The Hydro-Québec Smart Grid

Integrated innovation program for smart grid development at Hydro-Québec

Real-time system management
Power Grid Issues and Challenges

1. **Climate conditions**: Public appeals for reduced consumption: 800 MW on January 15, 2004, 600 MW on January 16, 2009 and 300 MW on January 24, 2011

2. **Demand growth**, slow but steady: 0.6%/year in energy and 0.9%/year in capacity (2009–2017 Strategic Plan)

3. **Increase in net exports**: from 15.2 TWh in 2008 to 24.9 TWh in 2013 (63%) and from 32% to 38% of net income

4. **System growth half as rapid as growth in peak demand** (3.5% vs 7.8% from 2002 to 2010)

5. **Significant and constant losses** since 2005: 8.4% in 2001 (gov’t order on heritage pool) versus 7.5% in 2009, including 5.4% transmission losses
Moving towards a smarter grid: A necessity, not a choice

- Increase grid reliability and availability
- Improve energy efficiency of facilities
- Increase capacity to integrate new sources of renewable energy and distributed generation
- Optimize investments (financial and other) in long-term operability, maintenance and security of supply
- Provide customers with the means to optimize consumption and reduce electricity bills, while meeting their electric transportation needs in a flexible manner
A Company-Wide Project

- Vision and innovation strategy defined with the business divisions
- Project portfolio developed and validated by the divisions and grouped under an integrated innovation program
- Coordinating committee for program implementation and follow-up

an integrated vision
an adaptive grid managed in real time
An Integrated Vision: From Generation to Consumption

- Generation optimization. Objective: Balance generation and load at least cost
- Develop a highly automated grid capable of executing complex functions through real-time collection and processing of data on generation, demand and system state, thus facilitating integration of intermittent and renewable distributed energy resources, outage prevention, etc.
- Incorporate new information and communication technologies (advanced metering infrastructure, networked meters, remote-controlled equipment, etc.) to facilitate real-time system and demand-side management
Characteristics and Advantages

1. Interactive data infrastructure communicating with all components
2. Extensive use of instrumentation, with advanced sensors and distributed calculation
3. Advanced automation and function optimization

Advantages

- High penetration of new and emerging energies
- EV intelligent charging
- Consumers have more control over their electricity bill and participate actively in optimizing power grid economics
- Efficient grid management and reduced losses
- Fewer and shorter power failures
- Improved reliability and security of integrated grid
A 20-year Vision: The Hydro-Québec Grid in 2030

An adaptive, highly automated grid, actively managed in real time through continuous monitoring of system state.
An Integrated Innovation Program with Four Objectives

- **Improve transfer capacity while meeting reliability criteria**
  - *Wide-area control*
  - *Optimization of system limits based on near-real-time data*

- **Improve end-to-end grid efficiency and availability**
  - *Technologies for optimizing thermal capacity of lines and equipment*
  - *Reduced losses, proactive maintenance*

- **Implement smart grid architecture**
  - *For a smart grid, System of Systems architecture sustainable to 2030*

- **Have simulation tools and an R&D infrastructure to support optimum integration and use of renewables (wind) and new flexible resources**
  - *Resulting from active customer participation*
Strategy for Deployment in Stages
5-year blocks

An adaptive, highly automated grid, actively managed in real time through continuous monitoring of system state.
Technology Deliverables Over the Next 5 Years

1. Prototypes and grid response testing of advanced command and control functions
   - Grid response testing of command and control systems for shunts and generating units
   - Delivery of a prototype system for situational awareness and vulnerability identification

2. Prototypes and grid response testing of closed-loop voltage control and reactive power management systems
   - Transmission and Generation: Delivery of a prototype integrated reactive power management system
   - Distribution: Grid response testing of an optimized volt/var controller
Technology Deliverables Over the Next 5 Years (cont.)

- **Prototypes and grid response testing of smart monitoring systems**
  - Delivery of a prototype integrated transformer monitoring and dynamic thermal rating system
  - Delivery of a prototype system for near-real-time optimization of operating limits and interchanges (OLS)
  - Demonstration of a smart fault location system (MILE)

- **Prototypes of proactive automated maintenance systems**
  - Delivery of a prototype decision support system for online transformer diagnostic testing
  - Delivery of a prototype integrated system for managing the condition of distribution assets
Technology Deliverables Over the Next 5 Years (cont.)

- Prototypes and grid response testing of systems and technologies for integration of new energy sources and flexible resources
  - Testing of technologies for direct control of domestic load (demand-side management)
  - Delivery of a prototype system for aggregation and optimum integration of customer-side distributed resources
  - Improved load forecasts with non-dispatchable resources
  - Assessment of the impact of electric vehicles, photovoltaic solar and MV storage on the grid

- Smart grid simulation tools
  - Delivery of system simulators incorporating new forms of generation and consumption
  - Delivery of a prototype simulator faster than real time and including virtual generating stations
Technology Deliverables Over the Next 5 Years (cont.)

- Demonstration of a target smart grid architecture that is scalable and takes into account the priorities in terms of corporate projects and technological innovation projects.
## Benefits for Hydro-Québec (2016-2020)

1. **Greater system efficiency**
   - Reduced transmission and distribution losses, as well as reduced consumption (energy efficiency)
   - Optimization of equipment rating (e.g. transformers)
   - Improved asset availability

2. **Greater transfer capacity**
   - Increased transmission margins (control)
   - Reduction in captive power generation (optimization)
   - Reduction in capacity needs (postponement of system expansions)

3. **Greater reliability and security of supply**
   - Improved fault and outage location
   - Automation of system restoration and reconfiguration
   - System stabilization under extreme contingencies
   - Ability to simulate the impacts of storage, electric vehicles, wind and solar generation etc. on the grid
   - Resource optimization (least-cost integration of new intermittent energy sources)

4. **Access to dedicated simulation tools for the smart grid**
   - Hydro-Québec will have simulation tools to support smart grid R&D as well as planning and operation, all in compliance with NERC reliability requirements

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**Sustainable target architecture that will transition the existing power system into a smart grid**
Appendix

R&D Projects: 5-Year Target

Some examples
3 WACS-compliant PMUs

9 Substation Control Units (SCU) and MF-MBPSS

PDC with EMS and SCU communication
IMAGINE Project – Real-time Remote System Management
CATVAR Project – Volt and VAR Control

- Anticipated savings 2 TWh
- Development began in 2008
- Proof of concept achieved and design frozen
- Demonstrated at Pierre Boucher substation
- Approved by Régie de l’énergie in 2011
**MILE Project – Smart Meter based Fault Localization**

- Objective: Identify and locate anomalies to prevent power failures.
  - Waveform analysis over about 10 cycles.
  - Significantly shorter response time.
  - Type of fault determined by comparing with recorded patterns.
Hydro-Québec Smart Zone Project

**Current**
- Pierre-Boucher Substation
- Volt-Var Control
- EV and Intelligent Charging
- Advanced Metering Infrastructure (AMI) and Demand Response
- Renewable Energy

**Future development**
- Distribution Management System (DMS)
- Monitoring, Data Exchange, And Telecom (WiMAX, telephone)
Smart Grid R&D Facilities

25 kV Test Line

ICT Experimental Infrastructure

Hypersim Simulator
Summary - A bridge to the future

2030 Vision

Smart maintenance based on actual equipment condition and risk of failure

Smart Operations with end-to-end optimization and automation

Smart grid built on integrated sensing, communications & controls

Smart Control and Response based Protection using wide-area information

Smart DER Dispatch through virtual power plants and responsive load control

Today

Grid-of-the-future

Maintenance
- Reactive and calendar based

Operations
- Human-centric and dispersed information based

Control and protection
- Localized actions and pre-planned events based

No DER Integration issue
- Centralized generation and inflexible demand