

2020 Green Ribbon Panel Report

Part 2: Investing in Made-in-Ontario Solutions: Policy Enabled Competitive Advantages Tuned for Growth

October 6, 2020



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Context: Recap of the project

Environmental Sustainability and Economic Growth are Synergistic

The Green Ribbon Panel Principles have shaped the planned deliverables:

1. Embracing the urgent need to address climate change is the foundation for action
2. Building a low-carbon electricity system enables the transition to a reduced emission economy



Report 1 - Combatting Climate Change in Ontario:
Leveraging Unique Low Cost Advantages

1. The Climate Change Imperative The public wants action, on climate and pollution Proven solutions exist <i>Preparing for low emission electrification must start now</i>	2. Leveraging Ontario's Advantage Ontario's world leading capabilities offer a low cost pathway to get there <i>Electricity costs could be halved</i>
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This document

3. Low-cost, low-carbon energy represents a competitive economic advantage for Ontario and Canada
4. Enabling policy frameworks are diverse and require participation from all levels of government



Report 2 - Investing in Made-in-Ontario solutions:
Competitive advantages tuned for growth

1. Climate and Economy Climate + energy = economic growth <i>Ontario well placed within the GLR to grow the region</i>	2. Policy Levers Evidence-based stable policies yield success <i>Policy tools across many areas suitable to Ontario can be used</i>
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The objectives of the Green Ribbon Panel are to provide policy recommendations to all levels of government



Final Report - A Made in Ontario Climate Leadership Advantage:
Enabled by strong policy choices by government

Recommendations

Ontario can achieve a low emissions competitive economy
Implementable measurable policy solutions drive the vision

EXECUTIVE SUMMARY

Investing in Made-in-Ontario climate solutions creates jobs

Policy tools can leverage Ontario's competitive advantages for growth in global clean economy

3. Climate and Economy

Ontario's sustainable advantages in the global clean economy are primed to enable domestic and regional growth → if acted upon

A. Made-in-Ontario investments enable Ontario to be a vendor not a buyer in the global clean economy

- Ontario's trade exposed businesses will gain advantage from the low cost of smart low emission energy system integration
- Nuclear and biomass components of Made-in-Ontario clean energy solutions will reduce emissions and create jobs
- Ontario's global advantages in hydrogen and transportation are a source for economic growth in addressing the greatest sources of global emissions

Targeted investments in these industries are strategic choices for Ontario's future growth in the new economy

B. Leadership in strategic sectors creates innovation and economic benefits across Ontario and the Great Lakes

- The development of the advanced technologies will nurture a world class innovation ecosystem in Ontario
- Low-emission energy, jobs, and energy security benefits of the Made-in-Ontario innovations will be visible across Ontario
- With the deep integration of Ontario's economy within the Great Lakes, clean economy investments will create prosperity across the region, growing trade and the market for Ontario's exports

Ontario's investments will help grow opportunity within the world's third largest economic region

4. Policy Levers

Many available global climate policy tools may be suitable for Ontario but require government and business alignment

C. Selective climate-related policies are being pursued around the world to balance climate and economic imperatives

- In response to Paris, policy actions are being taken globally to address climate change, but policy responses have been inadequate due to economic implications
- Many successful climate policies focus on reducing emissions in specific sectors to advance both climate and economic objectives
- Some climate policies are broad based enablers to encourage innovation across sectors based on economic principles

Climate policy measures and economic advancement must move forward hand in hand

D. Economic benefits of Ontario's policy responses can be augmented through design principles and collaboration with business

- Canada and Ontario have a number of policies underway to tackle climate change whose design can be informed by principles and lessons learned from other jurisdictions
- Success entails government & corporate leadership playing complementary roles
- The pandemic environment provides an opportunity to accelerate climate objectives and economic growth

With proactive measures, Ontario can fast track economic growth through climate action

CHAPTER 3. CLIMATE AND ECONOMY

Climate and Economy: Ontario's sustainable green economy advantages

Ontario's global advantages are primed to enable domestic and regional growth through action

Made-in-Ontario investments enable Ontario to be a vendor not a buyer in the global clean economy and create 150,000 jobs/yr			Leadership creates innovation/economic benefits across Ontario and Great Lakes	
<p>Low cost and low emission energy is a competitive advantage</p> <p>Investments in low cost low emission energy is of strategic importance</p> <ul style="list-style-type: none"> The energy sector is a source of competitive advantage for Ontario <p>Ontario manufacturers, particularly small ones, are trade exposed</p> <ul style="list-style-type: none"> Low cost energy matters, and smart energy system integration can be a solution <p>Lowering electricity cost can give Ontario manufacturers an advantage</p>	<p>Home grown energy solutions reduce emissions, create jobs</p> <p>The nuclear sector contributes to economic growth & prosperity</p> <ul style="list-style-type: none"> Nuclear generates economic activity while decarbonizing The supply chain underpins other sectors <p>Ontario and Canada are well positioned for future nuclear technologies</p> <ul style="list-style-type: none"> With emerging technologies – SMRs and Fusion <p>Biomass has strategically important economic implications</p> <ul style="list-style-type: none"> Biomass can support economic development in northern and remote communities <p>Investment in these sectors could enable Ontario to become a global leader</p>	<p>Growth of strategic domestic industries can be enabled</p> <p>A hydrogen economy to reduce Ontario emissions can be developed</p> <ul style="list-style-type: none"> Scale is sufficient at over 2 billion kgs and could reduce energy imports A hydrogen electrolyzer manufacturing sector can create jobs <p>Auto / truck manufacturing sector must shift to ZEVs</p> <ul style="list-style-type: none"> Consumer shift to ZEVs could undermine Ontario's sector ZEV manufacturing could sustain the industry <p>Ontario's trucking / logistics infrastructure is energy intensive</p> <ul style="list-style-type: none"> Decarbonizing will need new infrastructure enabled by the hydrogen economy <p>Investment in hydrogen and transportation is an enabler of future low emissions economic growth</p>	<p>Innovation/economic benefits will spread across Ontario</p> <p>The development of the advanced technologies will nurture a world class innovation ecosystem in Ontario</p> <p>A smart solution and focus on strategic industries can spur innovation</p> <ul style="list-style-type: none"> Long term sustainable competitive advantage can be established for these sectors in Ontario <p>Energy, jobs, and energy security benefits are widespread in Ontario</p> <ul style="list-style-type: none"> All regions of Ontario will benefit from the smart energy solution and robust key domestic sectors <p>Provincial prosperity can be created by improving Ontario's ability to innovate and upgrade key sectors</p>	<p>The entire integrated Great Lakes region will benefit</p> <p>Ontario's economy is deeply integrated within the Great Lakes Region</p> <ul style="list-style-type: none"> The Great Lakes region is the 3th largest economy in the world <p>Green economy investments will create prosperity across the region</p> <ul style="list-style-type: none"> Nuclear, auto and trucking are already significant sectors in the region Hydrogen has considerable potential <p>Regional synergies will grow trade and the market for Ontario's exports</p> <p>Ontario's investments will help grow opportunity within the world's third largest economic region</p>

Investments in low cost low emission energy is of strategic importance

The energy sector is a source of competitive advantage for Ontario

Ontario can attract and retain sustainable businesses by establishing a market perception as a long-term viable, reliable and sustainable place to conduct business

- Business leaders emphasize investment in clean, domestic energy infrastructure¹

Advantage of clean energy:

- Regardless of country of origin, CEOs believe that countries with the ability to provide access to clean and renewable energy at competitive costs will¹:
 - Have an advantage over their competitors
 - Be more attractive locations to conduct business

Advantage of self-sufficiency in energy:

- Executives favor self-sufficiency and domestic economic development through reduced reliance on foreign sources, in order to avoid economic risk associated with¹:
 - Energy market volatility
 - Political instability in key energy producing regions
 - Limited global supply

Advantage of low-cost reliable energy:

- Availability and cost of energy can affect a company's capital & operating decisions, such as facility location, R&D investments, operating efficiency targets and supply chain / logistics that make them want to invest in Ontario
- Energy intensive industries, like manufacturing, need to drive efficiency to remain competitive
 - Reliable, sustainable, cost-effective energy can help Ontario's manufacturing industries sustain a strong competitive position

1. WEF, 2013

Ontario manufacturers, particularly small ones, are trade exposed

Low cost energy matters, and smart energy system integration can be a solution

Most manufacturing in Ontario is trade exposed¹

- Traditionally recognized large energy intensive manufacturing and industrials represent 2% of GDP and are 54% trade exposed
- All other manufacturing represent 10% of Ontario's GDP and are over 80% trade exposed
- SMEs form 85% of manufacturing enterprises and are vulnerable²

Electricity costs are reflected in Ontario's trade

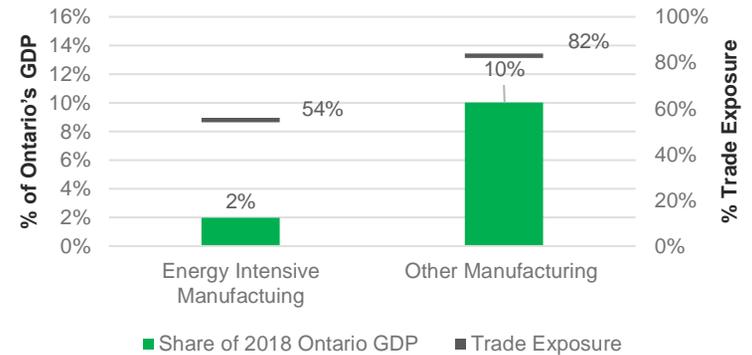
- Ontario's largest trading partners include Michigan, New York, the rest of the Great Lakes region and California
 - Collectively these states represented 60% of Ontario's manufacturing trade with the U.S. (2018)
 - 40% of manufacturing trade with those states is transportation manufacturing
 - ◆ Where Ontario has a rate advantage there is a trade surplus in manufacturing, e.g., Michigan and California
 - ◆ Where Ontario has rate disadvantage there is a trade deficit in transportation manufacturing, e.g., rest of Great Lakes region

Ontario has a low cost electricity advantage which it can utilize³

- Today's energy cost is \$125/MWh, which is too expensive⁴
 - Hydro/nuclear cost = \$66/MWh. Refurbishment costs are \$80/MWh. Ontario's low cost electricity advantage lies here
 - The remaining generation, e.g., renewables and natural gas is expensive, costing \$223/MWh
- Smart energy system integration can replace high cost generation and provide sizable cost advantages to Ontario's manufacturers⁵

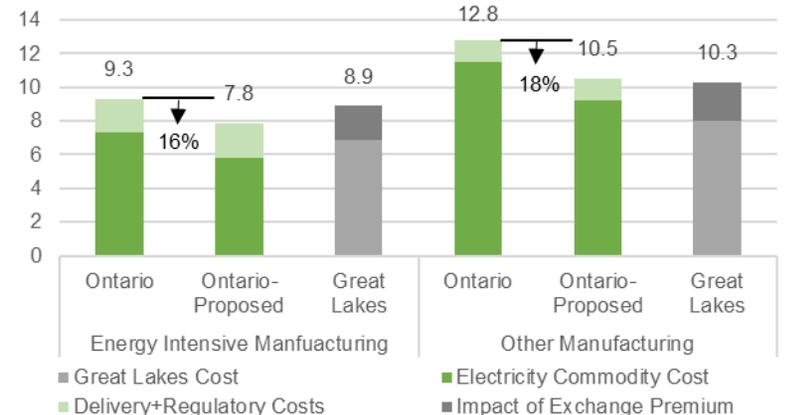
Ontario GDP and Trade Exposure

(% of total Ontario GDP, % Trade Exposure)



Sources: Statistics Canada 2020f for GDP and trade exposure, Energy intensity uses proxy based on Ecofiscal Commission, 2016 for emissions intensive sectors (Cement, Fertilizer, Oil refining, Steel, Other metals, Petrochemicals, Basic chemicals, and Paper); Strapolec analysis

Exhibit: Manufacturing Electricity Rate Comparisons, 2018 (CAD cents/kWh)



Sources: Ontario Industrial: OER Q4 2018. Great Lakes Industrial: EIA, n.d. average of Michigan, Ohio, Illinois, Pennsylvania, and Indiana. Ontario Class B Manufacturing: Hydro-Quebec, 2018 Medium Power users (500kW, 56% CF) Average of Toronto and Ottawa. Great Lakes Class B Manufacturing: Hydro-Quebec, 2018 based on average of Chicago and Detroit

Lowering electricity cost can give manufacturers an advantage

1. Strapolec Analysis based on: Statistics Canada, 2020f and Canada's Ecofiscal Commission, 2016; 2. CME, 2017; 3. Strapolec analysis based on OER, 2018; EIA, n.d.; Hydro-Quebec, 2018; 4. Strapolec, 2018; 5. Green Ribbon Panel, 2020



The nuclear sector contributes to economic growth & prosperity

Nuclear sector in Canada generates revenues of over \$6B per annum¹

The sector is a large creator of sustained, high quality jobs

- Canada's nuclear sector is estimated to employ 30,000 people across the country²
 - This includes uranium mining and other lifecycle jobs across Canada
 - The life extension and refurbishment of Bruce Power and Darlington reactors is estimated to contribute 14,000 jobs annually to the province^{3,4}
- Nuclear plant operations and supply chain are estimated to contribute 16,000 direct jobs per year in Canada⁵
 - The majority of these jobs are in Ontario, with approximately 12,000 jobs across 3 nuclear facilities^{6,7}
- Nuclear sector also has large indirect job benefits with the estimated impact in the same magnitude as direct jobs created⁵

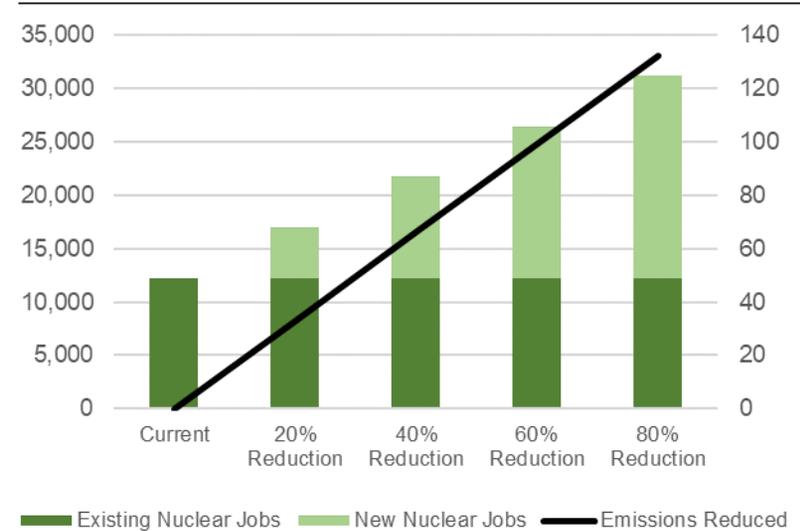
A smart energy system integration would require additional nuclear capacity depending on the desired emission reductions from the economy

- Additional capacity could provide up to 20,000 more annual direct jobs

The large nuclear supply chain supports other industries

- Over 250 companies in Canada are part of the nuclear supply chain
 - The OCNI, the largest industry association for nuclear suppliers in Canada, has 246 member organizations that support Ontario's nuclear industry in a number of capacities⁸
- There is a large overlap between Ontario's nuclear supply chain and other key industries in Ontario⁹
 - These supply chain companies play key roles in supporting Ontario's automotive, aerospace, and manufacturing sectors, among others and form a key part of Ontario's economy

Exhibit: Jobs Created by Ontario's Nuclear Industry
(Jobs created; Mt emissions reduced)



Source: Strapolec, 2019; Durham Workforce Authority, 2013; Bruce Power, 2020;
Note: Growth based on 0.6 jobs / MW of anticipated high efficiency plants

1. NRCAN, 2016; 2. World Nuclear Association, 2020; 3. Bruce Power, 2020a; 4. CBoC, 2015; 5. Canadian Manufacturers & Exporters, 2010; 6. Durham Workforce Authority, 2013; 7. Bruce Power, 2020b; 8. OCNI, 2020; 9. Strapolec Analysis

Emerging nuclear technologies could keep Canada at the leading edge



SMRs and fusion

SMRs could represent the next wave of nuclear innovation

- Canada can become a global leader in an emerging market estimated to be \$150B a year by 2040¹
 - Canada has a promising domestic market for SMRs with a potential value of \$5.3B between 2025-2040
 - ◆ Assuming that SMR development will generate jobs at the same jobs/value ratio as Ontario's current nuclear refurbishments, 3,000 incremental jobs annually can be expected
 - Has experience with nuclear reactor technology exports
 - Considerable economic and ancillary benefits can accrue, since Canada can lead in all necessary elements,
 - ◆ world class nuclear laboratories, and S&T in related areas (e.g., material science)
 - ◆ mature supply chain, domestic uranium mining
 - ◆ extensive nuclear operating experience and demonstration sites
- Ontario is actively working to develop an SMR ecosystem
 - CNL has set a target to host an operational SMR at its Chalk River Laboratories site by 2026²
 - ◆ CNL has 4 SMR developers officially working through its invitation process, and another two engaged in the process. Half of these entrants are from Canada, and 2 are based in Ontario (Global First Power and Terrestrial Energy)^{2,3}
 - ◆ Ontario Power Generation is collaborating with Global First Power⁴
 - Has an active nuclear supply chain for conventional nuclear power with the potential to support an SMR ecosystem¹
 - Premiers of Ontario, New Brunswick, Saskatchewan & Alberta have signed an MOU to support development & deployment of SMRs⁵

Fusion, the energy source that powers the sun, is the highest density energy source, with the best carbon lifecycle footprint

- Canada has core fusion expertise with General Fusion
 - Based in Burnaby, BC, General Fusion are developing a novel magnetized target fusion (MTF) system for electricity generation⁶
 - ◆ Has developed and successfully tested many of the component technologies⁷
 - ◆ Promises to be less complex and expensive than other fusion technologies, e.g. ITER
 - Recently raised \$65 million CAD, for a total of \$263 million CAD in funding, and counts Jeff Bezos as an investor⁸
 - ◆ Including \$49 million CAD from the Federal Government
 - Partnered with Hatch in January 2020 to develop a prototype, demonstration MTF plant over the next 5 years⁹

1. Canadian Small Modular Reactor Roadmap Steering Committee, 2018; 2. CNL, 2019; 3. Reuters, 2019; 4. Global First Power, n.d.; 5. WNN, 2020; 6. General Fusion, 2020; 7. The Star, 2018; 8. Betakit, 2019; 9. T-Net, 2020



Biomass has strategically important economic implications

Biomass can support economic development in northern and remote communities

Biomass is a renewable energy source derived from living organisms and / or their by-products

- Can be used to generate electricity
 - Ontario has 295 MW of grid-connected biomass capacity¹
 - ◆ Biomass electricity is produced from the combustion of various fuels, including wood, agricultural crops, waste, and other biogas and biofuels²
 - Biomass can reduce GHG emissions by 80% compared to electricity produced by natural gas³
- Considered to be carbon neutral if harvested sustainably in accordance with existing international standards
- Ontario's Atikokan 205 MW capacity biomass plant was created by converting a coal-fired generating facility
 - Atikokan is the largest 100% biomass plant in North America⁴

Ontario has vast amounts of available and accessible renewable biomass in northern Ontario

- Ontario has a renewable supply of biomass from logging residues and low-grade wood sufficient to supply 2 million tonnes of wood pellets annually for electricity production⁵
 - With strong forest management practices, a wood pellet industry can be added to existing forestry practices without causing total forest carbon to decline, and even allow total carbon stored in the forest to increase¹

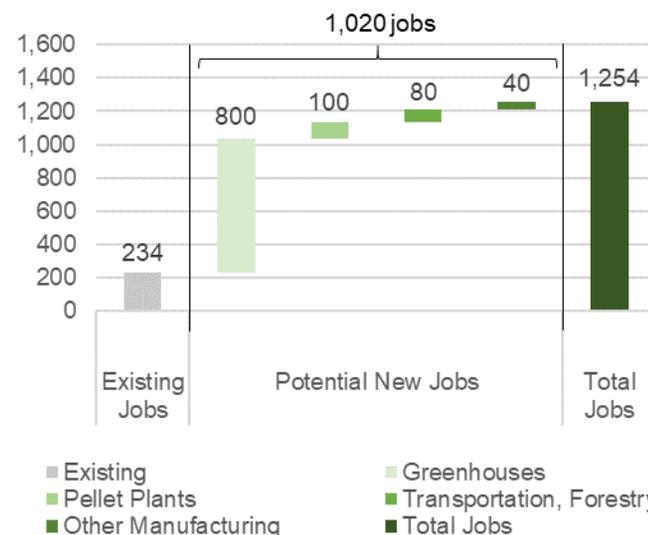
Biomass can be a creator of high-quality jobs in forest-dependent northern communities in Ontario

- A sample project considering potential job growth at the Thunder Bay and Atikokan plants saw a potential of 1,020 new jobs
- The total employment potential of biomass in Ontario is 3,569 jobs, and would generate 3.4 TWh of electricity through biomass³
 - These jobs are in power generation, as well as agriculture and forestry management, manufacturing, and trucking, all situated in northern communities

1. Ontario Energy Report, 2020; 2. EIA, 2018; 3. Pembina Institute, 2011; 4. OPG, 2020; 5. This represents the modelled maximum biomass production without contributing to a decline in total biomass in the area, Pembina Institute, 2011

Exhibit: Sample Job Creation of Biomass - Northern Ontario

(Sample of jobs created for two generating stations)



Source: Ontario Auditor General, 2015; Pembina Institute, 2011; Alberta Agriculture, 2011; Resolute Forest Products, 2016; Strapolec Analysis
Note: Job creation chart represents potential job growth at Atikokan and Thunder Bay generating stations. Analysis conducted prior to closure of Thunder Bay Biomass plant.

A hydrogen economy to reduce Ontario emissions can be developed



Scale is sufficient at over 2 billion kgs and could reduce energy imports by \$3.2B/year

Hydrogen production underpins a new hydrogen economy that serves many applications

- Hydrogen is a recognized option for the deep decarbonization of global energy systems
- While nations have started to focus on hydrogen, a global leadership position is available
 - Japan, Germany, South Korea, and the U.S. are proactively investing in research, development, demonstration, and fuel cell deployments, to position domestic manufacturers for economic advantage¹

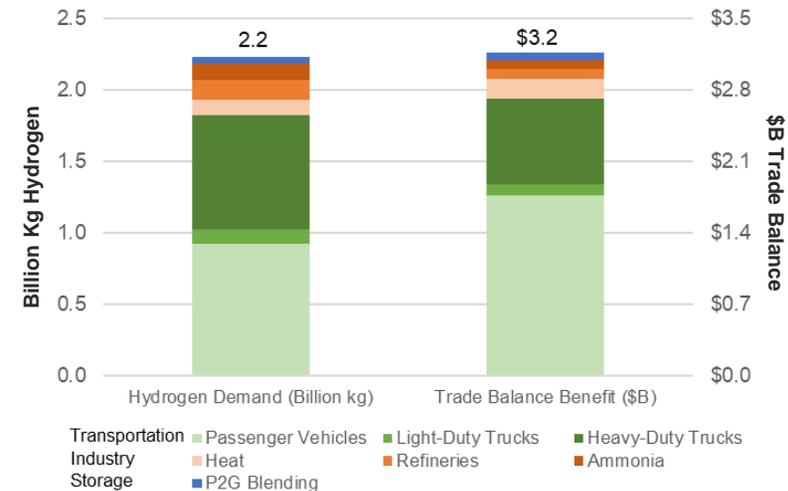
Canada is already amongst the top ten global hydrogen producers¹

- Over 100 Canadian companies are in the hydrogen & fuel cell sector¹ and several Ontario enterprises are among world leaders in electrolyzers, fuel cells, and hydrogen, e.g., Hydrogenics, NextHydrogen, Dana Canada, and Hydrogen Optimized²

Demand for clean hydrogen to reduce emissions in Ontario could be 2.2 billion kgs and reduce purchase of U.S. natural gas

- Transportation: 1.8 billion kgs
 - *Passenger vehicles*: Replacing 50% of gasoline consumption through hydrogen would result in demand of 0.92 billion kgs³
 - *Light duty trucks*: consumed 16% of all diesel fuel in Canada.⁴ Converting 50% to hydrogen means demand of 0.1 billion kgs³
 - *Heavy duty trucks*: consumed 84% of diesel fuel in Canada.⁴ Converting 80% to hydrogen results in demand of 0.8 billion kgs³
- Industry: 0.37 billion kgs
 - Shifting 25% of industrial natural gas could require 0.11 billion kgs⁵
 - Ontario refineries consume 0.14 billion kgs of hydrogen per year⁶
 - Hydrogen demand for ammonia production could be 0.12 billion kgs^{5,7}
- Power 2 Gas storage: 0.05 billion kgs
 - End use appliances are limited to 5% hydrogen blending by volume, with blend proportions feasible up to 15%.⁸ Replacing 5% of residential demand for natural gas in 2018 equates to 0.05 billion kg of hydrogen⁵

Exhibit: Potential Hydrogen Demand & Positive Trade Impact
(Billion kg hydrogen demand; \$B trade balance)



Source: Strapolec Analysis.

Notes: Electricity demand is 47.7 TWh per billion kg of hydrogen produced. 6.84 GW of electrolyzers are required to produce 1 billion kg of hydrogen

1. NRCan, 2020a; 2. CHFCA, 2020; 3. Statistics Canada, 2020b; 4. Statistics Canada, 2010; 5. Statistics Canada 2020e; 6. Dalcour Consultants, 2005; 7. Energy for global production of ammonia is 82% that of refineries, The Globe and Mail, 2020; 8. National Research Council Canada, 2017



A hydrogen electrolyzer manufacturing sector could be large

Creating up to 23,000 jobs and \$2.5B/year in purchased hydrogen equipment

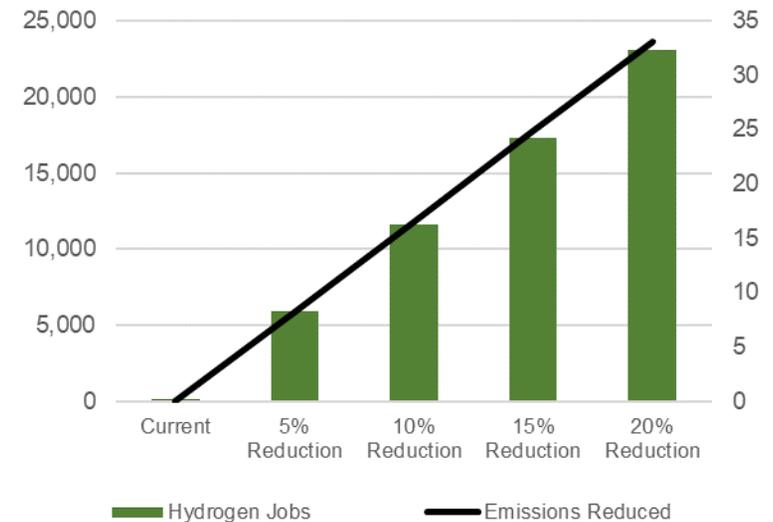
Creating an electrolyzer manufacturing base in Ontario to supply the required hydrogen can create jobs

- Several factors impact the potential jobs for Ontario
 - Canada's hydrogen sector employed 2,177 people in 2017, with only 200 being located in Ontario (46% are in B.C.)¹
 - ◆ High quality jobs are created for developing electrolyzers
 - The mid-century target for electrolyzer efficiency stands at 47.7 kWh/kg²
 - ◆ 15.3 GW of electrolyzers will be needed to supply Ontario, based on a Hydrogenics PEM electrolyzer³
 - Up to 15 jobs may be produced for each MW of electrolyzer⁴
- Supplying the required electrolyzers can potentially generate 23,000 high-quality jobs annually in the province
 - Based on hydrogen economy potential to reduce 20% of Ontario's emissions
 - Assuming that rollout is phased over 10 years

Manufacturing these electrolyzers in Ontario, as opposed to importing them, can benefit Ontario's trade balance

- Instead of importing the technology at a cost premium, Ontario can become a provider of this technology.
 - Building the necessary electrolyzers can create a \$2.5B spend per year in Ontario, instead of importing it.
 - ◆ The current cost is \$3.5M for each MW of electrolyzer⁴
 - ◆ For the purpose of this assessment, it is assumed that technological advances will bring down these costs by half
 - This is in addition to the trade balance benefit from avoiding purchase of U.S. natural gas

Exhibit: Jobs created by Ontario's Hydrogen Economy
(Jobs created; Mt emissions reduced)



Source: Hydrogenics, 2018b; Hydrogenics, 2018a; Strapollec analysis
Note: Represents annual jobs over a 10 year period

Hydrogen presents an opportunity for national unity

- Through NRCAN, the Federal Government is working with provinces and territories to develop a National Hydrogen Strategy⁵
- Combined with hydrogen experience across the country, these efforts could produce a pan-Canadian hydrogen sector

1. CHFC, 2018; 2. Strapollec, 2016; 3. Hydrogenics, 2018b; 4. Strapollec Analysis using Hydrogenics, 2018a, 5. NRCAN, 2020b

Ontario has a large, deeply integrated Auto & truck manufacturing sector

But there are few plans to shift to ZEVs



The auto sector is a key element of Ontario's economy

- Canada is the 12th largest manufacturer¹ and 5th largest auto exporter by value²
- In 2017, Ontario was North America's top auto-producing region, producing nearly 2.2 million vehicles³
 - And contributed 2.4% of Ontario's GDP, including 18.5% of Ontario's manufacturing GDP or \$20.6B
 - 85% of Ontario-made vehicles and parts are exported
- GM has launched its Canadian technical center in Markham, focused on its fully autonomous vehicle program³

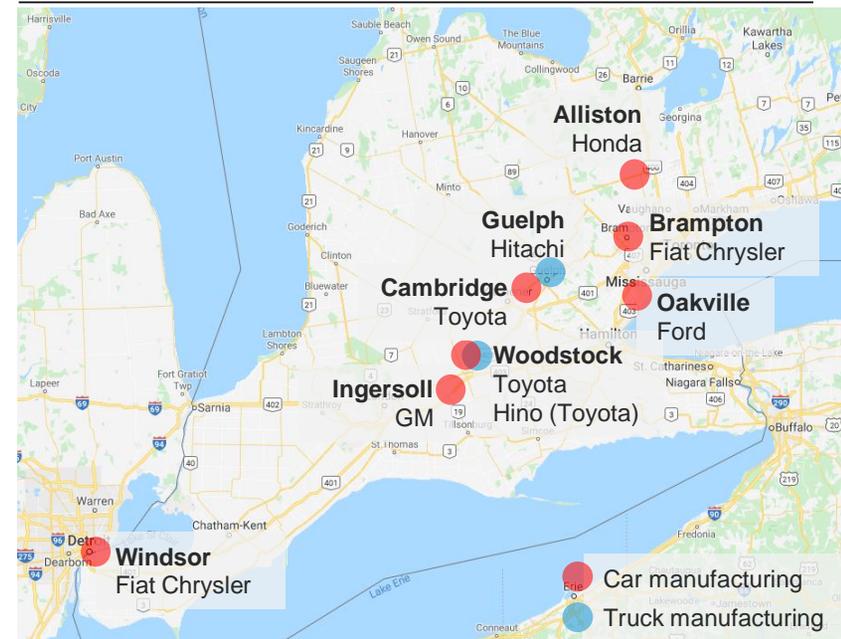
Ontario's auto sector employs 106K people directly⁴

- Generates hundreds of thousands of indirect jobs across the province⁵
- Supports a large education and research base
 - 11 Ontario universities and 24 colleges offer auto-related research initiatives and training programs³
- Ontario is the only province in Canada that builds both cars and trucks³

However, zero emission vehicle manufacturing has not taken off in Ontario

- Electric vehicle production makes up just 0.4% of total vehicles produced in Canada, 80% lower than the current global average share of EV production among auto producing nations⁶
- None of the U.S. \$300 billion in EV manufacturing investments announced by global manufacturers for North America between 2020 and 2025 has been explicitly slated for Canada⁶
- In September 2020, Ford Motor Co. made an agreement with its main union, Unifor, to invest \$2 billion to produce EV and battery production in Canada – a step in the right direction⁷
 - Aided by a \$500 million investment by the Federal Government

Exhibit: Vehicle Manufacturing Centres in Ontario



Source: Google; Government of Ontario, 2019

1. OICA, 2020; 2. World's Top Exports, 2020; 3. Government of Ontario, 2019; 4. Government of Ontario, 2020a; 5. Unifor, 2015; 6. Electric Autonomy Canada, 2020; 7. CBC, 2020

Auto & truck manufacturing must produce new kinds of vehicles

Converting to ZEV manufacturing will sustain Ontario's auto manufacturing sector



To increase the adoption of zero-emission vehicles (ZEVs), Transport Canada has set ambitious new vehicle sales targets¹

- By 2040, 100% of new vehicle sales are targeted to be ZEVs
- Steady progress towards these targets would translate to 2.7 million ZEVs on the road by 2030, and over 14 million by 2040
- ZEVs include: Battery electric vehicles (BEV), hydrogen fuel cell vehicles (FCEV) and Plug-in hybrid electric vehicles²
 - FCEVs are still in their infancy, while BEVs are more widely adopted

Ontario must prevent auto sector job erosion by leveraging its auto sector base to manufacture ZEVs

- As demand for traditional internal combustion engine (ICE) vehicles declines, manufacturing of these vehicles will decrease, and the entire auto sector will be at risk
 - Failure to shift to ZEV manufacturing could result in a loss of 30% of Ontario's auto sector jobs by 2030, and the entire sector by 2040
- Shifting to ZEVs would sustain the domestic auto sector
 - ZEV manufacturing can rejuvenate the auto-sector with high quality jobs, exports, and supply chain benefits
 - Canada is potentially well-positioned with its established auto ecosystem and supporting policies³
- Ontario is an attractive location for ZEV manufacturing
 - Low-cost, low-carbon electricity grid is suitable for ZEV owner's ambitions to reduce emissions
 - A strong local demand portends well for creating a manufacturing base
 - Existing auto sector with a highly skilled workforce
- Must also encourage EV adoption and necessary infrastructure

1. Transport Canada, 2020; 2. PHEVs have been in the mass market for over two decades, but having two drivetrains will make PHEV likely the more expensive, and least likely long term ZEV solution. InsideEVs, 2018; 3. Electric Autonomy Canada, 2020

Exhibit: Projected Sales of ZEVs in Canada
(Projected Annual ZEV Sales; 2015-2040)

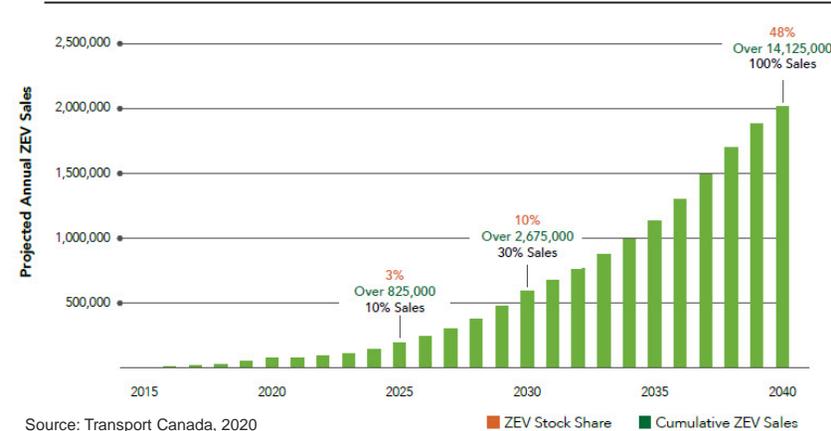
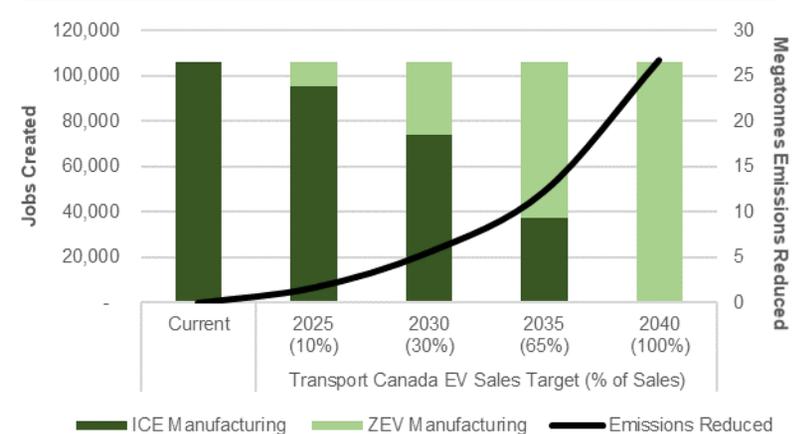


Exhibit: Jobs created by Ontario's auto industry
(Jobs created; Mt emissions reduced)



Notes: Assuming flat car sales and equivalent jobs/car for ZEV manufacturing. Projected demand for ZEVs in Canada by 2040 equals current production of vehicles in Ontario. Therefore, converting to manufacturing ZEVs stops ICE job erosion. It is assumed trucks will follow the same pattern as passenger cars. Assumed that the percent ZEV stock share corresponds to same percent reduction in emissions (e.g., 48% ZEV stock share equates to 48% emission reduction)

Ontario's trucking / logistics can change how goods are moved

Trucking is a vital economic sector, and contributes significantly to Ontario's GDP



The trucking sector allowed Canada to export \$234 billion in goods in 2019, serving almost every sector of the export economy¹

- 46% of the value of Canada's imports and exports was transported by truck in 2019²
- The trucking industry is the main mode of transportation for goods traded within Canada
 - Trucking handled 38% of interprovincial trade in 2018, with rail making up most of the rest³
 - The trucking industry is primarily occupied with domestic trade, with 87% of the tonnage hauled in 2018 being domestic⁴
 - ◆ Trucking dominates trade within provinces. 92% of goods moved within each province were via for-hire trucks in 2018³

Exhibit: Ontario's Exports through Trucking
(In billions of CAD)



Source: Statistics Canada, 2019f

Trucking contributes significantly to Ontario's GDP and employs thousands of Canadians, primarily in Ontario

- 480,000 Class 8 trucks (weighing over 15,000 kg) were registered in Canada in 2018⁴
 - Of these, 132,000 or 27% were registered in Ontario
- Trucking contributed \$7.1 billion to Ontario's GDP in 2016, 24% of the total Transportation and Warehousing contribution⁵
 - The Transportation and Warehousing sector contributed \$29.5 billion towards Ontario's GDP in 2018⁶
- The trucking sector in Ontario contains 54,500 companies and accounts for approximately 50% of Canada's trucking jobs⁷
- The sector is a necessary catalyst for the economy and efficient trucking is critical for all sectors

1. Statistics Canada, 2019f; 2. Statistics Canada, 2019d; 3. Statistics Canada, 2019c; 4. Statistics Canada, 2020c; 5. Statistics Canada, 2020f; 6. Government of Canada, 2019b; 7. Government of Canada, 2019b; Strapolec Analysis

Trucking is energy and emissions intensive

Conversion to ZEV will need new infrastructure and complement the hydrogen economy



The transportation sector is the most GHG-intensive end use sector in Canada, due to its high fossil fuel usage¹

- Across Canada, on-road freight produced 60 Mt of emissions in 2017. That's 34% of all emissions from transportation²
 - Trucking is second only to passenger vehicles in terms of emissions, and ahead of all other forms of freight transportation
 - Heavy-duty vehicles are also a major emitter of NOx's, which have adverse effects on air quality¹

Converting trucking to FCEVs has sound economic and climate rationale and complement the hydrogen economy

- Lowering emissions from trucking can reduce supply chain emissions for other sectors culminating in reduced emissions province-wide
- Conversion to FCEVs will improve trade balance with reduction of fuel imports

Domestic trucking infrastructure will need to be converted to support FCEVs

- FCEVs are well-suited for freight trucking, since fuel cells have a lower weight penalty and improved cold temperature performance when carrying heavy loads compared to battery electric trucks³
 - There is no expected impact on existing jobs (Same drivers, same truck stops)

Electrolyzers will be needed to bolster the trucking infrastructure

- High volume electrolyzers built at the gas station could be a new fuel distribution model
- Ontario would need 5.5 GW of electrolyzer capacity if it converted 80% of its heavy trucks to FCEVs⁴

1. Statistics Canada, 2019b; 2. NRCan, 2019c; 3. The International Council on Clean Transportation, 2020; 4. Strapolec Analysis based on Government of Canada, 2020f and Statistics Canada, 2019f

Climate and Economy: Ontario's sustainable green economy advantages

Ontario's global advantages are primed to enable domestic and regional growth through action

Made-in-Ontario investments enable Ontario to be a vendor not a buyer in the global clean economy and create 150,000 jobs/yr

Low cost and low emission energy is a competitive advantage

Investments in low cost low emission energy is of strategic importance

- The energy sector is a source of competitive advantage for Ontario

Ontario manufacturers, particularly small ones, are trade exposed

- Low cost energy matters, and smart energy system integration can be a solution

Lowering electricity cost can give Ontario manufacturers an advantage

Home grown energy solutions reduce emissions, create jobs

The nuclear sector contributes to economic growth & prosperity

- Nuclear generates economic activity while decarbonizing
- The supply chain underpins other sectors

Ontario and Canada are well positioned for future nuclear technologies

- With emerging technologies – SMRs and Fusion

Biomass has strategically important economic implications

- Biomass can support economic development in northern and remote communities

Investment in these sectors could enable Ontario to become a global leader

Growth of strategic domestic industries can be enabled

A hydrogen economy to reduce Ontario emissions can be developed

- Scale is sufficient at over 2 billion kgs and could reduce energy imports
- A hydrogen electrolyzer manufacturing sector can create jobs

Auto / truck manufacturing sector must shift to ZEVs

- Consumer shift to ZEVs could undermine Ontario's sector
- ZEV manufacturing could sustain the industry

Ontario's trucking / logistics infrastructure is energy intensive

- Decarbonizing will need new infrastructure enabled by the hydrogen economy

Investment in hydrogen and transportation is an enabler of future low emissions economic growth

Leadership creates innovation/economic benefits across Ontario and Great Lakes

Innovation/economic benefits will spread across Ontario

The development of the advanced technologies will nurture a world class innovation ecosystem in Ontario

A smart solution and focus on strategic industries can spur innovation

- Long term sustainable competitive advantage can be established for these sectors in Ontario

Energy, jobs, and energy security benefits are widespread in Ontario

- All regions of Ontario will benefit from the smart energy solution and robust key domestic sectors

Provincial prosperity can be created by improving Ontario's ability to innovate and upgrade key sectors

The entire integrated Great Lakes region will benefit

Ontario's economy is deeply integrated within the Great Lakes Region

- The Great Lakes region is the 3th largest economy in the world

Green economy investments will create prosperity across the region

- Nuclear, auto and trucking are already significant sectors in the region
- Hydrogen has considerable potential

Regional synergies will grow trade and the market for Ontario's exports

Ontario's investments will help grow opportunity within the world's third largest economic region

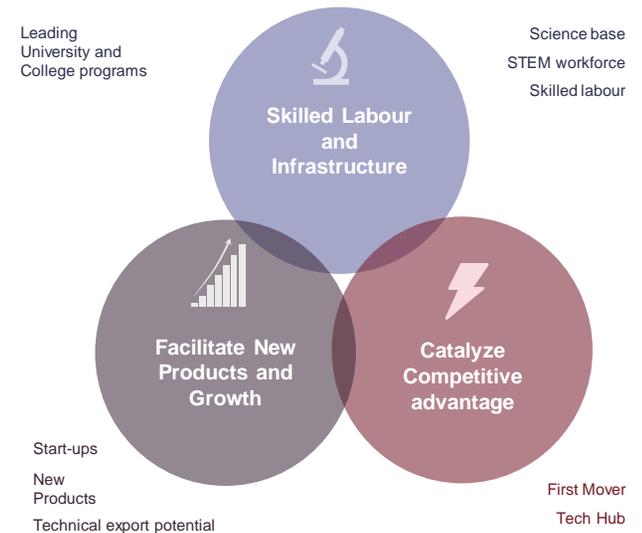
A smart solution and focus on strategic industries can spur innovation

Long term sustainable competitive advantage can be established in Ontario

Investments in clean solutions can create an innovation ecosystem:

- Enable skilled labor and infrastructure
 - Skilled labor and STEM workforce: Investments in nuclear, hydrogen, biomass and new types of manufacturing will incent jobs in the STEM fields
 - ◆ e.g., the development of GM autonomous technologies in Markham, ON
 - Leading university programs: University programs in these sectors will give rise to new fields of study, new innovations, and world leading experts
 - ◆ 98% Canadian universities conduct research using nuclear-licensed facilities¹
 - ◆ 6 Ontario universities are working on fuel cell R&D, including Queens, University of Toronto, McMaster, and Waterloo²
 - ◆ 35 Ont. colleges & universities have auto research initiatives & programs³
 - Science base supported by technical R&D: Aspiring for leadership positions in these cutting edge fields, will create science / research platform, encouraging the exchange of ideas, new basic research and technical R&D
- Facilitate new products and growth
 - Entrepreneurship and start-ups: An enabling environment including investors, networking opportunities and a high-quality workforce can give rise to start-ups that can advance and commercialize these technologies and creative innovative business models to spur growth for Ontario
 - New products: With available factors of production and a friendly, supportive environment, new types of products can be built with nuclear, hydrogen, ZEV manufacturing, logistics infrastructure, and biomass
 - Technology export potential: New technologies and products can build on Ontario's legacy as a technology exporter, e.g., CANDU reactor technology to increase value added exports
- Catalyze competitive advantage
 - First mover advantage: Ontario's existing advantages in nuclear, hydrogen, auto manufacturing, with investment, can be turned into leadership positions in SMRs, fusion, electrolyzers, biomass, and ZEV manufacturing
 - Innovating and moving first can mean long-term competitive advantage in export markets
 - Can give rise to tech hubs that foster ongoing innovation, providing platforms for business networking, skilled immigration, innovative financing, etc. This will also create spillover benefits into other industries

Exhibit: Domestic Investments in Ontario Clean Economy can Facilitate an Ecosystem of Innovation



1. Strapolec, 2019b; 2. Ontario, 2005; 3. Government of Ontario, 2019

Energy, jobs, and energy security benefits are widespread in Ontario

All regions of Ontario will benefit from Made-in-Ontario solutions and robust key domestic sectors



Large-scale air quality and GHG emissions benefits across the province

Public Health

- Switching from ICE vehicles to ZEVs would result in less gasoline and diesel being burnt, cleaning the air and reducing the risk of asthma and cardiovascular diseases across Ontario



Nuclear

Nuclear provides electricity to much of Ontario and SMRs can be anywhere

- Nuclear supply chain exists in southern Ontario, but the baseload electricity generated benefits all
- SMR innovation and manufacturing will benefit southern Ontario. On the other hand, SMR usage benefits northern communities that have fuel insecurity and rely on diesel for electricity. SMRs also have mining applications that benefit these communities



Biomass

Biomass can be the forestry/mining solution for the north

- Biomass can replace natural gas in the northern communities
- It can enable exports to Manitoba
- As well as innovations and high quality jobs in Northern Ontario



Hydrogen Economy

Hydrogen economy has many applications to benefit much of Ontario

- Big role in energy intensive industries across the province
- Innovation and export benefits likely to arise in Southern Ontario
- Emissions benefits to the entire province
- Domestic energy security for northern communities
- Production and distribution will be needed across the province
- Actions will influence national Hydrogen Strategy, spreading benefits nationally



Auto & Truck Manufacturing

Auto sector is based in southern Ontario, but supply chain is distributed

- Large job creator in Southern Ontario
 - Vast number of high quality jobs
- Deeply integrated supply chain within the province



Trucking / Logistics

Trucking – new depots, charging stations can be across the province

- Benefits accumulate to all industries and sectors
- Large scale emissions benefits, plus jobs and local spend from charging stations

Exhibit: Distributed Benefits of Made-In-Ontario

		Southern Ontario	Northern Ontario
Public Health	Cleaner Air	✓	✓
	Reduced Health Care Costs	✓	✓
Integrated Solution	Nuclear Power Industry	✓	
	SMR Development and Usage	✓	✓
	Biomass		✓
	Hydrogen Economy	✓	
Strategic Industries	Nuclear, Biomass and Hydrogen – Energy security in the north		✓
	Vehicle Manufacturing and Supply Chain	✓	
	Trucking Benefits to Industries	✓	

Provincial prosperity can be created by improving Ontario's ability to innovate and upgrade key sectors

Great Lakes region represents the 3rd largest economy in the world

Ontario is deeply integrated within the Great Lakes Region

The Great Lakes region has the population, GDP and employment reflective of the world's 3rd largest economy

- if it were a country¹
- It is best known as the industrial heartland of North America

It is a center for trade between Canada and the U.S.

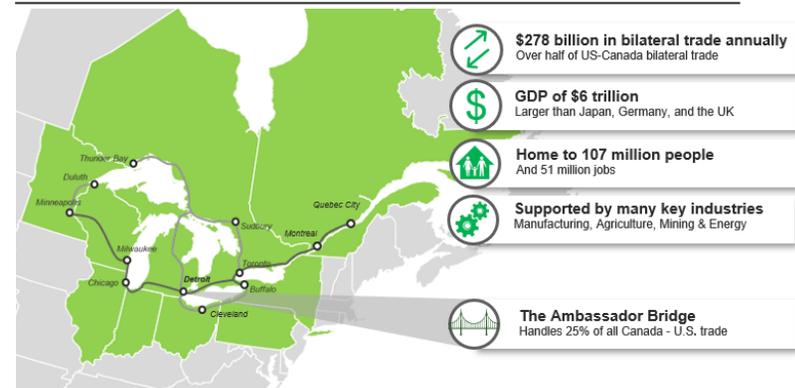
- 30% of U.S./Canada economic activity¹
- More than half of U.S./ Canada border trade¹

Ontario is highly integrated within the Great Lakes economy

- Each year there is over \$230 billion in bilateral trade in the Great Lakes region, more than the U.S. has with Mexico, China, the UK, Germany or Japan¹
- Ontario's trade exposure in the Great Lakes States is large
 - 42% of all exports are to the Great Lakes States²
 - 53% of exports to the U.S. including 92% of utilities exports and 54% of manufacturing exports are to the Great Lakes States²

All the strategies for emissions reductions extend into the Great Lakes

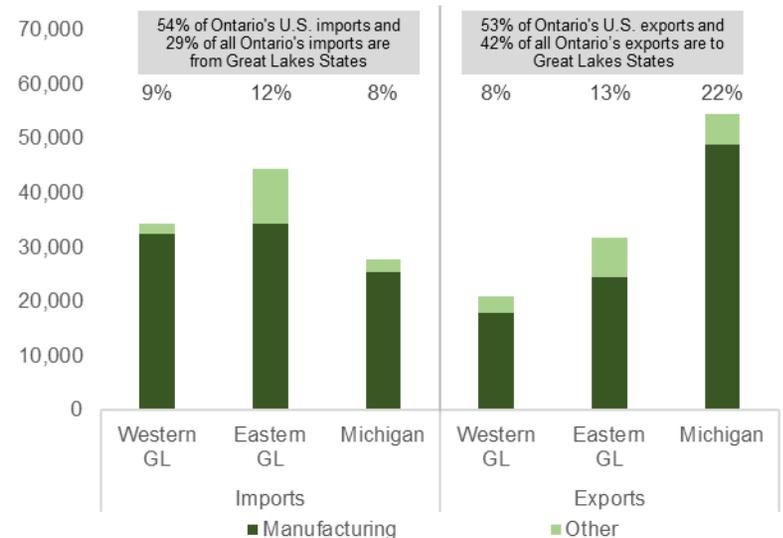
Exhibit: Overview of Great Lakes Economy



Sources: The Visual Capitalist, 2017; Statistics Canada, 2019b

Exhibit: Ontario's Exports to Great Lakes States, by Sector

(\$ in Millions; % of all Ontario exports/imports, 2019)



Sources: Government of Canada, 2020f (accessed July 10, 2020). Note that due to rounding, numbers may not sum perfectly

1. The Visual Capitalist, 2017; 2. Government of Canada, 2020f (accessed July 10, 2020)

Smart energy system integration will create prosperity across the region

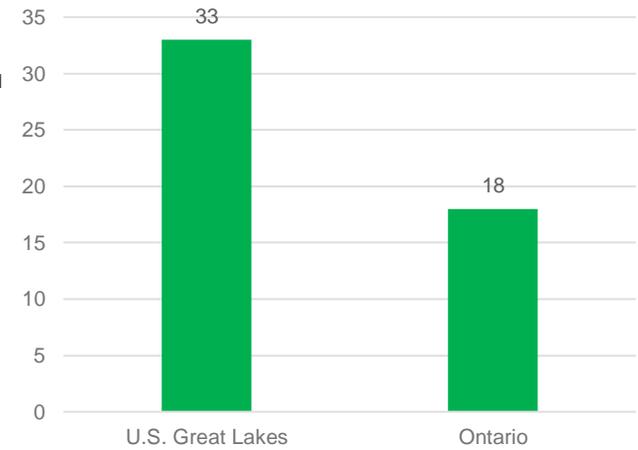
Nuclear is already a significant sector and hydrogen has considerable potential in the Great Lakes



Nuclear is a big part of the Great Lakes region and will benefit further from Ontario's investments

- Great Lakes region has its own large nuclear supply
 - Home to 51 power reactors across several generating stations, in Canada¹ and the U.S.^{1,2}
- Nuclear supply chain is deeply integrated in the Great Lakes region
 - While the U.S. and Canadian supply chains are independent, there may be reason to collaborate and integrate in the future
- Ontario's friendly nuclear environment is conducive to growing nuclear generation
 - Potentially first mover advantage to site and build nuclear plants, with a Great Lakes regional supply chain approach could extend benefits
- A Great Lakes regional approach could benefit the development of new nuclear technologies
 - Potential collaboration on SMRs with the global market in view

Nuclear Reactors in the Great Lakes
(Number of operational power reactors)



Sources: NEI, n.d.; Canadian Nuclear Safety Commission, n.d.. Note that New York's reactors on the Atlantic Coast do not count towards the total



The hydrogen economy is best developed on a regional basis

- Great Lakes has a large industrial base across several sectors that all require emissions solutions to heat
- The regional economy provides large scale
 - Developing a hydrogen economy will have supply chain benefits for the Great Lakes
 - Pooling R&D resources may be feasible, perhaps in the form of a Great Lakes hydrogen economy collaboration
 - ◆ e.g., EPRI is a North American R&D organization dedicated to advancing electricity technologies
- The Dawn Hub may provide an option to utilize hydrogen to reduce emissions from natural gas
 - Ontario's hydrogen can help the region benefit from blended gas
 - Gas storage in the Dawn Hub could provide a low-emission battery not only for Ontario, but also for the Great Lakes region

1. Canadian Nuclear Safety Commission, n.d.; Note that New York's reactors on the Atlantic Coast do not count towards the total 2. NEI, n.d.

A focus on strategic industries supports growth across the Great Lakes

Ontario's auto manufacturing as well as its trucking corridors are integrated & need regional solution



Auto & Truck Manufacturing

The Great Lakes region is known for its auto & truck manufacturing capabilities

- The significance of the auto sector for both Ontario and the Great Lakes economies means that they face the same threat
- With over 7 million vehicles produced, the Great Lakes area would be the 4th largest global auto manufacturer behind China, U.S., and Japan^{1,2}
 - Ontario is the 2nd largest producer in the region, after Michigan¹ and its supply chain is deeply integrated across the Great Lakes
- A Great Lakes regional approach could benefit the development of ZEVs in the region
 - Potential for a large scale approach allows for a regional solution and the ability to be globally competitive
 - Can bring to bear the entire strength of the region to lead ZEV manufacturing
 - ◆ This regional approach can replace the existing supply chain



Trucking / Logistics

Many trucks cross the border several times a year, underpinning trade with the U.S.

- In 2019, trucks crossed the U.S.-Canada border over 10 million times³
 - 80% were Canadian trucks returning to the country
 - Trucks accounted for 17% of all road traffic entering Canada
- Trucking and commercial traffic are responsible for 60% of the value of overall trade between Canada and the U.S.⁴
 - 97% of Canada's truck-carried exports were destined for the U.S.⁵
- Nearly half of all Canada-U.S. road trade goes through border crossings between the U.S. and Ontario (i.e., GL Region)
 - 60% of the value of all Canada-U.S. road trade passed through just three Great Lakes border crossings in 2019⁶
 - ◆ 29% from Windsor-Ambassador Bridge, 16% from Sarnia border crossing, and 15% from Fort Erie/Niagara Falls border
 - ◆ The Ambassador Bridge alone accounts for 25% of the bilateral trade (more than the entire trade between U.S. and U.K.)⁵
 - Trucks crossed these three routes over 5.5 million times in 2019⁷
- Supporting a trucking corridor along these three bridges alone can have an outsized impact on the economy & emissions
 - Without cross-border infrastructure, Ontario would be unable to transform much of its cross-border trucking fleet to FCEV
 - Truck stops with 1.1 GW hydrogen electrolyzer capacity, equalling demand of 6.5TWh will be needed in Great Lakes states

Regional synergies will grow trade and Ontario's exports within the world's third largest economic region

1. Government of Ontario, 2020b; 2. OICA, 2020; 3. Statistics Canada, 2020d; 4. Statistics Canada, 2020a; 5. Statistics Canada, 2019a; 6. Statistics Canada, 2019g; 7. Statistics Canada, 2019h

CHAPTER 4. POLICY LEVERS

Policy Levers: Many global climate policies may be suitable for Ontario

Enabling policy frameworks must be diverse & require participation from government and business

Selective climate-related policies are being pursued around the world

Most climate policy measures and barriers reflect economic implications

In response to Paris, policy actions are being taken globally to address climate change

- In aggregate, current policies fall short of the need due to economic implications, but some countries have developed policies to address the challenge

Many successful climate policies focus on reducing emissions in specific sectors

- Mandates, subsidies, incentives & strategic focus advance both climate and economic objectives

Some climate policies are broad based enablers to encourage innovation across sectors based on economic principles

- Several jurisdictions deploy carbon pricing, R&D, and financing policy tools to advance climate objectives

Climate policy measures and economic advancement must move forward hand in hand

Economic benefits of Ontario's policy responses can be augmented through design principles and collaboration

Ontario's climate policy framework can be optimized to enhance growth

Canada and Ontario are proactively responding to climate change

- Canada has developed overarching policy objectives and commitments
- Canada and Ontario have taken synergistic sector specific climate change policies
- Canada has taken cross-sector actions, which Ontario has not felt a need to replicate

Design principles exist to guide climate policy development

- Successful climate policies gain long term buy-in and benefits

Design principles and lessons highlight individual policy success factors

Applying design principles and lessons to Ontario's climate policy ingredients would enhance economic growth

Implementation implications of climate policy and opportunities today encourage collaboration

Climate policy is a complex challenge for Governments

- Business risks are now being dominated by environmental issues

Success entails government & corporate leadership playing complementary roles

The imperative of the post COVID-19 recovery can align government policy and business interests

- The conditions exist to seize the economic opportunity of climate action

The pandemic environment provides an opportunity to accelerate climate objectives and economic growth through private/public collaboration

Policy actions are being taken globally to address climate change

In aggregate, current policies fall short of the need while some countries have shown progress

Concerns about climate change led to the Paris accord, but policy responses have been mixed¹

- In 2016, nearly 200 countries signed up to the Paris climate accord, which set individual targets aimed at preventing global temperatures from rising above 2°C this century – and to pursue efforts to limit the temperature increase even further to 1.5°C or less
- Despite rhetoric, current policies are insufficient in aggregate

For many of the world's top polluters, e.g., the U.S., China, Russia, Saudi Arabia, climate policy responses have been critically or highly insufficient^{1,2}

- Canada's policy responses, like those of many Western European nations and Australia, while more meaningful, are still considered to be insufficient
- Potential implications on economic prospects and vitality are a common barrier for nations to act on climate change

Some countries have displayed policies and actions that are making progress on emission reductions^{1,2}

- India is investing more in renewables than fossil fuels, and its rapid progress portends well for achieving the Paris target
- Morocco has already achieved 35% of its Paris target by incorporating the largest concentrated solar farm in the world
- Costa Rica already has 98% renewable electricity and aims for generation to be 100% renewable by 2021

1. Climate Action Tracker, n.d.; 2. The Independent, 2019

Exhibit: Current Policies vs. Need

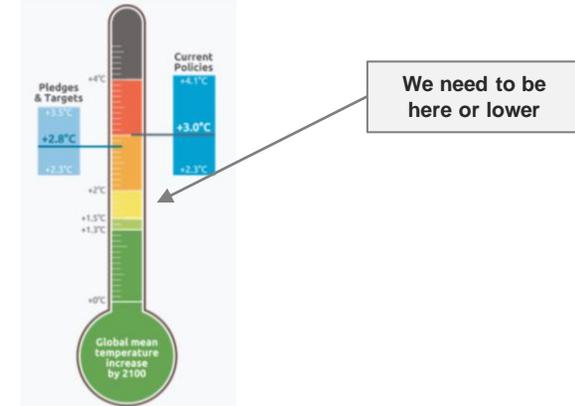
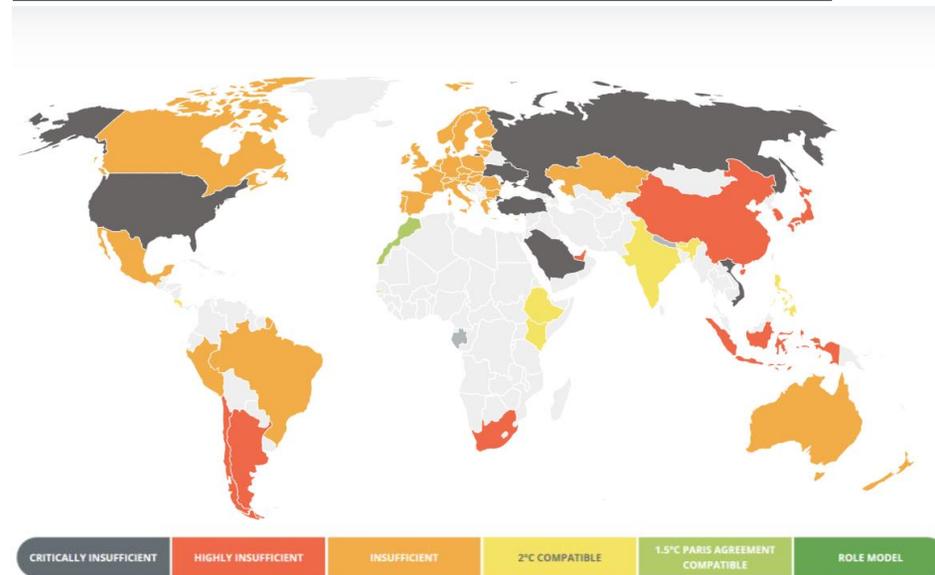


Exhibit: Assessment of Climate Policy Responses



Source: Climate Action Tracker, n.d.

Many climate policies focus on reducing emissions in specific sectors

Mandates, subsidies, incentives & strategic focus advance both climate and economic objectives

Sector specific climate policies can vary in nature but generally have targeted objectives for reducing related emissions while ensuring acceptable economic impacts*

Transportation: Increase fuel efficiency, reduce vehicle emissions and offer alternative transportation options

- Japan's Top Runner Program, Sweden's environmental zones, France's Bonus-Malus feebate program, EU's focus on hydrogen mobility

Electricity: Increase share of fossil-free generation

- China's clean emission standards and clean energy targets, Germany's feed-in tariffs, UK's RIIO

Buildings & Appliances: Decrease energy use and encourage fossil-free energy usage

- Mexico's national energy efficiency standards, Japan's ENE-FARM, California's Title 24, Mass.'s Alternative Energy Portfolio Standard

Industry: Industrial energy efficiency policies reduce emissions & improve energy use

- China's rebates for energy efficient equipment and top 10,000 program, The Netherlands' energy efficiency benchmarking covenant, special tax breaks in Denmark, U.S. Superior Energy Program

Targeted Investments: Calculated investments to develop emission free sectors

- Morocco's renewable energy goals, India's tax benefits for wind and solar, South Korea's national prioritization of hydrogen, China's renewables subsidies

* Considerations for acceptable economic impacts include the distributional impacts of the policies (i.e., who will bear the cost) and whether policies will be subsidized (e.g., through rebates or tax benefits) or will pay for themselves (e.g., feebates)

Note: Further information on policies available in the 'Policy Benchmarking' Appendix

Exhibit: Sector Specific Policies used Around the World - Samples

	 MANDATES	 SUBSIDIES	 INCENTIVES	 STRATEGIC FOCUS
Transport				
Electricity				
Buildings & Appliances				
Industry				
Targeted Investments				

Note: **Mandates** are actions taken by government and officially require certain behaviors from economic actors; **Subsidies** are typically grants of funds that government provide to boost economic activity; **Incentives** aim to attract more economic activity by making it less expensive to operate. **Strategic Focus** is typically a strategic decision taken by government to enable a certain sector, technology, etc.

Some climate policies are broad based enablers to encourage innovation

Such cross-sector policies advance climate objectives using economic principles

Broader based “cross-sector” climate policies encourage behavioral changes through economic pricing, R&D structures, and financing of commercialization endeavors

Carbon Pricing: Encourage emissions-reducing behavior and push investments to lower carbon options. Carbon pricing serves as an economic signal to reduce emissions, it can come in two forms

- Carbon tax, a set price per ton of CO₂ charged to emitters: robustly used in Nordic countries, prices ranging from \$25 to \$170 per tonne
- Cap and trade fixes the total amount of allowable emissions: EU has an emissions trading scheme; the U.S. has two schemes, the northeast electricity scheme, RGGI, and a broader based system in California; China is developing a cap and trade system for its power sector to start in 2021

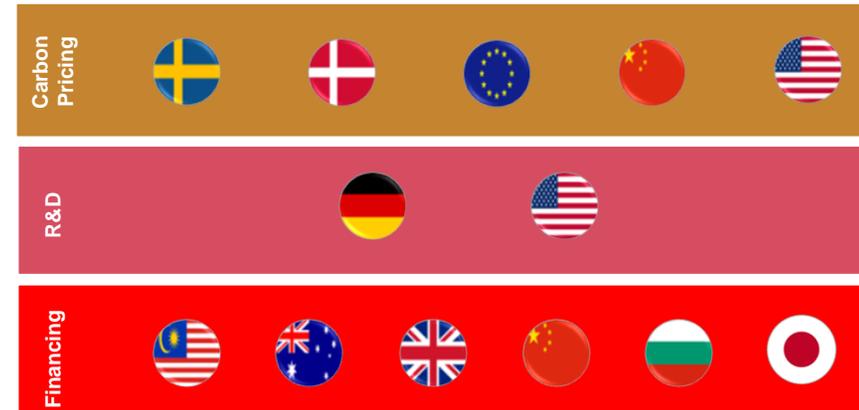
Research and Development: Leadership in reducing emissions requires government role in early stage basic & applied research traditionally not economic for industry

- Basic research: The U.S. Advanced Research Projects Agency–Energy is modeled after DARPA and focuses on funding research projects that are too early to attract private sector funding
- Applied research: Germany’s Fraunhofer-Gesellschaft focuses on immediate, applicable results and has delivered projects in renewable energy, electricity markets and infrastructure, and energy transition

Financing: Innovative approaches to financing growth in low emission industries by reducing the cost of risk

- Green Banks in U.S., UK, Australia, Japan and Malaysia, Bulgarian energy efficiency and renewable sources fund, Innovation Network Corporation of Japan, green bond issuances across the world

Exhibit: Cross Sector Policies used Around the World - Samples



Note: Further information available in the 'Policy Benchmarking' Appendix

Policy Levers: Many global climate policies may be suitable for Ontario

Enabling policy frameworks must be diverse & require participation from government and business

Selective climate-related policies are being pursued around the world

Most climate policy measures and barriers reflect economic implications

In response to Paris, policy actions are being taken globally to address climate change

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Many successful climate policies focus on reducing emissions in specific sectors

- Mandates, subsidies, incentives & strategic focus advance both climate and economic objectives

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- Several jurisdictions deploy carbon pricing, R&D, and financing policy tools to advance climate objectives

Climate policy measures and economic advancement must move forward hand in hand

Economic benefits of Ontario's policy responses can be augmented through design principles and collaboration

Ontario's climate policy framework can be optimized to enhance growth

Canada and Ontario are proactively responding to climate change

- Canada has developed overarching policy objectives and commitments
- Canada and Ontario have taken synergistic sector specific climate change policies
- Canada has taken cross-sector actions, which Ontario has not felt a need to replicate

Design principles exist to guide climate policy development

- Successful climate policies gain long term buy-in and benefits

Design principles and lessons highlight individual policy success factors

Applying design principles and lessons to Ontario's climate policy ingredients would enhance economic growth

Implementation implications of climate policy and opportunities today encourage collaboration

Climate policy is a complex challenge for Governments

- Business risks are now being dominated by environmental issues

Success entails government & corporate leadership playing complementary roles

The imperative of the post COVID-19 recovery can align government policy and business interests

- The conditions exist to seize the economic opportunity of climate action

The pandemic environment provides an opportunity to accelerate climate objectives and economic growth through private/public collaboration

Canada and Ontario are proactively responding to climate change

Respective climate plans provide broad policy objectives and commitments

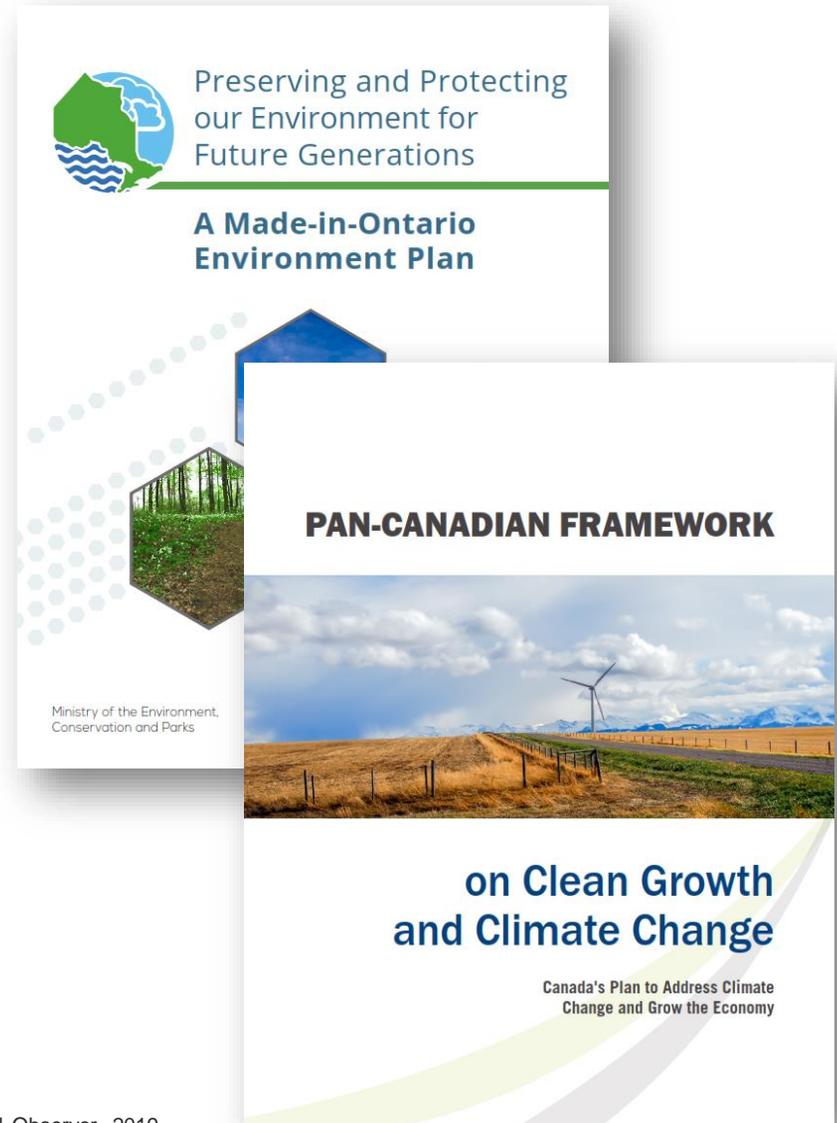
Both governments supported Paris

- Federal government has set an emissions target of 30% below 2005 levels by 2030¹
- Ontario government matched this target for its own emissions in 2018²
- Canadian government also has set a target for 2050 of 80% below 2005 emission levels¹
 - Ontario has no explicit target set for 2050²

Both governments have climate plans

- Ontario has its Made-in-Ontario climate plan
- Canada is incrementally implementing its Pan-Canadian Framework on Clean Growth and Climate, its overarching strategy for reducing emissions, adopted in 2016¹
 - The federal government has also pledged a net-zero target by 2050, with additional 5-year targets set by an independent committee of experts, but it is not yet in law³

Exhibit: Made-in-Ontario Plan and Pan-Canadian Framework



1. Climate Action Tracker, n.d.; 2. Ministry of the Environment, Conservation and Parks, 2018; 3. National Observer, 2019

Canada and Ontario have taken many sector specific policy actions

Most actions are yielding synergistic incentives

Sector specific climate and energy policies have also been developed in Canada and Ontario

Transportation

- Sales targets for ZEV passenger vehicles, e.g., 100% by 2040,¹ Federal carbon pricing benchmark, clean fuel standard for all modes of transportation,² more stringent GHG emission standards for heavy duty vehicles,³ allocation of \$300 million to support consumers and businesses purchase ZEVs,⁴ and investments in alternative fuel infrastructure development.⁵ Ontario has wound down supports but offers a clean electricity system pricing system favourable to EVs⁶

Electricity

- Canada, a member of the Powering Past Coal Alliance, adopted performance standards on coal and natural gas-fired power stations in December 2018, which will ensure it meets its 2030 coal phase-out date.² Ontario phased out coal years ago

Buildings & Appliances

- Updated model building codes for energy efficiency and set energy-efficient appliance standards,⁷ introduced the energy saving rebate program funded with \$200M over 2 years,⁸ supports building retrofits through the Low Carbon Economy & Climate Action Funds.⁷ Ontario retains conservation objectives for both electricity and natural gas⁹

Industry

- Canada has implemented an output based pricing system (OBPS) with its carbon tax to incent industrial consumers to produce more efficiently.² Ontario has adopted it, with its own OBPS design on hold

Targeted Investments

- A Federal Hydrogen Strategy,¹⁰ the Low Carbon Economy Fund for specific projects (e.g., fuel-saving trucking in Manitoba, biomass heating in Yukon, renewable HVAC in NB),⁷ and Canada's SMR Roadmap,^{11,12} Ontario has signed SMR MOUs with several provinces¹³

1. Transport Canada, 2020; 2. Government of Canada, 2019c; 3. Environment and Climate Change Canada, 2018; 4. Government of Canada, 2019a; 5. NRCAN, 2020a; 6. Strapolec, 2020; 7. Government of Canada, 2020a; 8. Government of Canada, 2020d; 9. Ministry of Energy, Northern Development and Mines, 2019; 10. NRCAN, 2020b; 11. Canadian SMR Roadmap, 2018; 12. Government of Canada, 2020c; 13. WNN, 2020

Exhibit: Domestic Sector Specific Policies - Samples

	MANDATES	SUBSIDIES	INCENTIVES	STRATEGIC FOCUS
Transport	ZEV Sales targets, Clean Fuel standard, HDV emission standards, EV rebates, Hydrogen infrastructure funding			
Electricity	Part of Powering Past Coal Alliance, will phase out coal by 2030			
Buildings & Appliances	Updated building codes, energy saving rebates for appliance and support for building retrofits			
Industry	Availability of output based pricing system for industrial customers to reduce carbon tax			
Targeted Investments	SMR Roadmap, Low Carbon Economy Fund, Federal Hydrogen Roadmap			

Canada has taken several cross sector climate policy actions

Ontario's policies leverage outcomes of federal programs

Cross-sector policies have also been utilized

Carbon Pricing

- Canada's carbon tax¹ implemented by the Federal Government
 - Carbon tax is not applied in cases where provincial governments have equivalent or greater carbon price in place, including Quebec's cap and trade market
 - Has two components: output-based pricing for large industry and a fuel charge based on CO₂ content for everyone else
- The carbon tax is controversial in many provinces but is currently applied in Ontario²
 - Ontario canceled its cap and trade market in 2018 which used the proceeds to fund various clean projects and R&D
 - Federal carbon tax gives a flat rebate to individuals

Research and Development

- Various R&D approaches are used for climate and clean growth R&D³
 - Canada's \$155M Clean Growth Program for cleantech R&D in energy, mining, and forestry, establishment of an independent think tank \$4.7M in funding for climate science research
- Strategic Innovation Fund: Developed to spur innovation by providing funding for large projects over \$10M including clean tech⁴
 - \$2.3B in contributions across 67 projects and 67K jobs created, Includes R&D and commercialization (\$930M were invested in Ontario) and covers clean tech
- Ontario assumes 15% of the 2030 target will be achieved through innovation⁵

Financing

- Canada has developed an expert panel on sustainable finance⁶ and is in the process of developing an infrastructure bank that would use public money to incent private sector investment in infrastructure projects⁷
 - The latter expected to be capitalized with \$35B in public money⁷
- Ontario Carbon Trust to use \$350M of public funding to leverage private investment in commercially viable clean technology⁵
 - Ontario projected this to result in a 0.7 MT reduction in emissions by 2030, or 4% of reductions for its 2030 target⁵

Exhibit: Domestic Cross-Sector Policies - Samples

Carbon Pricing	Federal government implemented a carbon tax with option for other measures such as Quebec's Cap n Trade
R&D	Climate and clean growth programs, strategic innovation fund with clean tech as one of the focus areas
Financing	Sustainable finance panel, international climate finance commitments, Canadian infrastructure bank

1. Government of Canada, 2020e; 2. CBC News, 2019; 3. NRCAN, 2019b; 4. Innovation, Science and Economic Development Canada, 2020; 5. Ministry of the Environment, Conservation and Parks, 2018; 6. Environment and Climate Change Canada, 2019; 7. Evergreen and Coalition for Green Capital, 2017

Design principles exist to guide Ontario's climate policy development

Successful climate policies follow a set of design principles to gain long term buy-in & benefits

Impactful climate policies consider the best practices for and synergies between economic signals, performance standards, and R&D support¹

■ R&D Support:

- Create long term commitments for research success
- Use peer review to set research priorities
- Use stage-gating to remove underperforming projects
- Concentrate R&D by type or subject to build critical mass
- Make high-quality public sector facilities and expertise available to private firms
- Protect IP without stymieing innovation
- Ensure companies have access to STEM talent

■ Performance standards

- Provide long term certainty of the standards
- Build in continuous improvement
- Focus standards on outcomes, not technologies
- Prevent gaming via simplicity and avoiding loopholes

■ Economic signals

- Create a long term goal and provide business certainty
- Price in the full value of all negative externalities for each technology
- Eliminate unnecessary soft costs e.g., need for paperwork for rebates
- Reward production not investment in clean energy technology
- Provide economic signal closer to the pinch point
- Ensure economic incentives are liquid

The applicability of principles depends on maturity and market penetration within the product lifecycle of solutions available

1. Harvey, Orbis, and Rissman, 2018

Exhibit: Climate Policy Design Principles & Synergies

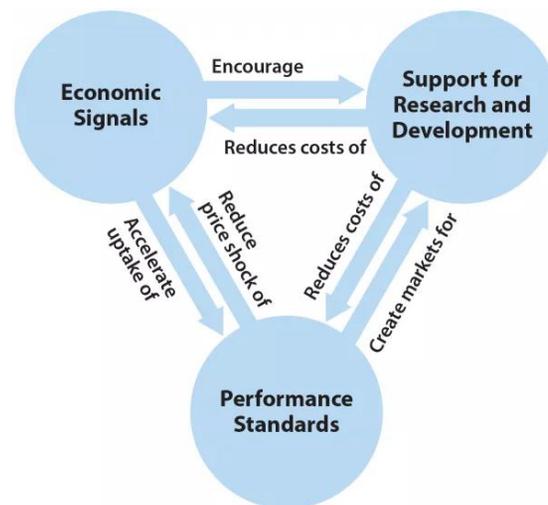
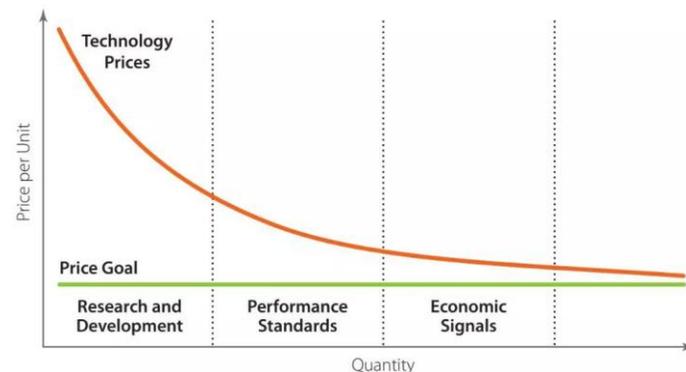


Exhibit: Relevance of Policy Type to Product Lifecycle



Design principles and lessons highlight policy success factors

Application of design principles and lessons learned can vary

Several design principles and learnings can be applied across policy types, e.g.,

- Stable policies and long term commitments are crucial for investors, manufacturers and consumers
- Targets, standards and objectives can create action
- Policies should incorporate continuous improvement
- Policies should be designed to be simple, and without loopholes that can create gaming
- Financial incentives should be liquid to the degree possible so that they can be used for working capital if needed

Other principles and learnings have specific applicability to policy types and/or domestic environments, e.g.,

- Invest in strategically important technologies early in their development to create competitive advantage
- Maximize existing low-carbon electricity assets
- Make building standards known well before implementation
- Financing and R&D should reduce barriers for entry
- Carbon pricing should be based on thoughtful design incorporating scientifically grounded emission targets

Exhibit: Policy Types and Success Factors

Sector specific policies	Transport	<ul style="list-style-type: none"> ■ Design for long term stability ■ Coordinated with related industry policies
	Electricity	<ul style="list-style-type: none"> ■ Emphasize continuous improvement ■ Maximize existing low-carbon electricity assets
	Buildings Appliances	<ul style="list-style-type: none"> ■ Make public years in advance ■ Ensure monitoring and enforcement
	Industry	<ul style="list-style-type: none"> ■ Enable education and technical assistance ■ Provide mandatory targets and equipment standards
	Targeted Investment	<ul style="list-style-type: none"> ■ Create strategic focus to develop competitive advantage ■ Make targeted investments early in development stage
Cross-sector policies	Carbon Pricing	<ul style="list-style-type: none"> ■ Refrain from being too cautious and generous ■ Incorporate scientifically grounded emission targets
	R&D	<ul style="list-style-type: none"> ■ Enable a pipeline of new technologies ■ Smart policies support pre-revenue & in-market techs
	Financing	<ul style="list-style-type: none"> ■ Provide capital at low cost, & increase liquidity ■ Enable access to funding and place appropriate

Applying design principles and lessons to Ontario's climate policy ingredients would enhance economic growth

Note: Further information available in the 'Policy Recommendations' Appendix

Climate policy is a complex challenge for Governments

Business risks are now being dominated by environmental issues

Stabilization of the climate is a global public good.¹ No single individual, business or group can solve the problem, but all can benefit

- Government intervention is required

Like many other areas of state intervention, environmental policy requires internalizing externalities and providing public goods

- However, additional complexity arises from the irreversibility of climate change, its intergenerational impacts, complex interdependencies, non-marginal nature, etc.²
- Some business interests will rent seek within policies while being developed
- These factors create the need for a nuanced and sophisticated approach to climate related intervention

Climate change is creating risks for businesses

- The environment is increasingly being recognized as a top risk both in terms of likelihood and impact

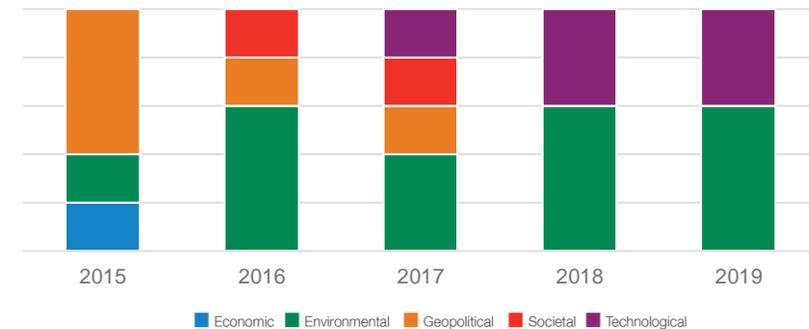
Approaches to resolve climate change are increasingly being recognized as involving roles for both government and business

Exhibit: Complexity Considerations for Climate Policy



Source: Oxford Review of Economic Policy, 2010a

Exhibit: Global Perceived Business Risks in terms of Likelihood
(Proportion of top 5 global risks)



Source: WEF, 2019

1. S. Niggol Seo, 2017; 2. Oxford Review of Economic Policy, 2010a

Success entails govt & corporate leadership playing complementary roles

The government mandate for climate policy and the role of business leadership

The two policy extremes are non-starters

- Complete dependence on government or business fails
- An appropriate model for climate intervention is in the middle:
 - A collaborative approach between govts and corporations

Government intervention in climate policy is required as investments are too long term and non-marginal, and carry international political considerations¹

- Systematic interventions such as setting rules and targets, ensuring fair implementation and providing appropriate signals in the form of regulations are needed
- Targeted actions can complement rule setting and implementation, by providing support for specific strategic pursuits, e.g., research and development in FCEVs

Businesses see that reducing environmental impact can be beneficial for consumers and investors

- Business leaders can take responsibility with an integrated, strategic approach to climate change & embedding relevant incentives, structures & disclosure requirements
- Organizations have recognized the importance of enabling long term business resilience through climate change tools
 - e.g., Canada saw 11 green bond issuances in 2018 totaling \$6.3B²

Exhibit: Climate Change Approaches – The two extremes

Complete dependence on government	Complete dependence on businesses
Nationalizing environmental protection is challenging because countries rarely have the depth and quality of information required to instruct all the relevant agents to make appropriate decisions.	Leaving environmental protection to the free market and relying on notions of corporate social responsibility and altruistic consumers does not typically deliver optimal results.

Exhibit: Climate change – Role of Government and Business

Government mandate	Business responsibilities
<ul style="list-style-type: none"> ■ Set out overarching vision & objectives ■ Develop ‘rules of the game’, e.g., S&T policies, energy efficiency ■ Ensure fair and impartial implementation of rules ■ Build stability in the rules and do not change them retroactively ■ Take targeted actions that can create markets, spur innovation <ul style="list-style-type: none"> • Support R&D by funding cross-sector and targeted research, e.g., in Hydrogen, SMRs • Price externalities fairly across the system, e.g., Sweden³ • Make substantial investments, e.g., E.U.s 750B Euro recovery plan⁴ • Targeted funding for public infrastructure • Develop public finance mechanism and long term signals to investors • Provide access to clean energy given its foundational importance 	<ul style="list-style-type: none"> ■ Ensure accountability and incentives: Climate should be a governance duty and management should have related incentives ■ Embed structure: Climate discussions embedded into existing board & management committee structures e.g., sustainability comm ■ Incorporate climate risks and opportunities: Material risks, opportunities & related scenarios should be embedded in corporate strategy ■ Report and disclose: Adequate reporting and disclosure, including voluntary climate-related reporting should be integrated ■ Measures to further climate objectives: Utilize existing opportunities (e.g., ESG) and innovate to create new opportunities

1. Oxford Review of Economic Policy, 2010a; 2. RBC Capital Markets, 2019; 3. Carbon Pricing Leadership Coalition, 2018; 4. World Resources Institute, 2020

The imperative of the post COVID-19 recovery can align interests

The conditions exist to seize the economic opportunity of climate action

The public health measures necessary to control the COVID-19 pandemic have caused an economic slowdown

- The IMF has declared the “Great Lockdown” to be the worst recession since the Great Depression, and projects global growth to fall by 3% through 2020¹
- Lockdown measures, while necessary, have meant economic hardship for many Ontario workers and businesses²
 - Ontario shed over 1 million jobs between March and June³
 - Manufacturers have been especially affected, as they cannot shift to remote-work business models⁴
 - ◆ Two-thirds of manufacturers have witnessed a drop in output greater than 25%⁵

In Ontario and globally, stakeholders see an opportunity to marry climate objectives with economic recovery

- World financial institutions agree that green recovery is necessary
 - The IMF is calling for countries to implement green recovery plans⁶
 - The World Bank has laid out a green stimulus framework⁷
 - A survey of top economists found that environmentally beneficial policies were just as good as other policy options⁸
 - A McKinsey analysis found that an EUR 75-150 billion stimulus package focusing on environmental benefits would have returns of 40% value-added, and cut emissions by 15-30%⁸
- Stakeholders in Ontario recognize the need to pair economic stimulus with climate goals
 - Pollution probe is advocating for stimulus that can address climate change and pollution while creating the conditions for sustained success⁹
 - The Ontario Chamber of Commerce is calling for clean energy innovation, to drive economic growth, job creation, and climate benefits¹⁰
 - The PWU is calling for investments in zero-carbon energy and transportation solutions¹¹
 - The Nuclear Innovation Institute has pledged to help nuclear lead the economic reconstruction that will follow the pandemic¹²
 - The CME is calling for investment to improve companies’ access to newer, less emitting technologies⁵

The pandemic environment provides an opportunity to accelerate climate objectives and economic growth

Sources: 1. IMF, 2020b; 2. Ontario Chamber of Commerce, 2020b; 3. CTV News, 2020; 4. CME, 2020a; 5. CME, 2020b; 6. IMF, 2020a; 7. World Bank Blogs, 2020; 8. McKinsey & Company, 2020; 9. Pollution Probe, 2020; 10. Ontario Chamber of Commerce, 2020a; 11. PWU, 2020; 12. Nuclear Innovation Institute, 2020

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APPENDIX: POLICY BENCHMARKING

Climate policies take several forms and can enable a cohesive response

Sector specific policies: Transportation

Sector specific and cross-sector climate and energy policies are needed

Transportation

Increasing fuel efficiency, reducing vehicle emissions and offering alternative transportation options



MANDATES

- Vehicle performance standards - Japan's Top Runner Program for passenger vehicles has successfully improved efficiency by identifying the most fuel-efficient vehicle in each weight class, using it to set the standard and offering tax breaks to manufacturers meeting the standard early¹
- Sweden's environmental zones allow municipalities to mandate ZEVs, FCEVs, or highly fuel-efficient vehicles in certain places²



SUBSIDIES

- China's plan to become the world leader in EV technology and manufacturing include large subsidies for EVs sold in the domestic market, installing charging stations in major cities and exempting owners from vehicle ownership taxes. In 2018, China had 1.1M in EV sales more than 55% of all EV sales globally³
- Japan offers subsidies for hydrogen LDV & on transit buses. It also offers capital & operating funding to support installation and operation of H2 fueling stations⁴
- Germany's clean truck procurement subsidies encourage a transition to lower emitting vehicles in the heavy goods transport. Vehicle buyers can choose between cheaper loans or direct grants of up to EUR 4,250 per truck⁵



INCENTIVES

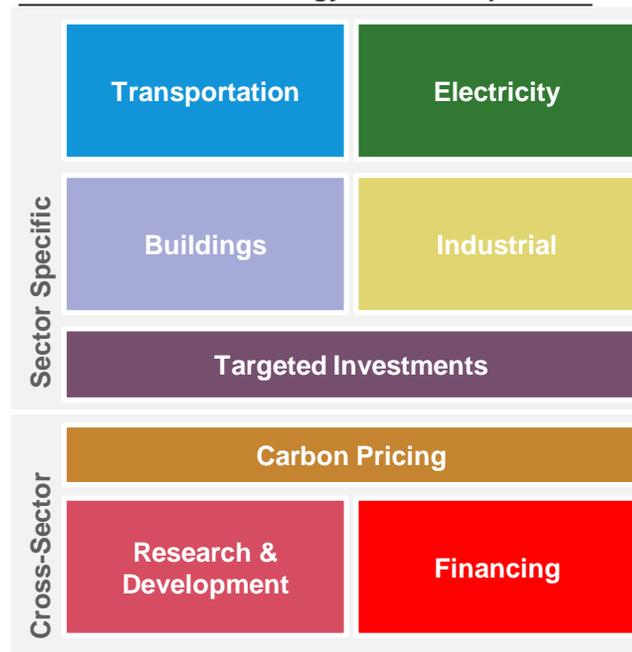
- California's Zero Emission Truck, Bus and Off-Road Vehicle and Equipment technology Program provides funding for R&D, pilots, and commercial implementation projects for zero (or near zero) emissions vehicles⁶
- France's Bonus-Malus feebate program imposes a fee on inefficient vehicles and provides rebates to efficient vehicles. It is technology and revenue neutral. It has successfully steered buyers toward vehicles that emit less CO2, encouraged development of new low-emission vehicle technologies, and accelerated retirements inefficient vehicles⁷



STRATEGIC FOCUS

- EU's Hydrogen Mobility Europe brings together Europe's most ambitious national hydrogen plans to create a pan-European network of hydrogen refueling stations, significantly expand hydrogen vehicles fleet and confirm technical & commercial readiness of FCEVs⁸

Exhibit: Climate & Energy Portfolio Options



1. Future Policy, n.d.; 2. IEA, 2019; 3. Marketwatch, 2019; 4. NRCAN, 2019a; 5. IEA, 2017; 6. US Department of Energy, n.d. a; 7. Adelphi & Ecofys, 2018.; 8. Hydrogen Mobility Europe, 2020

Climate policies take several forms and can enable a cohesive response

Sector specific policies: electricity, buildings and industrial

Electricity

Increasing share of fossil-free generation



MANDATES

- China's clean emission standards provide policy certainty and clean energy targets, which along other measures have helped China to develop the most renewable energy capacity of any country¹



SUBSIDIES

- Feed-in tariffs include guaranteed grid access, long-term purchase agreement and payments for renewable/clean generation, e.g., Germany's Euro 150 per MWh feed-in-tariff grew from 40MW in 2009 to 4,130MW in 2016²

Buildings

Decreasing energy use and encouraging fossil-free energy



MANDATES

- California's Title 24 was established in 1978 to provide a single coordinated, comprehensive building energy standard. It has saved more than \$74 billion in electricity bills & helped keep California's per capita electricity usage stable over four decades³
- Some of California's municipalities have mandated all-electric new construction—that is, gas won't be connected even for cooking purposes. Two of the state's big utilities, PG&E and Southern California Edison are in support of a statewide mandate⁴
- Mexico's national energy efficiency standards: Mexico intentionally chose stringent mandatory appliance standards and expanded the market for Mexican manufacturers, e.g., Refrigerator exports to the U.S. "increased 9-fold from 401 million U.S. dollars to about 3.7 billion U.S. dollars" per year from 2000 to 2014, whereas the domestic Mexican market only doubled⁵



SUBSIDIES

- United Kingdom has a feed-in tariff funded through the tax base for heat produced through renewable sources, including biomass boilers and electric heat pumps⁶
- Japan is the leading country in developing and deploying fuel cell micro-cogeneration. The ENE-FARM program provides for a hydrogen-based combined heat and power (CHP) system that generates hot water and home heating for households, in addition to the ability to generate power through the use of a fuel cell. The project has received steady financial support from the government⁷



INCENTIVES

- Massachusetts's Alternative Energy Portfolio Standard allows renewable heat producers to generate alternative energy certificates, which can be sold to emitters to meet compliance obligations. The revenue stream makes renewable heating attractive⁸

Industrial

Industrial energy efficiency policies reduce emissions & improve energy use



INCENTIVES

- United States' Superior Energy Performance Program is a voluntary program to provide assistance and give recognition to industries that improve fuel efficiency. To participate, a company must implement an energy management system, comply with a standard set ISO and demonstrate at least 5-15% energy saving depending on track record⁹

1. PV Tech, 2017; 2. Fraunhofer Institute, 2020; 3. California Energy Commission, 2015; 4. Forbes, 2019; 5. Berkeley National Laboratory, 2015; 6. Eco Power Supplies, n.d.; 7. Pace Energy, 2019; 8. Solid Fuels Sub-Working Group, 2019; 9. U.S. Department of Energy, n.d. b

Climate policies take several forms and can enable a cohesive response

Targeted policies and carbon pricing



INCENTIVES

- China's "Top-10,000 Program," aims to cover 15k industrial enterprises (along with buildings and large transportation) and 2/3rds of the national energy consumption. It provides training programs for energy managers, energy audits and an energy use reporting system, specific energy use reduction targets by province, both financial incentives and financing support for energy efficiency retrofits. The program has been credited with saving 309 million tons of coal equivalent or 121 percent of the program's target from 2010-2014¹

Targeted Investments

Calculated investments to develop emissions free sectors



INCENTIVES

- India provides a variety of tax benefits for wind and solar generation. Profits from sale of power generation are exempt from income tax for the first 10 years of the project's life and generation is exempt from inter-state transmission charges or taxes on transmission losses for the first 25 years of the project's life. GST on components is limited to 5% compared to the highest rate of 28%²



STRATEGIC
FOCUS

- Japan has developed an economy-wide vision of using hydrogen for vehicles, houses, and power production. It is estimated that Japan spent \$115 million on hydrogen and fuel cell R&D in 2018³
- South Korea's Investments are building private capacity. In 2018, the hydrogen economy was identified as one of the country's three drivers of growth. Government investments in Doosan, a Korean conglomerate have allowed it to build manufacturing capacity and become a leading supplier of industrial scale stationary fuel cells. Further, to encourage fuel cells Korea's Renewable Portfolio Standard recognizes fuel cell systems as renewable regardless of the type of energy used³
- EU's Fuel Cell and Hydrogen Joint Undertaking (FCH JU) is a public-private partnership that brings together government, research organizations, and the private sector to develop and deploy fuel cell and hydrogen technologies. Between 2008-2018, over €1.0 billion in EU funding was matched by the private sector and spent on more than 200 hydrogen and fuel cell projects³

Carbon Pricing

Encourage emissions-reducing behavior and pushing investments to lower carbon options



ENABLERS

- Carbon pricing serves as an economic signal to reduce emissions, it can come in two forms
 - ◆ Carbon tax, a set price per ton of CO₂ charged to emitters. Carbon taxes have been most robustly used in Nordic countries, range from \$25 to \$170 per ton⁴
 - Output-based pricing is a modification of carbon tax that charges for carbon tax based on emitters output above or below a benchmark⁵
 - ◆ Cap and trade fixes the total amount of allowable emissions while the price of emitting is determined through the buying and selling of emitting allowance allowances, e.g.,
 - EU has had an Emissions Trading Scheme since 2005 which covers 45% of EU emissions⁶
 - California and Quebec have been in a joint economy-wide cap and trade market since 2011 in the Western Climate Initiative⁷
 - U.S.-based Regional Greenhouse Gas Initiative, a cap and trade market for the power sector, has grown to 10 states since 2007⁸
 - China is developing a cap and trade system for its power sector to start in 2021, which would become the world's largest carbon market even though it is just limited to the power sector⁹

1. Ifri, 2018; 2. India Briefing, 2018; 3.NRCan, 2019a; 4. American Council for an Energy-Efficient Economy, 2016; 5. Government of Canada, 2020e; 6. EU, 2020; 7. WCI Inc., 2020; 8. RGGI, 2020; 9. Carbon Brief, 2018

Climate policies take several forms and can enable a cohesive response

Cross sector policies: research and development and financing

Research & Development

Reduces costs of all the policies and provides opportunities for new low-carbon technologies



ENABLERS

- Leadership in reducing emissions requires a concerted effort in basic and applied research
 - ◆ Basic research: The U.S. Advanced Research Projects Agency–Energy is modeled after DARPA and focuses on funding research projects that are too early to attract private sector funding but have the potential to rapidly advance and achieve commercialization¹
 - Advances have been achieved in grid-scale and flow batteries, electric vehicle systems, power flow and grid operations, power electronics, advanced materials, and more
 - ARPA-E awards also awards funding for futuristic ideas to the National Renewable Energy Laboratory, which is dedicated to R&D and commercialization of renewable energy and energy efficiency technologies²
 - ◆ Applied research: Germany’s Fraunhofer-Gesellschaft is a network of 74 research institutes throughout Germany. It focuses on immediate, applicable results. It helps to fill the budget gap between basic research and commercialization (the “valley of death”)³
 - 30% of the budget comes from the public sector and 70 percent is derived from contract research done for public or private entities. Relevant projects have been delivered in renewable energy, electricity market and infrastructure, and energy transition

Financing

Innovative approaches to financing growth in low emission industries



ENABLERS

- Green Banks are public institutions with a mandate to use public money to stimulate private investment in commercially viable technologies (as opposed to early stage innovation) for energy efficiency, clean energy, and other methods of decarbonization⁴
 - ◆ Green banks seek to reduce energy costs for ratepayers, stimulate private sector investment and economic activity and expedite the transition to the low-carbon economy
 - They vary in many respects including the mechanisms for leveraging public funds, the sources of both public and private funding, and the sectors targeted for investment, U.S., U.K, Australia, Japan and Malaysia have created national green banks
 - Green Banks have been most successful at mitigating barriers of high up-front costs for energy efficiency & clean energy investments, e.g., Michigan Saves uses public funds exclusively as a loan loss reserve (LLR) to de-risk private financing & lower loan interest rate
- Green bonds (unrelated to Green Banks) are bonds which are dedicated to funding projects which are environmentally friendly⁵
 - ◆ There are a variety of certification standards for green bonds that have different criteria for what kinds of projects qualify
 - CBI is an international certification scheme for green bonds
 - ◆ They function as a signal to investors that they’re investing in an environmentally responsible fashion
- Japan launched the Innovation Network Corporation of Japan, an investment company that is a \$1.9 billion collaboration between the public and private sectors to achieve advances in energy, infrastructure, and other high-technology sectors. The Japanese government invested 95 percent of the upfront capital. Example investments include laminated lithium ion batteries, smart meters, etc.⁶

1. APRA-E, 2016; 2. NREL, n.d.; 3. Fraunhofer Institute, n.d.; 4. American Council for an Energy-Efficient Economy, 2016; 5. Environment and Climate Change Canada, 2019; 6. Innovation Network Corporation of Japan, 2020

Canada has been at the forefront in reacting to climate change

Canada and Ontario policy actions taken to date – Sector specific

Transportation



MANDATES

- Canada has adopted sales targets for zero-emissions passenger vehicles of 10% by 2025, 30% by 2030 and 100% by 2040. To reach full decarbonization of road transport worldwide by 2050, the last fossil fuel car should be sold before 2035¹
- Federal carbon pricing benchmark, clean fuel standard for all modes of transportation - Includes funding to develop and implement heavy-duty vehicle retrofit and off-road regulations, as well as a clean fuel standard²
- New Federal regulations also establish more stringent GHG emission standards for heavy duty vehicles²



SUBSIDIES

- In the 2019 Federal Budget, the Canadian government allocated \$300 million CAD to support consumers and businesses purchase zero-emissions vehicles³



STRATEGIC FOCUS

- Electric Vehicle and Alternative Fuel Infrastructure Development Initiative¹: provided \$96.4M funding for 837 EV fast chargers, 23 natural gas refuelling stations and 8 hydrogen refuelling stations along highways⁴
 - 2019 Budget added \$130M

Electricity



MANDATES

- Clean energy standards: Canada, a member of the Powering Past Coal Alliance, adopted performance standards on coal and natural gas-fired power stations in December 2018, which will ensure it meets its 2030 coal phase-out date⁵

1. Transport Canada, 2020; 2. Environment and Climate Change Canada, 2018; 3. Government of Canada, 2019a; 4. NRCAN, 2020a; 5. Government of Canada, 2019c;

Canada has been at the forefront in reacting to climate change

Canada and Ontario policy actions taken to date – Sector specific (Cont'd)

Buildings



MANDATES

- Updated model building codes for energy efficiency which provinces can choose to adopt and has set energy-efficient appliance standards¹



INCENTIVES

- The Federal Government has introduced the energy saving rebate program funded with \$200M over 2 years. It provides consumers with a 25% rebate on select appliances²
- Supports building retrofits through the Low Carbon Economy Fund & Climate Action Incentive Fund¹

Industrial



INCENTIVES

- Through the output based pricing system, Canada has provided the opportunity for industrial consumers to reduce carbon tax by producing more efficiently i.e., reducing emissions per unit of production¹

Targeted Investments



STRATEGIC
FOCUS

- Nuclear - The SMR Roadmap⁶: NRCAN has brought together provincial and municipal governments, industry, indigenous peoples, and other key stakeholders to create a Canadian SMR roadmap, this resulted in 53 recommendations for Government, utilities, civil society, regulators, and others. Stakeholders convening for an SMR Action Plan in Fall 2020³



INCENTIVES

- Low Carbon Economy Fund: Canada's Low Carbon Economy Fund for specific projects (e.g., fuel-saving devices for Trucking in Manitoba, biomass heating in Yukon, renewable HVAC in St John, NB)¹

1. Government of Canada, 2020a; 2. Government of Canada, 2020d; 3. Government of Canada, 2020c

Canada has been at the forefront in reacting to climate change

Canada and Ontario policy actions taken to date – Cross sector

Carbon Pricing



ENABLERS

- Canada's carbon tax¹: Federal Government has implemented a Carbon tax: In cases where provincial governments have equivalent or greater carbon tax in place, the federal carbon tax is not applicable
 - Has two components: output-based pricing for large industry and a fuel charge based on CO₂ content for everyone else
- Ontario's carbon pricing system²: Ontario has its own Output-based carbon pricing system for industry that it has chosen not to implement until the federal fuel charge is removed

Research & Development



ENABLERS

- Climate and clean growth R&D³
 - Canada's \$155M Clean Growth program for cleantech R&D in energy, mining, and forestry
 - Establishment of Canadian Institute for Climate Choices as an independent think tank funded by the Government
 - Advancing Climate Change Science in Canada program, \$4.7M in funding for Climate Science Research
- Strategic Innovation Fund: Developed to spur innovation by providing funding for large projects over \$10M⁴
 - Has announced \$2.3B in contributions across 67 projects and 67K jobs created
 - Includes R&D and commercialization (\$930M were invested in Ontario) and covers clean tech

Financing



ENABLERS

- Sustainability and financing: Canada has developed an expert panel on sustainable finance which have developed recommendations for mobilizing Canada financial services industry⁵
- Canada has an international climate finance commitment of \$2.65B from 2015-2020⁶
- Infrastructure Bank: Canada is in the process of developing an Infrastructure Bank that would use public money to incent private sector investment in infrastructure projects⁷
 - Expected to be capitalized with \$35 billion in public money
 - Funding structure requires investments in infrastructure which provide positive cash flows to pay back Infrastructure Bank loans, and not projects which generate economics benefits without a specific cash flow, e.g., not suitable for roads and highways

1. Government of Canada, 2020e; 2 Ministry of the Environment, Conservation and Parks, 2018; 3. NRCan, 2019b; 4. Innovation, Science and Economic Development Canada, 2020; 5. Environment and Climate Change Canada, 2019; 6. Government of Canada, 2020b; 7. Evergreen and Coalition for Green Capital, 2017

APPENDIX: POLICY RECOMMENDATIONS

Design principles and lessons highlight policy success factors

Applying design principles and lessons learned – Sector specific policies

Policy Type and Success Factors	Considerations for Mandates, Subsidies, Incentives, and Strategic Focus
<p>Transportation</p> <p>Transportation policies must be designed for the long term horizon for both manufacturers and consumers Any measures applied must ensure that regressive nature of fees doesn't unduly impact lower income users Policy support should be coordinated with related and interdependent industry policies (e.g. hydrogen)</p>	<ul style="list-style-type: none"> • Mandates: Design standards which force manufacturers to either stop selling their most polluting vehicles or invest in better performing ones • Subsidies: Ensure subsidies keep up with technology & phase them out as tech matures • Incentives like feebates & pricing in negative externalities can be useful to take vehicles off the road, limit usage of inefficient vehicles and purchase higher efficiency vehicles • Strategic focus on transportation infrastructure should consider major corridors (e.g. Windsor-Toronto-Montreal) where ZEV charging stations can support passenger traffic and long-haul freight operations
<p>Electricity</p> <p>Focus on outcomes not technologies and emphasize continuous improvement Maximize existing low-carbon electricity assets by utilizing storage and energy efficiency to flatten demand curve and use excess clean energy during peak hour</p>	<ul style="list-style-type: none"> • Mandates: Clean energy portfolio standards can enable lowest cost clean energy sources to flourish • Incentives: Feed-in tariffs minimize developer risks and stimulate growth for non-emitting technologies • Complementary policies such as how markets operate, utility business models and how to treat emitting generators should also be considered to improve the effectiveness of the system
<p>Buildings</p> <p>The best building and appliance standards are publicly known years in advance, are resistant to gaming, and have built in mechanisms to tighten standards over time Monitoring and enforcement is critical, can save energy and reduce emissions</p>	<ul style="list-style-type: none"> • Mandates: Consider future-proofing new buildings by ensuring designs are compatible with ZEV charging stations, hydrogen fuel supply for appliances, etc. • Subsidies: Subsidies / access to low cost capital can encourage turnover to more efficient components • Incentives: Ensure sufficient knowledge of green buildings design and construction through education and incentive programs
<p>Industrial</p> <p>Improving industry energy efficiency requires five types of policies delivered in combination: education and technical assistance, financing, financial incentives, mandatory targets and equipment standards</p>	<ul style="list-style-type: none"> • Incentives: Consider encouraging alternative fuel uses (e.g. hydrogen, electricity) for high-temperature heat in new industrial builds, retrofits for existing facilities, etc.
<p>Targeted Investments</p> <p>Strategic focus on specific industries tends to allow competitive advantage for nations Targeted investments are more appropriate for technologies earlier in their development stage as opposed to technology-neutral policies Important to keep outcome in mind, e.g., emissions reduction, job creation, energy security</p>	<ul style="list-style-type: none"> • Strategic Focus: Ontario and Canada can consider making SMRs, hydrogen, FCEVs, biomass, trucking infrastructure, etc. a strategic priority

Application for domestic policy environment

Applying design principles and lessons learned – Cross sector policies

Policy Type and Success Factors	Specific considerations
<p>Carbon Pricing</p> <p>The major limitation in carbon pricing has been too much caution. Taxes have been too modest and caps too generous, substantial political hurdles and limits to economic and tech forecasting have also contributed.</p> <p>Carbon pricing needs thoughtful design incorporating scientifically grounded emission targets and collaboration with other nations.</p>	<ul style="list-style-type: none"> • Targeted programs can make up for insufficiently high carbon prices • However, risk of gaps in policy, gaming, and forgoing potential benefits of carbon pricing exist with targeted carbon pricing
<p>Research and Development</p> <p>A pipeline of new technologies is crucial to meet the energy demand and expand the economy.</p> <p>Smart policies to promote R&D before reaching the market, and supporting policies such as IP protection after reaching the market are helpful.</p>	<ul style="list-style-type: none"> • It is important to pay particular focus to applied research, which can strengthen Canada and Ontario's technological prowess and attract R&D investments from the private sector, since R&D benefits significantly from the presence of reliable institutional buyers • Support industry-university linkages in clean technology areas, and promote the development of private spin-offs, especially in potentially important new industries (e.g. the hydrogen economy)
<p>Financing</p> <p>Financing to support climate efforts can come in many forms but the objective is to provide capital at low cost, reduce the risk, increase liquidity, ensure measures and enable access to funding</p>	<ul style="list-style-type: none"> • Recommendations from the panel on sustainable finance: Establish an authoritative source of climate information and decision analysis, clarify the scope of fiduciary duty in the context of climate change, include climate risk within regulation of Canadian financial services, expand green bonds and other forms of green investing. • In addition, a Green Bank division within the Canadian Infrastructure bank has been proposed by the Evergreen and Coalition for Green Capital. This fits well within its mandate given that typical Green Bank investments result in positive cash flows

Applying design principles and lessons to Ontario's climate policy ingredients would enhance economic growth