Flexible Resources: Storage and Demand Response

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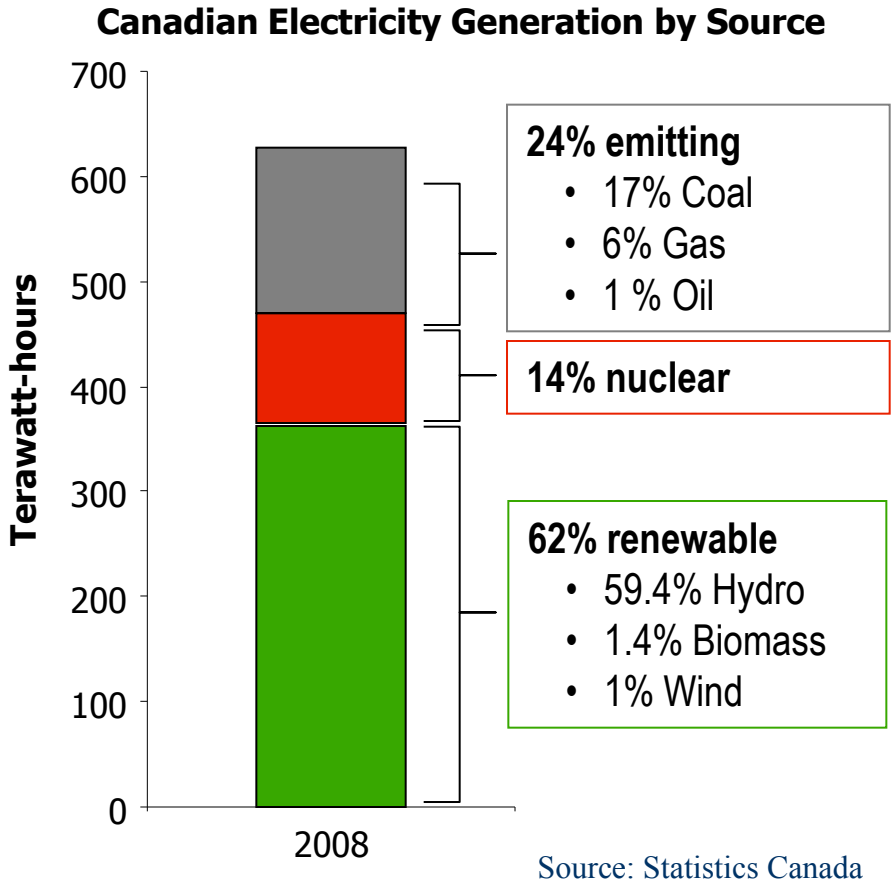
Canada's electricity mix is one of the cleanest in the world

- In 2008, 76% of electricity supply was from non-emitting generation
- Renewable electricity provided 62% of total generation
  - Canada is the 3rd world producer of hydroelectricity contributing about 59% of electricity in Canada
  - Wind contributed 1% but is increasing



Source: Statistics Canada

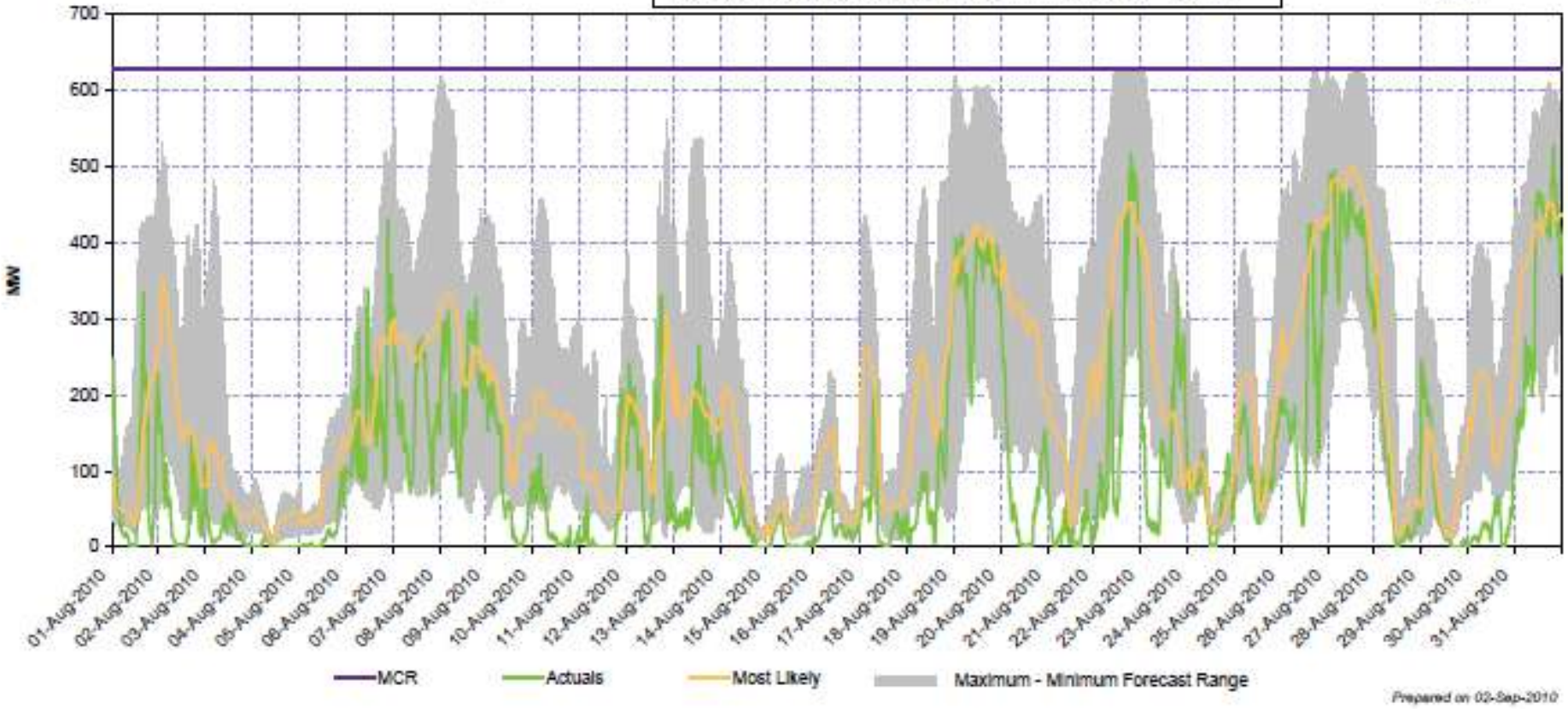
Current Canadian Wind Integration Issues

- Conventional wisdom has been that intermittent renewables can be connected to grid systems at up to 20% of system peak capacity without adverse impact.
- Recent experiences in Alberta and Ontario has indicated that market issues are arising well before the 20% capacity level is reached.
- In 2009 the Ontario IESO reported 351 hours of negative prices as surplus “must run generation” such as nuclear power competed with wind to remain dispatched on the system.
- In Alberta the AESO is reported to have curtailed wind supply for 890 hours in 2009,838 hours in 2009 and 236 hours in the first quarter of 2010. Improved wind forecasting contracted by AESO is anticipate to reduce these figures in the future.

Day Ahead Wind Power Forecast vs. Actual Wind Production for the Month of August 2010

This figure is intended to illustrate the correlation between the wind power forecast received from WEPROG and actual wind production.

Accuracy Statistics: Mean absolute percent error (MAPE) = 13.6%
Average range between the maximum and minimum forecast = 249 MW



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Flexibility of power areas

- Greater grid system flexibility is required for integration of a high share of variable renewable energy .

- What are the sources of flexibility ?
  - A. **Flexibility from dispatchable plant**
  - B. **Flexibility from the demand side**
  - C. **Storage**
  - D. **Interconnection to other areas**

Existing Hydro as an Energy Storage Resource

- With Canada having 59% Hydro supply, one might think that using this resource as a balancing supply to intermittent renewables would preclude higher cost options such as transmission upgrade, demand response/energy storage technologies. However a recent study (Ref 1) for NRCan concluded that:
- *"Both BC and Manitoba have limitations in their hydro electric facilities and transmission access that limit their ability to provide significant load shaping services to third parties."*
- *"In Quebec there is around 175 TWh of hydro storage available and Hydro Quebec is using this resource to balance its installed wind power. This balancing resource may be available to US and Canadian entities needing firming and shaping services but the opportunity cost to Hydro Quebec will increase the cost of this service."*

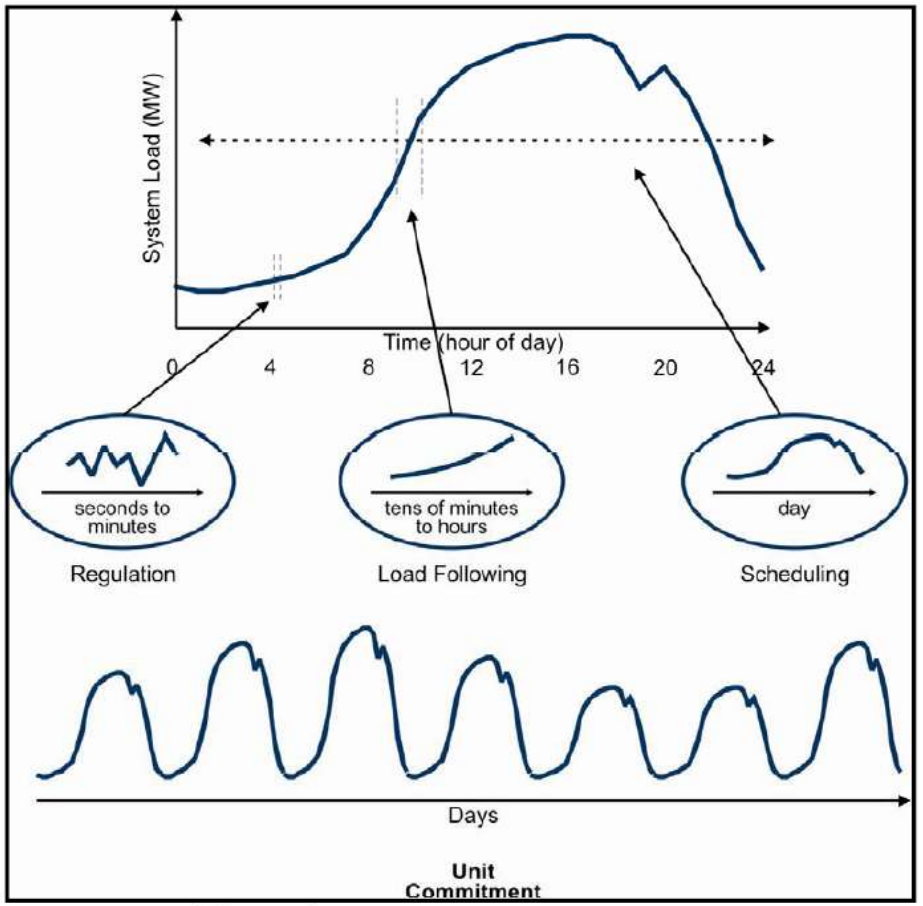
Ref 1 "Economic and Market Barriers to the Adoption of Energy Storage Projects for Renewable Energy Integration" Power Advisory LLC March 2010

Flexible loads – Demand Response

Demand Response improves the flexibility of a power system

3 “S” of Demand Response :

- Load **Shedding** or load curtailment that simply shuts off a device during peak events, typically fewer than 10 times per year.
- Load **Shifting**, moves loads away from the peaks, by preheating, precooling, delaying an activity (pool pumps, defrost cycles, ...).
- Load **Shaping**, which constantly fine-tunes demand in real time to adjust to fluctuations and maintain 60Hz.



Source: Smith et al. 2007

Flexible loads / storage

Thermal accumulation : Old technology renewed with the help of communications

Summer Peak

- Ice accumulation (for A/C)
  - Commercial
  - Residential buildings

Winter Peak

- Heat accumulation
  - Radiant floor instead of baseboards
  - Electricity Thermal Storage
  - Combined natural gas and electric furnace
  - Intelligent water heaters

- High potential in Canada, because of high penetration of electric water and air heating.

Ice Bear, by Ice Energy

Electricity Thermal storage by Steffes

Energy Storage
Large vs. Small Scale

- Energy Storage solutions can be conceived at different scales of capacity (MW) and energy (MWh)
  - **Community Energy Storage**: <100 kW located in the distribution grid utility controlled. (might included EV storage resources)
  - **Substation Energy Storage**: 1-10 MW located in the distribution grid. Could be controlled by the utility or by a renewable energy resource owner.
  - **Merchant Energy Storage**: 100-1000 MW. Connected to transmission grid
- Dominant Solution will depend on:
  - Economies of scale vs. the economy of mass production. (EV Storage will be a technology driver here)
  - Rules, regulations and market barriers
    - A promising technology solution may be restricted by market rules.

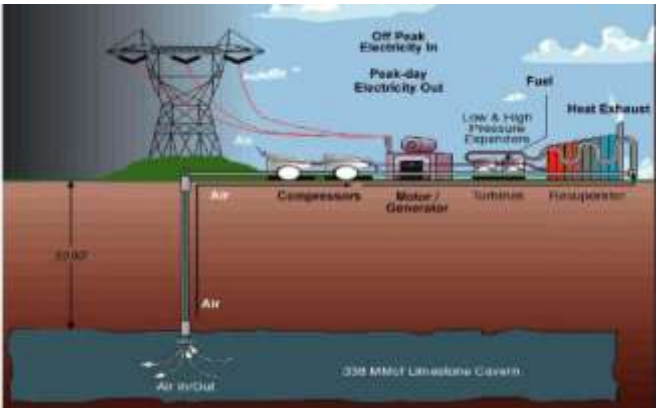
Storage options

Community Energy Storage
2MW/2MWH Fleet of 80 25 kWh units
Lithium-Ion technology

AEP OHIO
A unit of American Electric Power

Substation located Storage: NaS Technology from NGK

AEP



Merchant Energy Storage
An example of a storage technology that could be deployed as merchant supply of services under contract would be Compressed Air Energy Storage (CAES)

International Experience

Battery storage

- Significant capacity targets and investment in Wind has resulted in European interest in storage but strong well interconnected grids appear to offer cheaper alternatives for most situations.
- Japanese development of the NaS energy storage system (late 1984 with TEPCO) has resulted in a utility grade storage technology from NGK with a production capacity of 90 MW/yr and a new 60 MW/yr facility under construction.
- Most energy storage activity both in R&D and demonstration is currently in the United States.

Canadian Federal Activities

- The expected increase of intermittent resources coming online has spurred the need to address technology and policy challenges related to flexibility resources; energy storage and demand response
- The Canadian federal government, through its department Natural Resources Canada, started to fund R&D in the Smart Grid and Energy storage area in 2004.
  - A demonstration program, the Clean Energy Fund, that included wind/storage, demand response and Smart Grid projects was announced in 2009
  - Policy: Canada-U.S. Clean Energy Dialogue with a specific focus on Energy Storage. Background Policy Study on Storage completed 2010 (Ref 1)
  - International collaboration (IEA),NRCan participated in the GIVAR project

IEA – Flexibility Assessment Tool

- The GIVAR project (Grid Integration of VAriable Renewable) is lead by the International Energy Agency (IEA)
- The GIVAR project is developing a Flexibility Assessment Tool (FAST), which signals specific measures for different types of power systems to maximise their flexibility, and thus their capacity to 'digest' large shares of variable renewable.
- NRCan is collaborating with the Maritime utilities and the New Brunswick System Operator (NBSO) in submitting a Maritime "case study" for the IEA final report.
- Development of FAST is divided into four parts, each of which is outlined in the sections below :
  1. **Identify variability profiles of varRE technologies**
  2. **Build toolbox of measures to increase flexibility**
  3. **Identify power area paradigms**
  4. **Develop the Flexibility Assessment Method (A free Excel tool)**
- Report and Assessment Tool to be available in early 2011

Clean Energy Fund

Renewable and Clean Energy Demonstrations

- On May 19 2009 the Minister of Natural Resources announced the Clean Energy Fund which included a demonstration component for Renewable and Clean Energy Technologies
- Applications closed September 14 2009 with 178 applications requesting $1.7 billion in funding
- 19 projects were announced on January 11 2010 for agreement negotiation in six technology areas with $146 million in CEF contribution
  - Wind/Storage, Smart Grid, Marine/Hydro, Biomass, Built Environment/Solar, Northern and Hybrid Systems
- There are seven projects that have storage or related technologies for integrating renewables into the grid.

Wind/Storage

Cowessess First Nation

- First-nation managed wind/storage system.
- Single turbine connected to the distribution grid
- $5.6M project.

CEATI International

- Lithium/ion storage and load levelling at 3 utilities.
- Concept will demonstrate the reuse of PHEV storage for utility applications
- Target market is storage located adjacent to large buildings, or renewable energy supply firming
- $8.2M project

Wind Energy Institute of Canada

- 9MW wind-based research park combined with energy storage on a weak grid
- Target market is firming of renewable energy and utility grid support
- $25M Project

Smart Grid

Power Measurement Ltd

- Load curtailment and peak shaving in large commercial buildings
- Partners include Brookfield Properties, ENMAX
- $10M project

BC Hydro

- Installation of two 1MW storage systems at two locations to support remote and weak grid systems
- The technology chosen is NaS storage
- $13.4M project

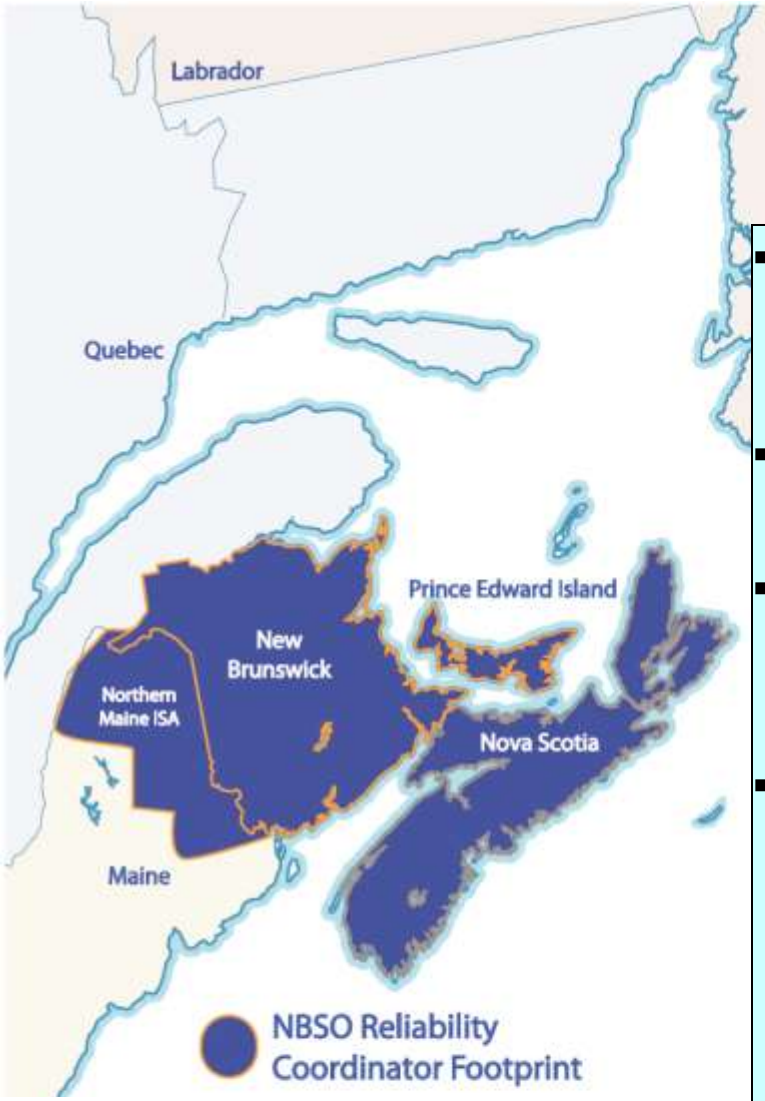
Hydro-Quebec-Institute de recherche

- Development of a smart zone in Boucherville including PHEV charging infrastructure
- $20M project

New Brunswick Power Corporation

- Project will install monitoring and control systems in 2500 buildings in PEI,NB and NS. Load control will be driven by availability of regional wind power
- 4 utilities involved
- $32M project

The Power Shift Atlantic Project



The Maritimes :

World class wind regime but limited grid balancing resources. Current generation is mainly fossil fuel based

- **A $32 million 4 year project led by NB Power and involving NS Power , St John Energy and Maritime Electric.**
- **Objective is to demonstrate smart grid technologies to use responsive demand to balance wind generation.**
- **Around 2500 buildings will be evaluated for responsive load along with technology and communication mechanisms.**
- **The project will**
  - **Evaluate if load control is a cost effective/reliable ancillary alternative.**
  - **Evaluate how load control can be co-ordinated with forecasted wind power**
  - **Engage and evaluate the customers role with different deployment models**

Conclusions

- Improving power system flexibility is required to integrate a high share of variable energy. The grid integration of renewable energy will be a major challenge, especially in areas with limited balancing resources.
- Each provincial grid system area has different strenghts and weakness in flexibility.
- A modernized grid may bring more flexibility to a power area. Storage technology and demand side management concepts may assist in the integration of more wind resources. Existing hydro resources may be able to provide increased flexibility but constraints exist.
- Storage and demand response technologies are moving along a rapid technology development and demonstration path. The conventional option of fast ramping natural gas generation may not always be the best option, in particular if all environmental impacts are considered
- The federal government, through the Clean Energy Fund, is involved with private, public and provincial partners in the demonstration of new concepts that will assist in increasing flexibility in a renewed electric grid.