MODELLING AND ANALYSIS OF *A HEALTHY ENVIRONMENT AND A HEALTHY ECONOMY*

CONTEXT

At the 21st Conference of the Parties (COP21) meeting in Paris in December 2015, Canada pledged to reduce its greenhouse gas emissions by 30% below the 2005 level by 2030, which means a drop from 730 million tonnes of carbon dioxide equivalent (Mt CO_2 eq.) in 2005 to 511 Mt by 2030. At the time of COP21, Canada's greenhouse gas emissions were projected to grow to 815 Mt by 2030.[1] In other words, in 2015, Canada's emissions were projected to increase 12% above 2005 levels by 2030 whereas Canada's target required a 30% decrease.

The Pan-Canadian Framework on Clean Growth and Climate Change (Pan-Canadian Framework) was adopted on December 9, 2016, as Canada's plan to take ambitious action to fight climate change and drive economic growth. The Pan-Canadian Framework included more than 50 concrete actions covering all sectors of the Canadian economy.

Over the past five years, an intensive national effort has advanced these measures. In 2019, Canada submitted its Fourth Biennial Report to the United Nations Framework Convention on Climate Change (UNFCCC). Accounting for all federal, provincial and territorial measures announced up to September 2019, the report projected Canada's greenhouse gas emissions in 2030 would be 588 Mt, 227 Mt lower than the 815 Mt projected before the adoption of the Pan-Canadian Framework.

Building on the foundation established by the Pan-Canadian Framework, *A Healthy Environment and a Healthy Economy* focuses on a series of new and strengthened federal climate actions to ensure Canada not only meets, but also exceeds its 2030 Paris Agreement target. The analysis presented in this Annex examines the effects of the measures in the plan on Canada's greenhouse gas emissions and the economy.

2020 REFERENCE CASE

The analysis starts with an updated reference case for the projected emissions in 2030 called the "2020 Reference Case". Included in the 2020 Reference Case are all policies and measures funded, legislated and implemented by federal, provincial, and territorial governments as of September 2020. It does not include all of the measures accounted for in the Fourth Biennial report because it does not include initiatives that had been announced by September 2020 but that had not yet been funded, legislated, or implemented. For example, the Clean Fuel Standard or post-2025 light-duty vehicle (LDV) regulations are not included in the 2020 Reference Case.

[1] Reference Case projections in Canada's Second Biennial Report (2015)

The 2020 Reference Case projections update the 2019 Reference Case published in the Fourth Biennial Report. The update includes a number of revisions in the historical data, macroeconomic assumptions and policy changes. The most important updates are listed below:

- Expected impact of the COVID-19 pandemic and economic recession in 2020 and a gradual recovery in the following years. GDP projections to 2021 are calibrated to Finance Canada's Economic and Fiscal Snapshot 2020 tabled on August 24, 2020 that reflect the impact of COVID-19 on the Canadian economy. The GDP projections between 2022 and 2030 are based on Finance Canada's long-term projections. The GDP growth rate assumed between 2018 and 2030 is on average 1.6% per annum, and population growth is about 1.1% per year.
- Revised oil and natural gas production and price assumptions based on the Canada Energy Regulator's Canada's Energy Future 2020 report of November 24, 2020. The West Texas Intermediate oil price is assumed to reach about US$70 per barrel, and the Henry Hub natural gas price about US$3.4/mmBtu, by 2030 in 2018 real US dollars.
- The 2020 Reference Case also includes updated projections of fuel consumption in the passenger transportation sector to better reflect the types of vehicles Canadians are using and the impact of the revised United States LDV standards.

Total Canadian greenhouse gas emissions in the 2020 Reference Case, in the absence of additional actions, are projected to be 637 Mt CO_2 eq. in 2020 and 674 Mt in 2030; or 612 and 657 respectively when taking into account the accounting contribution from Land Use, Land-Use Change and Forestry (LULUCF). Table 1 provides a sector-by-sector tabulation of projected emissions.

Table 1: 2020 Reference Case Emission Projections by Economic Sector from 2005 to 2030 (Mt CO_2 eq) (Including LULUCF Accounting Contribution)

	Historical				Projected		Change 2005 to 2030
	2005	2010	2015	2018	2020	2030	
Oil and Gas	158	159	191	193	177	194	36
Electricity	119	96	81	64	38	21	-98
Transportation	161	168	172	186	155	178	17
Heavy Industry	87	75	79	78	65	82	-5
Buildings	86	82	86	92	90	82	-5
Agriculture	72	68	71	73	73	77	5
Waste & Others	46	42	41	42	39	41	-5
LULUCF[2]	n.a.	11	-8	-13	-25	-17	-17
Total (excl. LULUCF)	730	691	720	729	637	674	-56
Total (incl. LULUCF)	730	702	712	716	612	657	-73

Note: Numbers may not sum to the total due to rounding. Historical emissions data comes from Canada's National Inventory Report (NIR) 2020.

[2] By design, the LULUCF accounting contribution for 2005 is zero. The LULUCF accounting contribution for the historical and projected periods cannot be compared directly, because the scope of available data differs between historical years and projections.

KEY ELEMENTS OF THE PLAN FOR *A HEALTHY ENVIRONMENT AND A HEALTHY ECONOMY*

The 2020 Reference Case serves as a baseline for the assessment in this Annex of the impacts of all currently announced initiatives. This includes federal, provincial and territorial climate actions up to and including the plan for *A Healthy Environment and a Healthy Economy*. Specifically, this analysis estimates Canada's 2030 greenhouse gas emissions based on the proposed changes in carbon pricing, the Clean Fuel Standard, complementary sectoral measures, and nature based solutions.

CARBON PRICING

Carbon pricing is a critical element of meeting Canada's climate target. Carbon pricing was introduced in 2019 at $20 per tonne and increases by $10 per tonne per year until 2022 when it will reach $50 per tonne. The new plan proposes increases to the carbon price from 2022 to 2030 of $15/tonne per year.

Carbon pollution pricing proceeds can support a range of activities that reduce energy use and deploy new technologies, which help individuals and businesses save money and reduce carbon pollution. How proceeds are used differs somewhat across jurisdictions. In some provinces and territories, the provincial or territorial government decides how to invest the proceeds. In Ontario, Manitoba, Alberta and Saskatchewan, proceeds from the federal fuel charge currently support individuals and households through the Climate Action Incentive, as well as small and medium-sized enterprises, municipalities, universities, schools and hospitals, and not-for-profit organizations through programs like the Climate Action Incentive Fund. Proceeds from the federal Output-Based Pricing System (OBPS) for industry will support projects by industrial facilities to cut emissions and use new cleaner technologies and processes.

For illustrative purposes, the modelling assumes consistent carbon pricing systems for all provinces and territories apart from Quebec. Quebec is assumed to maintain its current cap-and-trade carbon pricing regime. In direct pricing systems, the carbon price is assumed to rise $15 per year post-2022 until 2030 where it reaches $170/tonne, and applies to all emissions covered under a fuel charge. Large emitters are assumed to be covered under an OBPS-type system with a 2% tightening in stringency every year post-2022. Beginning in 2025, output-based standards for electricity generation decline to reflect new investments in the sector that are consistent with the goal of net zero emissions by 2050.

COMPLEMENTARY SECTORAL MEASURES

Complementary policies and investments work in concert with carbon pollution pricing to reduce emissions across the economy. These complementary measures serve various functions. Some create incentives for reductions from sources not covered by carbon pricing, while others make carbon pricing more effective, and create incentives for innovation and clean growth. Many of the funding programs are designed to reduce the costs of investing in fuel switching or energy efficiency retrofits that reduce emissions and exposure to carbon pricing and other regulatory requirements. Energy efficiency standards, building standards and retrofits, and zero-emission vehicle (ZEV) policies all help Canadians use less energy and make cleaner choices that can save them money, including by reducing their exposure to carbon prices. Investments in clean technology and innovation help accelerate the development of the next generation of technologies and ideas that will further improve efficiencies and lower emissions in the future.

Some of the specific sectoral measures in the plan modeled for this analysis include:

- Emissions regulations for LDVs and heavy-duty vehicles (HDVs), Canada meeting its ZEV targets, and incentives for the acquisition and use of passenger ZEVs;
- Net-Zero Ready Building Codes, home energy retrofits;
- The full suite of measures in the new plan to enhance the clean electrification of Canada, including investments in interties, smart grids, and renewables and power storage;
- Energy efficiency improvements and decarbonisation by industry as a result of the Net-Zero Challenge Program for Large Industrial Emitters, and the financial support for the industry;
- Strengthened methane regulations in the oil and gas sector and new methane capture regulations for solid waste facilities; and,
- Other investments in clean energy and clean infrastructure related to "building back better".

CLEAN FUEL STANDARD

In the context of the continued increase to the carbon price, the scope of the Clean Fuel Standard (CFS) has been narrowed to cover only liquid fossil fuels, like gasoline, diesel and oil, which are mainly used in the transportation sector. This is a progression in the design of the CFS from its initial discussion in 2016, when it was proposed that the new measure will cover liquid, gaseous and solid fuels. The CFS will require fuel companies to reduce the carbon intensity of their products. That means cutting down the amount of greenhouse gases produced when fuels like gasoline, diesel, propane or kerosene are produced, transported and burned to run vehicles, furnaces and machinery. The modelling of the CFS reflects the requirements in the forthcoming draft CFS regulations, which require that liquid fossil-based fuel suppliers reduce the carbon intensity of their fuels used in Canada from 2016 carbon intensity levels by 2.4 grams of CO_2eq./MJ in 2022, increasing to a 12 grams of CO_2eq./MJ reduction in 2030, an improvement of about 13% by 2030.

LULUCF, NATURE-BASED SOLUTIONS, AND AGRICULTURE MEASURES

According to the 2020 Reference Case projections, LULUCF accounting will contribute 17 Mt towards the 2030 target. Sequestration of greenhouse gases from nature-based solutions (NBS) and a target to reduce emissions from the use of fertilizers in the agriculture sector will reduce emissions by approximately a further 10 Mt for a total of 27 Mt of reductions.

ASSESSING THE IMPACT OF THE PLAN FOR A HEALTHY ENVIRONMENT AND A HEALTHY ECONOMY

MODELING APPROACH

To assess the emissions and economic impact of the plan, Environment and Climate Change Canada (ECCC) used its unique suite of models that support the Government's policy development process in the areas of air quality and climate change mitigation. These models support evidence-based analysis and policy decisions regarding the energy sector and its impact on the economy and the environment. The modeling capacity is robust and has been peer reviewed domestically and internationally.

The modeling analysis of the impact of the plan was undertaken using two ECCC models:

- E3MC – a modeling framework that combines Energy 2020 and a macroeconomic model working in tandem. ENERGY 2020 is a 10-province and three-territory, bottom-up, energy technology simulation model. Its granularity allows for the analysis of a wide range of complementary measures and targeted performance standards and regulations.
- EC-Pro is a 10-province and three-territor,y multi-sector, multi-region, computable general equilibrium model. The model has more than 25 sectors with focus on energy and energy-intensive industries.

MODELING RESULTS

Sectoral and economy-wide measures are expected to reduce Canada's emissions by 144 Mt by 2030, relative to 674 Mt of greenhouse gas emissions in 2030 under the 2020 Reference Case.

The LULUCF accounting contribution, plus the expected impact of the proposed nature-based solutions and the measures in the plan to reduce emissions from fertilizer use in agriculture combined are expected to reduce emissions by a further 27 Mt. Combined, these reductions arrive at approximately 503 Mt in 2030, or about 8 Mt below Canada's 2030 target. This represents about a 31% reduction below Canada's 2005 emissions.

Table 2 below illustrates the expected emission reductions of the measures included in the plan in 2030, and Table 3 shows emission reductions by sector from 2005 levels.

Table 2: Expected Emission Reductions of the Plan in 2030

	Projected Emissions in 2030 (MT)
2020 Reference Case	**674**
Sectoral Measures, post-2022 carbon price and CFS (liquid only)	**144**
LULUCF accounting contribution	**17**
Nature-Based Solutions and agriculture measures	**10**
Total Projected Emissions from the Plan	**503**
Canada's 2030 Target	**511**

Table 3: Expected Emission Reductions of the Plan in 2030 by Sector

	Historical				Projected		Change 2005 to 2030
	2005	2010	2015	2018	2020	2030	
Oil and Gas	158	159	191	193	177	138	-20
Electricity	119	96	81	64	38	11	-108
Transportation	161	168	172	186	155	151	-10
Heavy Industry	87	75	79	78	65	61	-26
Buildings	86	82	86	92	90	65	-21
Agriculture	72	68	71	73	73	74	2
Waste & Others	46	42	41	42	39	31	-15
LULUCF, NBS and agriculture measures	n.a.	11	-8	-13	-25	-27	-27
Total (incl. LULUCF)	730	702	712	716	612	503	-227

Note: Numbers may not sum to the total due to rounding. Historical emissions data comes from NIR 2020.

The ECCC modelling projects that the measures in the plan will to lead to a very small reduction in annual real GDP growth of about 0.05%, an amount that is considerably less than the average annual revision to GDP year-over-year.

The projected impact on GDP is likely overestimated, as it does not account either for the potential to help avoid the costs of unabated climate change, or for the opportunity that clean innovation spurred by these measures will have in helping Canadian companies create jobs and compete successfully in the global shift to cleaner growth (see the section *Economic Opportunities and Environmental Policies* below).

SENSITIVITY ANALYSIS

In light of the uncertainty regarding some of the key underlying drivers of greenhouse gas emissions, the emission projections for the 2020 Reference Case should be considered as one estimate within a range of plausible outcomes. The sensitivity analysis focuses on an uncertainty in world energy prices. Table 4 shows the different assumptions used in the development of the sensitivity scenarios and Table 5 presents the emission outcomes for the alternative cases.

Table 4: Oil and Gas Price Assumptions

Assumptions	Low Prices	Reference	High Prices
2030 West Texas Intermediate Oil Price (2018 US$/bbl)	36	70	114
2030 Henry Hub Natural Gas Price (2018 US$/mmBtu)	2.24	3.44	4.40

Table 5: 2030 Greenhouse Gas Emissions in Sensitivity Scenarios for the 2020 Reference Case

Reference Case Scenario	Greenhouse Gas Emissions in 2030 (Mt)	Difference From Reference Case	
		Mt	%
High World Oil Prices	707	33	5%
Reference Case	674	0	0%
Low World Oil Prices	648	-26	-4%
Sensitivity Range	648 to 707	-26 to 33	-4% to 5%

This suggests that the uncertainty around the reductions arising from the plan could be in the order of 4-5% in either direction.

ECONOMIC OPPORTUNITIES AND ENVIRONMENTAL POLICIES

The model likely underestimates emission reductions because it does not capture the full range of innovative technologies that are in the early stages of the commercialization process, nor does it reflect the likely improvements in technology performance or cost reductions. Moreover, these projections do not fully account for the reality that Canada is just starting along the innovation curves associated with some of the most promising decarbonization technologies, such as ZEVs, industrial electrification, carbon capture, utilization and storage (CCUS), and hydrogen. Investments in clean technology and innovation will accelerate the development of the next generation of technologies. As Canada and the rest of the world continues to invest in these and other areas, innovation will accelerate and costs will decline, as we have witnessed with renewable energy. Over the longer-term, these technologies will not only reduce greenhouse gas emissions but also enhance Canadians' quality of life, help Canadian companies create jobs and allow them to compete successfully in the global transition to net-zero emissions.

The model also likely overestimated economic costs as it does not account either for the potential to help avoid the costs of unabated climate change or for the full supply-chain benefits from commercializing the clean innovations spurred by the measures in the plan. The model does not account for any health benefits from reduced criteria air contaminants.

Climate change carries with it significant economic impacts that are not captured in standard economic models. These models are likely to overestimate negative economic impacts, as they do not capture the full range of long-term benefits from climate action. For example, the significant benefits from the avoided costs of climate change as natural disasters and extreme weather events increase in frequency and severity. Catastrophic losses due to these events have increased dramatically over the last decade.

The White House's Council of Economic Advisers suggested in 2014 that each decade of delayed climate mitigation effort leads to a 40% increase in net mitigation costs. The report further suggests that the economic impacts of increasing temperatures would lead to significant and permanent global GDP losses. Research by the Bank of Canada finds that climate change could cost the world nearly a quarter of GDP by 2100, and Sir Nicholas Stern calculates that the cost of inaction to climate change is equivalent to a 5% average reduction in GDP per capita.

Moreover, the Canadian Institute for Climate Choices released a new report on December 3, 2020, "*Tip of the iceberg: navigating the known and unknown costs of climate change for Canada.*" The report highlights that the combined losses per weather-related disaster have also ballooned—rising from an average of $8.3 million per event in the 1970s to an average of $112 million between 2010–2019, including public and private costs. This change represents a staggering 1,250% increase.

As well, the models do not capture the full range of future economic opportunities arising from the global transition to a clean and net-zero economy. Addressing climate change is critical for the long-term competitiveness and resilience of the Canadian economy. In particular, taking action now to provide certainty to industry on regulations and carbon pricing will enable the investments needed to support the low-carbon economy of the future.

There is considerable evidence that shows that greenhouse gas policies can reduce emissions with positive economic impacts. For example, research on the British Columbia carbon tax provides evidence that a revenue-neutral carbon tax shows a small but statistically significant annual increase in employment. Similarly, a study by Dechezlepretre et al (2019) shows that environmental regulations tend to improve environmental performance while not weakening economic performance. The United Kingdom (UK) Commission on Climate Change reports that UK carbon budgets have had little or no negative impact on business competitiveness and carbon leakage, and that evidence shows that climate change policies increase the competitiveness of the UK in the long term by encouraging greater innovation and efficiency. Similar results emerge from studies at the European level.

Climate policy packages have been shown to have positive effects on the economy. The The Organisation for Economic Co-operation and Development (OECD) report "Investing in Climate, Investing in Growth" shows how a climate-compatible policy package can increase long-run GDP by up to 2.8% on average across the G20 in 2050 relative to a continuation of current policies. If the positive impacts of avoiding climate damage are considered, the net effect on GDP in 2050 rises to nearly 5%. The Report of the High-Level Commission on Carbon Prices chaired by Nobel Laureate Joseph Stiglitz and the former Chief Economist at the World Bank Nicholas Stern also emphasizes the need to consider co-benefits such as effect on local air pollution, agricultural productivity, positive spillovers on technological change and long-term development benefits.

All of this evidence highlights the need to move beyond thinking of trading off economic and environmental objectives and accept that they are mutually reinforcing.

CONCLUSION

The analysis outlined above projects that *A Healthy Environment and a Healthy Economy*, combined with the various measures from the Pan-Canadian Framework already in place, will lead to reduced emissions in 2030 that will allow Canada to exceed its 2030 Paris Agreement target.

These projections are somewhat conservative as they do not fully account for the accelerating pace of innovation associated with some of the most promising decarbonization technologies, such as ZEVs, industrial electrification, CCUS, and clean hydrogen. As Canada and the rest of the world continue to invest in these and other areas, innovation will accelerate and costs will decline. Moreover, the incoming United States Administration promises to implement a similar, wide-ranging set of measures. This will further drive technology development while largely eliminating the competitiveness risks of Canada acting alone.

Finally, this analysis does not consider what potentially new or strengthened provincial and territorial climate policies could contribute. Many provinces have committed to deep greenhouse gas reduction targets – for both 2030 and 2050 – but not all have announced a complete set of measures to reach these targets. Additional provincial and territorial measures will build on the impacts of the proposed federal measures, leading to further emission reductions.