The Canadian Natural Gas Opportunity: GHG Reduction Potential to 2030

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Executive Summary

The Role of Natural Gas in the transition to a low carbon economy

Investment in transmission and distribution systems and access to an affordable, plentiful supply has dramatically changed the role of natural gas in the Canadian and continental market over several decades. At a national level, natural gas provides 32% of the energy used in Canada on an annual basis and plays a critical role as affordable energy for the Canadian economy.

Through the 1980's and 1990's, natural gas emerged as a replacement for higher emitting fuels (heating oil, propane and coal) in the residential and commercial heating markets and in the industrial sector for thermal energy. More recently, natural gas has supported lower electricity sector emissions as a backup for intermittent renewable electricity generation and as a replacement for coal fired power generation. Looking forward, natural gas in compressed (CNG) and liquefied (LNG) form is emerging as an important fuel alternative to reduce emissions from the transportation sector, and to reduce emissions in remote markets as a fuel for power generation. Also, the production and injection of renewable natural gas (or RNG) in the Canadian distribution system offers a carbon neutral source of natural gas for all sectors of the Canadian economy.

The Government of Canada has committed to significant further reductions in GHG emissions, and wants to work with provinces and territories on national efforts and with international partners on a global agenda. Building on the work of the last several decades, natural gas and Canada's distribution companies are key to the effort. The use of natural gas and of natural gas infrastructure offer a cost-effective means to further reduce emissions in Canada and abroad, and the Canadian natural gas distribution sector is well-positioned to help on both fronts.

Project Background and Approach

To illustrate the GHG emission reduction benefits associated with expanding natural gas' usage in Canada, the Canadian Gas Association commissioned ICF to assess the abatement potential in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- LNG as a replacement for propane, oil and refined fuels in communities and industrial sites without access to natural gas infrastructure
- The potential for reducing natural gas consumption through deep energy efficiency measures in homes, buildings and industry
- Natural gas fired electricity generation as a replacement for coal-fired generation and enabler of intermittent renewable electricity generation

Due to the nature of the gas distribution network in Canada, and in recognition of unique regional energy profiles, this study focused on regional level assessments for New Brunswick, Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia as well as the Northern Territories (combined analysis for Yukon, Northwest Territories and Nunavut). The national level data provided is a sum of these eight provincial-level and combined Northern Territories analyses.

Study Results

Since late 2015, the Government of Canada has taken on international commitments (Paris COP 21) to reduce emissions domestically and to support poorer countries to reduce their emissions and to

adapt to climate change. Emission reduction targets of 30% below 2005 levels by 2030 have been identified as the "floor" with steeper targets expected in the future.

The latest national inventory of Canada's GHG emissions[1] shows us that between 2005 and 2014 Canada's emissions declined by 2% from 747 $MtCO_2e$ to 732 $MtCO_2e$. During this timeframe GDP grew by 15% from $1,503B to $1,734B and total primary and secondary energy usage increased by 12% from 7,640 to 8,556 PJs per annum. Natural gas' contribution to total energy demand in Canada is now almost 3,000 PJs per annum meeting almost 50% of demand outside of transport use. Nationally, emissions associated with natural gas consumption total 146.4 $MtCO_2e$ compared to 235 $MtCO_2e$ from the use of refined petroleum products (including from transportation) and 78 $MtCO_2e$ from electricity generation. The remaining GHG emissions balance of 273 $MtCO_2e$ comes from energy sources like coal and coke (in industrial process heating applications) and non-energy sources like agricultural and waste emissions of methane.

Energy Source	2014 (TJs)[2]	GHG Emissions ($MtCO_2e$)*
Natural Gas	2,967,656	146.4
Electricity	1,768,384	234.6
RPP (predominantly transport)	3,208,722	78.0
Other Energy (coal, coke, NGLs)	611,603	273.6**
Non-energy related (process, Ag, waste)	NA	
Canada TOTAL	**8,556,365**	**732**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

As outlined in this report, the five areas of natural gas use where significant GHG reductions can be realized, and the potential reductions involved, are the following:

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	14,800,139	>5% of natural gas throughput replaced with RNG
Transport	5,555,848	~25% of heavy duty fleet converted to natural gas
LNG	4,390,499	Regional variability
Energy Efficiency	11,849,105	~6% reduction in energy usage vs BAU
Coal to Natural Gas	11,156,221	Regional variability
TOTAL	**47,751,811**	**~6.5% reduction in national emissions**

On a regional basis there are differences in total potential and relative potential for each of the five areas, based on factors such as size of the region, energy demand and energy / emissions profile:

[1] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[2] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

	RNG	Transport	LNG	EE	Coal to NG	TOTAL
NT*	58,453	16,317	97,337	16,008		188,115
NB	100,839	36,840	161,053	90,539	352,000	741,271
NS	134,291	58,850	263,381	52,301	821,618	1,330,440
QC	538,650	538,495	583,489	1,200,000		2,860,634
ON	8,078,800	3,266,546	1,174,699	5,669,924		18,189,969
MB	206,335	130,800	95,068	245,015		677,218
SK	620,456	205,450	162,195	813,865	2,196,253	3,998,218
AB	4,337,196	715,500	1,232,992	3,058,158	7,786,350	17,130,195
BC	725,119	587,050	620,285	703,296		2,635,751
TOTAL	**14,800,139**	**5,555,848**	**4,390,499**	**11,849,105**	**11,156,221**	**47,751,811**

*NT = Northern Territories (Yukon, Northwest Territories and Nunavut)

Governments in Canada are advancing significant emission-reduction targets, plans and policies. These have the potential to be both costly and inefficient without thoughtful consideration. Natural gas is a very affordable source of energy to the residential, commercial and industrial end user and the continental, national and regional natural gas systems are both reliable and efficient energy delivery vehicles. A focus on leveraging natural gas as a low emitting fossil fuel, and natural gas infrastructure as an efficient delivery system will help to maximize the cost-effectiveness of any emission-reduction plan. This report demonstrates the associated emission-reduction potential. Canada's gas utilities are prepared to work with governments on the implementation of the proposals in the report, and they welcome comment.

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1 Project Approach

To illustrate the GHG emission reduction benefits associated with expanding natural gas' usage in Canada, ICF and the Canadian Gas Association focused on the following main areas of abatement potential:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned infrastructure
- The potential for reducing natural gas consumption through deep energy efficiency measures in buildings
- Natural gas fired electricity generation as a replacement for coal-fired generation and enabler of intermittent renewable electricity generation

Collection and distribution of Renewable Natural Gas (RNG)

All distribution companies had an appreciation for the role of RNG in reducing the GHG intensity of the fuel delivered and most companies have (or are looking at) measures aimed at introducing RNG to supplement conventional natural gas within their distribution systems. There are differences in how RNG will be made available (driven by local demand, supply and local regulation) and source of RNG.

For the purposes of this analysis an October 2010 study commissioned by the CGA and carried out by the Alberta Research Council (ARC) was relied on to substantiate RNG supply potential and GHG emission reduction potential based on regional, source specific / bottom up analysis.

For Ontario, ICF also relied on a 2011 study by Alberta Innovates focused on Ontario and distinct Union and Enbridge distribution areas.

Most companies stressed that the introduction of RNG would need policy and infrastructure support similar to that provided renewable electricity generation and that RNG would be economically challenged vs. historically low-cost geological based natural gas without this appreciation and incentive.

CNG/LNG as a replacement for refined fuels in the transportation sector

Nearly all distribution companies have programs in place to drive natural gas usage as an alternate for refined petroleum products in some areas of the transport sector. Based on fuel switch potential and available technology most agreed that the focus should be on conversion of the long-haul heavy duty vehicles and that a 25% fleet conversion could be achieved by 2030. Certain companies are also examining the LNG opportunity for marine vessels.

It is important to note that this conversion potential is contingent on technological advances in the natural gas fired engine (especially engine capacity needed in the mountains), investment in continental infrastructure, and long term policy certainty.

Fuel switch / emission reduction potential was calculated based on emissions in the target transport sectors as reported by Environment Canada in the latest national GHG inventory, and the assumption that natural gas fired vehicles would be on average 25% less GHG intensive than conventional gasoline or diesel fired vehicles.

LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned infrastructure

In regions with mature and widespread natural gas distribution infrastructure (BC, Alberta, Saskatchewan, Manitoba, Ontario) natural gas has already displaced much of the refined petroleum products and propane as the primary source of energy. And potential is limited to deployment of LNG in remote communities and in industrial facilities not connected to the pipeline system.

The potential was higher in regions where natural gas is not yet widely accessible due to distribution system / connectivity constraints.

Fuel switch / emission reduction potential was calculated based on regional level demand for refined petroleum products and propane as reported by StatsCanada and emission intensities of different fuels.

The potential for reducing natural gas consumption through deep energy efficiency measures in buildings

Several provinces (B.C., Manitoba, Quebec and Ontario) have delivered natural gas energy efficiency programs (or demand side management programs) for years. These provinces have carried out detailed sector by sector conservation potential reviews per the regulator's requirement.

These studies (recent and historic) were used where available in assessing regional level energy and emission reduction potential. Where not available, these studies were used to develop a simplified assumption that a 6% reduction could be achieved (vs 2030 business as usual demand).

Natural gas fired electricity generation as a replacement for coal-fired generation and enabler of intermittent renewable electricity generation

In the provinces where coal is still used to produce electricity there is a recognition by all provincial governments that as existing facilities retire some or all of the generating capacity will be replaced with a combination of natural gas and renewables (vs. new coal).

This is true in Alberta, Saskatchewan, Nova Scotia and New Brunswick where there is the potential for natural gas fired generation to replace coal as baseload capacity and to enable intermittent renewables.

Fuel switch/emission reduction potentials were estimated based on a province by province assessment of vintage of existing coal fleet, targets for renewable generation (circa 2030), current generation mix (as reported provincially or by Environment Canada within the latest GHG inventory), and any detailed forecasts provided by the provincial government, electricity system operator or crown corporation generating company. It was assumed that any new natural gas fired generation would emit at 0.45 tCO_2e/MWh vs 1 tCO_2e/MWh for coal.

Contribution of the natural gas distribution companies

Due to the nature of the gas distribution network and recognizing unique regional energy profiles, enabling policy, regulation and local opportunities this study focused on provincial level assessments for Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia as well as the Northern Territories (combined analysis for Yukon, Northwest Territories and Nunavut).

Along with the CGA the following utilities were consulted to ensure an appreciation of current regional energy and emissions profiles and reduction opportunities.

- Enbridge Gas New Brunswick – New Brunswick
- Heritage Gas Limited – Nova Scotia
- Gaz Métro – Québec
- Union Gas Limited – Ontario
- Enbridge Gas Distribution Limited – Ontario
- Manitoba Hydro – Manitoba
- SaskEnergy – Saskatchewan
- ATCO Gas – Alberta
- FortisBC – British Columbia

2 Summary of Study Results

This section provides a dashboard showing the GHG emission reduction potential for each province (and the Northern Territories), by measure and a national summary. As illustrated, we estimate a total of over 47.7 $MtCO_2e$ in reductions per year nationally by 2030. The largest GHG emission reduction potential occurs in Ontario followed by Alberta, Saskatchewan, Quebec and British Columbia.

On a region by region basis we see differences in total potential and relative potential of each measured based on size of the province/territory, energy demand and energy / emissions profile.

	RNG	Transport	LNG	EE	Coal to NG	TOTAL
NT*	58,453	16,317	97,337	16,008		188,115
NB	100,839	36,840	161,053	90,539	352,000	741,271
NS	134,291	58,850	263,381	52,301	821,618	1,330,440
QC	538,650	538,495	583,489	1,200,000		2,860,634
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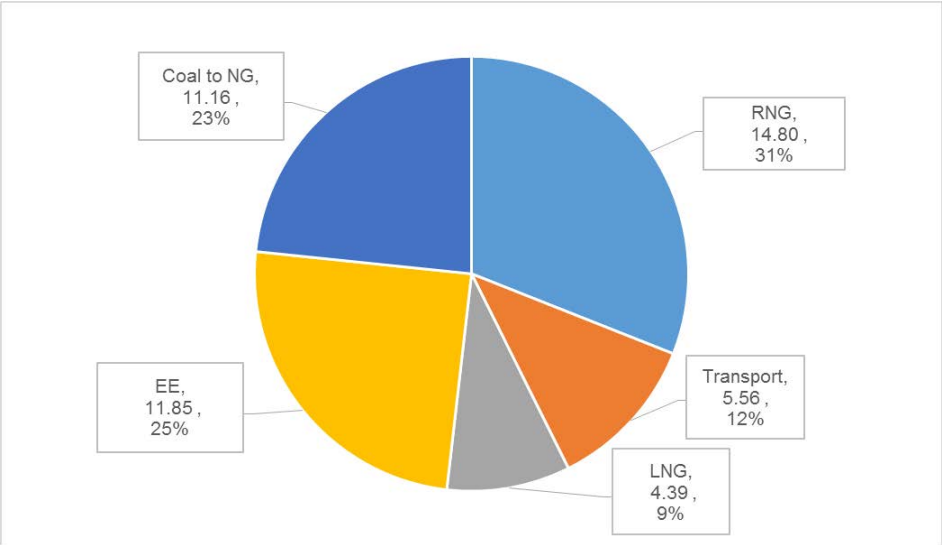
AB	4,337,196	715,500	1,232,992	3,058,158	7,786,350	17,130,195
BC	725,119	587,050	620,285	703,296		2,635,751
TOTAL	**14,800,139**	**5,555,848**	**4,390,499**	**11,849,105**	**11,156,221**	**47,751,811**

*NT = Northern Territories (Yukon, Northwest Territories and Nunavut)

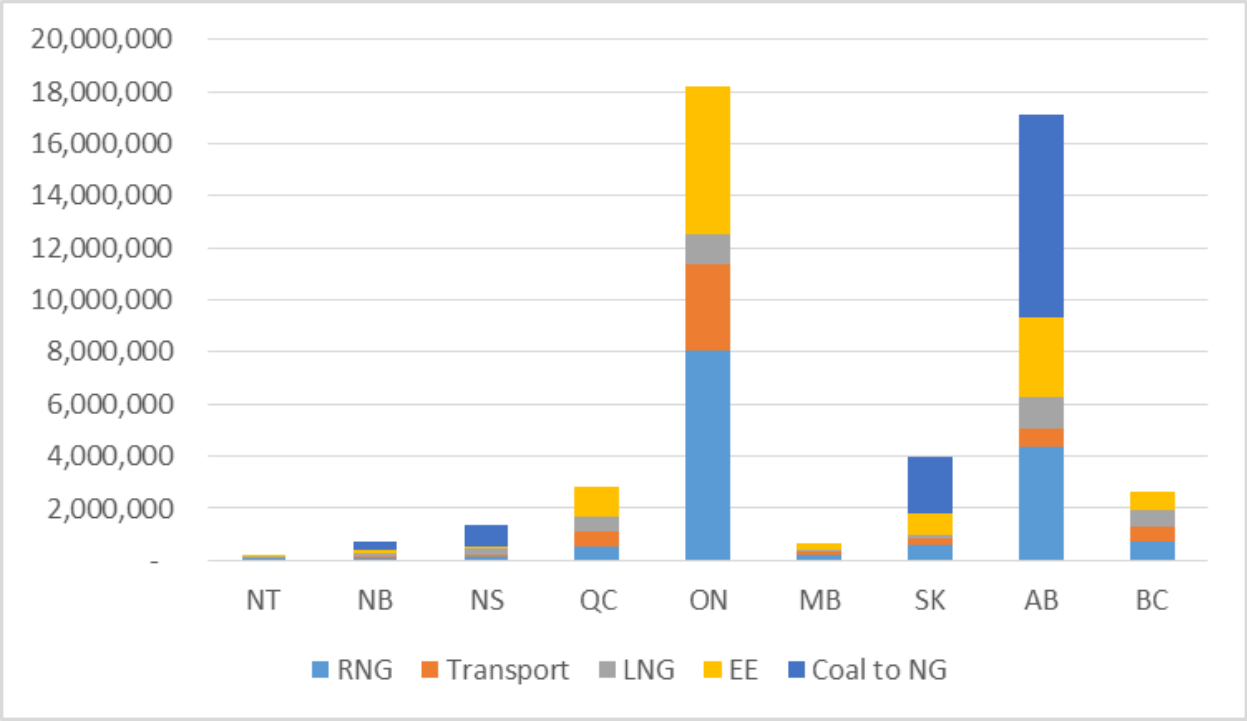
Nationally, the measures that are expected to deliver the largest potential benefits to GHG emissions are RNG, energy efficiency and coal to natural gas for power generation each of which contribute over 10 $MtCO_2e$ in reductions per year by 2030.

National Emission Reduction Potential by Measure by 2030 (in $MtCO_2e$/yr)



However, it is important to look at each province / territory distinctly as there are different opportunities in each jurisdiction. For example, whereas coal to gas is a significant opportunity in Alberta, Saskatchewan, Nova Scotia and New Brunswick, it is not an opportunity in British Columbia, Manitoba, Ontario, Quebec or the Northern Territories due to the absence of coal fired generation in the current and future supply mix. In contrast, while LNG and CNG for transportation and as a replacement for higher emitting fuels is a smaller contribution to overall national GHG emission reduction potential, there are opportunities for each of these measures in every region in the scope of this study. These regional similarities and differences are important considerations in any national policy setting exercise.

Regional Emission Reduction Potential by Measure by 2030 (in tCO_2e/yr)



Further detail is provided at the regional level along with discussion and measure by measure analytics.

British Columbia

For the last 20 years, British Columbia (B.C.) has met over 50% of its residential, commercial and industrial energy demand through the use of natural gas. Further, B.C. has one of the largest proven reserves of natural gas in the world and a robust transmission and distribution system ensuring affordable and reliable supply well into the future.

The province of B.C. emits around 63 Mt of CO_2e per year[3], with the combined natural gas consumption-related emissions from all sectors ranking second in contribution to total emissions, but only comprising about 40% of the emissions from the number one source, refined petroleum products (RPP) used in transportation. Due to vast hydroelectric resources and increasing supplies of other renewable electricity, B.C.'s electricity supply is virtually non-emitting.

Energy Source	2014 (TJs)[4]	GHG Emissions (tCO_2e)
Natural Gas	233,087	11,500,000
Electricity	195,901	~0
RPP (predominantly transport)	392,221	28,700,000
Other Energy (coal, coke, NGLs)	31,873	22,700,000**
Non-energy related (process, Ag, waste)	NA	
British Columbia TOTAL	**853,082**	**62,900,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

In addition, BC is home to several large ports, including Port Metro Vancouver, one of the largest ports in North America. Emissions from marine traffic calling in at BC ports, estimated at 70 Mt of CO_2e, are greater than the entire quantity of provincial emissions.[5] While outside the scope of this report, there is the potential for LNG bunkering in BC that could be used as a fuel source for some marine vessels calling in at BC ports.

Over the past decade, B.C. has implemented a number of legislative measures aimed at reducing GHG emissions through emissions reporting and mitigation, as well as renewable and low carbon fuel requirements, vehicle fuel efficiency standards, energy efficiency, building codes, and zero net deforestation. In 2008, British Columbia implemented a revenue-neutral carbon tax on combustion-related greenhouse gas emissions from transportation, as well as residential, commercial and industrial energy uses. The tax applies to the retail purchase or use of all fossil fuels (gasoline, diesel, natural gas, coal). It was initially set at \$10/tonne CO_2e and has increased by \$5/tonne per year until 2012 when it reached \$30/tonne, a level that has continued until today. The combination of this legislation, rate payer-based energy efficiency programs, and a changing economy appear to have resulted in reduced energy usage and lower GHG emissions vs. business as usual. However, lower market prices for oil and natural gas in recent years have had a countervailing effect on the price signal from the carbon tax.

B.C. has committed to reducing GHG emissions by 80% below 2007 by 2050, with interim targets along the way. Thus despite progress to date, more reductions must be achieved. Looking ahead,

[3] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[4] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
[5] STX Canada: Marine West Coast Marine LNG Supply Chain Project, October 2013

there are several opportunities for B.C. to realize further GHG emission reductions associated with expanding the usage of natural gas to displace higher carbon fuels or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- Natural Gas for Transportation (NGT) and LNG markets
    - CNG or LNG as a replacement for refined fuels (mainly diesel) in the high horsepower and heavy duty markets such as: on-road trucking, marine, mine haul trucks, locomotives and remote industrial power generation applications[6]
    - LNG as a replacement for propane, fuel oil and refined fuels in remote communities that do not have access to natural gas via existing/planned pipeline infrastructure, or electricity via existing/planned interconnections to electric grids
- The potential for reducing natural gas consumption through energy efficiency measures in all sectors

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	725,119	5% of natural gas throughput replaced with RNG
Transport	587,050	25% of heavy duty fleet converted to natural gas
LNG for Industrial and Remote Communities	620,285	~44% of RPP and NGL load converted to LNG
Energy Efficiency	703,296	6% reduction in energy usage vs BAU
TOTAL	**2,635,751**	**4% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions over 280,000 tonnes of CH_4 (the equivalent of 7 million tonnes of CO_2e)[7] are released to the atmosphere annually in B.C. from agriculture (enteric fermentation and manure management) and solid waste disposal. This is the equivalent of 15,400 TJs of natural gas, almost 7% of B.C. total annual demand. Beyond this source of methane for RNG the October 2010 study by the Alberta Research Council (ARC) concluded that forest residue gasification could be a significant source of RNG in B.C. considering mountain pine beetle forest destruction residue with an estimated total potential RNG production of 380 bcf per year (400,000 TJs/yr) almost twice B.C. current natural gas demand.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>400,000*	725,119	11,654 TJs of RNG (replacing 5% of total NG demand)

** total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

[6] Transportation includes diesel fuel consumed for heavy duty vehicles for On-road, Domestic Marine and Off-road transportation applications. LNG is best suited to replace diesel used in these applications.
Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

The study estimated emission reductions of 25.44 $MtCO_2e$ (or 62 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere. RNG project pilots in B.C. currently deliver over 400 TJs from waste and agricultural sources to 7,000 unique customers. This precedent and the potential defined above coupled with B.C.'s commitment to adopt a low-carbon fuel standard similar to that of California defined within the Renewable and Low Carbon Fuel Requirements of the Greenhouse Gas Reduction Act could drive the capture of over 11,654TJs of RNG by 2030. This would displace 5% of the conventional natural gas supply and reduce emissions in B.C. by over 725,000t CO_2e.

Natural Gas for Transportation

The transportation sector is defined as on-road, off-road (including locomotives), domestic marine and aviation transport applications. In 2014, B.C. emitted 24.8 $MtCO_2e$ from the transportation sector, or about 39% of B.C.'s total GHGs emitted. Most of these emissions originated from the combustion of gasoline and diesel. The main sources by segment are broken down as follows[8]:

- On-road transportation: 15.9 $MtCO_2e$
- Off-road transportation: 5.3 $MtCO_2e$
- Domestic Marine: 2.2 $MtCO_2e$
- Domestic Aviation: 1.4 $MtCO_2e$

In terms of suitability of natural gas as a transportation fuel, segments that primarily consume diesel (on-road, off-road and marine) are best positioned to adopt natural gas as a primary transport fuel.[9] As such, the transport segments that consume primarily diesel fuel emitted over 11.7 $MtCO_2e$ in 2014. This segment of the transport fleet could be cost effectively converted to natural gas by 2030. Assuming 25% of the diesel consuming fleet is converted to natural gas by 2030 GHG emissions could be reduced by 587,050 tCO_2e/yr. This is summarized in the table below.

Diesel Fuel Fleet	GHG Emissions (tCO_2e/yr)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
On-Road Diesel	**5,562,000**	**278,100**	25% conversion of fleet
Off-road Diesel (incl. locomotives)	**3,972,000**	**198,600**	25% conversion of fleet
Domestic Marine Diesel	**2,207,000**	**110,350**	25% conversion of fleet
TOTAL	**11,741,000**	**587,050**	

Natural Gas for Marine – Opportunity to Dramatically Reduce Global GHGs

In addition to natural gas for the on-road transportation segment, the marine segment represents a tremendous opportunity to further reduce GHGs through the increased use of natural gas as a marine propulsion fuel. Marine shipping is estimated to represent between 1.5 per cent[10] to more than 2 per cent[11] of total global GHG emissions, which is greater than all of B.C.'s emissions. Natural gas fueling and engine technologies are readily available in the marketplace today, which can enable rapid uptake of natural gas as a marine fuel. The transition to natural gas is currently

[8] http://www2.gov.bc.ca/gov/content/environment/climate-change/reports-data/provincial-ghg-inventory-report-bc-s-pir
[9] Natural gas is not well suited to displace fuel in the Aviation sector.
[10] http://www.c2es.org/technology/factsheet/MarineShipping
[11] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx

underway through a number of projects converting passenger and cargo ferries to natural gas and will begin operation in B.C. by the end of 2016.[12]

While progress is being made in the short-sea marine segment, more could be done to encourage regional/coastal freight and trans-Pacific vessels to adopt natural gas. Research shows that a typical trans-Pacific marine vessel consumes up to 3 petajoules of fuel per year and a typical coastal freight vessel consumes up to 1.5 petajoules of fuel per year. As the fourth largest port in North America by tonnage, Port Metro Vancouver received port calls from more than 1,100 different vessels in 2014. Just one of these vessels converting to natural gas could reduce GHG emissions by approximately 90,000 tonnes CO_2e per vessel per year[13], or the equivalent of removing about 19,000 passenger vehicles from the road.[14]

Ports such as Singapore and Antwerp, where LNG bunkering as a marine fuel is being developed today, should be viewed as examples of how to develop these capabilities here in Canada.

B.C.'s role as a West Coast hub for international marine traffic and its domestic natural gas resource and existing infrastructure should be leveraged to significantly increase the uptake of natural gas as a marine fuel. As the regional and global transition to natural gas (LNG) as a marine fuel continues due to tighter emissions regulations, there is an opportunity for B.C. to position itself as a premier global destination for LNG bunkering. The availability of LNG fuel at competitive prices would also be a competitive advantage for B.C. ports, thus encouraging shipping companies to select B.C. for their North American import and export hubs. The result would be the emergence of a new market segment in the country with the associated employment opportunities and revenues that would result from this development.

LNG Fuel Switching Potential

B.C. residential, commercial and industrial energy users consumed over 51,000 TJs of refined petroleum product and NGL derived energy in 2014 resulting in 4 $MtCO_2e$ emissions. The majority of the usage was in the industrial sector through the consumption of diesel where pipeline delivered natural gas was not available. Much of the current demand for refined petroleum product and NGLs could be met with LNG by 2030. Assuming approximately 10% of residential / commercial and 50% of industrial (25,346 TJs of the 51,042 TJs) load was met with LNG, emissions would be reduced by 620,285 tCO_2e/yr.

End User (RPP/NGLs)	2014 (TJs)[15]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	873	1,410	10%
Commercial	7,250	18,968	10%
Industrial	42,919	599,907	50%
TOTAL	**51,042**	**620,285**	**~44%**

[12] Total of 5 natural gas marine vessels are scheduled to be in full operation by mid-2017, with the potential to add 2 more passenger ferry vessels by 2020.
[13] Using carbon intensity values of 93.55 kg CO2e per GJ for diesel and 63.26 kg CO2e per GJ for LNG
[14] Assumes a typical passenger car emits about 4.75 metric tonnes of CO2e per year; http://www.epa.gov/cleanenergy/energy-resources/refs.html#vehicles
[15] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Beyond this domestic potential B.C's vast reserves of natural gas could drive emission reductions internationally (enabling coal to natural gas and diesel to natural gas fuel switching) through the production, liquefaction and exportation of natural gas via LNG.

Energy Efficiency

B.C. has led in the promotion of demand side management energy efficiency programs for both natural gas and electricity over the past 20 years. As a result, significant energy usage reductions have been achieved, resulting in the reduction of provincial GHG emissions (associated with reduced natural gas consumption).

A 2011-vintage study carried out by Fortis (representing 75% of natural gas demand in B.C.) concluded that by 2030 an additional 6-9% of demand reduction (vs BAU) could be achieved[16]. Across B.C. this would equate to 14,000 – 21,000 TJs of natural gas saved or 700,000 to 1,000,000 tCO_2e in avoided emissions.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	14,258	703,296	6% of total demand

Despite the savings to date, more can be achieved by incentivizing cost effective reduction in demand of natural gas. B.C. gas and electric utilities are currently working to develop an estimate of technical, economic, and achievable potential out to 2035.

Bibliography

http://www2.gov.bc.ca/gov/content/environment/climate-change/policy-legislation-programs/legislation-regulations
Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
Conservation Potential Review – 2010, FortisBC Residential, Commercial and Industrial Sectors: Energy-efficiency, Alternate Energy & Customer Behaviour Opportunities (2010-2030) Summary Report, by ICF Marbek.

[16] Conservation Potential Review – 2010, FortisBC Residential, Commercial and Industrial Sectors: Energy-efficiency, Alternate Energy & Customer Behaviour Opportunities (2010-2030) Summary Report, by ICF Marbek.

Alberta

The natural gas transmission and distribution system supplies over 50% of total primary and secondary energy demand and 75% of residential, commercial and industrial energy demand in Alberta. GHG emissions in the province of Alberta have grown by 57% or 100 $MtCO_2e$ since 1990 as a result of a growing economy and increased energy consumption associated with oil and gas production.

Energy Source	2014 (TJs)[17]	GHG Emissions (tCO_2e)*
Natural Gas	1,194,819	58,900,000
Electricity	233,572	48,900,000
RPP (predominantly transport)	605,402	58,700,000
Other Energy (coal, coke, NGLs)	311,243	107,500,000**
Non-energy related (process, Ag, waste)	NA	
Alberta TOTAL	**2,345,036**	**274,000,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

Alberta was one of the first jurisdictions in North America to regulate greenhouse gas emissions. Since 2007, Alberta's Climate Change and Emissions Management Act and the Specified Gas Emitters Regulation has required large industrial facilities to reduce their "emissions intensity" (i.e. emissions per unit of production) by 12%. Building on this, a newly elected government in Alberta is currently implementing a new strategy on climate change based on recommendations put forward by the Climate Change Advisory Panel. Implementation details are being finalized, but include four key areas that the Alberta government is moving forward on:

1. Phasing out emissions from coal-generated electricity and developing more renewable energy
2. Implementing a new carbon price on greenhouse gas emissions
3. A legislated oil sands emission limit
4. Employing a new methane emission reduction plan

The new plan will implement a carbon price of $20/tonne in 2017 rising to $30 in 2018, and will broaden the scope of program coverage from large industrial facilities to the retail purchase or use of all fossil fuels (gasoline, diesel, natural gas, coal) throughout the economy (residential, commercial and industry-small and large). In addition, the province will apply a legislated limit of 100 $MtCO_2e$ on emissions from the oil sands and phase out of coal-fired generation by 2030. Natural gas can play a key role in enabling all these measures.

Looking ahead, there are significant opportunities for Alberta to realize further GHG emission reductions associated with expanding natural gas usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector

[17] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

- LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned pipeline infrastructure
- Reducing natural gas consumption through energy efficiency measures
- Natural gas as a replacement for coal-fired generation and as enabler of increased renewables in the electricity system

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	4,337,196	5% of natural gas throughput replaced with RNG
Transport	715,500	25% of heavy-duty fleet converted to natural gas
LNG	1,232,992	35% of RPP and NGL load converted to LNG
Energy Efficiency	3,058,158	6% reduction in energy usage vs BAU
Coal to Natural Gas	7,786,350	Replacement of 2,065 MW of retiring coal-fired electricity generation with natural gas
TOTAL	**17,130,196**	**6% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions over 500,000 tonnes of CH_4 (the equivalent of 12.5 million tonnes of CO_2e)[18] are released to the atmosphere annually in Alberta from agriculture (enteric fermentation and manure management) and solid waste disposal. This is the equivalent of 27,600 TJs of natural gas. Beyond this source of methane for RNG the October 2010 study by the Alberta Research Council (ARC) concluded that including crop and forest residue gasification potential RNG production of 170 bcf per year (183,000 TJs/yr) or the equivalent of 15% of total 2014 demand. The study estimated emission reductions of 13.2 $MtCO_2e$ (or 72.6 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere.

For the purposes of this study, we assume that there is sufficient RNG potential in Alberta to displace 5% (60,000 TJs of RNG) of conventional natural gas supply by 2030. This would reduce emissions in Alberta by almost 4.4 $MtCO_2e$ through avoided release of CO_2 and CH_4 to the atmosphere.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>182,920*	4,337,196	59,741 TJs of RNG (replacing 5% of total NG demand)

** total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

[18] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

Natural Gas in the transport sector

Alberta emitted 26.7 Mt from road transportation in 2014. Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet of approximately 112,000 vehicles emitted over 14,300,000 tCO_2e per annum. Technically, much of this segment of the transport fleet could be cost effectively converted to natural gas by 2030. Assuming 25% of the fleet were converted to natural gas by 2030, emissions could be reduced by over 700,000 tCO_2e/yr.

Fleet	GHG Emissions (tCO_2e/yr)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty Diesel	12,000,000	600,000	25% conversion of fleet
Heavy-duty Gasoline	2,310,000[19]	115,500	25% conversion of fleet
TOTAL	**14,310,000**	**715,500**	

Beyond this potential in the heavy-duty fleet Alberta has over 16,000 buses and 183,000 medium-duty vehicles with potential to convert to natural gas and further reduce emissions.

LNG Fuel Switching Potential

Alberta residential, commercial and industrial energy users consumed over 130,000 TJs of refined petroleum product (RPP) and NGL derived energy in 2014 resulting in over 9.3 $MtCO_2e$ emissions. The majority of the usage was in the industrial sector through the consumption of RPPs (63,708 TJs) and NGLs (39,298 TJs).

Much of the current demand for refined petroleum product and NGLs could be met with LNG by 2030. Assuming 35% (45,383 TJs of the 130,748 TJs) of this load was met with LNG, emissions would be reduced by over 1,200,000 tCO_2e/yr.

End User (RPP/NGLs)	2014 (TJs)[20]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	1,708	5,726	30%
Commercial	26,034	297,555	50%
Industrial	103,006	929,711	50% of RPPs (0% NGLs)
TOTAL	**130,748**	**1,232,992**	**35%**

Energy Efficiency

It is widely recognized that increased efficiency is the lowest-cost source of energy and is three to six times cheaper than generating new supply. Utility-delivered demand side management (DSM) programs are one of the most successful, effective and sustainable approaches to increasing energy efficiency in residential, commercial and industrial facilities. Benefits of DSM include reduced energy

[19] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[20] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

consumption, lower energy costs for consumers, and emissions reductions. Consumer energy cost savings are reinvested in local economies, increasing competitiveness and providing macroeconomic benefits.

DSM programs focused on low income populations ensure all segments of society have the opportunity to benefit from increased energy efficiency. DSM programs focused on market transformation foster innovation and encourage the adoption of technologies which may otherwise be slow to penetrate the market. Therefore, they can play a significant role to accelerate market acceptance of renewables and a vast range of more energy efficient and lower carbon technologies such as natural-gas fired combined heat and power (CHP), gas heat pumps, etc.

In contrast to other major jurisdictions across Canada and North America, Alberta has historically stood alone, without public policy support for energy efficiency programs. However, this has recently changed. With the introduction of an economy-wide carbon levy of $20/t (2017) rising to $30/t (2018) and upward in future years, the government of Alberta has announced that they will invest a portion of the proceeds of the levy ($645 million over the next five years) back into the economy through energy efficiency programs through the Energy Efficiency Alberta agency. The Canadian Gas Association and the Alberta members look forward to continued dialogue with policy makers to determine how Alberta's natural gas distribution utilities can play a constructive role to assist government in the delivery of energy efficiency programs to Albertans.

To this end, ATCO, engaged Dunsky Energy Consulting to carry out an Alberta-specific bottom-up conservation potential study for natural gas that estimated 62,000 TJs in cumulative annual savings by 2030 resulting in 3.1 $MtCO_2e$ in emission reductions per annum across the province. While this level of emissions reduction is dependent upon energy efficiency program investment which exceeds announced funding, the study concluded that there was significant cost-effective energy efficiency potential in Alberta. The Alberta study results are consistent with comparable savings potential studies carried out recently in B.C., Manitoba, and Ontario.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	62,000	3,058,158	62,000TJs represents 5.2% of total 2014 demand

Coal to Natural Gas in the Electricity Sector

According to Canada's national inventory of GHG emissions, in 2014 the Alberta's electricity sector emitted almost 49 $MtCO_2e$. Over 69% of electrical generation (42,900 of 61,700 GWhs) was met with coal-fired capacity (6,300MW) while natural gas contributed 20% (12,100 GWhs from 7,080MW of capacity). Coal-fired generation alone in Alberta emitted 41.4 $MtCO_2e$.

Resource Type	2014 (GWhs)[21]	GHG Emissions (tCO_2e)
Coal	42,900	41,400,000
Natural Gas	12,100	7,490,000
Renewables / Other	6,700	18,000
TOTAL	**61,700**	**48,908,000**

The government of Alberta has begun to address this emissions source with the following initiatives and targets;

- Coal-fired electricity will be phased out and replaced by renewable energy and natural gas-fired electricity, or by using technology to produce zero pollution, by 2030.
- Starting in 2018, coal-fired generators will pay a $30/tonne carbon price based on an industry-wide performance standard.
- By 2030, renewable sources like wind and solar will account for up to 30% of electricity generation in Alberta.

Using the assumption that coal is phased out by 2030 and one third of existing coal capacity (~2,000 MW of 6,300MW) is converted to combined cycle natural gas-fired generation and the remainder is converted to non-emitting generation, approximately 14,100 GWhs of new natural gas fired generation would be created annually. This new natural gas fired generation would emit an estimated 6.4 $MtCO_2e$ (at 0.45 tCO_2e/MWh) and displace 14.1 $MtCO_2e$ of emissions associated with coal fired generation (at 1.0 tCO_2e/MWh) resulting in reductions of 7.8 $MtCO_2e/yr$.

Change in Capacity			GHG Emissions (tCO_2e)
Added Natural Gas	+2,065 MW (33%)	+14,157 GWhs	+6,370,650
Coal retired by Natural Gas	-2,065 MW (33%)	-14,157 GWhs	-14,157,000
Emission Reductions			**-7,786,350**

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Climate Leadership Plan: A summary of Alberta's new policy response to climate change. http://www.alberta.ca/climate-leadership-plan.cfm
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

[21] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

Saskatchewan

The natural gas transmission and distribution system dates back more than half a century in Saskatchewan. SaskEnergy delivers natural gas through a 68,500 kilometer distribution system connecting 93% of Saskatchewan communities (+385,000 residential, farm, commercial and industrial customers) throughout Saskatchewan.

Natural gas meets over 66% of residential, commercial and industrial energy demand. In addition natural gas-fired electricity generation meets approximately 32% (4,400 GWh of 13,800 GWh/yr) of total electricity demand in the province. GHG emissions in the province of Saskatchewan have grown by 67% or 20 $MtCO_2e$ since 1990 as a result of a growing economy and the increased energy consumption associated with production of a diversity of primary resources (oil, gas, grains, potash, uranium, etc.).

Energy Source	2014 (TJs)[22]	GHG Emissions (tCO_2e)
Natural Gas	275,000**	13,600,000
Electricity	76,862	15,800,000
RPP (predominantly transport)	218,773	16,000,000
Other Energy (coal, coke, NGLs)	18,487	30,100,000***
Non-energy related (process, Ag, waste)	NA	
Saskatchewan TOTAL	**589,122**	**75,500,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources*
***demand per SaskEnergy's 2014 Annual Report as StatsCanada data deemed incomplete*
****Includes GHG emissions from Other Energy and all Non-energy related emissions*

Saskatchewan is currently working with the federal government to develop a path forward on climate policy that balances the need for GHG reductions with the importance of continuing economic growth. Actions to date include the development of world-leading carbon capture and storage (CCS) technology and the development of renewable energy.

Looking ahead, there are significant opportunities for Saskatchewan to achieve GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned pipeline infrastructure
- The potential for reducing natural gas consumption through energy efficiency measures
- Natural gas as a replacement for coal-fired generation and as enabler of increased renewables in the electricity system

[22] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	620,456	5% of natural gas throughput replaced with RNG
Transport	205,450	25% of heavy duty fleet converted to natural gas
LNG	162,195	35% of RPP and NGL load converted to LNG
Energy Efficiency	813,865	6% reduction in energy usage vs BAU
Coal to Natural Gas	2,196,253	Replacement of 505 MW of retiring coal-fired electricity generation with natural gas
TOTAL	**3,998,269**	**5% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions, over 240,000 tonnes of CH_4 (the equivalent of 6 million tonnes of CO_2e)[23] are released to the atmosphere annually in Saskatchewan from agriculture (enteric fermentation and manure management) and solid waste disposal. This is the equivalent of 13,400 TJs of natural gas (or 5% of total demand). Beyond this source of methane for RNG, the October 2010 study by the Alberta Research Council (ARC) concluded that Saskatchewan's agricultural waste (unused crop residues and animal manures), forest waste (residues generated during harvest operations and subsequent wood treatment in either sawmills or pulp and paper plants), and municipal waste (from homes and businesses, gas from landfills, and waste from municipal waste water and bio-solids) could provide an estimated 137 bcf per year (147,000 TJs/yr) an amount equal to 60% of Saskatchewan's current natural gas demand. The study estimated emission reductions of 9.62 $MtCO_2e$ (or 65.3 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere.

For the purposes of this study, we assume that there is sufficient RNG potential in Saskatchewan to displace 5% (9,500 TJs of RNG) of conventional natural gas supply by 2030. This would reduce emissions in Saskatchewan by over 620,000 tCO_2e through avoided release of CO_2 and CH_4 to the atmosphere.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>147,000*	620,456	9,508 TJs of RNG (replacing 5% of total NG demand).

**total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

Natural Gas in the Transport Sector

Saskatchewan emitted 8.1 $MtCO_2e$ from road transportation in 2014. Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet of approximately 41,000 vehicles emitted over 4,100,000 tCO_2e per annum. This segment of the

[23] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

transport fleet could be converted to natural gas by 2030. Assuming 25% of the fleet were converted to natural gas by 2030, emissions could be reduced by over 205,900 tCO_2e/yr.

Fleet	GHG Emissions (tCO_2e/yr)[24]	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty Diesel	3,860,000	184,000	25% conversion of fleet
Heavy-duty Gasoline	429,000	21,450	25% conversion of fleet
TOTAL	**4,289,000**	**205,450**	

Beyond this potential in the heavy-duty fleet, Saskatchewan has over 4,000 buses and 49,000 medium-duty vehicles with potential to convert to natural gas and further reduce emissions.

LNG Fuel Switching Potential

Saskatchewan's residential, commercial and industrial energy users consumed over 31,000 TJs of refined petroleum product and NGL derived energy in 2014 resulting in almost 2.4 $MtCO_2e$ emissions. The majority of the usage was in the industrial sector through the consumption of NGLs (6,051 TJs) and RPPs (16,285 TJs).

Technically, much of the current industrial demand for refined petroleum product and NGLs could be met with LNG by 2030. There is little addressable potential in the residential and commercial space due to high current connectivity to natural gas. Assuming 30% (6,700 TJs of the 22,336 TJs) of industrial load was met with LNG, emissions would be reduced by over 162,000 tCO_2e/yr.

End User (RPP/NGLs)	2014 (TJs)[25]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	674	~	0%
Commercial	8,532	~	0%
Industrial	22,336	162,195	30%
TOTAL	**31,542**	**162,195**	**21%**

Energy Efficiency

To date SaskEnergy has effectively deployed several Demand Side Management (DSM) programs aimed at reducing energy usage within its customer base including; Residential Programs: Energy Star Loans, Thermostat Rebates, etc. and Commercial Programs: Boiler and HVAC (heating, ventilation, air conditioning). The programs have proven successful by achieving higher customer satisfaction in the residential and commercial segments, and delivering reductions in natural gas demand, thereby reducing associated GHG emissions. Conservation potential studies carried out recently in B.C., Manitoba, and Ontario (and to an extent Alberta) show that 2030 vintage demand can be reduced by between 5% and 10% with aggressive energy efficiency programs. Given

[24] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[25] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

SaskEnergy's experience to date and high degree of natural gas connectivity in the province, a 6% reduction should be achievable. This would result in 16,500 TJs of savings, reducing emissions by 813,865 tCO_2e by 2030.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	16,500	813,865	6% of total 2014 demand

Coal to Natural Gas in the Electricity Sector

In 2014 Saskatchewan's electricity sector emitted 15.8 $MtCO_2e$ (over 20% of total emissions in the province). Over 67% of electrical generation was met with coal-fired capacity (1,530 MW) while natural gas (including CHP units) contributed 32% (1,771 MW). Coal-fired generation alone in Saskatchewan emitted and estimated 9.3 $MtCO_2e$ in 2014[26].

SaskPower has developed a plan to reduce emissions by approximately 40% below 2005 levels by 2030. To achieve this SaskPower made the largest per-capita investment in the world to clean up coal-fired generation through installation of CCS technology at its Boundary Dam electricity generating facility in Estevan. Further, SaskPower has also set a target of having 50% of its electrical generation capacity come from renewable sources by 2030 through expansion in wind power, augmented by other renewables, such as solar, biomass, geothermal and hydro.

Natural gas will play a key role in backfilling for retired reliable baseload coal-fired generation and enabling deployment of significant intermittent renewable (wind and solar) capacity. Using the assumption that one third of existing coal capacity (505 MW) is converted to combined cycle natural gas-fired generation and two thirds (1,025 MW) to non-emitting generation, emissions from coal-fired generation could be reduced from 9.3 Mt to 1.8Mt. Of this reduction almost 2.2 $MtCO_2e$ of reductions can be attributed to conversion from coal to natural gas.

Change in Capacity			GHG Emissions (tCO_2e)
Added Natural Gas	505 MW (33%)	3,981 GWhs	1,791,284
Coal retired by Natural Gas	505 MW (33%)	3,981 GWhs	~3,987,000
Emission Reductions			**2,196,253**

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
http://www.environment.gov.sk.ca/climatechange
https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
SaskEnergy 2014 ANNUAL REPORT (http://www.saskenergy.com/about_saskenergy/annual_report/documents/2014/SaskEnergy_2014_Annual_Report.pdf)

[26] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

Manitoba

Manitoba's natural gas system supplies 275,000 customers across the province. In total, 28% of total provincial energy demands (including transportation) are met by natural gas and over 43% of total residential, commercial and industrial demand.

The province of Manitoba generates 21.5 Mt of CO_2e per year of which 4 Mt of CO_2e are related to natural gas consumption. The largest share of emissions comes from refined petroleum product (RPP) use in transportation fuel combustion. Due to the closure of coal-fired generating stations and its abundant hydroelectric resources, Manitoba's electricity supply has reduced emissions by 90% since 2000 and is currently very low-emitting.

Energy Source	2014 (TJs)[27]	GHG Emissions (tCO_2e)
Natural Gas	82,534	4,070,000
Electricity	81,839	122,000
RPP (predominantly transport)	121,774	8,900,000
Other Energy (coal, coke, NGLs)	5,484	>8,500,000
Non-energy related (process, Ag, waste)	NA	
Manitoba TOTAL	**291,631**	**21,592,000**[28]

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

To date Manitoba has driven emission reductions through energy efficiency (natural gas and electricity) as well as the development of non-emitting sources of electricity and the closure of coal-fired generation. Exports of non-emitting electricity from Manitoba to the U.S. have played a significant role in reducing continental emissions. A newly elected government in Manitoba appears to be assessing policy and legislative options related to climate change. Of particular relevance is the intention to join California, Ontario and Quebec under the Western Climate Initiative by introducing a cap-and-trade system to reduce greenhouse gas emissions.

The Manitoba Climate Change Green Economy Action Plan has committed to further reducing greenhouse gases:

- By 2030, Manitoba will reduce its greenhouse gas emissions by one-third over 2005 levels
- By 2050, Manitoba will reduce its greenhouse gas emissions by one-half over 2005 levels
- By 2080, Manitoba will be carbon neutral

Looking ahead, there are several opportunities for Manitoba to realize further GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned pipeline infrastructure

[27] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
[28] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

- The potential for reducing natural gas consumption through energy efficiency measures

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	206,335	5% of natural gas throughput replaced with RNG
Transport	130,800	25% of heavy duty fleet converted to natural gas
LNG	95,068	~17% of RPP and NGL load converted to LNG
Energy Efficiency	245,015	6% reduction is energy usage vs BAU
TOTAL	**677,218**	**3% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions over 157,000 tonnes of CH_4 (the equivalent of almost 4 Mt of CO_2e) are released to the atmosphere annually in Manitoba from agriculture (enteric fermentation and manure management) and solid waste disposal. This is the equivalent of 8,600 TJs of natural gas, or over 10% of Manitoba's total annual demand. Beyond this source of methane for RNG, the October 2010 study by the Alberta Research Council (ARC) concluded that Manitoba's agricultural waste (unused crop residues and animal manures), forest waste (residues generated during harvest operations and subsequent wood treatment in either sawmills or pulp and paper plants), and municipal waste (from homes and businesses, gas from landfills, and waste from municipal waste water and bio-solids) could provide an estimated 69 bcf of RNG per year (74,000 TJs/yr) an amount equal to 90% of Manitoba's current natural gas demand. The study estimated emission reductions of 5.48 $MtCO_2e$ (or 74 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere.

Manitoba Hydro contracted (DLF Consulting) to carry out an additional study, "Heating with Biomass: Using a Manitoba Renewable Resource Manitoba Hydro Biomass Fuel Heating Study", which demonstrated that Manitoba's wealth of biomass resources can significantly contribute to reducing the Province's environmental footprint by providing a renewable source of heat. This study estimated significant potential (102,300 TJs related to agriculture and forest biomass), it also illustrated the challenge recognizing that there would be competition (heat vs. gasification to RNG) for biomass as a fuel.

Manitoba Hydro through their Power Smart programs are working to displace RPP and electric space heating in remote locations in Manitoba through the beneficial use of available biomass. The beneficial use of biomass will provide economic benefits to the end users, the potential for local employment, while also contributing to GHG emission reductions.

For the purposes of this study, we assume that there is sufficient biomass in Manitoba to displace 5% of the conventional natural gas supply. This would reduce emissions in Manitoba by 206,335 tCO_2e per year.

Natural Gas in the Transport Sector

Manitoba emitted almost 6.3 $MtCO_2e$ from the road transport sector in 2014 (29% of total provincial emissions). Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet of approximately 28,000 vehicles emitted over 2,600,000 tCO_2e

in 2014. This segment of the transport fleet could be converted to natural gas, as either LNG/CNG by 2030. Assuming 25% of the fleet was converted to natural gas by 2030, GHG emissions could be reduced by over 130,800 tCO_2e/yr.

At present, there is minimal infrastructure in place in Manitoba and the Canadian prairie provinces to support the wide spread adoption of LNG/CNG as a heavy duty transportation fuel. In addition, the province of Manitoba has a transportation NG fuel tax in place, which is equivalent to the provincial fuel tax on diesel. The Manitoba NG fuel tax erodes the economic benefit to transportation end users for switching to LNG/CNG. Nonetheless, with the appropriate supporting Provincial and Federal policies, LNG and CNG as a transportation fuel offers significant GHG reduction potential.

Fleet	GHG Emissions (tCO_2e/yr)[29]	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty Diesel	2,330,000	116,500	25% conversion of fleet
Heavy-duty Gasoline	286,000	14,300	25% conversion of fleet
TOTAL	**2,616,000**	**130,800**	

LNG Fuel Switching Potential

Manitoba's residential, commercial and industrial energy users consumed over 21,000 TJs of refined petroleum product and NGL derived energy in 2014 resulting in almost 1,700,000 tCO_2e emissions. The majority of the usage was in the industrial sector through the consumption of RPPs (12,367 TJs). Technically much of the current residential, commercial and industrial demand for refined petroleum product and NGLs could be met with LNG by 2030.

In the Manitoba market, the majority of RPP and NGL are utilized in remote locations which are not serviced by NG pipelines, and in some cases the locations are not served by year round all weather roads. The lack of year round all weather roads is an impairment to fuel supply options for some remote communities. Manitoba Hydro and other groups have explored the potential to substitute RPP and NGL with alternate energy sources, such as renewable electricity, biomass and LNG. Manitoba will continue to evaluate the technical and economic opportunities to replace RPP and NGL with alternate energy sources, which when implemented will result in GHG reductions. There is modest (10%) addressable potential in the residential and commercial space due to high current connectivity to natural gas. Assuming 20% of industrial load was met with LNG and 10% of residential/commercial, GHG emissions would be reduced by over 95,000 tCO_2e/yr.

[29] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

End User (RPP/NGLs)	2014 (TJs)[30]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	494	958	10%
Commercial	7,013	18,332	10%
Industrial	14,028	75,778	20%
TOTAL	**21,535**	**95,068**	**17%**

Energy Efficiency

Manitoba has successfully delivered both gas and electric energy efficiency programs, and recognizes there is further potential to improve efficiency and reduce emissions going forward. As defined in Manitoba's Climate Change and Green Economy Action Plan (December 2015), Manitoba is pursuing;

- creating a new demand side management agency,
- establishing NG and electric energy savings targets,
- expanding the Power Smart program, and
- supporting the adoption of green-heating alternatives to fossil fuels such as geothermal technology.

Manitoba has committed to set electricity and natural gas savings targets under the Energy Savings Act. Targets will range between 1.5 per cent of the total domestic electrical demand and 0.75 per cent of domestic natural gas demand, annually, through DSM activities. These targets will be driven by "Conservation Electricity Rates" and "Energy Efficiency Product Standards" and will add to savings to date, incentivizing cost effective reduction in demand of natural gas. A recent study carried out by Manitoba Hydro concluded that by 2030 an additional 130 Mm^3 of natural gas savings (or almost 5,000 TJs) could be achieved via natural gas programs in the province. This represents a further 6% of demand reduction (vs BAU) could be achieved which would equate to over 245,000 tCO_2e in avoided emissions across Manitoba.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	4,967	245,015	6% of total demand

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
https://www.gov.mb.ca/conservation/climate/pdf/mb-climate-change-green-economy-action-plan.pdf
http://www.gov.mb.ca/conservation/climate/

[30] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Ontario

Ontario's natural gas transmission, distribution and storage systems have provided Canada's largest province with reliable and affordable energy for over a century. Excluding transport, natural gas provides over 54% of the total energy supply to the residential, commercial and industrial energy end users. Over 75% of residential customers are connected to the natural gas distribution systems and rely on natural gas as their primary source of energy for space heat and hot water.

The province of Ontario emits 170 Mt of CO_2e per year and natural gas consumption-related emissions rank second in contribution to total emissions, after refined petroleum product (RPP) use in transportation. Due to the shuttering of coal-fired generating stations and reliable baseload supply from nuclear and hydroelectric resources, Ontario's electricity supply has reduced emissions by over 37 Mt or 85% since 2000 and is currently very low-emitting. Natural gas-fired generating stations supplied 10,700 GWh (6% of total generation) in 2014[31].

Energy Source	2014 (TJs)[32]	GHG Emissions (tCO_2e)*
Natural Gas	956,865	47,200,000
Electricity	406,147	6,200,000
RPP (predominantly transport)	975,638	71,300,000
Other Energy (coal, coke, NGLs)	188,442	45,300,000
Non-energy related (process, Ag, waste)	NA	
Ontario TOTAL	**2,527,092**	**170,000,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

To date Ontario has driven emission reductions through energy efficiency (natural gas and electricity), the development of non-emitting sources of electricity and closure of coal-fired generation, vehicle fuel efficiency standards, and investment in public transportation (The Big Move). The government passed new legislation and regulation in 2016 setting a path to commence a cap and trade system in 2017. Ontario plans to join with Quebec and California under the WCI as early as 2018. The government's Climate Change Action Plan released in June 2016 defines between $6B and $8.3B in funding for a variety of measures aimed and reducing emissions between 2017 – 2020 and beyond. Within in this plan there is recognition for the role that natural gas and more broadly the natural gas system can play in reducing emissions (RNG, natural gas for transportation and energy efficiency).

There are significant opportunities for Ontario to realize further GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- CNG / LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned pipeline infrastructure
- The potential for reducing natural gas consumption through energy efficiency measures

[31] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada
[32] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	8,078,800	16% of Ontario's forecast natural gas needs
Transport	3,266,546	Segment specific fleet conversions to natural gas
LNG	1,174,699	~35% of RPP and NGL load converted to LNG
Energy efficiency	5,669,924	12% reduction in energy usage vs BAU
TOTAL	**18,189,969**	**11% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions over 528,000 tonnes of CH_4 (the equivalent of 13.2 $MtCO_2e$) are released to the atmosphere annually in Ontario from agriculture (enteric fermentation and manure management), solid waste disposal, and waste water. A 2011 study by Alberta Innovates identified that from this waste 162,000 TJs (4,435 Mm^3) could be created into RNG in Ontario from anaerobic digestion and gasification from agriculture, forestry and municipal wastes[33]. The GHG reductions from the displacement of conventional natural gas with 4,435 Mm^3 of RNG is in excess of 8 $MtCO_2e$, and this does not account for any GHG reduction would be based on the destruction of fugitive methane from agricultural or waste sources were these fugitives captured for combustion as pipeline fuel.

Additional studies have also suggested Ontario's RNG potential represents a significant abatement opportunity. One such report is the October 2010 study by the Alberta Research Council (ARC). The ARC study concluded that Ontario's agricultural waste (unused crop residues and animal manures), forest waste (residues generated during harvest operations and subsequent wood treatment in either sawmills or pulp and paper plants), and municipal waste (from homes and businesses, gas from landfills, and waste from municipal waste water and bio-solids) could provide an estimated 265 bcf of RNG per year (285,000 TJs/yr) and estimated emission reductions of 25.95 $MtCO_2e$ (or 91 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere. At this intensity of avoided emissions the 4,452 Mm^3 of RNG would reduce emissions by over 14.6 $MtCO_2e$.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>170,000*	8,078,800 to 14,681,981	162,000 TJs of RNG per year by 2030

**total RNG potential (short and long term / anaerobic digestion and gasification) in Ontario from the Alberta Innovates Potential Production of Renewable Natural Gas from Ontario Wastes study.*

This RNG potential can only be realized with the appropriate policy, market, regulatory and technology funding support aligned with this emergent RNG renewable energy supply. Developing and retaining this renewable resource to Ontario's marketplace will require supportive government and regulatory policies, suitable market support mechanisms and substantive technology development funding.

[33] Alberta Innovates Technology Futures, Potential Production of Renewable Natural Gas from Ontario Wastes, May 2011

Natural Gas in the Transport Sector

Ontario emitted 48.3 $MtCO_2e$ from the road transport sector in 2014 (28% of total provincial emissions), almost exclusively originating from the combustion of gasoline and diesel. Heavy duty vehicle fleets alone emitted over 15.2 $MtCO_2e$ associated with gasoline and diesel in 2014[34] and when combined with marine and rail emitted over 51 $MtCO_2e$. With investment in natural gas transport related infrastructure (e.g. fuelling stations and service lines) much of this segment could be cost effectively converted to natural gas by 2030 using currently available technologies and existing distribution infrastructure. Assuming the 2030 natural gas fleet conversion rates below (9 to 85%) and a 22% improvement in vehicle emissions intensity in conversion from diesel/gasoline to natural gas, emissions could be reduced by over 3.2 $MtCO_2e$/yr.

Fleet	GHG Emissions (tCO_2e/yr)*	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Marine	1,104,452	120,160	49% of fleet converted by 2030
Rail	1,109,670	180,575	74% of fleet converted by 2030
On-Road Diesel	11,669,410	2,187,594	85% of fleet converted by 2030
On-Road Gasoline	37,754,768	778,215	9% of fleet converted by 2030
TOTAL	**51,638,299**	**3,266,544**	

**Raw energy data drawn from StatsCanada sites (Rail transportation, Diesel fuel consumed by province or territory, all carriers and Sales of fuel used for road motor vehicles, by province and territory (Quebec, Ontario, Manitoba, Saskatchewan). Calculation of emissions by ICF.*

LNG Fuel Switching Potential

Ontario's residential, commercial and industrial energy users consumed over 128,000 TJs of refined petroleum product and NGL-derived energy in 2014 resulting in over 9.5 $MtCO_2e$ emissions. The majority of the usage was in the industrial sector through the consumption of RPPs and NGLs (65,977 TJs). A portion of the current demand for refined petroleum product and NGLs could be met with LNG by 2030. There is modest (20%) addressable potential in the residential and commercial space due to high current connectivity to natural gas. Assuming 50% of industrial load was met with LNG and 20% of residential/commercial, GHG emissions would be reduced by almost 1,200,000 tCO_2e/yr[35].

End User (RPP/NGLs)	2014 (TJs)[36]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	26,732	126,413	20%
Commercial	35,859	166,893	20%
Industrial	65,977	881,393	50%
TOTAL	**128,568**	**1,174,699**	**35%**

[34] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada
[35] The fuel switching potential calculated herein differs from work carried out by ICF on behalf Enbridge Gas Distribution, Union Gas (Results from Aligned Cap & Trade Natural Gas Initiatives Analysis, November 2015), due to an expansion of scope of fuel considered available for switching to natural gas in this study.
[36] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Energy Efficiency

Ontario has successfully delivered both gas and electric energy efficiency programs. Recognizing this success in improving efficiency and reducing emissions as well as the future program potential the province is moving forward with more. As defined in Ontario's Climate Change Action Plan the government points to learnings from Efficiency Vermont and the NY Green Bank as well as defined funded ($1.3B to $1.8B) line items for many residential, commercial and industrial natural gas energy efficiency measures. It is unclear if these funds are beyond the $700M defined in the OEB managed DSM program, however it provides potential to deliver considerable cost effective savings to 2020 and beyond.

A recent study carried out by Enbridge Gas Distribution and Union Gas concluded that by 2030 114,000 TJs (3,000 Mm^3) of natural gas savings could be achieved via cap and trade proceed funded natural gas program savings in the province. This represents 12% of demand reduction (vs base case). Across Ontario this would equate to over 5.6 $MtCO_2e$ in avoided emissions per year by 2030[37].

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	114,950	5,669,924	12% of total demand

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (Accessed: 2016-05-10)
Statistics Canada Transport Fuel Usage Data for Ontario: http://www.statcan.gc.ca/pub/57-003-x/57-003-x2015002-eng.pdf , http://www.statcan.gc.ca/pub/52-216-x/2009000/t003-eng.htm , and http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/trade37b-eng.htm
Alberta Innovates Technology Futures, Potential Production of Renewable Natural Gas from Ontario Wastes, May 2011
https://www.ontario.ca/page/cap-and-trade
https://www.ontario.ca/page/climate-change-action-plan
ICF, Enbridge Gas Distribution and Union Gas: Results from Aligned Cap & Trade Natural Gas Initiatives Analysis, November 2015

[37] The energy efficiency potential determined herein is consistent with the medium/constrained scenario defined in work carried out by ICF on behalf Enbridge Gas Distribution, Union Gas (Results from Aligned Cap & Trade Natural Gas Initiatives Analysis, November 2015). The high scenario estimated over 4,000 M m^3 of savings and 7.8 $MTCO_2e$ of reductions.

Québec

Québec's natural gas system supplies over 240,000 customers across the province. Only 14.9% of total provincial residential, commercial and industrial energy demand (or 22% of energy demand excluding transportation) is met by natural gas while 37.3% (or 54% of energy demand excluding transportation)[38] is met with electricity. Provincial energy use is particularly unique in the residential sector where only 6.8% of energy demand is met with natural gas (66% by electricity) vs the national average of over 45% natural gas[39].

The province of Québec emitted 81.1 Mt of CO_2e per year, natural gas consumption related emissions rank second after refined petroleum product (RPP) use in transportation as a contributor to total emissions[40]. Due to its significant hydroelectric resources Québec's electricity generation is essentially non-emitting.

Energy Source	2014 (TJs)[41]	GHG Emissions (tCO_2e)*
Natural Gas	278,006	14,000,000
Electricity	647,252	379,000
RPP (predominantly transport)	621,045	45,400,000*
Other Energy (coal, coke, NGLs)	44,824	21,321,000
Non-energy related (process, Ag, waste)	NA	
Québec TOTAL	**1,591,127**	**81,100,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

Québec developed legislation and regulation creating a cap and trade system in 2012. Québec system was launched in 2013 and formally linked its system, under the Western Climate Initiative (WCI), with the California equivalent on January 1, 2014 creating a linked market. The cap and trade system covers approximately 85% of emissions. The first compliance period, 2013-2014, only applied to large (>25,000tCO_2e/yr) industrial emitters and in 2015 the system was expanded to include natural gas and transport fuel distribution companies. Québec allocated all revenue from carbon market auctions per their 2013-2020 Climate Change Action plan to a "Green Fund".

Québec committed to firm targets under the cap and trade system and has set forward targets in line with those of other WCI partners);

- The 2020 target: 20% below 1990 levels
- The 2030 target: 37.5 % below 1990 levels
- The 2050 objective: 80 to 95% below 1990 levels

[38] Source énergie : données 2013 du MERN http://www.mern.gouv.qc.ca/energie/statistiques/statistiques-consommation-forme.jsp and Transport : données 2012 sur la consommation d'énergie, Ressources naturelles Canada http://oee.rncan.gc.ca/organisme/statistiques/bnce/apd/menus/evolution/tableaux_complets/liste.cfm
[39] Source: http://oee.rncan.gc.ca/organisme/statistiques/bnce/apd/menus/evolution/tableaux_complets/liste.cfm
[40] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada
[41] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Looking ahead, there are significant opportunities for Québec to realize further GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- The potential for reducing natural gas consumption through energy efficiency measures
- Production, injection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- LNG as a replacement for propane, oil and refined fuels in communities without access to natural gas via existing/planned pipeline infrastructure and/or coupled with renewable energy as an energy storage solution.

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	538,650	5% of natural gas throughput replaced with RNG
Transport	538,495	Various, see page 36
Fuel oil	583,489	75 % of industrial, commercial and institutional
Energy Efficiency	1,200,000	625 million of cubic meter from Energy Efficiency programs from 2015 to 2030
TOTAL	**2,860,634**	**3.4% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Québec's MDDELCC 1990-2013 Inventory of GHG emissions over 648,000 tonnes of CH_4 (the equivalent of almost 13.6 Mt of CO_2)[42] are released to the atmosphere annually in Québec from agriculture (enteric fermentation and manure management), solid waste disposal, biological treatment of solid waste and waste water treatment[43]. This is the equivalent of over 36,100 TJs of natural gas representing over 16% of Québec's total annual demand. Beyond this source of methane for RNG the June 2010 study by the Natural Gas Technology Centre (NGTC) concluded that Québec's agricultural waste (unused crop residues and animal manures), forest waste (residues generated during harvest operations and subsequent wood treatment in either sawmills or pulp and paper plants), and municipal waste (from homes and businesses, gas from landfills, and waste from municipal waste water and bio-solids) could provide an estimated 273 bcf of RNG per year (293,000 TJs/yr).

Saint-Hyacinthe was the first city in Québec to produce energy through biomethanation and move one step closer to energy independence. Implemented in partnership with Gaz Métro, this initiative will heat municipal buildings and fuel city vehicles while reducing greenhouse gas emissions. This project will, in time, lead to an annual reduction of 25,000 tonnes of greenhouse gas. Other similar projects are being developed in Beauharnois (BIOM), Québec (CBAQ), Montreal, Longueuil, Laval, Rivière-du-Loup (SEMER) and Pierrefonds.

For the purposes of this study, based on the addressable potential identified in study and precedent (numerous projects in development) coupled with government incentives to drive RNG collection, we assume that there is sufficient RNG potential in Québec to displace 5% (10,730 TJs of RNG) of

[42] Data from quebec ghg inventory (p.8): Les secteurs de l'agriculture, des déchets et de l'électricité produisaient les autres émissions, avec respectivement 7,5 Mt éq. CO2 (9,2 %), 5,9 Mt éq. CO2 (7,2 %) et 0,21 Mt éq. CO2 (0,3 %). http://www.mddelcc.gouv.qc.ca/changements/ges/2013/Inventaire1990-2013.pdf

[43] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada

conventional natural gas supply by 2030. Based on data from the October 2010 study by the Alberta Research Council (ARC) emissions could be reduced by 945,914 tCO_2e (88 tCO_2e/TJ) and by 538,650 tCO_2e under the conservative assumption that none of the RNG would have otherwise been emitted to the atmosphere as CH_4.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>293,000*	538,650 to 945,914	10,730 TJs of RNG (replacing 5% of total NG demand).

**total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

Natural Gas in the Transport Sector

Québec emitted almost 34.9 $MtCO_2$ from the road transport sector in 2013 (43% of total provincial emissions). Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet of approximately 185 000 vehicles emitted almost 9 $MtCO_2$ in 2013. This segment of the transport fleet could be cost effectively converted to natural gas by 2030. Assuming 17.4 % of the heavy duty fleet were converted to natural gas by 2030, emissions could be reduced by almost 433 000 tCO_2e/yr.

Fleet	Emission Reduction Potential (tCO_2)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty fleet	351,049	12,290	17.4 % conversion of fleet
Medium duty vehicles	36,250	11,475	10.0% conversion of fleet
Buses	24,066	3,489	20.0% conversion of fleet
Light duty vehicles	22,130	17,303	5.0% conversion of fleet
Ferry	105,000		23 ferries
TOTAL Transport	**538,495**	**44,557**	

Gaz Métro currently offers natural gas (LNG) as an alternative to diesel for road transportation. Gaz Métro is currently supplying LNG to nearly 176 heavy trucks and 370 CNG vehicles in Québec through a network of 20 CNG stations and 6[44] refueling stations. If expanded successfully beyond the heavy-duty fleet more reductions could be achieved cost effectively from the 11 475 medium-duty vehicles and 3 489 buses. Further the Société de traversiers du Québec (STQ) operates an LNG ferry between Matane, Godbout and Baie Comeau and has two more LNG ferries on order.

Industrial, Commercial and Institutional Switching Potential

Québec's residential, commercial and institutional energy users emitted 7.7 $MtCO_2$ in 2013. The majority of the emissions originated of the industrial sector with 25.0 $MtCO_2$ in 2013.

[44] 4 stations in Quebec and 2 in Ontario (Cornwall & Mississauga)

Much of the current industrial demand for refined petroleum product and NGLs could be met with LNG by 2030. There is negligible addressable potential in the residential and commercial space due to availability of reliable and affordable low emitting electricity. Assuming 75 % of the fuel oil potential GHG emissions would be reduced by approximately 580,000 tCO_2.

End User (RPP/NGLs)	GHG Emissions 2013 (tCO_2)[45]	2030 Emission Reduction Potential (tCO_2)	Conversion Potential Fuel oil
Residential	3,620,000	--	0%
Commercial & Institutional	4,080,000	580,000	75%
Industrial	24,990,000	3,489	20% conversion of fleet
TOTAL	**32,690,000**	**583,489**	**67%**

Energy Efficiency

Québec utilities have successfully delivered both gas and electric energy efficiency programs. Natural gas programs have been delivered since 2001. Gaz Métro has multiplied its energy efficiency efforts by creating and offering innovative solutions allowing its customers to cut their energy consumption and costs and reduce their greenhouse gas emissions. Gaz Métro offers more than 20 energy efficiency programs tailored to its customers' needs. Since 2001, more than 111,000 energy efficiency projects have been carried out with Québec customers, reducing emissions by more than 800,000 tCO_2e. These measures will continue to create savings into the future. Across Québec this would equate to at least 1 200 000 tCO_2 in avoided emissions on a cumulative perspective by 2030.

Year	Achievable Potential Savings - ($M m^3$)	2030 Emission Reduction Potential (tCO_2)	Conservation Potential
2030	625	1,200,000	

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
http://www.gazmetro.com/en/about/our-energies/energy-efficiency/customer-support/
http://www.mddelcc.gouv.qc.ca/changementsclimatiques/marche-carbone_en.asp
http://www.mddelcc.gouv.qc.ca/changementsclimatiques/plan-action-fonds-vert-en.asp
http://www.mddelcc.gouv.qc.ca/changementsclimatiques/strategie-adaptation-en.htm
www.mern.gouv.qc.ca/energie/statistiques/statistiques-consommation-forme.jsp
http://oee.rncan.gc.ca/organisme/statistiques/bnce/apd/menus/evolution/tableaux_complets/liste.cfm
http://www.mddelcc.gouv.qc.ca/changements/ges/2013/Inventaire1990-2013.pdf

[45] http://www.mddelcc.gouv.qc.ca/changements/ges/2013/Inventaire1990-2013.pdf

Nova Scotia

Nova Scotia's natural gas system is still in development, constrained by its distribution system and supply. Natural gas demand (excluding CNG) was approximately 7,000 TJs in 2014 and made up only 5% of total energy demand – an increase however from 1% in 2005. Distribution system expansion and better connectivity to affordable supply are expected to continue to drive up total natural gas demand through 2030. Evidence of the opportunity can be seen in the residential sector where less than 1% of energy demand is met by natural gas (compared to 50% for Canada as a whole).

GHG emissions in the province of Nova Scotia have declined by 17% or 3.4 $MtCO_2e$ since 1990 as a result of a decline in energy demand due to reduced industrial capacity and implementation of electricity demand side management programs, and stagnant population growth. Natural gas-fired electricity generation made up 17% (1,500 GWh) of total electrical generation in 2014.

Energy Source	2014 (TJs)[46]	2014 GHG Emissions (tCO_2e)
Natural Gas	7,011**	346,000
Electricity	36,553	7,240,000
RPP (predominantly transport)	92,464	6,760,000
Other Energy (coal, coke, NGLs)	3,062	2,254,000***
Non-energy related (process, Ag, waste)	NA	
Nova Scotia TOTAL	**139,090**	**16,600,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources*
***2014 demand provided by Heritage Gas in line with total StatsCanada data once CNG is excluded*
****Includes GHG emissions from Other Energy and all Non-energy related emissions*

To date Nova Scotia has focused on reducing emissions from the electricity sector (energy efficiency measures, coal closure plan and renewables development) and transport sector (via vehicle fuel efficiency). In 2009 Nova Scotia released Greenhouse Gas Emissions Regulations establishing GHG emission caps on the electricity sector. Amendments were also made to the Air Quality Regulations to set tighter limits on Nova Scotia Power Inc.'s, sulphur dioxide and nitrogen oxide emissions for 2015 and 2020.

The Environmental Goals and Sustainable Prosperity Act requires a reduction in GHG emissions by at least 10 per cent by 2020 below 1990 levels. Looking ahead, there are opportunities for Nova Scotia to realize further GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- Increased use of natural gas through expansion of the natural gas pipeline infrastructure and conversion of buildings from oil or propane to natural gas
- The potential for reducing natural gas consumption through energy efficiency measures
- Natural gas as a replacement for coal-fired electricity generation and as enabler of increased renewables in the electricity system

[46] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	134,291	10% of natural gas throughput replaced with RNG
Transport	58,850	25% of heavy duty fleet converted to natural gas
NG/LNG Fuel Switch	263,381	29% of current RPP load converted to LNG
Energy Efficiency	52,301	6% reduction in 2030 energy usage vs BAU
Coal to Natural Gas	821,618	Replacement of 1,500 GWh of retiring coal-fired generation with natural gas
TOTAL	**1,330,440**	**8% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions over 33,000 tonnes of CH_4 (the equivalent of 843,000 tCO_2e)[47] are released to the atmosphere annually in Nova Scotia from agriculture (enteric fermentation and manure management), solid waste disposal, and waste water treatment. This is the equivalent of 1,854 TJs of natural gas (or 25% of total demand). Beyond this source of methane for RNG the October 2010 study by the Alberta Research Council (ARC) concluded that crop and forest residue gasification potential could create RNG production of 32 bcf per year (34,000 TJs/yr) or 5 times total 2014 demand. The study estimated emission reductions of 2.68 $MtCO_2e$ (or 79 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere.

Assuming the capture of 1,700 TJs of RNG by 2030 close to 10% of forecast 2030 natural gas demand (17,672 TJs) could be met with RNG. Emissions would be reduced in Nova Scotia by over 134,000 tCO_2e through avoided release of CO_2 and CH_4 to the atmosphere.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>34,000*	134,291	1,700 TJs of RNG (replacing 10% of total NG demand)

** total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

Natural Gas in the Transport Sector

Road transportation emissions have been falling in Nova Scotia since 2011 however emissions still totaled 3.4 $MtCO_2e$ in 2014. Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet of approximately 9,000 vehicles emitted over 1,170,000 tCO_2e in 2014. This segment of the transport fleet could be cost effectively converted to natural gas by 2030. Assuming 25% of the fleet were converted to natural gas by 2030, emissions could be reduced by almost 59,000 tCO_2e/yr.

[47] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

Fleet	GHG Emissions (tCO_2e/yr)[48]	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty Diesel	1,040,000	52,000	25% conversion of fleet
Heavy-duty Gasoline	137,000	6,850	25% conversion of fleet
TOTAL	**1,177,000**	**58,850**	

Beyond this potential in the heavy-duty fleet, Nova Scotia has over 1,900 buses and 10,000 medium-duty vehicles with potential to convert to natural gas and further reduce emissions.

Natural Gas Fuel Switching Potential

Nova Scotia's residential, commercial and industrial energy users consumed over 31,000 TJs of refined petroleum product (RPP) derived energy in 2014 resulting in close to 2.5 $MtCO_2e$ emissions. The majority of the usage was in the residential sector through the consumption of RPPs (16,942 TJs).

Much of the current demand for RPPs could technically be met with a combination of natural gas and LNG by 2030. Assuming 10% of residential, 50% of commercial and 50% of industrial RPP demand could be converted to natural gas and/or RNG by 2030 (9,024 TJs of the 33,721 TJs), emissions would be reduced by over 263,000 tCO_2e/yr.

End User (RPP)	2014 (TJs)[49]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	16,942	48,837	10%
Commercial	8,762	125,853	50%
Industrial	5,956	88,692	50%
TOTAL	**31,660**	**263,381**	**27%**

Energy Efficiency

Due to the modest role natural gas has historically played in Nova Scotia, there has not been a focus on natural gas energy efficiency programs. However the province has precedent for the delivery of energy efficiency programs aimed at electricity via Efficiency Nova Scotia. Current programs are only available to homes that are heated with electricity. Heating accounts for the majority of home energy use, but in Nova Scotia only 29% of homes are heated with electricity. Transforming programs to focus on broader energy efficiency, not just electrical energy efficiency could yield reductions in natural gas consumption and emissions.

[48] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[49] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

The province of Nova Scotia has not carried out detailed stakeholder reviewed conservation potential / achievable potential reviews for natural gas. However, comparable savings potential studies carried out recently in B.C., Manitoba, Ontario (and to an extent Alberta) show that 2030 vintage demand can reduced by between 5% and 10% with aggressive energy efficiency programs. Given the province's experience to date, 6% reduction in 2030 forecast demand should be achievable, resulting in 1,060 TJs in savings through energy efficiency and reduced emissions of 52,301 tCO_2e/yr by 2030.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	1,060	52,301	6% of total 2030 demand

Coal to Natural Gas in the Electricity Sector

Nova Scotia's current electricity supply mix will change dramatically over the next 25 years due to the refurbishment and replacement of the existing fleet, and in response to recent provincial and federal environmental regulations aimed specifically at the electricity generating sector.

Nova Scotia has a regulation intended to reduce GHG emissions in the Province as part of a larger strategy to transform the electricity sector from one largely based on coal, to one using cleaner energy sources. In response to the federal Coal Regulation, Nova Scotia was successful in gaining recognition for the provincial strategy and Environment Canada and the Province have published an equivalency agreement that would allow the province's GHG regulations to apply in Nova Scotia instead of the federal coal regulation. The equivalency agreement recognizes Nova Scotia's current Greenhouse Gas (GHG) regulations until 2020 and further reductions by 2030.

Nova Scotia's Renewable Electricity Plan (2010) defines a commitment to increase renewable electricity to 25 per cent by 2015 and 40 per cent by 2020. The Renewable Energy Standard (RES) eligible generation is in addition to the Community Feed–In Tariff projects that support the use of locally-based renewable electricity projects and a net-metering program.

In 2014 the electricity sector emitted 7.2 $MtCO_2e$ (over 43% of total emissions in the province). Over 64% of electrical generation was met with coal-fired capacity while natural gas contributed 17%. Coal-fired generation alone in Nova Scotia emitted an estimated 5 $MtCO_2e$ in 2014[50].

Nova Scotia's existing coal-fired generating stations have capacity of over 1,250 MW and since 2011 have generated between 5,500 and 6,000 GWhs annually. By 2030 much of this capacity will be retired with only Point Aconi 1 (171 MW) and Trenton 6 (154 MW) units still viable. These units could generate 2,500 GWhs in 2030 (assuming 90% capacity factor). Thus Nova Scotia could be 3,000-3,500 GWhs short based on this generation potential vs historic.

Natural gas will play a key role in backfilling for retired reliable baseload coal-fired generation and enabling deployment of significant intermittent renewable (wind and solar) capacity. Using the assumption that 50% of retired coal generation (1,500 GWh) is converted to combined cycle natural gas-fired generation, annual emissions could be reduced by 821,000 tCO_2e as a result of the fuel switch to natural gas.

[50] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

Change in Capacity		GHG Emissions (tCO_2e)
Added Natural Gas	1,494 GWhs	672,233
Coal retired by Natural Gas	1,494 GWhs	1,493,850
Emission Reductions		**821,618**

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
https://efficiencyns.ca/about-us/
https://climatechange.novascotia.ca/
http://climatechange.novascotia.ca/sites/default/files/uploads/ccap.pdf
Our Electricity Future Nova Scotia's Electricity Plan 2015-2040
(http://energy.novascotia.ca/sites/default/files/Our-Electricity-Future.pdf)

New Brunswick

New Brunswick's natural gas system currently supplies only 2% of residential and 15% of commercial energy demand. Total provincial natural gas demand was approximately 20,400 TJs in 2014 with industrial demand making up over 80% of that (16,875 TJs) and meeting only 14% of total energy demand – an increase however from 3.7% in 2005.

GHG emissions in the province of New Brunswick have declined by 27% or 5.6 $MtCO_2e$ since 2005 as a result of a decline in energy demand and reduction in emissions from coal and oil fired electricity generating stations. Natural gas-fired electricity generation made up 30% (1,710 GWh) of total electrical generation in 2014 vs. 16% in 2005[51].

Energy Source	2014 (TJs)[52]	2014 GHG Emissions (tCO_2e)
Natural Gas	20,396	1,000,500
Electricity	47,333	4,660,000
RPP (predominantly transport)	72,670	5,320,000
Other Energy (coal, coke, NGLs)	1,739	3,919,500**
Non-energy related (process, Ag, waste)	NA	
New Brunswick TOTAL	**142,138**	**14,900,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

New Brunswick is focused on reducing emissions via energy efficiency, renewable energy, and the transport sector (via vehicle fuel efficiency and low emissions vehicles). To do its part under the Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP) 2013 Climate Change Action Plan, New Brunswick has committed to achieving GHG reduction targets of: 10 per cent below 1990 levels by 2020; and 75–85 per cent below 2001 levels by 2050[53]. There are opportunities for New Brunswick to grow its economy and realize further GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- Increased use of natural gas through expansion of the natural gas pipeline infrastructure and conversion of buildings from oil or propane to natural gas
- The potential for reducing natural gas consumption through energy efficiency measures
- Natural gas as a replacement for coal-fired electricity generation and as enabler of increased renewables in the electricity system

[51] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[52] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
[53] New Brunswick Climate Change Action Plan 2014-2020; http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/ClimateChangeActionPlan2014-2020.pdf

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	100,839	5% of 2030 natural gas demand replaced by RNG
Transport	36,840	15% of heavy duty fleet converted to natural gas
NG/LNG Fuel Switch	161,053	30% of current RPP load converted to LNG
Energy Efficiency	90,539	6% reduction in 2030 energy usage vs BAU
Coal to Natural Gas	352,000	Replacement of 640 GWh of retiring coal-fired generation with natural gas
TOTAL	**741,271**	**7% reduction in provincial emissions**

Renewable Natural Gas (RNG)

According to Canada's latest National inventory of GHG emissions almost 36,000 tonnes of CH_4 (the equivalent of 899,000 tCO_2e)[54] are released to the atmosphere annually in New Brunswick from agriculture (enteric fermentation and manure management), solid waste disposal, and waste water treatment. This is the equivalent of 1,977 TJs of natural gas (or 10% of total demand). Beyond this source of methane for RNG the October 2010 study by the Alberta Research Council (ARC) concluded that crop and forest residue gasification potential could create RNG production of 64 bcf per year (68,000 TJs/yr) or over 3 times total 2014 demand. The study estimated emission reductions of 4.51 $MtCO_2e$ (or 66 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere.

Assuming the capture of 1,500 TJs of RNG by 2030 close to 5% of forecast 2030 natural gas demand (30,500 TJs) could be met with RNG. Emissions would be reduced in New Brunswick by over 100,000 tCO_2e through avoided release of CO_2 and CH_4 to the atmosphere.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	>68,000*	100,839	1,530 TJs of RNG (replacing 5% of total forecast 2030 NG demand)

** total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

Natural Gas in the Transport Sector

Road transportation emissions in New Brunswick totaled 3.1 $MtCO_2e$ in 2014. Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet of approximately 12,000 vehicles emitted close to 1,230,000 tCO_2e in 2014. This segment of the transport fleet could be cost effectively converted to natural gas by 2030. Assuming 15% of the fleet were converted to natural gas by 2030, emissions could be reduced by 36,840 tCO_2e/yr.

[54] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

Fleet	GHG Emissions (tCO_2e/yr)[55]	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty Diesel	1,110,000	33,300	15% conversion of fleet
Heavy-duty Gasoline	118,000	3,540	15% conversion of fleet
TOTAL	**1,228,000**	**36,840**	

Beyond this potential in the heavy-duty fleet, New Brunswick has over 2,400 buses and 8,000 medium-duty vehicles with potential to convert to natural gas and further reduce emissions.

Natural Gas Fuel Switching Potential

New Brunswick's residential, commercial and industrial energy users consumed over 18,000 TJs of refined petroleum product (RPP) derived energy in 2014 resulting in over 1.4 $MtCO_2e$ emissions. A portion of the current demand for RPPs could technically be met with a combination of natural gas and LNG by 2030. Assuming 10% of residential, 25% of commercial and 50% of industrial RPP demand could be converted to natural gas by 2030 (5,518 TJs of the 18,692 TJs), emissions would be reduced by over 161,000 tCO_2e/yr.

End User (RPP)	2014 (TJs)[56]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	6,013	17,550	10%
Commercial	4,937	36,024	25%
Industrial	7,365	107,480	50%
TOTAL	**18,315**	**161,053**	**30%**

Energy Efficiency

Due to the modest role natural gas has historically played in New Brunswick, there has not been a focus on natural gas energy efficiency programs. The province of New Brunswick has not carried out detailed stakeholder reviewed conservation potential / achievable potential reviews for natural gas. However, comparable savings potential studies carried out recently in B.C., Manitoba, Ontario (and to an extent Alberta) show that 2030 vintage demand can reduced by between 5% and 10% with aggressive energy efficiency programs. Given the province's experience to date, 6% reduction in 2030 forecast demand[57] should be achievable, resulting in 1,826 TJs in savings through energy efficiency and reduced emissions of 90,539 tCO_2e/yr by 2030.

[55] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[56] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
[57] It is assumed that demand for natural gas in the province of New Brunswick will increase by 50% between 2014 and 2030.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	1,836	90,539	6% of total 2030 demand

Coal to Natural Gas in the Electricity Sector

In 2014 the electricity sector emitted 4.6 $MtCO_2e$ (over 30% of total emissions in the province). Coal-fired generation emitted an estimated 2.5 $MtCO_2e$ in 2014[58]. In its Climate Change Action Plan New Brunswick[59] has committed to increase the amount of electricity generated from non-emitting sources from current 60% - 70% to 75% by 2020. Further there is a recognition of the role of natural gas to date in in low emission energy production by replacing energy sources that emit more GHG emissions when used, such as heavy fuel oil and coal and as a partner for renewable energy in a low-carbon future.

New Brunswick's coal-fired generating stations generated over 2,500 GWhs of electricity in 2014. Natural gas could play a key role in backfilling for this generation as units retire and enable deployment of significant intermittent renewable (wind and solar) capacity. Using the assumption that 25% of current coal generation (640 GWh) was converted to combined cycle natural gas-fired generation, annual emissions could be reduced by 352,000 tCO_2e as a result of the fuel switch to natural gas.

Change in Capacity		GHG Emissions (tCO_2e)
Added Natural Gas	640 GWhs	288,000
Coal retired by Natural Gas	640 GWhs	~640,000
Emission Reductions		**~352,000**

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
New Brunswick Climate Change Action Plan 2014-2020; http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/ClimateChangeActionPlan2014-2020.pdf)

[58] Calculated based on generation data provide in the Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada (Table A13-5).
[59] New Brunswick Climate Change Action Plan 2014-2020; http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/ClimateChangeActionPlan2014-2020.pdf

Northern Territories

Energy and emissions related information is not available is as much detail or frequency for Canada's Northern Territories (Yukon, Northwest Territories and Nunavut) as it is for the provinces. Based on review total energy demand (residential, commercial, industrial) was 25,854 TJs in 2014, natural gas (3,606 TJs) and electricity (3,551 TJs) each met 14% of that demand, while RPPs (17,566 TJs) met 68%.

GHG emissions in the Northern Territories totaled over 2 $MtCO_2e$, with the Yukon contributing 268,000 tCO_2e, Northwest Territories 1,530 tCO_2e and Nunavut 269,000 tCO_2e[60].

Energy Source	2014 (TJs)[61]	2014 GHG Emissions (tCO_2e)
Natural Gas	3,606	177,900
Electricity	3,515	227,200
RPP (predominantly transport)	17,566	1,283,500
Other Energy (coal, coke, NGLs)	1,130	378,400**
Non-energy related (process, Ag, waste)	NA	
Northern Territories TOTAL	**25,854**	**2,067,000**

**Natural gas and RPP emissions calculated by ICF, Electricity emissions per Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*
***Includes GHG emissions from Other Energy and all Non-energy related emissions*

There are opportunities for the Northern Territories to grow their economy and realize GHG emission reductions associated with expanding natural gas' usage or conservation measures in the following areas:

- Collection and distribution of Renewable Natural Gas (RNG)
- CNG/LNG as a replacement for refined fuels in the transportation sector
- Increased use of natural gas through expansion of the natural gas pipeline infrastructure and conversion of diesel fired generating stations to natural gas
- The potential for reducing natural gas consumption through energy efficiency measures

Measure	2030 GHG Reduction Potential (tCO_2e/yr)	Assumptions
RNG	58,453	5% of 2030 natural gas demand replaced by RNG
Transport	16,317	25% of heavy duty fleet converted to natural gas
NG/LNG Fuel Switch	97,337	30% of current RPP/NGL load converted to NG
Energy Efficiency	16,008	6% reduction in 2030 energy usage vs BAU
TOTAL	**188,115**	**9% reduction in Northern Territory emissions**

[60] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.
[61] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

Renewable Natural Gas (RNG)

An October 2010 study by the Alberta Research Council (ARC) concluded that RNG production of 0.43 bcf per year (462 TJs/yr) could be met in the Northern Territories. The study estimated emission reductions of 100,000 tCO_2e (or 216 tCO_2e/TJ) through the avoided release of CO_2 and CH_4 to the atmosphere.

Assuming the capture of 270 TJs of RNG by 2030 close to 5% of forecast 2030 natural gas demand (5,409 TJs) could be met with RNG. Emissions would be reduced in the Northern Territories by almost 58,500 tCO_2e through avoided release of CO_2 and CH_4 to the atmosphere.

Year	RNG Potential (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
2030	462*	58,453	270.4 TJs of RNG (replacing 5% of total forecast 2030 NG demand)

** total RNG potential and resulting emission reductions identified in October 2010 study by the Alberta Research Council (ARC), sponsored by the Canadian Gas Association (CGA)*

Natural Gas in the Transport Sector

Road transportation emissions in the Northern Territories totaled 1.14 $MtCO_2e$ in 2014. Almost all of these emissions originated from the combustion of gasoline and diesel. The heavy-duty gasoline and diesel fleet emitted 326,340 tCO_2e in 2014. This segment of the transport fleet could be cost effectively converted to natural gas by 2030. Assuming 25% of the fleet were converted to natural gas by 2030, emissions could be reduced by 16,317 tCO_2e/yr.

Fleet	GHG Emissions (tCO_2e/yr)[62]	2030 Emission Reduction Potential (tCO_2e/yr)	Assumptions
Heavy-duty Diesel	306,400	15,320	25% conversion of fleet
Heavy-duty Gasoline	19,940	997	25% conversion of fleet
TOTAL	**326,340**	**16,317**	

Natural Gas Fuel Switching Potential

The Northern Territories' residential, commercial and industrial energy users consumed 10,692 TJs of refined petroleum product (RPP) and NGL derived energy in 2014. In addition an estimated 1,070 TJs of RPP was consumed to fire diesel fired generating stations. In total this 11,762 TJs of RPP and NGL resulted in over 900,000 tCO_2e emissions. A portion of the current demand for RPPs and NGLs could technically be met with a combination of natural gas and LNG by 2030. Assuming 20% of residential, 20% of commercial, 33% of industrial, and 33% of electricity generation RPP and NGL demand could be converted to natural gas by 2030 (3,504 TJs of the 11,762 TJs), emissions would be reduced by over 97,000 tCO_2e/yr. Note that in this study we do not examine the GHG emission reduction potential that could arise from future mining operations using LNG vs. diesel fuel.

[62] Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.

End User (RPP/NGL)	2014 (TJs)[63]	2030 Emission Reduction Potential (tCO_2e/yr)	Conversion Potential
Residential	1,572	8,227	20%
Commercial	1,335	6,123	20%
Industrial	7,785	72,682	33%
Electricity Generation	1,070	10,304	33%
TOTAL	**11,762**	**97,337**	**30%**

Energy Efficiency

Due to the modest role natural gas has historically played in the Northern Territories, there has not been a focus on natural gas energy efficiency programs. Nor has a detailed stakeholder reviewed conservation potential / achievable potential review for natural gas been carried out. However, comparable savings potential studies carried out recently in B.C., Manitoba, Ontario (and to an extent Alberta) show that 2030 vintage demand can reduced by between 5% and 10% with aggressive energy efficiency programs. Assuming a 6% reduction in 2030 forecast demand[64] we estimate 325 TJs in savings through energy efficiency and reduced emissions of 16,008 tCO_2e/yr by 2030.

Year	Achievable Potential Savings - (TJs)	2030 Emission Reduction Potential (tCO_2e/yr)	Conservation Potential
2030	325	16,008	6% of total 2030 demand

Bibliography

Canada National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1
Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)

[63] Statistics Canada. Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual (terajoules), CANSIM (database). (accessed: 2016-05-10)
[64] It is assumed that demand for natural gas in the Northern Territories will increase by 50% between 2014 and 2030.

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