Hydro-Québec Research Institute (IREQ) Simulation and Distribution Testing Facilities

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First International Workshop on Grid Simulator Testing of Wind Turbine Drivetrains
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Hydro-Québec’s Power System:
Major Generating and Transmission Facilities

- Hydro-Québec generates, transmits and distributes electricity, mainly using renewable energy sources, in particular hydroelectricity.

- Installed capacity: 36 000 MW

- 15 interconnections with systems in neighboring provinces and states.

- By 2015, HQ will be carrying about 4 000 MW of wind power over the transmission system.
Hydro-Québec Power System Simulation Activities

> Hardware-in-the-Loop (HIL) testing of controllers for HVDC, FACTS (SVC, UPFC, ...) and protection relays

> Developing power equipment models (FACTS, Wind Generators, ...)
  - Detailed 3-phase Electromagnetic Transient (EMT) models
  - Phasor models for Stability Studies

> Developing simulation tools: HyperSim Real-Time Simulator, Matlab/SimPowerSystems and EMTP-RV
IREQ’s Power System Simulator

Mid-2012

Today
IREQ’s Power System Simulator
2 * 500 MW Back-to-Back HVDC
Québec – USA Interconnection
HyperSim Digital Simulator

> **Software**
- Based on nodal method (EMTP)
- Graphical user interface
- Automatic testing environment
- Interface to MATLAB Real-Time Workshop

> **Hardware**
- SGI multiprocessor computer
- Fast input/output modules for HIL testing of real controllers

> **Applications:**
- HIL testing of real controllers
- Studies of very large power grid in Off-line mode (like a very fast EMTP simulation)
Applications: Examples

> **Protection system testing:**
  - HQ-TransÉnergie et HQ-Production have their own HyperSim facilities.
  - Also in HQ substations for maintenance and training.

> **HVDC Testing**
  - Outaouais HVDC Interconnection, (Quebec-Ontario)
  - Châteauguay HVDC Interconnection (Quebec-USA)
  - LG2-Nicolet-Boston Multi-terminal HVDC
  - Champlain-Hudson Power Express Interconnection (?)

> **Wind turbines and Wind Power Plants (WPP)**
  - Model Validation
  - Ability to Simulate “Black Box” Manufacturer’s Models
  - Large-Scale Integration Studies (Real-time or Off-line)
Example of a Large-Scale Integration Studies (Real-Time)

HVDC Interconnection

Gaspé Peninsula

New England

Hydro–Québec Network

780 bus
189 lines
25 WPPs (DFIG single-machine eq.)
35 synch. generators
7 SVC
6 synch. Condensers
Series compensation
1 Multi-Terminal HVDC interconnection
CASIR:
IREQ’s High Performance Computing Data Center

- 84 TFlops of x86 processing
- 21 TFlops of GPU processing
- 4124 CPU cores (x86)
- 16 TB of distributed RAM
- 120 TB GPFS parallel file system
- QDR/FDR (40/50 Gbps) Infiniband network
- A team of 3 scientists specialized in HPC
IREQ’s Distribution Test Line
**Distribution Test Line**

- **Conducteur de Distribution Test Line**
- **Ligne souterrain 25 kV / 120 kV**
- **Δ-Ү 28 MVA**
- **Charges B1**
- **Conducteur de neutre 600 V / 25 kV**
- **3-167 kVA X**
- **X1, X2, X3**
- **CED/ DMS**
- **S4, S5**
- **Ligne 4**
- **Centre de commande**
- **Charges**
- **Génération**
- **Microréseau**
- **Groupe – Technologie**

**Five technology areas:**

- Advanced Protection & Microgrid Controller
- Distributed Energy Ressources (DER)
- Underground Infrastructure
- Metering & Telecommunications
- Distribution Management System (DMS)
Distribution Test Line - Details of DER

> **Synchronous generators**
  - 400 kVA diesel, Caterpillar engine

> **Induction generator**
  - 200 kVA dc motor driven Baldor IM

> **Inverters**
  - 250 kVA SMA PV inverter, dc supply fed
  - 135 kVA Satcon inverter, solar concentrator fed
  - 250 kVA BESS converter with 100 kWh Li-ion FePO4 batteries

> **Controllable RLC load - this could incorporate some interruptible component**
Ideas of some R&D Avenues in an Open Innovation Perspective

- More Real-Time Performance
  (very demanding power electronics applications, very large grid simulation…)

- More interoperability between simulation tools
  (Common Models, Human Interface, …)

- Multi-Domain Simulation
  (Phasor – EMT, Telecommunications, Thermal, Magnetic …)

- Manufacturer Virtual Controller
  (“black box concept”, …)

- RT - Grid Power Simulator
  (Characterization of wind turbine, storage systems, electric car, …)
Up to now it’s just a concept, but …
RT – Grid Power Simulator for Testing and Integrating of Wind Turbines

> Model validation and performance validation for:
  - Low Voltage Ride Through
  - High Voltage Ride Through
  - Inertia Emulation
  - Subsynchronous Resonances
  - Subsynchronous Control Interactions (series compensation and HVDC)
  - Connection to Weak AC system

> Development and Validation of Advanced Protection Systems in Distribution Network

> Development and Validation of Advanced Controllers for Wind-Diesel-Storage Systems in Isolated Network