST released the first *Framework and Roadmap for Smart Grid Interoperability Standards* that identified standards for long-term Smart Grid development as well as gaps in current standards.

Figure 2: The North American grid has stronger interconnectedness between Canadian and US resources than amongst Canadian Provinces. Lines shown are 345kV and above. There are many other interconnections under 345kV that are not shown on the map. (Map copyright CEA, reprinted with permission).

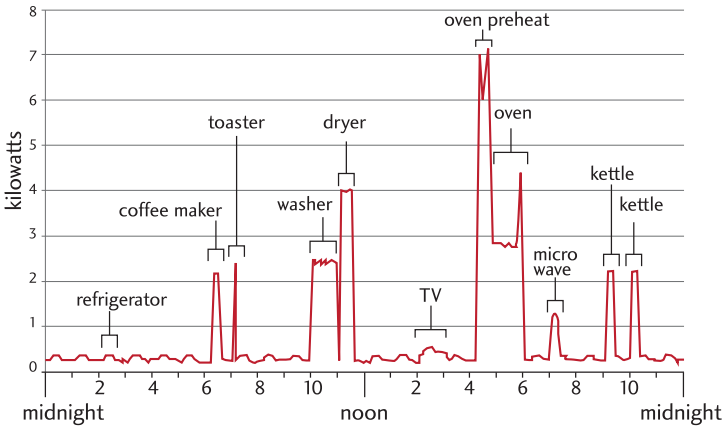

Figure 3: Household electricity demand profile recorded for one-minute intervals.

Meters keep Track
A smart meter - the piece of technology that links a home to the smart grid - can keep track when the refrigerator kicks on in the middle of the night, when the washing machine runs in the morning and when the kettle is put on to make the bedtime cup of herb tea.

Source: http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Consumer Concerns

Smart Grids, with the help of Smart Meters, will increase the depth of personal information collected for electricity billing purposes and for energy conservation planning. While this information is important for helping customers to determine appropriate energy management solutions, there are concerns about access to such information by third parties. Utility companies or unauthorized users can deduce the approximate number of occupants of a residence, whether they are at home, asleep, and their usage patterns, such as when they cook, do laundry, watch TV or exercise (see Figure 3). Privacy standards and policies in Canada are beginning to address this issue. *Privacy by Design* is an Ontario initiative to understand how "Fair Information Practices" could be incorporated into Smart Grid design.

New provincial pricing structures, incentives for renewable energy options, implementation of Smart Meters and Smart Appliances may increase consumer electricity bills. Shifting to renewable energy sources also challenges the grid's ability to meet electricity demand during peak consumption hours. In order to meet peak demand, utility companies could directly control consumer's smart appliances, such as air conditioners, to reduce consumption at peak times.

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Canadian Investments in Smart Grid Development

Canada has made significant investments in Smart Grids. As of May 2010, at least 65 Smart Grid related projects have been initiated in Canada. Ontario has focused its attention on advanced metering technology and demand response. The province plans to invest $50 million in Smart Grid research and demonstration projects, $2.3 billion in new transmission lines to improve access to green energy and $9 billion in renewable energy contracts under its FIT program. British Columbia and Quebec have the highest number of network automation technology projects that will make the grid more efficient by allowing technology to take over simple tasks.

The Canadian government plans to invest $146 million in 20 clean energy projects under the Clean Energy Fund. Part of this fund will be used to demonstrate Smart Grid technology projects in commercial buildings in Alberta, Ontario and British Columbia. It will also fund *Interactive Smart Zone* projects in Quebec. These include electric car charging infrastructure as well as voltage and reactive power management. In July 2010, $32 million over four years was committed to the *Power Shift Atlantic Project*, a consortium of four Maritime utility companies. They will demonstrate the potential of demand response to balance wind energy. Recently, the Canadian government invested $4.6 million over five years in Smart Grid research at the British Columbia Institute of Technology. This will allow researchers to develop Smart Grid technologies and solutions in a simulated environment. Research on Smart Grids is also done at CanmetENERGY run by NRCan.

International Investments

Internationally, several countries are increasing their investments in Smart Grids. A recent report published by Innovation Observatory, named 10 countries which, by 2030, will be responsible for 80% of global Smart Grids investments, for a total of $378 billion. The report predicts that over the next five years the U.S will be a global leader with $60 billion invested in Smart Grid technology and infrastructure. After 2016, Innovation Observatory predicts China will lead with investments of $99 billion over 15 years. Canada is not among the top 10 investor countries.

Canada along with 14 other countries formed the International Smart Grid Action Network (ISGAN) as part of the International Energy Agency (IEA). ISGAN promotes cooperation in the development of Smart Grids around the world and addresses gaps in policy, standards, technologies, labour force and consumer engagement areas. The annual budget for ISGAN is expected to be $8 million. This cost will be evenly split between all participating countries.

Further reading :

1. Hyperlinks to supporting information are embedded in the electronic version of this SciencePages issue, available at www.sciencepages.ca. The documents listed below are suggested further reading:
2. NSERC Smart Microgrid Network: http://www.nserc-crsng.gc.ca/Partners-Partenaires/Networks-Reseaux/NSMGNet-NSMGNet_eng.asp
3. CanmetENERGY - Smart Grid Activities in Canada : http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/integration_der/publications.html?2010-087
4. IEEE – Power & Energy Society: http://www.ieee-pes.org/
5. Privacy by Design: http://www.privacybydesign.ca/
6. Ontario Green Energy Act: http://www.greenenergyact.ca/

About *SciencesPages*

SciencePages (www.sciencepages.ca) is an initiative of the Partnership Group for Science and Engineering (www.pagse.org).

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