Decarbonizing Heavy Industry:
The Low-Carbon Transition of Canada's Emission-Intensive and Trade-Exposed Industries

Report of the Standing Senate Committee on Energy, the Environment and Natural Resources

The Honourable Rosa Galvez, Chair
The Honourable Michael L. MacDonald, Deputy Chair

April 2018

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CANADA

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The Honourable Yuen Pau Woo (or Raymonde Saint-Germain)
The Honourable Joseph A. Day (or Terry M. Mercer)

The Committee would like to recognize the following Senators who are no longer serving members of the committee whose contribution to the study was invaluable:

The Honourable Senators: Douglas Black, Tony Dean, Joan Fraser (retired), Diane F. Griffin, Daniel Lang (retired), Elaine McCoy, Grant Mitchell, Pierrette Ringuette

Other Senators who have participated from time to time in the study:

The Honourable Senators: Salma Ataullahjan, Diane Bellemare, Lynn Beyak, Joseph A. Day, Michael Duffy, Nicole Eaton, Tobias C. Enverga (deceased), Stephen Greene, Janis Johnson (retired), Yonah Martin, Paul E. McIntyre, Don Meredith (retired), Ratna Omidvar, Nancy Greene Raine, Bob Runciman (retired) and Scott Tannas.

Parliamentry Information and Research Service, Lilbrary of Parliament:

Sam Banks and Marc LeBlanc, Analysts

Senate Committees Directorate:

Maxime Fortin, Committee Clerk
Brigitte Martineau, Administrative Assistant

ORDER OF REFERENCE

Extract from the *Journals of the Senate*, Thursday, March 10, 2016:

The Honourable Senator Neufeld moved, seconded by the Honourable Senator Frum:

That the Standing Senate Committee on Energy, the Environment and Natural Resources be authorized to examine and report on the effects of transitioning to a low carbon economy, as required to meet the Government of Canada's announced targets for greenhouse gas emission reductions. Recognizing the role of energy production, distribution and consumption in Canada, the committee shall be authorized to:

(*a*)identify and report on the impact transitioning to a low carbon economy will have on energy end users, including Canadian households and businesses;

(*b*)identify and report on the most viable way the following sectors — electricity, oil and gas, transportation, buildings and trade-exposed energy intensive industries — can contribute to a low carbon economy in meeting Canada's emission targets;

(*c*)examine and report on cross-sector issues and undertake case studies, if necessary, on specific programs or initiatives aimed at reducing greenhouse gas emissions;

(*d*)identify areas of concern and make any necessary recommendations to the federal government that will help achieve greenhouse gas emission targets in a manner that is sustainable, affordable, efficient, equitable and achievable.

That the committee submit interim reports on identified sectors, cross-sector issues and case studies and submit its final report no later than September 30, 2017, and that the committee retain all powers necessary to publicize its findings until 180 days after the tabling of the final report.

After debate,

The question being put on the motion, it was adopted.

Charles Robert
Clerk of the Senate

Extract from the *Journals of the Senate*, Tuesday, September 26, 2017:

The Honourable Senator Neufeld moved, seconded by the Honourable Senator Martin:

That, notwithstanding the order of the Senate adopted on Thursday, March 10, 2016, the date for the final report of the Standing Senate Committee on Energy, the Environment and Natural Resources in relation to its study on the transition to a low carbon economy be extended from September 30, 2017 to June 30, 2018.

The question being put on the motion, it was adopted.

Nicole Proulx
Clerk of the Senate

ACRONYMS

bbl	Barrel
CCS	Carbon capture and sequestration
CO_2	Carbon dioxide
CO_2 eq	Carbon dioxide equivalents
ECCC	Environment and Climate Change Canada
EITE	Emission-intensive and trade-exposed
GDP	Gross domestic product
GHG	Greenhouse gas
GJ	Gigajoule
Mt CO_2 eq	Megatonne (1 million tonnes) of carbon dioxide equivalent
NRCan	Natural Resources Canada
TSM	Towards Sustainable Mining
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

The Standing Senate Committee on Energy, the Environment and Natural Resources is studying what it will cost ordinary Canadians and businesses to meet Canada's greenhouse gas (GHG) emission reduction targets. It is examining the effects Canada's GHG reduction targets will have on five sectors of the Canadian economy: electricity, transportation, oil and gas, buildings and emission-intensive trade-exposed industries that are mostly heavy industries that compete in international markets.

Emission-intensive trade-exposed industries (or heavy industries) are the subject of the committee's current study of the low-carbon transition and it represents the committee's third interim report. The committee released its first interim report on the electricity sector in March 2017 and its second interim report on transportation in June 2017.

In a final report, the committee will make recommendations to the federal government that will help achieve Canada's emission reduction commitments in a manner that is sustainable, affordable, efficient, equitable and achievable.

Canada's manufacturers of refined petroleum products, iron and steel, cement, aluminium, chemicals, fertilizer and pulp and paper, together with the country's mining sector, employ over one million Canadians and contribute significantly to Canada's economy by transforming natural resources into the basic building blocks into which most goods are made. As the country's heavy industries, they require large amounts of energy to operate and are large emitters of carbon emissions. Since industries compete with international firms at home and abroad, they are highly vulnerable to carbon pricing programs and other emission reduction requirements that place them at a competitive disadvantage among foreign competitors that are not bound by similar emission restrictions.

Overall, the carbon footprint of Canada's heavy industries is among the smallest in the world due to the country's clean electricity generation and abundant supply of natural gas as a feedstock for industrial processes. This stands in contrast to that of Canada's major foreign competitors which rely on coal for electricity and industrial feedstock.

Carbon pricing is a central component of Canada's plan to achieve its Paris Agreement emission reduction commitments of 30% below 2005 levels by 2030. It marks new fiscal territory for many Canadian governments. Witnesses representing industries within Canada's emission-intensive and trade-exposed sector expressed concern over the ability to compete with foreign firms who operate with no or lower emission requirements. The federal government and many provincial governments have introduced or announced measures to limit the potential carbon pricing impact on emission-intensive and trade-exposed firms while incenting them to reduce emissions. Ideally, measures to limit the impact should be temporary until carbon pricing or its equivalent is more uniformly applied across trading partners.

The committee also explored the federal government's proposed Clean Fuel Standard which would impose carbon intensity requirements on fossil fuels. Some industry representatives believed that industrial use of these fuels should be exempt from the standard since it marks an incremental cost to carbon pricing programs.

The committee considers whether the federal government should make the carbon intensity of materials a condition for purchasing decisions and for federally-funded infrastructure projects. It seems counterproductive to award government contracts that use products produced by foreign producers that have an unfair costs advantage because of weaker emission reduction requirements.

Finally, the committee underscores the importance of research, innovation and explores options for deep decarbonization within the industrial sector.

ADDRESSING CLIMATE CHANGE

Climate change is a destabilizing threat to global health and security that could define the current century more than any other. The effects of climate change are already observable. For example, since the 1960s, the earth's ocean heat content increased at all depths by approximately 0.7ºC and global sea level has risen up to 21 centimetres.[1] Globally, 16 of the 17 warmest years since the late 1800s have occurred in the period from 2001 to 2016.[2] If temperatures continue to rise unabated, the world risks substantial species extinction, significant global and regional food insecurity, increased risks of violent conflict and large population displacements.[3]

Canada is not immune to the effects of climate change. Temperatures in Canada have risen at approximately double the global rate.[4] The country's northern regions are particularly vulnerable to accelerated losses of sea ice and permafrost affecting wildlife and ecosystems. Climate change is also jeopardizing northern infrastructure including roads, buildings, communication towers and other facilities. According to the Final Report of the Federal Provincial and Territorial Working Group on Adaption and Climate Resilience all regions will be affected:

> *Climate change is impacting the severity and frequency of extreme events, including the likelihood of flooding, droughts, storm surges, high winds, and heat waves. Changes in temperature and precipitation patterns have made the wildfire season longer, while drought- and pest-stressed forests, woodlots, and rangelands are increasing the severity of wildland fires. Sea level rise is increasing the frequency and height of storm surges, causing flooding in higher, previously unaffected areas and more frequent flooding in low lying areas.*[5]

The financial costs of these climate occurrences are mounting. According to the Insurance Bureau of Canada, expected losses due to severe weather currently exceeds $1 billion annually in Canada whereas in the 1980s and 1990s these costs averaged at below $300 million a year.[6]

While climate change is a pressing problem, many countries, including Canada, have postponed for several decades difficult decisions needed to curb greenhouse gas (GHG) emissions. The 2017 Fall Report of the Commissioner of the Environment and Sustainable Development reported that Canada has failed to achieve every emission target it has set since 1992. These include reducing emissions to: 1990 levels by 2000 (the Rio Earth Summit); 6% below 1990 levels by 2012 (Kyoto Protocol); and 17% below 2005 levels by 2020 (Copenhagen Accord). Reducing GHG emissions is a complex problem but inaction in addressing climate change will have severe consequences on this and future generations.

Considering that everyone shares the atmosphere, climate change solutions require an ambitious level of global co-operation. On 12 December 2015 in Paris, Canada and 194 other countries party to the United Nations Framework Convention on Climate Change (UNFCCC) reached an agreement (Paris Agreement) to limit rising global average temperatures to less than 2°C above pre-industrial levels, and aim to limit that increase to 1.5°C.[7] This was a pivotal moment in the effort to address climate change as both developed and developing countries were part of the agreement, representing nearly all of the world's anthropogenic emissions. In June 2017, the United States, a major GHG emitter, submitted a formal notice of withdrawal from the agreement. However, many U.S. states, municipalities, institutions and companies have maintained their commitment to reduce emissions to achieve Paris Agreement objectives.[8]

Climate change is occurring as global energy demand is growing. The International Energy Agency's 2017 World Energy Outlook estimates that global energy use will increase by 28% by 2040 due to increased demand from emerging economies.[9] Of that increase, more than half (51%) comes from the demand for oil, natural gas and coal. Also, current low prices for oil are challenging policy efforts to switch to cleaner fuels.

Canada's Emission Commitment

GHGs are associated with almost every activity, product and service and are supported by long-lived capital infrastructure.[10] Addressing climate change will require a rapid and substantial retooling of energy systems that have supported economies for nearly a century. It is an energy transition chiefly driven by public policy through regulation, taxes and/or incentives and it will likely require a change in lifestyle and energy/resource consumption habits. It will not be cost-free, meaning that it will likely require higher demands on public revenues, result in higher energy prices, impact households and businesses, and will probably strand existing productive capital assets that support fossil fuel energy systems.[11]

In accordance with its contribution to the Paris Agreement under the UNFCCC, Canada committed to reduce its emissions by 30%

below 2005 levels by 2030. This target is a minimum target. Further reductions will be needed to reach the Paris Agreement goals. This envisions an 80% reduction in emissions from 2005 levels by the second half of the century.[12]

In the wake of the Paris Agreement, federal, provincial and territorial governments have committed to working together to reduce emissions. In December 2016, Canada's First Ministers released the Pan-Canadian Framework on Clean Growth and Climate Change, which was adopted by all Canadian provinces and territories with the exception of Saskatchewan.[13] The Framework builds on previously announced initiatives, such as a national benchmark price on carbon emissions and an acceleration of the phase-out of traditional coal-fired electricity units.

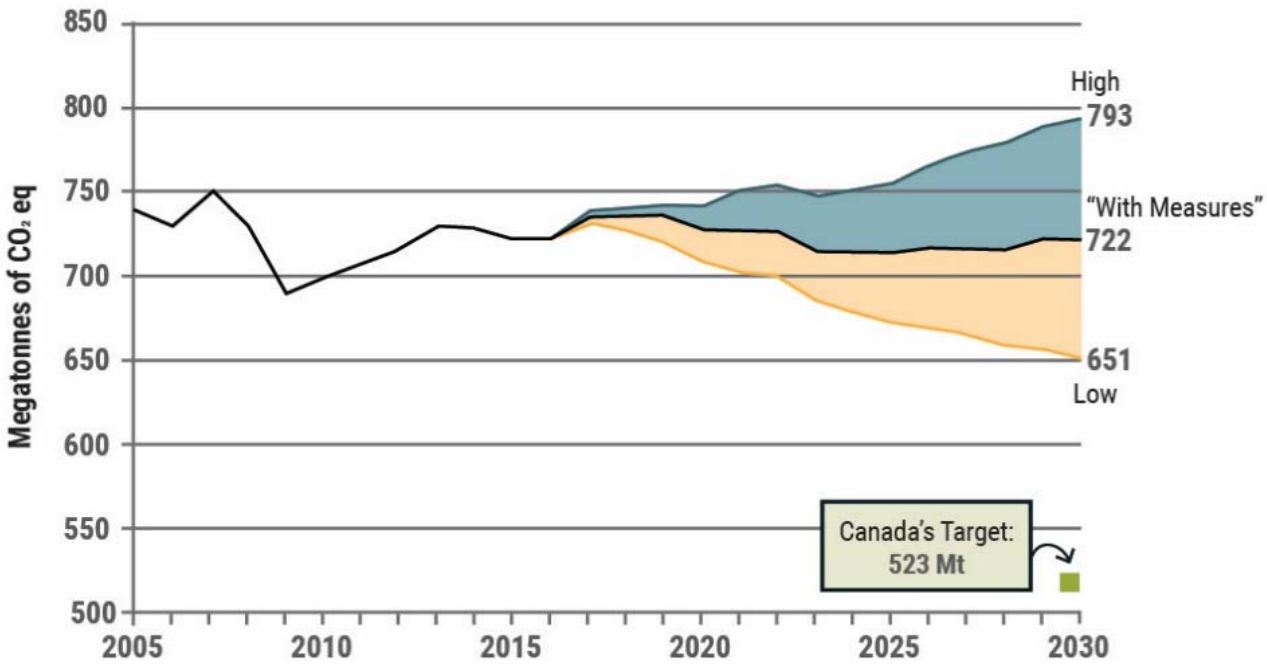
The projections from Environment and Climate Change Canada illustrated in Figure 1 reflect forecasts for gross domestic product (GDP) and oil and gas prices and production. They also include "actions taken by governments, consumers and businesses put in place over the last two years, up to September 2017. This scenario does not account for all measures of the Pan-Canadian Framework as a number of them are still under development."[14] These actions are referred to by the Government of Canada as the "with measures" scenario.

The projections do not include additional policies and measures under development but have not yet been fully implemented. Some of these were announced as part of the Pan Canadian Framework such as pan-Canadian carbon pricing or federal regulations to reduce methane emissions in the oil and gas sector.

The projections show a range of GHG emission level outcomes based on the uncertainty inherent in modelling climate policy and other macroeconomic conditions that are beyond the control of government. The reference case scenario assumes business-as-usual oil and gas prices and GDP growth. It is contrasted with scenarios assuming high oil and gas prices and GDP growth and one assuming low oil and gas prices and GDP growth.

These emissions projections incorporate oil and gas price forecasts set out in the National Energy Board's energy outlook, *Canada's Energy Future 2016: Update – Energy Supply and Demand Projections to 2040*, published in October 2016.

Figure 1 – Canada's Domestic Emissions Projections (Mt CO_2 eq): Low, "With Measures" and High Scenarios



Note: In 1990, Canada's GHG emissions totalled 611 Mt CO_2

Mt CO_2 eq. = megatonne (1 million tonnes) of carbon dioxide equivalents. Different greenhouse gases have different radiative forcing potentials depending on their lifetimes in the atmosphere and how efficiently they contribute to the greenhouse effect. The global warming potential of the different greenhouse gases can be expressed in relative terms to those of carbon dioxide, known as carbon dioxide equivalents, or CO_2 eq.

Source: Environment and Climate Change Canada, *Canada's Seventh National Communication on Climate Change and Third Biennial Report—Actions to meet commitments under the United Nations Framework Convention on Climate Change,* Page 155.

Legend: Emissions projections in three scenarios:

1. High oil and gas prices and high GDP growth – blue line
2. Business-as-usual oil and gas prices and GDP growth – black line
3. Low oil and gas prices and low GDP growth – yellow line

Fuel Price Assumptions	High	With Measures	Low
Annual GDP Growth Rate (2015-2030)	2.5%	1.7%	1.0%
Crude Oil Price (West Texas Intermediate) 2014 US$/bbl	116	77	37
Heavy Oil (Western Canadian Select) 2014 US$/bbl	90	56	21
Natural Gas (Henry Hub) 2014 US$/GJ	4.67	3.77	2.86

Figure 2 provides a breakdown of Canadian emissions by economic sector. In 2015, the upstream oil and gas and transportation sectors each accounted for nearly one quarter of total emissions in Canada. Emissions from buildings was 12%, followed by electricity generation at 11% and agriculture 10%. Emission-intensive and trade-exposed industries (EITE) consisting of steel, aluminium, cement, petrochemical, pulp and paper, fertilizer and mining production totalled 10% of total emissions in Canada. Petroleum refining, which is also an EITE, was 3% total emissions. Table 1 provides the breakdown for different years including projections for 2020 and 2030.

Figure 2 – Breakdown of Canada's Greenhouse Gas Emissions by Sector, 2015 (Mt CO_2 eq)

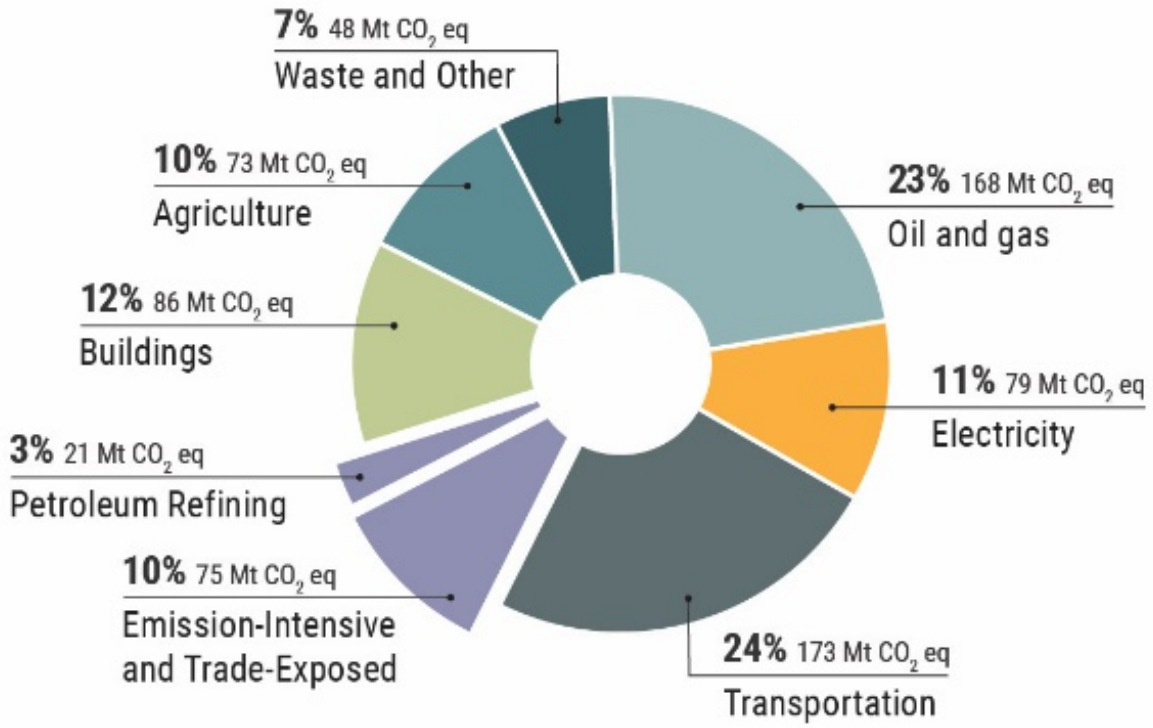


Table 1 – Emissions by Economic Sector 2005-2030 (Mt CO_2 eq)

	2005	2015	2020	2030
Oil and Gas	137	168	175	193
Emission-Intensive and Trade-Exposed Industries (Includes Petroleum Refining)	108	96	105	119
Electricity	117	79	71	46
Transportation	163	173	168	155
Buildings	85	86	88	83
Agriculture	74	73	71	72
Waste & Others	54	48	50	53
Total	***738***	***724***	***728***	***722***
Emission Target				***523***
Difference				***(199)***

Notes: Includes actions taken by Canadian governments, consumers and businesses put in place over the last two years, up to September 2017.

Numbers in all figures and tables may not add up to the total due to rounding.

Source: Figure and table prepared by the Library of Parliament using data obtained from Environment and Climate Change Canada, Canada's 2016 Greenhouse Gas Emissions Reference Case and National and Provincial/Territorial Greenhouse Gas Emission Tables.

Carbon dioxide accounts for a majority of the anthropogenic GHG emissions released in Canada. The next major GHG is methane followed by nitrous oxide. Not all GHGs have the same radiative forcing potential. For example, over a 100 year time horizon[i], methane is 25 times more potent in trapping heat in the atmosphere than carbon dioxide and nitrous oxide is nearly 300 times more potent than carbon dioxide. Table 2 provides a breakdown of GHG emissions in Canada expressed in carbon dioxide equivalent (CO_2 eq) a commonly used standard that facilitates comparisons by adjusting for the global warming potential of each GHG in terms of how much carbon dioxide would be required to produce a similar warming effect.[15]

[i] The 100 year time horizon is consistent with reporting under the UNFCCC.

Table 2 – Breakdown by Type of Greenhouse Gas Emissions, 2014 (Mt CO_2 eq) - 100 Year Time Horizon

Sector	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Hydrofluorocarbon (HFCs[4])	Perfluorocarbon (PFCs[4])
Oil and Gas	143	48	1	0	0
Electricity	77	0	0	0	0
Transportation	165	0	4	3	0
EITE	73	0	2	0	1
Buildings	77	3	1	6	0
Agriculture	15	29	29	0	0
Waste & Others	23	28	2	0	0
Total	**574**	**108**	**39**	**9**	**1**

Note: Numbers may not sum to the total due to rounding

Source: Table prepared by the Library of Parliament using data obtained by Environment and Climate Change Canada, Canada's 2016 greenhouse gas emissions reference case, Detailed emissions by gas and by economic sector.

The 2030 target is ambitious. According to projections made by Environment and Climate Change Canada in December 2017, Canada must reduce annual emissions by 199 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) in order to meet its 2030 target.[16] To put this into context, the required reduction is above the projected emissions from Canada's entire upstream oil and gas industry in 2030, which are expected to be 193 Mt CO_2 eq. However, this does not mean Canada should not be ambitious; if we delay emission reduction efforts it will only become more difficult to meet future targets. Canada's Commissioner of the Environment and Sustainable Development underscored the failure by the federal government in implementing measures to address oil and gas industry emissions as a reason for missing past emission targets.[17]

Achieving the 2030 target will require a herculean shift in how energy is produced and consumed in Canada. For the years beyond 2030, one must imagine a society essentially transformed and decarbonized. Witnesses offered conflicting testimony on whether or not the economy would be harmed by achieving government targets. In any case, a decarbonized society means new economic opportunities, lower pollution and better air quality, improved

health outcomes and increased productivity through more energy efficiency improvements.[18]

Canada has a vast geography, relatively cold climate, low and dispersed population and a large resource-based industrial sector. Canada's per capita emissions are among the highest in the world[19] and every nation's effort to address climate change adds up and collective action will be the only way to meet this challenge. ***If Canada does not make a concerted effort to meet its own targets, then how can we, as an advanced economy, ask other nations to meet theirs?*** Canada's global reputation and credibility would be damaged if we failed to act.

Canadians must do their part to address climate change even if Canada's portion of global emissions is relatively small at 1.6 %[20] and expected to decline as emissions from emerging countries, such as China, India, Brazil and Indonesia increase in the future.[21] The United States' (U.S.) announced withdrawal from the Paris Agreement challenges global climate change co-operation efforts and makes it harder to reach global emission reduction goals.

It is estimated that the global market for clean technologies is approximately $5.8 trillion per year and growing at a rate of three percent annually. Canada should not miss this opportunity to capture local economic benefits and to export technologies and expertise in clean energy solutions.[22] Reducing or capturing emissions can create whole new industries and supply chains.

At the same time, the speed and magnitude of the transition being considered will affect the lives of all Canadians. The impacts of the transition may be unevenly felt depending on income levels or geographic location. Policies should be designed to ensure that the most vulnerable in society are not adversely affected and that all Canadians have an opportunity to benefit by the move to a cleaner economy.

The question is how much of our welfare are we willing to risk to meet our climate change commitments? On the other hand, how much do we risk in delaying emission reduction policies? What is the cost of "business as usual?" If we wait until the future to act, it will likely be more costly to decarbonize since the pace of the transition would have to accelerate.

EMISSION-INTENSIVE AND TRADE-EXPOSED INDUSTRIES

The emission-intensive and trade-exposed (EITE) sector is a grouping of industries that are predominantly export-oriented, large-emitters of GHGs that compete with international firms in foreign and domestic markets. They are the country's heavy industries and are involved in metal and non-metal mining, smelting and refining, and the production of industrial goods, such as refined petroleum products, chemicals, fertilizers, aluminium, pulp and paper, iron and steel, and cement.[23] For the most part, these industries transform natural resources into the building blocks into which most goods and materials are made. Upstream oil and gas activities, such as oil and gas extraction, upgrading, as well as production are left out of this grouping, even though they are emission-intensive and trade-exposed, because they are being examined in a separate report by the committee.

The EITE sector is a diverse group of industrial firms that share common attributes. They are capital-intensive and require large amounts of energy to operate. Many of these firms are bound by fixed-process emissions, that is, emissions from industrial processes in which GHGs (typically carbon dioxide) are a basic chemical by-product of production but not from the combustion of a fossil fuel. For the most part, EITE companies produce undifferentiated products, are price takers in international markets, and are highly

dependent on the health of the global economy.[ii]

EITE firms often represent the lifeblood of a local and/or regional economy. Witnesses representing the EITE sector told the committee that they were a major source of both direct and indirect jobs. Brendan Marshall, Vice President, Economic and Northern Affairs of the Mining Association of Canada, told the committee that the mining industry was a key employer of rural and northern communities and was responsible for a large share of the value of Canadian exports. For example:

> *The mining industry employs 563,000 people and is, proportionally, the largest employer of indigenous Canadians. With operations from coast-to-coast-to-coast, the industry contributes approximately 3.5 per cent of GDP, which is $57 billion in 2015, accounts for 19 per cent of the value of Canada's exports — that exceeded $91 billion in 2015 — and is a major economic driver of rural, urban and Northern economies across Canada.[24]*

Robert Larocque, Vice President, Climate Change, Environment and Labour of the Forest Products Association of Canada, explained that the forest products sector is:

> *…a $65 billion-a-year industry that represents 2 per cent of Canada's GDP. The industry is one of Canada's largest employers, operating in 200 forest-dependent communities from coast to coast. We directly employ about 230,000 Canadians across the country.[25]*

Michael McSweeney, President and Chief Executive Officer of the Cement Association of Canada, explained that the cement industry "contributes $82 billion in direct, indirect and induced economic impact and employs directly or indirectly 170,000 Canadians in well-paid, high-skilled jobs."[26]

The Chemistry Industry Association of Canada, which represents petrochemical, inorganic and specialty chemical producers and bio-based manufacturers, outlined that the chemistry industry contributes $53 billion to the economy. It directly employs 87,500 Canadians and indirectly supports 525,000 jobs in the economy.[27]

It should be noted that the agriculture and agri-foods sector is trade exposed and is responsible for 10% of total emissions in Canada. Most of its emissions are derived from biological processes inherent in animal and crop production.[28] This sector faces unique challenges in reducing emissions while maintaining competitiveness with our trading partners. At the same time, the transition to a lower carbon economy provides opportunities for Canadian farmers. The committee is not

[ii] Undifferentiated products are essentially identical products and can be easily substituted. These products compete primarily on the basis of price and availability. A company is a price taker; if it is unable to affect the market price of the product it is selling and must sell at the prevailing price.

examining the effects that transitioning to a low carbon economy will have on the agriculture and agri-foods sector as this task is part of a comprehensive study on adaptation and emission reduction strategies currently undertaken by the Standing Senate Committee on Agriculture and Forestry.[29]

Large Industrial Emitters

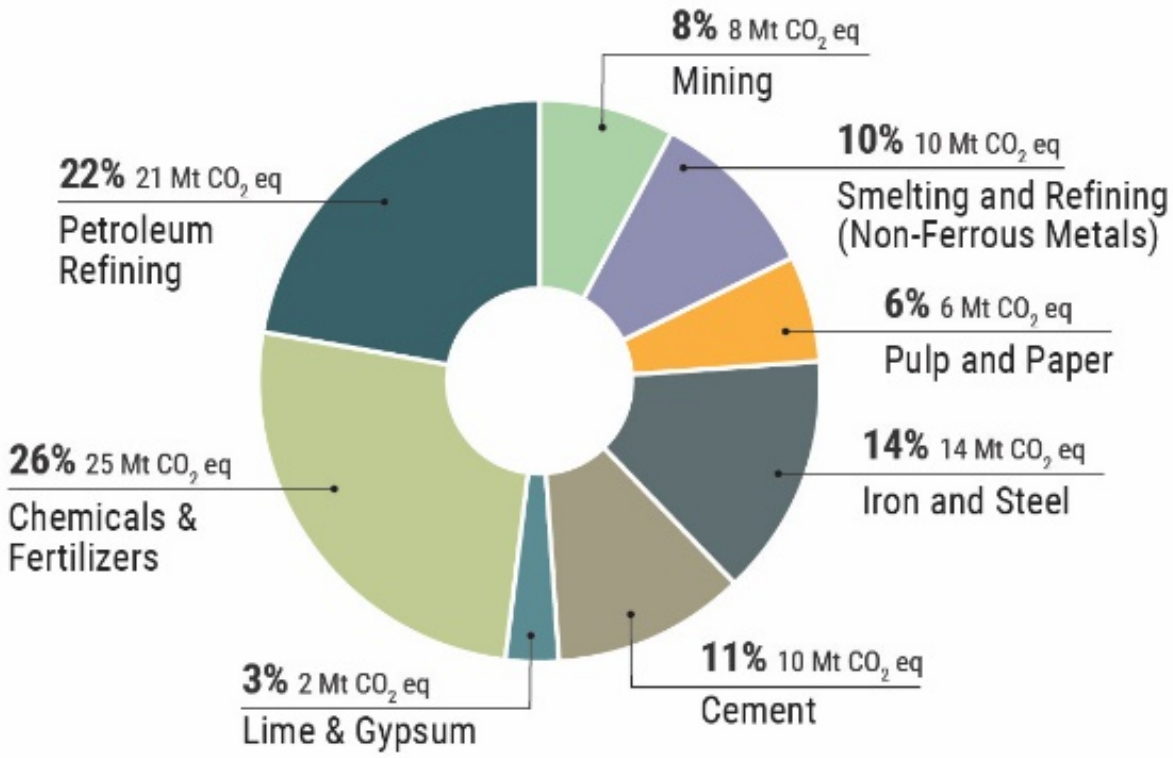
Large industrial emitters use substantial amounts of energy mainly to produce heat and mechanical movement for their production processes. Fuels used by Canadian EITE industries are primarily electricity, natural gas, still gas and petroleum coke and coal.[30] The type of fuels used varies depending on the industrial process. For example, steelmaking predominantly relies on coke and electricity, aluminium manufacturing requires electricity, chemical and fertilizer industries rely on natural gas, and cement production uses coal.[31] The pulp and paper industry makes use of wood waste and pulping liquor for a large portion of its energy needs.[32]

GHG emissions are mainly caused by the combustion of fuels as well as the non-combustion of chemical and physical reactions.[33] These latter emissions are referred to as fixed-process emissions. For example, a fertilizer manufacturing facility uses intensive heat and other processes to strip hydrogen from natural gas to then combine the hydrogen with nitrogen, found in the air, to produce ammonia, a plant fertilizer. Fixed-process emissions, in this case, are the molecules of carbon dioxide created when hydrogen is removed from natural gas.[34] Iron and steel, cement and aluminium production are other industries similarly subject to sizable fixed-process emissions, but through different chemical and physical reactions.

Large industrial emitters use substantial amounts of energy mainly to produce heat and mechanical movement for their production processes.

EITE industries (including downstream petroleum refining) were responsible for over 13% of Canada's GHG emissions in 2015.[35] As illustrated in Figure 3, chemical and fertilizer manufacturing firms represented 26% of all EITE emissions, followed by petroleum refining at 22% and iron and steel manufacturing at 14%. Cement manufacturing represented 11% of all EITE emissions, roughly the same percentage as smelting and refining of non-ferrous metals at 10%. Finally, mining and lime & gypsum manufacturing represented 8% and 3% of total EITE emissions respectively.[36]

Figure 3 – Breakdown of Canada's Emission-Intensive and Trade-Exposed Emissions, 2015 (Mt CO_2 eq)



Note: Aluminium manufacturing is part of non-ferrous smelting and refining of metals

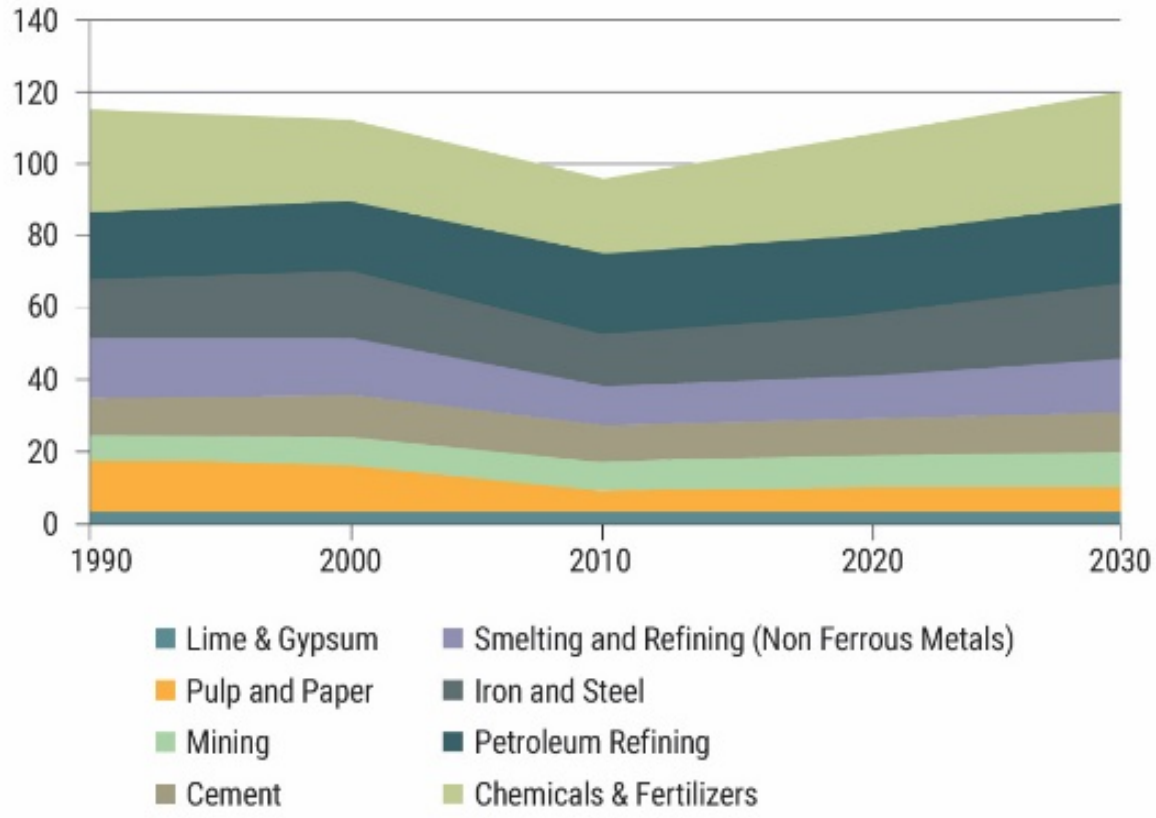
Source: Figure prepared by the Library of Parliament using data obtained from Environment and Climate Change Canada, Environment Canada Data.

A) Emission Trends and Projections

In 1990, emissions from heavy industry were 115 Mt CO_2 eq, accounting for 19% of total Canadian emissions. By 2015, heavy industrial emissions decreased to 96 Mt CO_2 eq or 13% of total emissions. According to Environment and Climate Change Canada's 2016 reference case projection, Canada's heavy industry emissions in 2030 will be 119 Mt CO_2 eq accounting for 16% of total emissions. [37]

Figure 4 illustrates a reduction in emissions due to the effects of the global economic downturn in 2008.[38] Emissions are projected to grow after 2015 but emission intensity (GHG emissions per unit of output) is expected to decline.[39] Projections are based on Environment and Climate Change Canada's 2016 reference case scenario. They only include federal, provincial and territorial government measures that have legislative or funding certainty as of 1 November 2016.

Figure 4 – Canada's Heavy Industry Emission Trends and Projections (Mt CO_2 eq)



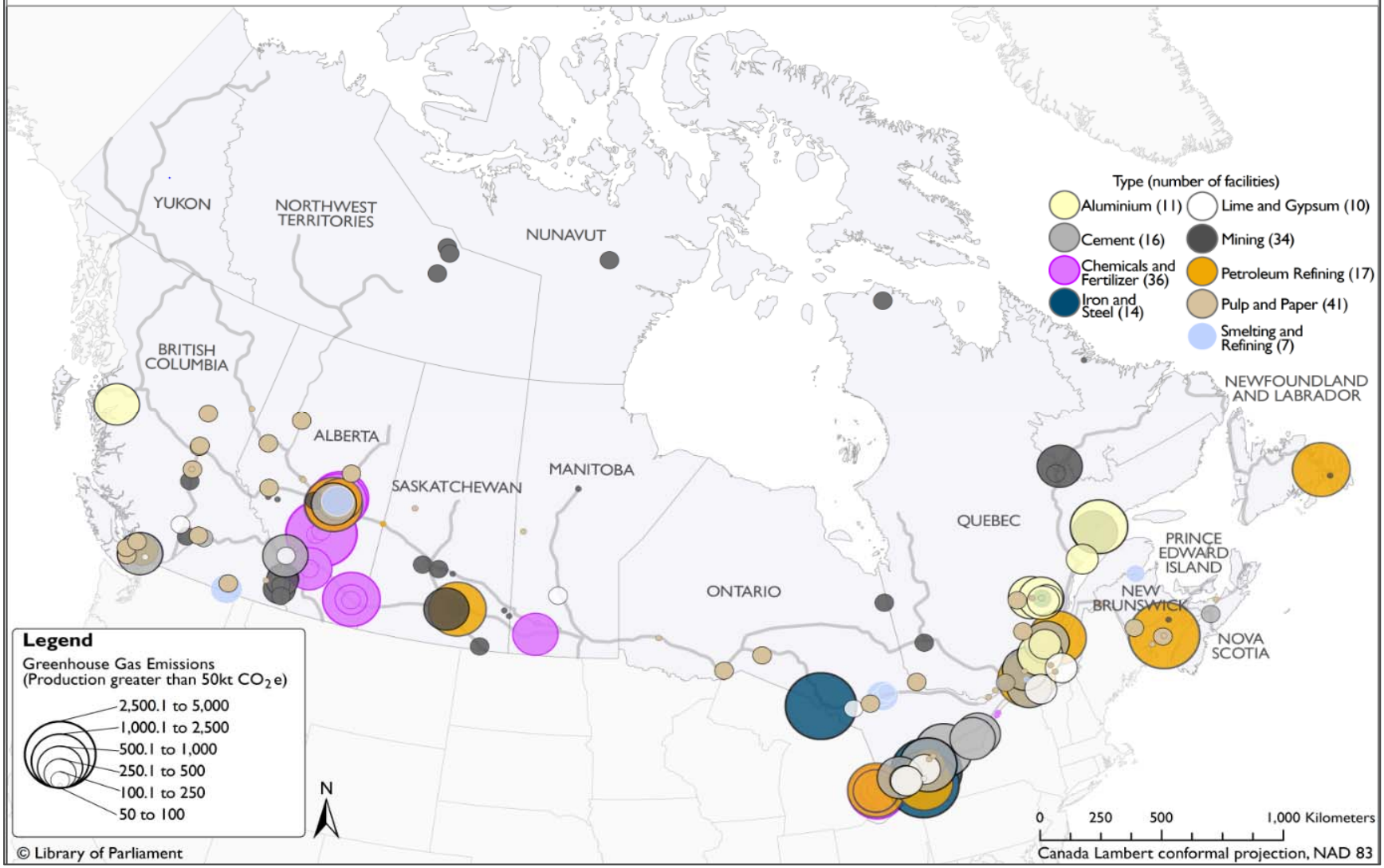
Source: Figure prepared by the Library of Parliament using data obtained from Environment and Climate Change Canada, Canada's 2016 Greenhouse Gas Emissions Reference Case and National and Provincial/Territorial Greenhouse Gas Emission Tables.

B) Heavy Industrial Facilities Across Canada

As illustrated in Figure 5, EITE emissions are not evenly distributed across the country. Ontario is the largest source of EITE emissions followed by Quebec, Alberta and Saskatchewan. EITE industries accounted for approximately a quarter of total provincial emissions in Ontario, Quebec, and New Brunswick.[40]

Petroleum refining occurs in seven provinces; the top emitting provinces in this industry are Ontario, Alberta, New Brunswick, and Quebec. New Brunswick houses the largest refinery in Canada accounting for a sizable portion of the province's total emissions. The chemical and fertilizer industry is mainly located in Alberta, Ontario, and Quebec. Most of the country's steel producing facilities are located in Ontario, followed by Quebec. Aluminium production is the largest source of emissions in non-ferrous smelting and refining of metals; there are nine aluminium smelters in Quebec and one in British Columbia.[41] Mostly these are from fixed-process emissions and emissions from combustion of natural gas, as electricity generation in Quebec and British Columbia is predominantly non-emitting hydro.

Figure 5 – Greenhouse Gas Emissions from Large Industrial Facilities, Canada, 2015



Source: Map prepared by the Library of Parliament, Ottawa, 2017, using data from Environment and Climate Change Canada (ECCC). *Greenhouse Gas Emissions for Large Facilities, Canada, 2015*; Ottawa: ECCC, accessed September 2017; Natural Resources Canada (NRCan). *Boundary Polygons*. In: *Atlas of Canada National Scale Data 1:5,000,000 Series.* Ottawa: NRCan, 2013. The following software was used: Esri, ArcGIS, version 10.3.1. Contains information licensed under *Open Government Licence – Canada*.

EITE AND THE NEW CLEAN ECONOMY

Industrial commodities are widely used in society and industry representatives expect their use not only to continue, but in some cases also expand as economies decarbonize. Carl Weatherell, Executive Director and Chief Executive Officer of the Canada Mining Innovation Council, predicted that the need for raw mining materials would increase to meet growing demands of the clean technology sector. He told the committee:

> *...it is estimated that Tesla alone will consume 5 per cent of copper production, or 900,000 tonnes of copper, for its electric motors by 2030. This is but one example from one company for one technology.*[42]

Similarly, Bob Masterson, President and Chief Executive Officer of the Chemistry Industry Association of Canada, argued that his industry:

> *...is the key solutions provider for many of the world's pressing sustainability problems, including climate change. It's those trends that analysts use to predict that we will see a near tripling of the largest volume of what we call our platform chemicals over the next 30 years.*[43]

Members of the committee learned about the challenges faced by the aluminium industry when visiting Rio Tinto in Kitimat, British Columbia, even though the facility underwent a $5 billion capital modernization.

Jean Simard, President and Chief Executive Officer of the Aluminium Association of Canada, told the committee that aluminium is set to play a vital role in making vehicles lighter and more fuel efficient.[44] Joseph Galimberti, President of the Canadian Steel Producers Association, also saw opportunities for new high strength and ultra-light steel materials in the transportation sector.[45] Additionally, he highlighted the use of

steel for new energy infrastructure projects and the construction of wind turbines and solar panels. Robert Larocque of the Forest Products Association of Canada pointed to the use of new forest bioproducts, such as wood fibre composite as an alternative to plastics for vehicle consoles.[46]

Garth Whyte, President and Chief Executive Officer of Fertilizer Canada, told the committee that fertilizer products will likely play a greater role in global food production in the future as climate change threatens food productivity and existing farming systems.[47]

The Canadian Advantage

EITE witnesses placed the carbon footprint of their industry's operations among the lowest in the world. There are several reasons for this. Unlike most other countries, Canada's electricity is extremely clean: over 80% of Canada's electricity is generated by non-emitting sources.[48] The Aluminium Association of Canada told the committee that aluminium production was fuelled nearly entirely by hydroelectric power. In contrast, the committee was told that Chinese-made aluminium, which represents 50% of global production, relies on coal-fired generation for 90% of its electricity. As such, the carbon footprint of China's aluminium is seven times larger than that from Canadian aluminium smelters.[49]

In many cases, high quality raw materials for Canadian EITE industries are sourced close to production facilities and therefore do not have to be imported from abroad. Mr. Galimberti of the Steel Producers Association explained that along with lower emitting electricity, these factors make a big difference in terms of emission intensity:

> *… the GHG emission differentials associated with one tonne of steel are significant. Production in Canada for use in Canada implies 1.1 tonnes of GHG emission per tonne of steel while production in China implies 3.5 tonnes of GHG per tonne of steel. Production in India implies 2.3 tonnes of GHG per tonne of steel, and production in Korea implies 2.4 tonnes of GHG per tonne of steel.*[50]

Similarly, Canadian petrochemical and fertilizer companies have access to large supplies of natural gas, which serve as a low

carbon chemical feedstock for their operations compared to coal, a source of energy used extensively in China for chemical feedstock for example.[51] The committee notes that the International Energy Agency projects a reduction of coal as a chemical feedstock in China for future years.[52] However, Canada maintains a significant low carbon advantage as Bob Masterson of the Chemistry Industry Association of Canada explained:

> *We have among the highest and richest reserves of natural gas and natural gas liquids that allow for chemical production from methane, ethane and propane, which have the lowest greenhouse gas potential of all the remaining chemical feedstocks.*[53]

The Forest Products Association of Canada told the committee that Canada's leadership in forestry practices can be used to promote its forest products abroad:

> *Promoting the use of Canadian forest products abroad is a key strategy to mitigate climate change. It's not just that good work should be recognized-because competing products often come from countries with high rates of deforestation and weak regulatory regimes, promoting Canadian products in the global marketplace can help keep forests healthy abroad.*[54]

Members of the committee visited the "Chemical Valley" in Sarnia Ontario, where a large number of Canada's petrochemical industries are located.

CARBON LEAKAGES AND COMPETITIVENESS RISKS

The EITE sector consists of industries that are, by definition, large sources of emissions and are exposed to global competition. Being heavy emitters, these industries are highly vulnerable to the increased costs associated with carbon compliance requirements. Further considering that they are exposed to global competition, the increased costs place them at a disadvantage among foreign competitors that are not subject to similar emission restrictions. Generally, EITE products are priced in global markets and they are unable to pass on increased costs to their customers.[55]

Many witnesses expressed concerns that without compensating provisions, rising compliance costs could lead to a displacement of production activity to other jurisdictions with lower emission standards and/or that it could lead to an increase of less expensive, but higher carbon intensive imports. In both these scenarios, the end result could be a shrunken Canadian industrial sector and loss of jobs, while at the same time not addressing global emissions. This effect is commonly called "carbon leakage." Several witnesses emphasized the need to prevent this effect when developing carbon reduction policies. Garth Whyte of Fertilizer Canada pointed out that:

> *Energy-intensive trade-exposed sectors are competing globally with industries that are not subject to equivalent targets or climate change policies, and we are therefore at high risk for decreased investment and carbon leakage.*[56]

Peter Boag, President and Chief Executive Officer of the Canadian Fuels Association, told the committee that if Canadian petroleum refineries become uncompetitive and reduce production due to carbon restrictions, the country will then import fuels and export jobs. He elaborated:

> *We export the economic activity that's important in many communities across Canada, and we just export those emissions. We actually don't achieve anything, and that is the classic case of carbon leakage.*[57]

Chris Ragan, Chair of Canada's Ecofiscal Commission, explained:

> *What you don't want to do, in our view, is achieve emissions reductions by having our businesses close down or shrink, lose in the marketplace, lose market share to their rivals from low carbon priced jurisdictions. We certainly don't want them to shut down operations and move across the border to some jurisdiction where there is a lower or no carbon price.*[58]

Joseph Galimberti of the Canadian Steel Producers Association noted:

> *What is in the steel industry's interest is to make sure that commodities are able to compete fairly, that our producers are able to compete fairly with a producer in the U.S. or China who does not bear costs that governments have decided to impose for the purposes of commodifying carbon. It's just that simple. The alternative is to probably dramatically reduce steel production in Canada, and that doesn't do anyone any favours.*[59]

POLICY OPTIONS: WHAT THE COMMITTEE HEARD

The federal government's involvement in emission reduction in EITE industries in the past has been mostly limited to improving energy efficiency and offering research and development initiatives to improve environmental performance.[60] Nearly a decade ago, the federal government provided targeted funding of $1 billion to the pulp and paper industry to improve energy efficiency, emission reduction and encourage renewable energy production with biomass.[61] This resulted in a more than 10% decrease in GHG emissions from 2009 levels.[62]

Faced with the task of reaching Canada's Paris Agreement commitments, the federal government announced new measures, such as a carbon pricing and the proposed Clean Fuel Standard that will have direct and indirect financial implications to the country's large industrial emitters.[63] It is expected that the federal government will introduce further measures to drive the low-carbon transition.

Policy options to reduce emissions across all economic sectors including large industrial emitters were outlined in the final report by the federal/provincial/territorial Working Group on Specific Mitigation Opportunities. Options include the use of both the "carrot" (grants, tax incentives and loans) and the "stick" (regulatory requirements) to achieve short, medium and long term emission reduction goals.[64] Policy options are intended to provide a broad menu from which federal, provincial and territorial governments can choose or adapt to meet their jurisdictional circumstances.

Policy options developed for large industrial emitters include:

- Provide incentives to promote cogeneration;[iii]
- Apply equipment regulations and/or rate based incentives to increase use of electricity;
- Mandate or use incentives to promote energy efficiency;
- Ban routine flaring from industrial facilities;
- Encourage fuel switching to lower carbon alternatives, through regulation or incentives;
- Support carbon capture and sequestration technologies; and
- Support research and development to drive transformative changes in technology. [65]

The following section presents the views that committee members heard from Canada's EITE industries, federal department officials, energy and environmental experts and stakeholders.

[iii] The National Energy Board defines cogeneration as the production of electricity and another form of useful thermal energy, such as heat or steam, from the same energy source. The byproduct heat from industrial processes can either be used to power an electrical generator, or can be used for industrial purposes.

Carbon Pricing

Carbon pricing is a central component of the Pan-Canadian Framework on Clean Growth and Climate Change and marks new fiscal territory for the federal government. By 2018, a national broad-based carbon benchmark price will be applied in all provinces and territories starting at $10 per tonne of carbon dioxide equivalent (t/CO_2 eq). The benchmark will increase by $10 each year through 2022, when it will reach $50 t/CO_2 eq.[66] In light of the unique energy circumstances of the territories, the Government of Canada has committed to work with territorial governments to address their specific challenges with respect to carbon pricing.[67]

As described in the Framework, each jurisdiction can choose between a carbon tax, a hybrid approach composed of a carbon tax and an output-based pricing system or an emissions trading scheme (cap-and-trade) -see below for description of carbon pricing options. If a province or territory does not implement a carbon pricing system that aligns with the federal benchmark, the federal government will implement, as a backstop, a federal carbon tax applied to fossil fuels and an output-based pricing system for large industrial emitters in that province or territory.[68] Revenues will be returned to the province or territory from which they were collected.[iv]

Under the backstop, large industrial emitters will pay a carbon tax if they emit above a performance threshold while efficient facilities may pay no tax or even receive emission credits. According to the federal government, the output-based pricing system is expected to create a pricing incentive that reduces:

... greenhouse gas emissions from industrial facilities while limiting

Members of the Senate Committee on Energy, the Environment and Natural Resources learned about the Summerside Wind Farm initiative from city officials in Summerside, Prince Edward Island.

[iv] The carbon tax under the federal backstop will come into effect in 2018 while the output-based pricing system will not come into effect before January 1, 2019.

the impacts of carbon pricing on their international competitiveness, particularly on their ability to compete with similar businesses in countries that do not have carbon pricing. This approach thus minimizes the risk that businesses could move from Canada to jurisdictions that do not price carbon.[69]

On 15 January 2018, the Government of Canada released draft legislation on the federal backstop for public comment.[73] The backstop provides the minimum threshold to which provinces and territories must design and implement their carbon pricing systems. The backstop will supplement or "top-up" systems that do not fully meet the national benchmark.[74] Provinces and territories have until 1 September 2018 to outline how their carbon pricing systems will meet the federal benchmark.[75] The federal government indicated that it will continue to engage provincial and territorial governments, Indigenous Peoples and other affected stakeholders on the design of the federal carbon pricing system during the winter and spring of 2018.[76]

Carbon Pricing Options

Carbon tax: A government-imposed tax on carbon, usually implemented by taxing fossil fuels but it can be designed to apply to non-combustion emissions such as industrial venting or fixed-process emissions.[70]

Cap and trade: An approach to controlling carbon emissions that requires a government to cap total carbon emissions on regulated sectors (usually large emitters) and either sells or gives carbon permits to companies (large emitters) that add up to the cap. Companies that are successful in reducing emissions can sell permits (also referred to as carbon credits or allowances) that they do not use to other companies emitting above their permits. The price of permits varies depending on the market for permits. Over time, governments introduce stringency by lowering the overall cap.[71]

Carbon Tax and Output-Based Pricing System: A carbon pricing system that combines a carbon tax with a high performing benchmark feature for large emitters. This feature is sometimes called an output-based allocation system or performance-based emission system. It sets a high performing benchmark for large emitters based on an emission intensity basis, for example CO_2 per ton of steel. Each regulated emitter is allocated free emissions credits that correspond to what their emissions would have been if their emission intensity had matched the benchmark. A company will have a carbon liability for any emissions it does not have emission credits to cover. This would happen if a company's emission intensity fails to reach the benchmark. In this case, the company would have to pay the carbon tax on, or buy credits to cover, its excess emissions. If its emission intensity outperforms the benchmark then it receives performance credits, which it can sell. Governments can introduce stringency by setting higher performing benchmarks.[72]

A) Carbon Pricing: Addressing Competitiveness Issues

Carbon pricing is generally regarded as an efficient way to lower GHG emissions since it harnesses the power of market forces by providing a price signal to drive innovation and behaviour in favour of lower carbon goods and services. This view is shared by the World Bank, the Organisation for Economic Cooperation and Development (OECD), the International Monetary Fund and the Final Report of the federal, provincial and territorial Working Group on Carbon Pricing Mechanism.[77]

Many witnesses, including those from the Forest Products Association of Canada, the Mining Association of Canada, the Aluminium Association of Canada, the Canadian Fuels Association and the Canadian Chamber of Commerce supported the use of carbon pricing as a policy tool to address emissions. Other witnesses, such as Fertilizer Canada, Chemistry Industry Association and Canadian Steel Producers Association, did not openly oppose carbon pricing, but made it clear that such an approach was a threat to their industry due to both the difficulty of reducing their fixed-process emissions and having to compete with jurisdictions that do not price carbon. In fact, all EITE witnesses raised concerns about carbon pricing and the risk it carries if its design does not explicitly safeguard the competitiveness of their industries. These safeguards include carbon credits or the exemption of industrial emissions from carbon pricing until trading partners adopt similar carbon pricing programs. EITE witnesses stressed that it would be counterproductive to place the burden of reducing emissions on the backs of heavy industry which competes with global firms.

> *...all EITE witnesses raised concerns about carbon pricing and the risk it carries if its design does not explicitly safeguard the competitiveness of their industries.*

The Canadian Chamber of Commerce told the committee that carbon pricing and other measures are being introduced within a context where businesses are being asked to bear rising fees and payroll taxes, higher minimum wage rates, increasing electricity rates and additional regulatory requirements. Overall, there is concern that this rising burden is making it harder for Canadian businesses to grow and compete for investment and customers abroad. On the other hand, the recycling of carbon revenues in the economy can create economic growth.[78] Also, there are inherent risk and long term costs associated with not moving to a clean growth economy and not addressing emissions.

British Columbia, Alberta, Ontario and Quebec have implemented carbon pricing systems ahead of the federal government's requirements. In October 2017, Manitoba announced details of its carbon pricing program and implementation is set for 2018. Other provinces and territories are studying carbon pricing options or are in the process of legislating their carbon pricing

approaches.[v] Provinces have differed in their approach to carbon pricing and in the manner they supported their EITE sectors:

- **British Columbia** applies a broad-based carbon tax of $30 per tonne of CO_2 eq on all fuels in the province. Starting on 1 April 2018, the government proposes to increase the tax by $5 per tonne per year until rates reach $50 by 2021. Non-combustion industrial process emissions are not taxed.[79] In its Budget 2017 September update, the government committed to "develop strategies with industries to support the transition of carbon intensive sectors to a lower carbon economy"[80] in future budgets.

- **Alberta** applies a $30 per tonne carbon levy on transportation and heating fuels. The province has adopted an output-based approach for large emitters starting 1 January 2018. Facilities will be allowed to emit a certain amount of GHGs, free of charge from the carbon levy in order to protect industries from competitiveness impacts.[81]

- **Ontario** and **Quebec** have adopted cap-and-trade systems with free allocation of carbon allowance to large emitters and/or emission-intensive and trade-exposed industries. Free emission permits were issued to EITE industries to protect their competitiveness and non-combustion fixed-process emissions were excluded from the first compliance period of the programs.[82]

- **Manitoba** announced a $25 carbon tax levied on fuels and natural gas starting in 2018. The province will also be introducing an output-based carbon price during 2019.[83]

Several witnesses represented industries that operate in provinces with carbon pricing programs. The committee was told by representatives from the aluminium and cement industries that cap-and-trade was favoured over carbon taxes because of the use of free emission allowances for large emitters. Also, they believed that cap-and-trade was more flexible in achieving compliance while still providing incentives to large emitters to reduce emissions. For example, if a firm reduces emissions to an extent that leaves a surplus of carbon permits/credits, then it can benefit from selling them on the market. As Jean Simard of the Aluminium Association of Canada explained:

> *Our assessment as an industry when we look at cap-and-trade versus a tax, cap-and-trade is the most incentivizing type of carbon pricing policy for an industry because you can earn something out of improving the way you operate. It incentivizes the whole organization. When you plan expansions you plan expansions to be a winner on the cap-and-trade market.*[84]

[v] Nova Scotia introduced legislation to implement a cap-and-trade system in September 2017. Newfoundland and Labrador has passed legislation for a performance-based system for large onshore industrial emitters and has put in place reporting requirements.

This view was echoed by Michael McSweeney of the Cement Association of Canada:

> *…on carbon tax versus cap-and-trade, our industry, as an energy-intensive trade-exposed industry, supports cap-and-trade, because it works for energy-intensive trade-exposed industries…In my mind, if we are really committed to reducing GHGs, government has to have that carrot and stick. The stick is the cap: this is what you're going to reduce and this is where we will be in 2030. The carrot in cap-and-trade jurisdictions are the free allowances, which also decline over time, but they allow companies that are better to do better and companies that need to do more do more over time.*[85]

> *The Pan-Canadian Framework includes a commitment for the federal government to work with provinces and territories to review the overall approach to pricing carbon by early 2022 to determine the path forward.*

Katrina Marsh of the Canadian Chamber of Commerce spoke favourably of the output-based system being introduced in Alberta for large emitters in 2018.[86] Similarly, Louis Thériault, Vice-President, Industry Strategy and Public Policy of the Conference Board of Canada, highlighted the output-based approach as a means to address competitiveness issues.[87] Mr. Ragan of the Ecofiscal Commission compared this system to the free emission allocations under cap-and-trade as a means to prevent businesses from leaving:

> *The first instrument is the carbon price, which is the best way to reduce emissions, but if you provide cash value, whether in the form of a free permit in a cap-and-trade system or what in Alberta is called an output-based allocation, which is effectively an output subsidy, you're giving cash value to a firm as long as they remain in the jurisdiction, they remain producing and they keep hiring your workers. If they do not do that, they don't get the cash value. That is a way you can deal directly with the competitiveness problem.*[88]

The Pan-Canadian Framework includes a commitment for the federal government to work with provinces and territories to review the overall approach to pricing carbon by early 2022 to determine the path forward. An interim report will be completed by 2020 to specifically review approaches and best practices to address the competitiveness of EITE industries.[89] Sean Keenan, Director, Sales Tax Division, Tax Policy Branch of the Department of Finance Canada told the committee that the federal government is looking at options, including those implemented in other countries, to address the concerns of the industrial sector.[90]

The committee questions whether the review to address EITE competitiveness should be undertaken sooner than 2020.

Mr. Masterson of the Chemistry Industry Association of Canada raised concerns that

the uncertainty over carbon pricing after 2020 created a poor environment to attract investment:

> *We're also talking about operations that have 30- to 40-year lifetimes. When we can't tell people what the regulatory and pricing environment looks like after three years from today, in 2020, they're going to be very hesitant to put their money into Canada.*[91]

Will the proposed federal backstop sufficiently limit the emissions from large industrial emitters? How effective will the backstop safeguard the competitiveness of large industrial emitters? Will the federal backstop be flexible to adapt to new types of industries and policy changes abroad? How will the federal government determine if a province's or territory's carbon pricing system is aligned with the benchmark given that there is flexibility in how the pricing systems are implemented?

B) Managing the Transition

The committee heard from representatives from the steel, cement, fertilizer and aluminium industries that it would not be possible to maintain production and reduce fixed-process emissions without a major technological breakthrough. They recommended slowing the pace of the carbon transition for heavy emitters. For example, these witnesses were concerned about the forthcoming stringency of Quebec and Ontario's cap-and-trade programs. Michael McSweeney of the Cement Association of Canada said:

> *In Quebec, early thinking on the next phase of their cap-and-trade system proposes emission reductions from process emissions in our sector, and those are mathematically impossible to meet without carbon capture technologies, which are at a minimum a decade or more away from any technological or commercial viability. In Ontario, the performance benchmark declines at a rate that cannot be sustained beyond the first compliance period.*[92]

Jean Simard of the Aluminium Association of Canada told the committee that significant reductions in emissions were achieved in the industry through modernization, but a breakthrough in technology is needed to reduce emissions further and this cannot be counted on when implementing carbon compliance measures.[93]

Peter Boag, President of the Canadian Fuels Association, recommended that governments recognize the unique circumstances of the petroleum refining industry by adopting a broader view when developing frameworks under cap-and-trade for the compliance periods beyond 2020. Essentially, the association is recommending that governments assess the overall impact of decarbonization efforts on the demand for transportation fuels before applying further stringency to the oil refining sector. Mr. Boag said:

> *In considering the design of those new post-2020 systems, we're suggesting and recommending to them that they would think about looking beyond 2023 for additional*

stringency in the refining sector. I understand those provinces in their cap-and-trade systems are aggressively going after the transportation fuels side of it. That is to my point. If the governments are successful in reducing the demand for transportation fuels, we believe that will naturally cause a reduction in refining capacity and refining activity in Canada.[94]

Should the pace of decarbonisation be slowed for emission-intensive and trade-exposed industries to reflect the technological challenges facing this sector?

C) Northern and Remote Regions

Carbon pricing will have a disproportionally greater impact on northern and remote communities because many of these communities rely solely on carbon-based fuels, mainly diesel or fuel oil for electricity and heating, with limited options to make use of alternative fuels.[95] These communities also rely heavily on air travel and other motive-fuel vehicles to travel long distances to transport people and to deliver food, fuels, other supplies, as well as essential services.

Canada's northern and remote regions are less economically diversified than the rest of the country, relying heavily on exploration and extraction of minerals, as well as on oil and gas activities, which are emission-intensive and trade-exposed. In many cases, diesel fuels have to be transported long distances to produce electricity and heat for these operations.

Carbon pricing would raise the costs of these industrial operations disproportionally more than other regions of the country.[96] On that topic, Brendan Marshall, Vice President of Economic and Northern Affairs, Mining Association of Canada, told the committee that even without a carbon price, it is 2 to 2.5 times more expensive to build a base or precious metal mine in the North. He noted that "[t]here are many projects in the North that are currently economically unviable. A carbon price just pushes them further away without the appropriate EITE and other policy considerations."[97]

However, Mr. Marshall sees opportunity in carbon pricing for the North by investing in

northern infrastructure to facilitate the transition to a lower carbon future. He noted:

> *We would like to see the carbon pricing reality as an opportunity. The government has given itself substantial infrastructure dollars. It's our view that this infrastructure investment is, at least substantially in part, intended to facilitate the transition to a lower carbon future. In our view, ensuring that … remote and Northern regions are eligible for that funding, that there is a consideration of Northern realities in the mandate and funding criteria for those investments is critical to ensuring that you can have a harmonious implementation of any carbon pricing in the North, as well as maintaining business competitiveness.* [98]

The Pan-Canadian Framework recognizes the unique challenges facing territories, indigenous communities, and remote and northern communities in general.[99] John Moffet, Acting Associate Assistant Deputy Minister, Environmental Protection Branch of Environment and Climate Change Canada, told the committee that the federal government "has committed to address the specific challenges of the territories with respect to carbon pricing before making any final decisions about the application of carbon pricing in the territories."[100] Mr. Moffet explained that the department was in discussion with each of the territories and that it plans to map out a common approach and then move to three bilateral reviews to look at specific issues in each of the territories.

How should carbon pricing be applied to businesses and households in the Canadian territories? Should non-territorial remote communities which face similar challenges as the territories be given special consideration under carbon pricing programs?

D) Revenue Recycling

Revenues raised by carbon pricing are expected to be significant. How these revenues are recycled in the economy were a key concern among witnesses. Chris Ragan of Canada's Ecofiscal Commission told the committee that the environmental benefits of carbon pricing are driven by emissions reductions over time, but the economic impact of carbon pricing on the economy largely depends on what is done with the revenues.[101]

Carbon pricing revenues can be used in a number of ways. They can be used to lower corporate and personal income taxes including targeted rebates. They can fund clean technology adoption, research and investment in green infrastructure. They can also provide assistance to EITE industries through emission allowances or exemptions, as described in the previous section.

Mike Cleland, Senior Fellow, University of Ottawa, told the committee that carbon revenues should first be directed to vulnerable households, then used to assist EITE industries and then used to lower income taxes.[102] This view was echoed by Trevor McLeod, Director of the Centre for

Natural Resources Policy, Canada West Foundation:

> *Our view is that some combination of the revenue neutrality where you're cutting taxes and also easing the blow for energy-intensive, trade-exposed sectors makes good sense. There should be some benefit to those on the lower end of the income spectrum.*[103]

The Association of Major Power Customers of BC told the committee that revenues from carbon taxes are best used to advance GHG reduction measures and to help businesses and individuals adapt to the transition to a low-carbon economy.[104] The need to support businesses was echoed by Katrina Marsh of the Canadian Chamber of Commerce, who shared the following with the committee:

> *The Canadian Chamber has supported putting a price on carbon since 2011. However, higher costs for everyone can only be justified if these revenues are applied to the mission at hand. Funds raised from carbon-pricing schemes must be applied to reducing competitiveness impacts to business or promoting climate innovation. Otherwise, governments are just using the climate as an excuse to raise taxes.*[105]

Benjamin Dachis, Associate Director of Research at the C.D. Howe Institute, also supported funding research, but did not believe funding technology adoption, such as low-emission vehicles or home retrofits, was a good use of carbon revenues:

> *It makes the overall program of carbon pricing far less effective because it's the government picking and choosing where it wants emissions reductions to happen, independent of the carbon price. With that level of massive subsidies of technology adoption, it amounts to a bad program crowding out the good program.*[106]

What are the best ways to recycle carbon pricing revenues to achieve emission reduction goals while growing the economy? What is the best way to incent emission-intensive and trade-exposed industries to reduce emissions while protecting them from global competition from higher carbon jurisdictions?

Clean Fuel Standard

The federal government announced on 25 November 2016 that, in consultation with provinces and territories as well as affected groups, it would develop a Clean Fuel Standard to reduce GHG emissions from fuels used in transportation, buildings and industry.[107] The details are currently being developed, but standards will likely set carbon intensity requirements for liquid, gaseous and solid fossil fuels.[108]

The proposed Clean Fuel Standard is a separate initiative from the existing federal Renewable Fuels Regulations, which requires petroleum fuel producers and importers to have an average renewable content of at least 5% based on their volume of gasoline and an average renewable content of at least 2% based on their volume of diesel fuel and heating distillate.[109]

Five provinces – British Columbia, Alberta, Saskatchewan, Manitoba and Ontario – have renewable fuel standards. British Columbia is the only province that also has a low carbon fuel standard in place. Fuel suppliers in British Columbia are required to reduce the carbon intensity of fuels by 10% by 2020 from a 2010 baseline.[110] They can do so by improving agriculture practices for growing biofuel crops or by supplying more low-carbon fuels, such as natural gas, electricity, biodiesel or ethanol, or by purchasing low-carbon fuel credits. The province intends to increase the carbon intensity target to 15% by 2030.[111]

According to officials from Environment and Climate Change Canada, the performance goal of the proposed Clean Fuel Standard is a reduction of 30 megatonnes of carbon dioxide equivalent. The federal government argues that the standard will incent the creation of lower carbon fuel options and drive technology and innovation.[112]

In October 2016, during a visit to the Canfor Pulp Ltd, Intercontinental pulp mill in Prince George, British Columbia, committee members were told that the mill was investing in technology that would convert waste biomass into renewable biocrude. Officials from Canfor explained that the low carbon fuel standards in California and British Columbia were providing economic incentives to pursue this business investment and they supported a carbon intensity-based federal clean fuel standard.

Five provinces – British Columbia, Alberta, Saskatchewan, Manitoba and Ontario – have renewable fuel standards.

Witnesses from the Forest Products Association of Canada and the Cement Association of Canada believed that fuels used for industrial use should be exempted from the proposed Clean Fuel Standard since it would be already covered under carbon pricing. Robert Larocque of the Forest Products Association of Canada told the committee the following:

> *We are the users of industrial fuel so we are not only going to be paying a carbon tax, we may be paying that extra cost for the fuel supplier to put renewable content and give it to us. That's two costs we're paying, and we can't pass it on. That's the cumulative impact of all those carbon policies that you need to recognize the trade-exposed industries. In those cases, I would exempt the industrial users of that fuel [to avoid taxing the same product twice].*[113]

Michael McSweeney of the Cement Association of Canada told the committee that introducing a Clean Fuel Standard could add regulatory complexity and competitive challenges to the industry:

> *…while the federal government has effectively derogated the responsibility for carbon pricing and competitiveness to the provinces, they are simultaneously contemplating other regulatory interventions, such as implementing a clean fuel standard for industry, which could disrupt the integrity of provincial approaches and compound competitiveness challenges to industry.*[114]

Alternatively, Peter Boag of the Canadian Fuels Association supported the proposed national Clean Fuel Standard because it would avoid policy fragmentation in Canadian fuel markets:

> *We very much support the Clean Fuel Standard, at a national level, as an opportunity to bring greater coherence and alignment to the regulation of fuels and to avoid what is, in our view, an unhelpful fragmentation of the Canadian fuels market into many what we would call boutique markets.*[115]

Green Procurement and Infrastructure

The federal government is a significant purchaser of goods and services and the source of substantial infrastructure funding. Some witnesses argued that the federal government should consider the carbon intensity of materials when making purchasing decisions and when framing conditions for federally-funded infrastructure projects. Joseph Galimberti of the Canadian Steel Producers Association explained that it is important not to award government contracts for projects that use commodities manufactured by foreign producers that have an unfair cost advantage because of weaker carbon compliance requirements. He noted:

> *At a minimum, government procurements and funded infrastructure projects should include consideration of the domestic cost of carbon in the sourcing of material. If additional costs are incurred to produce materials in Canada because of carbon pricing, it is incumbent on government to ensure that foreign producers, not bearing the same financial obligations, do not then gain an unfair cost advantage when competing for government contracts. To achieve this goal, Canada's government procurement policies should exclude steel imports from countries that do not have a demonstrably implemented and equivalent national carbon pricing regime.*[116]

Katrina Marsh of the Canadian Chamber of Commerce emphasized that an expanded green procurement criteria should be framed as “buy green” policy instead of a “buy Canadian” initiative. She believed Canadian manufacturers could benefit from green procurement policies:

> *I do believe that green procurement, the idea where you are judging inputs based on some sort of criteria based on their sustainability, could be an idea for government procurement policy, which might have the impact of increasing Canada's competitive position when bidding for these kinds of products...*[117]

Micheal McSweeney of the Cement Association of Canada told the committee that he endorsed the use of life-cycle cost analysis and life-cycle environmental assessments for all federal funded infrastructure projects:

> *By using a life-cycle approach for all infrastructure decisions, the*

federal government will be able to understand and optimize opportunities to build infrastructure at the least cost over its lifetime while at the same time invest in infrastructure that produces the lowest carbon footprint.[118]

> *Some witnesses argued that the federal government should consider the carbon intensity of materials when making purchasing decisions and when framing conditions for federally-funded infrastructure projects.*

Mr. McSweeney believes that a life-cycle cost analysis would reveal the environmental advantages of concrete materials. He explained that concrete pavements last between 40 and 50 years, cost less over their life and can improve fuel efficiency by up to 7% over asphalt pavements. He also highlighted the thermal properties of concrete to reduce the operational energy involved in heating and cooling buildings. Mr. McSweeney told the committee that he was disappointed that the federal Budget 2017 targeted the use of wood only for a new $39.8 million program aimed at supporting greener material for infrastructure projects.

Robert Larocque of the Forest Products Association of Canada told the committee that the federal government should consider the carbon footprint of materials used in constructing new federal buildings:

I think the governments have a place as leaders for procurement policies. If you're going to build a new federal building, why don't you look at it from a carbon perspective? A lot of other jurisdictions are doing it, and our perspective also is a carbon-first policy. It should be based on carbon, not on material per se.[119]

Officials from Treasury Board and Public Services and Procurement Canada confirmed that the federal government does not currently consider the carbon footprint of materials as a condition of federal procurement. However, Nick Xenos, Executive Director, Centre for Greening Government, Treasury Board of Canada Secretariat, explained that efforts are underway to explore that option:

We are having discussions with the National Research Council construction institute because that's exactly the problem we're trying to figure out. How do we look at materials and their embodied carbon? What is the competitive advantage for Canadian materials versus others?[120]

Should the carbon footprint of goods and services be a condition for federal purchases and/or federally-funded infrastructure projects?

Clean Technologies and Long Term Decarbonization

New types of low carbon industrial commodities and/or significant innovations in the way existing industrial products are made will be required in order to achieve long term emission reduction targets. As a

result, clean technologies represent an important and growing market opportunity. Many countries are mobilizing resources to address the competitiveness of their existing industries and to achieve benefits from the transition to a low-carbon economy.[121]

During the committee's visit to Sarnia, Ontario in November 2016, committee members were provided many examples of the work being done to advance the next generation of industrial technologies including the manufacturing of bio-chemicals. In Sarnia, a focus was placed on leveraging the existing petrochemical and petroleum refining supply chains and infrastructure in the region to develop sustainable industrial solutions.

Major new technological developments can take years or even several decades to achieve commercial application. Thus, the question is: ***given the government's emission reduction commitments, what should be the federal government's strategy to advance the research, development and adoption of clean technologies?***

A number of long term solutions are being explored by industry and the public sector including switching to lower emission fuels, capturing, utilizing and storing industrial emissions and developing breakthrough technologies that substantially decarbonize the way industrial products are made.

A) Electrification

EITE industries rely heavily on carbon-based fuels for their energy needs. That said, some companies are transitioning away from fossil fuel use, where feasible. For example, Brendan Marshall of the Mining Association of Canada highlighted the industry's Towards Sustainable Mining (TSM) initiative which helps mining companies improve their energy management procedures. He provided examples of the use of wind turbines in remote mining operations and switching to 100% electric power for mine-haul fleets and other operations.[122]

The committee heard from energy policy experts and federal department officials that the electrification of the economy, including industrial activities, is a pathway to deep emission reductions. Electrification was considered an option in the 2016 federal government's mid-century long-term GHG strategy submitted to the United Nations Framework Convention on Climate Change (UNFCCC).[123] Electrification is being considered because electricity consumption produces no emissions at point-of-use and many regions of the country have access to non-emitting electricity and/or can expand their clean electricity supply.

How technically and economically feasible is a fully electrified EITE sector? What industrial sectors show the most promise for further electrification? What role, if any, should the federal government play in facilitating or regulating a transition to renewable "deep electrification?" Does the high carbon emission profile of electricity systems in certain regions of the country present challenges in pursuing a policy of "deep electrification?"

B) Carbon Capture and Sequestration

Carbon capture and sequestration (CCS) technologies represent a group of technologies that capture carbon dioxide (CO_2) either before or after fuels are burned, or from fixed-emission processes. The captured CO_2 is compressed, transported by pipeline and either stored in deep underground formations or used for enhanced oil recovery in mature petroleum reservoirs or utilized as a feedstock to produce industrial products.

the Global CCS Institute told the committee that CCS applied to industrial processes was essential in meeting global emission targets.[125] This view is supported by the International Energy Agency, which estimates that in order to keep global average temperature increases below 2 degree Celsius, 50% of captured CO_2 globally will have to come from industrial applications other than electricity generation.[126]

CCS is currently being used, on a large scale, to capture emissions from a coal-fired

Committee members visiting SaskPower's Boundary Dam Power Plant in Estevan, Saskatchewan, to learn about Canada's first large-scale commercial carbon capture and storage facility.

The potential for CCS technologies to capture large volumes of carbon dioxide from large industrial emitters is an important pathway to achieving long-term decarbonization because there are few options, at this time, to avoid emissions from industrial processes.[124] Jeff Erikson of

electricity generation unit at the Boundary Dam Power Station in Saskatchewan where the majority of the captured CO_2 is used for enhanced oil recovery. CCS technology is also deployed at the Shell Quest Scotford upgrader facility in Alberta where hydrogen is pulled out of methane.[127] In this case, the

CO_2 is stored deep underground. Finally, the Alberta Carbon Trunk Line is a project under development that is expected to transport captured CO_2 from multiple industrial sources for use in depleted oil fields for enhanced oil recovery operations.[128]

> *The potential for CCS technologies to capture large volumes of carbon dioxide from large industrial emitters is an important pathway to achieving long-term decarbonisation…*

Although CCS is a proven technology, there are nonetheless obstacles preventing its widespread industrial application. First, CCS technologies require sizable infrastructure investment and technology to capture large amounts of CO_2 and transport it for sequestration. Second, the option to sequester the CO_2 deep underground or in enhanced oil recovery operations is limited since these sequestration formations or oil operations are not always located near existing industrial facilities. Third, there are significant risks and uncertainty associated with the adoption of new technologies to a facility.[129]

As an alternative to storing carbon underground or using it in mature oil fields, CO_2 can be utilized to produce a wide range of industrial goods including concrete, methanol, polymers and biofuels. The committee was told by clean technology entrepreneurs that CO_2 utilization technologies represent an emerging and promising opportunity.

In May 2017, committee members in a visit to Halifax, Nova Scotia heard from CarbonCure Technologies, a company that sources CO_2 from industrial emitters and injects it into concrete during production. Also, in a written submission from Advanced Chemical Technologies (AChT), a company based in Waterloo, Ontario, the committee was informed of opportunities to convert carbon industrial emissions into methanol. While promising, these technologies have yet to be deployed at a large scale. The committee heard that the expansion of CO_2 utilization technologies faces obstacles due to financial, market and technical risks associated with early adoption by industrial emitters.[130]

Should additional federal funding be devoted to the development and deployment of CCS technologies? How should the federal government encourage the use of CCS technology to the emission-intensive and trade-exposed sector? Should a funding program be introduced to accelerate industry adoption of Canadian CO_2 utilization technologies?

C) Addressing Fixed-Process Emissions

The essential methods of making iron and steel, aluminium, cement and chemical fertilizer have not changed in over 100 years.[131] These new technological innovations were revolutionary and they helped create the modern world we enjoy today. Because of the threat of climate change, we are faced with the need to develop a new form of technological revolution.

Jean Simard of the Aluminium Association of Canada told the committee that new processes for producing low carbon aluminium are being developed but are

several years away from being commercialized:

> *It would have to be a new process without the use of carbon anodes. Right now it's on the drawing board everywhere around the world. It's the Holy Grail of the industry, but we're very far from it. It's probably 15 or 20 years down the road. It's a major effort that has to be done. We think that Canada could play a role in that eventually, but it's not something that can be accounted for today in terms of capacity of greenhouse gas reductions.*[132]

Mr. Galimberti of the Canadian Steel Producers Association told the committee that there was progress being made to address emissions including using biochar to replace metallurgical coal to reduce fixed-process emissions. He explained these technologies are not yet available but the industry is very motivated globally to find a solution.[133]

How should the federal government support or encourage the development and deployment of new technologies that significantly reduce fixed-process emissions from large industrial emitters?

MOVING FORWARD

Emission-intensive and trade-exposed industries produce commodities that are traded globally and form the basic building blocks from which many goods are produced. As such, these industries are directly affected when carbon reduction requirements are uneven between countries. It is in this context that governments balance the goal of reducing carbon emissions with the need to minimize carbon leakages and competitiveness risks. Since international trade drives a large part of Canada's economy, it is important for Canadian governments to get the balance right.

Governments have many tools to transition to a decarbonized economy. These include carbon pricing, regulations, procurement policies, grants and incentives. Considering the extent of the challenge that this transition entails, multiple approaches will be required. Policymakers must carefully assess the different policy options available to them in order to minimize unintended negative consequences. In so doing, we should not lose sight of the advantages of creating a positive environment to attract investment for businesses to grow and be innovative. Economic growth should be part of the solution.

Carbon pricing is a central component of the Pan-Canadian Framework on Clean Growth and Climate Change and marks new fiscal territory for many Canadian governments. Most carbon pricing programs that have been established to date across Canada contain features that reduce the carbon compliance burden on emission-intensive and trade-exposed industries. The challenge will be in how to manage emissions from the emission-intensive and trade-exposed sector over time. ***How should increased stringency be applied? Further, how should revenues from carbon pricing be allocated among different industries and individuals? How does Canada minimize the financial burden on households and businesses?***

There are technological limits to how much emissions can be reduced from heavy industries. ***Do governments need to be strategic in identifying where they can make carbon reduction gains from this sector? How should they prioritize research and innovation funding to address these technical challenges?***

De-carbonization also creates opportunities. New industrial technologies carry the possibility of substantially improving energy efficiency and cost-effectively mitigating industrial emissions. These technologies create new industries and provide competitive advantages, particularly since the world has few options but to transition away from carbon-based economies to avoid the worst effects of climate change.

Julie Gelfand, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada, told the committee that Canada failed every emission reduction commitment it has set since 1992 and that the country's 2020 target (17% below 2005 levels by 2020) is unlikely to be met. The Commissioner's 2017 Fall Report emphasized that opportunities were lost in the past when the federal government did not pursue its announced sector-specific oil and gas regulations or the regulations for EITE industries.

APPENDIX A – LIST OF WITNESSES

March 22, 2016	
Environment and Climate Change Canada	Dan McDougall, Assistant Deputy Minister, Strategic Policy Branch Derek Hermanutz, Director General, Economic Analysis Directorate, Strategic Policy Branch Mike Beale, Assistant Deputy Minister, Environmental Stewardship Branch
April 12, 2016	
National Energy Board	Jim Fox, Vice President, Integrated Energy Information and Analysis Shelley Milutinovic, Chief Economist
April 14, 2016	
Natural Resources Canada	Jeff Labonté, Director General, Energy Safety and Security Niall O'Dea, Director General, Electricity Resources Branch Marc Wickham, Director, Science and Technology Programs, Innovation and Energy Technology Sector, Office of Energy Research and Development Drew Leyburne, Director General, Energy Policy Branch Patricia Fuller, Director General, Office of Energy Efficiency Paula Vieira, Director, Transportation and Alternative Fuels Division Laura Oleson, Director, Demand Policy and Analysis, Office of Energy Efficiency, Energy Sector Debbie Scharf, Director, Equipment Division
April 19, 2016	
Canadian Council on Renewable Electricity	Jacob Irving, President, Canadian Hydropower Association
April 21, 2016	
Canadian Nuclear Association	John Barrett, President and Chief Executive Officer

May 3, 2016	
Ecologic Institute US	Max Gruenig, President
TransAlta Corporation	Don Wharton, Managing Director for Carbon Transition
May 5, 2016	
Canadian Electricity Association	Sergio Marchi, President and CEO Devin McCarthy, Director, Generation and Environment
Capital Power	Martin Kennedy, Vice President, External Affairs
Nova Scotia Power Inc.	Terry Toner, Director, Environmental Services
Canadian Biogas Association	Jennifer Green, Executive Director Kevin Matthews, Director Donald Beverly, Director
May 10, 2016	
As an individual	Andrew Leach, Associate Professor, Alberta School of Business, University of Alberta Mike Cleland, Senior Fellow, University of Ottawa
HEC Montréal	Pierre-Olivier Pineau, Professor, Chair in Energy Sector Management
May 12, 2016	
Association of Major Power Customers of BC	Brian Wallace, Counsel Carlo Dal Monte, Director, Energy, Catalyst Paper Corporation Karina Brino, President and CEO, Mining Association of BC
May 17, 2016	
SaskPower	Mike Marsh, President and Chief Executive Officer Guy Bruce, Vice President, Planning, Environment and Sustainable Development
BC Hydro	Chris Sandve, Director of Policy and Reporting
May 19, 2016	
Transport Canada	Ellen Burack, Director General, Environmental Policy Jim Lothrop, Director General, Sustainable Transportation Stewardship

May 31, 2016	
National Airlines Council of Canada	Marc-André O'Rourke, Executive Director Teresa Ehman, Chair, Environment Subcommittee
Green Aviation Research and Development Network	Sylvain Cofsky, Executive Director Fassi Kafyeke, Senior Director, Strategic Technology and Advanced Product Development, Bombardier Aerospace
June 2, 2016	
Ontario Power Generation	Jeff Lyash, President and Chief Executive Officer
NB Power	Neil Larlee, Director, Strategic Planning
June 9, 2016	
Canadian Hydrogen and Fuel Cell Association	Eric Denhoff, President and Chief Executive Officer
Renewable Industries Canada	Andrea Kent, President
Canadian Automated Vehicles Centre of Excellence	Barrie Kirk, Executive Director
September 27, 2016	
Association of Canadian Port Authorities	Wendy Zatylny, President Debbie Murray, Director, Policy and Regulatory Affairs
Conference Board of Canada	Louis Thériault, Vice President, Public Policy
September 29, 2016	
Canadian Natural Gas Vehicle Alliance	Bruce Winchester, Executive Director
Pollution Probe	Steven McCauley, Acting Chief Executive Officer
October 18, 2016	
Electric Mobility Canada	Chantal Guimont, President and Chief Executive Officer
Canadian Trucking Alliance	Jonathan Blackham, Policy and Government Affairs Assistant
October 20, 2016	
Coal Association of Canada	Robin Campbell, President
October 25, 2016	
VIA Rail Canada	Yves Desjardins-Siciliano, President and Chief Executive Officer Pierre Le Fèvre, Senior Advisor to CEO and Chief Executive Officer Bruno Riendeau, Director, Safety and Environment

Railway Association of Canada	Michael Bourque, President and Chief Executive Officer Michael Gullo, Director, Policy, Economic and Environmental Affairs
October 27, 2016	
Canadian Vehicle Manufacturers' Association	Mark Nantais, President
Fertilizer Canada	Garth Whyte, President and Chief Executive Officer Clyde Graham, Senior Vice President
November 1, 2016	
Canadian Manufacturers & Exporters	Mathew Wilson, Senior Vice President, National Policy Nancy Coulas, Director, Energy and Environment Policy
CMC Research Institutes, Inc.	Richard Adamson, President
November 3, 2016	
Canadian Urban Transit Association	Alex Maheu, Director, Public Affairs Jeff Mackey, Policy Analyst
Hydro-Québec	Louis Beauchemin, Senior Director, Subsidiary Management France Lampron, Director, Transportation Electrification
November 24, 2016	
Sustainable Development Technology Canada	Leah Lawrence, President and Chief Executive Officer
Alberta Innovates	John Zhou, Vice President, Clean Energy
November 29, 2016	
C.D. Howe Institute	Benjamin Dachis, Associate Director, Research
December 1, 2016	
PTAC Petroleum Technology Alliance Canada	Soheil Asgarpour, President
December 6, 2016	
Council of Canadian Academies	Eric M. Meslin, President and Chief Executive Officer Eddy Isaacs, Scientific Advisory Committee Member
In Situ Oil Sands Alliance	Richard Sendall, Chairman Patricia Nelson, Vice Chair

December 8, 2016	
Federation of Canadian Municipalities	Clark Somerville, President Dallas Alderson, Manager, Policy and Research
As an individual	Mark Jaccard, Professor, Simon Fraser University
December 13, 2016	
Canada West Foundation	Trevor McLeod, Director of the Centre for Natural Resources Policy
December 15, 2016	
Canadian Energy Research Institute	Allan Fogwill, President and Chief Executive Officer
January 31, 2017	
Global CCS Institute	Jeff Erikson, General Manager, Americas Region
February 2, 2017	
Institute for Oil Sands Innovation	Qi Liu, Scientific Director
Emissions Reduction Alberta	Steve MacDonald, Chief Executive Officer
February 16, 2017	
Canada Mining Innovation Council	Carl Weatherell, Executive Director and Chief Executive Officer
As an Individual	Jennifer Winter, Assistant Professor, School of Public Policy, University of Calgary
February 28, 2017	
Chemistry Industry Association of Canada	Bob Masterson, President and Chief Executive Office David Podruzny, Vice-President, Business and Economics
Petroleum Services Association of Canada	Mark A. Salkeld, President and Chief Executive Officer
March 2, 2017	
Forest Products Association of Canada	Robert Larocque, Vice President, Climate Change, Environment and Labour Kate Lindsay, Director, Environmental Regulations and Conservation Biology
Mining Association of Canada	Brendan Marshall, Vice President, Economic and Northern Affairs
March 9, 2017	
Canadian Steel Producers Association	Joseph Galimberti, President
March 28, 2017	
Aluminium Association of Canada	Jean Simard, President and Chief Executive Officer

March 30, 2017	
Cement Association of Canada	Michael McSweeney, President and Chief Executive Officer Adam Auer, Vice-President, Environment and Sustainability
Canada's Ecofiscal Commission	Chris Ragan, Chair
April 6, 2017	
Environment and Climate Change Canada	John Moffet, Acting Associate Assistant Deputy Minister, Environmental Protection Branch Derek Hermanutz, Director General, Economic Analysis Directorate, Strategic Policy Branch Matt Jones, Director General, Climate Policy Office, Strategic Policy Branch Helen Ryan, Director General, Energy and Transportation, Environmental Protection Branch
Department of Finance Canada	Sean Keenan, Director, Sales Tax Division, Tax Policy Branch Gervais Coulombe, Chief, Sales Tax Division, Tax Policy Branch
April 11, 2017	
Shell Canada	Tim Wiwchar, Portfolio Business Opportunity Manager
Big Moon Power	Lynn Blodgett, President and Chief Executive Officer Jamie MacNeil, Country Manager
April 13, 2017	
Canadian Gas Association	Timothy M. Egan, President and Chief Executive Officer
The Canadian Chamber of Commerce	Katrina Marsh, Director, Environment and Natural Resources Policy

May 11, 2017	
International Energy Agency	Tim Gould, Head of Energy Supply Outlook Division Jean-François Gagné, Head of Energy Technology Policy Division Sylvia Bayer, Country Desk Officer in the Energy Policy and Security Division Aad van Bohemen, Head of Energy Policy and Security Division Peter Fraser, Head of Gas, Coal and Power Division
June 8, 2017	
Newfoundland and Labrador Oil & Gas Industries Association	Robert Cadigan, President and Chief Executive Officer
Canadian Association of Petroleum Producers	Terry Abel, Executive Vice-President Patrick McDonald, Director, Climate and Innovation
June 15, 2017	
Canadian Labour Congress	Donald Lafleur, Executive Vice-President Chris Roberts, Director, Social and Economic Policy
Canadian Fuels Association	Peter Boag, President and Chief Executive Officer Lisa Stilborn, Vice-President, Ontario Division
September 19, 2017	
Natural Resources Canada	Martin Gaudet, Deputy Director, Housing Division, Office of Energy Efficiency, Energy Sector Dean Haslip, Director General, CanmetENERGY-Ottawa, Innovation and Energy Technology Sector Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector
September 21, 2017	
Canada Mortgage and Housing Corporation	Duncan Hill, Manager, Housing Needs Research
CSA Group	Michael Leering, Director, Environment and Business Excellence Dwayne Torrey, Director, Construction and Infrastructure

September 26, 2017	
As an Individual	Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University
Canadian Association for Renewable Energies	Bill Eggertson, Executive Director
September 28, 2017	
As an Individual	James Tansey, Executive Director, Centre for Interactive Research on Sustainability, University of British Columbia
October 3, 2017	
Canadian Construction Innovations	Pierre Boucher, President Jim Ilkay, Senior Partner, Innovia Corporation
Canadian Home Builders' Association	Kevin Lee, Chief Executive Officer
October 5, 2017	
BC LNG Alliance	David Keane, President and Chief Executive Officer
The Conference Board of Canada	Louis Thériault, Vice-President, Industry Strategy and Public Policy
October 17, 2017	
Public Services and Procurement Canada	Kevin Radford, Assistant Deputy Minister, Real Property Branch Veronica Silva, Director General, Technical Services
Treasury Board of Canada Secretariat	Taki Sarantakis, Associate Secretary Nick Xenos, Executive Director, Centre for Greening Government
October 19, 2017	
National Research Council Canada	Michel Dumoulin, Acting Vice-President, Engineering Philip Rizcallah, Director, Research and Development, Construction
Canada Green Building Council	Thomas Mueller, President and Chief Executive Officer
October 24, 2017	
Federation of Canadian Municipalities	Brock Carlton, Chief Executive Officer Matt Gemmel, Policy Advisor

Canadian Propane Association	Nathalie St-Pierre, President and Chief Executive Officer Greg Thibodeau, Manager, Marketing, Pembina Pipeline Corporation Guy Marchand, President and Chief Executive Officer, Budget Propane 1998 Inc. Taylor Granger, Business Development Leader, SLEEGERS Engineered Products Inc.
October 26, 2017	
BOMA Canada	Benjamin L. Shinewald, President and Chief Executive Officer
Engineers Canada	David Lapp, Practice Lead, Globalization and Sustainable Development
Royal Architectural Institute of Canada	Bruce Lorimer, Interim Executive Director Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut
November 2, 2017	
Insurance Bureau of Canada	Nadja Dreff, Director, Economics and Assistant Chief Economist Craig Stewart, Vice-President, Federal Affairs
December 7, 2017	
Office of the Auditor General of Canada	Julie Gelfand, Commissioner of the Environment and Sustainable Development David Normand, Director Elsa DaCosta, Director Doreen Deveen, Director
February 8, 2018	
As an Individual	Blair Feltmate, Head, Intact Centre on Climate Adaptation, University of Waterloo
Canadian Energy Efficiency Alliance	Philippe Dunsky, Vice-Chair Martin Luymes, Chair
February 15, 2018	
As an Individual	Warwick F. Vincent, Full Professor, Centre for Northern Studies, Laval University
QUEST	Brent Gilmour, Executive Director Tonja Leach, Managing Director

March 1, 2018	
Ecovert Sustainability Consultants	Jim Lord, Founding Principal
Yukon Housing Corporation	Pamela Hine, President
Government of the Northwest Territories	Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation
Nunavut Housing Corporation	Gary Wong, Director of Infrastructure Stephen Hooey, Chief Operating Officer

APPENDIX B – FACT FINDING MISSIONS –LIST OF WITNESSES

Western Canada – October 2-7, 2016 (Vancouver, Kitimat and Prince George, British Columbia, Calgary, Alberta and Estevan, Saskatchewan)	
Alberta Electric System Operator	Miranda Keating Erickson, Vice President Operations Angela Anderson, External Relations Advisor
ARC Financial Corp	Peter Tertzakian, Chief Energy Economist and Managing Director
Canada's Oil Sands Innovation Alliance	Dan Wicklum, Chief Executive Officer
Canfor Pulp Ltd	Martin Pudlas, Vice President, Operations Peter Lovell, General Manager Robert Thew, Manager, Strategic Capital and Energy
CanmetENERGY	Cécile Siewe, Director General, Devon Research Center Jinwen Chen, Director, Hydrocarbon Conversion Michael Layer, Senior Program Manager
Legislative Assembly of Saskatchewan	Lori Carr, Member of the Legislative Assembly
Pembina Institute	Chris Severson-Baker, Managing Director
Petroleum Technology Research Centre	Norm Sacuta, Communications Manager
Powertech Laboratories	Madhvi Ramnial, Manager, Client Engagement and Business Development Angela Das, Senior Manager, Advanced Transportation Jeff Turner, Project Manager, Electric Vehicles and Energy Systems David Facey, Legal Counsel Frankie Nash, Policy Analyst

Rio Tinto	Blair Dickerson, Vice President Richard Prokopanko, Director of Government Affairs Gareth Manderson, General Manager Kevin Dobbin, Manager Communications and Communities, BC Works Manny Arruda, Casting Coordinator, BC Works Alain Bouchard, Business Partner HSE Graham Caven, Reduction PTA Trainer, BC Works Carolyn Chisholm, Principal Advisor, Vice President Canada Office Marion Egan, Executive Assistant, BC Works Joe Velho, Coordinator, BC Works
SaskPower	Howard Matthews, Vice President, Power Production Sandra Beingessner, Executive Co-ordinator, Executive Offices Dave Jobe, Director, Carbon Capture and Storage Mike Zeleny, Tour Ambassador, Carbon Capture and Storage
Seven Generations Energy Ltd	Alan Boras, Director, Communications and Stakeholders Relations
University of Calgary	Dan McFadyen, Program Director, School of Public Policy Robert Mansell, Academic Director, School of Public Policy Shantel Jordison, Manager, Extractive Resource Governance Program
University of Northern British Columbia	Daniel Weeks, President Daniel Ryan, Interim Vice President, Academic and Provost Geoffrey Payne, Interim Vice President, Research Tim Tribe, Vice President, Advancement Robert Knight, Vice President, Finance and Business Operations Chris Buse, CIRC Project Lead

	Stephen Déry, Canada Research Chair in Northern Hydrometeorology Kevin Ericsson, Chief Engineer David Claus, Assistant Director, Facilities Management
Vancouver Fraser Port Authority	Duncan Wilson, Vice President, Corporate Social Responsibility Carrie Brown, Director, Environmental Programs Evangeline Englezos, Director, Community and Aboriginal Affairs Christine Rigby, Environmental Specialist, Air Emissions
Ontario – November 14-17, 2016 (Sarnia and Hamilton, Ontario)	
ArcelorMittal Dofasco	Sean Donnelly, President and Chief Executive Officer Tony Valeri, Vice President, Corporate Affairs Henry Wegiel, Director, Trade and Government Relations Ian Shaw, Manager, Energy Management Jim Stirling, General Manager, Environment Richard Do Couto, Specialist, Corporate Responsibility Tom Kuhl, General Manager of Primary Manufacturing Technology Dan Evans, Reliability Coach Errol Hilado, Process Reliability Specialist
BioAmber	Mike Hartmann, Executive Vice President Ann Waddell, Vice president, Government Affairs Fabrice Orecchioni, Chief Operations Officer
Bioindustrial Innovation Canada	Sandy Marshall, Executive Director
Biox Corporation	Alan Rickard, Chief Executive Officer Courtney Quinn, Vice President, Finance Ryan Doell, Operations Manager Bozena Millivojevic, Production Manager

Canadian Fuels Association	Lisa Stilborn, Vice President, Ontario Division Erin Brophy, Communications Manager
CanmetMATERIALS	Philippe Dauphin, General Manager Mark S. Kozdras, Program Manager, Automotive Materials Hitesh Jain, Manager, Business and Contracts
Chemistry Industry Association of Canada	Bob Masterson, President and Chief Executive Officer David Podruzny, Vice President, Business and Economics Erika Adams, Director, Communications
City of Hamilton	His Worship Fred Eisenberger, Mayor Andrew Grice, Director, Water and Wastewater Operations Geoff Lupton, Director, Energy, Fleet and Traffic John Mater, Director, Corporate Assets and Strategic Planning Dan Chauvin, Director, Woodward Upgrades Dan McKinnon, General Manager, Public Works Mark Bainbridge, Acting Director, Hamilton Water Greg Crone, Strategic Initiatives and Policy Advisor Frank Gazzola, Superintendent, Energy Engineering Plamen Nikolov, Senior Project Manager, Capital Works
Imperial	Brian M. Fairley, Sarnia Refinery Manager George E. Vincent, Senior Regulatory Affairs Advisor Dave Luecke, Sarnia Chemical Plant Manager Jon Harding, Community Affairs and Aboriginal Relations Advisor

McMaster University	Ishwar Puri, Dean Faculty of Engineering Rob Baker, Vice President Research Nick Markettos, Acting Director, McMaster Institute for Transportation and Logistics Altaf Arain, Director, McMaster Centre for Climate Change Gillian Goward, Acting Associate Dean Research and External Relations Lori Dillon, Manager, Research Communications Alex Lawson, Executive Advisor, Public Affairs Kristen Munro, Manager, Public Affairs Ali Emadi, Director of MacAUTO Saeid Habibi, Professor, Mechanical Engineering Megan Wood, Team Lead, McMaster Engineering EcoCAR3 Team Theo Abraham, Communications Manager, McMaster Engineering EcoCAR3 Team
NOVA Chemicals	Rob Thompson, Regional Manufacturing Director Ken Faulkner, Director of Government Relations Meaghan Kreeft, Communications Consultant
Sarnia-Lambton Chamber of Commerce	Shirley de Silva, President and Chief Executive Officer Monica Shepley, Manager of Advocacy and Policy Development Mark Lumley, Chairman, Board of Directors Michael Kooy, 1st Vice Chair Peter Smith, Co-Chair, Energy Committee Alex Palimaka, Board Member Cathy MacLellan, Vice President Human Resources and Outreach, Ubiquity Solar Ed brost, President, Je&M Consulting Ltd. Maike Luiken, Bluewater Technology Access Centre

	Joe Lasowski, CF Industries
Sarnia-Lambton Economic Partnership:	George Mallay, General Manager.
Shell	Helen Bennett, Emerging Regulatory Policy Issue Advisor
Union Gas	Sarah Van Der Paelt, Director, Distribution Business Development and Strategic Accounts
Suncor Energy	Michael Kandravy, Director, Fuels Quality and Regulatory Affairs Michael Southern, Manager, Government Relations
Western Sarnia-Lambton Research Park	Tom Strifler, Executive Director Katherine G. Albion, Commercialization Centre Director Victoria Townsend, Research Engineer and Project Manager Stephen Reaume, Coordinator Mike Nesdoly, Manager, Applied Research and Innovation
Quebec – February 7-8, 2017 (Montreal and Varennes, Quebec)	
AQPER (Association québécoise de la production d'énergie renouvelable)	Jean-François Samray, President and Chief Executive Officer
CanmetENERGY	Gilles Jean, Managing Director Lisa Dignard, Director, Integration of Renewable and Distributed Energy Resources R&D Program Éric Soucy, Director, Industry R&D Program Chantal LeRoy, Acting Director, Building R&D Program Amélie Richard, Commercialisation Officer
City of Laval	Stéphane Boyer, City Councillor Ian Dessureault, Environment Services
Écotech Québec	Denis Leclerc, President and Chief Executive Officer Marie-Hélène Labrie, Vice-President of the Board Élise Laferrière, Vice-Presidente, Partnerships and Operations

Gaz Métro	Stéphanie Trudeau, Principal Vice-President, Regulations, Clients and Communities Frédéric Krikorian, Director, Sustainable Development, Public and Governmental Affairs
Hydro-Québec's Research Institute	Jérôme Gosset, Director Jean-Pierre Tardif, Advisor – Communications and Marketing
McGill	Jim Nicell, Professor & Dean of Engineering Subhasis Ghoshal, Director, Trottier Institute for Sustainability in Engineering and Design Lauren Penney, Manager, Trottier Institute for Sustainability in Engineering and Design Benoit Boulet, Associate Dean, Research & Innovation François Bouffard, Associate Professor Yixin Shao, Professor Jeff Bergthorson, Associate Professor
Union des producteurs agricoles	Pierre Lemieux, Second Vice-President Daniel Bernier, Research and Agricultural Policy Advisor – Environment
Eastern Canada – May 1-4, 2017 (St. John's, Newfoundland and Labrador, Summerside, Prince Edward Island, Saint John, New Brunswick and Halifax, Nova Scotia)	
Amec Foster Wheeler	Jonas Roberts, Climate Change Consultant, Environment and Infrastructures
CarbonCure Technologies	Jennifer Wagner, Vice-President, Sustainability
City of Summerside	His Worship Bill Martin, Mayor Norma McColeman, Deputy Mayor Greg Campbell, Councillor Brian McFeely, Councillor Gordie Whitlock, Councillor Bob Ashley, Chief Administrative Officer Greg Gaudet, Director of Municipal Services J.P. Desrosiers, Director of Community Services Rob Philpott, Director of Finance

	Mike Thusuka, Director of Economic Development Lorri Laughlin, Director of Communications Sam Arsenault, Waste Water Operations Supervisor Chad Fraser, Waste Water Treatment Operator
Dalhousie University	Dr. Richard Florizone, President Dr. Steven Mannell, Director, College of Sustainability Dr. Jeff Lamb, Deputy Chair, Dalhousie Facilities Management Dr. Ian Hill, Professor Dr. Mita Dasog, Assistant Professor Sara Daniels, Government Relations Advisor Emma Norton, Alumna Rochelle Weber, Student Jon-Paul Sun, Student Colby Deighton, Student
Emera	Chris Huskilson, President and Chief Executive Officer Robert Hanf, Executive Vice-President, Stakeholder Relations and Regulatory Affairs Lisa Merrithew, Vice-President, Communications and Corporate Affairs Sharon Scattolon, Facilities Manager Brad Stronach, HVAC Technician
Emera Newfoundland and Labrador	Norm Dimmell, P.Eng., Vice-President, Corporate Services
Fortis Inc.	Barry Perry, President and Chief Executive Officer Nora Duke, Executive Vice-President and Chief Human Resource Officer Gary Smith, President, Newfoundland Power Karen McCarthy, Director, Communications and Corporate Affairs

	Paul Fitzpatrick, Director, Regulatory and Compliance
Government of Newfoundland and Labrador	Walter Parsons, P.Eng., Assistant Deputy Minister, Energy Perry Canning, Assistant Deputy Minister, Mines
Irving Oil	Jeff Matthews, Chief Business Development Officer Graham Little, Government Relations Specialist James Walsh, Manager, Government Relations
J.D. Irving	Mary Keith, Vice-President, Communications Mark Mosher, Vice-President, Pulp & Paper Dion Hanrahan, Vice-President, Industrial Business Development Chris MacDonald, Director, Government Relations
McInnes Cooper	J. Alex Templeton, Associate
Nalcor	Gilbert Bennet, Executive Vice-President, Power Development Mark King, Stakeholder Relations and Communications Gayle St. Croix, Communications Consultant
Narl Refining LP	Tim Derksen, Management Program
NB Power	Keith Cronkite, Senior Vice-President Business, Development and Strategic Planning Brett Plummer, Vice-President Nuclear and Chief Nuclear Officer Robert Scott, Director, Government Relations Kathleen Duguay, Manager, Community Affairs and Nuclear Regulatory Protocol
Newfoundland and Labrador Environmental Industry Association	Kieran Hanley, Executive Director
NS Power	Karen Hutt, President and Chief Executive Officer

	Sasha Irving, Vice-President Corporate Affairs and Stakeholder Relations
Prince Edward Island Climate Change Secretariat	Todd Dupuis, Executive Director
Prince Edward Island Energy Corporation	Heather MacLeod, Manager, Energy Assets
St. John's Board of Trade	Dorothy M. Keating, Chair Nancy Healey, Chief Executive Officer Rhonda Tulk-Lane, Policy and Advocacy Specialist
Transportation, Infrastructure and Energy Efficiency - Prince Edward Island	Mike Proud, Manager, Office of Energy Efficiency
Trout River Homes Inc.	Terry and Natalie Perry, Owners Ralph and Beth Peters, House Owners
University of Prince Edward Island's Climate Lab	Dr. Adam Fenech, Director Hope Parnham, PhD Student
University of Prince Edward Island	Dr. Robert Gilmour, Vice-President Academic and Research

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