Ontario's Emissions and Long Term Energy Planning

The Waterloo Institute For Sustainable Energy

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STRATEGIC POLICY ECONOMICS

Ontario's Emissions and Long Term Energy Planning

Project Overview and Discussion Points

Perceived Challenge in 2016:

- Inputs were being sought for LTEP consultation submissions
- No data available on emission reduction implications for electricity

Syndicated peer-reviewed study inspired by Bob Chiarelli and John Godfrey

- Approached diverse Ontario energy system stakeholders
  - Natural gas distribution companies
  - Local distribution companies, Baseload energy providers
  - Emission reducing technology stakeholders/researchers

2016 Project Objectives:

- Identify Ontario stakeholder ideas for reducing emissions
- Quantify the associated cost of emission reduction
- Assess the electrification implications for Long Term Energy Plan
- Seek out alternative electricity system approach at much lower cost

Discussion Points

- Ontario's Emissions Targets
- Politics of "Charting a Course" vs "Value to Taxpayers"
- Buildings: Example of The Challenge
- Known solutions are expensive
- Electrification Implications
- Politics of "Popular" vs the Politics of "Cost"

Ontario's Emission Challenge

Ontario has legislated Greenhouse Gas (GHG) emission reduction targets.

Legislated CO_2 emission reduction targets

- 15% below the Province's 1990 emission level by 2020;
- 37% below 1990 levels by 2030;
- 80% below 1990 levels by 2050;

Under a "no climate policy" assumption, emissions were projected by the Ministry of Environment and Climate Change (MOECC) to be 176 Mt in 2030.

- The emission target for 2030 means 65 Mt of emissions must be removed from the projected level by 2030.

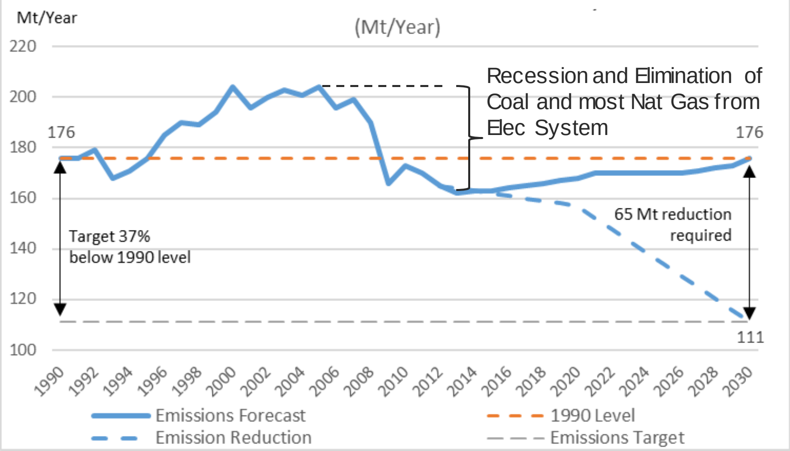
Background on Ontario's emissions

Emissions in Ontario are generated from six sectors.

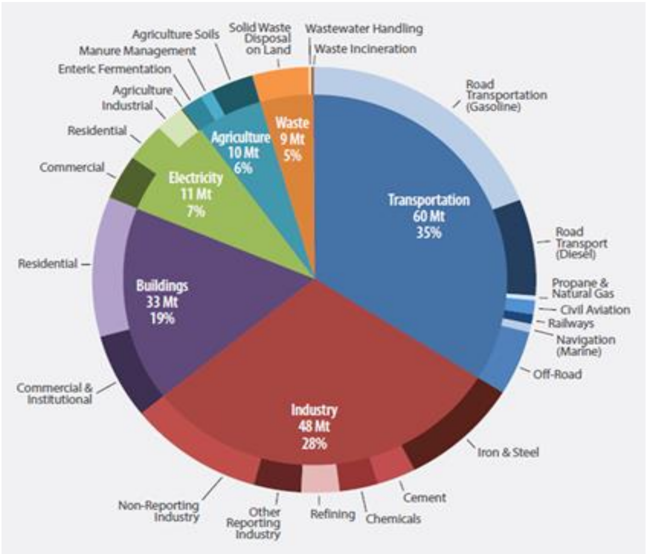
82% of the province's 171 million tonnes (Mt) of emissions came from three sectors:

- Transportation (60 Mt)
- Industry (48 Mt)
- Buildings (33 Mt)

MOECC Ontario Emissions Forecast



Ontario's 2013 Emissions



Source: MOECC Climate Change Strategy 2016

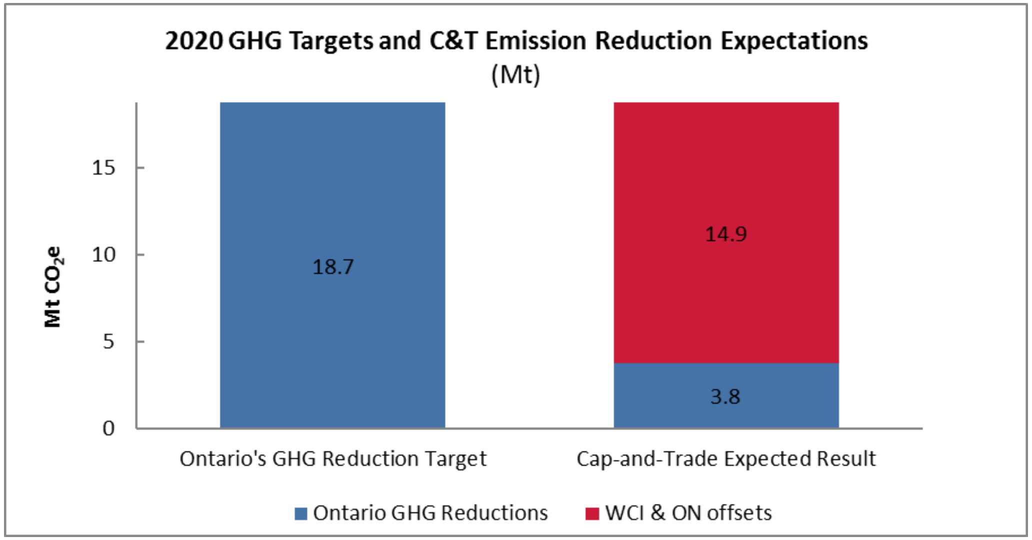
The Politics of "Charting a Course" vs "Value to 'Tax' payers"

→ Cap & Trade (C&T) program is not expected to achieve reductions

Auditor General: Cap & Trade program only "allows claim" of target achievement

- MOECC C&T Economic Assessment:
  → No intent to achieve targets
- Reducing Emissions: → Harder in Ontario than California
- Cap & Trade: → Untracked cost to taxpayers/ ratepayers
- MOECC CCAP: → Targeted use of proceeds likely to fall short

Neither Cap & Trade or CCAP are currently designed to achieve emission reduction targets



Source: MOECC commissioned study by Dillon Consulting, 2016, Strapolec Analysis

But we need to reduce emissions!

Why are policies crafted in an unachievable way?

→

Because emission reduction is

HARD and EXPENSIVE

Secondary Research Sources for Emission Reduction Ideas

Multi-stakeholder research approach for innovations in reducing emissions

Energy Solution Provider/ /Transmitters/Distributers	Energy Consumers	Interest Groups
Association of Power Producers of Ontario (APPrO)	Association of Major Power Consumers of Ontario (AMPCO)	Canadian Environmental Law Association (CELA)
Canadian Biogas Association (CBA)	Association of Municipalities Ontario (AMO)	Clean Economy Alliance (CEA)
Canadian Electricity Association (CEA)	Building Owners and Managers Association of Canada (BOMA Canada)	Clean Energy Canada
Canadian Energy Efficiency Alliance (CEEA)	Business Council of Canada (BCC)	Environmental Defence
Canadian Gas Association (CGA)	Canadian Manufacturers and Importers (CME)	Greenpeace Canada
Canadian Nuclear Association (CNA)	Canadian Vehicle Manufacturers' Association (CVMA)	Ontario Clean Air Alliance (OCCA)
Canadian Solar Industries Association (CanSIA)	Ontario Chamber of Commerce (OCC)	Ontario Sustainable Energy Association (OSEA)
Canadian Wind Energy Association (CanWEA)	Ontario Home Builders' Association (OHBA)	Ontario Society of Professional Engineers (OSPE)
Electricity Distributors' Association (EDA)	Ontario Road Builders' Association (ORBA)	Ontario Trucking Association (OTA)
Decentralized Energy Canada (DEC)	Toronto Atmospheric Fund (TAF)	Pembina Institute
Energy Storage Ontario (ESO)	Ontario Petroleum Institute (OPI)	Pollution Probe
Ontario Energy Association (OEA)		Toronto Environmental Alliance (TEA)
Ontario Waterpower Association (OWA)		

Buildings Emission Reduction Challenge Example

It is HARD

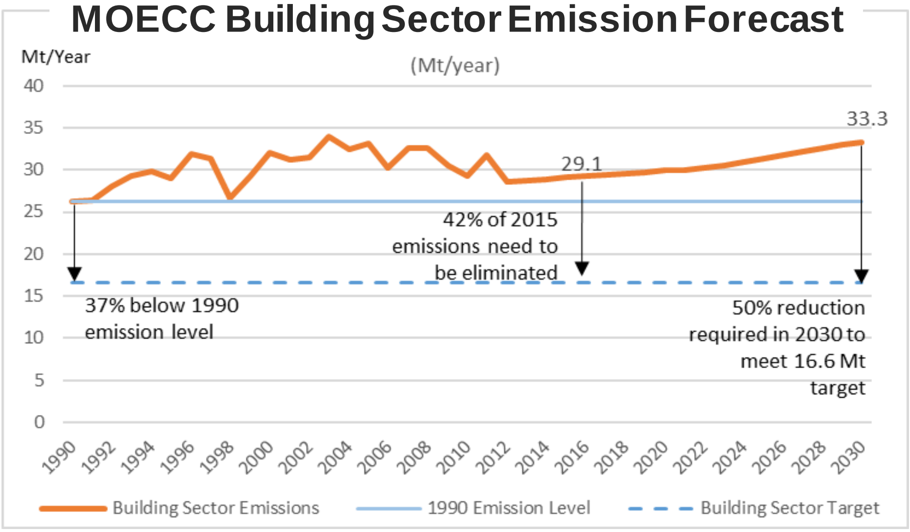
Buildings

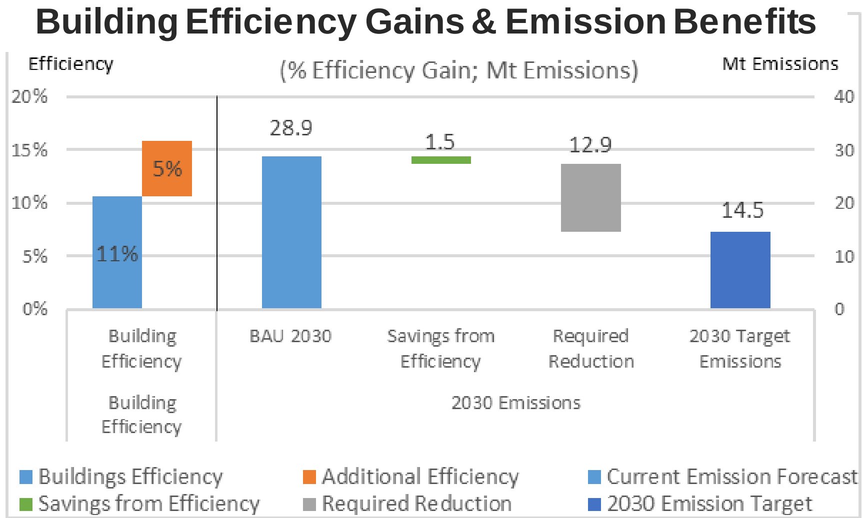
Almost 17 Mt of emissions must be removed from Ontario's buildings by 2030 in order to meet the legislated targets.

- Ontario economic and population growth will drive building emissions up
- Expected 2030 emissions must be reduced by 50%
- Building efficiency in Business As Usual (BAU) projections are assumed to improve by 11%
- Buildings is mostly about removal of natural gas use

Improving Building Efficiencies

- Modelling assumed 16.5% thermal efficiency improvement in buildings,
  - 50% more than from planned BAU building codes and standards
  - Across the province
- 1.5 Mt of emission reductions are assumed to come from efficiency improvements.
- To achieve this efficiency assumption, 50% of Ontario homes need a 33% increase in efficiency.
  - → in ~10 years
  - Transform TO seeks 40% by 2050





Only natural gas heating options illustrated

Annual Cost of Emission Reduction

It is EXPENSIVE

$27 Billion per year

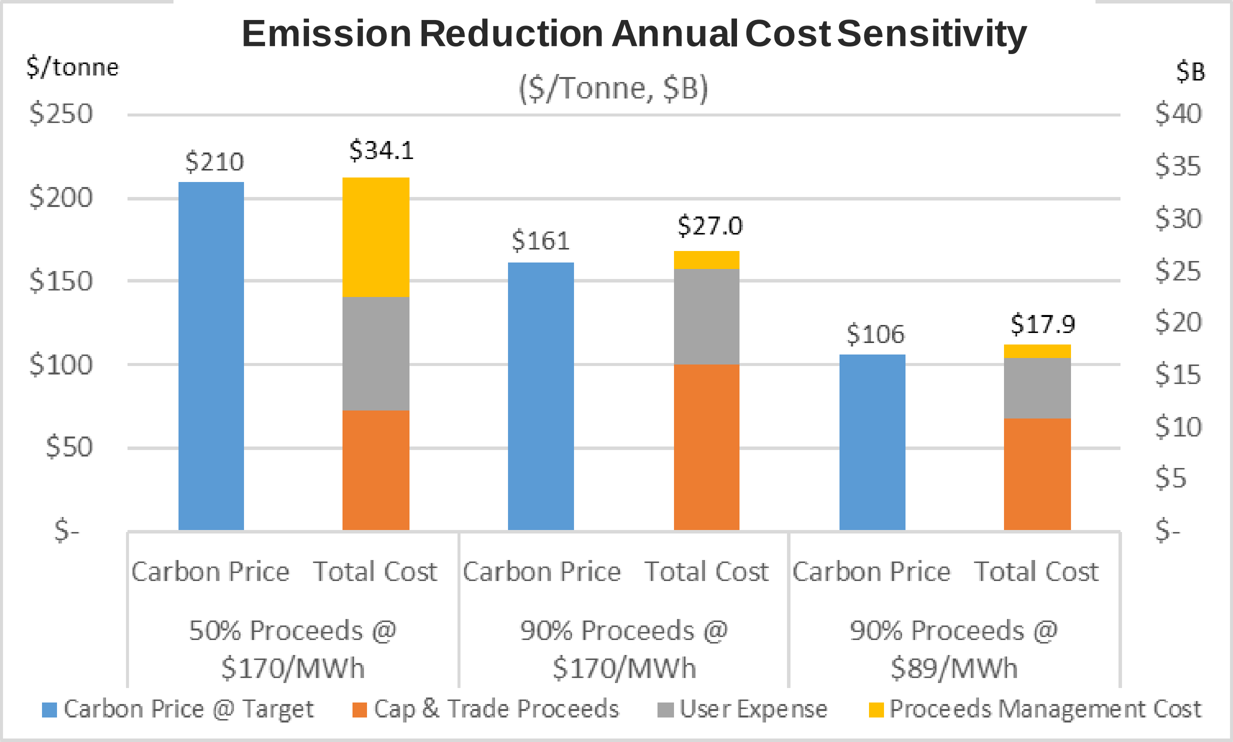
- If we are lucky

Purpose of carbon price:

- Increase cost on emitting technology to make low emission alternative equally attractive on a cost basis
- Creates a "User Pay Cost"

Market Carbon Price could vary from

- $106/tonne if we are ***Smart***
- to $210/tonne if unlucky



Varies by Price of Electricity

- Determined by LTEP policy choices

Varies by Cost of Administration

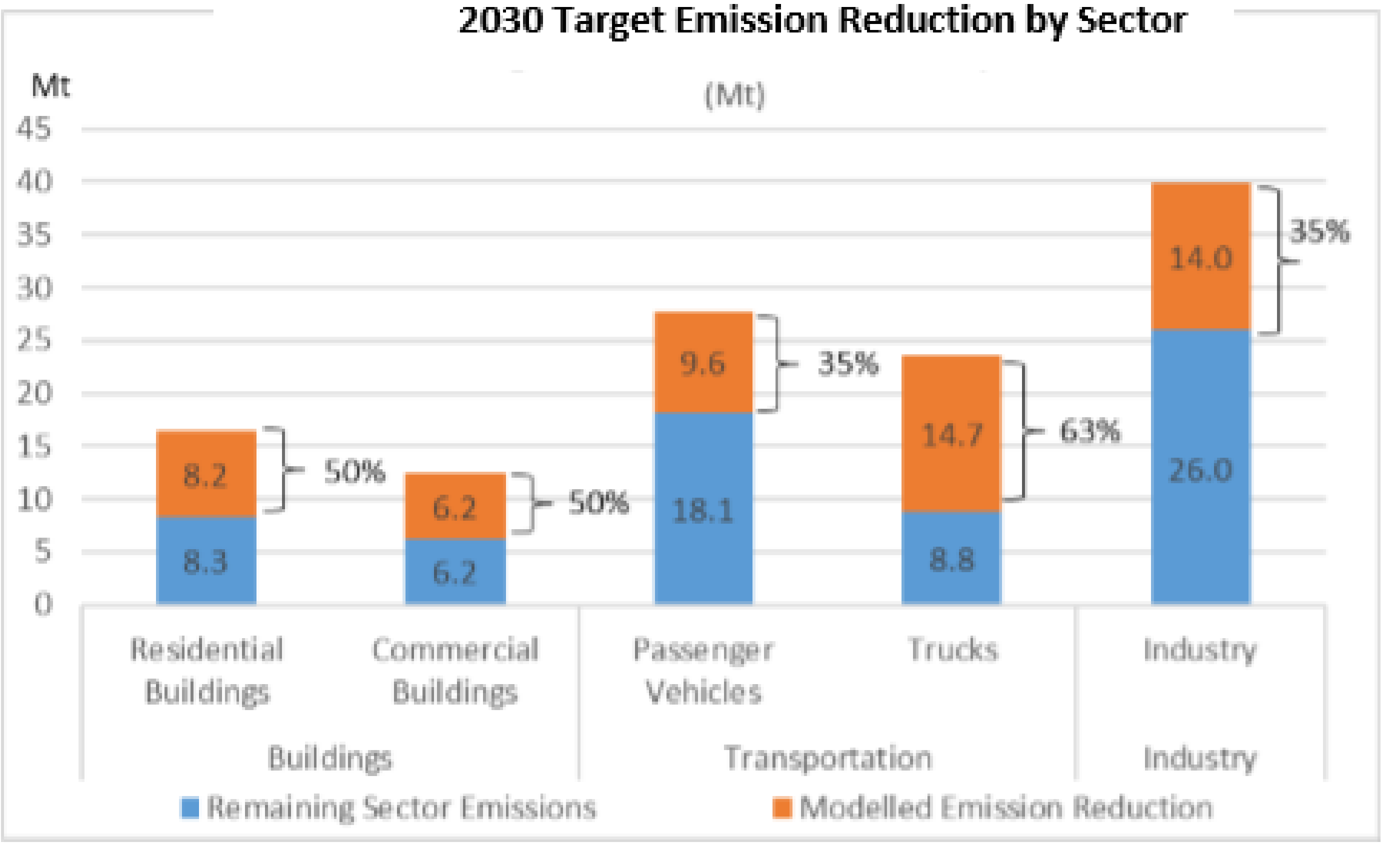
- Is it humanly possible for a government to effectively administer $16B/year?

Why is it so Expensive?

Because a LOT needs to change, fast

Buildings, transportation vehicles, and industry each need to reduce their emissions by at least 37% *in just 13 years.*

- And because these sectors are growing, they will need to offset even more than that

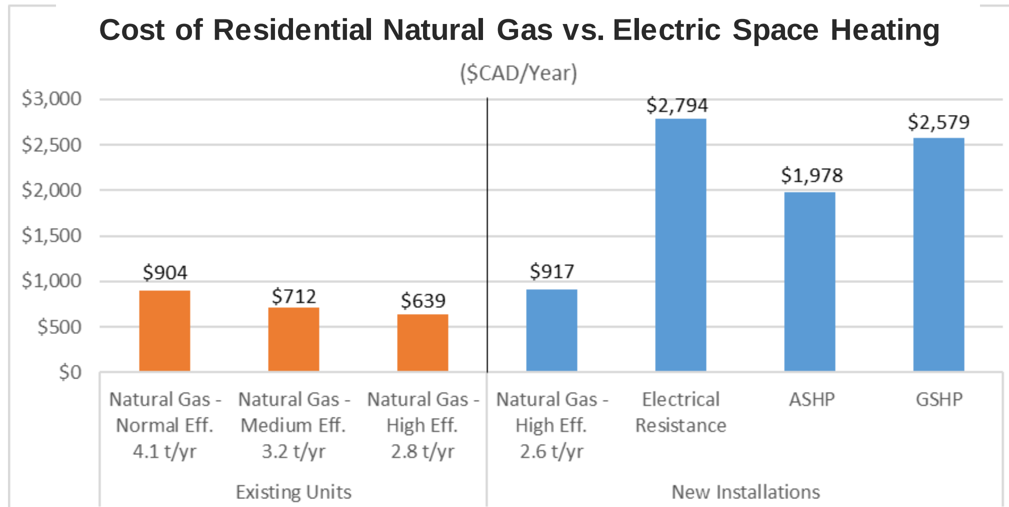


Reducing Space Heating Emissions by 50%

Very aggressive and expensive ambitions to achieve in 13 years

Challenge could be approached in several ways:

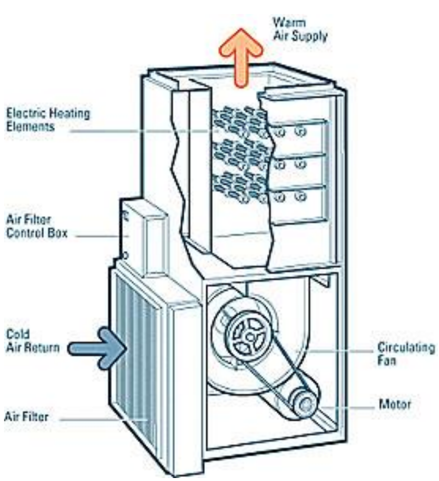
- Improve energy efficiency of all appliances within buildings;
- Replace 50% of natural gas appliances and devices with electrical devices;
- Reduce by 50% the CO_2 content of natural gas;
- Some combination of the above



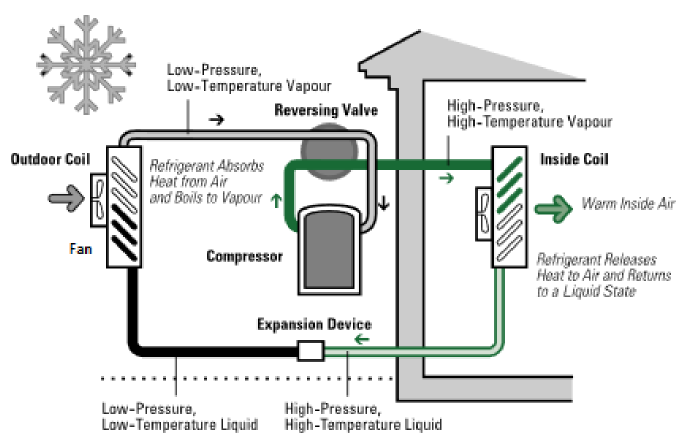
Assuming the current cost of electricity of $140/MWh

Three technology options were identified

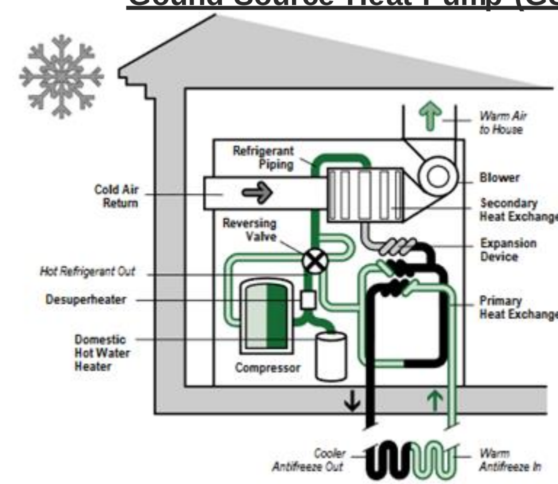
Electric Furnace



Air Source Heat Pump (ASHP)



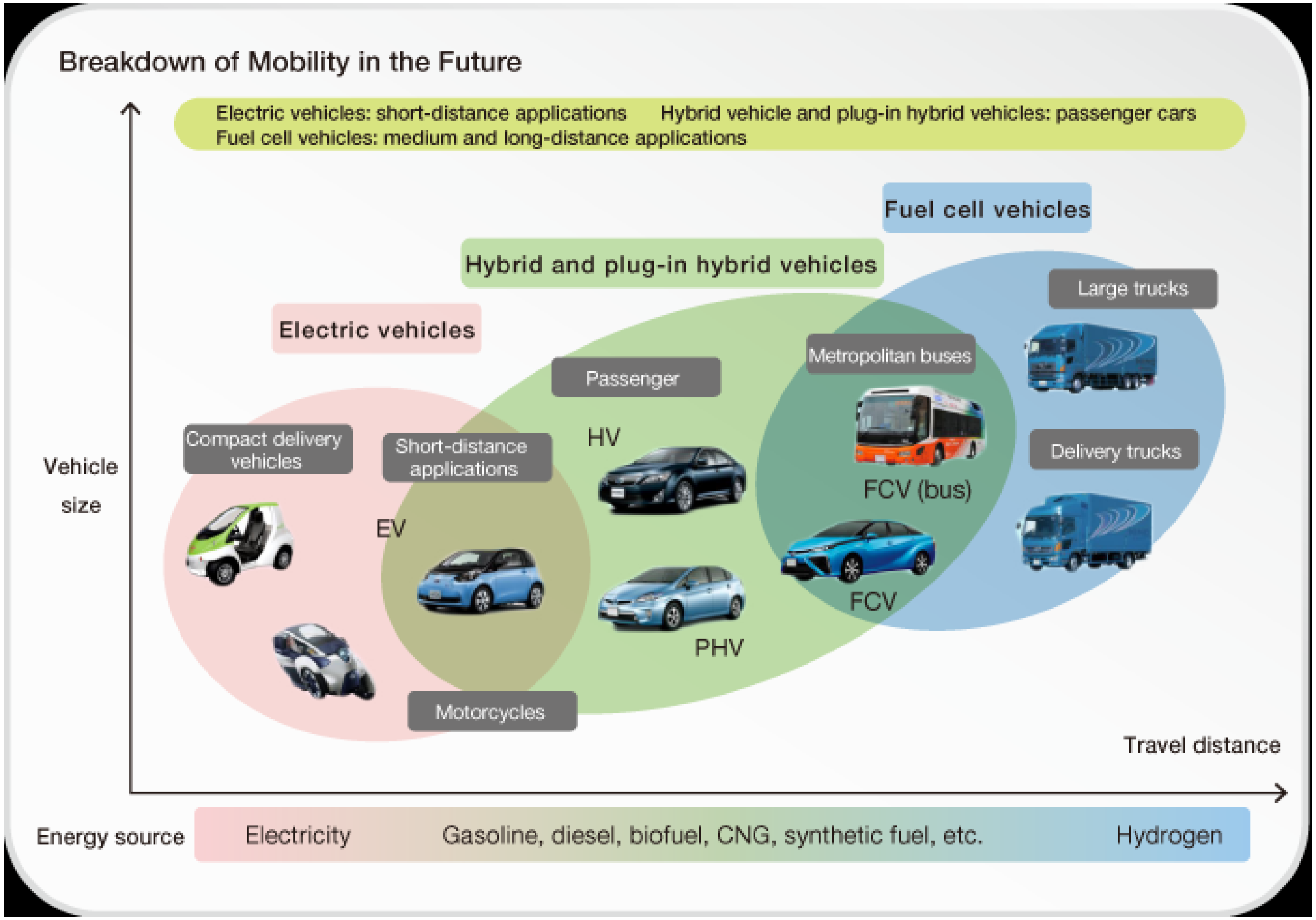
Gound Source Heat Pump (GSHP)



Vehicle Technology Options

Vehicle classes have different alternatives

Which vehicle is right depends on the primary use of the vehicle, and other factors such as vehicle size required and distance to be travelled.



Source: Toyota 2014 Annual Report, http://www.toyota-global.com/investors/ir_library/annual/pdf/2014/02.html#8

Transportation

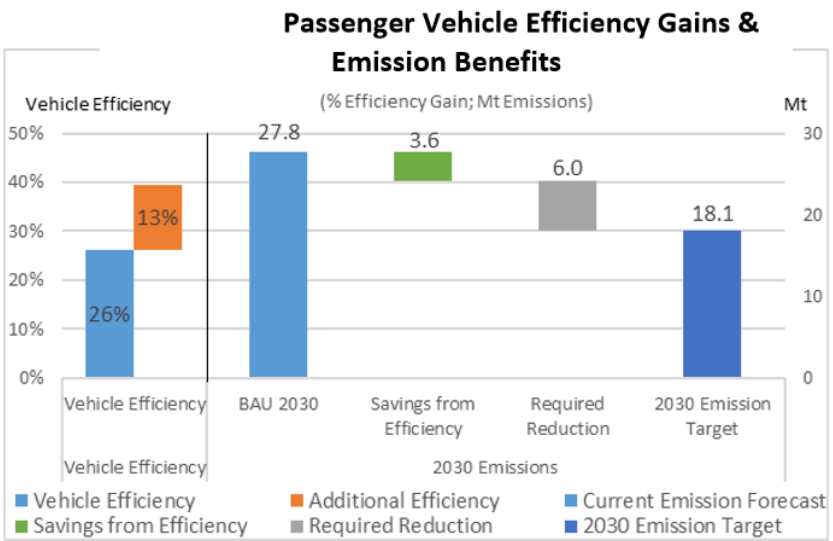
A lot of hype around electric cars, but trucks are the larger problem

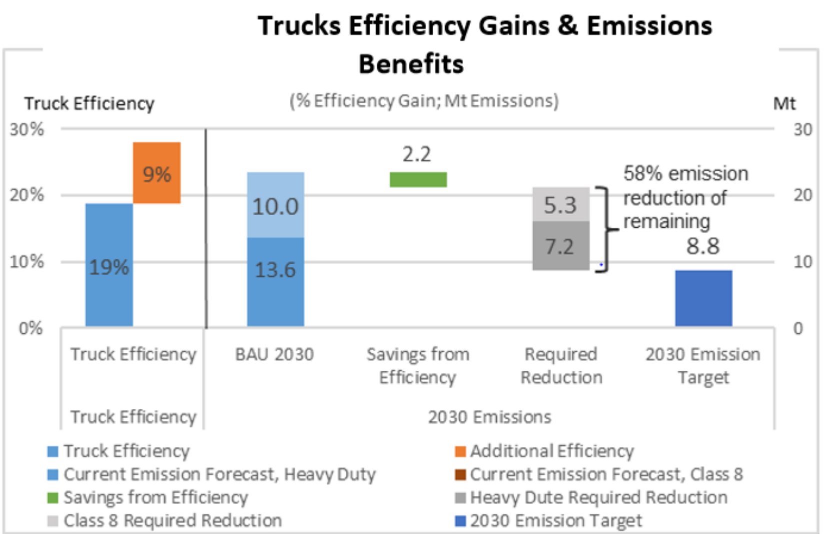
Efficiency assumptions are significant to achieve targets

- Passenger vehicle efficiencies are assumed to improve by 39% by 2030
- Trucks need to improve by 27%,
- Both targets are 50% greater than current regulations

After efficiency objectives have been achieved:

- 6 Mt of emissions must then be removed from passenger vehicles
  - A 30% reduction
- 12.5 Mt must be removed from trucks
  - A 50% reduction



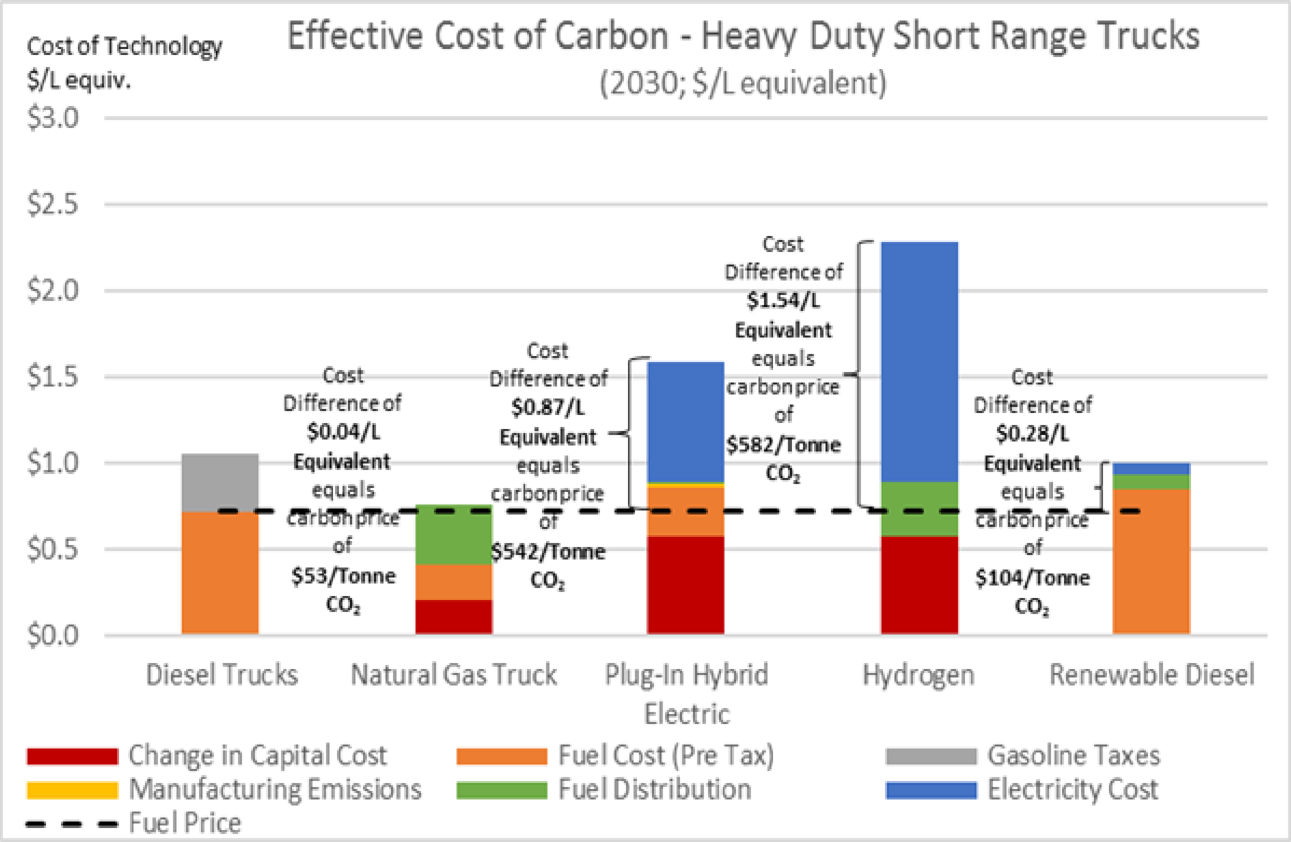


Equivalent Carbon Price of Alternatives: → Transportation

Can be computed based on the incremental cost of the energy solution

Some technology options appear to have reasonable equivalent carbon costs in the range of $100/tonne

- These are all feedstock limited
  - Even if 100% of trucks were converted to renewable diesel, targets could not be achieved
  - There is insufficient feedstock to produce renewable diesel for the continent
- The higher cost hybrid and hydrogen solutions will be required



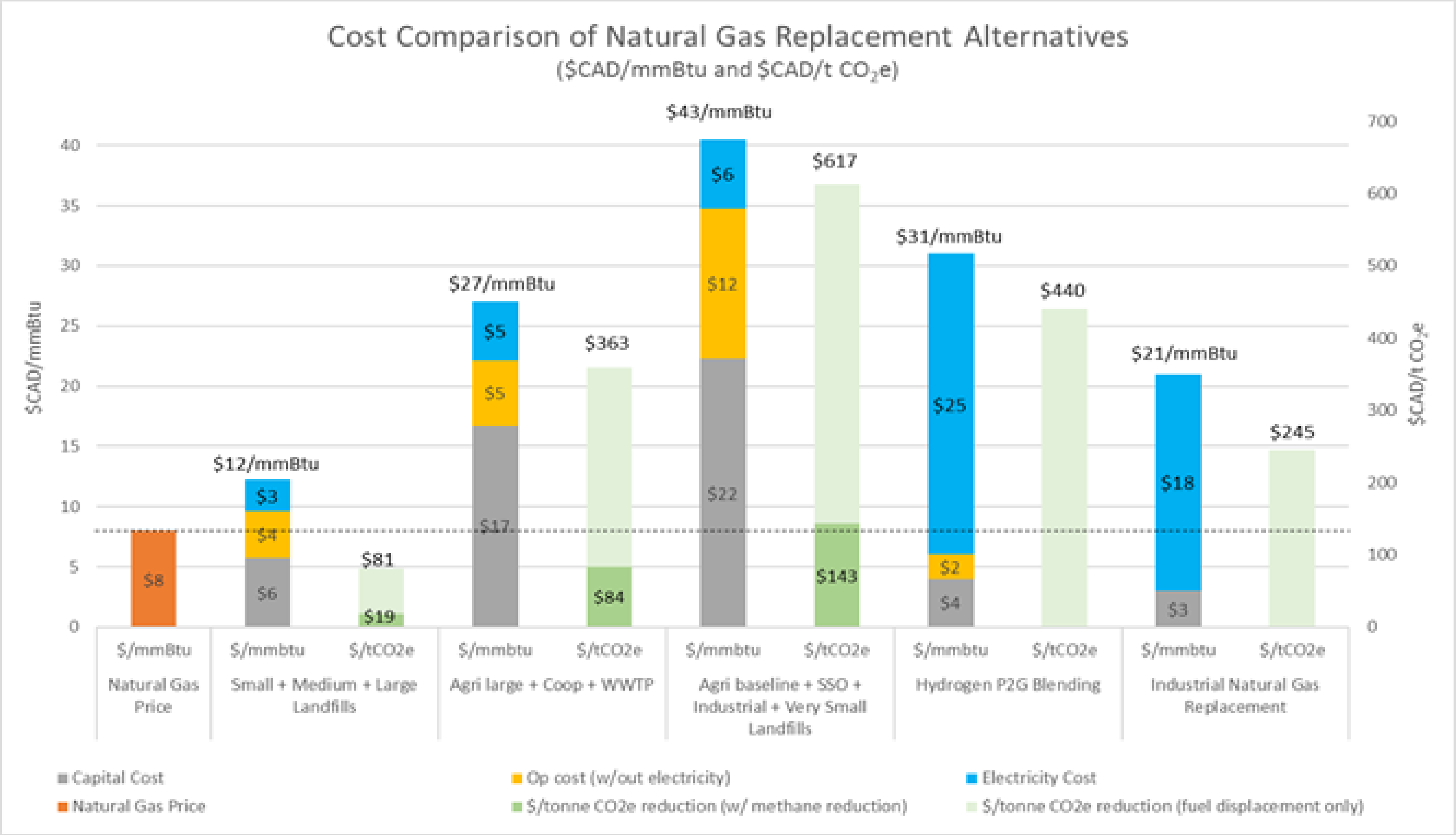
Equivalent Carbon Price of Alternatives: → Natural Gas

But lowest cost options are feedstock limited

Using landfill gas from large landfills has a reasonable equivalent carbon costs under $100/tonne

- But there are only a few landfills that meet this criteria
- Total landfill gas can only blend down 5% of the natural gas system, but small landfills options are not economical

Hydrogen and electrification of industrial process will lead to high carbon price equivalents



Emission Cost Curve

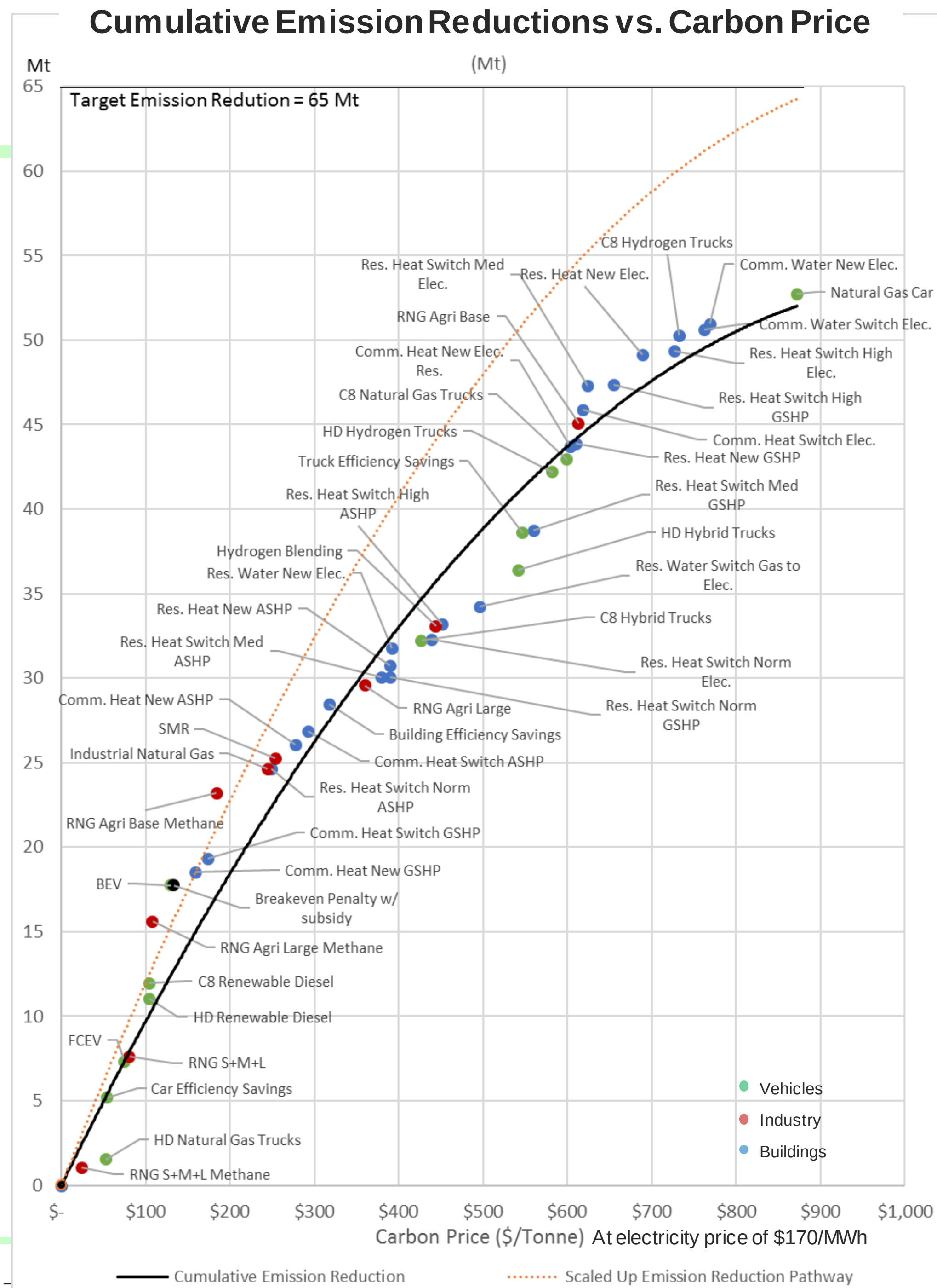
45 technology switching options evaluated

- Only addresses 80% of needed emission reductions

Carbon price calculation

- Cost difference between emitting technology and cleaner alternative

Home heating and trucking challenges lead to very high carbon prices



Source: Strapolec Analysis, modelled technologies

STRATEGIC POLICY ECONOMICS

Climate Economics

Carbon price proceeds and user costs both contribute to offsetting higher cost alternatives

Use of Cap and Trade Proceeds

Proceeds calculated as carbon price times province's allowable emissions

- Defined by the "cap" or emissions target
- Carbon price of $50/tonne will yield $5.5B proceeds in 2030

Technologies are subsidized until available proceeds run out

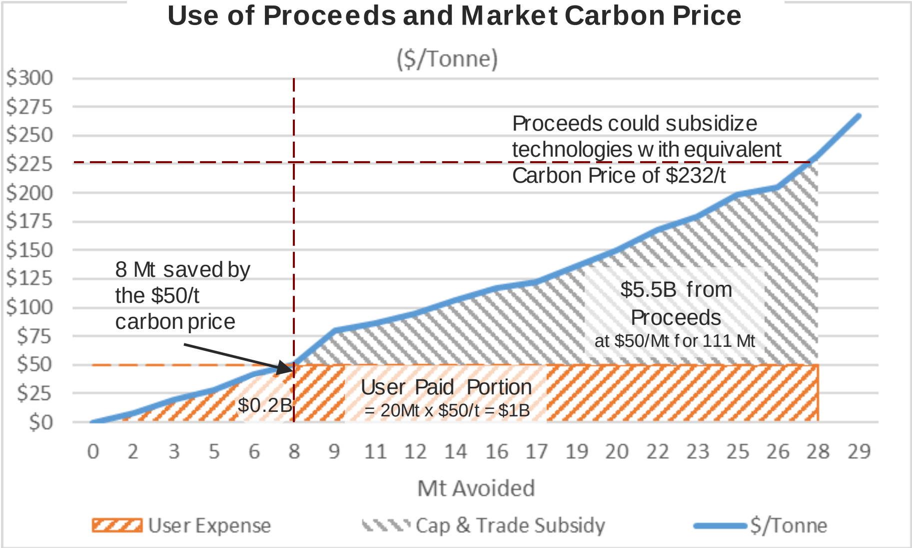
- Cost to subsidize technologies is calculated as product of:
  - Difference between required carbon price for that technology and the market carbon price ($50/tonne)
  - Emission reduction the technology will achieve.

User Paid Expense

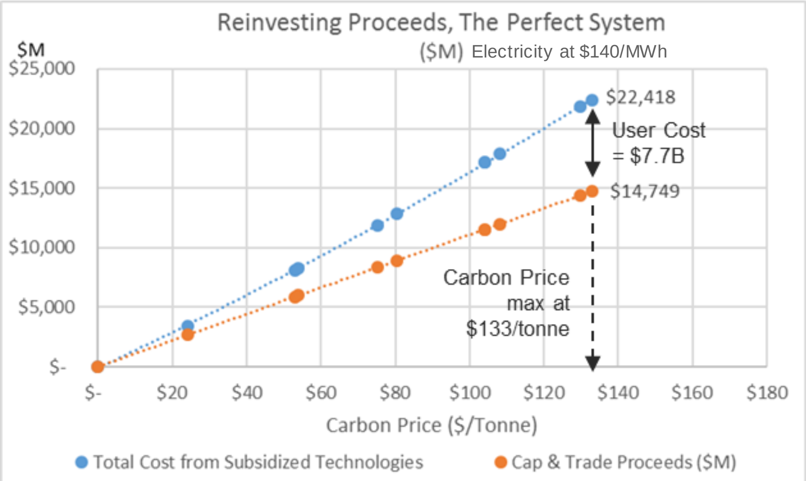
Represents the unsubsidized cost of carbon that users pay.

- For alternative technologies, users will pay the equivalent of the carbon cost below and up to the market price.
- Total user expense is the product of:
  - Required carbon price or Market price
  - Cumulative emissions of the technologies being subsidized
- For example, user expense is the sum of:
  - Cost of emissions avoided for technologies whose carbon cost would be less than the market price of $50/tonne
  - $50/tonne multiplied by the emissions greater than 8 Mt

Model allows for calculation of the carbon price and total cost to achieve emission reductions



In this example, the cap and trade proceeds of $5.5B will subsidize technologies with a carbon price up to $232/tonne that reduce emissions by 28 Mt

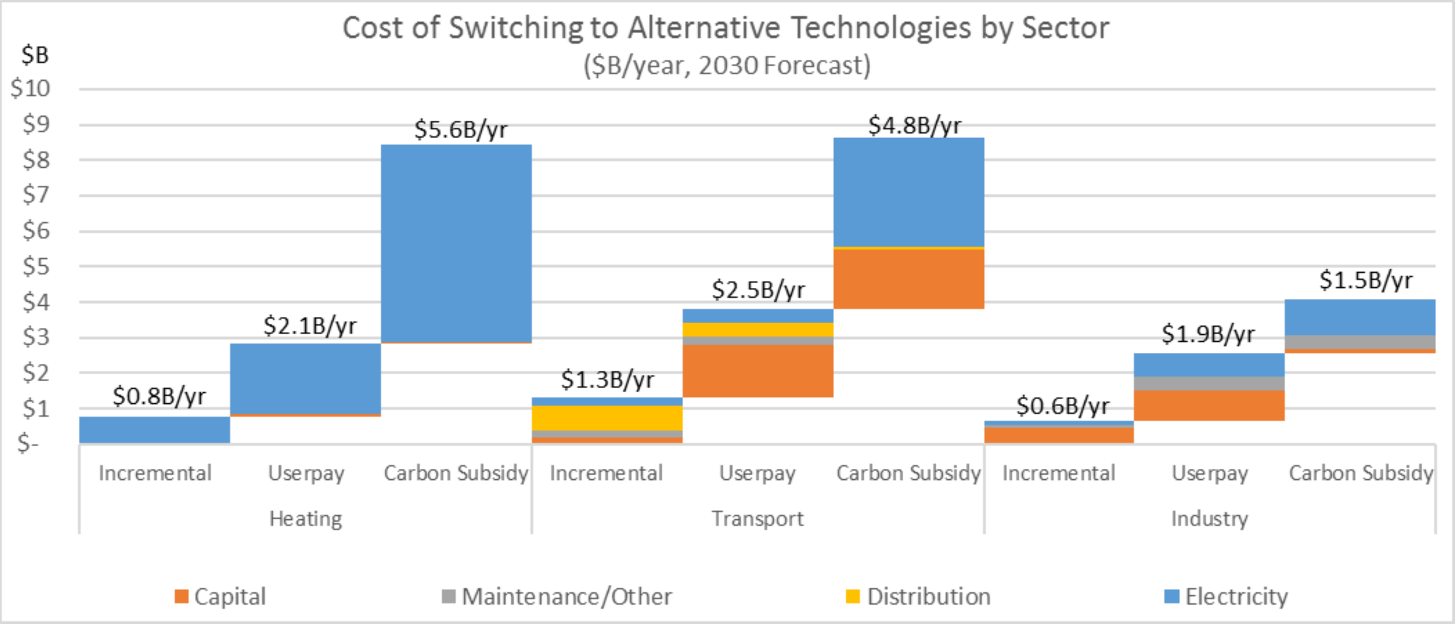


Electrification: A significant component of switching cost

Cost of each technology depends on many factors, including:

- Capital cost of switching
- Cost of fuel/electricity
- Distribution cost of the fuel

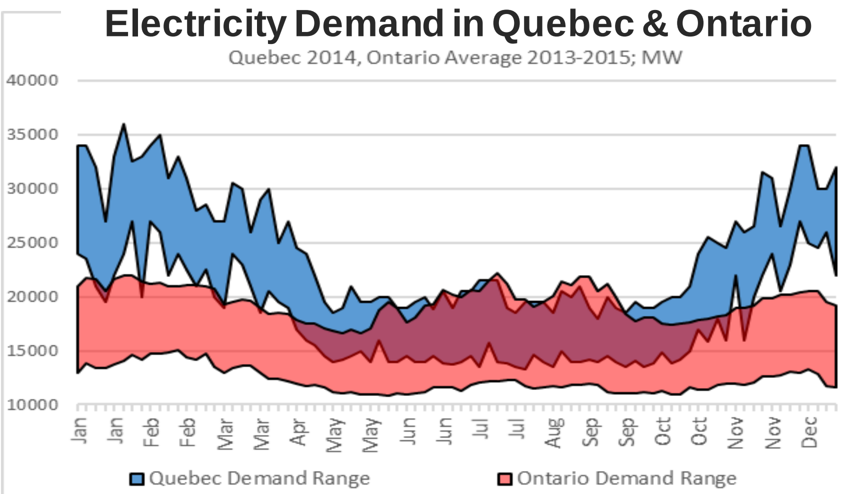
The visible impact of electricity cost on consumers will mostly be to heat homes



Source: Strapolec Analysis, $2016 for electricity at $170/MWh, only directly assessed technology options illustrated,

Not all new electricity demand is the same

The face of home heating

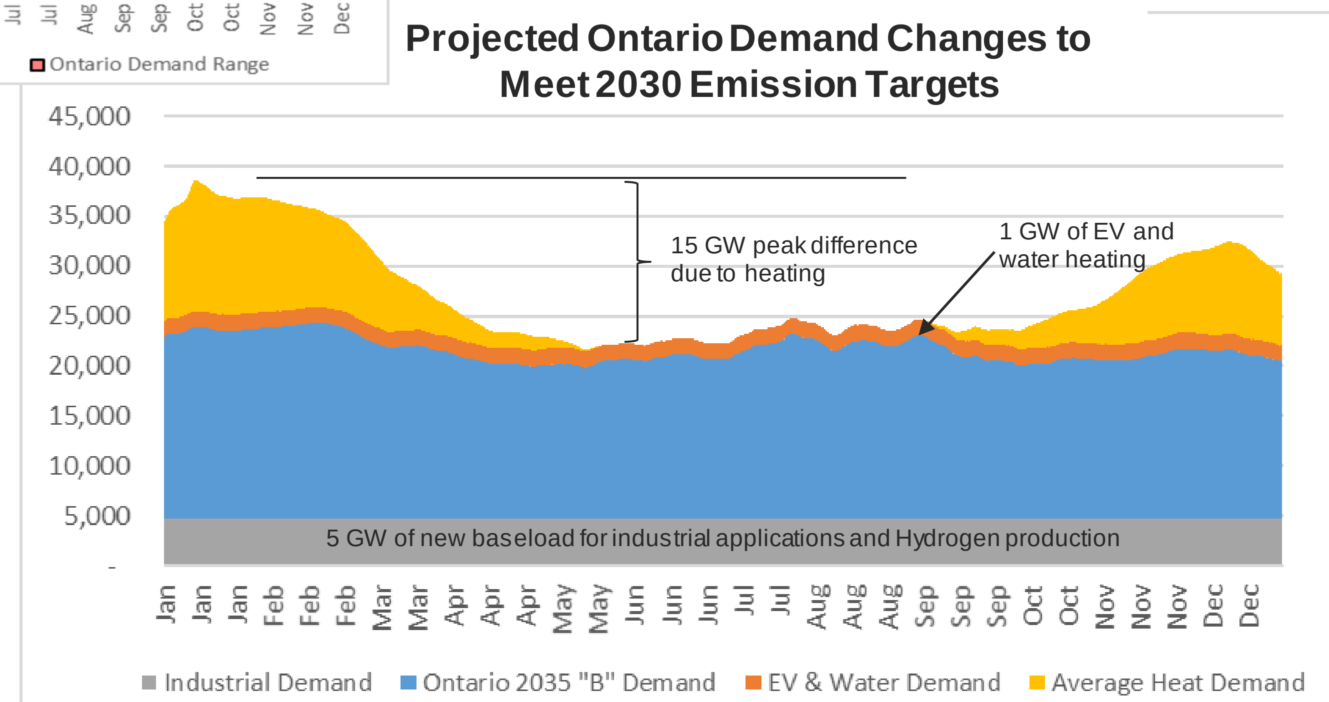


TODAY: The Quebec/Ontario Electricity Trade agreement

- Quebec needs capacity from Ontario in Winter
- Ontario needs capacity from Quebec in summer

Tomorrow (2030):

- There is not enough electricity
- Need 20 GW of new peak supply



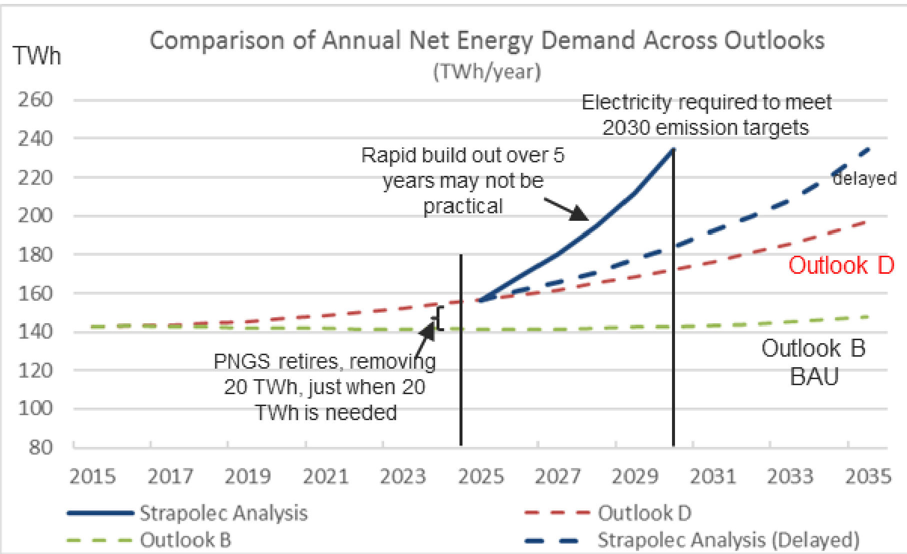
Electrification Implications:
Government policy is not achievable, but costs are committed...

New electricity generation ***Cannot be Built*** in time to achieve 2030 emissions reduction target

- Particularly after loss of Pickering's 20 TWh
- Emission targets **Cannot be Met**

Ontario's Environmental Commissioner concurs
MoE commissioned plans do not reflect goals

90 TWh of new generation required, much more than today



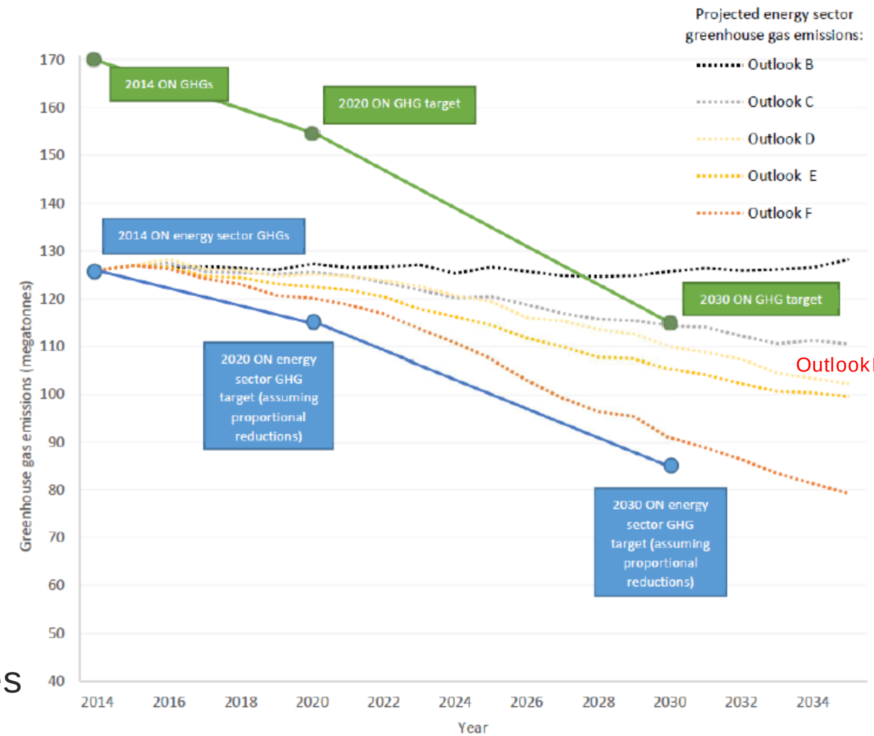


Figure 3: Comparison of LTEP Energy Sector Greenhouse Gas Emissions Projections with Ontario Climate Targets

Cap & Trade commits Ontario to purchasing allowances

- IESO outlook D misses target by ~40 Mt,
  - @ $50/tonne = $2B/year
  - @ $160/tonne = $6B/year

Source: Strapolec Analysis, IESO OPO, Environmental Commissioner of Ontario, 2016

"Popular Politics" vs Generational Cost to Ontarians

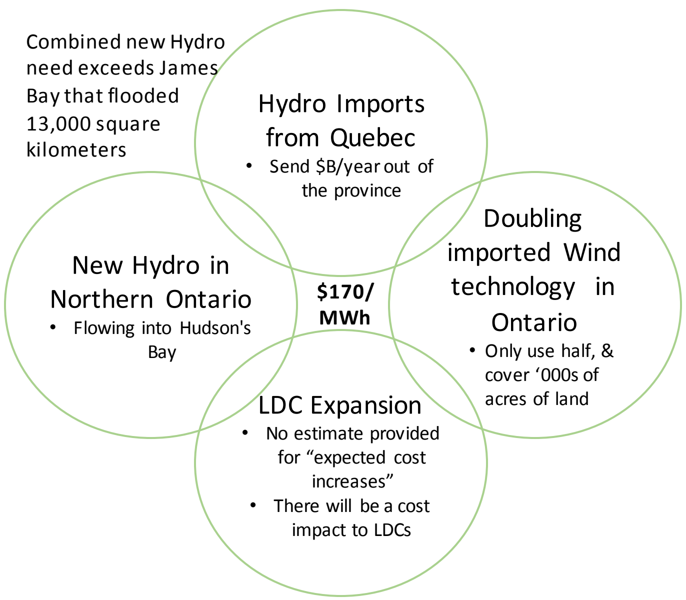
→ Supply Mix Choices: *Popular or Smart?*

Ontario needs a smart solution that reduces electricity cost by half

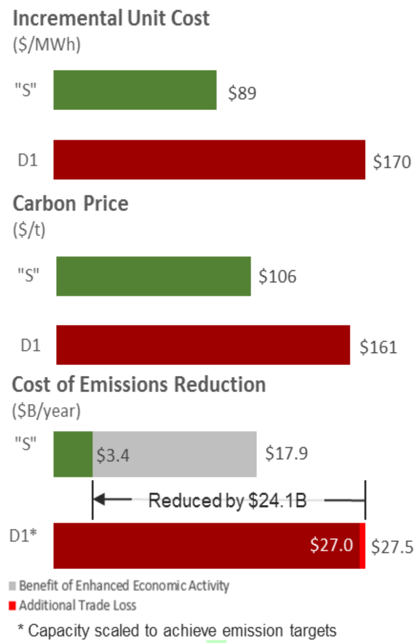
And makes Ontario an economic powerhouse in the global combat against climate change

A "Popular" Solution Does Not Benefit Ontarians

Propagating alternative facts will cost a lot of money



Benefits of Smart over OPO D1*

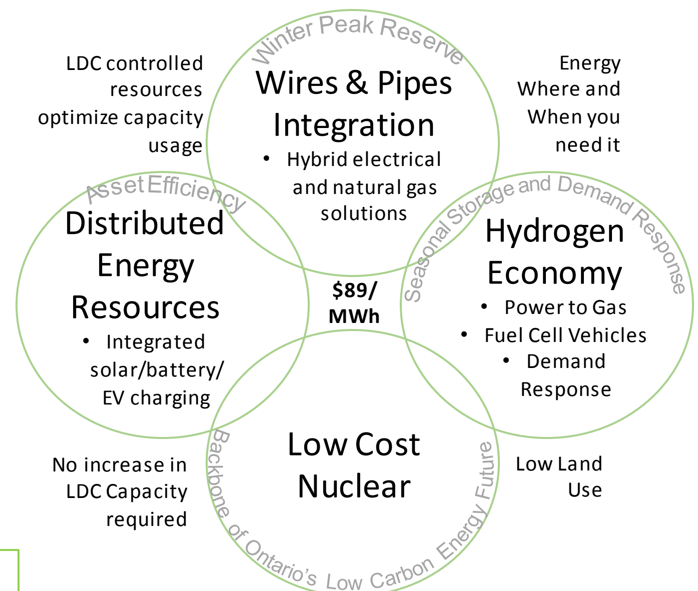


Enhanced Economic Activity From:

- Improved Trade Balance
- Low cost domestic energy
- Export energy
- New industries
- Global low carbon solution exports

A Smart Solution addresses Ontario's unique needs with Homegrown innovations

Enabled by four paradigm shifts



*OPO D1 = IESO Ontario Planning Outlook, Outlook "D" demand forecast, Option 1 supply mix

Nature of new demand complicates options for supplying it

Ontario Power Outlook assumptions

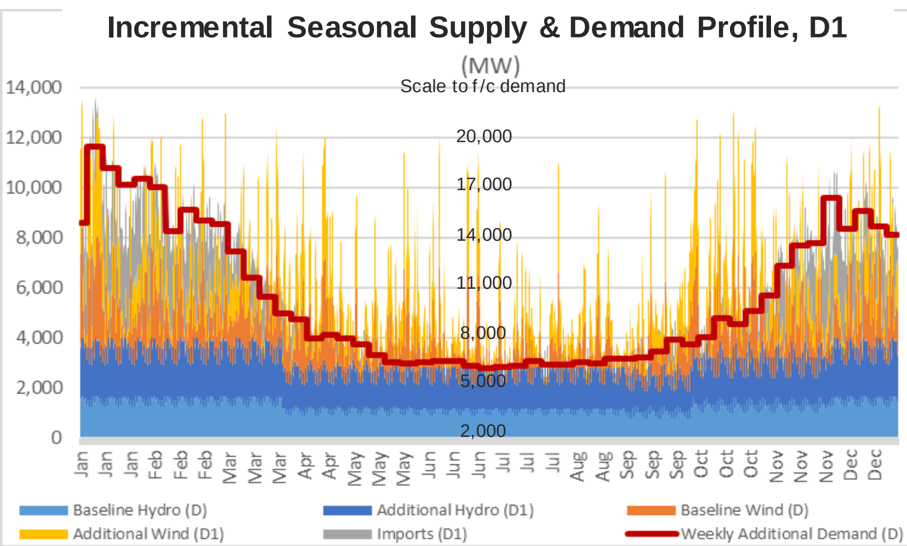
- Illustration based on extrapolating 2015 patterns
- Only use 50% of wind generation, drives up the cost
- Imports from Quebec assumed in winter
  - Significant new reservoir based supply is required
  - Assumed to “dance” with wind
  - Reduces operating factor of hydro facility and transmission
- New hydro supply in Ontario operates mostly all year

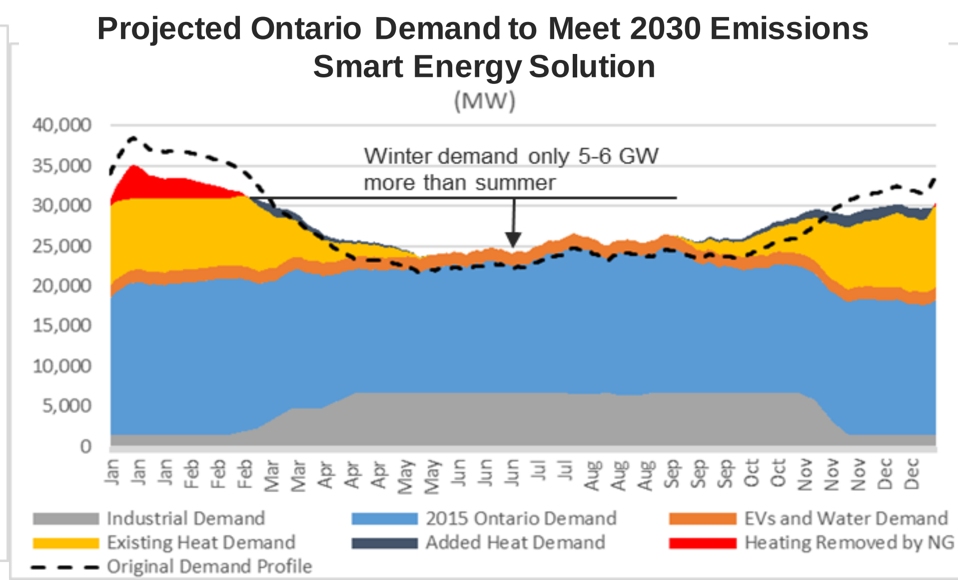
Needs 20,000 MW of peak capacity

A Smart Energy solution helps flatten demand and make it easier to supply

- Flatten seasonal peaks by using natural gas for coldest temperatures
- Concentrating hydrogen production in the summer to further flatten annual profile
- Smart DER coupled with LDC controls for EV charging and water heating all year to help flatten daily demand

Needs 5,000 MW of peak capacity





Solar and Wind Renewables do not reflect demand patterns

Solar

Generation profile of solar is opposite to the new winter heating demand

- A consequence of electrification of heating
- Daily storage for summer months would help make solar useful, but costs need to come down

Wind

The well recognized challenge of wind energy in Ontario is its intermittency.

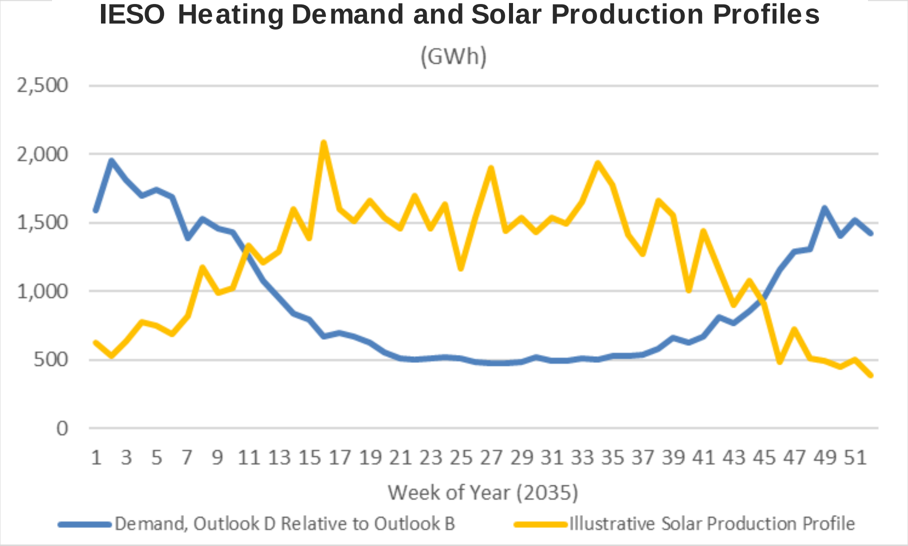
- Intermittency occurs on a seasonal basis and a daily basis.

Seasonally, not well matched to demand

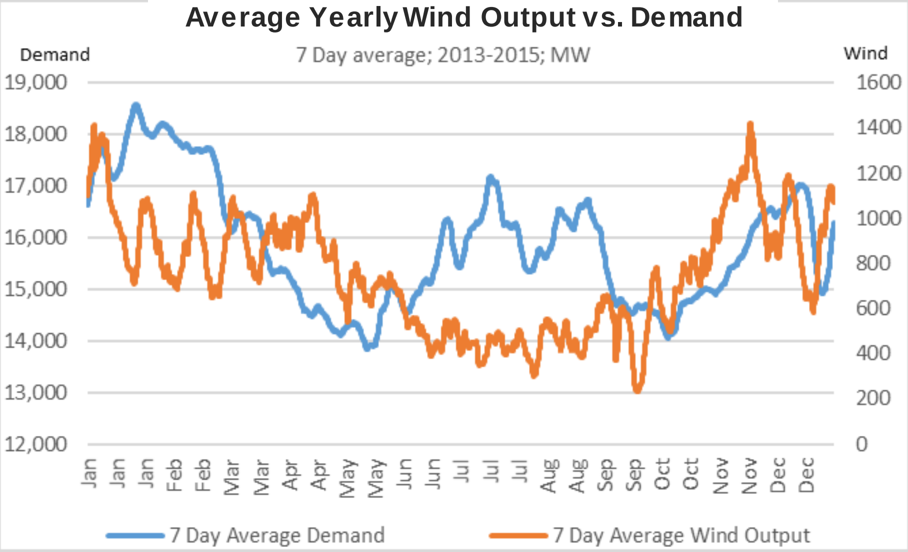
- Wind is lowest in the summer when Ontario's demand is the highest.
- Wind generating increase during Ontario's' low spring and fall seasons, and
- Does not provide peak power during the winter months..

There is no known grid scale storage option for seasonal wind variability

- On the magnitude of the new energy needed



Source: Ontario Power Outlook, Module 4: Supply Outlook



Hydro

Developing hydro faces both technical and geographic challenges.

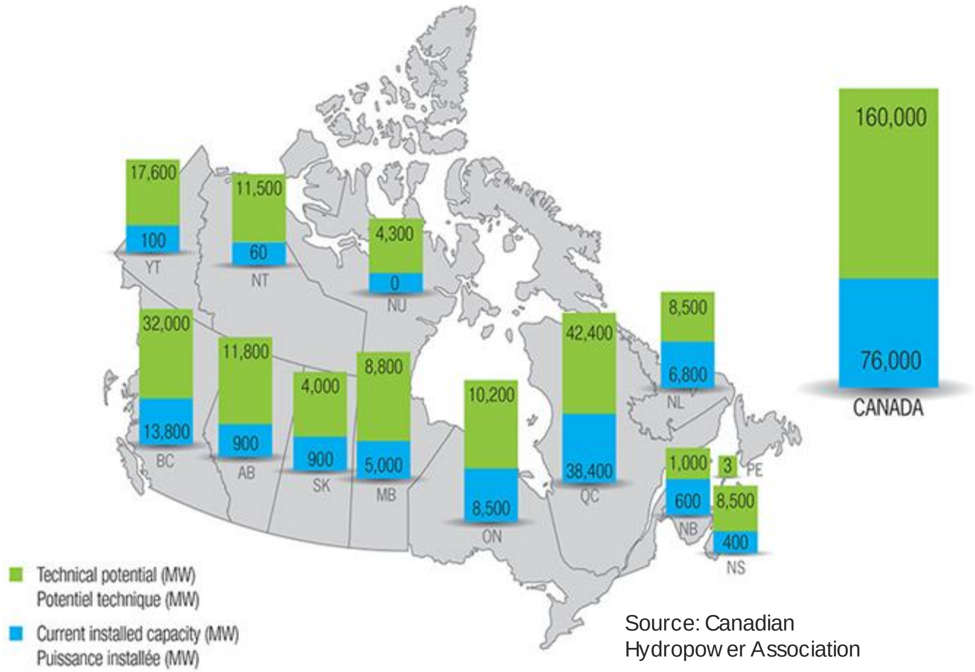
Ontario and Quebec have large amount of potential untapped hydropower still remaining.

- Much of this untapped potential is located in the far north, away from major cities where power is needed
- High development costs, cost of transmission upgrades, losses from transmission increase cost of hydro development

Mother Nature does not deliver water in a manner that matches demand

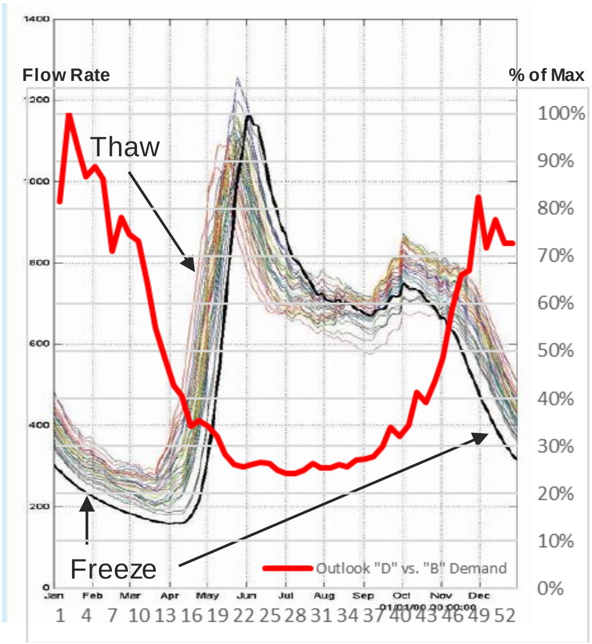
- Large reservoirs can be built to match water flow to demand
- Needed capacity by 2030 is similar to Quebec's James Bay region in which 13,000 kms of land were flooded

Canadian Hydro Capacity and Potential
(MW)



Source: Canadian Hydropower Association

Projected Quebec 30 Year Hydrograph vs. New Heating Demand



Source: United Nations World Water Assessment Programme: Water and Climate Change in Quebec

Distributed Energy Resources

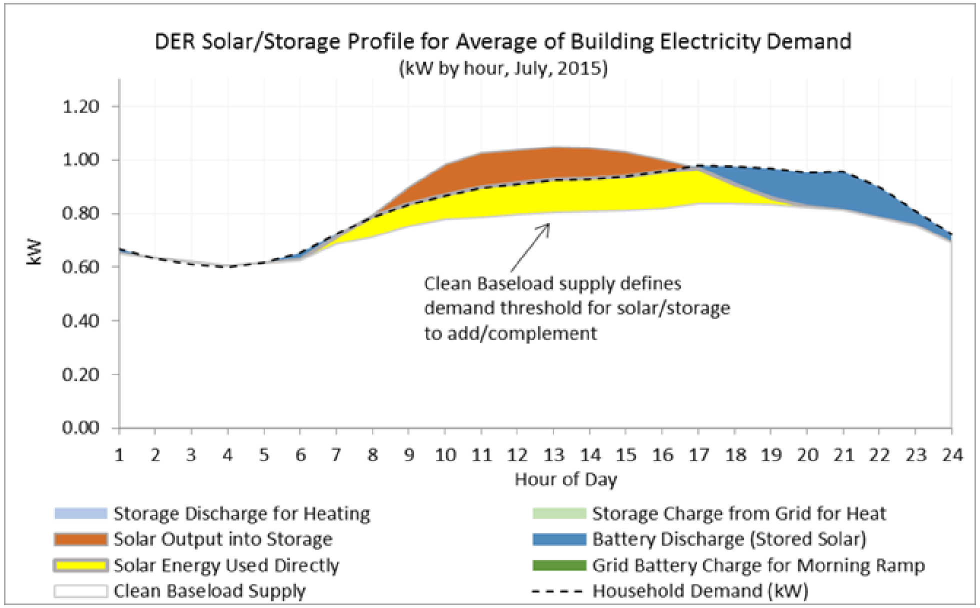
Matching new technologies to electricity requirements

Distributed energy resources, or DER, involve the use of small-scale generation at the point of use

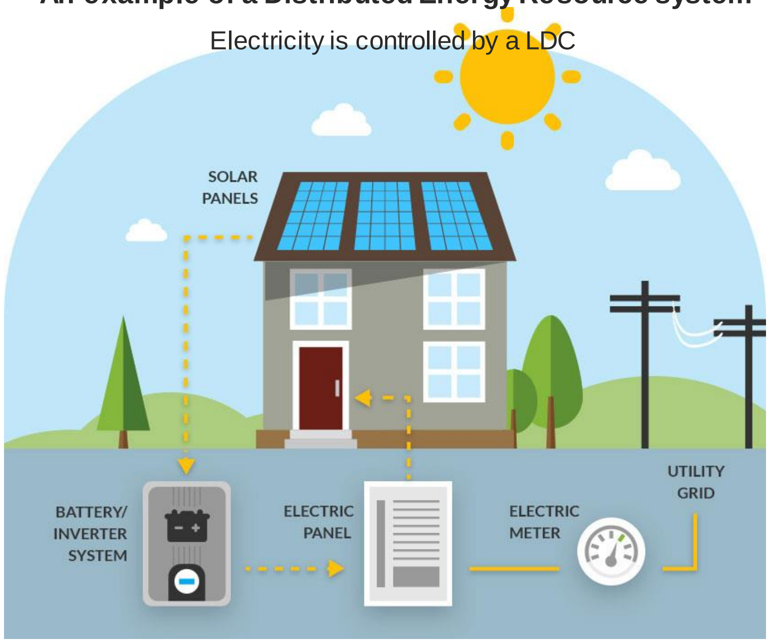
- Integrated with storage, demand, and supply technologies

Intelligently controlled by the local distribution company more efficiently uses electricity from the grid.

An integrated DER system could eliminate the need for peak demand power plants and flatten demand



An example of a Distributed Energy Resource system



Integrating Wires and Pipes

Leveraging infrastructure to flatten demand and reduce peaks saves cost

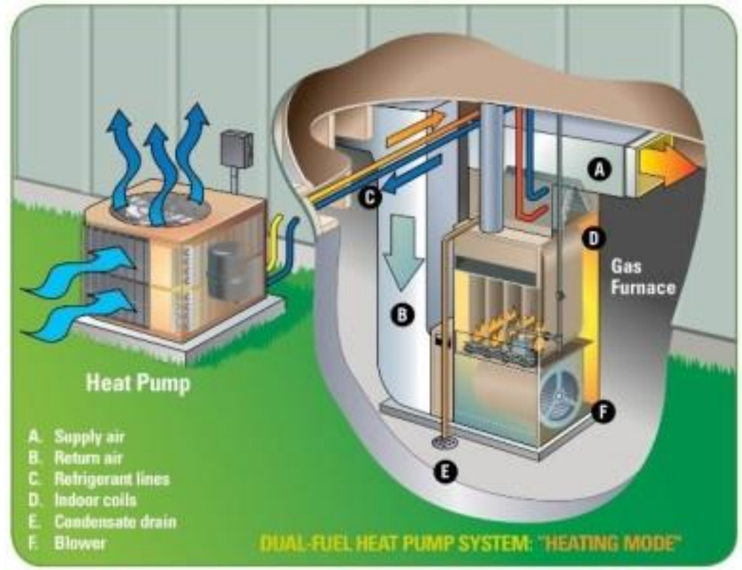
Electrifying heating is needed to achieve emission targets

- Converting natural gas to electric heating will place a burden on the electricity system during winter

Existing natural gas infrastructure could be a peak reserve capacity for heating

- Offsetting the need for peaking supply, and build out of distribution system

Hybrid heating devices that use both electricity and natural gas enable this transformation



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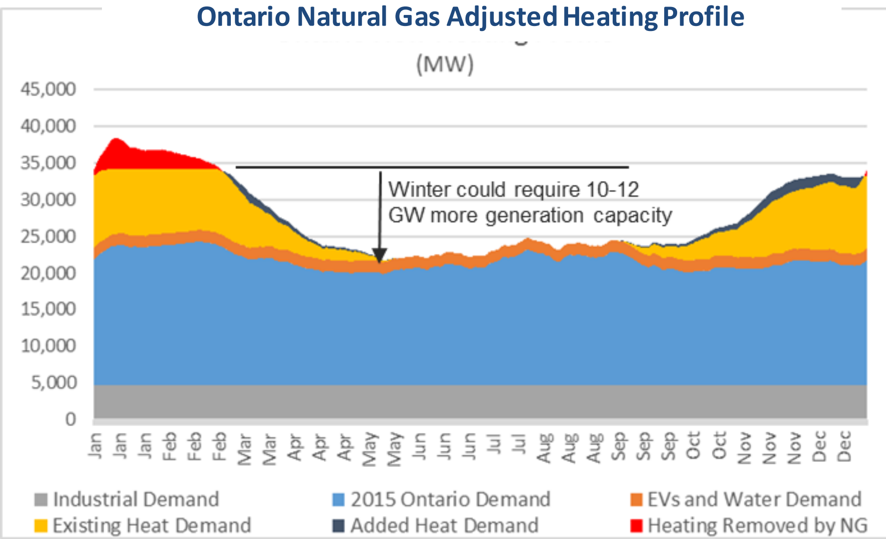


Hydrogen Economy

Emissions reduction capabilities for many applications

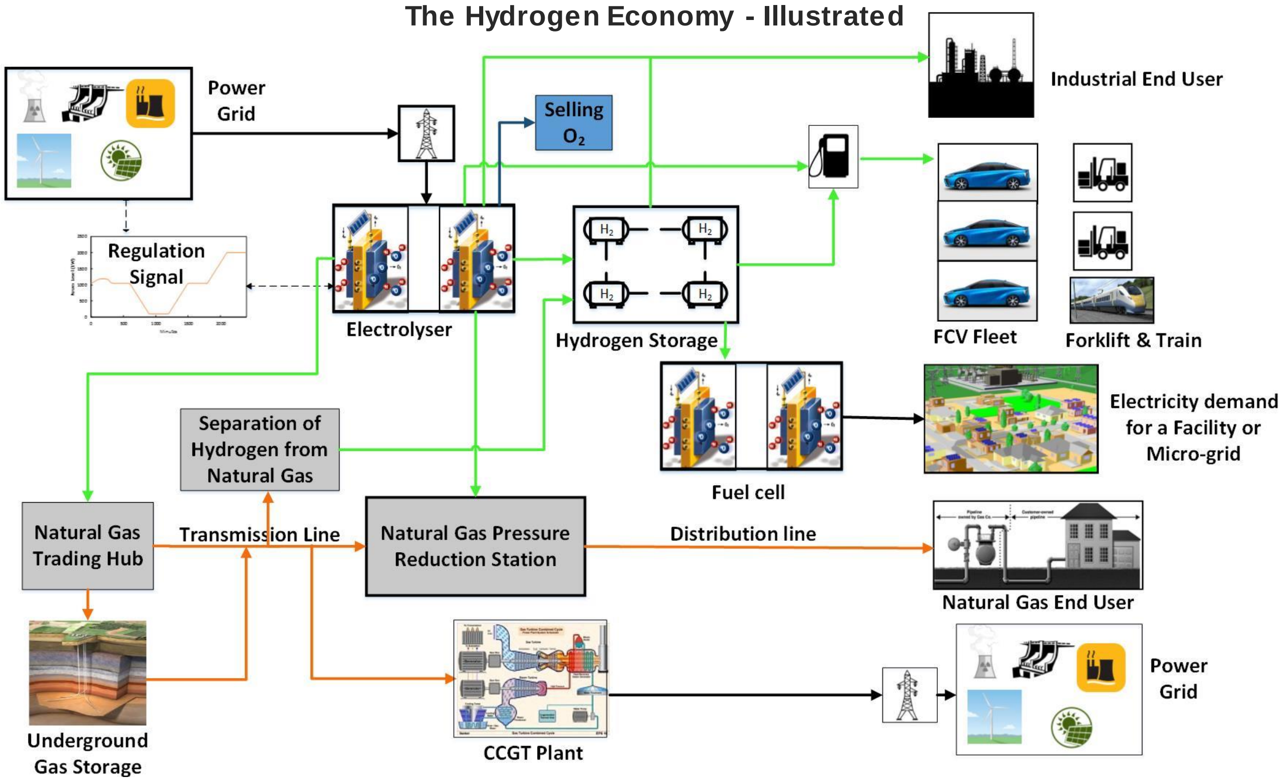
Hydrogen has direct fuel switching applications

- Fuel cell vehicles
- Blending down of natural gas
- Displacing fossil based production of hydrogen.

Hydrogen represents flexible energy storage

- Hydrogen can be produced and stored in Ontario's vast existing natural gas storage facilities,
- Could then be distributed and used around the province in winter.

Hydrogen can act as grid level demand response to further flatten load on the grid



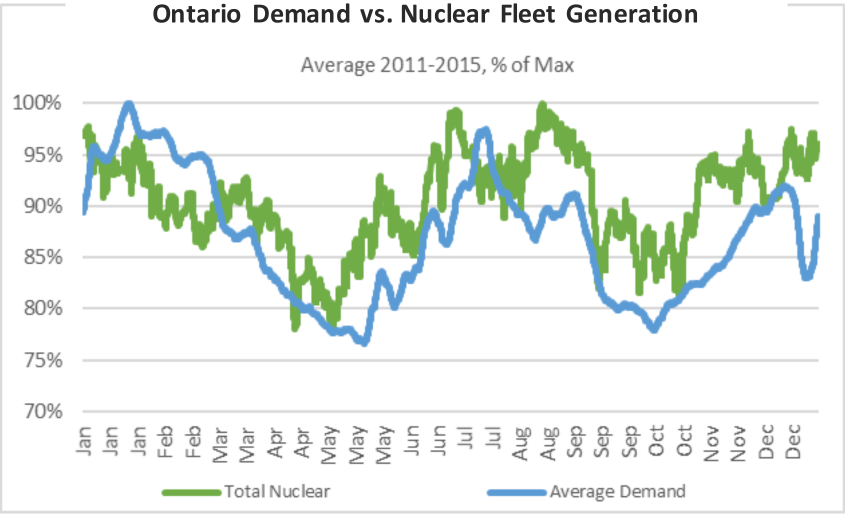
Source: Maroufmashat, A., Mukherjee, U., Fowler, M., Elkamel, A., Adaptive Energy Ecosystems - Improved Operability, Efficiency and Economics for Electricity and Gas- Power to Gas Energy Storage- Poster Presentation, Technology Innovation and Policy Forum 2016, 24 November, 2016, Waterloo, Canada.

Nuclear

A clean and reliable source of electricity with several system benefits:

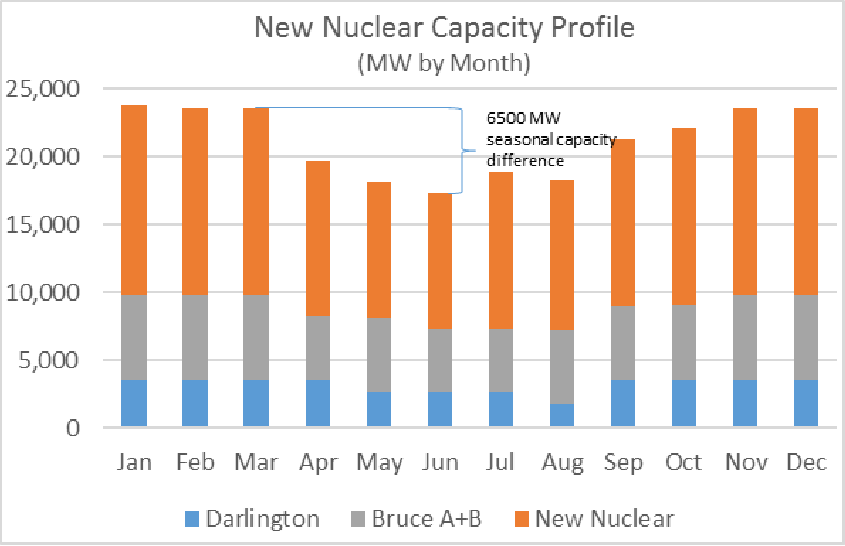
Benefits

- Provides a reliable, low cost baseload electricity supply;
- Can follow seasonal demand
- Can be built to desired capacity
  - Located where generation is most needed;
- Costs moderated as many Ontario sites already have transmission infrastructure substantially in place.



Nuclear fleet has normal operating requirement for maintenance

- Can be managed to match the new demand profile expected from the grid



Summary

- Achieving emissions targets is hard
- Available technologies represent $27B/year of new costs on how Ontarians use energy
- Required electrification cannot be achieved
- Cap and Trade will cost Ontarians $2B/year in purchased allowances after 2024
- Ontario can be an economic powerhouse in combatting climate change if we are ***Smart***