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LOW CARBON FUEL STANDARDS IN CANADA

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Smart Prosperity Institute (formerly Sustainable Prosperity) is a national research network and policy think tank based at the University of Ottawa. We deliver world-class research and work with public and private partners – all to advance practical policies and market solutions for a stronger, cleaner economy.

Key Messages

- A Low Carbon Fuel Standard (LCFS) is a flexible regulation that specifies mandatory reductions in the GHG intensity of fuels sold within a jurisdiction. Existing LCFSs have been applied exclusively to transportation fuels. LCFSs define the emissions performance required and allow suppliers flexibility in reaching the standard, including through credit trading. Suppliers of alternative low-carbon fuels — which in the transportation sector include biofuels, propane, hydrogen, and electric vehicle charging — can earn credits.
- British Columbia is the only Canadian jurisdiction with an existing LCFS, however both Ontario and the federal government are currently proposing LCFSs. The LCFS proposed by the federal government looks to extend the policy beyond just transportation fuels to include fuels used in buildings and industry as well. This raises a number of new questions about policy design.
- LCFSs have high greenhouse gas (GHG) reduction potential. BC's Renewable and Low Carbon Fuel Requirements Regulation is credited with 25% of BC's emissions reductions from 2007-2012. The federal government has indicated that a national LCFS could achieve up to 30MT of GHG emissions reductions annually by 2030.
- Not only do LCFSs have an immediate effect by improving the emissions intensity of fuels used today, they also encourage clean innovation and accelerate the transition to cleaner fuels for tomorrow.
- There are some key design elements for an effective LCFS, including broad coverage, stringent and predictable targets, and flexible compliance mechanisms. However there remain important design questions around regional impacts, equity concerns, cost effectiveness, and innovation impacts.
- LCFSs can complement other national and sub-national GHG mitigation policies, including carbon pricing, renewable fuel standards and existing LCFSs, but policy interactions are complex and need to be considered in the early stages of policy design.

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10%:
target reduction in GHG intensity of transport fuels in BC and California by 2020

THE ISSUE

Fuel use represents a major source of greenhouse gas (GHG) emissions in Canada, with fuel use in the transportation sector alone accounting for more than a quarter of Canada's emissions.[1] Low Carbon Fuel Standards (LCFS) have become an increasingly popular policy to reduce emissions in the transportation sector, thanks to their high GHG reduction potential and low cost to consumers.[2] In 2010, British Columbia (BC) included an LCFS as part of its Renewable and Low Carbon Fuel Requirements Regulation (RLCFRR), following the lead of California and the European Union* (EU), and recently joined by Oregon. Currently, both the Government of Canada and the Government of Ontario have proposed LCFSs, with the notable difference that the federal government's proposal also applies to fuels outside the transportation sector.

A Low Carbon Fuel Standard (referred to as a 'clean fuel standard' by the Government of Canada and as a 'modern renewable fuel standard' by the Government of Ontario) is a performance-based, technology-neutral regulation that specifies mandatory reductions in GHG intensity of fuels sold within the regulating jurisdiction. It defines the emissions performance required — for example, both BC[3] and California[4] aim to reduce GHG intensity of transportation fuel in line with progressive annual targets to reach a reduction of 10% from a 2010 baseline by 2020 — and allows fuel suppliers flexibility in determining the lowest-cost compliance strategy.

Low Carbon Fuel Standards, as they currently exist in practice, are applied to suppliers of gasoline and diesel as a measure of average GHG intensity of fuels sold, with individual requirements for gasoline and diesel. Regulated fuel suppliers can reduce the average GHG intensity of their fuel sales by mixing less carbon-intense fuels into their products (such as ethanol in gasoline or biodiesel in diesel), selling alternative low-carbon fuels such as biofuels, propane, hydrogen, and electricity through electric vehicle (EV) charging stations†, or purchasing credits through the flexibility mechanism.

The flexibility mechanism takes the form of tradeable compliance credits. Any fuel supplier or importer who supplies fuel that falls below the maximum carbon intensity for that year will generate credits, which can then be saved for a future year or sold. Suppliers of alternative low-carbon fuels can opt in to the regulation in order to generate credits for sale. Regulated firms choose their lowest cost compliance method from among the options available, which generally include:

- Reducing the carbon content of the fuels they supply;
- Switching fuels or technologies in favour of lower carbon alternatives;
- Purchasing credits; and/or,
- Using credits banked from previous compliance years.

Ultimately, a LCFS works by discouraging high-carbon fuels and by incentivizing low-carbon fuels, while encouraging clean innovation and minimizing costs to fuel suppliers and consumers.[5]

*The EU Fuel Quality Directive was legislated in 2009 but has yet to be implemented by all member countries.
†EV charging stations are typically able to earn credits based on the emissions from electricity generated in that area.

The difference between Low Carbon Fuel Standards and Renewable Fuel Standards

To date, Renewable Fuel Standards (RFS) have been the primary policy tool used to encourage GHG emission reductions from transportation fuels, having been adopted by five provinces and the federal government. In contrast to an LCFS, an RFS requires a certain volume of renewable fuel content in diesel and gasoline fuel sales, but it does not include alternative fuel sources and technologies as an LCFS does. Under an RFS, there is incentive to reach the required standard, but no incentive for additional emission reductions, unlike under an LCFS where the lower the carbon intensity of the fuel, the greater the reward (which stimulates further clean innovation).[6] Evidence suggests that an RFS, in isolation, results in more costly emission reductions than a flexible performance standard such as an LCFS.[7]

Evidence from existing LCFSs shows that they can: (1) lead to significant reductions in GHG emissions, (2) bring important co-benefits in the form of improved health, (3) come at lower cost and induce more innovation than less flexible standards, and (4) be relatively cost effective. This Policy Brief highlights the key design elements and potential policy interactions to consider in creating a Low Carbon Fuel Standard.

THE KNOWLEDGE BASE

Interest in Low Carbon Fuel Standards is growing. Currently, The Government of Ontario is undergoing consultations to design a Modern Renewable Fuel Standard[8] – which, while the title suggests otherwise, resembles more closely an LCFS than an RFS. Similarly, in late 2016 The Government of Canada announced it will begin consultations in early 2017 to develop a national Clean Fuel Standard.[9] The federal government aims to reduce up to 30 million tonnes of GHG emissions annually by 2030 with this proposed policy and, notably, plans to extend the clean fuel standard beyond transportation fuels to include fuels used in homes and buildings as well as in industry.[10]

Impact of Low Carbon Fuel Standards

Because a Low Carbon Fuel Standard works by inducing substitution of lower carbon fuels for higher carbon fuels, it achieves emissions intensity improvements but does not necessarily reduce overall fuel use and does not guarantee absolute emissions reductions. However, the Canadian experience to date has shown that significant emissions reductions can in fact occur. Not only does British Columbia's Renewable and Low Carbon Fuel Requirements Regulation receive significant public support, it is credited with 25% of BC's emission reductions from 2007-2012.[11]

Evidence also suggests that LCFSs come at a moderate cost. Credits in California started at around US$17 and rose to US$62 per ton in 2015 as policy stringency increased.[12] The Working Group on Mitigation created under The Vancouver Declaration on Climate Change and Clean Growth estimated that a national LCFS for only the transportation sector could reduce 10-20MT of GHG emissions with

"The overall objective of a clean fuel standard would be to achieve annual reductions of 30 megatonnes (MT) of GHG emissions by 2030... This reduction is like removing over 7-million vehicles from the roads for a year."

Government of Canada, November 2016

an abatement cost between zero and C$50 per ton.[13] Analysis suggests little of this impact is passed on to consumers directly.* Relative to other policies, evidence suggests abatement costs of an LCFS are lower than an RFS but higher than a carbon pricing system (though there is a case for having the policies work in tandem, discussed further below).[14]

Implementing an LCFS can also have broad societal benefits. These include health and productivity benefits from cleaner air, greater technological innovation, and development of new industries (e.g., BC's RLCFRR has been credited with helping create a thriving biofuels industry in the province). It is estimated that California's LCFS and cap-and-trade system together could avoid more than US$23 billion in societal damages — including health, environment, and energy insecurity — and save more than 400 lives by 2025.[15]

Design Elements of Low Carbon Fuel Standards

While each jurisdiction can design its LCFS to match its specific context, needs, and emissions targets, there are some design elements emerging from the academic literature and real-world experience that can provide guidance to current policy development. Table 1 describes the current and proposed LCFSs with respect to these design elements.

1. **Coverage – The fuels that are included and how emissions are measured**

Coverage refers to both the fuels that are subject to the standard and the way their emissions are measured. Broad coverage of fuels, both in terms of which fuels are covered and how emissions are measured throughout the fuel life cycle, can prevent fuel switching as a compliance strategy and encourage innovation throughout the value chain.

Fuel Coverage: Transportation fuels – and more?

LCFSs generally apply to gasoline and diesel, with electricity, propane, hydrogen and biofuels eligible to contribute towards reducing GHG intensity. Typically, there are two separate targets: one for diesel (and its substitutes); and one for gasoline (and its substitutes).

A unique aspect to the Government of Canada's proposed LCFS is that it extends beyond gasoline and diesel in the transportation sector to include fuels used in residential and commercial buildings, as well as industry. While the proposal does not state which fuels would be covered, they could range from those used in backyard barbecues, to heating for industrial greenhouses, to aviation fuels. Because such broad coverage is novel, there is little evidence available regarding how this major design difference will alter the performance and policy interactions of the LCFS.

Measurement of Emissions Intensity

In existing LCFSs, GHG intensity is measured as the life cycle emissions per unit of energy. Measurement of emissions over the entire life cycle of the fuel, from production to end-use, helps account for different emissions profiles

"The transition to a low carbon transportation sector in Ontario will require a holistic approach that lowers greenhouse gas (GHG) emissions across the sector, while providing compliance flexibility and encouraging the use of green technology."

Government of Ontario, Modern Renewable Fuel Standard Discussion Paper 2017

*An LCFS imposes an implicit tax on high-carbon fuels with the equivalent subsidy to low-carbon fuels. Credits are exchanged through direct producer-producer sales which helps to dampen the cost pass-through to consumers as low-carbon fuels become less expensive and high-carbon fuels become more expensive.

of fuels. For example, around 80% of emissions from traditional gasoline occur at the tailpipe, whereas the production of hydrogen for vehicle use is emissions-intensive with almost zero tailpipe emissions.[16] By covering life cycle emissions, an LCFS also incentivizes innovation throughout the supply chain, wherever emissions reductions can be made at the lowest cost.

Inclusion of Indirect Land-Use Change

While all fuel standards include direct land-use change emissions in their life cycle analysis, one major difference relates to the inclusion (or not) of indirect land use change (ILUC). Studies have shown that incentivizing biofuel production can create emissions from ILUC through new farmland replacing forests, grasslands, and other agricultural land, resulting in the release of stored carbon.[17] Estimating life cycle GHG emissions is a challenge,[18] and different jurisdictions use different methods. California's and Oregon's LCFSs includes estimations for ILUC, while British Columbia's does not. The European Union is currently undertaking consultations to improve methodology and decide on the inclusion of ILUC. Including ILUC can provide a more complete picture of a fuel's life cycle emissions which tends to favour advanced biofuels from waste and crop residues, whereas not including ILUC may indirectly cause land-use change and undermine emission reductions.

Classification of Crude Oil

The classification of crude oil production intensity is a point of particular debate. In existing policies, as well as the proposed national Clean Fuel Standard, crude oil feedstocks are not differentiated by life cycle emissions so long as the total average crude oil production intensity is below a required threshold. In contrast, renewable fuel feedstocks such as ethanol are differentiated by the production process used and their respective country of origin.[19] This feature is designed to avoid competitive disadvantage for domestic heavy oil production and prevent fuel switching between crude oil sources to meet intensity reduction targets. However, this reduces accuracy and fails to incentivize emission reductions from the crude oil production process. To address this shortcoming, California's LCFS grants special credits to crude oil producers that implement innovative technologies that reduce GHG emissions.[20]

2. **Stringency – The degree of emissions reduction required**

Setting long-term, predictable and stringent targets creates an incentive for firms to invest in innovative technologies and fuels.[21] A common feature in existing LCFSs is modest emissions reduction targets in early years ramping up to greater reduction requirements over time.[22] This is to allow time for investment to take place and for new fuels and technologies to be developed and deployed that help reduce compliance costs. The long-term nature of the policy gives investors the certainty needed to make major investments in clean fuel production facilities and infrastructure like electric vehicle charging stations.

A Low Carbon Fuel Standard works by discouraging high-carbon fuels and by incentivizing low-carbon fuels, while encouraging clean innovation and minimizing costs to fuel suppliers and consumers

Existing policies tend to set a ten-year target schedule with incremental annual compliance targets that escalate over time (refer to Table 1). British Columbia's 2016 Climate Leadership Plan has committed to extend the current target of a 10% intensity reduction by 2020 to 15% by 2030 from a 2010 baseline.[23] Ontario has proposed a 5% reduction in the GHG intensity of gasoline by 2020, though the baseline is not clear.[24] Designing targets for a national LCFS will require consideration of the achieved and planned trajectories in BC and Ontario, as well as the role of complementary policies in all provinces.

3. **Flexibility – The options available to meet the standard (and induce more innovation)**

The inclusion of flexibility mechanisms such as credit trading and banking helps reduce the cost of compliance. **Banking** offers temporal flexibility, helping to lower compliance costs and stabilize credit prices. Further, it provides recognition that regulators cannot perfectly predict future technological advancement and cannot know the optimal, most cost effective phase-down schedule.[25] **Trading** allows for reductions to take place where they are most affordable, reducing compliance costs.[26] Typically, there are separate targets for diesel and gasoline, with generation of credits occurring individually for each fuel but credits being eligible for compliance with either target. This is designed to avoid fuel switching between gasoline and diesel as a compliance strategy to generate credits.

Enacting a back-stop mechanism for the cost of compliance credits can enhance predictability and limit potential cost to consumers by setting a price ceiling that is predictable yet still seeks to incentivize innovation. California and BC have enacted different price back-stop mechanisms at around $200 per ton (USD and CAD respectively) for this reason.

Low Carbon Fuel Standards generally apply to gasoline and diesel, with biofuels, propane, hydrogen, and electric vehicle charging eligible to earn credits towards reducing GHG intensity

Table 1. Low Carbon Fuel Standards at a Glance

	British Columbia	California	European Union	Oregon	Canada*	Ontario*
Standard	Renewable and Low Carbon Fuel Requirements Regulation	Low Carbon Fuel Standard	Fuel Quality Directive	Clean Fuels Program	Clean Fuel Standard	Modern Renewable Fuel Standard
Year Enacted	2010	2007	2009	2010	TBD	TBD
First Compliance Year	2013	2011	Yet to be implemented by all parties[27]	2016	TBD	TBD
Coverage	Life cycle of transport fuels, not including ILUC	Life cycle of transport fuels, including ILUC	Life cycle of transport fuels, ILUC reported but not counted, inclusion under review	Life cycle of transport fuels, including ILUC	Transportation fuels as well as fuel use in industry and residential and commercial buildings. ILUC inclusion TBD	Gasoline and its substitutes. ILUC inclusion TBD
Stringency: GHG Intensity Reduction Target	10% by 2020 (2010 baseline)	10% by 2020 (2010 baseline)	6% by 2020 (2010 baseline)	10% by 2025 (2015 baseline includes 10% ethanol gas and 5% ethanol diesel)	TBD	5% by 2020 (baseline unclear)
Flexibility Mechanisms	Tradeable credits, banking, C$200/tonne compliance penalty	Tradeable credits, banking, credit clearance mechanism	Not yet implemented	Tradeable credits, banking, credit price backstop under development	TBD	TBD
Complementary Policies	Federal and provincial RFS, carbon tax including fuel use (C$30/tonne)	Federal RFS, ETS including fuel use (approx. US$12.50/tonne)	Fuel Quality Directive RFS, individual countries have different transportation tax models	Federal renewable fuel mandate	Federal and 5 provincial RFSs, carbon taxes in BC and AB, C&Ts in ON and QC, carbon pricing in all provinces in 2018, potential additional interactions in industry and building GHG policy	Greener diesel regulation, RFS, cap and trade system

*Proposed LCFSs for Canada and Ontario are in the early stages of development and details have yet to be finalized.

Potential Policy Interactions

The economic and environmental effectiveness of low carbon fuel policies are impacted by their potential interactions with existing policies.

Combining an LCFS with a carbon price can lead to greater emissions reduction from transportation fuel use than either policy in isolation

1. **Carbon Pricing**

In theory, and in the absence of other market barriers or failures in the transportation sector, a stringent economy-wide cap on emissions with tradeable permits or a sufficiently high carbon tax would negate the need for an LCFS. However in reality, both inadequate stringency and incomplete coverage exist. In practice, combining an LCFS with a carbon price can lead to greater emissions reduction from transportation fuel use than either policy in isolation.[28] However, an LCFS interacts differently with a carbon tax compared to a cap-and-trade system. This is particularly relevant to Canada as the Government of Canada works to develop a national LCFS that will interact differently with carbon pricing policies in BC, Alberta, Ontario, Quebec, and all provinces by 2018.

Carbon tax

A carbon tax explicitly prices carbon emissions without setting a fixed quantity of reductions. When the tax covers fuel emissions, as it does in BC and Alberta, an LCFS can create even greater incentives for emission reductions from fuel use by adding an implicit tax to high-intensity fuels and the equivalent subsidy to low-intensity fuels in addition to the explicit price of the carbon tax.[29] The carbon tax tends to affect consumers' driving patterns and vehicle purchases, while the LCFS reduces the emissions intensity of the fuels used in those vehicles.

Cap and trade:

Cap-and-trade systems that do not include transportation fuels have little interaction with LCFSs. This is the case in the EU where the emissions trading system (ETS) does not include transportation fuels. However, some cap-and-trade systems do include transportation fuels and have important interactions with LCFSs. This is the case in California where the cap-and-trade system was expanded in 2015 to cover emissions from gasoline, diesel, and natural gas for on-road use, while exempting biofuels.[30] As such, there are currently two side-by-side but unlinked emissions trading markets in operation in California: one for the cap-and-trade system; one for the LCFS.

When emissions trading and LCFSs coincide, an LCFS may reduce the compliance costs for emitters subject to the ETS system because it incentivizes emissions reductions in transportation, thus reducing demand for ETS permits and putting downward pressure on ETS permit prices.[31] However, the LCFS may not create additional overall emission reductions than what the ETS would otherwise accomplish, but simply displace emissions from transportation to other sectors.[32] This may result in forcing emissions reductions from transportation fuels that have a higher abatement cost than other sectors, with the trade-off benefit of driving innovation in the transportation sector, which faces significant barriers to decarbonisation. These effects are anticipated to be small prior to 2020 based on the current credit prices and caps.[33] This interaction is likely to be similar in Quebec and Ontario where cap-and-trade systems have been designed to be linked with California's system.[34]

2. **Renewable Fuel Standard**

Currently, every jurisdiction with an LCFS also has an RFS. Canada and the US employ RFS policies at the federal level while subnational jurisdictions employ varied (and in some cases more stringent) policies, and the European Union has an RFS in its fuel quality directive. For example, Ontario currently has an RFS for diesel (the Greener Diesel Regulation, which it aims to combine with its proposed LCFS) and is also subject to Canada's federal Renewable Fuel Mandate.[35]

When used in combination an LCFS and RFS can achieve greater GHG emission reductions than an RFS alone.[36,37] This occurs in part by the LCFS encouraging biofuels with lower life cycle emissions. However, existing RFSs incentivize biofuels and not alternative fuels and technologies, resulting in costlier emission reductions than an LCFS alone. For this reason, some argue that existing RFS policies should be removed in favour of a technology-neutral LCFS.[38]

3. **Other Complementary Policies**

Introducing a new policy requires situating it within the existing suite of policies. A host of complementary policies exist to target GHG emissions in the transportation sector[39] such as those aiming to increase the fuel efficiency of vehicles and the market share of EVs.

As EVs continue to gain market share, credits generated from EV charging stations can play an increasingly important role in an LCFS. Zero-emission vehicle mandate policies, such as in Quebec where 15% of automakers' sales are required to be zero-emission vehicles by 2025, will therefore influence the performance of a clean fuel standard.[40] A report from Simon Fraser University (2016) further identified 96 policies aimed at increasing electric vehicle sales in Canada.[41]

In the same vein, an LCFS can also be complemented by reducing the GHG intensity of electricity used as fuel in EVs through renewable portfolio standards, feed-in tariffs, and a host of other policies. Similarly, corporate average fuel economy standards, harmonized between the US and Canada, target vehicle fuel efficiency to support GHG mitigation, a natural complement to an LCFS.[42, **]

However, in order to avoid double counting emissions reductions, it is important that governments estimating emissions reductions from changes in the transportation sector do not attribute those emission reductions to more than one policy. Each policy must be modeled in the context of existing and likely policies in order to take into account all the interactions.

Applying an LCFS beyond transportation opens up a suite of other policy interactions. There are many existing policies that may interact with an LCFS that applies to fuel use in industry and commercial and residential buildings. However, since Canada's national LCFS will be the first policy of its kind to extend beyond transportation fuels, the impacts of these interactions have not been fully explored and will be an obvious area for further research during the policy development process.

Well-designed LCFSs include broad coverage, stringent and predictable targets, and flexible compliance mechanisms

** Interactions with the breadth of biofuel policies in Canada and abroad are complex and beyond the scope of this paper, for a more detailed look at the economics of biofuel policies and effects on GHG emissions, land use change, and food and fuel prices, see Canada's Ecofiscal Commission (2016).

Equity Considerations

Consideration of the possible equity impacts of an LCFS should not be neglected. While studies are scarce, an LCFS could interact with existing policies to affect fuel and food prices, where price increases could have a disproportional impact on low-income households, rural communities or other socioeconomic groups. For this reason, more investigation is needed regarding the policy interactions and potential social impacts that could occur.

A key consideration in designing a cross-jurisdictional LCFS, such as Canada's proposed national policy, is potential regional impacts. Early research recognizes that costs and benefits from LCFSs are not equally distributed and tend to be regionally skewed to favour areas that produce renewable fuel feedstocks.[43] With Canada's regional diversity, consideration of regional impacts, interprovincial trade, and potential equivalency mechanisms will have to be carefully examined.

Additionally, with the proposed Canadian national LCFS extending beyond transportation fuels, it will be important to consider how an LCFS may impact industry competitiveness and carbon-intensive and trade-exposed sectors in particular.

The federal government's proposed LCFS intends to extend beyond gasoline and diesel in the transportation sector to include fuels used in residential and commercial buildings, as well as industry

IMPLICATIONS FOR POLICYMAKERS

Low Carbon Fuel Standards are a high-impact policy – they can bring significant GHG emission reductions, stimulate clean innovation, and spur growth in some sectors. But they raise important and complex questions regarding policy interactions that require consideration in the early stages of policy design. Significant questions remain regarding the key design features of the newly proposed federal and Ontario LCFSs, including questions relating to how national and sub-national LCFSs will be linked and/or deemed equivalent. Careful consideration of regional impacts is necessary in designing such a cross-jurisdictional policy as a national LCFS.

The literature and real-world evidence available to date suggests that broad coverage, stringent and predictable targets, and flexibility mechanisms for compliance are key elements of a well-designed LCFS. There are a number of interesting questions related to LCFS design that could be explored further, such as:

- How can an LCFS be designed to maximize innovation and technological advancement?
- How can a national LCFS be designed to account equitably for regional differences in alternative fuel production and distribution capacity?

More research is also needed in the area of possible interactions between an LCFS and other policies such as carbon pricing, renewable fuel standards, and other transportation and industry fuel use policies. Interesting questions include:

- What are the real-world effects of California's LCFS interacting with the cap-and-trade system (since 2015)?
- What might the effects of a national LCFS be in interacting with existing LCFSs in BC and potentially Ontario?

- How will a national LCFS interact with varying existing and potential jurisdictional transportation policies, such as renewable fuel standards and EV policies?
- What are the opportunities and trade offs in allowing credit trading between jurisdictions? Between cap and trade and LCFS?

The federal government's proposal to extend an LCFS to fuels outside of the transportation sector further raises the stakes. The emissions reduction potential is greater, as are the policy design questions and the potential policy interactions. Fruitful areas to investigate may include:

- Which fuels beyond diesel and gasoline can reasonably be covered by a national LCFS, at what baseline levels? What are the opportunities for GHG intensity reduction of each fuel and how stringent should requirements be set?
- What kind of substitutions between fuels will merit credits? For example, if electricity is considered an alternative fuel for industry and home use, what are the implications for the electricity sector and electricity policy?
- How will different industries be impacted? What support or exemptions for carbon-intense trade-exposed industries might warrant consideration?
- How will this policy interact with existing and potential industrial and commercial/residential GHG mitigation policies?

As a performance-based technology-neutral standard, a well-designed LCFS means immediate emissions intensity improvements are achieved at the same time that innovation in alternative fuel technologies and infrastructure are incentivized. As such, not only do LCFSs improve the emissions intensity of the fuel used in today's vehicle fleets, they encourage clean innovation and help accelerate the energy transition in the transportation sector. This dual benefit suggests that it is worth taking the time at the policy design stage to address these important questions in order to design the standards well.

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