The Hydro-Québec Smart Grid

Integrated innovation program for smart grid development at Hydro-Québec

Real-time system management

ADVANCED ENERGY CONFERENCE 2011
October 12-13, 2011
Buffalo, New York

Hydro Québec

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

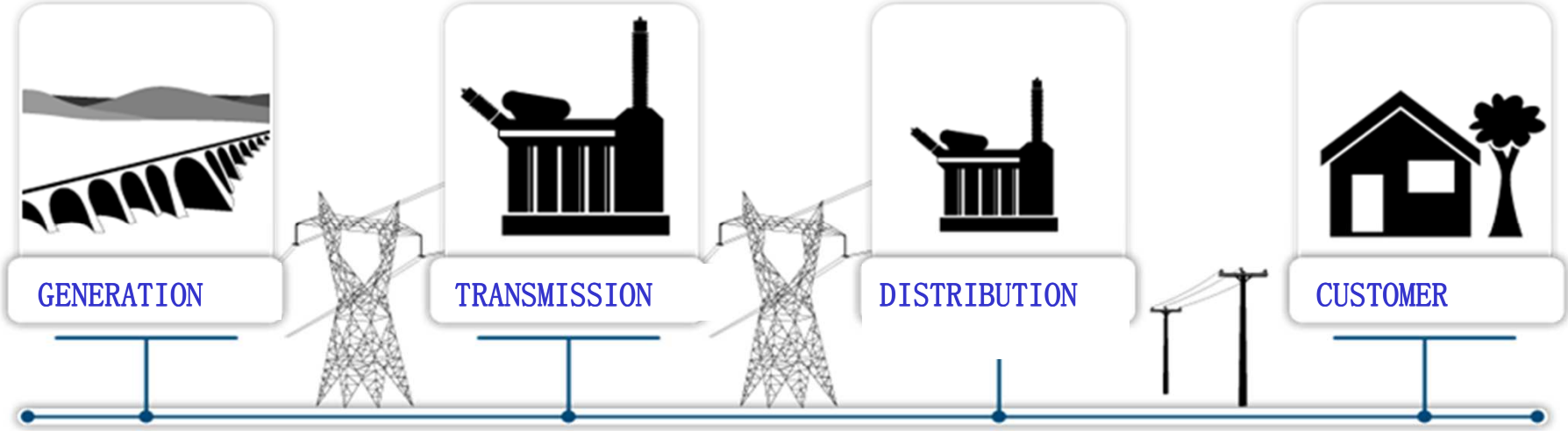
- Increase grid reliability and availability
- Improve energy efficiency of facilities
- Increase capacity to integrate new sources of renewable energy and distributed generation
- Optimize investments (financial and other) in long-term operability, maintenance and security of supply
- Provide customers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

A Company-Wide Project

an integrated vision
an adaptive grid managed in real time

- 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: From Generation to Consumption

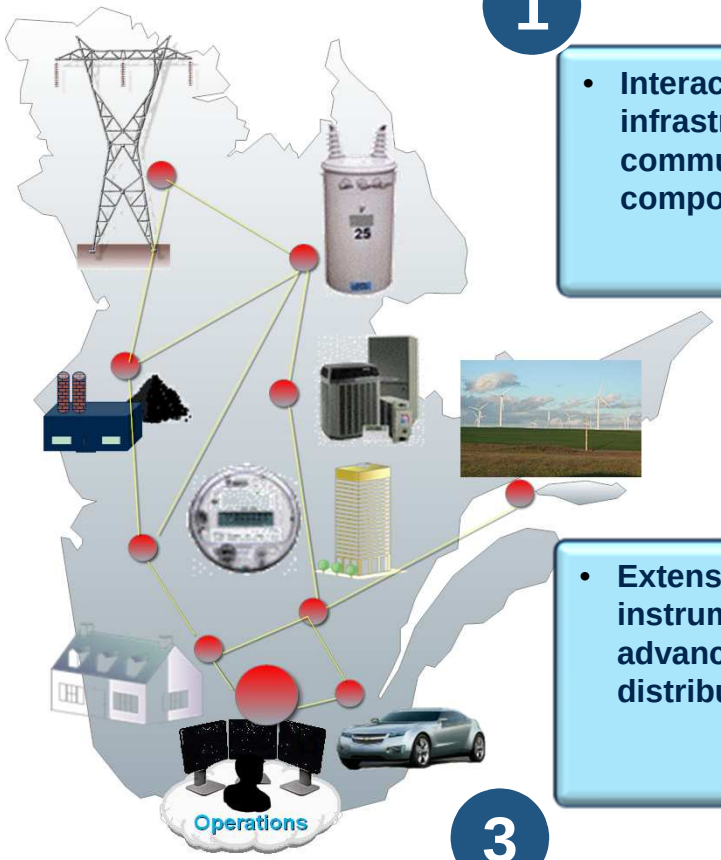


- Generation optimization. Objective: Balance generation and load at least cost

- 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*

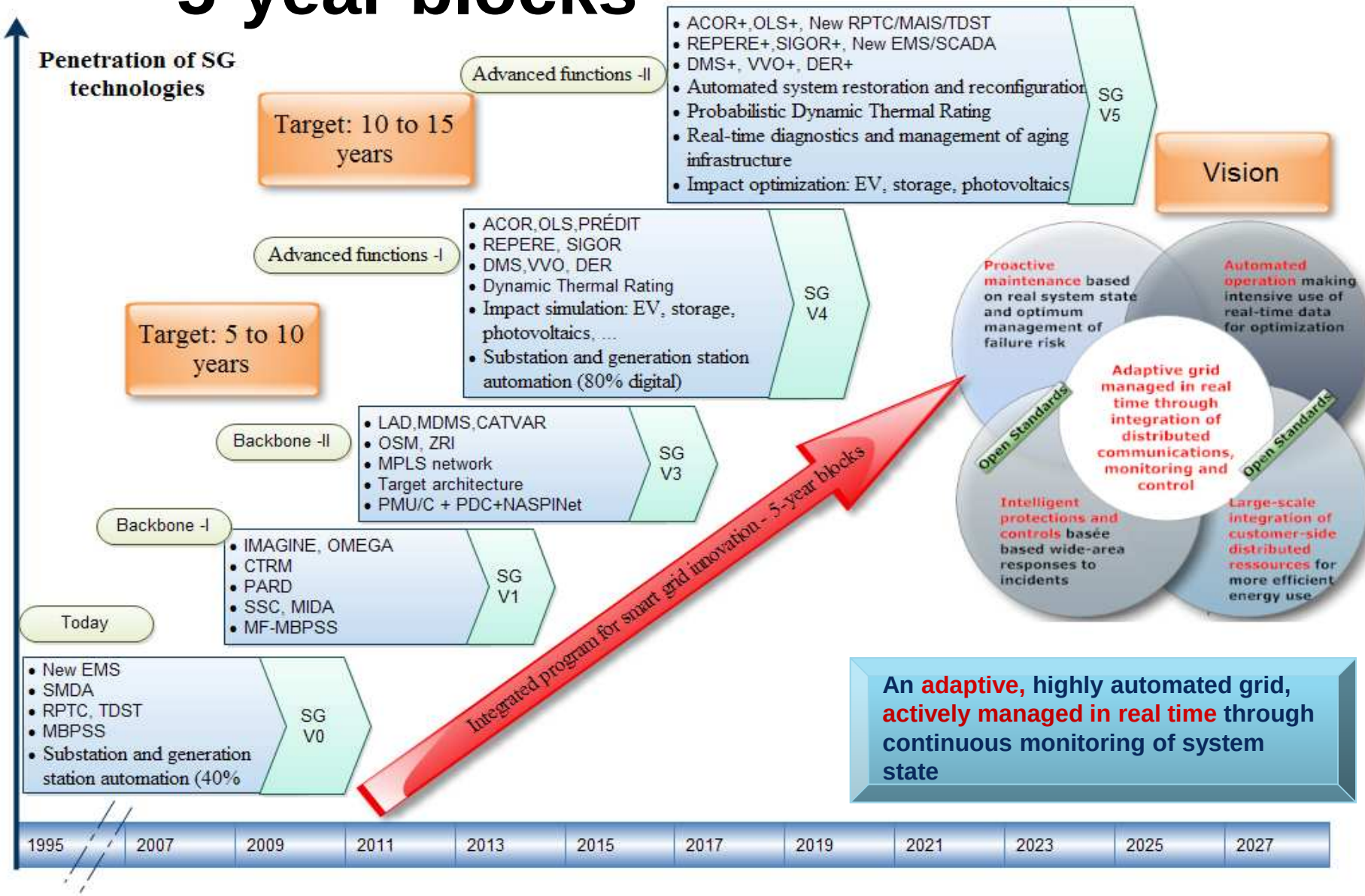
- **Implement smart grid architecture**

- *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



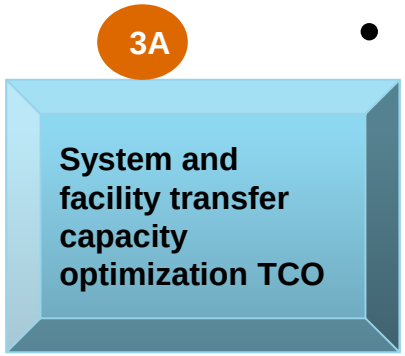
An adaptive, highly automated grid, actively managed in real time through continuous monitoring of system state

Technology Deliverables Over the Next 5 Years

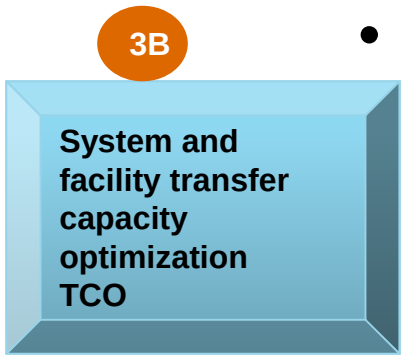
- **Prototypes and grid response testing of advanced command and control functions**
  - Grid response testing of command and control systems for shunts and generating units
  - Delivery of a prototype system for situational awareness and vulnerability identification

- **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.)



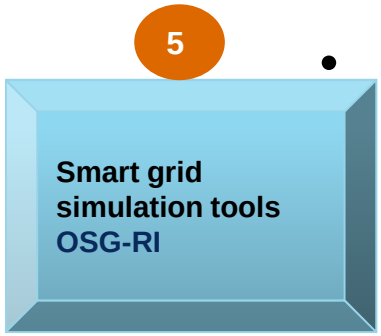
- **Prototypes and grid response testing of smart monitoring systems**
  - Delivery of a prototype integrated transformer monitoring and dynamic thermal rating system
  - Delivery of a prototype system for near-real-time optimization of operating limits and interchanges (OLS)
  - Demonstration of a smart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

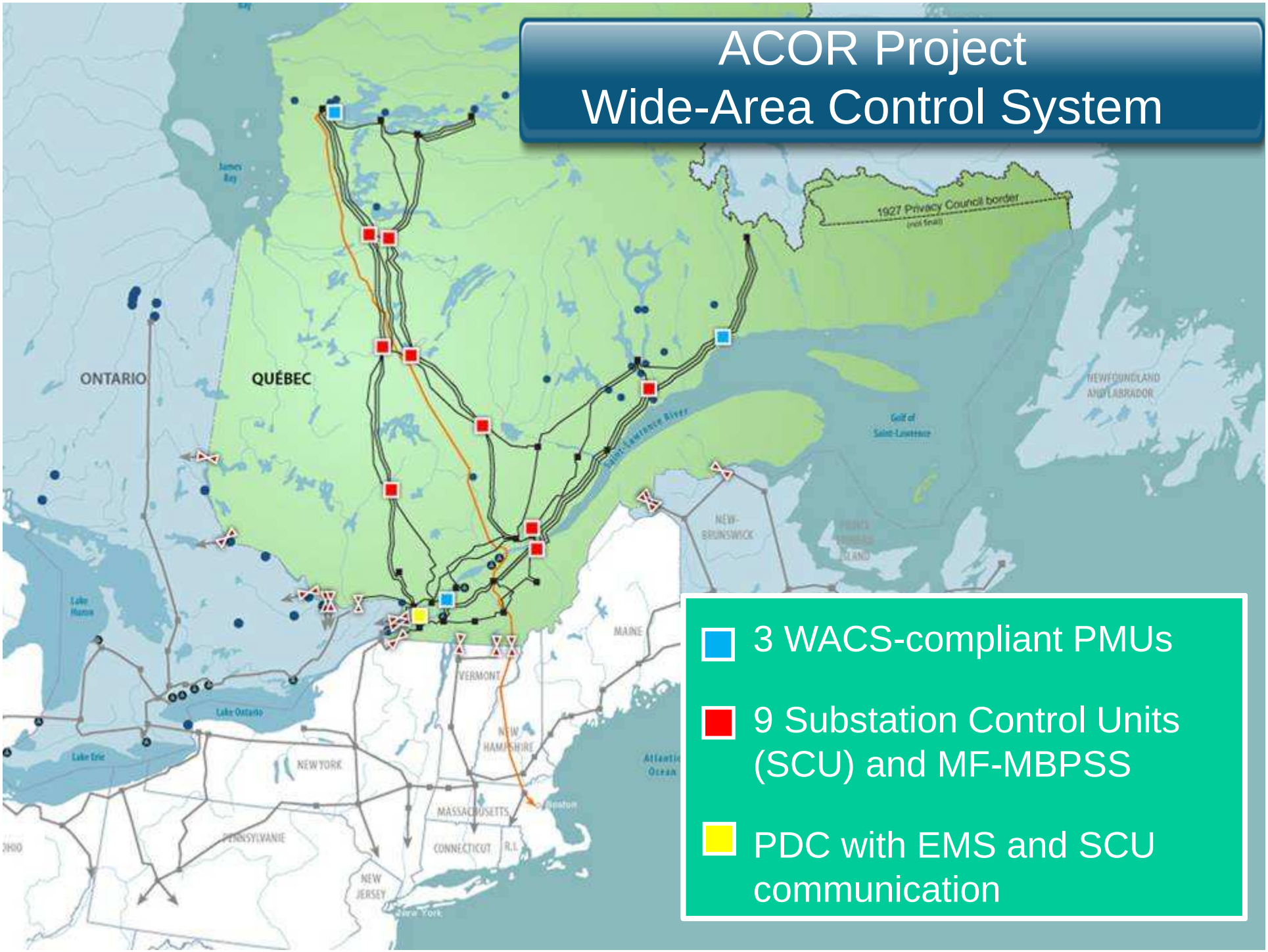
- *Hydro-Québec will have simulation tools to support smart grid R&D as well as planning and operation, all in compliance with NERC reliability requirements*

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

Appendix

R&D Projects: 5-Year Target

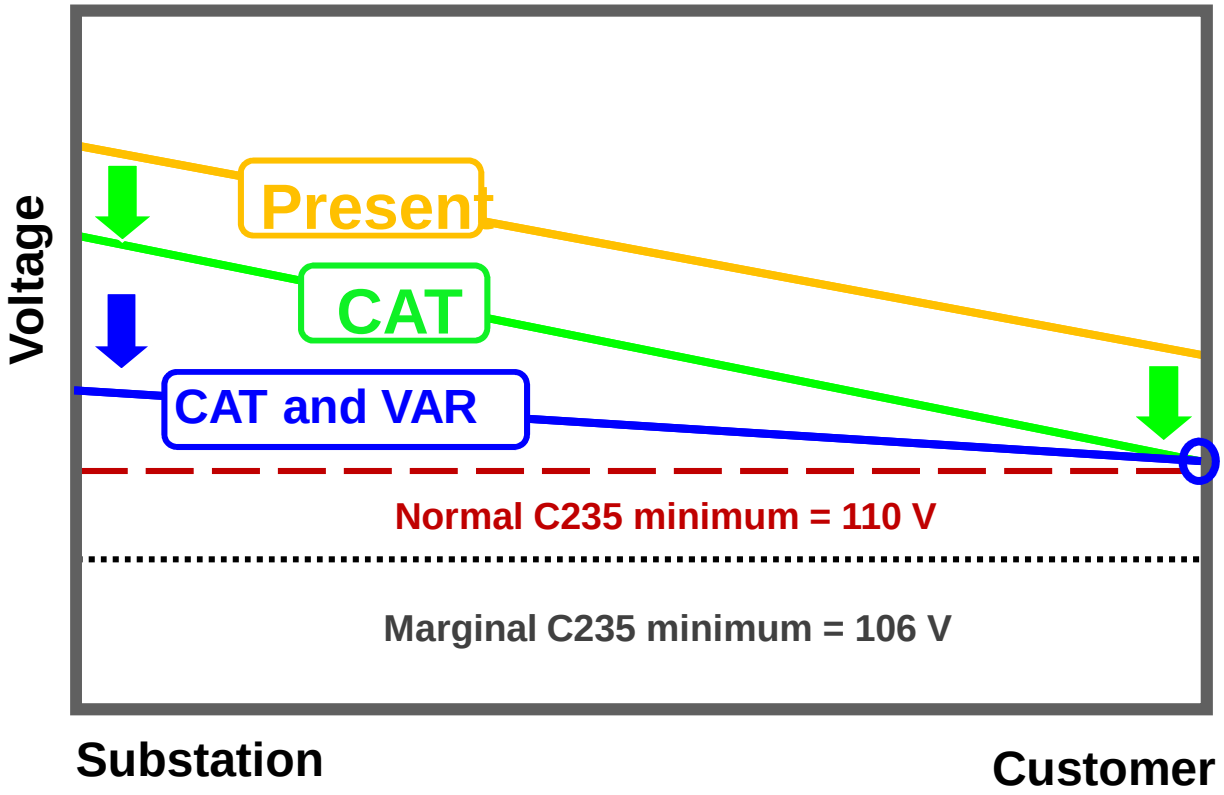
Some examples


ACOR Project
Wide-Area Control System
ONTARIO
QUÉBEC
1927 Privacy Council border
(not final)
NEWFOUNDLAND AND LABRADOR
Gulf of Saint-Lawrence
Saint-Lawrence River
NEW-BRUNSWICK
MAINE
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
CONNECTICUT
R.I.
PENNSYLVANIE
NEW JERSEY
Lake Huron
Lake Ontario
Lake Erie
Atlantic Ocean
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

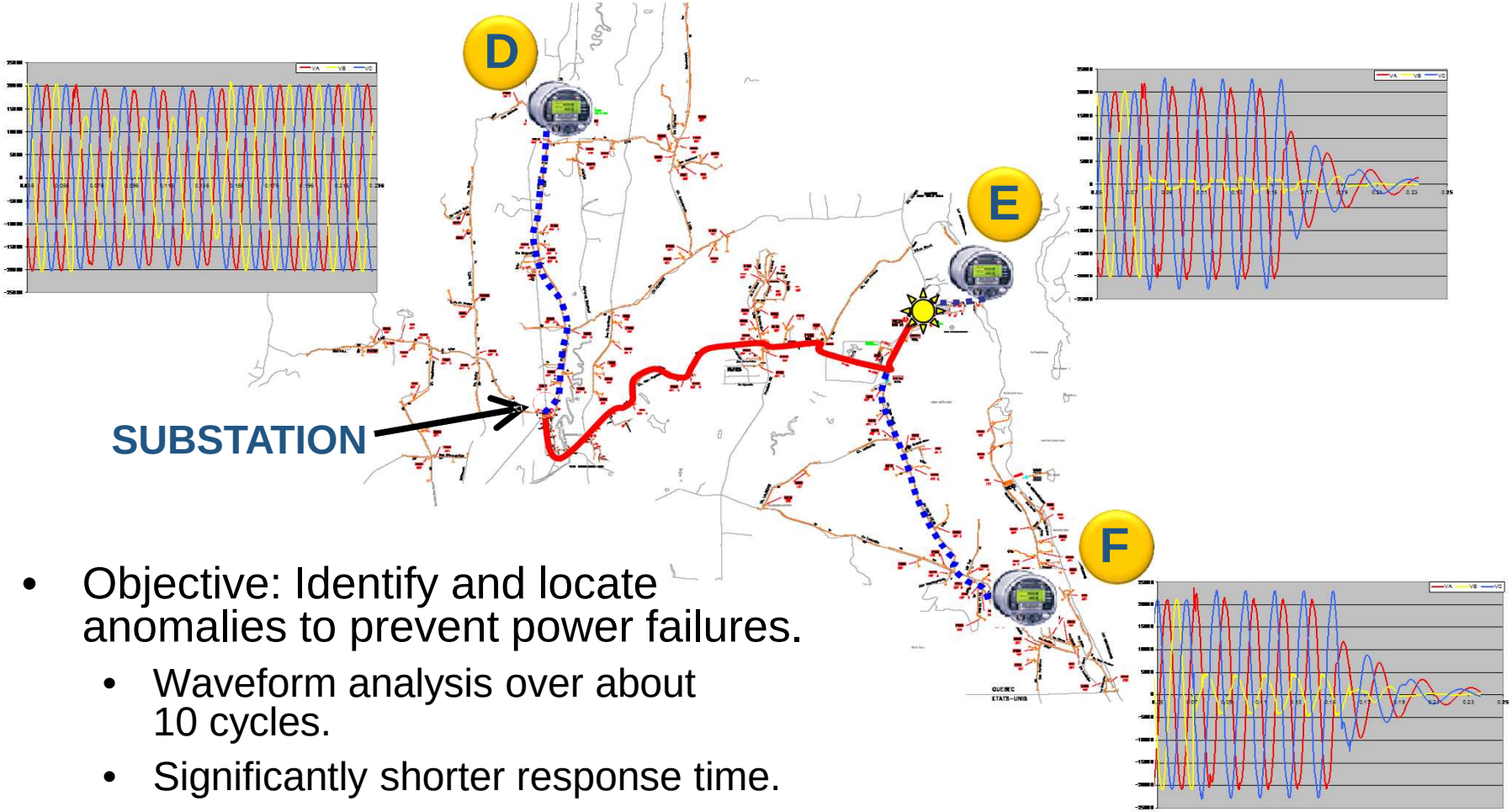
CAMPUT - 3 mai 2010

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

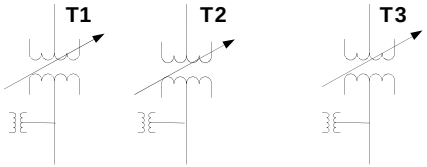


- Objective: Identify and locate anomalies to prevent power failures.
  - Waveform analysis over about 10 cycles.
  - Significantly shorter response time.
  - Type of fault determined by comparing with recorded patterns.

Hydro-Québec Smart Zone Project

Current

Pierre-Boucher Substation



Volt-Var Control

EV and Intelligent Charging

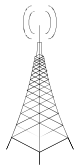
Advanced Metering Infrastructure (AMI) and Demand Response

Renewable Energy

Future development

Distribution Management System (DMS)

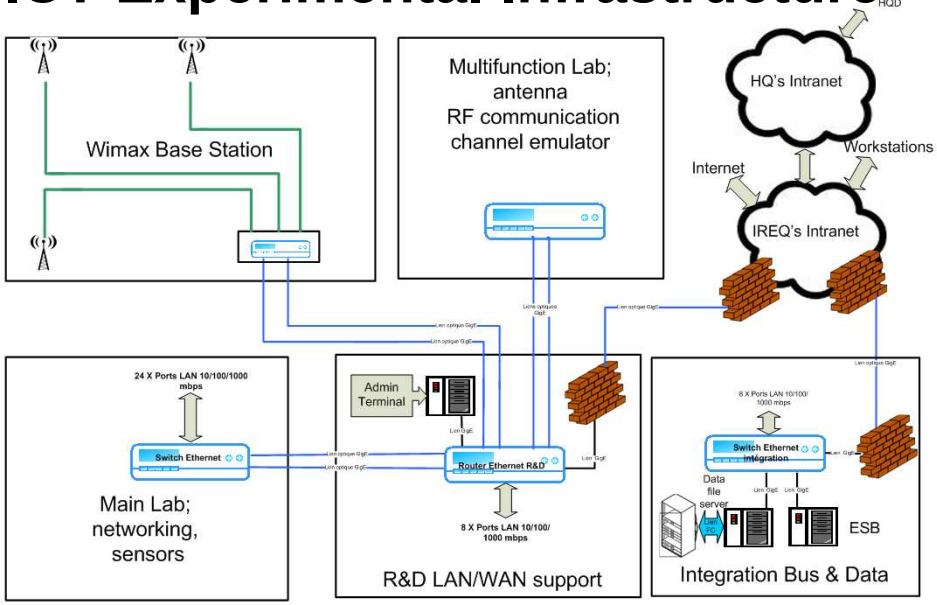
Monitoring, Data Exchange, And Telecom (WiMAX, telephone)



Smart Grid R&D Facilities

25 kV Test Line

ICT Experimental Infrastructure



Hypersim Simulator

Summary - A bridge to the future