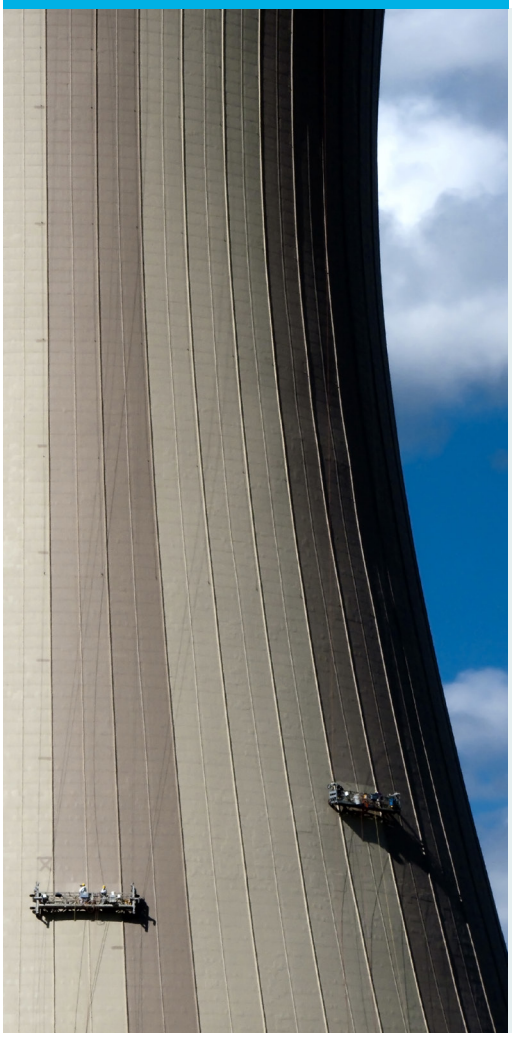
White Paper

Nuclear Fall-Out: Ontario's Supply Dilemma in a Decarbonizing World

By Duncan Rotherham, Chris MacCracken, and Felix Amrhein, ICF



Shareables

1. Distributed resources, demand response and imports will be key elements to any plan designed to meet Ontario demand in the light of nuclear retirements/outages and carbon regulation.
2. A constant and consistent stakeholder process that coordinates utility programs with federal incentives will be necessary to meet challenges in concert.
3. Success depends on utilities to sculpt a grid system flexible enough to dispatch a low-carbon supply portfolio while meeting growing demand.

Executive Summary

Local distribution companies and generators in Ontario must address tectonic shifts in the province's power sector during the next decade. By 2025, a quarter of the installed nuclear capacity in the province will retire, with additional units cycling on and offline for refurbishment in the next 15 years. Many factors may leave the province short on options to meet electricity demand, including the province's cap-and-trade program, developing federal CO_2 initiatives, the recently suspended large renewable procurements, and potential demand growth due to carbon policy-driven electrification.

Building a solid foundation for this unprecedented portfolio of challenges requires integrated and holistic resource planning and policy incentives that

feature large-scale deployment of emerging technologies such as flexible demand response, renewable grid- and distributed-generation, and storage. The supply cushion the province has been accustomed to during the last decade, accommodated by demand decline, bears the risk of lulling companies and regulators into a false sense of security and inaction. The first nuclear refurbishments are under way and a carbon price, along with carbon policy measures funded by cap-and-trade regulation, start in just a month. The time is now to start a conversation between all stakeholders and to build a sustainable strategy for an increasingly decarbonizing Ontario.

Advancing CO_2 Regulations in Ontario

The past two years have been characterized by rapid political progress on implementing climate change policy, and further action will be needed to move Ontario—and Canada—onto a trajectory to 2030 reduction targets. Ontario faces the challenge of aligning these provincial and federal requirements:

1. Provincial emission reductions targets—Although Canada has set emission reduction targets of 17% below 2005 levels by 2020 and 30% below 2005 levels by 2030, Ontario has committed to more profound emission reductions of 15% by 2020 and 37% reductions by 2030, both relative to 1990 levels.
2. Federal carbon pricing—In October, the federal government announced that it will implement a federal carbon price of CAD$10/tonne in 2018, rising to CAD$50/tonne by 2022. This price will be enacted in any province that fails either to set a carbon tax equal to or larger than the federal tax or to implement a cap-and-trade program with emission reduction targets reflective of the national reduction target.

Setting emission targets and enacting measures to reach these targets go hand in hand. Several Canadian provinces already have implemented carbon pricing. British Columbia has instituted a CAD $30/tonne carbon tax, and Alberta is matching the CAD $30/tonne price in 2018. Quebec is a member of Western Climate Initiative (WCI) and California's cap-and-trade program. In January 2017, Ontario will implement a cap-and-trade program, putting a price on carbon for the first time in the province. It then plans to link with Quebec and California in January 2018.

Coordination of carbon policies will go beyond the provincial and federal level and extend to the United States. Even without a clear path to a national carbon pricing scheme like the Clean Power Plan, Ontario is deeply connected to several jurisdictions in the United States:

- Most notably, the cap-and-trade program is expected to link with Quebec and California in 2018, which will require regulatory approval from California and Quebec.
- Beyond the cap-and-trade program, Ontario is engaged in electricity trade with other jurisdictions with a carbon price such as New York (as part of the Regional Greenhouse Gas Initiative).

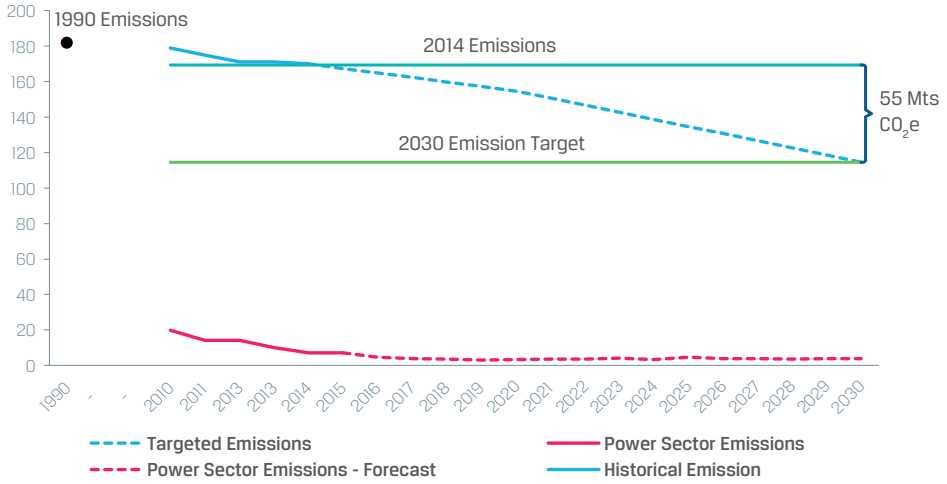
Upcoming Milestones in Ontario Climate Policy

- January 1, 2017: Launch of cap-and-trade program
- Early 2017: Release of updated long-term energy plan
- Early 2017: Further guidance expected on national carbon price
- 2018: Linkage of cap-and-trade program with Quebec and California

- Additional trading partners do not face a carbon price, including the Midcontinent Independent System Operator that trades with Ontario through its interconnection with Michigan and Manitoba.

The emission reductions achieved through Ontario's coal phase-out pale in comparison with the emission reductions required to meet the province's 2030 target (see Exhibit 1). Ontario's domestic emissions are expected to exceed these emissions targets, which would render the province reliant on allowances purchased from California to meet the cap. Whether these allowances will meet compliance with the federal government's plan of either a price on carbon or a cap on emissions is not clear.

EXHIBIT 1: ONTARIO EMISSIONS—HISTORICAL AND TARGETED (MTONS CO_2E)



Source: IESO Ontario Planning Outlook 2016, Environment and Climate Change Canada, ICF, Ministry of the Environment and Climate Change Canada—Ontario

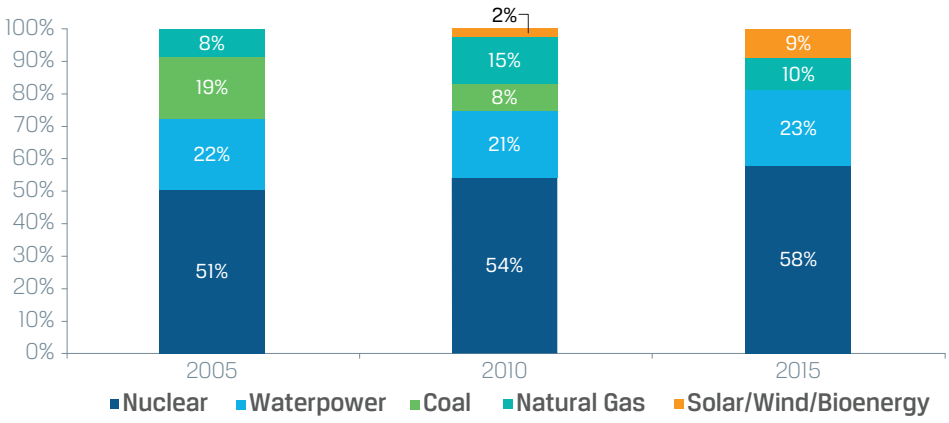
A carbon price, potentially rising to up to CAD $50/tonne by 2022, will improve the economics of emerging technologies. Revenues from the cap-and-trade program are expected to flow into programs funding the deployment of those same measures and technologies. Electrification of personal vehicles could save up to 4t CO_2/yr/vehicle, manage and even reduce peak demand through smart charging and vehicle-to-grid technology, and only modestly increase demand by 3-4 TWh/million vehicles. Additional measures modeled by the Independent Electricity System Operator (IESO) will require financial incentives from the government to reach widespread adoption.

Converting heating systems from natural gas to electricity raises the price per unit of energy from CAD $36/MWh to CAD $142/MWh—a jump that would only be economic at a potential carbon price of more than CAD $500/tonne. High-efficiency electric heat pumps could reduce the energy consumed by heating systems, mitigating the impact of the per unit energy price difference. However, these technologies would still require carbon prices of more than CAD $300/tonne to be economic. Where implemented at scale, they would require massive investment in added winter-peaking capacity, transmission, and distribution systems.

Ontario's Historic Transformation of Power Supply

Driven in part by the Green Energy and Economy Act of 2009, Ontario's supply mix has undergone a transformation toward clean energy sources. The most important milestone has been the phase-out of coal from its supply mix in 2015. As shown in Exhibit 2, the share of coal generation has declined steadily since 2005 when coal provided more than 19% of the power generation. By 2010, the share of coal had declined to 8%, with a complete phase-out by 2015. At the same time, the share of renewable generation has increased to slightly less than 10% in 2015. The increasing penetration of conservation measures has reduced demand in the past five years, causing Ontario to become a net exporter of power. Exports from Ontario have grown from 13 to 23 TWh in that period, while imports only increased from 3.9 to 5.8 TWh. More than 80% of Ontario's exports are flowing into markets south of the border, particularly into New York and Michigan.

EXHIBIT 2: ONTARIO GENERATION MIX—HISTORICAL



Source: IESO Ontario Planning Outlook 2016 and ICF

Demand forecasts for Ontario vary drastically depending on the degree of electrification—specifically of heating and hot water.

Demand projections from IESO in Ontario include negative growth scenarios and high demand scenarios, ranging from 133 TWh to 197 TWh in 2035. The main driver of demand in the high-demand scenarios is the electrification of other sectors, including electric vehicles and electric space and water heating. Although Ontario is expected to remain summer peaking in the non-electrification scenarios (Outlook A and B), the province switches to a winter-peaking system in the electrification scenarios, with a peak demand up to 43% above the non-electrification scenario (Outlook B). At the currently forecasted capacity expansion, an additional 11+ GW would be required to satisfy peak demand requirements.

Ontario's Supply Cliff—Meeting Demand in the Mid-2020s

The coal phase-out marked the most significant development in Ontario's supply mix in decades and enabled the province to make progress on its emission reduction goals—recording 6% lower emissions in 2014 than in 1990. Although the path to reducing power-sector emissions necessitated a phase-out of coal, the path forward is much less clear. The most significant change in Ontario's electricity supply mix during the next 15 years will be the retirement and refurbishment of the province's nuclear generation fleet. Three gigawatts (GW) of Ontario's 13 GW of nuclear capacity will retire by the mid-2020s, with an additional 8 GW undergoing refurbishment during the next 16 years. The refurbishment schedule will take offline between 0.8 and 3.3 GW of the remaining nuclear capacity annually until they are complete in 2033. The nuclear refurbishment program is one of the largest—and one of the most expensive—in North America with expected capital expenditures of more than $20 billion.

The retirements and refurbishments will leave a hole in the province's supply, with up to 40 TWh of generation unavailable in 2025—equal to ~30% of annual demand in 2015. To achieve the ambitious 37% reduction targets by 2030, this hole must be filled largely with emission-free generation. Additionally, the hole may deepen further as emission reductions in other sectors lead to higher climate policy-driven electric demand. IESO's electrification scenarios project between 12% and 21% additional load by 2030, compared with its non-electrification scenario. Peak demand is projected to increase by up to 17% in 2030—and up to 43% higher in 2035.

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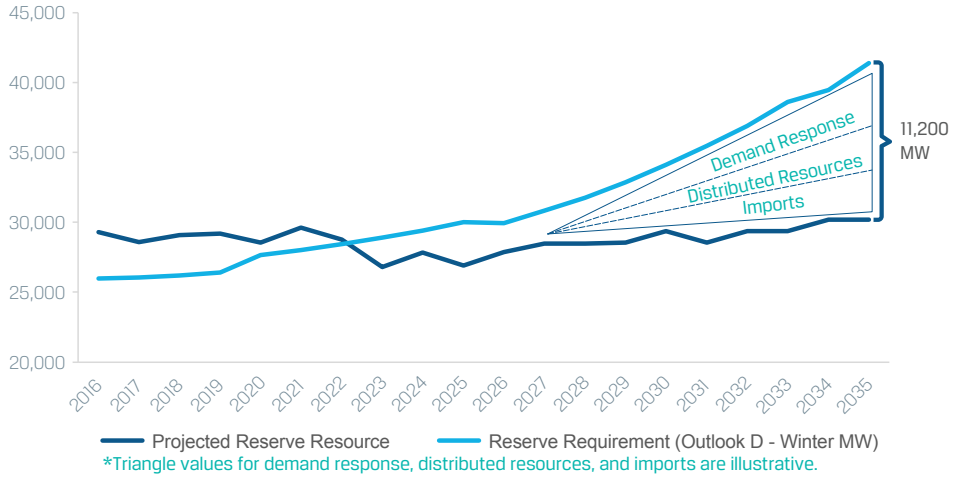
As shown in Exhibit 3, the supply gap starts widening in 2027, with the start of electrification measures. Ontario will have options to fill this gap, but each comes with its own challenges.

- **Utilization of natural gas fleet**: Ontario has nearly 10 GW of gas-fired power generation stations, with more additions planned in the coming years. At less than 20% capacity factor in 2015, the fleet is underutilized and could increase generation to meet additional load. The prospect of a $50/tonne carbon price by 2022 and ambitious emission reduction targets, however, cast doubt on the feasibility of expanding generation from CO_2-emitting sources. Any increase in gas generation would furthermore neuter the potential to reduce emissions through the replacement of gas-fired space and water heaters with electric heaters.
- **Expansion of renewable capacity**: Ontario has developed into a Canadian renewable energy leader through its large renewable procurement (LRP) process. Phase I of the LRP comprises awarded contracts worth 455 MW to developers, with projects now under development. However, LRP Phase II,

designed to procure another 1 GW of renewable capacity, was canceled in part due to concerns about cost impacts to ratepayers. Although new renewable capacity could still be developed, these additions would provide limited support in meeting baseload generation and reserve requirements.

- **Shifting the import/export balance**: In 2015, Ontario exported almost 23 TWh of power. Those exports could be repurposed to meet provincial demand as nuclear generation declines into the mid-2020s. Although the export surplus would not address baseload capacity requirements, strong wind generation in the early morning hours could, for example, be used through smart electric vehicle charging rather than being exported. Absent any additional capacity expansion, the IESO itself is projecting that Ontario will become a net importer of power in 2025.
- **Leveraging distributed energy resources (DER) and demand-side management (DSM)**: Increased reliance on DER could diversify the supply portfolio, increase the flexibility of grid operations, mitigate the need for new transmission, and provide local reliability and resiliency benefits. The rapidly improving economics of solar photovoltaic and storage technologies, combined with the potential to compensate resources at attractive rates based on societal value, could make Ontario a prime market for developers looking to accelerate penetration of DER. New analytical tools for optimizing DER portfolios—including demand-side management such as demand response and energy efficiency—can greatly expand the potential for reducing system costs by avoiding incremental grid investments. Ontario also can look to take advantage of the experience in California and New York regarding the role of utilities and public policies in supporting the deployment of electric vehicles and supply equipment.

EXHIBIT 3: SUPPLY SHORTAGES UNDER ELECTRIFICATION OUTLOOK D (MW)*



Source: IESO Ontario Planning Outlook 2016, ICF

IMPLICATIONS TO ONTARIO—DE-COMMISSIONING, DE-CARBONIZATION, REVOLUTION?

Ontario's success in meeting its emission reduction targets will be paramount to Canada's overall federal climate change progress. Two factors are instrumental to Ontario's success:

1. *The ability of utilities to sculpt a grid system that is flexible enough to dispatch a predominantly low-carbon supply portfolio while meeting growing demand needs*. Proposed measures to move commercial and residential energy systems to electricity and away from natural gas will be costly and introduce additional challenges to the reliability of the grid through demand and peak load requirements. The grid must, therefore, be integrated across sectors to take advantage of DSM and energy efficiency programs, smart grid technology, and large-scale distributed generation.
2. *A constant and consistent stakeholder process that coordinates utility programs with federal incentives*. Much is ahead for Ontario: Upwards of $100 billion will be potentially spent on 20 GW of added capacity and nuclear refurbishments, transmission upgrades, import contracts, and electrification measures. Billions of cap-and-trade revenue will be distributed. Details are pending on the coordination between Ontario's climate and energy policy as well as federal and provincial measures. Thus, the Ontario energy system and economy can only reform if all players involved work in concert.

In these challenges lies Ontario's chance to establish a model for achieving emission reduction targets through innovation and policy guidance—without losing sight of industrial competitiveness and costs to ratepayers. Other provinces will look to Ontario for lessons learned and measured to meet their respective emission reduction targets in a carbon-price environment.

About ICF

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For more information, contact:

Duncan Rotherham
duncan.rotherham@icf.com +1.416.341.0389

Chris MacCracken
chris.maccracken@icf.com +1.703.934.3277

Felix Amrhein
felix.amrhein@icf.com +1.703.251.0922

facebook.com/ICFInternational/
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linkedin.com/company/icf-international

About the Authors

Duncan Rotherham has more than 19 years of experience providing a wide range of services to North American and international industry, utilities, and public-sector organizations in the planning, design, and implementation of energy and environment and management systems. Mr. Rotherham has worked on the forefront of the energy and environmental markets as well as sustainability for the past 15 years. He has led work for utilities, financial services companies, government, and industry. He has supported the development of energy, emissions and sustainability strategies, target setting and compliance/risk management tools. In the past two years, he has led ICF's analytics related to Ontario's climate and energy policy and impacts on natural gas, electricity utilities and energy end users, supporting work for clients from Union Gas, Enbridge, Ontario Energy Association, Electricty Distributors Association, Industrial Gas Users Association, Ministry of Energy, Ontario Energy Board, and IESO. He has a B.Sc. from the University of Victoria and a graduate diploma in Ecotoxicology from Concordia.

Chris MacCracken has more than 15 years of experience in energy and economic modeling and assessing the potential impacts of environmental policies on the energy sector. He has directed several studies examining the impacts of environmental regulation on emission, power and fuel markets, compliance planning, and electric generating unit valuations for electric utilities, independent power producers, industry associations, and nonprofit policy organizations. He is lead author of the "Emission Markets" chapter in ICF International's quarterly Integrated Energy Outlook publication.

Felix Amrhein has two years of experience modeling carbon policies and their impact on the energy sector in North America. He has led modeling of several studies on federal and regional carbon policies, including the Clean Power Plan. Having worked out of the United States and out of Toronto, he also has conducted analysis on emission reduction measures within the Ontario climate change action plan. He holds a B.Sc. from the University of Marburg and an M.A. in International Economics from the Johns Hopkins School of Advanced International Studies.