Integrating Renewable Generation: Ontario’s Smart Grid Approach

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Three Part Presentation

• Ontario’s Long Term Energy Plan Review

• Renewable Integration

• Smart Grid and Distribution
Ontario (Canada)

- 13 million inhabitants
- GDP of $638 billion (CAD)
- Energy-intensive industries remain an important part of the provincial economy
- Hybrid market electricity structure
- Home to some of North America’s densest urban areas, as well as a number of remote and isolated Northern communities
Ontario’s Long-Term Energy Plan Review

- In November 2010 the government released its Long-Term Energy Plan (LTEP), a comprehensive direction for Ontario’s energy future on all aspects of Ontario’s electricity system, including conservation, generation, transmission, distribution, and emerging technologies such as energy storage.

- On April 16, 2013, Minister Chiarelli announced a formal review of LTEP to be completed within six months. He noted that the review process would include:
  - A strong and transparent consultation process with the public, municipalities and the energy sector;
  - Consultation sessions being held in every region of the Province;
  - Engagement with Aboriginal communities and leaders; and
  - Opportunity for the public to comment through the web.
Ontario’s supply mix has changed over the years

System Capacity in Ontario (MW)

<table>
<thead>
<tr>
<th>Installed Capacity</th>
<th>2003</th>
<th>2013 (est.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>11,600 MW</td>
<td>12,900 MW</td>
</tr>
<tr>
<td>Hydro</td>
<td>7,700 MW</td>
<td>8,400 MW</td>
</tr>
<tr>
<td>Wind</td>
<td>--</td>
<td>2,500 MW</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>70 MW</td>
<td>300 MW</td>
</tr>
<tr>
<td>Solar PV</td>
<td>--</td>
<td>1,100 MW</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>4,400 MW</td>
<td>10,000 MW</td>
</tr>
<tr>
<td>Coal</td>
<td>7,500 MW</td>
<td>2,300 MW</td>
</tr>
<tr>
<td>Efficiency/DR</td>
<td>0 MW</td>
<td>2,600 MW</td>
</tr>
<tr>
<td>Total</td>
<td>31,300 MW</td>
<td>40,100 MW</td>
</tr>
</tbody>
</table>

Efficiency/DR = Efficiency / DR

Coal
Natural Gas
Hydro
Wind
Bioenergy
Solar PV
Nuclear

2003
2013 (est.)
As the Portfolio evolved, the amount of energy produced from different sources has also changed.

### Electricity Generation and Conservation in Ontario (TWh)

<table>
<thead>
<tr>
<th>Energy</th>
<th>2003</th>
<th>2013 (est.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>63 TWh</td>
<td>89 TWh</td>
</tr>
<tr>
<td>Hydro</td>
<td>35 TWh</td>
<td>36 TWh</td>
</tr>
<tr>
<td>Wind</td>
<td>--</td>
<td>6 TWh</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>1 TWh</td>
<td>2 TWh</td>
</tr>
<tr>
<td>Solar PV</td>
<td>--</td>
<td>1 TWh</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>12 TWh</td>
<td>20 TWh</td>
</tr>
<tr>
<td>Coal</td>
<td>37 TWh</td>
<td>3 TWh</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0 TWh</td>
<td>8 TWh</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>148 TWh</strong></td>
<td><strong>164 TWh</strong></td>
</tr>
<tr>
<td><strong>Imports</strong></td>
<td>7 TWh</td>
<td>3 TWh</td>
</tr>
<tr>
<td><strong>Exports</strong></td>
<td>4 TWh</td>
<td>16 TWh</td>
</tr>
</tbody>
</table>
Greenhouse gas emissions are much lower

Source: OPA
Total costs for electricity service in Ontario have increased, but less than projected in 2010; future costs depend on choices subject of this consultation.

*Distribution component is an estimate*
Households are increasing, energy efficiency is increasing

Energy intensity decrease due to price impacts, momentum from past conservation efforts, codes & standards and new efficiency programs
Commercial floor spaces are growing, energy efficiency is increasing

Energy intensity decrease due to price impacts, momentum from past conservation efforts, codes & standards and new efficiency programs.
Industrial energy intensity has improved since 1990.
Energy demand is expected to grow slower than forecast in 2010, efficiency and end-use will reduce growth even further.
Peak Demand is lower than projected into 2010, efficiency and demand reduction measures will reduce it even further.
The assumptions about efficiency reduce the expectations for demand of electricity - how best to achieve this efficiency is subject of this consultation.
Ontario has surplus generation in the near term, needs begin to emerge in 2018; options are part of our consultation.

Notes:
Resource requirements is comprised of demand plus planning reserve as required by reliability standards.
Contracted resources include contracted renewables and contracted natural gas.
Different scenarios may unfold that result in different electricity demands and consequent infrastructure needs.

Notes:
Resource requirements under low, medium and high scenarios are comprised of demand plus planning reserve as required by reliability standards.
Contracted resources include contracted renewables and contracted natural gas.
Three Part Presentation

- Ontario’s Long Term Energy Plan Review
- Renewable Integration
- Smart Grid and Distribution
Integrating Renewables: A Global Challenge

- Achieving very high shares of renewable energy requires proactively addressing challenges shared across jurisdictions:
  - Managing intermittency and variability.
  - Balancing supply and demand.
  - Addressing power quality issues leading to connection constraints.

- Jurisdictions around the world are increasing the presence of distributed renewable generation on their electricity systems.

- Ontario is moving forward with an aggressive expansion of smart grid technologies in order to enable its renewable energy ambitions.

- Ontario is looking to share experiences and learning with other jurisdictions.
Off-Peak Generation

Source: Ministry of Energy
Output Variability

Daily Wind Output for One Month

Daily Solar Output

Source: IESO
Surplus Baseload

Source: IESO
The extent and pace of further increases to wind, solar, and bioenergy resources is subject of our consultations.

Notes:
This diagram illustrates the components of non-hydroelectric renewables. The pace of development depends on how each of these categories evolves.
Options work together in an integrated fashion to meet customer needs.

System needs and resource attributes must be taken into account when making supply decisions:

- Efficiency
- Energy
- Capacity
- System Quality
- Openness

Resources must reliably and efficiently be available to balance supply and demand:
Integrating Renewable Assets

- Currently, system operators cannot see the performance of embedded distributed generators. This makes it difficult to accurately predict how these resources will perform on any given day.
- Expanding the capabilities of Ontario’s utilities in these areas is vital to effectively integrating renewable generation assets, and reducing the negative impacts of intermittency, variability, and surplus baseload.
- Ontario’s Independent Electricity System Operator (IESO) is implementing an integration plan that expands its forecasting, visibility, and dispatch capabilities for renewable generation resources.

<table>
<thead>
<tr>
<th>Forecasting</th>
<th>Visibility</th>
<th>Dispatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to predict output from variable resources is essential for maintaining system reliability and market efficiency.</td>
<td>New processes such as direct telemetry and reporting may be needed to ensure visibility of large-scale embedded wind and solar generators.</td>
<td>Integration of renewables into economic dispatch model should help resolve issues like surplus baseload generation.</td>
</tr>
</tbody>
</table>
MINISTRY OF ENERGY

Three Part Presentation

• Ontario’s Long Term Energy Plan Review

• Renewable Integration

• Smart Grid and Distribution
Renewable Integration at the Distribution Level

- Achieving Province’s renewable integration and conservation goals requires a smart grid and its associated technologies, like storage.

- Already the case for conservation, increasingly more of the renewable impact will be felt on the distribution grid (see right).

- In addition, storage itself can help mitigate potential issues on both the DX/TX system related to power fluctuations in the grid from very high shares of renewable energy.

Source: IESO
Smart Grid: Integration Through Communication

**Intelligence/Communications Layer**

- Telecom Network
  - Phone
  - Internet
  - Smart Meter communication infrastructure

**Conventional Grid**

- Integrates with smart grid intelligence through enhanced devices:
  - Smart meters
  - Auto Switches
  - Intelligent Transformers

Diagram source: EPRI
Ontario’s Push for Smart Grid

1. Aggressive integration of renewable, distributed generation into the distribution grid
2. One of North America’s most ambitious conservation targets
3. One of the largest smart meter and time of use rollouts globally
4. Significant effort to create conditions for accelerated electric vehicle adoption
5. Economic benefits being created from the opportunity to leverage existing leading edge assets in manufacturing, research, and electricity distribution systems
The Green Energy Act has provided guidance on smart grid for Ontario. Our energy regulator is undertaking a regulatory review exercise to respond to this policy framework.

### Focus Area

- **Customer Control**
  
  *Enable more conservation through a shift to smarter homes*

- **Power System Flexibility**
  
  *Enable more renewables and better efficiency in grid operation*

- **Adaptive Infrastructure**
  
  *Encourage more innovation and ensure adaptability to future conditions (e.g. electric vehicles)*

### Expected Outcomes

#### More Conservation

- Smart meters
- Time-of-use rates
- Home Energy Management
- Load control

#### Cleaner supply and lower costs

- Customer based micro-generation
- More distributed generation, used more efficiently (i.e. less transmission investment)

#### More Innovation

- Mobile charging infrastructure to support EVs
- Storage opportunities
- Enabling innovative technologies
Ontario has 80 LDCs

• Each with Mandatory Conservation Targets

• And Each Required to Develop Smart Grid Plans
# Smart Meters

## What do Smart Meters do?

- Modernize outdated meter infrastructure
- Enable time-of-use pricing and conservation
- Provide basis for smart grid / smart homes

## Ontario’s Unique Rollout:

- **1st** in North America to implement (beginning in 2004)
- 5 different AMI systems (Trilliant, Elster, Sensus, Silver Springs, Tantalus)
- Integration with Meter Data Management/Repository

## Ontario’s Advantages:

- Attractive as a test bed for emerging technology development
- Early mover advantage: ready for next steps
- Enhanced access to interval data improves broader system planning

## Progress:

- 4.7 million deployment complete

## TOU Pricing

- **1st** in the world to mandate for all residential and small business customers (2010)
- Prices set independently by Ontario Energy Board
- Implemented following successful pilot studies across a variety of utilities

## Progress:

- 4.5 million
### Examples of Ontario Research Activities

<table>
<thead>
<tr>
<th>Focus Areas</th>
<th>High Profile Researchers</th>
<th>Centres*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Mgt.</td>
<td>UofT: High vol. data management (R. Miller) Waterloo: Database structures (F. Tompa)</td>
<td>4</td>
</tr>
<tr>
<td>Wind Energy</td>
<td>Waterloo: Aerodynamic (D. Johnson) UWO: Grid connection (R. Varma)</td>
<td>6</td>
</tr>
<tr>
<td>Behind the Meter</td>
<td>Waterloo: Energy Efficiency (I. Rowlands), Demand-side Management (D. Mountain) McMaster: Modeling &amp; Simulation (S. Chidiac)</td>
<td>3</td>
</tr>
<tr>
<td>AMI</td>
<td>Waterloo: Energy Management (I. Rowlands)</td>
<td>3</td>
</tr>
<tr>
<td>Storage</td>
<td>Queen's: Fuel cell (B. Peppley), Waterloo: Fuel cell reliability (M. Fowler), Materials (L. Nazar)</td>
<td>14</td>
</tr>
</tbody>
</table>

| % Research Centres, Laboratories, and Initiatives* Established in Ontario |
|-----------------------------|---------------------|---------------------|
| 58%                         | 20%                 | 23%                 |
| Total                       | 85                  |

### Federal and Provincial Research Funding

<table>
<thead>
<tr>
<th>Funding Source</th>
<th>Year of Funding</th>
<th>Amount (in million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSERC</td>
<td>2011 – 2015</td>
<td>$5.3</td>
</tr>
<tr>
<td>MEDI (MRI) to establish CONIL</td>
<td>2006 – 2012</td>
<td>$13.7</td>
</tr>
<tr>
<td>Knowledge Infrastructure Program</td>
<td>2009 – 2013</td>
<td>$122.3</td>
</tr>
<tr>
<td>Ontario Research Fund **</td>
<td>2008 – 2013</td>
<td>$250</td>
</tr>
</tbody>
</table>

### NSERC Canada Excellence Research Chair (CERC), Research Chair (CRC) and Industry Research Chair (IRC)

<table>
<thead>
<tr>
<th>Type of Chair</th>
<th># of Research Chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERC</td>
<td>1</td>
</tr>
<tr>
<td>CRC</td>
<td>26</td>
</tr>
<tr>
<td>IRC</td>
<td>14</td>
</tr>
</tbody>
</table>

* Most research centres are active in multiple areas
** Program funds other non-related energy research

Source: Ontario Centres of Excellence
The Smart Grid Fund is a $50M competitive grant program designed to leverage Ontario’s advantages in the energy sector and build the smart grid industry. SGF is currently sponsoring 11 projects in the areas of behind the meter, integrating distributed energy resources, regional integration, data management, and grid automation. The SGF launched Round 2 on July 2nd, 2013. Applications close on September 6th.
Conclusions

1. The global push for a cleaner and more reliable electricity system is resulting in a number of technical challenges, and Ontario is not unique in this regard.

2. Ontario’s position as a world leader in Smart Grid is allowing it to take a proactive role in integrating distributed renewable generation through expanded forecasting, visibility, and dispatch capabilities.

3. The Ministry is in the process of reviewing Ontario’s Long-Term Energy Plan. Please contribute to the discussion by submitting comments to Ontario’s Environmental Registry or by filling out the online survey.
APPENDIX: Helpful Links

- Making Choices: Reviewing Ontario’s Long-Term Energy Plan: 
  http://www.energy.gov.on.ca/en/lttep/
  o Environmental Registry: http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTE5OTg3&statusId=MTc5NTIx&language=en
- IESO Renewable Integration Initiative: 
  http://www.ieso.ca/imoweb/consult/consult_se91.asp
- Videos Highlighting Ontario’s Smart Grid Progress: 
  http://canmetenergy.nrcan.gc.ca/news/varennes/3131