THE END OF COAL
An Ontario Primer on Modernizing Electricity Supply
The Province of Ontario, Canada, is the first jurisdiction with a significant reliance on coal in North America to eliminate all coal-fired electricity.

The story of eliminating coal in Ontario begins properly in 2001, when the Province announced that it would close its 2,400 MW Lakeview Generating Station. In 2001, Ontario issued seven smog advisories covering 23 days, the most on record at that time. 2005 remains the worst year on record, with 15 advisories covering 53 days (sources: Air Quality in Ontario 2002 report; Air Quality Ontario summary of smog advisories 2003-2014). A 2005 independent study estimated that the total annual cost of coal-fired electricity, including health, financial and environmental costs, was $4.4 billion (2004$).
Coal went from 25% of Ontario’s supply mix in 2003 to zero in 2014, all while grid reliability and domestic supply improved. The elimination of coal stands as the single largest GHG emissions reduction action on the continent and was primarily responsible for Ontario achieving its ambitious 2014 emissions reduction target of 6% below 1990 levels.

The elimination of coal-fired electricity was a shared effort between the Ontario Ministry of Energy and two of its agencies:

» **Ontario Power Generation (OPG)**, the largest generator of electricity in the province, primarily through hydroelectric and nuclear sites.

» **The Independent Electricity System Operator (IESO)**, whose duties include both procuring electricity supply and planning the electricity system over the long-term.
In 2003, Ontario committed to eliminate all of its coal-fired generation — in a phased approach. Lakeview ceased operation in 2005, followed — by Atikokan in 2012, Lambton and Nanticoke in 2013 and Thunder Bay in 2014. The IESO was responsible for ensuring system reliability and sustainability during and following coal phase-out. A number of gas generators were built to replace much of the coal capacity that was phased out; these were operated through 2-3 peak seasons (summer and winter) and had to demonstrate consistent reliable performance before IESO allowed the controlled shutdown of the coal-fired generating fleet.

Bringing on large numbers of generators with a different fuel-type than coal posed new administrative and operational challenges to overcome:

- Establishing new processes for reporting and monitoring
- Enhancing new focus on gas-electric coordination
- Adapting to new operational characteristics such as ramp-up time.

OPG established a schedule for coal phase-out based on fuel type, fuel flexibility, emissions, unit condition, labour and location. Its phase-out schedule was built with a staged approach to:

- Allow for flexibility in the event of a shift in supply/demand forecasts
- Manage fuel supply
- Allow for effective labour management
- OPG allowed for approximately 18-months of lead time to reduce scope and scale of operations
- OPG optimized coal inventories by developing a strategy on how to bid coal-fired electricity into the market. This strategy allowed for an increased/decreased rate of coal consumption to draw down the coal inventory in the lead up to closure dates.

THE ACTION PLAN

In 2001, Ontario had five coal-fired generating stations, comprised of 19 units totalling about 8,800 MW. That year, the province announced its intention to close the remaining four-unit Lakeview GS (2,400 MW).


The IESO was responsible for ensuring system reliability and sustainability during and following coal phase-out. A number of gas generators were built to replace much of the coal capacity that was phased out; these were operated through 2-3 peak seasons (summer and winter) and had to demonstrate consistent reliable performance before IESO allowed the controlled shutdown of the coal-fired generating fleet.
Coal-fired generating stations (GS) in Ontario:

- Nanticoke GS (3,940 MW)
- Atikokan GS (211 MW)
- Thunder Bay GS (306 MW)
- Lambton GS (1,980 MW)
- Lakeview GS (2,400 MW)
- Hearn GS (1,200 MW) – closed 1983

OPG established a multi-disciplinary senior team consisting of Station Operations, Fuel Supply, Energy Planning & Forecasting and Market Operations.

New IESO approaches were required to manage variable generation (i.e. wind and solar), including:

» Increased visibility of current variable generation output
» Enhanced methods to forecast variable generation output
» Processes to dispatch variable generation resources.

Ontario enshrined its commitment in the Cessation of Coal Use Regulation (2007), which set an end date of December 31, 2014, and the Ending Coal For Cleaner Air Act (2015, pending legislative approval) which stipulates that coal cannot be used in future to generate electricity in Ontario.
THE ACTION PLAN

TIMELINE OF EVENTS

Ontario commits to the phase-out of coal by 2007

Ontario adjusts phase-out target to 2009 to maintain system reliability

Cessation of Coal Use Regulation directs end date of Dec. 31, 2014

The 2010 Long-Term Energy Plan (2010 LTEP) commits to coal phase-out by 2014

Ending Coal for Cleaner Air Act is introduced


Ontario announces that it will close Lakeview GS

Ministry of Energy instructs the former Ontario Power Authority (OPA) to plan for coal phase-out at the earliest practical time, but still ensure adequate system capacity and reliability

The 2009 Green Energy and Green Economy Act commits to adding new clean and renewable energy resources to the electricity system, and encourage energy conservation

LAKEVIEW GS CLOSES

ATIKOKAN GS CLOSES

NANTICOKE GS AND LAMBTON GS CLOSE
Coal capacity was reduced in a staged approach from 2003-2014 to maintain system reliability and operational efficiency.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakeview</td>
<td>1,150</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Nanticoke</td>
<td>3,940</td>
<td>3,940</td>
<td>2,960</td>
<td>1,980</td>
<td>1,980</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Lambton</td>
<td>1,980</td>
<td>1,980</td>
<td>1,010</td>
<td>1,010</td>
<td>1,010</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Atikokan</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>7,587</td>
<td>6,437</td>
<td>4,487</td>
<td>3,507</td>
<td>3,296</td>
<td>306</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note: Hearn GS closed in 1983*
A NEW SUPPLY MIX FOR ONTARIO

Coal-fired electricity was replaced by a mix of baseload, intermittent and peaking capacity and a strong conservation and demand management approach.

**Nuclear**

+1,500 MW

Two units at Bruce Power were refurbished and returned to service in 2012.

**Natural Gas**

+5,500 MW

The addition of new combined cycle facilities, a peaking plant and combined heat and power facilities.

**Non-Hydro Renewables**

+5,500 MW

Added generation under procurements including Renewable Energy Standard Offer Program (RESOP), and Feed-in-Tariff Program (FIT).
Percentage Share of Total Generation (2003)

- Nuclear: 25%
- Hydro: 42%
- Gas: 11%
- Coal: 23%

Percentage Share of Total Generation (2014)

- Nuclear: 60%
- Hydro: 24%
- Non-Hydro Renewables: 7%
- Gas: 9%
Ontario outlined its post-coal energy strategy in its 2013 Long-Term Energy Plan (LTEP), designed around five principles:

- Cost-effectiveness
- Reliability
- Clean energy
- Community engagement, and
- Conservation and demand management before building new generation.

The LTEP sets out procurement targets for different forms of supply to help ensure system reliability over a 20-year timeframe. The LTEP includes commitments to leading practices such as procurement of energy storage and encouragement of net metering.
Ontario has more than 14,800 MW of wind, solar, bioenergy, and hydroelectric energy online, and almost 3,000 MW of renewable energy projects contracted and under development. 20,000 MW of renewable energy will be online by 2025, representing about half of Ontario’s installed capacity.

Two generating stations were converted from coal to biomass. As a result, Ontario was able to maintain local economic development and jobs, and build new research capacity in the area of biomass (i.e., established a biomass research centre).

» The 153 MW Thunder Bay GS now runs exclusively on advanced biomass, which has similar storage and handling characteristics of coal but produces 75 per cent less NOx and virtually no SOx. The station also houses OPG’s Bioenergy Learning Research Centre.

» The 205 MW Atikokan GS is now the largest 100 per cent biomass facility in North America and is supplied entirely by local biomass producers.
As a result of the phase-out of coal-fired electricity generation, Ontario has transformed its energy supply mix which has helped to decrease GHG, nitrogen oxides, sulphur dioxide and mercury emissions. The opportunity contributed to the development and growth of renewable energy sector in Ontario.

Ontario’s clean energy initiatives have attracted billions of dollars in public and private sector investments, generated thousands of jobs and significantly increased the amount of clean energy in our supply mix. Ontario has the fastest growing clean technology sector in Canada, and has strong potential to provide Ontario-manufactured solar photovoltaic modules, wind turbines and related components, as well as Ontario’s expertise, to external markets. More than 30 solar and wind manufacturing companies are operating in Ontario.

The province is working with municipalities and project developers to help ensure that cost-effective and well-supported renewable energy projects are being developed.
Electricity Sector Emissions Reductions in Ontario

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>Decrease</th>
<th>2015 (est.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG (MT)</td>
<td>32.9</td>
<td>87%</td>
<td>4.25</td>
</tr>
<tr>
<td>NOx (T)</td>
<td>48.1</td>
<td>86%</td>
<td>6.8</td>
</tr>
<tr>
<td>SOx (T)</td>
<td>114.3</td>
<td>99.6%</td>
<td>0.4</td>
</tr>
<tr>
<td>Hg (kg)</td>
<td>326</td>
<td>100%</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Source: LTEP Module 5 (http://www.ontarioenergyreport.ca/data-catalogue.php#LTEP Modules)

Greenhouse Gas Emissions Forecast

Mercury Emissions Forecast

Nitrogen Oxides, Sulphur Oxides and Particulate Matter Emissions Forecast
The burning of coal for electricity generation is a significant source of greenhouse gas emissions, local and regional air pollution and mercury emissions. Proponents of coal-fired electricity long argued that there were no viable alternatives that could produce reliable, affordable power, particularly in jurisdictions without natural hydroelectric supply.

The long-term cost-effectiveness of nuclear, an expansion in natural gas supply, increasingly affordable renewable energy, and improvements in conservation and demand management mean there are now a number of cleaner procurement options available. When environmental and clean air considerations are taken into account, a strong case emerges to eliminate the use of coal for electricity generation.

With more and more jurisdictions introducing greenhouse gas emission reduction targets and carbon pricing, electricity systems are being driven to change their supply mix to ensure reliability and control costs while lowering emissions.

The merits of eliminating coal-fired electricity include:

**ECONOMICS**
- Increased North American natural gas supply has driven down prices, making gas-fired electricity more competitive.
- The cost of renewables, especially solar photovoltaic, have been falling steadily and are projected to continue to improve.
- Economic growth is increasingly decoupled from energy demand.
- Technology-enabled conservation is helping reduce demand.

**THE ENVIRONMENT**
- Coal use is a major source of air pollutants, including nitrogen oxides (NOx), sulphur oxides (SOx), mercury and particulate matter (PM).
- GHG reduction targets incent adoption of cleaner technology.
The End of Coal
The End of Coal

KEYS TO SUCCESS

The Ontario experience can be replicated in other jurisdictions while maintaining system reliability. Some of the lessons learned are highlighted here.

» **Build a broad implementation team:** The Ministry of Energy worked with OPG and the IESO. OPG established a multi-disciplinary senior team consisting of Station Operations, Fuel Supply, Energy Planning & Forecasting, and Market Operations. The IESO procured electricity supply, and planning the electricity system over the long-term.

» **Manage your supply:** OPG optimized coal inventories by developing a strategy on how to bid coal-fired electricity into the market. This strategy allowed for an increased/decreased rate of coal consumption to draw down the coal inventory in the lead up to closure dates.

» **Develop a long-term, coordinated plan** including the conversion of existing infrastructure and overall supply-mix changes.

» **Keep the plan flexible** in the event of a shift in supply/demand forecasts.

» **Consider how to mitigate cost increases in the sector** (i.e., developing programs for industrial and residential consumers).

» **Have a diverse supply mix** to reduce reliance on any single supply source.

» **Take the time to get it right:** have a planned and staged approach to ensure system reliability.

» **Be prepared to develop new approaches** to monitor and operate different forms of generation.

» **Incorporate Labour:** Obtain agreement with labour unions, ensuring operating staff are available on final day of operation. Scale staff throughout decommissioning and retain key roles throughout.

» **Communication planning is critical** to anticipate and address issues from the public and stakeholders (e.g., price impact, system reliability and adequacy concerns).
Thanks to its experience in replacing large coal-fired generators with a diverse mix of clean supply and demand management, Ontario can offer advice and guidance in key areas, including:

» Energy supply and demand long-term planning and modelling
» Supply procurement and contract management
» Smart grid development and implementation
» Renewables integration
» Conservation and demand management planning and implementation.

There is potential for OPG to partner with other jurisdictions looking to convert coal facilities to cleaner fuel types or build advanced biomass generating stations.
Ontario’s Supply Mix, 2014

- Ontario
- Minnesota
- Wisconsin
- Michigan
- Illinois
- Indiana
- Ohio
- West Virginia
- Quebec
- New York
- Pennsylvania
- West Virginia

Legend:
- Coal
- Petroleum
- Natural Gas
- Nuclear
- Hydroelectric
- Non-Hydro Renewables
- Other

Ontario data: 2014
All other data: 2012
## APPENDIX B

### 2003 Coal Fleet Details

<table>
<thead>
<tr>
<th>Generating Station</th>
<th>No. of Units</th>
<th>Fuel Type</th>
<th>Delivery Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atikokan</td>
<td>1</td>
<td>Lignite</td>
<td>Rail</td>
<td>Northwestern Ontario</td>
</tr>
<tr>
<td>Thunder Bay</td>
<td>2</td>
<td>Lignite / Northern Powder River Basin Blend</td>
<td>Rail/ Vessel</td>
<td>Northwestern Ontario</td>
</tr>
<tr>
<td>Lambton</td>
<td>4</td>
<td>2 Units (with Scrubbers) – High Sulfur Coal</td>
<td>Vessel</td>
<td>Southern Ontario</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Units – Low Sulfur Coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nanticoke</td>
<td>8</td>
<td>Southern Powder River Basin / Low Sulfur Blend</td>
<td>Vessel</td>
<td>Southern Ontario</td>
</tr>
<tr>
<td>Lakeview</td>
<td>4</td>
<td>Low Sulfur Coal</td>
<td>Vessel</td>
<td>Southern Ontario</td>
</tr>
</tbody>
</table>

The schedule for phase-out was as follows:

- Four Lakeview Units
- Two Lambton Units (with low sulfur coal)
- Four Nanticoke Units
- Two Lambton Units (with high sulfur coal) and 1 Atikokan Unit
- Four Nanticoke Units
- Two Thunder Bay Units