Modelling the Impact of the Climate Leadership Plan & Federal Carbon Price on British Columbia's Greenhouse Gas Emissions

Methods and Results of a Greenhouse Gas Forecasting Analysis

SUBMITTED TO

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SUBMITTED BY

Michael Wolinetz
Navius Research Inc.
1199 West Hastings Street
PO Box 48300 Bentall,
Vancouver BC V7X 1A1

Phone: 778-970-0355
Email: Michael@NaviusResearch.com

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1. Introduction and Summary

In August 2016 the Government of British Columbia released its Climate Leadership Plan (CLP). That plan was announced as the first step in a series of actions British Columbia (BC) would be taking to meet the province's legislated 2050 emissions reduction target of 80% below 2007 levels.

This report presents the method and results of an analysis that forecasts the impact of BC's CLP on provincial greenhouse gas (GHG) emissions from the present (2016) to 2050. The model covers all provincial GHG emissions, except those resulting from human induced changes to forest carbon.

The results show that with the implementation of all policies described in the CLP and the recently announced federal carbon price floor (50 $/t$CO_2$e by 2022), BC's emissions will be above the 2050 target as well as the 2020 target (33% below 2007 levels). By providing a breakdown of the remaining emissions by sector, this analysis can help identify what additional GHG reduction policies are required to achieve these targets.

2. Methods

2.1. Overview

This analysis uses an energy-economy model (CIMS) to simulate how energy prices, real and perceived technology costs, and policies are likely to affect BC's GHG emissions from the present to 2050. This method allows us to understand whether BC's proposed policies will significantly change GHG emissions from current trends, and put BC on course to reach its legislated GHG emissions targets.

The methodology and model used in this analysis is essentially the same as that used in the report titled "A Plan for Climate Leadership in British Columbia", submitted by Navius Research to Clean Energy Canada in October 2015.

In this report, we provide a brief review of the drivers of GHG emissions used (e.g. economic growth). Specifically, we describe the GHG policy scenarios we analysed and our assumptions for liquefied natural gas (LNG) production and upstream natural gas activity. Additionally, we also explain our rational for excluding human-caused changes to net-forest carbon emissions.

We simulated the impact of two different policy scenarios on BC's GHG emissions from the present to 2050. The first scenario is the reference scenario, which represents the impact of emissions policies in BC that were implemented before August 2016.

The second scenario includes the policies announced in BC's 2016 CLP and the federal carbon price schedule announced on October 3, 2016. This scenario includes the policies that are well described in the CLP, as well as policies that are not well described or whose implementation seems uncertain. The scenarios are described in greater detail below.

2.2. The Reference Scenario

The basic drivers of GHG emissions in BC in the reference scenario are the same as was used in the 2015 analysis for Clean Energy Canada by Navius. They include a growing population and economy (population growth averages 1.1% per year, GDP growth averages 2.1%/yr). Energy commodity prices are from the 2015 Energy

Information Agency's reference forecast:[1] natural gas prices rebound from roughly 3 $/GJ today to 6 $/GJ in 2030 and 10 $/GJ in 2050 (real 2013 USD), and oil prices rebound to 100 $/bbl by 2030, eventually reaching 170 $/bbl in 2050 (West Texas intermediate, real 2013 USD).

Consistent with the Climate Leadership Team's assumptions,[2] LNG production reaches 12 Mt/yr in 2020, rising to 36 Mt/yr in 2025, and 48 Mt/yr from 2030 onward. This production forecast is similar to the combined production of all phases of Pacific NorthWest, LNG Canada and Woodfibre LNG's projects. However, this analysis does not explicitly represent these projects and the process technologies of these facilities. We assume 75% of the LNG export volume is produced in BC and is additional to current production of natural gas produced in BC. Natural gas production rises to 5.4 Bcf/day in 2020, and plateaus at 9.1 Bcf/day from 2030 to 2050. By 2030, most production comes from tight gas resources (e.g. Montney). Methane losses upstream of LNG facilities from leaks and vents are calibrated to the BC GHG inventory and account for roughly 0.5% of gas production. Natural gas production not for LNG export remains relatively constant at 4.2 Bcf/day out to 2050.

The reference scenario includes most current energy and emissions reduction policies that were implemented in BC before 2016:

- The carbon tax on combustion emissions at 30$/t$CO_{2e}$.
- The Clean Energy Act, which requires 93% of electricity generation in BC to come from renewable non-emitting sources. It also requires that BC have no net-electricity imports.
- The Renewable and Low Carbon Fuel Regulation Requirement (i.e. the fuel standard) that mandates a 10% reduction in the lifecycle GHG emissions of transportation fuels relative to 2010 by 2020.
- Building codes that require new buildings and homes to be more energy efficient than standard construction practices prior to 2005.
- The Clean Energy Vehicle Program, which offers a $5,000 subsidy for electric and plug-in hybrid vehicles. We assume the subsidy runs to 2020.
- The current LNG performance standard, which for simplicity, we have assumed requires an average LNG production GHG intensity of roughly 0.16 tCO_2e/tLNG

[1] US Energy Information Administration, 2015 Annual Energy Outlook. Navius extrapolated price forecasts from 2040 to 2050.

[2] Personal Correspondence, B.C. Government. 2015

(excluding upstream emissions). Note that we do not model compliance through the use of offsets and technology fund contributions that would result in larger average emissions intensity.

- A landfill gas regulation that requires the control of landfill gas emissions from medium and large landfills.
- Current efforts from local governments to divert organic waste away from landfills, resulting in a diversion rate of 45% by 2020
- Federal light and heavy duty vehicle emissions standards and minimum energy performance standards for appliances.
- Note that we did not include the carbon neutral government requirements in the reference scenario. Unfortunately, the model does not explicitly represent emissions of government entities separately from other entities, and it does not represent forest carbon emissions, which have been a source of offsets to the government.
- We did not model a national clean fuel standard. At the time of publishing the report, Canada had just announced a clean fuel standard and regardless of timing there are insufficient details to determine the impact on B.C.'s greenhouse gas emissions.

2.3. The CLP & Federal Carbon Price Scenario

This is the same as the reference scenario, except that it includes the policies described in the CLP as well as the recently announced federal carbon price floor. As of the writing of this report, these are the policies that will likely influence BC's greenhouse gas emissions over the study period.

To define the scope of this scenario, we first excluded all policies in the CLP that are non-material in terms of GHG reductions (Appendix A.). We then assessed each of the material GHG policies to see if they have implementation dates, committed funding (if appropriate), and sufficient detail on the policy instrument to model. We included in this scenario the policies that met these criteria in the CLP & federal carbon price scenario. The policies that are missing some of the details described above are still included in the scenario, but we made assumptions to characterize them where necessary. The policies are described below and are listed in Table 3.

Policies that will materially change GHG emissions and are well described in the CLP report:

- A commitment to reduce leaked and vented methane emissions from natural gas production. Specifically we modelled a 45% reduction in the methane emissions intensity of existing natural gas extraction and processing facilities. We extended this intensity target to new facilities built after 2021.

- Increased stringency for the fuel standard, requiring a 15% reduction in the carbon intensity of transportation fuel by 2030 relative to 2010. We also include incentives for increased LNG use by marine vehicles, mining vehicles and remote power generation, resulting in GHG abatement of 0.3 $MtCO_2e/yr$ by 2030. However, this policy facilitates achieving the 15% carbon intensity reduction, but does not provide additional GHG reductions. In other words, because the fuel standard sets a binding cap on transportation emissions intensity, other policies that reduce transportation emissions from one end-use (e.g. marine) simply reduce the abatement required from other end-uses (e.g. road).

- Regulations that require more efficient natural-gas space and water heating in homes and buildings. By 2020, new furnaces and boilers must be at least 90% efficient. By 2025, new natural gas water heaters must have an energy factor of at least 84.

- A net-zero energy buildings standard for new homes and buildings built after 2032. Building envelopes must have a thermal demand intensity that would allow net-zero energy consumption if the building were equipped with highly efficient mechanical systems (e.g. heat pumps) and on-site renewable electricity generation (e.g. solar photovoltaic).

Policies that are in the CLP report, but are not well described

- A commitment to electrify upstream natural gas production. We modelled capital cost support and electricity rates that make electrically powered compression for natural gas extraction and processing cost comparable with natural gas powered compression. We set the incentive so this policy would have the impact estimated by the BC government in the CLP: a reduction of roughly 2.4 $MtCO_2e$ by 2030.[3]

- A requirement for new gas-fired industrial boilers installed after 2020 to be at least 90% efficient.

- A requirement to divert at least 90% of organic waste away from landfills by 2030.

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[3] The BC government expects that current electrification projects in the Montney will reduce emissions by 1.6 $MtCO_2e/yr$. This policy achieves an additional reduction of 2.4 $MtCO_2e/yr$, resulting in a total reduction of 4 $MtCO_2e/yr$ compared to a scenario with no electrification, as per the CLP document.

- An extension of the $5,000 Clean Energy Vehicle subsidy to 2030 and capital incentives for freight vehicles using natural gas engines. Both policies facilitate achieving the 2030 fuel standard, but do not provide additional GHG abatement in 2030. Nonetheless, the policies can help make alternative fuel vehicles more mainstream technologies, which may result in additional abatement after 2030.
- A commitment to use natural gas electricity generation only where significant costs or issues of system reliability require it. We modelled this statement by allowing single cycle gas turbines to be used for peak and reserve power, generating no more than 2.5% of annual electricity. No other gas-fired generation is allowed.

The federal carbon price floor:

- We assume BC's carbon tax will align with the federal carbon price floor. Under this assumption, the carbon tax will rise to $\$40/tCO_2e$ in 2021 and $\$50/tCO_2e$ in 2022. The price and coverage remain fixed thereafter and is not adjusted to account for inflation (i.e. the real value of the carbon tax declines as other prices rise from inflation).

2.4. Omission of Forestry Emissions

Because the CIMS model does not represent forest carbon dynamics, the human impact on net-forest carbon emissions is not part of this analysis. These emissions are influenced by human activities such as deforestation, afforestation or forest management. This omission reduces current emissions in our scenarios by roughly 3 $MtCO_2/yr$ relative to the provincial emissions inventory report. It also means we exclude the BC government's announcement that improved forest management will reduce annual emissions by 12 Mt/yr by 2050, and we do not represent any offsets of GHG emissions from forest carbon management, from government or other entities.

3. Results

Figure 1 shows BC's GHG emissions (not including human-induced changes to forest carbon flows) in each of the scenarios. Under the policies in the reference scenario, GHG emissions rise to roughly 76 $MtCO_2e/yr$ by 2030 and remain there until 2050. A significant driver of the emissions is the activity in the LNG and natural gas sectors.

The policies in the CLP & federal carbon price scenario reduce the rate at which emissions increase to 2030, with emissions peaking at 68 $MtCO_2e/yr$ in that year. From 2030 to 2050, emissions decline somewhat to 66 $MtCO_2e/yr$. Both scenarios fall short of meeting BC's legislated GHG emissions targets for 2020 and 2050 (-33% and -80% from 2007 levels respectively). Similarly, they do not achieve a 2030 target equal to Canada's national target of -30% from 2005 levels. Even if this analysis had included human-induced changes to forest carbon, the BC government's stated reduction of 12 $MtCO_2e/yr$ in 2050 resulting from improved forest management would still leave provincial emissions roughly 40 $MtCO_2e/yr$ above the legislated target. Table 1 contains the numeric results shown in the figure while Figure 2 shows emissions by sector in each scenario.

Figure 1: British Columbia's GHG Emissions by Scenario (Excluding Afforestation, Deforestation and Forest Management)

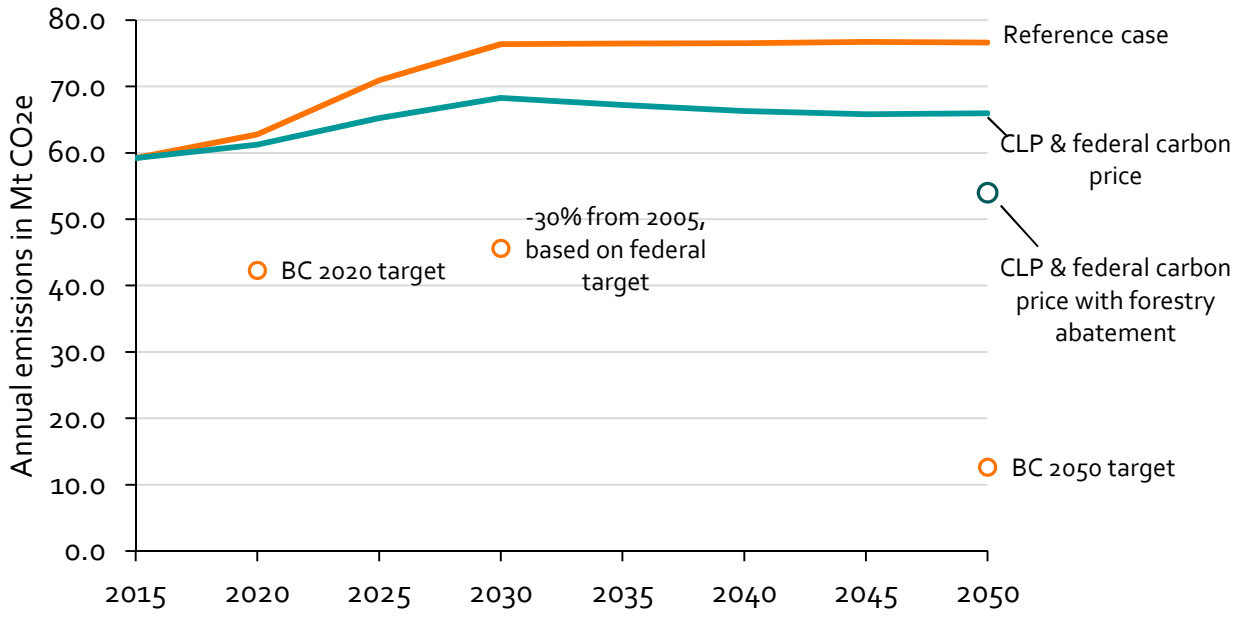


Table 1: British Columbia's GHG Emissions by Scenario and Targets ((Excluding Afforestation, Deforestation and Forest Management), $MtCO_2e/yr$

	2020	2025	2030	2035	2040	2045	2050
Reference case	62.8	70.9	76.4	76.5	76.5	76.7	76.7
CLP & federal carbon price	61.2	65.2	68.3	67.2	66.3	65.8	66.0
BC 2020 and 2050 target	42.3						12.6
-30% from 2005, based on federal target			45.6				

Figure 2: GHG Emissions by Sector and Scenario

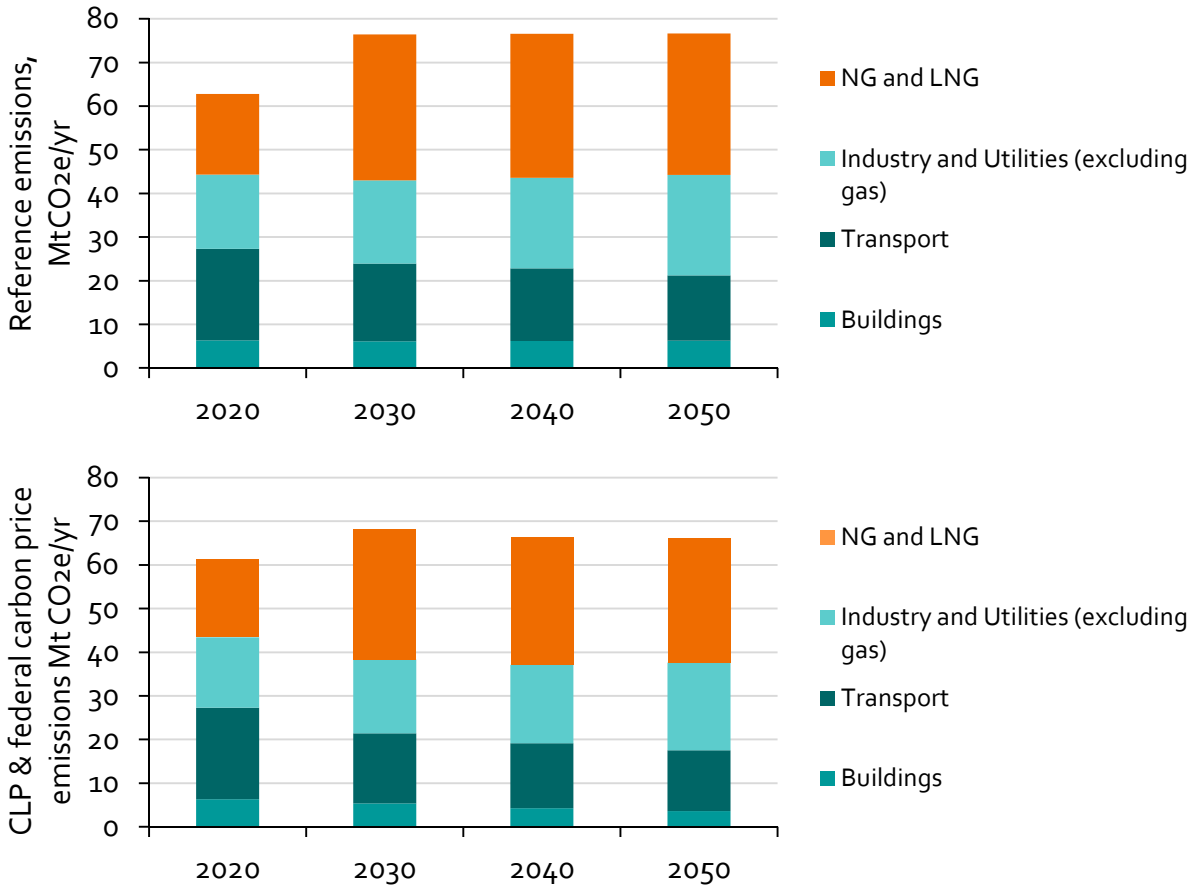
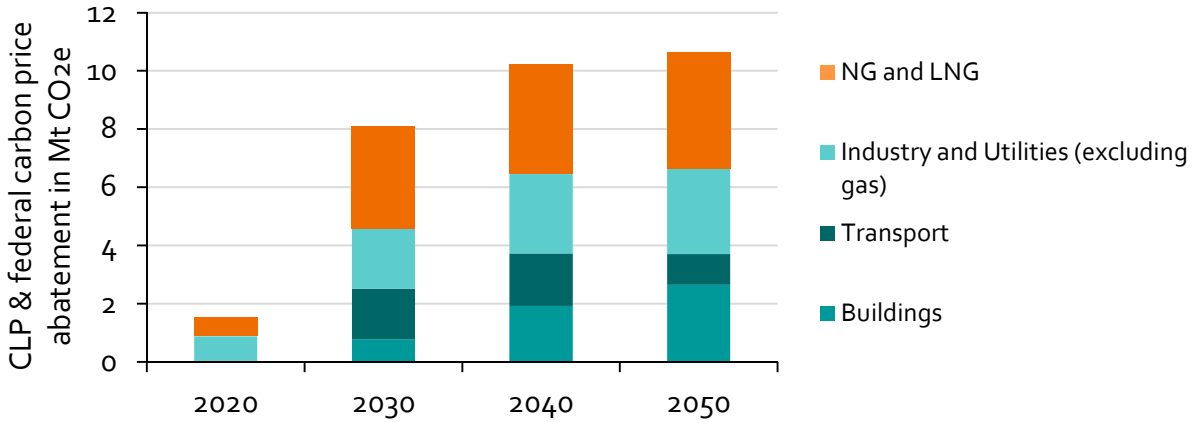


Figure 3 shows GHG abatement from the reference scenario in CLP & federal carbon price scenario. Abatement is shown relative to the reference scenario emissions in each forecast year and does not represent a change from current emissions. Abatement from the natural gas and LNG sectors in the CLP scenario is due to reduced methane emissions and increased electrification of natural gas production and processing. Abatement from industry and utilities is driven by the additional constraint

on the electricity sector (i.e. at most 2.5% non-renewable generation rather than 7%) and the requirement for high-efficiency industrial gas-fired boilers. Abatement in the transportation sectors is greatest in 2030, when the stringency of the fuel standard plateaus. Abatement declines thereafter because some of the changes brought about by that policy occur at a later date in the reference scenario (e.g. electrification of light-duty vehicles and increased use of natural gas heavy-duty vehicles occurs sooner in response to the CLP). Finally, GHG abatement from buildings increases during the forecast as the total stock of new high-efficiency buildings and heating appliances increases.

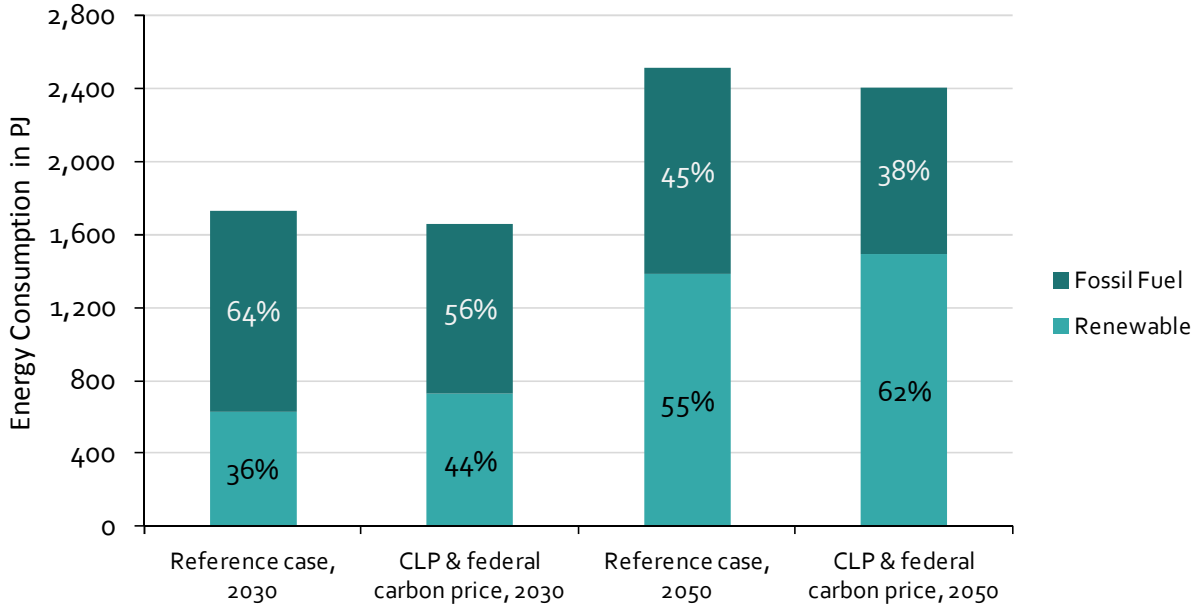
Figure 3: GHG Abatement by Sector and Scenario from Reference Emissions in Each Year



Increased use of renewable energy is an important means of reducing emissions, and so we consider what this policy package implies for a transition to renewable energy in BC. Figure 4 shows the renewable fuel share of primary energy consumption in BC in 2030 and 2050. Renewable fuel includes biomass and biofuel (measured by energy content) and wind, hydro and solar energy (measured as equivalent to the electricity produced from these sources). Primary energy consumption includes 100% of energy consumed in BC: all fossil fuel and renewable energy consumption. However, it excludes consumption of energy carriers like electricity or hydrogen (i.e. secondary energy that is produced from the transformation of primary energy).

The renewable fuel share increases between 2030 and 2050 in both scenarios due to increased electricity demand (primarily renewable) and the ongoing trend towards increased biomass waste consumption in pulp, paper and wood products manufacturing. The stronger policies in the CLP & federal carbon price scenario further reduce primary energy consumption and further increase renewable energy consumption. By 2050, the implementation of all policies in the CLP in conjunction with the federal carbon price floor increases the renewable energy share to 62%.

Figure 4: Fossil vs. Renewable Energy Consumption by Scenario in 2030 (left) and 2050 (right)



Our model confirms that the government's reduction estimates relative to the reference scenario are reasonable (see Table 2). Differences between abatement by sector in our analysis and in the CLP likely exist due to different assumptions for sector activity, energy prices, and policy specification. The CLP, being a public facing document, does not communicate those assumptions in detail, meaning we could not replicate them accurately. The primary difference in the abatement forecast comes from transportation emissions. Unfortunately, due to the limited description of transportation policies in the CLP, it is impossible to explain this difference. It likely exists due to differing interpretations of how transportation energy consumption will evolve with and without the increased stringency of B.C.'s low-carbon fuel standard.

Table 2: GHG abatement ($MtCO_2e$) by sector in the Climate Leadership Plan compared with this analysis

	Climate Leadership Plan	This Analysis
NG & LNG	5.0	4.0
Industry & Utilities	2.0	2.9
Transport	3.0	1.0
Buildings	2.0	2.7
TOTAL	**12.0**	**10.6**

4. Conclusion

This analysis demonstrates that the policies in the CLP combined with the federal carbon price floor are not currently strong enough to put BC on a path towards its 2050 emissions target of 12.6 $MtCO_2e/yr$ which is an 80% reduction from 2007 levels. Excluding the forest sector, the net result of actions in the CLP combined with the federal carbon price floor lead to a net increase in total emissions by 2050 to 66 $MtCO_2e/yr$. Even with the CLP stated mitigation from forests, total net emissions are 54 $MtCO_2e/yr$.

The proposed policies combined with the federal carbon price floor, excluding the forest sector actions, will achieve modest GHG reductions from transportation and buildings as well as utilities and industry, and slightly increase the proportion of renewable energy consumption in BC. Relatively large increases in emissions are projected from the growth of the LNG and natural gas sectors, even with constraints on methane emissions and the electrification of some gas extraction facilities.

Although there is uncertainty in our assumptions, it is likely that that BC's GHG emissions will be above its legislated targets based on the climate policies modelled. For example, there is uncertainty in how many of the policies included in this analysis will be fully implemented, but this uncertainty would only increase our emissions forecast. On the other hand, the emissions forecast could be lower if we have overestimated the rate at which LNG and natural gas production will grow.

Appendix A: Detailed Policy List

Table 3 lists the policies noted in the CLP that were not included in this analysis and provides a rational for their exclusion.

Table 3: Excluded Policies

Sector	Policy	Rational for Exclusion
Industry & Utilities	Efficient electrification: Allow BC Hydro to expand its demand side management program	The policy is non-compulsory and has no funding attached to it yet. Because other policies will keep electricity generation GHG emissions low, changing electricity demand will not significantly affect emissions.
Industry & Utilities	Expanding Incentives for Efficient Gas Equipment: Allow Fortis to expand its demand side management program	Other policies already regulate the efficiency of gas-fired boilers and home appliances, so this will have little additional impact.
Forestry & Agriculture	Enhancing the Carbon Storage Potential of B.C.'s Forest	The modelling framework of this analysis does not account for forest carbon. However, its impact should be considered additional to these results.
Natural Gas	Regulating carbon capture and storage (CCS) Projects	This policy is just a commitment to provide the regulatory framework under which CCS could happen.
Transport	Support vehicle charging development for zero emission vehicles	This policy just proposes to develop regulation to allow for charging stations to be deployed.
Transport	10-year plan to improve B.C. transport network	Not a new policy. Transit and transport infrastructure development is already occurring in the reference scenario.
Forestry & Agriculture	Nutrient Management program	These are monitoring and pilot projects only
Buildings	Refreshing the Climate Action Charter for Communities	This policy includes no additional funding or jurisdiction for communities to reduce GHG emissions.
Public Sector	Promote use of low-carbon and renewable materials in infrastructure	Specifically, requires some use of portland lime cement for some public buildings: the emissions impact will be very small and could occur without policy, as portland lime cement is already used in other regions.
Public Sector	Reduce emissions and planning for adaptation in the public sector	Not materially different from existing carbon neutral government initiatives. There may be some impact not already captured in the analysis, but it will small relative to total emissions.

Table 4 and Table 5 list the detailed policies and policies that required additional assumptions included in the CLP and federal carbon price scenario.

Table 4: Detailed policies included

Sector	Policy	Rational for inclusion
Natural Gas	Reduce methane emissions by 45% by 2025	Contains both date, targeted reduction and intent to regulate.
Transport	Increase LCFS from 10% to 15% by 2030	Contains date, targeted reduction, existing regulation and intent to increase regulation.
Buildings	Increase efficiency of gas fire places, heat pumps by 2020 and efficiency of natural gas water heaters by 2025.	Contains date and intent to regulate.
Buildings	Encourage development of net-zero buildings built after 2032.	Contains date, target and intent to regulate.

Table 5: Policies that required additional assumptions

Sector	Policy	Rational for Inclusion in low-detail section
Natural gas	Upstream natural gas electrification	Potential for material reductions, but lacking detail on date and funding.
Industry & Utilities	New energy efficiency standards for gas fired boilers	Potential for material reductions, but missing detail on date and targets.
Industry & Utilities	Waste to resource strategy	Potential for material reductions, but missing detail on regulation and timing.
Transport	Incentive for renewable natural gas	Potential for material reductions, but missing detail on budget and timing. GHG reductions captured under the LCFS.
Transport	Incentive for purchasing an EV vehicle	Potential for material reductions, but missing detail on budget and timing. GHG reductions captured under the LCFS.
Industry & Utilities	Making B.C.'s incremental electricity 100% renewable	Potential for material reductions, but missing detail on budget, timing and regulation.