Role of the Natural Gas Grid in Our Low-Carbon Future
OSEA’s Combined Energy Options Ontario (CEOO) Workshop

Sept. 21, 2016
Ontario’s Emission Reduction Forecast (2017-2030)

- Natural Gas Initiatives offer 21 Mt CO2e
- Electrify light-duty cars and biofuels offer 10 Mt CO2e
- Price-related demand reductions offer 11 Mt CO2e
- Technology Innovation can address 20 Mt CO2e

The natural gas sector can support significant GHG reductions.

Chart Source: ICF International Consulting
Resiliency & The Role of Natural Gas Pipelines For Low GHGs

Low-carbon energy strategy can leverage existing infrastructure to drive cost-effective GHG reductions

---

**Ontario Energy Delivery by Infrastructure Type**

<table>
<thead>
<tr>
<th></th>
<th>Peak Natural Gas Demand</th>
<th>Avg Natural Gas Demand</th>
<th>Peak Electricity Demand</th>
<th>Avg Electricity Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ontario Peak natural gas demand</strong></td>
<td>84,261</td>
<td>34,193</td>
<td>24,706</td>
<td>15,959</td>
</tr>
</tbody>
</table>

---

- Ontario’s electricity grid must balance in real-time or use relatively short-term storage
- Ontario’s existing natural gas network offers equivalent of 80 TWh of seasonal storage
- On peak heating days, storage reserves deliver energy equivalent of 90 Bruce reactors
- Orderly transition to a low-carbon economy can leverage existing pipelines and storage with increasing quantities of green gas supply

---

Footnotes:
1. Ontario Peak natural gas demand is 6.9 bcf/day
2. Avg. natural gas demand includes refill of storage
3. Peak electricity demand recorded in Summer 2006 (IESO)
Supporting A Low-Carbon Economy With Energy Diversity

Primary Energy Use in Ontario (2013)

Cost Impacts; Replacing ~849,000 TJ of Natural Gas Energy with Low-Carbon Alternatives

Source: Statistics Canada Table 128-0016
Biogas – Early Focus for Renewable Natural Gas (RNG)

- **Digester - Farm-based / Agricultural Waste**
  - Highest market potential for GHG offsets

- **Digester - Municipal Source Separated Organics (SSO)**
  - Divert organics from waste stream for the creation of renewable biogas

- **Wastewater Treatment Facilities**
  - Today this biogas is flared or inefficiently used for generating electricity

- **Landfill Gas Clean Up and Injection into Pipelines**
  - Earliest entry market entry point for lower-cost RNG
Greening the Natural Gas Grid: Renewable Natural Gas (RNG)

Renewable Natural Gas is part of a diversified supply meeting Ontario’s renewable energy needs

- Local supply (i.e. landfill, source separated organic programs, agricultural waste, wastewater, etc.)
- Local employment opportunities and partnerships with agriculture, forestry, and waste and sectors
- Once injected into natural gas pipelines, multiple pathways exist to deliver this renewable energy
  - Renewable home heating, CHP and fuel for transit and truck fleets

Role for next-generation clean-tech development in gas upgrading
Policy Shift Needed – Prioritize Conversion of Biogas to RNG

Ontario a leader in end-use energy efficiency. More efficient production of renewables is logical next step.

- Today’s energy policy incents the conversion of biogas to power (average efficiency of ~ 35%)
- Biogas cleanup to RNG, has matured to offer a more cost-effective option ~ 90% efficient
- 6% RNG market penetration would:
  - Diversify green energy delivery with pipelines
  - Supply Renewable heating / hot water for ~ 575,000 homes.
  - Use existing gas storage / not intermittent
Helping Consumers – Improving Green Energy Affordability

To decarbonize economy; it is more cost-effective to purchase renewables by pipeline if green gas is an option

- Cooking /cloths drying with renewables:
  - Green Power ~ $90/year
  - Green Gas ~ $30/year
  - Savings ~ 69%

- Cost of home heating with renewables:
  - Green Power ~ $3,500/yr.
  - Green Gas ~ $1,430/yr.
  - Savings ~ 60 % and consumers retain exiting heating appliances

Footnote Assumptions: a) Green power $128/MWh + Toronto Hydro Residential Rate; b) Green Gas $12.30/GJ + Enbridge Residential Rate; c) Gas heating 90% efficient
Natural Gas Fleets & Transit – Up To 25% less GHGs

- Natural gas for heavy duty trucking offers a path to zero-carbon transport with RNG (no limit on the amount of RNG blending)

Municipal biomass to RNG for Zero-Carbon Transport

RENEWABLE NATURAL GAS CYCLE

1. Communities generate waste.
2. Waste is collected from a landfill.
3. Landfill systems collect biogas.
4. Biogas is purified to biomethane.
5. Biomethane powers refuse trucks.

Courtesy of energy vision.

ENBRIDGE
Power-to-Gas Energy Storage

2 Megawatt Energy Storage Project Scheduled for GTA Operations in Early 2017

- Power-to-Gas energy storage converts off-peak & surplus electricity to green hydrogen
- Can provide grid reliability service and bulk power mgmt. to the Independent Electricity System Operator (IESO)
- Future opportunity exists to green natural gas pipelines with hydrogen injection and provide green fuel for vehicles

Source: Hydrogenics
Other Global Markets Adopting Power-to-Gas

- Over 30 Power-to-Gas Installations have been deployed or are under construction

- Germany has largest number of installations to increase wind adoption, green the natural gas pipelines and provide zero emission transportation fuel for fuel cell vehicles

- Information Links:
  - https://www.youtube.com/watch?v=BpZV6qtl_kY

Images: Power-to-Gas installation at E.ON in Germany; European Installations of Power-to-Gas (map by DNV Kema)
Power-to-Gas can store energy as hydrogen (H₂) or upgrade to Substitute Natural Gas (SNG)
Expanding Infrastructure Pathways for Low-Carbon Electricity

Power-to-Gas can leverage off-peak, low-carbon power for deeper GHG reductions in other commodity markets

- Today the technically and economical potential for low-carbon power generation is limited by our wire-infrastructure
- Power-to-gas to a bridge to larger portfolio of infrastructure (expand renewable power options)
- Decarbonize energy infrastructure while adopting new low-carbon end-use technologies
Deep GHG Reductions - Portfolio of Green Pipeline Supplies

By 2035, Power-to-Gas could supply over 600 million m³/yr of renewable fuel from off-peak and surplus power.

- Every 550 MW of Power-to-Gas (P2G) is the equivalent to 180 million m³/yr of renewable fuel.
- Over the medium and long-term, CO2 upgrading to RNG and solar fuels complement biogas & P2G.
### Home of the Future - Adopting New End-Use Technologies

<table>
<thead>
<tr>
<th>Description:</th>
<th>Home of the Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner(s):</td>
<td>Electric Utility, Enbridge, Home Builder &amp; others</td>
</tr>
<tr>
<td>Technology Use:</td>
<td>Hot water boiler, force air fan coil (replaces furnace), solar PV, battery storage, mCHP, etc.</td>
</tr>
<tr>
<td>Location:</td>
<td>GTA</td>
</tr>
<tr>
<td>Status:</td>
<td>Home builder engagement underway - testing with builders community &amp; city planners</td>
</tr>
<tr>
<td>In-Service:</td>
<td>2017-2018 winter</td>
</tr>
<tr>
<td>Objective:</td>
<td>Demonstrate improved affordability for home design that achieves deep GHG reductions</td>
</tr>
<tr>
<td>Repeatability</td>
<td>Potential model for community redevelopment</td>
</tr>
</tbody>
</table>

### Key Objectives:
- Develop a low-carbon home design strategy that enables smart energy micro-grid design principles (electricity and thermal)
- Demonstrate how a microCHP ready home can help right-size energy equipment and costs, for solar PV, battery storage, etc.
- Enable cost-effective mCHP integration and create a market-pull strategy for mCHP technologies
The Evolving Smart Energy Micro Grid (Electrical and Thermal)

mCHP becomes an enabler to right-size solar PV and battery storage

Potential to integrate PV/Storage/mCHP with new demand response services for LDC/ISO networks

Net-Zero Strategy needs to evolve to ensure buildings become interactive within the larger energy community
Home of the Future – Leverage Hot Water Micro Grids

Today’s furnace a barrier to mCHP
• Builders have standardized on forced air
• Domestic Hot Water (DHW) not large enough load to thermally optimize mCHP

Solution:
• Shift builder / homeowner preference to hot water air handler
• Potential for single gas-fired appliance to supply DHW and heating loads
• Thermal micro-grids for mCHP heat recovery, solar thermal, air-source heat pumps, etc.
• Improved occupant comfort options with combination of forced air and in-floor radiant heating
Home of the Future: Managing Plug Load Growth, EV Charging and Enable Dispatchable Heating Loads

Change Thinking: Plug Loads & EV Charging
- Understand LDC & homeowner benefits if large plug loads – like clothes dryers and ranges – operate on renewable natural gas
  - Lessen homeowner exposure to TOU
  - Future CDM opportunity for LDC?
- Incorporate electric vehicle charging in design of main AC panel as to optimize battery storage for critical loads, etc.

Hybrid Heating & Cooling (Dispatch Concept)
- Hybrid heating with electric heat pump and gas
- Units are controlled through remote dispatch like Peak-Saver (GHG reductions are
  - During off-peak / surplus electricity operate on heat pump cycle
  - When large gas-fired power / peaking plants needed to meet heating dependent loads the heat pump is dispatched off
- Aggregation of thousand of homes become virtual, low-carbon power plant
Technology Commercialization Priority (Natural Gas Heat Pump)

- Emerging technology needing commercialization support
- Potential to reduce energy consumption by up to 40%
- Building envelope improvements, natural gas heat pumps and renewable gas blending can meet 2050 carbon reduction objectives
Summary

1. Greening the Natural Gas Grid is complementary to low-carbon power grid

2. Diversity in energy infrastructure enhances energy resiliency, affordability of renewable energy and offers improved energy planning flexibility for deep GHG reductions

3. Power-to-Gas energy storage offers a unique way to integrate our low-carbon power grid with the larger wholesale energy market in Ontario
   • Our wealth in low-carbon power can be leveraged for our competitive advantage – not exported

4. Significant opportunities exist for the development of next-generation, clean technology for the natural gas sector
Questions?

David Teichroeb
Business Development – New Ventures, Low Carbon Solutions
david.teichroeb@enbridge.com