Assessment of the Proposed Canada-Wide Clean Fuel Standard

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Executive Summary

The Canada-wide Clean Fuel Standard (CFS) was proposed in 2016 by the Canadian government as part of the Pan-Canadian Framework on Clean Growth and Climate Change. The proposal aims to limit the carbon intensity (CI) of regulated fuels over their lifecycle, from production through to end-use. Unlike CFS's in place elsewhere, the new proposal covers all forms of fossil fuel, including liquid fuels (i.e., gasoline), gaseous fuels (i.e., natural gas) and solid fuels (i.e., coal). It is intended to be set at the national level, with a goal of reducing 30 megatonnes (MT) nationally of annual greenhouse gas (GHG) emissions by 2030.

We first review a number of problems with the proposed policy.

(a) Introduction of the CFS represents an abandonment of the government's main argument for carbon pricing. Emission pricing can be an efficient way of reducing GHG emissions but not if costly regulations are also introduced that force emitters to adopt strategies that far exceed the carbon tax rate.

(b) The name of the policy is misleading since it is not a mechanism for improving air quality. With respect to pollution reduction Canadians have already achieved clean usage of fuels. Despite substantial increases in national fossil fuel consumption since the 1970s, emissions from motor vehicles and industrial activity have fallen sharply due to technological improvements. Violations of our stringent air quality standards are now very rare in Canada and the CFS is superfluous to maintaining this outcome.

(c) Despite its cost, the CFS will accomplish relatively little, especially in the context of a growing economy.

(d) Depending on options for compliance the CFS may end up being even worse for the environment than conventional fuels.

There are a number of existing estimates of the implications for fuel prices of the CFS. The Canadian Energy Research Institute estimates potential natural gas cost increases of over 60%, and fuel price increases of 5-11%. However these cost increases are inconsistent with the planned relative burden sharing between gaseous and liquid fuels, and the availability of permits at the stated backstop prices make it unlikely the percentage reductions in CI of fuels will be achieved. Under various implementation scenarios the overall emission reductions mostly come from the effects of fuel price increases with the CI contributing a smaller portion depending on how much compliance is attained through permits purchases rather than changes to the fuel blends. While it is possible to achieve the 30 MT target overall on a one-time basis, it is not possible to do so while focusing the compliance burden on liquid fuels, and the reductions in emissions from the CFS are likely to be completely offset by population and economic growth well before 2030.

We examine an implementation strategy that is consistent with the 30 MT target and with the relative burden sharing goals between sectors as they have been put forward during consultations by the federal government. We find that the costs to Canadians of the CFS far exceed the environmental benefits. Using the maximum social cost of carbon estimate in the current federal carbon pricing system to value the benefits of emission reductions, Canadian businesses will pay approximately $6 in CFS compliance costs for every $1 of environmental benefits achieved. We estimate the proposed CFS regulation will lead to approximately 30,000 job losses nationally and will put approximately $22 billion of capital at risk of exiting the country to avoid investment losses.

The net losses of the policy annually amount to about $440 per employed person and will increase combined federal and provincial budget deficits by over $7 billion. If the policy is structured to be fiscally neutral there will need to be additional spending cuts or new taxes to eliminate the deficit consequences, which would add to the economic costs.

Notwithstanding these costs the emission reduction effects of the policy will be completely offset by a 7% increase in the size of the Canadian labour force (compared to a 2016 base). Since the Canadian population typically grows by about 1% per year and the government has undertaken to increase the rate of immigration to the workforce the effects of the CFS will have been completely nullified well before 2030. If the government intends the emission cut to be permanent it will need to substantially tighten the requirements of the policy, however doing so will worsen the cost-benefit ratio further.

Assessment of the Proposed Canada-Wide Clean Fuel Standard

1 Background: The Proposed Clean Fuel Standard

The Canada-Wide Clean Fuel Standard (CFS) was proposed in 2016 by the Canadian government as part of the Pan-Canadian Framework on Clean Growth and Climate Change. The proposal aims to limit the carbon intensity (CI) of regulated fuels over their lifecycle, from production through to end use. CI is measured in grams per CO2 equivalent per megajoules of energy (gCO2/MJ). For example, California's CFS mandates that the CI for gasoline be below 79.55 gCO2/MJ by end of the 2030 (California Air Resources Board, 2018). The Canadian CFS envisions a CI reduction in liquid fuels of approximately 10 to 12% by 2030 (CERI 2019).

While many details remain to be worked out, the goal of the CFS is to cut 30 megatonnes (nationally) of annual greenhouse gas (GHG) emissions by 2030. Compliance options will include some scope to trade credits among affected industries, however the main option for compliance will be the blending in of renewable fuels. The regulation will exempt aviation fuels, fossil fuels used as a feedstock in industrial processes, exported fuels and coal used in electrical generating stations covered under existing coal phase-out rules (CERI 2019).

British Columbia has had a CFS since 2011. In the United States, California and Oregon started similar programs in 2011 and 2016, respectively (California Air Resources Board,2018; Oregon State Department of Environmental Quality, 2020).

Though the CFS proposed by the Canadian government has similarities to those currently adopted in other jurisdictions, there are two key differences: it is a national-level regulation, and it includes a broader spectrum of fuel types, as it covers liquid fuels (e.g., gasoline and diesel), gaseous fuels like natural gas and propane, and solid fuels like coal (Environment and Climate Change Canada, 2016). In contrast, all CFS's currently in place only cover transportation fuels like gasoline and diesel. Consequently the proposed policy represents the first time any jurisdiction in the world has attempted to implement a CFS on all fuel types. As such there is considerable need to assess carefully the potential costs of such a measure.

In this study we critically assess whether a CFS is necessary for achieving Canadian environmental goals, what its likely economic impacts will be, and whether it is likely to be a cost-effective policy option.

Our analysis is based in part on a computable general equilibrium (CGE) model. One of the advantages of the CGE approach is the ability to track the indirect costs of a policy, such as changes in prices of regulated fuels under CFS on Gross Domestic Product (GDP) and employment. In contrast, Environment and Climate Change Canada (2019) proposed a partial equilibrium model framework. In this type of modelling, key parameters are omitted or are set at pre-determined values rather than being determined within the model. The relative strengths and weaknesses of different modeling methods are discussed below.

2 General Criticisms of the Proposed CFS

2.1 The proposed CFS contradicts the Government's rationale for carbon taxes

Introduction of the CFS represents an abandonment of the government's main argument for carbon pricing. The Canadian government introduced a pan-Canadian framework for carbon pricing in 2017 based on the longstanding recommendation among economists that taxing GHG emissions was the most cost-effective way to achieve an emission reduction target. However, that recommendation assumes emission pricing is the only instrument being applied. For example:

> "It is widely recognized among economists that a price on carbon emissions, through a carbon tax or a price on tradeable emission permits, is the most important policy instrument to reduce such emissions. Standard economic reasoning also implies that in the absence of other market failures, an appropriately set carbon price is the ***only*** instrument needed to achieve an efficient climate policy."
>
> Michael Hoel, Professor of Economics, University of Oslo, 2020 (emphasis in original)

Similarly, Nobel prize-winning research by Yales' William Nordhaus on the optimal design of climate policy assumes carbon taxes are used in isolation.

The government's claim that carbon pricing is supported by expert opinion among economists is therefore misleading, since expert opinion does not support the form of implementation being pursued in Canada: layering taxes on pre-existing regulations, then adding even more regulations on top. It has long been known that combining emission taxes with emission regulations destroys the efficiency property of the pricing mechanism. Likewise numerous authors have pointed out that even in cases in which properly-set emission taxes could make us better off once environmental benefits are taken into account, adding emission regulations to the mix can change the balance and make society worse off overall.

This is why statements like the one found in the report by Environment and Climate Change Canada on their cost-benefit analysis framework of CFS that "….. the CFS may complement carbon pricing systems by sending a stronger price signal for change in the production and use of fossil fuels by creating a double-incentive"(p12) are incorrect. If the "double-incentive" creates higher compliance costs compared to the carbon price, the policy is no longer cost-effective, thus rather than "complementing" carbon pricing it undermines it.

The federal government has indicated by its carbon pricing framework that it views the appropriate price range to be $20-$50 per tonne, which is in line with the expert assessment of the United States Inter-Agency Working Group (2013). By contrast, in the case of the CFS, in recognition that compliance may become very expensive, permits will be offered at a target price of $200 per tonne, far higher than the carbon tax rate.

[1]See Government of Canada website http://news.gc+.ca/web/article-en.do?nid=1132149.

[2]See, for example Turvey (1963), Bovenberg and Goulder (1996) Parry et al. (1997), McKitrick (2016).

2.2 Canadians have already achieved clean fuel usage

A more appropriate name for the policy would be a "Reduced CO2 Intensity Standard." By calling it a "Clean Fuel Standard" the government may be trying to give the impression it is a clean air policy, but the record shows that clean air objectives have already been met by other means, including in the transportation sector. The proposed CFS is unlikely to yield measurable improvements to Canadian air quality, in part because violations of air quality standards are already quite rare.

More specifically, what matters for the environment is not the chemical characteristics of the fuel but the emissions generated by its usage. The record shows that Canadians have already achieved some of the cleanest methods of fuel usage anywhere in the world, and as a result they enjoy abundant and affordable energy with very low levels of pollution.

The CFS does not address the local contaminants that are the subjects of air quality regulations: carbon monoxide (CO), sulphur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM), volatile organic compounds (VOCs) and ground-level ozone (O3). Canadians have used other means over the years to address these, including adopting new technologies for cars, industrial equipment and other applications to reduce emissions of these contaminants. As a result, while fuel use has increased since the 1970s, local air pollution has dramatically fallen. Canadians have thereby already achieved clean fuel usage.

For example, Figure 3.1 shows that Canadian consumption of gasoline and diesel rose by about 25% from the year 2000 to 2017, as did total vehicle-kilometers traveled on Canadian roads. Yet over the same interval, total motor vehicle-related CO, Total Particulate Matter (TPM) and NOx fell by 50% or more.

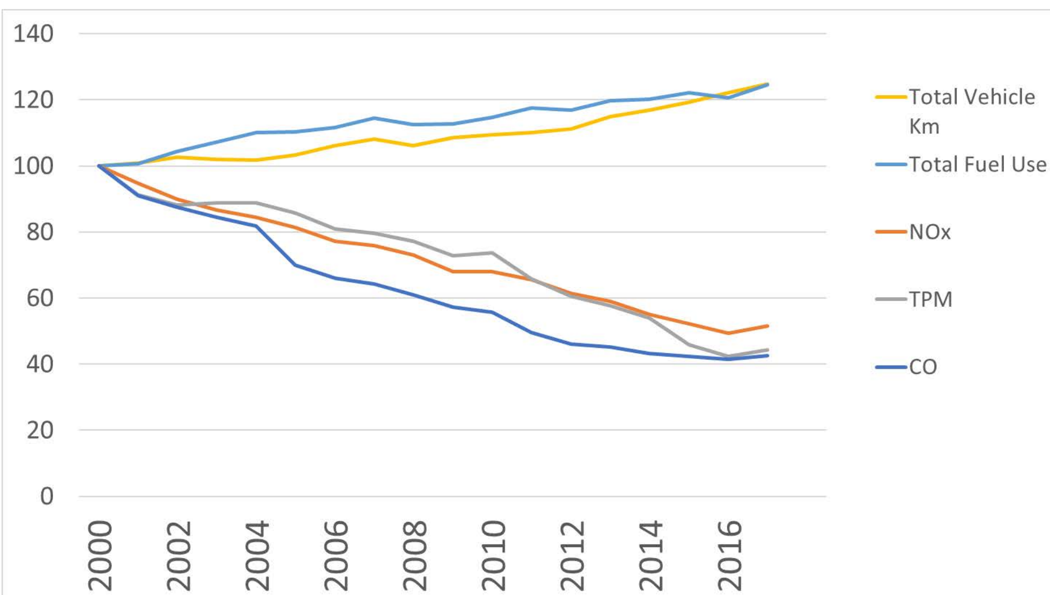

Figure 3.1: Total Vehicle km traveled on Canadian roads and total fuel use (top lines) versus emissions of NOx, Total Particulate Matter (TPM) and carbon monoxide (CO) from Canadian motor vehicles, 2000 to 2017. All series scaled so 2000 = 100.
Sources: Statistics Canada 2020a & 2020b; OECD/ITF 2015 & 2016; ITF 2018; Air Pollutant Emission Inventory.

Figure 3.2 contrasts the growth of the Canadian vehicle fleet from 1975 to 2015 with the change in the percentage of air quality monitoring stations reporting levels of pollution that would violate present day (most-stringent) air quality standards. The vehicle fleet nearly tripled over that interval, yet violations of air pollution standards related to vehicle emissions fell almost to zero across the board. In 1975, 54% of monitoring locations reported violations of Nitrogen Dioxide (NO2) standards and 84% reported violations of CO standards, yet by 2015 the reported violation rate for both contaminants had fallen to zero. SO2 violations fell from 63% to 3%. The percent non-compliance for Ozone fell from 73% to 17% (note in that case the start date is 1977).

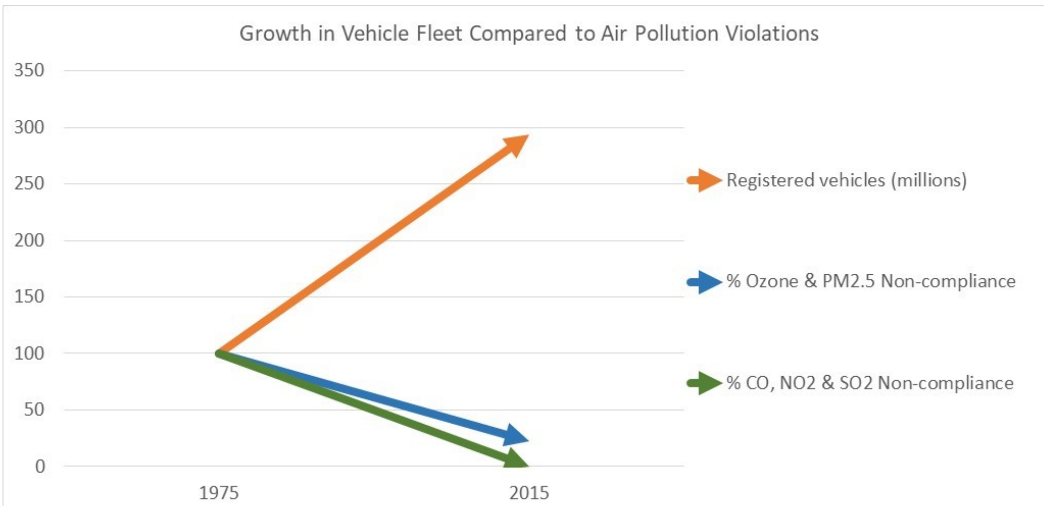

Figure 3.2: Growth of the Canadian vehicle fleet compared to the declining percentage of Canadian air quality monitoring stations out of compliance with current standards. All series scaled so 1975=100.
Sources: British Petroleum Company 2019; McKitrick and Aliakbari 2017; Statistics Canada 2020d & 2020e

A key reason why Canada has been able to triple its vehicle fleet while nearly eliminating fossil fuel-related air quality violations is that our vehicles are far cleaner than they used to be. A lot of progress was made on this from the 1970s to 2000. Figure 3.3 shows North American vehicle emission standards in grams per mile from 1975 to 2005 for four main contaminant types: CO, VOCs, NOx and Particular Matter under 10 microns (PM10). The CO emission limit in grams per mile fell by 90% over that interval, while those for VOC and NOx fell by 96% and 98% respectively. The PM10 standard fell by 87% but it was already low compared to the others by 1970.

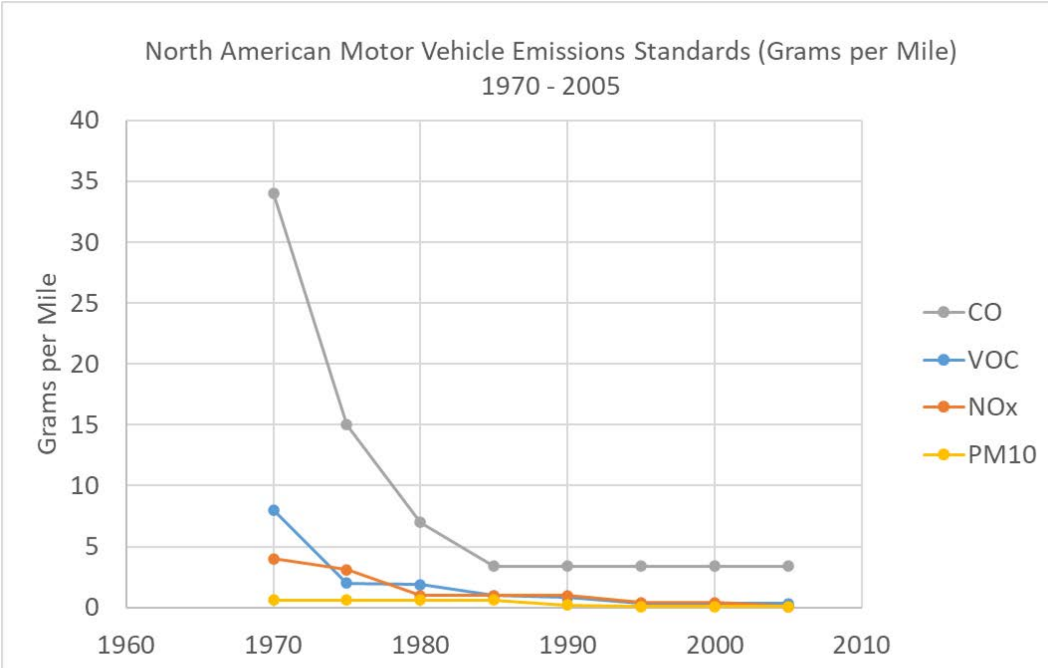

Figure 3.3: North America automobile emission standards pre-2005.
Source:
https://www.fhwa.dot.gov/environment/air_quality/publications/fact_book_06/page14.cfm

Thus from 1970 to 2005, total automobile tailpipe emissions measured on a per-mile or per-km basis fell by 92%. Put another way, it would take 17 cars made in 2005 to generate the same amount of pollution generated by one car in 1970. That's why even with three times as many cars on the road in 2015 compared to 1975, total air emissions fell dramatically.

Progress has continued to the present, to the point where continued tightening of the vehicle fleet emission standards has very little marginal effect. Figure 3.4 shows the post-2004 evolution of the NOx vehicle standards and the fleet average emission characteristics in Canada.

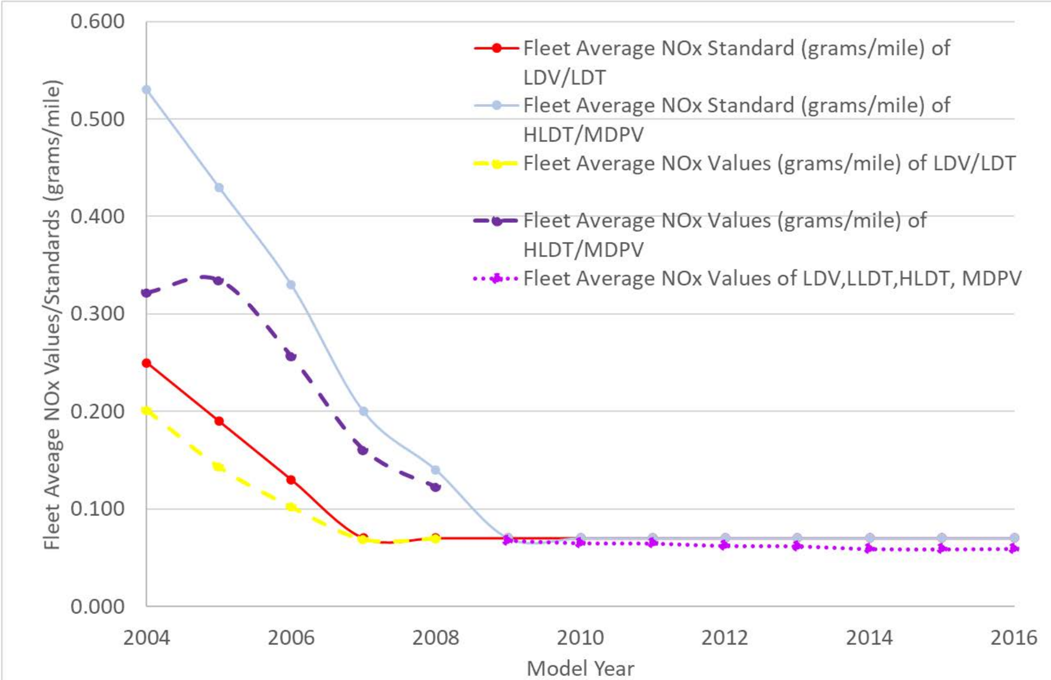

Figure 3.4: North American vehicle NOx standards and fleet average performance after 2004.
LDV/LDT: Light-Duty Vehicles, Light Duty Trucks. HLDT/MDPV: Heavy Light-Duty Trucks, Medium Duty Passenger Vehicles
Source: Environment and Climate Change Canada https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/fleet-average-emission-performance-vehicles.html

Improvements in air quality have also come from cleaner electricity generation and manufacturing processes. Just as more cars are on the road today than in the 1970s with fewer emissions, more manufactured goods and electricity are being produced with fewer emissions.

Figure 3.5 shows the total emissions of four air pollutants from the electricity generation sector from 1990 to 2018 (scaled to 1990=100). According to Statistics Canada, over this interval total sectoral output increased by about 90%, yet total emissions of Total Particulate Matter (TPM), SOx, CO, and NOx went down by between 25 and 87%, with TMP showing the largest reduction.

Figure 3.6 shows the total emissions of four air pollutants from the manufacturing sector from the 1990 to 2018 (scaled to 1990=100). According to Statistics Canada, over this interval total sectoral output rose by about 70%, yet all emission types fell by more than half, and in two cases (CO and SOx) the reductions are 80% or greater. Figures 3.4 and 3.5 thus confirm that the favourable pattern observed with motor vehicles—increased usage and declining emissions—is common to other major Canadian economic sectors as well.

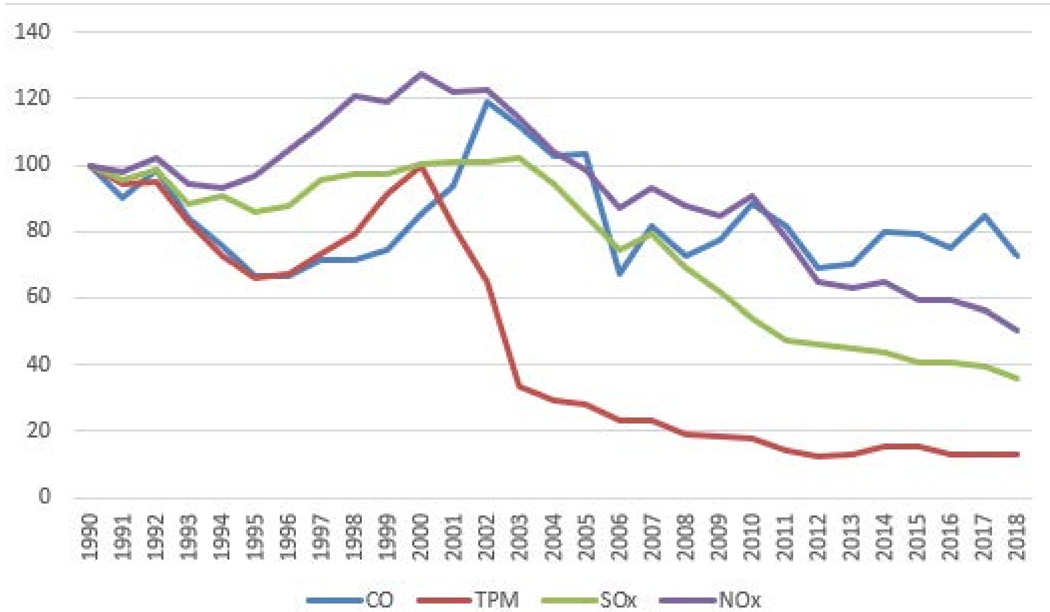

Figure 3.5: National emissions of Total Particulate Matter (TPM), Sulphur Oxides (SOx), Carbon Monoxide (CO), and Nitrogen Oxides (NOx), from electric power generation, 1990 to 2018. All series scaled so 1990 = 100.

Sources: Air Pollutant Emissions Inventory (APEI)

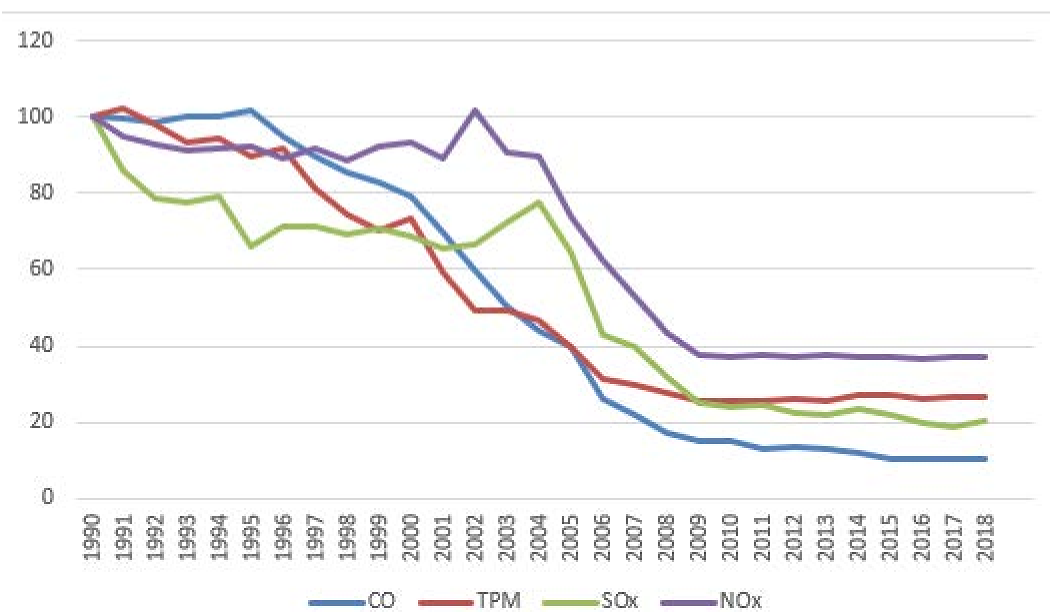

Figure 3.6: National emissions of Total Particulate Matter (TPM), Sulphur Oxides (SOx),Carbon Monoxide (CO), and Nitrogen Oxides (NOx), from manufacturing, 1990 to 2018. All series scaled so 1990 = 100.

Sources: Air Pollutant Emissions Inventory (APEI)

In sum, Canadians already use fuels in very clean ways. The proposed CFS is improperly named since it is aimed at reducing carbon dioxide (CO2), which is not a local air contaminant. Reductions in local air pollution have been achieved over the past 40 years without a CFS in place, and these achievements will be unaffected whether or not the CFS is implemented.

2.3 Despite its cost, the proposed CFS will accomplish very little

While the goal of the proposed national level CFS is to reduce total CO2 emissions by 30 Mt by 2030, a study by Navius Research (2020) concluded that it would likely achieve far less, namely a reduction of less than 7 Mt. This is in part because Canada already has a number of policies targeting GHG emissions, both federally and provincially, reducing the marginal impact of the new policy, and the described parameters of the proposed CFS are not consistent with a 30 Mt reduction. Existing policies include the federally mandated carbon pricing system and federal renewable fuel regulations, which already cover most of what CFS is aimed at achieving. In addition to these two policies many provinces have regulations that go beyond federally mandated ones. For example, British Columbia has had a CFS since 2008, and Quebec has been operating a cap-and-trade system for GHG emissions since 2013.

The emissions impact of the CFS policy will be strongly affected by details of the permits trading option which are not yet finalized, and by the government's tolerance for price impacts on energy. Current indications are that full compliance with the 20% CI reduction will have very large adverse price impacts on energy and we may legitimately question whether the government can credibly commit to long term enforcement of the requirements. It should further be noted that over the coming decade the economy will grow and along with it demand for fuel use. As noted by CERI (2019), in jurisdictions like British Columbia and California where a modest CFS has been implemented, the reductions in emissions due to reduced carbon intensity were offset by increased overall fuel consumption, resulting in no net emission cuts. The Government of Canada is committed to increasing the domestic population and labour force by achieving ambitious immigration growth targets, which will likewise counteract the results of the CFS.

Consequently in evaluating the costs and benefits of the proposed CFS it is important to apply a realistic parameterization of the policy. By calibrating the policy simulation to reflect fuel cost impacts as outlined by CERI (2019) as well as discussions with industry personnel, and allowing for some reductions in emission intensities of domestic fuels, we find that the CFS could yield a 30 MT emission reduction over the next decade, but this would be completely offset by the additional economic activity associated with a 7% increase in the size of the labour force. At current growth rates that represents about three or four year's growth.

2.4 Depending on the options for compliance, a so-called Clean Fuel Standard may end up being worse for the environment than conventional fuels

Under the CFS, regulated parties have a few options for complying with the CI requirement. One is by blending in fuels with lower CI (i.e., mixing gasoline with ethanol). The second option is buying credits from the credit market, the availability of which requires that other firms producing or using fuels can generate credits to be sold on the market. The third is by participating in actions such as process improvements and carbon capture and storage. The fourth is by switching to a different fuel type altogether (i.e., gasoline to natural gas).

Reliance on ethanol blending raises the possibility that the increased demand will lead to greater imports of US-sourced biofuels, which are produced using fossil fuel-intensive processes because of the nature of the US electricity grid. Mullins, Griffin and Matthews (2009) found that many forms of biofuels have CI levels exceeding that of gasoline on a life-cycle basis. Hoel (2020) points out that, after taking account of the indirect effects, "…the production of bioenergy in most cases will have a negative direct climate impact" (p12) and instead of being promoted through policies like the CFS, they should be taxed like conventional fuels.

US demand for bioenergy, such as ethanol, increased almost 8-fold from 2000 to 2011 (Auld and McKitrick, 2014). Policies like the US federal Renewable Fuel Standard established in 2005 and California's Low Carbon Fuel Standard in 2011 have forced up demand for biofuels. Canada has had similar mandates like the federal Renewable Fuels Regulations, which require a certain percentage of renewable content in gasoline, diesel fuel and heating distillate oil (Environment and Natural Resources, 2017). While it may superficially appear that mixing gasoline with biofuel(s) would reduce carbon intensity, this ultimately depends on how the biofuels are manufactured. Additional factors such as land-use change, the type of feedstock used and even the type of fertilizer used to grow the feedstock (i.e., corn) matters for the value of CI (Auld and McKitrick, 2014).

There are other unintended indirect negative impacts of using biofuels ignored in the models used for CI estimation. For example, the production of corn-based ethanol increases the total demand for corn, resulting in a higher food costs. Auld and McKitrick (2014) have estimated that "[b]etween 2008-2012, Canada spen[t] between $3.00 – 3.50 for every dollar of benefit derived from transportation biofuels"(p17). In other words, there is a negative net benefit of using biofuels.

3 Economic Impacts of the CFS as Proposed

3.1 Modeling Approach

We used the LFX Canadian Model (LFXCM) to simulate the impacts and costs of the CFS. A description of the model is provided in Appendix B. The LFXCM is a computable general equilibrium model of the Canadian economy that allows us to examine changes in many individual sectors, including prices, outputs and employment, resulting from a policy change.

The model traces through the direct and indirect impacts on markets for goods and services, labour and capital in each province from the assumed production cost increases associated with the CFS. This modeling approach has certain strengths and weaknesses in comparison to other analytical methods that need to be understood by the reader. The model represents the provincial and federal economies at a relatively high level of abstraction, dividing economic activity into 26 separate goods and services (see list in the Appendix) in each of 10 provinces plus the northern territories. The underlying data are taken from the Canadian provincial Input-Output tables published by Statistics Canada. The energy sector is represented as a network of primary producers (Oil Sands, Conventional Crude, Natural Gas, Oil and Gas Support Activities, Crude Pipelines and Natural Gas Pipelines) and sellers of final goods (Refined Fuels, Other Petrochemicals and Utilities). Firms respond to prices and are generally able to make substitutions among categories of inputs, as are households. Some important technical details about production and consumption processes, including capacity constraints and limits to substitution, are not directly represented in the model but are in some cases represented in the way the policy is implemented in the model (see below).

The CGE model starts by assimilating data from the Input-Output tables, government financial accounts and other macro sources. Because data come from a variety of different surveys, there are inherent discrepancies between revenue and spending estimates by sector, household income estimates versus observed consumption and savings, and so forth. The model therefore computes an initial base case equilibrium outcome in which markets for goods, services and labour clear and all budget constraints balance. The policy is then implemented using the parameters described below, and a new equilibrium is computed.

Unemployment does not exist in a Computable General Equilibrium model, instead the wage rate is assumed to adjust freely to ensure that national labour supply matches labour demand. In the real economy, if wages cannot adjust then persistent unemployment may arise. Also there may be an imbalance between labour supply and demand within any one province in this model, but the labour surpluses add up to zero nationally.

The capital stock in the model is fixed based on a historical estimate, but capital utilization is determined in each run of the model based on the factor demand equations. The policy change may result in an increase or reduction in capital utilization. In the latter case the dollar value of the capital thus idled is identified as a capital loss, on the assumption that the owner has the option of relocating the capital out of the province (or the country) in order to pursue a higher rate of return elsewhere. Capital losses of this kind are not deemed costs of the policy for the purpose of this analysis since the capital can be redeployed elsewhere, but in practice it is costly and harmful for an economy in general if large amounts of the capital stock exit the economy.

3.2 Policy Assumptions

The intent of the CFS is to reduce the CO2 emissions per unit of fuel consumed across the categories of solids, liquids and fuels. The policy allows compliance either by blending the fuel so as to reduce the carbon intensity (CI) or paying for credits which are generated by other economic agents who have either achieved greater compliance than necessary in fuel production or who have implemented other types of projects that may in the future be approved for the purpose of generating CFS credits. In order to simulate the effects of the policy we need to make assumptions about the following parameters:

a) The effects on the supply costs of each type of fuel from reducing CI
b) Specific operating constraints faced by major entities in the Canadian energy sector
c) The overall effects on the carbon intensity of Canadian fuels
d) Additional constraints on the policy impact as expressed by the government
e) Background growth in the economy over the course of the policy's implementation
f) The effects of the backstop credit price

Each of these issues affects the outcome, including changes in greenhouse gas emissions. As fuel costs go up due to the new blending requirements, demand will decline and so will GHG's even if CI doesn't decline. If the compliance measures are effective in reducing the CI, this will yield a further reduction in emissions. But both these reductions will be offset by growth in the labour supply and capital stocks of the Canadian economy over time. And the credit system means that compliance may be partially or largely achieved by expenditures that do not reduce fuel CI. In addition to examining existing documentation we conducted extensive discussions with industry professionals to gain insight into each of these issues.

a) CERI (2019) estimates that a $200 per tonne credit price under a 20% CI reduction target implies a 58—116% increase in the price of natural gas, and a 9—10% increase in the price of gasoline. CERI (2019) also estimates a cost increase for coal of about $3.50 per Gigajoule (GJ) and in view of the recent reduction in the cost of coal this is about a 150% price increase. However coal used in electricity production is exempted from the regulation, as is coal destined for export. The application of the rule to solid fuels is thus confined only to their use in some heavy industries in Ontario and Quebec. Taken at face value these are dramatic cost increases for Canadian fuel prices and they raise the question of whether any government could credibly commit not only to implement the policy but also to bind future governments to maintain it.

b) In discussion with industry experts we were alerted to the specific challenges facing the fuel supply chain in the BC Lower Mainland. Gasoline prices there are very high compared to the rest of the country. A key contributing factor, according to the sources we spoke with, is that most of the fuel used in that region is imported from Alberta and Washington state, but pipeline capacity is inadequate for the size of the market, as is local tank storage space. Combined with rapid local population growth, this situation has resulted in persistent shortages of fuel and the attendant rising prices. Expansion of the infrastructure to support the growing demand in the region has been stymied by various local regulations. The Trans-Mountain pipeline will eventually bring more refined petroleum products from Alberta but the longstanding delays in this project are well-known and completion of the pipeline is a long way off. Consequently the fuel supply infrastructure in the BC Lower Mainland faces some specific challenges in dealing with the CFS, chiefly a lack of storage space for increasing the volume of imported ethanol and inadequate local refining capacity. We represent this in the LFXCM simulations by assuming the marginal cost of compliance with the fuel regulations in BC will be double that in other provinces.

c) The goal of the policy is to achieve a 20% reduction in fuel CI. However most of the industry people we spoke to seemed to assume that compliance will mainly be achieved through credit purchases rather than changes to the fuel blends themselves, though we were not able to ascertain who would be on the sell side. On the assumption that permits will be available we expect the actual CI reduction to be relatively small for both gaseous and liquid fuels.

If we were to run the model with the assumptions outlined thus far, namely a 60% increase in the cost of natural gas, a 10% increase in the production cost of fuels (20% in BC), a 150% increase in the cost of coal used outside of the electricity sector, and a 5% reduction in CI across all fuels, we find that the policy would yield the following outcome.

- A 53 MT reduction in domestic carbon dioxide emissions, more than meeting the federal target of 30 MT. 20 MT of the reduction would be from reduced liquid fuel emissions, 31.5 MT from reduced natural gas emissions, 1.6 MT from reduced coal emissions and 0.1 MT from reduced cement manufacture.
- However this comes at a steep economic cost: a 0.8% drop in real GDP, 1.4% decline in real household consumption, nearly 50,000 jobs lost nationally, a 1.4% drop in combined federal and provincial government revenue and a $12 billion increase in the deficit.
- The majority of the reduction (33 MT) results from the increased price of fuels and the accompanying recession, the other 20 MT coming from the CI reduction itself.
- The policy would cost about $560 in lost nominal GDP for every tonne of emission reductions.
- The compliance costs for industry would be approximately $15.3 billion annually, or $288 per tonne of emission reductions, exceeding the permit backstop price. Additionally, because of the drop in the return to capital, a further $35.8 billion in invested capital would be removed from use in the economy.

Consequently there is a conflict between implementing the policy as stated and keeping compliance costs to below $200 per tonne.

d) These analyses imply that natural gas will bear the brunt of the CFS policy, yielding about 1.5 times the emission reductions of fuels. However, some industry contacts indicated their expectation, based on federal government consultations, that the federal government is only looking to get 6 MT from natural gas and 23 MT from liquid fuels.[3] The price implications of the credit system are not consistent with this outcome. If we were to try to simulate this outcome it would require a somewhat tighter restriction on fuels and a much looser restriction on natural gas.

e) One of the main deficiencies of the analysis thus far is that it assumes the baseline is a non-growing economy. Over the coming decade, if trends continue the Canadian labour supply will grow by 1-2% per year and the capital stock (including financial capital) will grow by more than that. Re-running the above analysis while allowing the labour supply to grow by 5% and the capital stock to grow by 10%, we find the emission reductions almost completely offset with a net overall decline of only 8 MT, consisting of a 16 MT net decrease in emissions from natural gas and a 7 MT net increase in emissions from fuel. This result is close to the estimate by Navius (2019) that the policy will only yield a net reduction of 7 MT, although their finding is based in part on the overlap of the CFS with pre-existing emission reduction measures. If the goal of the policy is to yield a 30 MT reduction against a rising benchmark this is not a problem. But the Paris targets are fixed: they don't increase as the economy grows. If the CFS is likewise intended to be a fixed target, namely a 30 MT reduction compared to a specific year regardless of how much the economy grows, the policy will need to be tightened every year, which will make it progressively more and more expensive.

f) Finally, the backstop credit price will play an important role in limiting costs of the policy but will also limit its effectiveness depending on how credits are generated. If many emitters achieve compliance by buying permits, and if the origination of the permits doesn't itself involve much direct emission reductions, then the costs per tonne actually achieved can become quite high. It is noteworthy, for instance, that many analysts consider US-sourced ethanol to be as carbon-intensive as gasoline on a life-cycle basis (see discussion in Section 2.4) which means it into blending in Canadian fuels yields no net global CO2 reductions, even if it generates domestic credits.

Policy Simulation Sequence

In light of these considerations there does not seem to be any plausible scenario in which natural gas prices rise by 60% while emissions fall by only 6MT, gasoline prices rise by only 5% while emissions fall by 23 MT, and the labour supply grows by 1% annually while national GHG emissions fall by 30 MT. Nor is there any plausible scenario in which the CFS policy can achieve a 20% CI reduction while keeping total compliance costs below $200 per tonne.

Therefore to provide a meaningful assessment of the costs of the CFS we need to make some arbitrary assumptions. We will examine the implications of a policy enacted as follows:

- The bulk of the policy burden falls on liquid fuels, with a goal of achieving approximately 23 MT reduction. The cost of gasoline rises by 15% (30% in British Columbia) and this accompanies a reduction in the associated CI of 5.5%.
- Gaseous fuels go up in price by 5% and the associated CI falls by 1%.
- The cost of using coal (other than for export or electricity) rises by 150% but the CI of coal itself does not change.

[3] The 23 MT requirement on liquids is taken from here: https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard/regulatory-design.html.

- The labour supply and capital stocks are not adjusted upwards to reflect annual growth but remain at their 2016 base case levels. Later we will discuss the implications of allowing for growth of the population and labour force.

3.3 Canada-wide Macro Effects

Greenhouse Gas Emissions

Table 1 summarizes the changes in greenhouse gases and some of the main economic impacts nationally and by province as a result of the CFS policy as implemented. Relative to the 2016 base, national GHG emissions decline by 30.5 MT, thus achieving the federal target. Half this (15.3 MT) is attributable to the increased fuel costs and reduction in economic activity, and the rest is attributable to the assumed CI reductions. Emissions due to liquid fuels decline by 22.3 MT, those due to natural gas decline by 6.7 MT, and those due to coal use decline by 1.5 MT.

	Reduction in GHG Emissions (Mt)	Direct Compliance Costs ($m)	Loss of Capital ($b)	Employ-ment Changes	Increase in Govt Deficit ($b)	Increase in HH Cost of Gasoline (%)	Increase in HH Cost of Natural Gas (%)
Canada	**30.5**	**$9,149**	**$21.7**	**-30,107**	**$7.3**		
British Columbia	4.0	$601	$2.2	-2,016	$0.6	19.4	3.7
Alberta	4.1	$1,553	$5.0	-6,834	$0.9	10.1	4.1
Saskatchewan	1.9	$323	$1.1	-890	$0.5	10.9	3.1
Manitoba	1.8	$33	$0.4	30	$0.2	11.0	4.2
Ontario	9.1	$3,908	$6.8	-11,279	$2.5	10.1	3.8
Quebec	3.2	$1,276	$3.3	-2,325	$1.4	10.1	4.2
New Brunswick	2.5	$1,106	$1.8	-5,151	$0.7	11.8	4.1
Nova Scotia	1.2	$40	$0.4	-286	$0.3	11.7	4.2
PEI	0.7	$10	$0.1	-44	$0.0	12.0	4.2
NFLD & Labrador	1.0	$264	$0.7	-1,261	$0.2	10.5	n/a
Far North	1.1	$33	$0.1	-57	$0.1	10.7	n/a

Table 1: Summary of Main Impacts of CFS Policy Compared to the 2025 base.

Direct and Indirect Compliance Costs

Direct regulatory compliance costs, measured as the economy-wide burden of the higher costs of producing fuels, sum to $9.1 billion, with the largest share ($3.9 billion) incurred by Ontario, followed by Alberta ($1.6 billion), Quebec ($1.3 billion) and New Brunswick ($1.1 billion). Increased fuel costs and other indirect price effects cause a reduction in the return to fixed capital. These lead to a drop in capital utilization rates, idling $21.7 billion worth of capital nationally. The $9.1 billion in regulatory compliance costs are unavoidable. The additional $21.7 billion in capital costs may be mitigated by capital owners choosing to shift capital out of the country. Consequently, for the purpose of evaluating the cost of the policy we highlight the $9.1 billion in regulatory compliance costs as a lower bound and note that an additional $21.7 billion is at risk of leaving the country. Of the latter amount, the largest risk of loss is in Ontario ($6.8 billion) followed by Alberta ($5.0 billion) and Quebec ($3.3 billion).

A cost of $9.1 billion to accomplish a 30.5 MT reduction in emissions implies a national marginal abatement cost of $301 per tonne, six times higher than the maximum federally-mandated carbon price. Since the federal government has signalled that it wants compliance costs to be capped at $200 per tonne it is likely that the cost constraint will bind, in which case the effect of the policy will be reduced.

We project a drop in equilibrium employment nationally of just over 30,000 jobs. Of these, 11,000 are in Ontario, nearly 7,000 are in Alberta, 5,000 are in New Brunswick and about 2,000 are in each of Quebec and BC. Job losses are not merely in the refining and natural gas sectors but are spread widely across Construction, Manufacturing, Retail Sales, Trucking, Professional Services and other areas.

It is a feature of Computable General Equilibrium models that the wage rate is allowed to decline in order to clear the labour market. This implies that some sectors experience net employment gains due to falling wages. If wages are “sticky” in the actual economy this adjustment does not happen and the policy instead generates persistent unemployment. Sectors that, in the model, expand net national employment in response to declining real wages, thereby offsetting employment losses elsewhere, include Education and Health and Government. If these sectors do not expand to take on new workers the overall national job losses will be correspondingly higher.

The model allows the government to increase its deficit as revenue declines. The figures shown by province in Table 1 are for the combined federal and provincial governments. Nationally the deficits of various governments rise by $7.3 billion. Combined federal and provincial government revenue declines by 0.8% nationally. If we required the policy to be fiscally neutral this would require either a reduction in spending or higher taxes in order to maintain the budget balance, either of which would cause the macroeconomic consequences of the policy to be costlier. Note that the fiscal position of the government is assumed to be pre-COVID-19 so we have not attempted to simulate the combined effects of the current economic shutdown with the CFS-induced contraction.

The cost of purchasing gasoline increases by between 10.1 and 19.4% across the country depending on the province. The cost of natural gas increases by between 3.1 and 4.2% depending on the province. Most other price effects in the economy are small.

Table 2 presents additional detail about the economic consequences of the policy. Most of the effects are relatively stable across the country although they are typically somewhat larger in percentage terms in Atlantic Canada.

	Change in Real GDP (%)	Change in Real Consumption (%)	Change in Investment (%)	Change in Real Wages (%)
Canada	**-0.5**	**-0.9**	**-0.5**	**-0.7**
British Columbia	-0.4	-0.7	-0.3	-0.7
Alberta	-0.7	-0.9	-0.6	-0.7
Saskatchewan	-0.6	-0.9	-0.5	-0.7
Manitoba	-0.1	-0.5	-0.2	-0.7
Ontario	-0.5	-0.9	-0.5	-0.7
Quebec	-0.4	-0.7	-0.4	-0.7
New Brunswick	-3.3	-3.7	-2.5	-0.8
Nova Scotia	-0.3	-0.7	-0.3	-0.8
PEI	-0.4	-0.8	-0.3	-0.8
NFLD & Labrador	-1.0	-1.2	-0.9	-0.7
Far North	-0.1	-0.8	-0.4	-0.7

Table 2: Changes in GDP, Consumption, Investment and Wages

Our overall assessment is that a CFS designed to achieve the goal of a 30 Mt GHG reduction with 22 MT of the burden falling on liquid fuels will impose compliance costs well in excess of $200 per tonne. We assess that the direct costs of compliance will be about $9.1 billion, with as much as $21.7 billion in additional costs as owners of capital reallocate investments out of the country to preserve their rates of return. We estimate the overall labour market in Canada will shrink by about 30,000 jobs.

3.4 Effects of Economic Growth Through 2025

We now consider the GHG consequences of a modest increase (7%) in the size of the labour force and a 15% increase in the size of the capital stock, while leaving the fuel cost increases and CI decreases unchanged. These are conservative estimates of the overall factor market changes we can anticipate between 2016 and 2025. By comparison, according to Statistics Canada's Labour Force Survey (Table 14-10-0287-03) total employment in Canada grew by 11% from 2016 to 2020. Consequently the change we are simulating represents only about 3 years of growth in the size of the labour force.

The changes completely offset the overall GHG reductions of the policy. Emissions from gasoline use rise to a level only 6.1 MT below the starting value and emissions from natural gas use rise to a level 4.7 MT higher. Adding in the changes due to coal and cement use we end up with an overall reduction of only 1 MT nationally compared to the base case. Consequently, for all the costs of implementing the CFS, the resulting emission reductions will be completely offset by about three years of population and capital growth. Unless the federal government intends to substantially tighten the requirements of the regulation or freeze the population at its current level, any emission reductions from the CFS will have been more than offset by economic growth long before 2030.

4 Comparing Overall Benefits and Costs

We will conclude by measuring the overall costs to the economy as the direct regulatory compliance costs. We do not include the loss in capital valuation, which would make the cost calculation considerably more unfavourable. Also, for the reasons explained in Section 2.2 we do not impute benefits due to reductions in conventional air contaminants, chiefly because they are already strongly controlled by other measures and it is currently the case that communities nationwide are in nearly continuous compliance with very stringent air quality standards. The CFS will thus have ancillary air quality effects that are too small to measure.

The attributable benefits are limited to the 30.5 MT reduction in CO2, which we value at $50 per tonne, reflecting the maximum value in the federal carbon pricing schedule. This totals $1,525 million.

Based on compliance costs of $9.1 billion the net loss from the CFS is $7.6 billion. The base case simulation has a labour force of 17.7 million workers, so the loss equates to $432 annually per employed person. The cost-benefit ratio shows that the proposed CFS will cost Canadians $6 for every $1 in benefits from reducing CO2 emissions, even using the maximum emission price.

	CFS Costs and Benefits
Compliance Costs ($m)	$9,148
Value of Reduced CO2 Emissions ($m)	$1,525
Net Gain or (Loss) ($m)	($7,623)
Net Loss per Worker	$442
Ratio of Costs to Benefits	6.0

Table 3: Cost-Benefit Analysis of CFS Policy

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Appendix A: A Snapshot of Fuel Use in Canada

Policies that make energy more expensive are harmful to Canadians' economic welfare unless they generate benefits that exceed the costs. As we have already shown the CFS fails this test, it is worth examining the essential role energy plays in Canadians' lives.

Total Energy Use

According to data from Canada Energy Regulator (2016), the total (secondary) energy[4] consumption increased by 8.4% in Canada between 2005 and 2016. Natural gas grew the most (26.5%) followed by electricity and refined petroleum products (RPP) (3.1% and 2.6%, respectively). Despite the myriad policies promoting alternative energy, biomass and emerging fuels (solar, geothermal, hydrogen, ethanol and biodiesel) declined by 1.6%. Other fuels (coal, coke, coke oven gas and steam) declined 30.6% over the same period.

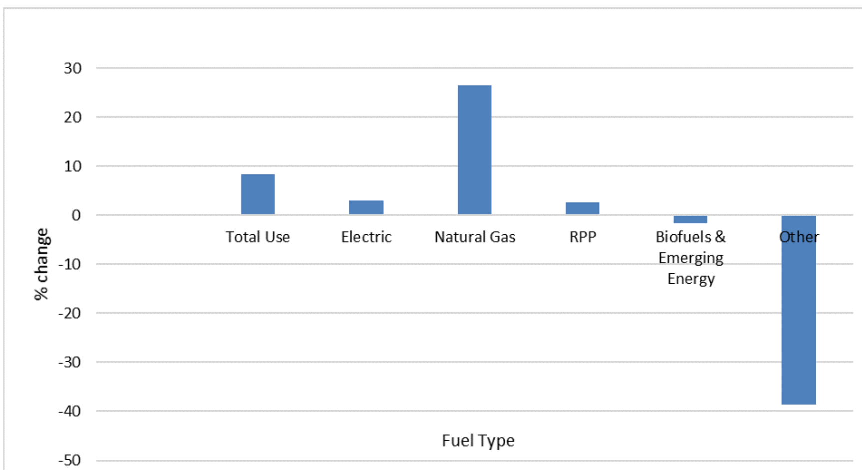

Figure 6.1: Percent change in secondary energy use in Canada, 2005 to 2016.
Source: Canada Energy Regulator 2016

Over the same interval, consumption of refined petroleum products was very steady in most provinces.

[4]Secondary energy refers to the end-use energy.

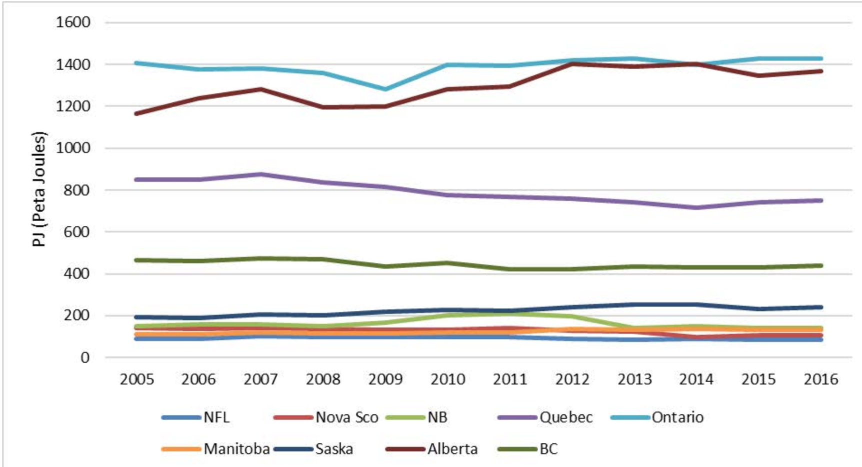

Figure 6.2 Total refined petroleum products consumption by provinces in Canada between 2005 and 2016

Source: Canada Energy Regulator 2016

Crude Oil Production and Imports

In 2018, Canada's crude oil production was the fourth-largest in the world (International Energy Agency, 2019). According to Natural Resources Canada (2020), in 2018, Canadian crude oil production was 4.6 MMb/d (million barrels per day), of which 3.7 million MMb/d were exported, roughly 80% of the total output. Canada also imported oil from the U.S, which accounted for 0.8 MMb/d for the same year.

Most of Canada's crude oil production comes from Alberta's oil sands, which accounted for roughly 81.3% in 2018. Saskatchewan's production share was 11.7% for the same year. Together, they produced 93% of the total production in Canada (Statistics Canada, 2020g).

Not surprisingly, refineries play a crucial role in the oil industry by transforming crude oil into refined petroleum products (RPPs). RPPs are types of fuels which are directly useable by consumers and businesses such as gasoline and diesel. According to National Energy Board (2018), in Canada, there are a total of 14 full refineries. The refineries with the largest capacities are in Quebec and Atlantic Canada, about 782 Mb/d (thousand barrels per day). The next largest is in western Canada, followed by Ontario at 683 Mb/d and 390 Mb/d, respectively. The total refining capacity in Canada ranks 11th in the world.

In western Canada, two refineries are in British Columbia (Prince George, Burnaby), five in Alberta (two in Edmonton, Redwater, Fort Saskatchewan, Lloydminster), and two in Saskatchewan (Moose Jaw, Regina). In Ontario, there are four refineries (three in Sarnia, Nanticoke). In eastern Canada, there are two in Quebec (Levis, Montreal), one in New Brunswick (Saint John), and one in Newfoundland (Come by Chance).

Locations of refineries play a key role in the origin of the crude oil they process. In western and central Canada, most of the crude is transported via pipeline. Though some is delivered via rail, it is a small percentage. The estimated percentages of crude moved by pipeline and rail from western Canada are summarized in Table 6 below. In eastern provinces like Nova Scotia and Newfoundland and Labrador, there is no pipeline for transporting oil, therefore the majority of oil is delivered by tankers and the rest by rail. This is one of the reasons why Canada imports crude oil, despite having some of the world's largest proven oil reserves.

	2010	2011	2012	2013	2014	2015	2016
Export (%)							
Rail used for export	0.01	0.24	2.14	5.25	6.12	3.87	3.03
Pipeline used for export	99.99	99.76	97.86	94.75	93.88	96.13	96.97
IntraCanada (%)							
Rail used for intraCanada	0.79	0.78	0.89	0.93	0.85	1.00	0.80
Pipeline used for intraCanada	99.21	99.22	99.11	99.07	99.15	99.00	99.20

Table 6. Estimated percentage of crude oil moved by pipeline and rail from Western Canada

Sources: Canada Energy Regulator 2020 a and 2020b; Statistics Canada 2020f.
Note: Estimation on the percent of crude oil moved by pipeline for intraCanada was based on available data on crude oil moved by pipeline and rail for exports and intraCanada via rail.

Gasoline prices across the country

Canada has the third-largest proven oil reserves in the world, and it was the world's fourth-largest crude oil producer in 2018 (International Energy Agency, 2019).[5] Despite this, Canada's gasoline prices have gone up steadily across all provinces over the years. Victoria, B.C, and Toronto saw price increases of 159% and 116% respectively since 1993 (Statistics Canada, 2020c). The per litre price of gasoline at the pump also varies greatly between provinces. In 2019 it was as low as $1.079 (Calgary, September) to as high as $1.613 (Victoria, B.C, May) (See Figure 6.3).

Taxes play a big role in Canadian fuel prices. The federal excise tax is currently set at $0.1 per litre. Other tax rates vary significantly across provinces. For example, B.C has three provincial gasoline excise tax rates for three regions: Vancouver area, Victoria area, and rest of province. In the Vancouver and Victoria areas, the provincial excise tax is $0.27 per litre and $0.20 per litre respectively. Other provinces like PEI and New Brunswick have relatively lower rates of $0.0847 per litre and $0.1087 per litre, respectively. There is also the carbon tax (a regulatory tax) attached to the gasoline price. Provinces without a pre-existing carbon tax like Manitoba and PEI charge the federally mandated tax of $0.0663 per litre of gasoline. B.C charges a carbon tax rate of $0.0889 per litre. Finally, all Canadians pay sales taxes, both federal and provincial, that also vary across provinces. For instance, total sales tax on gasoline in Ontario, PEI, and Quebec are 13%, 15%, and 14.975% respectively (Retail Council of Canada, 2020)

[5]See Figure 3.1 for consumption of gasoline in Canada from year 2000 to 2017.

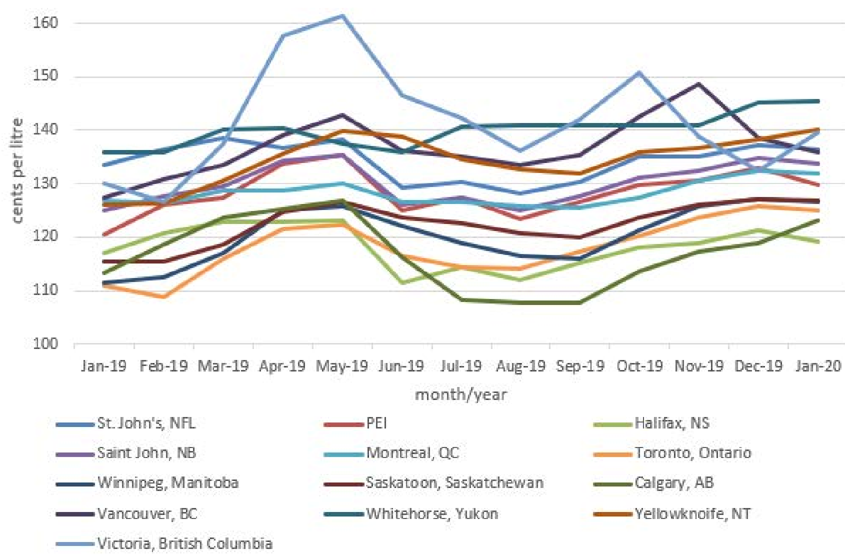

Figure 6.3: Gasoline prices in various Canadian cities, 2019.
Source: Statistics Canada 2020c

Appendix B: The LFX Canadian Model

We use a computable general equilibrium model of the Canadian economy which resolves private sector activity into 26 sectors with associated outputs in each of ten provinces plus the far north territories. Within each province we identify the following industry sectors:

1 Agriculture Fishing and Trapping
2 Forestry and Logging
3 Oil Sands
4 Conventional Crude Oil
5 Natural Gas
6 Oil and Gas Support Activities
7 Coal
8 Other Mining
9 Electricity
10 Other Utilities incl Gas Distribution
11 Construction
12 Food Production
13 Semi-durables
14 Refined Fuels
15 Other Petrochemicals
16 Cement and Concrete
17 Automotive Parts and Assembly
18 Other Manufacturing
19 Wholesale and Retail Sales
20 Air Rail & Bus Transportation
21 Gas Pipelines
22 Crude Pipelines
23 Trucking Courier and Storage
24 Media, Banking, Finance, Information and related Professional Services
25 Education and Health
26 Entertainment, Travel, Restaurants and Miscellaneous Services

The list of commodities is the same and all outputs are assigned to the corresponding sector. Petroleum products are distinguished between fuels and those used for non-combustion applications. The model resolves output, labour demand and intermediate input demand for every commodity in every sector for each province, calibrated so as to reproduce the 2016 provincial-level Canadian input-output tables.

Final demand categories include Households, Government, Gross Fixed Capital Formation, Domestic (inter-provincial) Exports and Foreign Exports. Output includes net supply by domestic sectors, Domestic Imports and International Imports. Gross Fixed Capital Formation is determined by the availability of domestic investment funds, which is the sum of household savings plus the government surplus less the current account surplus. Household savings are determined by a two-period optimal allocation between current and future consumption.

Factors of production include employment (by sector and province) and capital. Capital stock valuations by sector and province are developed as scalar multiples of the operating surplus reported in the input-output tables, averaged over 2014-2016. The model also generates real and nominal capital demand in each solution, yielding an endogenous capital utilization rate.

Industry intermediate demands and household final demands are organized using nested CES functions. Separate intermediate tax rates by industry and province are computed using the input-output table values of output and input taxes net of subsidies on outputs and inputs, with the current federal carbon charge ($20/tonne) added in the policy base case. Households also pay consumption taxes computed at the province-specific level to take into account PST and HST rates across the province as well as the federal carbon tax levy. Households also pay income taxes which are computed using the national total income tax revenues recorded by Statistics Canada.

The model uses the Leontief equation to clear goods and service markets at the provincial level after computing endogenous (price-adjusted) input-output coefficients for each sector in each province. This yields sectoral outputs, which then determine labour and capital demands. The capital demand determines the capital utilization rate. The household model yields an endogenous labour supply and the model solves for a national market-clearing wage rate. Interprovincial exports and imports are adjusted based on overall economic activity in the province subject to a national market-clearing constraint. International export demand adjusts in response to domestic marginal costs of production.

Regulations are modeled as exogenous shifts to sectoral supply curves. Regulatory details can be specified down to the sectoral level within each province. A regulatory measure is quantified as a scarcity rent. A tax drives a wedge between buyer and seller prices with the difference accruing to the government. A regulation, by contrast, drives up the cost to the buyer but the wedge does not accrue as extra revenue either to the seller or the government, instead it is dissipated in the form of higher marginal costs of producing the same output. The model tracks these regulatory rents in the process of computing the overall cost of the policy measure.

Greenhouse gas emissions are computed using coefficients calibrated on consumption of coal, natural gas, refined fuels and cement production so as to reproduce exactly the 2016 national carbon dioxide emissions inventory.

The government budget can be balanced in several ways. In the standard implementation the government deficit is set to zero, implying a neutral fiscal position, government labour demand and transfers to households are fixed, and government spending on goods and services adjusts to reflect total remaining revenue from direct and indirect taxes. In the event other policy experiments are undertaken, such as tax swaps or changes to household transfers, these parameters may vary.

The wage rate is adjusted at the national level to ensure market clearing in the labour market. The software verifies that Walras' law holds at every iteration, ensuring full closure of the macroeconomy is achieved.

More details about the LFXCM are available at LFXassociates.ca.