Economic Assessment of Climate Policy in Alberta

Alberta

Environment and Parks, Government of Alberta
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Economic Assessment of Climate Policy in Alberta
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Executive summary

Alberta completed an economic assessment of the former Climate Leadership Plan (CLP) to support commitments made in the government's 2019 election platform. The assessment also outlines the potential costs if the federal government's carbon pricing policy were applied in Alberta.

This report summarizes the expected economic impacts of the CLP on Alberta's total economy, key industrial sectors and households. Four economic scenarios or cases were evaluated, with outcomes forecasted through to 2030:

- Scenario 1: Continue the 2015 climate policies, a reference case using climate policies that were in place in 2015.
- Scenario 2: Continue the CLP with a carbon price of $30 per tonne until 2030.
- Scenario 3: Continue the CLP with carbon prices increasing to $40 per tonne in 2021 and $50 per tonne in 2022, in line with the federal government's announcements.
- Scenario 4: Apply the federal carbon pricing backstop in Alberta.

To quantify the impacts of the CLP and the federal carbon pricing backstop, the outcomes from Scenarios 2, 3 and 4 are compared to Scenario 1.

Key economic findings

Scenario 1: Continue the 2015 climate policies

This is the reference case for comparison and includes Alberta's climate policy of 2015, specifically the Specified Gas Emitters Regulation (SGER). That regulation required facilities with large greenhouse gas (GHG) emissions to reduce emissions by 12 per cent compared to the facility's historic emissions intensity; or, the facility can contribute to a fund at $15 per tonne of carbon dioxide equivalents (CO_2e). Gross Domestic Product (GDP) was forecasted to grow at a rate of 2.57 per cent per year, on average from 2016 through 2030.

Scenario 2: Continue the CLP with a carbon price of $30 per tonne for all years

The previous government announced the CLP in 2015. It included a carbon tax on households and small businesses, and a revised climate policy for industries called the Carbon Competitiveness Incentive Regulation (CCIR) that replaced the SGER. The carbon tax started at $20 per tonne in 2017 and increased to $30 per tonne in 2018. For CCIR compliance, facilities could contribute to a fund at $30 per tonne in 2018. This scenario assumed that both the carbon tax and the CCIR fund amount remained at $30 per tonne each year through 2030. Revenue was invested in areas like household rebates and programs to reduce emissions. The CLP also included methane regulations and support for renewable electricity.

With the CLP in place, Alberta's GDP was expected to grow on average 2.52 per cent per year from 2016 through 2030. This compares to the expected growth rate of 2.57 per cent per year under 2015 climate policies, a reduction of 0.045 per cent per year. This was a $2 billion[1] decrease in GDP in 2020 and $2.6 billion decrease in 2030 compared to Scenario 1. The annual GDP decrease is approximately 0.6 per cent of GDP compared to Scenario 1 in a given year.

The carbon tax portion of the CLP would account for GDP losses of between $0.6 billion and $1.8 billion per year to 2030 (0.2 per cent to 0.4 per cent of GDP in Scenario 1). The CCIR and other CLP polices account for the remainder of the CLP impacts.

The CLP impacts differ by industry and sector due to the policy design. The impact on the oil and gas sector is slightly lower than the economy-wide impact. Oil and gas sees a 0.2 per cent to 0.4 per cent GDP decrease per year, compared to Scenario 1 in different years. Other large industrial emitters such as paper, electric power plants, and chemical producers were projected to have GDP losses of 2 per cent to 3.7 per cent in different years. Other sectors (mining, agriculture, forestry, light manufacturing, and construction as a group) would be impacted to a lesser degree, with a GDP loss between 0.7 per cent and 1.3 per cent in different years.

Alberta households would experience a negative impact between $1,361 million and $1,561 million in forecasted years to 2030. This averages $781 to $843 per household. Household impact includes the carbon tax, directly on fuel use and indirectly on goods and services, and rebates to about 60 per cent of households. It also includes the economic benefits of rebates for energy efficiency or renewables, increased government spending for new transit, and decreased household consumption due to lower economic growth. Employment was projected to grow

[1] All GDP and household economic impacts are reported in 2018 dollars.

annually under the CLP, but with 9,200 to 10,400 fewer jobs each year (0.4 per cent lower annual employment than in Scenario 1).

The carbon tax portion of the CLP accounted for between $435 million and $1,235 million of the CLP costs to households, which is $215 to $633 per household (the range reflects different years). The carbon tax reduced annual employment by between 4,000 and 8,200 jobs, or 0.2 per cent to 0.3 per cent, depending on the year, of estimated employment under Scenario 1.

Scenario 3: Continue the CLP with carbon prices increasing to $40 per tonne in 2021 and $50 per tonne in 2022

This scenario considers what would happen if the carbon price for both the carbon tax and the CCIR increased to $40 per tonne in 2021 and $50 per tonne in 2022 through to 2030.

Alberta's economy was expected to grow an average of 2.5 per cent per year from 2016 through 2030. This is 0.07 per cent less than the expected growth of 2.57 per cent in Scenario 1. This is between $2 billion and $3.9 billion per year (0.6-0.9 per cent) lower than in Scenario 1. The impact on the oil and gas industry was forecasted to be a 0.4 per cent to 0.6 per cent decrease in GDP, depending on the year. Other large emitters' GDP would be 2 to 5 per cent lower, while other sectors' GDP would decrease by 0.9 to 1.3 per cent.

The $50 per tonne carbon price by 2022 would negatively impact households by between $1,361 million and $2,498 million, which averages to $843 to $1,326 per household per year. The number of people employed was projected to grow annually in this scenario, but annual employment would be 10,000 to 16,000 fewer jobs (0.4 per cent to 0.6 per cent lower) compared to Scenario 1.

Scenario 4: Apply the federal carbon pricing backstop in Alberta

This scenario assumes that both the federal fuel charge on non-industrial emitters and the output-based pricing system were applied in Alberta. The carbon price would be $30 per tonne in 2020, $40 per tonne in 2021 and $50 per tonne in 2022 and all subsequent years. With these policy assumptions, GDP was expected to grow on average by 2.51 per cent per year from 2016 through 2030. This is a reduction of 0.055 per cent per year, compared to the 2.57 under Scenario 1. That reduces GDP by $2.7 billion to 3.3 billion per year (0.7 per cent to 0.9 per cent). The impact on the oil and gas sector would decrease by 0.1 per cent to 1.2 per cent, while other sectors' GDP would decrease by 0.8 per cent to 1.1 per cent. Large emitters' GDP would be 1.5 per cent to 4 per cent lower.

The federal carbon pricing backstop would negatively impact households by between $844 million and $936 million, which averages to $483 to $557 per household. Annual employment was projected to grow annually, but would be 10,400-14,200, or 0.4-0.5 per cent lower each year.

Greenhouse gas emissions impacts

The CLP's primary intended outcome was to decrease GHG emissions. The carbon price of $30 per tonne was projected to reduce emissions by about 34 megatonnes annually by 2030, compared to Scenario 1. Increasing the carbon price to $50 per tonne in 2022 would have decreased emissions by a further four megatonnes in 2030 (comparing Scenario 3 to Scenario 2). The total reductions for Scenario 3 compared to Scenario 1, would be 38 megatonnes in 2030. With the federal carbon pricing backstop (Scenario 4), GHG reductions were expected to be at least 35 megatonnes annually by 2030 compared to Scenario 1.

Potential additional reductions from funding research and innovation for low carbon solutions were estimated at 20 megatonnes in 2025 and 24 megatonnes in 2030, based on CLP funding expectations with a $30 per tonne carbon price. The other scenarios could realize similar or more reductions but estimates were not available. The impacts of the potential uptake of innovative solutions on GDP, household costs and employment were excluded due to higher uncertainty, less technology information and model limitations.

The GHG emissions reductions were estimated to avoid health and environmental damages of $0.7 billion in 2020, increasing to $2.1 billion in 2030 under Scenario 2. The estimated avoided damages increased by $0.1 billion and reach $2.4 billion in 2030 under Scenario 3. If the potential reductions from research and innovation were realized, the avoided damages would increase by an additional $1.5 billion in 2030.

Introduction

This report summarizes an economic impact analysis of previous and potential climate policies in Alberta. The policies considered are:

- Alberta's CLP as implemented in 2016-2018, with reporting decomposed into two parts (i) the carbon levy and (ii) all other CLP programs.
- CLP with a higher carbon price than implemented as of 2018.
- The federal carbon pricing backstop, including the fuel charge for non-industrial emitters and the carbon pricing system for industry.

Objectives

This analysis estimates the impacts of climate policies implemented by the previous government and proposed climate policies of the federal government. Sharing these results provides Albertans with information on the costs of climate policies and achieves the following commitments stated in government's platform document released in March 2019.

- Release detailed assessments of the impact of the carbon tax and the previous government's CLP on Alberta's economy, and on key sectors including electricity, oil and gas, and homes.
- Share an impact report with Albertans of the costs of adopting the CLP with a $50 per tonne carbon tax.
- Immediately tender a bid for a comprehensive independent assessment of the costs of the previous government's CLP.

Scope and analytical approach

The Government of Alberta used an economic modelling system that:

- has details on Alberta's most energy-intensive industries
- allows users to adjust input variables to represent a variety of government climate policies
- includes trade within Canada and to the United States

See Appendix 1 for more details on the modelling system. The assessment covers costs and benefits in Alberta through to 2030.

Scenarios

The Government of Alberta assessed four scenarios that are summarized in Table 1 below and described in more detail in Section 2 and Appendix 2. The impacts of the climate policies were calculated as the differences between the scenarios that include or exclude the policies in question.

Table 1 Description of scenarios

Scenario 1: 2015 Climate Policies	This is the reference case for comparison. It includes Alberta's climate policy in 2015, specifically the Specified Gas Emitters Regulation (SGER) that required facilities with large GHG emissions to reduce emissions by 12 per cent relative to the facility's historic emissions intensity. Reductions could be achieved through on-site reductions, buying carbon credits, or contributing to an emissions fund at a rate of $15 per tonne. The emissions fund directed investments to low carbon technology development, such as carbon capture and sequestration.
Scenario 2: Climate Leadership Plan (CLP)	Scenario 2 represents Alberta's 2016-2018 climate policies, referred to collectively as the CLP. It includes the carbon tax for households and small businesses[2] and the pricing regulation on industry, called the Carbon Competitiveness Incentive Regulation (CCIR). The CLP contained 40 policies and programs, mostly funded by the carbon tax. The carbon price for both the carbon tax and CCIR was $30 per tonne in 2018 and this scenario maintains that price through 2030. The modelling for this scenario also includes CLP policies such as the renewable electricity program, coal emissions phase-out, the oil sands emissions limit, and investments in renewable energy, energy efficiency, oil sands innovation, and the methane regulations for upstream oil and gas. The CLP also included rebates for

[2] In this report, "carbon tax" refers to the carbon price levied for households and small businesses, but excludes the carbon pricing regulation faced by large industrial emitters.

	approximately 60 per cent of households, and tax reductions for small businesses.
Scenario 3: CLP with price increasing to $50	This scenario includes the same CLP policies as Scenario 2. The difference is the carbon price for both the carbon tax and the CCIR increases to $40 per tonne in 2021 and $50 per tonne in 2022 that continues through to 2030. The incremental revenue from the $50 per tonne carbon price is used to reduce provincial debt, according to the directions laid out in the “Path to Balance” in the 2018-19 Alberta Budget.
Scenario 4: Federal carbon pricing backstop	Scenario 4 shows the cost of a potential implementation of the federal carbon pricing backstop in Alberta. The federal government developed its carbon pricing backstop for provinces that request it or do not have a carbon pricing system that meets the federal benchmark. It includes a carbon price of $30 per tonne in 2020, $40 per tonne in 2021 and $50 per tonne in 2022,and is assumed to stay at that level through 2030. The carbon price is applied to households and small businesses through the federal fuel charge. Industrial emitters would be subject to the output-based pricing system with the same carbon price. Revenue from carbon pricing is directed back to households in line with federal implementation of its provincial backstop, and invested in technology innovation to reduce emissions in large industry.

Key assumptions

All scenarios use consistent assumptions for external economic forces that affect Alberta. The only differences among scenarios are the climate policy and revenue use configurations. This allows the analysis to focus on the impacts of these policies only and not on larger external economic forces.

The cases are informed by:

- economic growth projections from Treasury Board and Finance (TBF)
- plus oil and gas price and production projections from the Alberta Energy Regulator (AER) reflecting economic conditions as of 2019

Climate and energy policies in jurisdictions outside Alberta reflect policies in place in January 2019 for all scenarios.[3]

Assumptions for the CLP (Scenarios 2 and 3)

The analysis includes these CLP policies:

- carbon pricing (both the carbon tax for households and small emitters) with an exemption for conventional oil and gas until 2023
- the Carbon Competitiveness Incentive Regulation (CCIR) for larger emitters
- the phase-out of GHG emissions from coal-fired electricity by 2030
- Oil Sands Emissions Limit
- the methane regulation to reduce emissions by 45 per cent below 2012 levels by 2025
- the Renewable Electricity Program (REP)

The Oil Sands Emission Limit (100 megatonnes per year) is characterized in the analysis, but was not binding. It is assumed that once the carbon levy exemption expires in 2023, conventional oil and gas will opt-in to the CCIR and all categories of their emissions face the marginal carbon price.

[3] British Columbia's carbon tax and Quebec's cap and trade policies are included explicitly. For simplicity, all other provinces and territories are modelled as following the federal fuel charge and output-based pricing system with the carbon price increasing to $50 in 2022 and remaining at that level through 2030.

The CLP was to reinvest revenues from carbon pricing into household rebates, small business tax decreases, renewable energy and energy efficiency programs, public transit, company and community support to transition off coal, oil sands innovation, and support for companies adversely affected by the CCIR. These funding flows are characterized and forecasted based on the best available knowledge. Where there was uncertainty about how much funding would flow, past decisions were used as a guide.

Assumptions for the federal carbon pricing backstop (Scenario 4)

The federal carbon pollution pricing system has two parts:

- A regulatory charge on liquid transport and heating fuels (federal fuel charge).
- A regulatory system for industry with a carbon price and flexible compliance mechanisms – the federal output-based pricing system.

These regulatory systems (defined in the *Greenhouse Gas Pollution Pricing Act*) work in similar ways as the CLP's carbon pricing, but they differ in scope and policy design in some cases. The policy assumptions for this case reflect the act's design as understood at the time of publication.

This case assumes that methane regulations and the coal phase out policy are the same as in the CLP case. In line with current announcements of the federal government, it is assumed that methane venting and methane fugitive emissions from oil and gas facilities will not be subject to pricing under the output-based pricing system. The oil sand emissions limit is included, but is also not binding by 2030.

REP is assumed cancelled in this scenario. This program was funded by CLP carbon tax revenue, and the federal carbon pricing backstop does not provide specific support for renewable electricity.

The federal carbon pricing backstop requires that revenue be provided back to province that paid. This scenario assumes that revenue from the fuel charge is returned in lump sum to households (though the Climate Action Incentive Payments) and revenue from the output-based pricing system is returned to industry through investments in low-carbon technologies and lump sum transfers to corporations.

Further details on the assumptions are included in Appendix 2.

Economic impact of the CLP

Scenario 2 represents Alberta's 2016-2018 climate policies, referred to collectively as the Climate Leadership Plan (CLP). This includes the carbon tax for households and small businesses[4] and the carbon pricing regulation on industry, called the Carbon Competitiveness Incentive Regulation (CCIR). The CLP contained 40 policies and programs, mostly funded by the carbon tax and the CCIR. The carbon price for both the carbon tax and CCIR was $30 per tonne in 2018. This scenario maintains that price through 2030.It also includes changes from 2016 and 2017. In 2016, the industrial climate policies (SGER) had a carbon price at $20 per tonne, with facility reduction targets of 15 per cent. In 2017, the carbon price was $30 per tonne, with facility reduction targets of 20 per cent). Also in 2017, the carbon tax for households and small businesses was $20 per tonne. See section 2 for assumptions for this scenario.

The modelling for this scenario includes CLP policies such as the renewable electricity program, phasing out GHG emissions from coal-fired power plants and the Oil Sands Emissions Limit. It also includes investments in renewable energy, energy efficiency, oil sands innovation and the methane regulations for upstream oil and gas facilities. The CLP contained rebates tor about 60 per cent of households, and tax reductions for small businesses. This section covers the economic impacts of the CLP on Alberta's economy and key sectors including electricity, oil and gas, and homes. The economic impacts are measured by changes to GDP and by household costs. Note that these two impacts have different scopes and cannot be added (for example, a portion of the change in GDP will show up in the change in household costs).

- The net **change in provincial GDP** is the measure for economic costs in the scenarios. GDP measures the monetary value of all final goods and services produced in a region. The values in this report use an income-based GDP[5] calculation where the value of final goods and services is the payments to factors of production such as labour, capital and energy (i.e., labour income, corporate profits, investment income, and own-business payments). This measure excludes any costs or benefits that would occur as GHG reductions affect climate.
- The **change in household costs** accounts for household costs or benefits directly from climate policies or indirectly from changes in costs of goods or services, and changes in household consumption. The household costs are derived from expenditure-based estimates of GDP.

[4] In this report, "carbon tax" refers to the carbon price levied for households and small businesses, but excludes the carbon pricing regulation faced by large industrial emitters.
[5] Further information on GDP definitions is included in Appendix 5.

Impacts of the CLP on Alberta's economy and key industries

Scenario 2 saw carbon prices remaining at $30 per tonne. Alberta's total GDP was projected to increase annually, but real GDP would be between $2 billion to 2.6 billion (0.6 per cent) lower each year compared to the 2015 climate policies (Scenario 1). With the CLP in place, Alberta's economy was expected to grow an average of 2.52 per cent from 2016 through 2030. This compares to the average annual expected growth rate of 2.57 per cent per year under Scenario 1, a reduction in growth of 0.045 per cent per year.

The CLP is further decomposed into the impact of carbon tax on households and small businesses, and the impact of all other CLP measures such as CCIR, methane regulation, and coal emissions phase out. These two impacts would add up to the impact of the whole CLP policy measures.

The carbon tax alone accounts for GDP losses of 0.2 to 0.4 per cent per year, or $0.6 billion to $1.8 billion out to 2030, which is 31 to 67 per cent of the total CLP impact. This includes the impact of climate programs that would have been funded exclusively by carbon tax revenue.

This analysis assumed that household rebates, small business tax reductions, capital investment tax credits, and the transit subsidy would be funded by the carbon tax revenue.

Table 2. GDP impacts of the CLP Scenario (1), relative to the 2015 climate policies case.

	2020	**2025**	**2030**
% change in GDP (Total CLP)	-0.6%	-0.6%	-0.6%
Carbon tax alone[6]	-0.2%	-0.3%	-0.4%
Rest of CLP measures	-0.4%	-0.2%	-0.2%
% change in average annual growth from 2016 (Total CLP)	-0.16%	-0.07%	-0.04%
Carbon tax alone	-0.05%	-0.04%	-0.03%
Rest of CLP measures	-0.11%	-0.03%	-0.01%
GDP change (billion 2018 dollars) (Total CLP)	-2.0	-2.2	-2.6
Carbon tax alone	-0.6	-1.3	-1.8
Rest of CLP measures	-1.4	-0.9	-0.9

[6] The effect of carbon alone and the rest of CLP measures might not add up to total CLP impact due to rounding.

Sectors covered under CCIR have more abatement opportunities and their emission intensity declines more rapidly (see sectoral emissions in Appendix 4). The decline in emission intensity reduces the cost of carbon pricing, and the impact of carbon pricing, on these sectors over time.

Sectors covered by the carbon tax, however, have fewer abatement opportunities, and fewer emission reductions are expected to occur in these sectors. These sectors are forecasted to grow faster than the rest of the economy, as well. The two effects together result in a higher economic impact over time due to the carbon tax.

While the change in GDP for the whole province provides insight at a high level, policy impacts differ by industry or sector due to (1) the portion of the carbon price that each industry or sector faces, (2) its cost of reducing emissions and (3) its emissions intensity.

As shown in Figure 1, oil and gas industries face GDP losses of $0.4 billion per year, on average – approximately 0.4 per cent of that industry's GDP under 2015 climate policies (Scenario 1). The non-oil and gas large emitters, including electricity, would expect a loss of $0.4 billion per year on average across all industries, but this is a larger percent reduction, 3 per cent loss on average since their GDP is relatively smaller.

Other sectors (mining, agriculture, forestry, light manufacturing, and construction as a group) would be impacted to a lesser degree, with a GDP loss between 0.7 per cent and 1.3 per cent in different years out to 2030.

The impact by sector is due to the design of the CLP and the emissions intensity of economic activity. The CLP was designed to limit the economic impacts of exposure to the carbon price for large industrial emitters to maintain competitiveness and avoid carbon leakage.

Within the Commercial/Transportation/Services sectors, the GDP in the transportation sector[7] is the most impacted by the carbon tax and other CLP policies. Unsurprisingly, public transit shows an economic uplift as CLP carbon revenue is reinvested. Air transportation has a close-to-zero impact because this sector is exempt from carbon pricing.

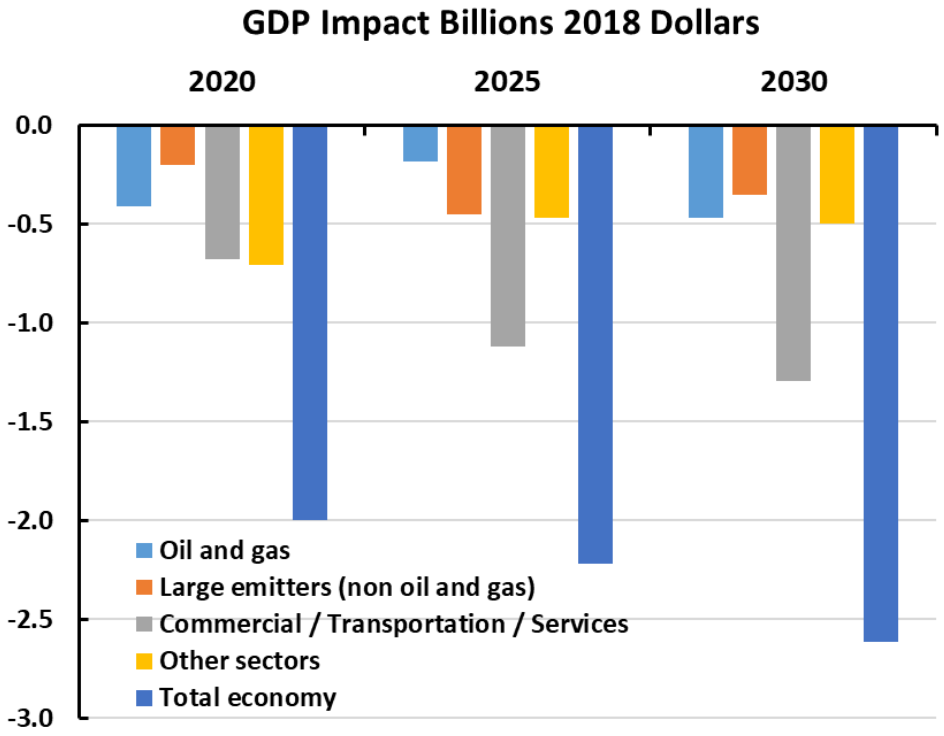
The impact of carbon pricing on rail transportation is the main driver on overall large negative impact on the transportation sector. We saw a large volume of crude oil shipped by rail in Alberta in the past two years, and we expect this to continue until there is greater pipeline capacity. These model results are in line with recent monthly data releases on oil exports by rail.

[7] Sectoral GDP reported here uses income-based GDP; therefore, passenger vehicles are not included in the transportation sector.

Data show that oil shipments by rail is very responsive to the price spread[8] between West Texas Intermediate (WTI) and Western Canadian Select (WCS).[9] The carbon tax increases the cost of oil shipment by rail (rail transportation is very emissions-intensive and no free emissions are allocated to this sector). This makes shipping oil by rail less profitable for rail companies and oil producers.

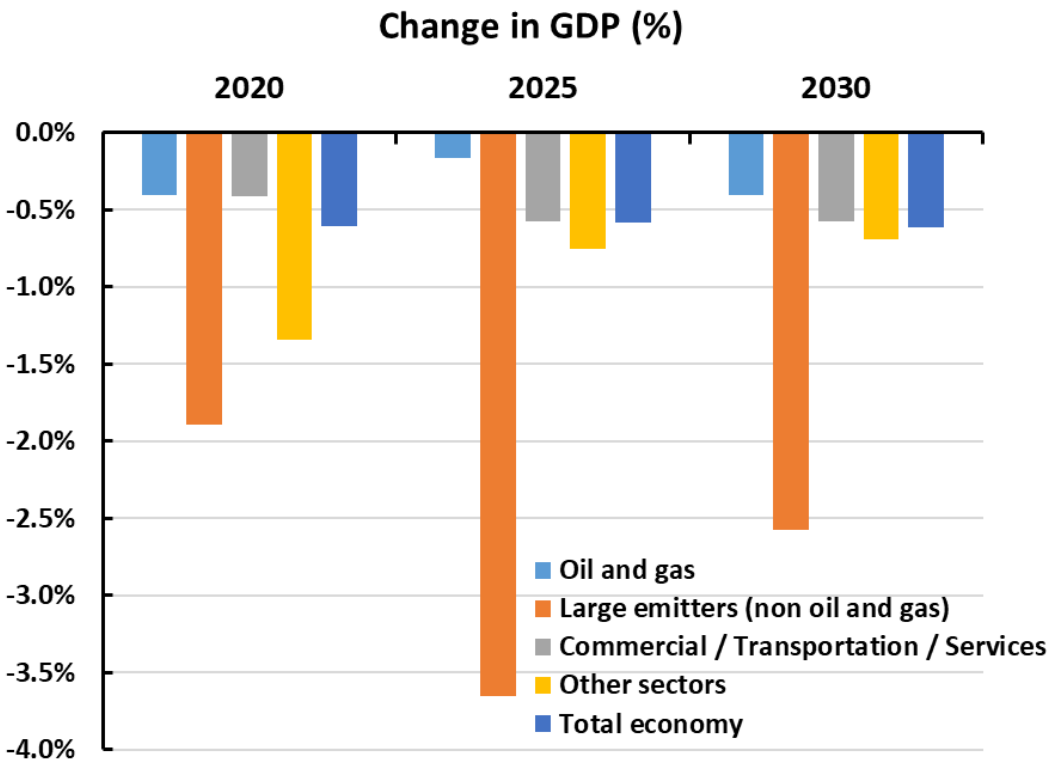
Model results show that the carbon tax and CLP in Alberta slightly reduces the amount of oil produced and reduces the oil shipment by rail by a large amount compared to Scenario 1. Since marginal barrels of oil are shipped by rail, it is expected that oil shipment by rail, and the corresponding GDP impacts, to be very responsive to carbon pricing and small changes in overall bitumen production.

Figure 1. GDP impacts of the CLP scenario (Scenario 2) by sector/industry, relative to the 2015 climate policies case (Scenario 1)



[8] Oil shipment by rail increased by more than 100 per cent (from 146,000 barrel per day to 354,000 b/d) during 2018 when the price spread reached to more than $60 CAD per barrel. Oil shipment declined by more than 50 per cent (122,000 b/d in February and 168,000 b/d in March 2019) mainly due to the oil curtailment policy in Alberta, which also had a significant impact on price spread (price spread declined to $11-14 CAD per barrel).

[9] Western Canadian Select is the benchmark price for Alberta heavy oil.



Notes:

- *Oil and gas includes oil sands, conventional oil, natural gas, oil and gas services, refineries and pipelines.*
- *Large emitters (non-oil and gas) includes emissions-intensive trade-exposed industries – metal smelting, paper production, non-metallic minerals, chemicals, fertilizer, and electricity generation.*
- *Commercial/transportation/services includes a wide range of non-manufacturing services (financial, software development), retail, restaurants, and commercial transportation services such as freight and people movement by trucks, rail, air and transit.*
- *Other sectors include mining, agriculture, forestry, light manufacturing, and construction.*

Results in table format are included in Appendix 4.

Economic impacts of the carbon tax and CLP on households

While change in GDP captures the impacts on Alberta's entire economy, we also consider the portion of CLP costs borne by Alberta households. The calculations below for household costs include both the policy impacts on costs of goods and services, plus changes to household consumption that result from changes to overall economic growth.[10]

The impact of the CLP on households depends on individual factors such as energy use, participation in CLP programs, and income levels. While the CLP would affect households in different ways, this analysis does not determine impacts by type of household. Rather, it considers the total costs for all households and a calculated average household cost. The average cost is calculated as total costs divided by the total number of households, but may not reflect impacts on a typical, or median, Alberta household due to the range of impacts across households. The household impacts included in the analysis are grouped into three categories as shown in Table 3: direct costs, household rebates, and other effects on household consumption. Direct costs are the carbon tax impacts of higher energy prices for fuel such as gasoline and natural gas. Direct costs accounted for an increase in costs of approximately $314 million to $438 million (in 2018 dollars) per year across all households, with an average direct cost of $215 per household per year across homes in Alberta.

The CLP included household rebates to individuals and families with incomes below thresholds based on the size of the household. The CLP was designed to provide rebates to approximately 60 per cent of households. The rebates would lead to $353 million to $490 million returned directly to households each year out to 2030.

The CLP affects households by more than combustion fuel purchases. Other effects on household consumption were calculated to be $1,414 million to $1,599 million annually due to:

- the increased costs of carbon pricing on producing goods and services that are passed on to consumers
- household benefits from rebates for energy efficiency or renewables and increased government spending for new transit
- the estimated value of the loss to households of consuming less due to lower economic growth (see Appendix 3 for a description of the calculations completed for this work)

[10] Relative to the economy-wide GDP impact provided above, the total household costs excludes changes in government expenditure and net costs on businesses (after passing portion of costs to households). The change in households' consumption uses expenditure-based GDP.

Table 3. Economic impacts of the CLP scenario (Scenario 2) on households, relative to the 2015 Climate policies case (Scenario 2).

	Total costs (million, in 2018 dollars)			Average cost per household (in 2018 dollars)		
	2020	2025	2030	2020	2025	2030
Direct cost (Total CLP)	-438	-359	-314	-271	-205	-167
Carbon tax alone	-438	-359	-314	-271	-205	-167
Rest of CLP measures	0	0	0	0	0	0
Household rebates	490	401	353	304	229	187
Carbon tax alone	490	401	353	304	229	187
Rest of CLP measures	0	0	0	0	0	0
Other effects on household consumption	-1,414	-1,407	-1,599	-875	-805	-849
Carbon tax alone	-488	-976	-1,274	-302	-558	-676
Rest of CLP measures	-926	-431	-325	-573	-247	-173
Total cost	-1,361	-1,366	-1,561	-843	-781	-829
Carbon tax alone	-435	-934	-1,235	-269	-534	-656
Rest of CLP measures	-926	-431	-325	-573	-247	-173

Notes:

- *Average cost is calculated as total costs divided by total households. Costs will vary significantly based on household characteristics (energy use and level of household rebate, if any).*

- *Direct cost refers to carbon tax payments for gasoline, diesel and natural gas by households. Household rebates are the funds provided by the government directly to households based on income/household characteristics. Other effects on household consumption include increased costs from the carbon tax on producing goods and services, rebates for energy efficiency or renewables, increased government spending for new transit, and the cost of decreased household consumption due to lower economic growth.*

It is important to note that the three types of impact on households reported in Table 3 varies across households.

- **Direct cost:** The distribution of direct cost on households varies by their energy consumption, which depends on various factors such as household size, income, type of dwelling, and geographical location.

- **Rebates:** About 60 per cent of households are eligible to receive rebates from CLP carbon revenue. However, the amount depends on households' size and income level. The negative impact on households that do not receive any rebate would be larger than the estimated total cost on the average household in Table 3. Similarly, the negative impact on households receiving rebates would be smaller than numbers reported in Table 3.

- **Other effects on household consumption:** The impact on economic activities varies significantly across sectors. Households where the primary income earners depend on the most negatively impacted sectors are expected to experience a larger decline in their income and consumption. For example, people working in the coal mining sector experience a significant income loss, but people working in renewable energy sector benefit from more jobs and higher income.

Part of the reduced household consumption is due to lower employment as a result of the CLP. Employment was projected to grow annually, adding about 51,000 jobs per year – but this is 9,200 to 10,400 fewer jobs gained each year (0.4 per cent lower), compared to keeping 2015 climate policies in place in Scenario 1 (see Table 4).

Table 4. Employment impacts of the CLP scenario (Scenario 2), relative to the 2015 climate policies case (Scenario 1).

	2020	2025	2030
% Change in employment	-0.4%	-0.4%	-0.4%
Carbon tax alone	-0.2%	-0.3%	-0.3%
Rest of CLP measures	-0.2%	-0.1%	-0.1%
Change in employment (jobs)	-10,017	-9,229	-10,374
Carbon tax alone	-4,056	-6,767	-8,262
Rest of CLP measures	-5,961	-2,461	-2,111

Additional results are available in Appendix 4.

In the model, changes in real wage rates resulting from varying levels of economic activity directly impacts the level of labor supply. However, the model does not spatially capture changes in labour supply as a result of changes in migration or changes in working hours. Recent studies found that accounting for migration, changes in working hours, labour force participation rate, and other market frictions can produce forecasts for a more responsive labour supply to policy impacts. We acknowledge that labour market effects in this report may underestimate the negative impact on employment, considering recent historical migration to Alberta to participate in one of Canada's fastest growing economies. This is be an important area of future study research and analysis.

The change in sectoral employment over time provides insight into the sectors where jobs would be impacted the most by climate policies.

- **Oil and Gas:** This group of industries experiences the least impact in terms of the both number of jobs and per cent of employment. CLP was designed to limit the impacts on such trade-exposed industries and the upstream industries were projected to further reduce their policy costs by reducing methane emissions.
- **Large emitters:** These industries show more impact on jobs than oil and gas. Declines in employment in chemical, paper, and metal manufacturing are the main drivers of total negative employment effect. The electricity sector experiences an increase in

employment. Employment gains at renewable and natural gas power plants outweighs employment losses at coal-firing power plants.

- **Commercial/Transportation/Services:** These sectors experience the most job loss due to the CLP. However, the employment change is very small compared to total employment in these sectors (about 1.6 to 2 million workers are employed in these sectors).
- **Other sectors:** This mix of sectors faces a relatively large impact in 2020 but this declines over time as the facilities and economy adjust.

The negative impact on employment is smaller for sectors covered under CCIR since the policy is designed to limit the economic impact of carbon pricing and maintain competitiveness. Sectors covered by the carbon tax experience the most employment effects.

Table 5. Employment impacts of the CLP scenario (Scenario 2), relative to the 2015 climate policies case (Scenario 1) by sector.

	Change in employment (jobs)			**% Change in employment**		
	2020	2025	2030	2020	2025	2030
Oil and gas	-860	-178	-454	-0.5%	-0.1%	-0.3%
Large emitters (non-oil and gas)	-619	-1,647	-1,253	-1.4%	-3.3%	-2.3%
Commercial / Transportation / Services	-2,816	-4,954	-6,574	-0.2%	-0.3%	-0.3%
Other sectors	-5,722	-2,450	-2,092	-1.2%	-0.5%	-0.4%
Total economy	-10,017	-9,229	-10,374	-0.4%	-0.4%	-0.4%

Economic impact of the CLP with a carbon price rising to $50 per tonne

This section considers the impacts of keeping the CLP, but with the carbon price increasing to $50 per tonne in 2022. The CLP contained 40 policies and programs, mostly funded by the carbon tax on households and small businesses and the pricing regulation on industry. The CLP policies and programs included in this scenario are described in Section 2, Key Assumptions.

While the CLP had a carbon price of $30 per tonne for 2018 and following years, the federal government's *Greenhouse Gas Pollution Pricing Act* (GGPPA) increases the carbon price to $40 per tonne on April 1, 2021, and $50 per tonne on April 1, 2022. Then it stays flat. The extra funds from the higher carbon price are assumed to be reinvested in reducing government debt.

As shown in Table 6, if the CLP had a carbon price that followed the GGPPA price of $40 per tonne in 2021 and $50 per tonne in 2022 (Scenario 3), Alberta's GDP would be approximately $2-3.9 billion (0.6-0.9 per cent) lower each year, compared to keeping the 2015 climate policies in place (Scenario 1). Under Scenario 3, Alberta's economy was expected to grow at 2.50 per cent per year, on average from 2016 through 2030. This compares to the expected growth rate of 2.57 per cent per year under 2015 climate policies (Scenario 1), a reduction of 0.07 per cent per year.

Table 6. GDP impacts of the CLP with carbon price increasing to $40 per tonne in 2021 and $50 per tonne in 2022 and following years (Scenario 3), relative to the 2015 climate policies (Scenario 1).

	2020	**2025**	**2030**
% change	-0.6%	-0.9%	-0.9%
% change in average annual growth from 2016	-0.16%	-0.10%	-0.07%
GDP change (billion 2018 dollars)	-2.0	-3.3	-3.9

The GDP impacts by key sector and details on the household costs are included in Appendix 4.

Economic impact of applying the federal carbon pricing backstop in Alberta

This section covers the economic impacts if the federal carbon pricing backstop (federal backstop) were implemented on Alberta's economy and key sectors.

As described in section 2, the federal carbon pollution pricing system has both a regulatory charge on fuel (federal fuel charge) and a regulatory trading system for industry (the federal output-based pricing system). For this assessment, the carbon price is assumed to be $30 per tonne in 2020, $40 per tonne in 2021 and $50 per tonne in 2022, then stays at that level through 2030. This scenario assumes that methane regulations and the coal emissions phase out policy remain in place. The Oil Sand Emissions Limit is kept in place as well, but it is not binding by 2030.

The Renewable Electricity Policy (REP) is assumed to be cancelled, because this program was funded by carbon revenue under the CLP, and the federal carbon pricing backstop does not provide specific support for renewable electricity. However, renewable electricity is forecasted to increase compared to 2019, based on the cost-dynamics in the power market and the design of the output-based pricing system.

The federal carbon pricing backstop requires that revenue be provided either back to the province or to the entities that paid. This scenario assumes that revenue from the fuel charge is returned in lump sums to households (though the Climate Action Incentive Payments) and revenue from the output-based pricing system is returned in industry through investments in low-carbon technologies and lump sums to corporations. At the time of writing, it is uncertain how funds collected to large industry regulated by the output-based pricing system would be reinvested. Assumptions were simplified so policy compliance revenues that are returned to their province of origin are invested into emissions reductions.

Economic impact of the federal carbon pricing backstop on key sectors

The economic impacts are measured by changes to GDP and by households' costs.[11]

Under the federal backstop scenario (Scenario 4), Alberta's GDP was expected to grow an average of 2.51 per cent per year from 2016 through 2030. This compares to the expected growth rate of 2.57 per cent per year under 2015 climate policies. That's a reduction in growth of 0.055 per cent per year, resulting in $2.7 billion to 3.3 billion (0.7-0.9 per cent) GDP loss, compared to Scenario 1.

Table 7. GDP impacts of the federal backstop (Scenario 4), relative to the 2015 climate policies case.

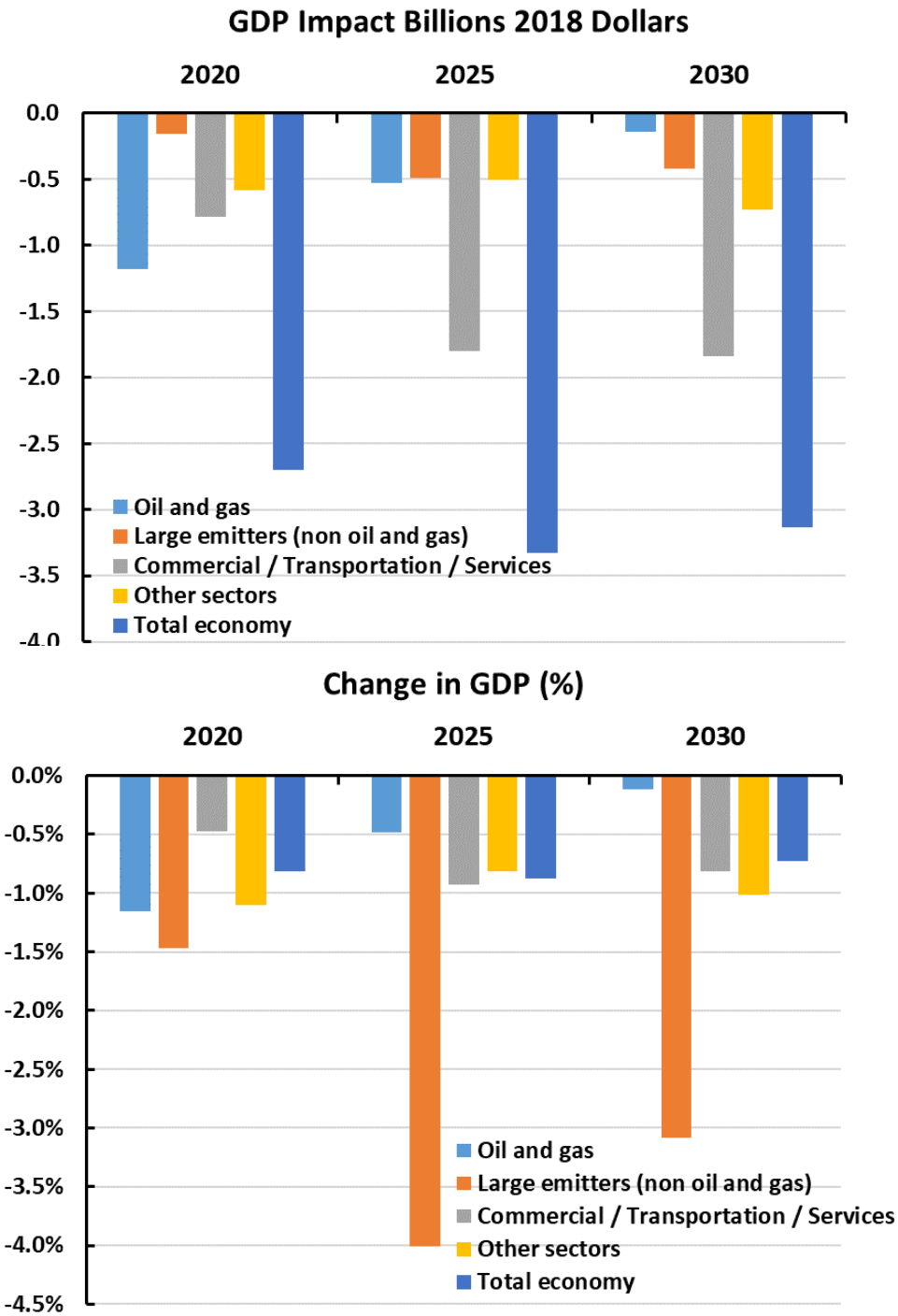
	2020	**2025**	**2030**
% change in GDP	-0.8%	-0.9%	-0.7%
% change in average annual growth from 2016	-0.21%	-0.10%	-0.05%
GDP change (billion 2018 dollars)	-2.7	-3.3	-3.1

The policy impacts differ by industry or sector due to (1) the portion of the carbon price that each industry or sector faces, (2) its cost of reducing emissions and (3) its emissions intensity.

As shown in Figure 2, oil and gas industries face GDP losses of $0.6 billion per year, on average from 2020 through 2030 – approximately 0.6 per cent on 2015 climate policies. The non-oil and gas large emitters, including electricity sector, would expect a loss of $0.4 billion per year on average across all industries, but this is a larger reduction, 2.9 per cent on average.

[11] Note that these two impacts have different scopes and cannot be added (for example, a portion of the change in GDP will show up in the change in household costs). See section 3, *Economic Impacts of the CLP,* for a description of the measurement differences for the two economic impacts.

Figure 2. GDP impacts of the federal backstop (Scenario 4), by sector/industry, relative to the 2015 climate policies case (Scenario 1)



Notes:

- *Oil and gas includes oil sands, conventional oil, natural gas, oil and gas services, refineries and pipelines.*
- *Large emitters (non-oil and gas) includes emissions-intensive trade-exposed industries – metal smelting, paper production, non-metallic minerals, chemicals, fertilizer, and electricity generation.*
- *Commercial/transportation/services includes a wide range of non-manufacturing services (financial, software development), retail, restaurants, and commercial transportation services such as freight and people movement by trucks, rail, air and transit.*
- *Other sectors include mining, agriculture, forestry, light manufacturing, and construction.*

Results in table format are included in Appendix 4.

Economic impacts of the federal carbon pricing backstop on households

While change in GDP captures the impacts on Alberta's entire economy, we also consider the portion of federal backstop costs borne by Alberta households. The calculations below for household costs include both the policy impacts on costs of goods and services, plus changes to household consumption that result from changes to overall economic growth.[12]

The impacts of the federal carbon pricing backstop on households depends on factors such as energy use and any amount rebated through the Climate Action Incentive Payments. As stated previously, this analysis does not determine impacts by type of household; rather, it considers the total costs and an average household cost. The federal government's Climate Action Incentive Payments and the previous government's carbon levy rebates were designed differently and would impact certain households in different ways. Since this analysis is focused on provincial impacts, the average cost is calculated as total costs divided by total households. This may not reflect a typical household.

The household impacts included in the analysis are grouped into three categories: direct costs, household rebates, and other effects on household consumption (see Table 7).

Direct costs are the fuel charge impacts resulting in higher energy prices for fuel such as gasoline and natural gas. Direct costs accounted for an increase in costs of approximately $436 million to $590 million (in 2018 dollars) per year across all households, with an average direct cost of $300 per household per year across homes in Alberta.

The Climate Action Incentive Payments are household rebates to individuals and families based on the number of people in each household. The rebates would lead to $1,267 million to $1,910 million returned directly to households each year.

Other federal backstop effects on household consumption are forecasted to be $1,731 million to $2,190 million annually due to both:

- the increased costs of carbon pricing on producing goods and services that is passed on to consumers, and
- the estimated value of the impact (loss) to households of consuming less due to lower economic growth (see Appendix 3 for a description of the complete calculations).

[12] Relative to the economy-wide GDP impact provided above, the total household costs excludes changes in government expenditure and net costs on businesses (after passing a portion of costs to households). The change in households' consumption uses expenditure-based GDP accounting.

Table 8. Economic impacts of the federal backstop (Scenario 4) on households, compared to the 2015 Climate policies case (Scenario 1)

	Total costs (million 2018 dollars)			Average cost per household (2018 dollars)		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Direct cost	-436	-590	-508	-270	-337	-270
Climate Action Incentive Payments	1,267	1,910	1,762	784	1,093	936
Other effects on household consumption	-1,731	-2,165	-2,190	-1,072	-1,238	-1,163
Total cost	-900	-844	-936	-557	-483	-497

Notes:

- *Average cost is calculated as total costs divided by total households. Costs will vary significantly based on household characteristics (energy use and level of household rebate, if any).*
- *Direct cost refers to fuel charge payments for gasoline, diesel and natural gas by households. Household rebates are the funds provided by the government directly to households based on income/household characteristics. Other effects on household consumption include increased costs from the federal fuel charge on producing goods and services and the cost of decreased household consumption due to lower economic growth.*

Part of the reduced household consumption is due to lower employment as a result of the federal system. Under the federal system, employment was projected to grow annually, adding about 51,000 jobs per year – but this is 10,400 to 14,200 fewer jobs (0.4 per cent-0.5 per cent lower employment) each year, compared to keeping the 2015 climate policies in place (see Table 9).

Due to how the model characterizes the labour market, changes in real wage rates resulting from varying levels of economic activity directly impact the labor supply. However, the model does not capture changes in labour supply as a result of changes in migration or changes in working hours. Recent studies find that accounting for migration, changes in working hours, labour force participation rate and other market frictions can result in larger policy impacts on the labour market, than excluding such nuances. We acknowledge that the labour market effects in this

report may underestimate the negative impact on employment, especially considering recent historical migration to Alberta. This is be an important area of study for future research and analysis.

Table 9. Employment impacts of the federal backstop (Scenario 4), relative to the 2015 climate policies case (Scenario 1).

	2020	**2025**	**2030**
% Change in employment	-0.4%	-0.5%	-0.5%
Change in employment (jobs)	-10,404	-13,788	-14,268

Additional results are available in Appendix 4.

Impact of climate policies on greenhouse gas emissions

Estimated GHG emission reductions and their economic impacts are included in this section help the reader understand the net cost to society of various climate policies, by taking into account both the costs and benefits of different policy regimes. The economic impacts in Sections 3 to 6 exclude estimated avoided health and environmental damages because of high uncertainty, as explained below.

GHG Impacts of the CLP

The CLP was projected to reduce GHG emissions by 14 to 15 megatonnes in 2020, and by 34 to 58 megatonnes by 2030, compared to 2015 climate policies.[13] The range reflects uncertainty in the size of future reductions due to CLP investments in research and innovation.

Most projected emissions reductions were due to reduced coal combustion from the electricity sector, and to equipment and process changes to reduce methane from upstream oil and gas operations. Research and innovation were expected to reduce emissions in oil sands production (see details in Appendix 4) mostly with small reductions across other sectors as well.

Results of the other scenarios are as follows and have similar impacts by sector as the CLP scenario:

- Scenario 3: Increasing the carbon price to $50 per tonne decreases emissions by a further 4 megatonnes compared to Scenario 2 in 2030 (38 to 62 megatonnes annual total decrease in 2030, relative to Scenario 1 with 2015 climate policies).
- Scenario 4: Applying the federal backstop in Alberta is projected to reduce GHG emissions by 15 megatonnes in 2020 and by 35 megatonnes per year by 2030, compared to 2015 climate policies.

[13] These reductions differ from reductions provided in the *Climate Leadership Plan Progress Report 2017-18* (Government of Alberta 2019). The reductions here are relative to 2015 climate policies with the 2019 economic forecast. The reductions in the CLP Progress Report 2017-18 are relative to 2015 climate policies with economic outlook from 2015, to be consistent with the Climate Change Advisory Panel's Report to Government and previous CLP progress reports.

Table 10. GHG emissions (in carbon dioxide equivalent, megatonnes)

	2020	2025	2030
Historical forecast (ECCC 2015), adjusted*	291	304	314
Scenario 1: 2015 climate policies	282	297	303
Scenario 2: CLP scenario at $30	268	265	269
Change relative to 2015 climate policies	-14	-32	-34
Carbon tax alone	-1	-5	-5
Rest of CLP measures	-13	-27	-29
Scenario 3: CLP with price increasing to $50	268	261	265
Change relative to 2015 climate policies	-14	-36	-38
Scenario 4: Federal carbon pricing backstop	267	263	268
Change relative to 2015 climate policies	-16	-34	-35
Potential additional GHG change from the impacts of research and innovation as estimated for Scenario 2.	-1	-12	-24

*Historical Forecast based on Canada's Second Biennial Report on Climate Change, ECCC (2015) with Government of Alberta adjustments. All CLP cases from Government of Alberta analysis.

In 2015, before the CLP was enacted, the Government of Alberta reported emissions relative to a third party forecast, Environment and Climate Change Canada (ECCC). Associated policies were characterized in subsequent forecasts. Since the emissions forecast was published in 2015, ECCC updated some methodologies and re-stated emissions inventories accordingly[14]. The economic model used to perform this analysis is calibrated to the National Inventory Reports with the methodological updates taken into account.

[14] See http://publications.gc.ca/collections/collection_2018/eccc/En81-4-2016-1-eng.pdf for more information.

To compare those past forecasts to the results in this report, the 2015 ECCC emissions forecast for Alberta is slightly adjusted and can be used as a historical point of reference.

Table 10 includes information on the potential change in GHG emissions due to government funding for research and innovation for low carbon technologies. This could possibly increase commercialization and uptake of technology advances, such as using solvents for in-situ production, or greater use of CO2 in industrial production or enhanced oil recovery.

Since this report uses a model that only uses commercially available technologies, an assessment of technology potential is performed outside the model. These estimates were developed for Scenario 2 through collaboration with experts from the ministry of Economic Development Trade and Tourism. Similar reductions could occur in the other scenarios. However, insight on the economic impacts of innovative technologies coming into maturity is more limited and uncertain than for other climate policy elements. As such, the economic uplift of these technology innovations is excluded in the economic assessment.

To include the economic impacts of reducing GHG emissions, analysts frequently use the social cost of carbon (SCC). This is a measure of the economic impacts expressed as the dollar value of the total global economic damages from emitting one additional tonne of carbon dioxide into the atmosphere[15].

In 2016, the Government of Canada updated its guidance for SCC values to be used in regulatory impact assessment.[16] *Table 11* shows the SCC values using ECCC's central SCC estimate with a 3 per cent discount rate. [17]

Table 11. Social cost of carbon (2018 dollars per tonne)

	2020	**2025**	**2030**
ECCC Social Cost of GHG emissions, March 2016. Central estimate discounted. at 3 per cent	$50.79	$56.08	$61.38

[16] *Technical Update to Environment and Climate Change Canada's Social Cost of Greenhouse Gas Estimates*. March 2016. Environment and Climate Change Canada. http://publications.gc.ca/collections/collection_2016/eccc/En14-202-2016-eng.pdf

[17] Discount rate shows how much individuals discount the value of consumption delayed by a year.

Critics raise concerns on the wide range in SCC values, depending on the choice of discount rate and geographic scope. The most important factor is the discount rate. Depending on the rate, the monetary value of the environmental gain could vary significantly from negative (net benefits for increasing GHG emissions) to much higher positive costs. (The 95th percentile SCC estimate for the Government of Canada in 2020 is $215 per tonne, $240 in 2025, and reaches $265 by 2030). There is no consensus on what discount rate should be used.

Second, the SCC varies significantly across regions. Some regions are more prone to climate change damage, and some regions might even benefit from climate change. The choice of whether a global or regional SCC is the appropriate measure for cost-benefit analysis also lacks consensus. The SCC analysis to date has also been criticized for not fully accounting for non-catastrophic and potential catastrophic damages. The SCC in this report is based on Government of Canada guidance of 3 per cent discount rate and global geographic scope.

Table 12 shows the estimated benefits, calculated by multiplying the SCC with the GHG reductions reported in Table 10. The avoided health and environmental damages from GHG emissions reductions were estimated to be $0.7 billion in 2020, increasing to $2.1 billion in 2030 for the CLP at $30 per tonne, (Scenario 2). The estimated avoided damages increase by $0.1 billion in 2030 to $2.4 billion total under Scenario 3 (CLP with the carbon price increasing to $50 per tonne). If the potential reductions from research and innovation were realized, the avoided damages would increase by an additional $1.5 billion in 2030. For example, by including potential GHG reductions from research and innovation, the estimated avoided damages from implementing the CLP with a carbon price at $30 per tonne would be $3.6 billion in 2030.

Table 12 Benefits of GHG reductions from CLP (in billion 2018 dollars), using SCC discounted at 3 per cent

	2020	**2025**	**2030**
Scenario 2: Climate Leadership Plan (CLP) at $30	$0.7	$1.8	$2.1
Scenario 3: CLP with price increasing to $50	$0.7	$2.0	$2.4
Scenario 4: Federal carbon pricing backstop	$0.8	$1.9	$2.2
Potential additional GHG change from the impacts of research and innovation as estimated for Scenario 2.	$0.0	$0.7	$1.5

These calculations do not account for the co-benefits related to air quality improvements, for example, commonly realized by actions to reduce greenhouse gases.

Conclusions

To put the results of this study in context, it is useful to consider the strengths and limitations of the methods used, and to review other studies in this area to determine if the results are reasonable, given the assumptions. Despite government's practice to use the best available models, it is necessary to acknowledge that models have their limitations and all forecasted policy impacts have inherent uncertainties. Valuable work of particular relevance relate to the likely in-sector impacts, since different firms have very different energy use, emissions profiles, and abilities to react to policy changes. There is, however, a trade-off in the ability to communicate forecasted impacts on facilities or firms, given confidentiality concerns.

To study the impacts of policies on households in Alberta, macroeconomic models representing households in an aggregate way do not allow for an understanding of how the consequences of different policy regimes are distributed across types of households. This is especially notable given the range of carbon intensities different household types exhibit, and the fact that policy features are designed to interact with different types of households differently. Further analysis would reveal how climate polices can impact certain parts of the population or labor market more or less, which could allow government to consider implementing details accordingly.

Modelling future economic and environmental impacts of climate change policies relies on many internal and external assumptions (see Section 2 and Appendices 1 and 2). An empirical sensitivity analysis was not completed for this study, and uncertainty ranges are not included on purpose. The intent of this report is to give Albertans an understanding of the order of magnitude of climate policy impacts. Based on previous external analyses, the economic impacts of climate policy in Alberta are likely to be impacted by:

- **Technological innovation.** The potential impacts on GHG emissions are included in Section 6, but the economic impacts of a strong uptake of new technologies were not estimated. Innovation would likely reduce the future costs of emissions reductions and may lead to growth in certain industries, or employment reductions.
- **Market access and demand for oil sands products.** While changes to these external conditions would significantly impact Alberta's GDP growth, the connection with Alberta's climate policy is more uncertain. Social license is a nebulous concept that is difficult to quantify and is explicitly scoped out of this analysis.

- **New products and industries in Alberta.** The economic model accounts for shifts in Alberta's industrial mix over time resulting from the climate policies, but does not add new products or industries that currently are not in Canada or the United States.
- Future climate policies implemented by Alberta's trading partners could change GDP impacts in Alberta, but this analysis did not speculate or test such changes.

The economic impacts of the CLP reported here (an annual reduction of GDP in the range of 0.5 to 1 per cent per year) are on the same order of magnitude as recent studies for Canada and previous estimates for Alberta's CLP. Note that differences are expected, since even if the same carbon price is being assessed, the decisions on how revenue is used can have a large impact on GDP changes.

- In 2016, the Government of Alberta used a different economic model than is used to perform this analysis, stating: "The impact of the Climate Leadership Plan on real GDP is expected to be 0.75 per cent by 2024."[18]
- In 2016, the Office of the Parliamentary Budget Officer (PBO) estimated real GDP would decrease by approximately 0.5 per cent under policies, with the carbon price increasing to $50 per tonne in 2022 and revenue being returned as a lump sum to households.[19]

There are multiple external studies on the economic impacts of climate policies for at the national level, but there are few studies focusing solely on Alberta over the last few years. We expect this to change in the near future as data emerges on the outcomes of climate policies. Even taking into account the carbon intensity of the Albertan economy, the expected economic impacts of the climate change policies examined in this analysis are of comparable order of magnitude to results from other jurisdictions. Finally, as the Government of Alberta continues to evaluate past policies and programs, and explores new options to support environmental protection and economic growth, evaluating the models and other assessment tools will also continue. Policy shifts under the CLP represented significant changes from the past: increasing the carbon price to $30 per tonne, adding the carbon tax for small emitters and households, and many programs for energy efficiency and renewable energy. All economic forecasts rely on assumptions to some degree to capture the behaviour and technology impacts. Assessing the forecasts in relation to actual impacts will form a key next step in continuous improvement.

[18] Government of Alberta. (2018) "Climate Leadership Plan Economic Impact Assessment" https://www.alberta.ca/climate-economic-impact.aspx. From August 15, 2018 cache https://web.archive.org/web/20180815192418/https://www.alberta.ca/climate-economic-impact.aspx

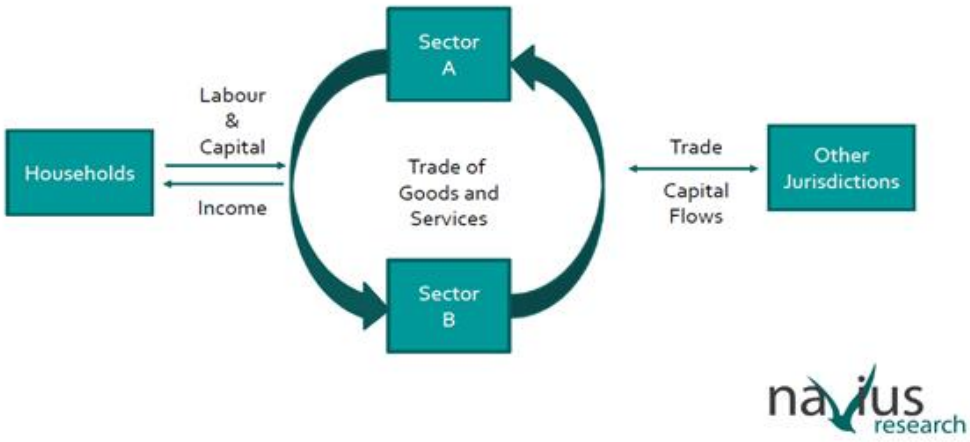
[19] Office of the Parliamentary Budget Officer. 2016. *The Impact of a Pan-Canadian Carbon Pricing Levy on PBO's GDP Projection*. https://www.pbo-pb.gc.ca/web/default/files/Documents/Reports/2018/Carbon%20Tax%20Levy/PBO_carbon_levy_impact__EN.pdf. This report used analysis by ECCC in 2018 for the GDP estimate of the GGPPA.

Appendix 1: Modelling tools and gross domestic product (GDP) definitions

The Government of Alberta's modeling systems are developed and hosted by Navius Research, Inc.[20] and operated by government staff. The main tool for the GHG projections, a macro-economic model called gTech, is a technology-rich computable general equilibrium model. It is built on Statistics Canada input-output tables and calibrated to the Environment and Climate Change Canada 2018 National Inventory Report (NIR). The model's projections match the Government of Alberta forecasts of economic activity and oil and gas production projections from the AER.

The gTech model includes a representative household in each region that provides labour and capital to production sectors and receives income in exchange. People in these households use their income for consumption and saving. Production sectors use labour, capital, and intermediate goods (i.e., energy and materials) to produce products that can be used domestically by households and other sectors, or can be exported to other regions.

The economic structure of gTech is as follows:



[20] Navius Research, Inc. is a consulting company that advises governments and organizations on the impact of climate and energy policy. In addition to providing analyses and modeling services to the Government of Alberta, Navius Research advises the governments of British Columbia, Saskatchewan, Ontario, New Brunswick, Nova Scotia, Environment and Climate Change Canada, the Canadian Association of Petroleum Producers, Clean Energy Canada, the Pembina Institute, among other clients.

The gTech model combines a detailed representation of energy-related technologies (from vehicles to fridges to crude oil extraction) with key economic transactions within the economy allowing a sophisticated assessment of most climate policies. gTech includes over 50 economic sectors and about 600 technologies in each region and can provide insight about technology switching as a response to economic and climate policies. The model allows simulating various forms of revenue recycling (such as household transfers, subsidies to renewable energy programs, corporate and labor income tax cuts, and technology funds) and more complex policies such as the elements of the CLP, low carbon fuel standards, and cap and trade systems.

The GHG emissions forecasts for the electricity sector are developed outside of the gTech model to provide extra detail for this sector, which is emissions-intensive with relatively few facility operators (decision makers). Results of detailed modeling from the Alberta Electricity System Operator (AESO) 2017 Long Term Outlook (LTO) were used as the main input for the CLP cases, supplemented with modeling from ECCC for the pre-2015 climate policies case. AESO's modeling is publically available and accounts for the specific coal-fired power plants in Alberta. ECCC results are also publically available and reflected expected generation mix under the pre-2015 policies. The federal carbon pricing backstop required additional assumptions for expected renewable generation; these assumptions were informed by power plant cost information from the AESO 2019 LTO and analysis of market-driven renewable generation reflected in the government's March 2019 platform document. The dynamics of the electricity sector in response to the evolution of climate policy is an area of continuous study with future updates highly likely.

The potential GHG emissions reductions from technology innovation funded through the CLP were also estimated outside of the gTech model. The CLP had several funding programs for innovation and staff at the ministry of Economic Development Trade and Tourism provided estimates of potential GHG reductions. Innovations that could further reduce emissions include use of solvents for in-situ production, increased use of carbon dioxide for enhanced oil recovery (EOR) and more digital oilfield technologies. These potential impacts are included when reporting future GHG emissions, but were excluded from the economic assessment. Such innovations would be expected to decrease the costs of the CLP.

Appendix 2: Assumptions for CLP policies

Topic	Scenario 1: 2015 Climate Policies
Carbon price	$15 per tonne for each year to 2030.
Carbon price coverage	Based on the Specified Gas Emitters Regulation (SGER) for industrial facilities that emitted over 100,000 tonnes CO_2e.
Free allocations (relief from carbon price) for large GHG emitters	SGER used benchmarks based on each facility's historic baseline. Assume that the regulation as of June 2015 remains through 2030 with benchmarks at approximately 88 per cent of each facility's historic baseline.
Cost containment	No cost containment.
Compliance flexibility limit and behavior	No limit.
Electricity generation mix	Based on forecasts from Environment and Climate Change Canada released in 2014.
EPC and Offset Credit supply	Offsets are estimated by historic trends between 2002 and 2015.
Future opt in of non-regulated facilities	Same assumption as CLP scenarios due to model limitations.
Conventional oil and gas	Excluded from SGER (unless large emitters).
Revenue reinvestment	Funds directed to technologies based on Climate Change and Emissions Management Corporations direction.
Methane regulation	None.
Impacts of Research and Innovation	No new technologies/major innovations. Carbon reinvestment assumptions based on Technology fund in June 2015.

Topic	Scenarios 2-3: CLP cases
Carbon price	$20 per tonne in 2017, $30 per tonne for each year 2018-2030. For CLP with $50 case, assume price increases to $40 per tonne in 2021 and $50 per tonne for 2022-2030.
Carbon price coverage	CO_2e emissions from all fuel sources, including methane, plus process emissions. Small oil and gas producers are exempt until 2023. Exemptions for marked fuel are not included in the modelling.
Free allocations (relief from carbon price) for large GHG emitters	The Carbon Competitiveness Incentive Regulation (CCIR) uses product-specific or other benchmarks to determine free allocations. The assumed benchmarks through 2030 reflect the CCIR as of November 20, 2018.
Cost containment	Assumptions are based on 2018 applications for cost containment. Assume impacts in 2023-30 are same as 2022 reported value.
Compliance flexibility limit and behavior	Assume credit use is limited to 60 per cent of compliance obligation. When supply exceeds demand, credit use is further limited to 85 per cent of the 60 per cent cap to account for some emitters not taking part in the credit market.
Electricity generation mix	Based on modeling by the Alberta Electricity System Operator 2017 Long term Outlook reference case, with adjustments by GoA modelers for $50 per tonne case using gTech results.
EPC and Offset Credit supply	Carbon offsets as estimated by past trends and estimated uptake for new protocols, The Emissions Performance Credits are based on past trends and facility forecasts.

Future opt in of non-regulated facilities	Assume all facilities in industries with any CCIR regulated facilities will opt in to the regulation starting in 2018.
Conventional oil and gas	Most facilities in the conventional oil and gas industries are exempt from carbon pricing until 2023. This is assumed in the analysis and in 2023 assume that all facilities opt in to CCIR and benchmarks are to account for mandated methane reductions.
Revenue reinvestment	Based on the CLP investment plans as of March 2018 (for Budget 2018).
Methane regulation	Assume implementation of Directive 60 based on the information provided by the Alberta Energy Regulator to Government of Alberta in July 2018.
Impacts of Research and Innovation	For economic impacts, the analysis assumes no new technologies or major innovations beyond current commercial availability. Carbon reinvestment assumptions combined with assumptions for low carbon technologies within model are used to capture impacts of research funding.

Topic	**Scenario 4: Federal carbon pricing backstop**
Carbon price	$20 per tonne in 2017, $30 per tonne for each year 2018, $40 per tonne in 2021 and $50 per tonne for 2022-2030.
Carbon price coverage	CO_2e emissions from all fuel sources, excluding methane, plus process emissions. Small oil and gas producers are assumed to opt into the output-based pricing system, starting in 2020. Exemptions for marked fuel are not included in the modelling.

Free allocations (relief from carbon price) for large GHG emitters	The output-based pricing system uses product-specific or other benchmarks to determine free allocations. The assumed benchmarks through 2030 reflect information as of October 2018.
Cost containment	None.
Compliance flexibility limit and behavior	Assume no limits but all offsets are provided by Alberta industries.
Electricity generation mix	Same as CLP cases. There are some differences in the output-based pricing system design compared to the CCIR but the impacts on electricity generation mix are assumed similar enough to have limited impact on the economic impacts reported here.
EPC and Offset Credit supply	Supply was not explicitly estimated for this case but revenue from the output-based pricing system will be reinvested in industry through technology funds, offsets or output-based pricing system credits.
Future opt in of non-regulated facilities	Assume all facilities in industries with any output-based pricing system regulated facilities will opt in to the regulation starting in 2020.
Conventional oil and gas	All facilities in the conventional oil and gas industries are assumed to opt into the output-based pricing system starting 2020.
Revenue reinvestment	Revenue from the federal fuel charge is returned to household as lump sum. Revenue from the output-based pricing system is directed to industry through technology funds.
Methane regulation	Assume implementation of Directive 60 based on the information provided by the Alberta Energy Regulator to Government of Alberta in July 2018.

Impacts of Research and Innovation	For economic impacts, the analysis assumes no new technologies or major innovations beyond current commercial availability. Carbon reinvestment assumptions combined with assumptions for low carbon technologies within model are used to capture impacts of research funding.

Assumptions that are the same in all scenarios	
Macroeconomic growth	Aligned with Treasury Board and Finance macro forecast for GDP and employment provided January 7, 2019
Oil price and production	Forecasts from the Alberta Energy Regulator (AER) in ST98 released in May 2019.
Natural gas price and production	Forecasts from the Alberta Energy Regulator (AER) in ST98 released in May 2019.
Electricity demand	Alberta Electricity System Operator 2017 Long Term Outlook.
Renewable fuel standard	Based on the Alberta's renewable fuel standard regulation as of 2012.

Climate policy assumptions for rest of Canada and U.S.

Federal fuel charges and output-based pricing system are assumed to start in 2019 for all provinces except Quebec, where cap and trade regulation is assumed, and British Columbia, which follows the carbon tax and reinvestment policies as of April 1, 2019.

Federal methane regulation is included for Saskatchewan and is not included for any other province for simplicity since other provinces have very small oil and gas methane emissions.

Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations as of November 2018 are assumed for all jurisdictions (including Alberta).

Appendix 3: Methodology for estimating the cost of climate policies on households

Climate policies affect households through different channels:

- **First,** climate policies that include carbon pricing increase the price of fossil fuel energies. The increase in the price of energy imposes a direct cost, which is equal to the amount of carbon tax households pay on their fossil fuel consumption.
- **Second,** the carbon price results in lower economic activities, lower capital gain, and lower business revenues, in particular for activities with high emissions intensity. All these factors could result in lower incomes for households.
- **Third,** some households are eligible to receive rebates that compensate part of their costs.
- **Fourth,** when revenue from carbon pricing is returned to households or corporations, or invested on clean energy and infrastructure, the revenue could result in higher economic activity and lower emissions.
- **Fifth,** climate policies resulting in lower emissions lead to better air quality and environmental impacts that positively affect households. All these effects need to be accounted for to fully capture the impact of climate policies on households.

A common theoretical approach is to look at the change in household aggregate utility[21] due to a climate policy. In practice, it is difficult to use this method since utility measures are not easy to interpret and compare with other measures.

To deal with this challenge, the concepts of compensating and equivalent variation, which convert utility measure to dollar values, are commonly used. Compensation variation (CV) calculates how much individuals need to be compensated due to a climate policy so they retain the same utility. Equivalent variation (EV) is a similar concept, but calculates the amount of income that make individuals equivalent to what they would be after a policy change affects prices.

[21] Utility is the satisfaction an individual gains from consuming various goods and services or leisure.

Another common measure is the change in household real consumption as a proxy for a change in household welfare. For more information on different welfare measures, their calculation methods, and their advantages and disadvantages, refer to the study published by the U.S. Energy Information Administration (EIA)[22].

In this analysis, a Computable General Equilibrium (CGE) model is used, and the change in household real consumption due to the Alberta's climate policy is used as a proxy for the change in households' welfare. The change in household real consumption due to policy change is calculated for 43 goods and services, and aggregated to estimate total effect on households. The change in total consumption provides the net total cost on households, which is then divided into direct costs, rebates, and other effects on household consumption.

The drawback of this approach is that consumption does not capture utility gained from non-market activities such higher environmental quality as a result of climate policies. Another drawback is that the CGE model used here does not have the capacity to estimate the effect on different types of households (i.e., households based on their income level). For simplicity, we assume a representative household (i.e., all households are identical and have similar incomes and preferences). For example, the model cannot separately estimate the impact on high- and low-income households.

[22] *EIA Working Paper Series: "Alternative Measures of Welfare in Macroeconomic Models"* https://www.eia.gov/workingpapers/pdf/welfare-vipin-wappendix.pdf

Appendix 4: Results

Table 1 Gross Domestic Product (GDP) (in 2018 dollars, billions)

	2020	2025	2030
Scenario 1: 2015 climate policies			
GDP (billions, 2018 dollars)	329.8	378.9	428.2
Scenario 2: CLP with carbon price at $30 per tonne through 2030			
GDP (billions, 2018 dollars)	327.8	376.7	425.6
Change relative to 2015 climate policies (billions, 2018 dollars)	-2.0	-2.2	-2.6
Scenario 3: CLP with price increasing to $50 per tonne in 2022 through 2030			
GDP (billions, 2018 dollars)	327.8	375.6	424.3
Change relative to 2015 climate policies (billions, 2018 dollars)	-2.0	-3.3	-3.9
Scenario 4: Federal carbon pricing backstop			
GDP (billions, 2018 dollars)	327.1	375.6	425.1
Change relative to 2015 climate policies (billions, 2018 dollars)	-2.7	-3.3	-3.1

Table 2: Forecast change in sectoral GDP, relative to 2015 Climate policies

GDP (billions, 2018 dollars)	2020	2025	2030
CLP scenario with price at $30			
Total economy	-2.0	-2.2	-2.6
Oil and gas	-0.4	-0.2	-0.5
Large emitters (non-oil and gas)	-0.2	-0.4	-0.4
Other sectors	-0.7	-0.5	-0.5
Commercial/ transportation/ services	-0.7	-1.1	-1.3

GDP, % change	2020	2025	2030
CLP scenario with price at $30			
Total economy	-0.6%	-0.6%	-0.6%
Oil and gas	-0.4%	-0.2%	-0.4%
Large emitters (non-oil and gas)	-1.9%	-3.7%	-2.6%
Other sectors	-1.3%	-0.7%	-0.7%
Commercial/ transportation/ services	-0.4%	-0.6%	-0.6%

GDP (billions, 2018 dollars)	2020	2025	2030
CLP with price increasing to $50			
Total economy	-2.0	-3.3	-3.9
Oil and gas	-0.4	-0.3	-0.7
Large emitters (non-oil and gas)	-0.2	-0.6	-0.5
Other sectors	-0.7	-0.6	-0.6
Commercial/ transportation/ services	-0.7	-1.8	-2.0

GDP, % change	2020	2025	2030
CLP with price increasing to $50			
Total economy	-0.6%	-0.9%	-0.9%
Oil and gas	-0.4%	-0.3%	-0.6%
Large emitters (non-oil and gas)	-1.9%	-5.1%	-3.9%
Other sectors	-1.3%	-1.0%	-0.9%
Commercial/ transportation/ services	-0.4%	-0.9%	-0.9%

GDP (billions, 2018 dollars)	2020	2025	2030
Federal carbon pricing backstop			
Total economy	-2.7	-3.3	-3.1
Oil and gas	-1.2	-0.5	-0.1
Large emitters (non-oil and gas)	-0.2	-0.5	-0.4
Other sectors	-0.6	-0.5	-0.7
Commercial/ transportation/ services	-0.8	-1.8	-1.8

GDP, % change	2020	2025	2030
Federal carbon pricing backstop			
Total economy	-0.8%	-0.9%	-0.7%
Oil and gas	-1.2%	-0.5%	-0.1%
Large emitters (non-oil and gas)	-1.5%	-4.0%	-3.1%
Other sectors	-1.1%	-0.8%	-1.0%
Commercial/ transportation/ services	-0.5%	-0.9%	-0.8%

Notes:

- *Oil and gas includes oil sands, conventional oil, natural gas, oil and gas services, refineries and pipelines.*
- *Large emitters (non-oil and gas) includes emissions-intensive trade-exposed industries – metal smelting, paper production, non-metallic minerals, chemicals, fertilizer, and electricity generation.*
- *Other sectors include mining, agriculture, forestry, light manufacturing, and construction*
- *Commercial/transportation/services includes a wide range of non-manufacturing services (financial, software development), retail, restaurants, and commercial transportation services such as freight and people movement by trucks, rail, air and transit, etc.*

Table 3. Economic impacts on households

Scenario 2: CLP scenario

	Total costs (million real 2018$)			Average cost per household (real 2018$)		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Direct cost	-438	-359	-314	-271	-205	-167
Household rebates	490	401	353	304	229	187
Other effects on household consumption	-1,414	-1,407	-1,599	-875	-805	-849
Total cost	**-1,361**	**-1,366**	**-1,561**	**-843**	**-781**	**-829**

	2020	**2025**	**2030**
% Change in employment	-0.4%	-0.4%	-0.4%
Change in employment (jobs)	-10,017	-9,229	-10,374
Change in unemployment rate	0.4%	0.4%	0.4%

Scenario 3: CLP with price increasing to $50

	Total costs (million real 2018$)			Average cost per household (real 2018$)		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Direct cost	-438	-590	-513	-271	-337	-272
Household rebates	490	401	353	304	229	187
Other effects on household consumption	-1,414	-2,073	-2,338	-875	-1,186	-1,241
Total cost	**-1,361**	**-2,262**	**-2,498**	**-843**	**-1,294**	**-1,326**

	2020	**2025**	**2030**
% Change in employment	-0.4%	-0.5%	-0.5%
Change in employment	-10,017	-14,405	-15,909
Change in unemployment rate	0.4%	0.6%	0.6%

Scenario 4: Federal carbon pricing backstop

	Total costs (million real 2018$)			Average cost per household (real 2018$)		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Direct cost	-436	-590	-508	-270	-337	-270
Household rebates	1,267	1,910	1,762	784	1,093	936
Other effects on household consumption	-1,731	-2,165	-2,190	-1,072	-1,238	-1,163
Total cost	**-900**	**-844**	**-936**	**-557**	**-483**	**-497**

	2020	**2025**	**2030**
% Change in employment	-0.4%	-0.5%	-0.5%
Change in employment (jobs)	-10,404	-13,788	-14,268
Change in unemployment rate	0.4%	0.4%	0.4%

Notes:

- *Average cost is calculated as total costs divided by total households. Costs will vary significantly by household characteristics.*
- *Direct cost refers to carbon tax payments for gasoline, diesel and natural gas by households. Household rebates are the funds government provides directly to households based on income / household characteristics. Other effects on household consumption include increased costs from the carbon tax on producing goods and services, rebates for energy efficiency or renewables, increased government spending for new transit, and the cost of decreased household consumption due to lower economic growth.*
- *Employment is defined using Statistics Canada definition from the Labour Force Survey as the, "number of persons who, during the reference week, worked for pay or profit, or performed unpaid family work or had a job but were not at work due to own illness or disability, personal or family responsibilities, labour dispute, vacation, or other reason."*

Table 4: Greenhouse gas emissions in megatonnes carbon dioxide equivalent (CO_2e)

	2020	2025	2030
Historical forecast (ECCC 2015), adjusted*	291	304	314
2015 climate policies	282	297	303
CLP scenario	268	265	269
Change relative to 2015 climate policies	-14	-32	-34
Carbon tax alone	-1	-5	-5
Rest of CLP measures	-13	-27	-29
CLP with price increasing to $50	268	261	265
Change relative to 2015 climate policies	-14	-36	-38
Federal carbon pricing backstop	267	263	268
Change relative to 2015 climate policies	-16	-34	-35
Potential additional GHG change from the impacts of research and innovation.**	-1	-12	-24

* Historical Forecast based on *Canada's Second Biennial Report on Climate Change*, ECCC (2015) with Government of Alberta adjustments. The Government of Alberta previously reported emissions relative to a third party forecast, Environment and Climate Change Canada that was available in 2015, before the CLP was enacted and those associated policies were built into the forecasts. Since the emissions forecasts was published in 2015, ECCC has undergone some methodological changes and re-stated emissions inventories accordingly. The economic model used to perform the analysis is calibrated to the National Inventory Reports with the methodological updates taken into account. To be able to compare those past forecasts to the results presented in this report, the 2015 ECCC emissions forecast for Alberta is slightly adjusted and can be used as a historical point of reference.

*Potential GHG change from the impacts of research and innovation were estimated based on the CLP at $30 per tonne (see Appendix 1). Estimated impacts from research and innovation for the other climate policies were not available. Due to limited information and higher uncertainty these GHG estimates, impacts of research and

innovation were excluded from the economic assessment for all cases. The information is provided here to indicate a potential range in GHG reductions that accounts for this impact and a similar range may also apply to the other scenarios.

Table 5: Greenhouse gas emissions in megatonnes carbon dioxide equivalent (CO2e) by scenario and sector, excluding potential reductions from research and innovation.

Scenario 1: 2015 climate policies

Emissions	**2020**	**2025**	**2030**
Total economy	**282**	**297**	**303**
Oil and gas	150	159	167
Large emitters (non-oil and gas)	59	62	57
Other sectors	23	24	24
Commercial/ transportation/ services	35	38	41
Households (homes and cars)	16	14	14

Scenario 2: CLP scenario

Emissions	2020	2025	2030
Total economy	268	265	269
Oil and gas	142	148	156
Large emitters (non-oil and gas)	54	44	37
Other sectors	22	22	22
Commercial/ transportation/ services	34	37	40
Households (homes and cars)	16	14	14

Change relative to 2015 climate policies	2020	2025	2030
Total economy	-14	-32	-34
Oil and gas	-7	-11	-11
Large emitters (non-oil and gas)	-5	-18	-20
Other sectors	-1	-2	-2
Commercial/ transportation/ services	-1	-1	-1
Households (homes and cars)	0	0	0

Scenario 3: CLP with price increasing to $50 per tonne

Emissions	2020	2025	2030
Total economy	268	261	265
Oil and gas	142	146	154
Large emitters (non-oil and gas)	54	43	36
Other sectors	22	22	22
Commercial/ transportation/ services	34	37	39
Households (homes and cars)	16	14	14

Change relative to 2015 climate policies	2020	2025	2030
Total economy	-14	-36	-38
Oil and gas	-7	-13	-13
Large emitters (non-oil and gas)	-5	-19	-21
Other sectors	-1	-2	-2
Commercial/ transportation/ services	-1	-2	-2
Households (homes and cars)	0	0	-1

Scenario 4: federal system

Emissions	2020	2025	2030
Total economy	267	263	268
Oil and gas	141	148	155
Large emitters (non-oil and gas)	54	43	38
Other sectors	22	22	22
Commercial/ transportation/ services	34	37	39
Households (homes and cars)	16	14	13

Change relative to 2015 climate policies	2020	2025	2030
Total economy	-16	-34	-35
Oil and gas	-9	-11	-12
Large emitters (non-oil and gas)	-5	-19	-19
Other sectors	-1	-2	-2
Commercial/ transportation/ services	-1	-2	-2
Households (homes and cars)	0	0	-1

Notes:

- *The change in emissions might not add up due to rounding.*
- *Oil and gas includes oil sands, conventional oil, natural gas, oil and gas services, refineries and pipelines.*
- *Large emitters (non-oil and gas) includes emissions-intensive trade-exposed industries – metal smelting, paper production, non-metallic minerals, chemicals, fertilizer, and electricity generation.*
- *Other sectors include mining, agriculture, forestry, light manufacturing, and construction.*
- *Commercial/transportation/services includes a wide range of non-manufacturing services (financial, software development), retail, restaurants, and commercial transportation services such as freight and people movement by trucks, rail, air and transit, etc.*

Appendix 5: Gross domestic product estimates

Gross domestic product (GDP) as the main measure to estimate the economic impacts of the CLP. There are three different methods to calculate GDP.

- **Production approach:** This is also known as the value-added approach. Businesses produce and sell some final goods and services but also use some intermediate goods in their production process. To avoid double counting, in this approach the value of intermediate goods is subtracted from total value of outputs produced in an economy.
- **Income approach:** We add payments to factors of production such as labour, capital and land (i.e., labour income, corporate profits, investment income, own-business payments) to calculate the value of final goods and services.
- **Expenditure approach:** This calculates the value of the final consumption of goods and services by households, corporations, and government. GDP by expenditure is the sum of household consumption, government spending, business investment in equipment used in production process (excluding intermediate goods), and net exports (i.e., export minus import).

All three methods should lead to the same GDP estimate in theory, but in practice there might be some differences due to data availability and methodology. In our analysis, we use income-based GDP to estimate total and sectoral GDP impacts.