The Conference Board of Canada | Le Conference Board du Canada

Renewable Fuel Standards Within a Low-Carbon Fuel Strategy.

At a Glance

- Governments in Canada are looking to further reduce GHG emissions from the transportation sector by introducing low-carbon fuel standards.
- The existing federal Renewable Fuels Regulations (i.e., the ethanol blend mandate) plays a key role in reducing the carbon intensity of gasoline while providing market access and economic stability for the ethanol industry.
- Ethanol is made from renewable resources and, as measured by life cycle analysis, reduces GHG emissions by more than 60 per cent relative to gasoline. Further, ethanol is currently the lowest cost source of low-carbon octane for gasoline blending.
- Based on econometric analysis, the positive economic impacts and associated tax revenues resulting from the production and use of ethanol exceed the historical costs of government support programs.

BRIEFING SEPTEMBER 2017

Executive Summary

Canada and its provinces are formulating a broad range of programs and regulations to reduce greenhouse gas emissions across the economy. Clean Fuel Standards (CFS) are being considered as part of the process. One of the fundamental questions is whether and how existing renewable fuel standards, including blend mandates, might support CFS regulations.

Blend mandates were introduced in Canada as part of a renewable fuels strategy. The mandates set a minimum renewable fuel content in gasoline and diesel fuel sold to consumers. Clean Fuel Standards take a broader approach in that they set a maximum carbon content in gasoline and allow fuel suppliers to determine how to meet the standard. To date, only British Columbia has both a blend mandate and a CFS.

This briefing examines the role of blend mandates in a CFS strategy.

- Blend mandates provide market certainty and a stable investment environment for expanded domestic ethanol capacity and continued technology development.
- Renewable fuel standards ensure market access for renewable fuels.
- Blend mandates ensure the societal benefits of ethanol continue.
- Ethanol is the lowest-carbon source of octane for gasoline blending and contributes to meeting tighter CFS targets, particularly with mid- to high-level ethanol blending (e.g., E15, E20–30, and E85).

Recent work indicates that, in the Canadian context, life cycle greenhouse gas emissions from the use of Canadian-produced ethanol are as much as 60 per cent lower than from gasoline use. Canada's Ecofiscal Commission has conservatively estimated that ethanol's 5 per cent mandated content in gasoline reduces national GHG emissions by 2.1 million tonnes per year (just over 1.5 per cent of road transport emissions).

ECCC is considering the introduction of Clean Fuel Standards to regulate a gradual decrease in the average carbon intensity of transportation fuels and others.

In addition, ethanol provides a low-carbon source of octane for gasoline blending. On this point, the renewable fuels strategy and a pending CFS work in the same direction, although perhaps through different pathways. Retaining the blend mandate helps to ensure the availability of low-carbon octane (in the form of ethanol) to the Canadian fuels market.

The blend mandate also provides a measure of investment certainty for capacity additions and for technology development. These investments are critical to ensuring that Canada's fuels market continues to have access to this important contributor to a sustainable, low-carbon future.

Background

Environment and Climate Change Canada (ECCC) is considering the introduction of Clean Fuel Standards (CFS) to regulate a gradual decrease in the average carbon intensity of transportation fuels and others. The general idea is to set a maximum carbon content for fuels sold within the jurisdiction, and to require that the carbon content is reduced over time. The regulations typically include trading mechanisms that allow suppliers, whose fuels are cleaner than the standard, to sell allowances to suppliers who are otherwise unable to meet the standard.

The CFS approach broadens the coverage of fuels included in the regulation. It also provides greater flexibility in terms of the actions that can be taken to reduce GHG emissions from fuel combustion. To date, only three jurisdictions have implemented a CFS: California; British Columbia (a blend mandate in 2010 and reductions in carbon intensity from 2013 onward); and Oregon. All three jurisdictions also have volumetric blending requirements or renewable fuel standards (RFS) in conjunction with the CFS. Renewable fuels are producing between 75 and 99 per cent of the GHG emission reductions under the low-carbon fuel standards in these jurisdictions.

A recent ECCC discussion paper outlined the broad framework for a federal CFS, which is to focus on the full range of fuels being used for transportation and heating. ECCC raises several questions—one of

Ontario is contemplating an updated approach to transportation fuels regulation.

which is how an RFS could support the CFS (i.e., maintaining, increasing, or decreasing renewable fuels volume requirements).[1]

Ontario also posted a discussion paper to develop modern, renewable fuel standards for gasoline that would reduce GHG emissions by 5 per cent by 2020. This is part of the province's considerations of an updated approach to transportation fuels regulation.[2] The current blend mandate of 5 per cent ethanol in gasoline in Ontario came into force in 2007. The Ontario discussion paper indicates intent to maintain existing renewable fuels content requirements with the potential to increase volume requirements that meet threshold carbon intensity.

Quebec recently announced its intention to introduce a 5 per cent ethanol volumetric requirement for gasoline sold in the province in a manner consistent with current federal requirements.

Other jurisdictions around the world have introduced, or are in the process of introducing, volumetric requirements for renewable fuel blending in gasoline. Many countries are already operating with more ambitious requirements than Canada. The mandate for ethanol is 27.5 per cent in Paraguay; 27 per cent in Brazil; 10 per cent in the United States; 1 per cent in China, Ecuador, Ethiopia, Fiji, Mozambique, Panama, and Zimbabwe; and 6 per cent in the European Union.[3]

In Canada the current federal requirement of 5 per cent ethanol in gasoline has been in force since December, 2010.[4] A similar requirement for diesel fuel was set at 2 per cent renewable content. At the time the federal Renewable Fuels Regulations were enacted, the program was expected to reduce GHG emissions by 2 million tonnes per year, with about half of the reduction resulting from the gasoline requirement.

1 Environment and Climate Change Canada, *Clean Fuel Standard*: *Discussion Paper*. See Section 7, question 36.

2 Government of Ontario, *Ontario's Regulatory Registry.*

3 United States Environmental Protection Agency*, Renewable Fuel Standard Program*.

4 Environment and Climate Change Canada, *Renewable Fuels Regulations*.

In addition to reducing GHG emissions as part of the 2007 Climate Change Action Plan, the stated purposes of the renewable fuels strategy were to:

- increase the retail availability of renewable fuels;
- support the expansion of the Canadian production of renewable fuels;
- assist farmers to participate in the economic benefits associated with a new renewable fuels industry;
- accelerate the commercialization of new technologies.[5]

Is There a Case for a Continuation of the RFS for Gasoline?

Across Canada, governments are updating their regulatory frameworks for climate change. Their efforts have led to the recent release of a Pan-Canadian Framework on Clean Growth and Climate Change.[6] This framework is evidence of a new, collaborative approach to reducing GHG emissions using a broad range of tools. The tools include carbon pricing, emissions targets, support for technology development, sector-specific regulations, direct actions to eliminate certain sources of emissions (e.g., coal-fired electricity), educational programs, and other regulatory approaches.

Within this context, previous Conference Board of Canada research has pointed to the challenges that road transport faces in reaching aggressive emissions reduction targets.[7] Numerous studies have identified a strong role for biofuels (both ethanol and bio-based diesel) in helping to meet emissions targets.[8] Transportation is the single largest source of GHG emissions in Canada, and transportation demand is projected to grow with population and GDP growth. Lowering the carbon footprint of the fuels we use will play an integral role in our transition

5 Environment and Climate Change Canada, *Federal Renewable Fuels Regulations: Overview*.

6 Government of Canada, *The Pan-Canadian Framework*.

7 Robins, Knowles, and Coad, *A Long Hard Road*.

8 For example, in 2016, the Trottier Energy Futures Project in partnership with the Canadian Academy of Engineering released a detailed report of technical pathways to emissions reduction. The transportation analysis in that report identified a growing role for biofuels across the full range of technical options examined.

This briefing considers the policy options and requirements that will ensure that Canada's ethanol industry continues to expand.

to a low-carbon future. Ethanol is the only low-carbon, renewable fuel alternative for gasoline available at commercial scale.[9]

This briefing examines the following arguments in favour of retaining a minimum blend mandate within a CFS:

- Blend mandates provide market certainty and a stable investment environment for expanded domestic ethanol capacity and technology development for the next generation of renewable fuels.
- Renewable fuel standards ensure market access for renewable fuels.
- Without blend mandates, the full societal benefits of renewable fuels, like ethanol, would be lost (e.g., GHG emissions reductions from ethanol's clean octane properties, and rural economic development).
- CFS targets are almost certainly unattainable without mid- to high-level ethanol blending (e.g., E15, E20–30, and E85). Given the nature of wholesale fuel distribution, an unequivocal mandate is required to establish infrastructure (wholesale and retail) to enable mid- to high-level ethanol blends in the market.

There are two supplementary examinations to be described in this briefing. One is an overview of historical government support programs. The other is to examine the emerging anti-knock requirements of leading-edge engine technologies that rely on higher compression ratios to achieve greater efficiency in reducing the fuel consumption of smaller engines.

This briefing considers the policy options and requirements that will ensure that Canada's ethanol industry continues to expand and commercialize future production technologies. The briefing also contemplates the fuels distribution infrastructure that will be required to accommodate higher-level ethanol blends. This is particularly important as Canada seeks to reduce GHG emissions from transportation. Subsequent briefings will consider several of these elements in further detail.

9 Renewable gasoline (high-octane gasoline blendstock is a potential candidate) has not been commercialized and is not anticipated to be available in the CFS time frame. The only potential renewable gasoline would be from the co-processing of crude/refined lipids and pyrolysis oil (biocrude). This technology has been demonstrated at commercial scale—i.e., in petroleum refineries—but is in pre-commercial status for CFS-relevant volumes.

Ethanol production and the related historical Canadian government incentive programs have been widely examined. The form of government participation and its impact have changed over time. The debate on the cost and impacts of government support has focused on agricultural subsidies, capital subsidies, and operating cost support. In addition, the environmental impacts of producing ethanol and blending it into gasoline have been examined. Many analysts consider the entire amount of government support as though it applied to only one benefit: the reduction of greenhouse gas emissions. In addition, the usefulness of blend mandates is being examined more critically by those who feel that carbon pricing and related policies should supersede the policies of the past.

This briefing compiles data for the assessed benefits of ethanol—benefits to farmers and the economic value of blending ethanol as a source of octane rather than alternatives. It also compiles data with respect to the financial contributions that Canadian governments have made through the years. The net cost or benefit can then be compared with produced volumes of ethanol over the life cycle of the production plants that have received financial support. This provides a balanced economic scorecard of the life cycle net benefits or costs of ethanol production in Canada.

Greenhouse Gas Emissions

The impact of ethanol blending on GHG emissions has been extensively debated, with a wide range of reported results. However, over the past decade or more, life cycle analysis has become the standard tool for comparing ethanol blends to gasoline that contains no ethanol. These results are typically based on 100 per cent ethanol and then scaled to a 10 per cent blend of ethanol in gasoline, assuming no change in combustion efficiency.

Life cycle analysis sets clear boundaries around the factors being considered, gathers specific data for the included factors, and results in reliable estimates of emissions from the various pathways examined. The analysis is location and time dependent. For example, farming practices as well as ethanol production emissions differ between corn and other

Current estimates demonstrate that ethanol blending in 2013 reduced Canada's gasoline-related GHG emissions by at least 2.1 megatonnes.

feedstocks. Further, Canadian corn farming practices are different than those used in the United States. The differences are in terms of the amount of chemical versus organic fertilizer applied, irrigation practices, yields, the use of petroleum fuels, tillage practices, and so on. Farming practices are also evolving in both nations with the adoption of precision farming techniques, and yields continue to increase—leading to a continuing reduction in the carbon footprints. The differences between the two countries impact the relative life cycle emissions from ethanol production. In addition, the inclusion or exclusion of indirect land use changes (ILUC) in life cycle work, together with the timing of the work, can have a significant impact on the results. (See "The Influence of ILUC on Life Cycle Analysis.")

Recent work indicates that, in the Canadian context, life cycle greenhouse gas emissions from the use of Canadian-produced ethanol are as much as 60 per cent lower than from gasoline use. The climate benefits of ethanol blending are clear and well documented. The overall level of GHG emissions abated from ethanol production and consumption in Canada have also been estimated many times. A recent estimate of 2.1 million tonnes of CO2e per year was published by Canada's Ecofiscal Commission. The Commission's estimate assumes the full mileage penalty for ethanol is based on energy content and it does not include the octane benefit. The Ecofiscal work on emissions reductions is cited here because it is based on a reasonably careful review of the impacts of Canadian ethanol production—both within Canada and externally. The calculation is lower than other estimates cited in the report, which range from 2.3 to 4.3 megatonnes (Mt) per year. The Ecofiscal number should therefore be considered conservative. However, current estimates demonstrate that ethanol blending in 2013 reduced Canada's gasoline-related GHG emissions by at least 2.1 megatonnes. Given the blend mandate of only 5 per cent, this corroborates the estimates from life cycle analysis regarding the emissions reductions achieved from ethanol use.

The Influence of ILUC on Life Cycle Analysis

Indirect land use changes (ILUC) occur when the demand for land in one nation influences land use in another. The simplest example is when agricultural producers in one nation sell their crop to meet new demand from a domestic biofuel producer, rather than export it. Producers in another country then expand their cropland to meet the demand that used to be supplied by the imported product. The expanded cropland may have been grassland or forest and the conversion of this land releases GHGs.

Recent analyses of ethanol policies have debated how ILUC emissions should be quantified and how to include them in life cycle analyses. For example, the life cycle analysis that underpins the U.S. RFS2 (renewable fuel standard program) work from 2010 concludes that the life cycle emissions of corn ethanol are 81,207 grams of CO2e per million BTUs (LHV) of ethanol produced. Of this, 31,790 grams were attributed to ILUC. A 2017 study by ICF[10] updated the data used for the RFS2 study. It found that, in 2014, the actual GHG emissions were 30 per cent less than previously thought (55,731 grams of CO2e per million BTUs of ethanol produced). Additionally, the emissions attributable to ILUC fell by over 70 per cent (9,082 grams were attributed to ILUC in the 2014 study).

Sources: The Conference Board of Canada; ICF.

Ethanol as a Low-Carbon Source of Octane

Gasoline blending is a complex process. Refineries produce blending components with varying octane ratings, depending on various factors. The factors include the crude oil and other feedstocks being processed; the refinery's configuration; refinery input costs; expected wholesale prices of refined products; demand for products; availability of blending components; and seasonal conditions. The maximum vapour pressure of gasoline is a more important consideration in summer when temperatures are higher and gasoline becomes more volatile. Refineries use complex optimization models (either linear or non-linear programming) to identify the best combination of the factors listed above—with "best" defined as either minimum cost or maximum profit.

10 ICF, *About ICF*.

Canada's current renewable fuel standards place significant emphasis on supporting renewable fuels' domestic production, expansion, and retail availability.

Ethanol is an attractive blending component for two reasons. First, it is a low-carbon fuel sourced primarily from biomass. For jurisdictions like British Columbia that currently have a low-carbon fuel standard in place, blending ethanol contributes to meeting the regulatory requirements. In addition, ethanol has a higher octane rating than the conventional or reformulated gasoline blend stock to which it can be added. Therefore, it can help meet the anti-knock requirements of current engines, as well as the higher octane requirements of future engines designed around higher compression ratios.

Some Canadian oil refiners reportedly produce, or have access to, sufficient relatively high-octane blending stock components—such as reformate and alkylate—to meet the octane ratings of the various gasoline products that they produce without adding ethanol. In such cases, while mandating ethanol/gasoline blends may increase the refiners' costs, the low-carbon content of ethanol contributes to the lowering of GHG emissions in the transport sector that will be necessary in the transition to a low-carbon economy.

Some oil refinery products that otherwise would have been destined for the gasoline pool can be expected to be displaced when an ethanol mandate is introduced. However, a refinery optimization model is needed to assess the impact that this may have on a typical oil refiner. The results will depend on the configuration of the refinery in question and whether alternative commercial opportunities, such as sales to other refiners or exports, are available. Refer to Appendix B for a further discussion of the octane advantages of ethanol.

A Stable Investment Environment

Canada's current RFS places significant emphasis on supporting renewable fuels' domestic production, expansion, and retail availability. The historical investments in support of the strategy have borne fruit. Production has grown and ethanol producers are leading in advanced biofuels technology development and related investments. The blend mandate has played, and continues to play, a role in the financial stability and growth prospects it faces.

The financial support provided historically to the ethanol industry and the return on that investment are described in some detail later in this briefing. Capital contributions and operating cost programs (direct financial support) have been part of that support, but have all been phased out. Those measures were instrumental in expanding Canada's ethanol production capacity to its current level of approximately 1.8 billion litres per year.

The main points for discussion are the ability to fund future capacity expansions and technology investments with or without a blend mandate. The argument is that the blend mandate supports the ability to finance both new plant construction and technology development. A case in point is a significant expansion of operations at IGPC Ethanol Inc.'s Aylmer, Ontario facility—which will double IGPC's annual ethanol production capacity and subsidiary products.[11]

As is true in any industry, raising both equity and debt for a new project is a challenging process, even when the equity is available and privately sourced. Investors and lenders must put forward the entire capital amount during the project development and construction stages. They then depend on the revenues net of costs produced by the plant over its life to repay the capital with a return.

One of the key risk factors for any project is the revenue stream it generates, particularly compared to costs. The revenue stream for ethanol is strongly influenced by the need to compete against petroleum fuels for blending purposes. Where ethanol is available in high blends, it also competes more directly as a transportation fuel. Further, as economic cycles take place, ethanol revenues are subject to fluctuations in transportation demand. These irregularities have all been experienced within the past decade.

For any capital project in any industry, investors and lenders carefully examine the risk of a plant being built that is unable to sell its output at a price that covers costs and generates an acceptable return. This barrier is particularly important for projects that have only one function and cannot be easily repurposed. Ethanol plants fit in this category.

11 IGPC Ethanol Inc., *Assessing Major Investment*; McIntosh, *Fuelling Innovation*.

The ethanol blend mandate supports industry expansion by reducing the competitive pressure new ethanol plants face.

The issue is simple. Where a project is fully exposed to a highly competitive market, finance becomes significantly more expensive and more difficult to obtain. A risk premium is attached to any available funding to reflect that uncertainty. Given that the cost of capital is a major component of annual costs, the size of the risk premium influences project competitiveness. The role of the RFS blend mandate is evident. The blend mandate reduces the competitive pressures a new ethanol plant will face because it sets a lower bound on the volume of ethanol that will be required. However, the lower bound is still subject to variations in the demand for gasoline. With the blend mandate, ethanol producers compete against ethanol imports, and against each other, but only to the extent that the mandated volumes are oversupplied. The competition from imports creates an incentive for domestic producers to manage costs. From a financial point of view, the mandate is important because it reduces the risk of exposure to competitive forces and potentially reduces the risk premium that is required to finance any given project and technological advancement.

From the available data, it is clear that ethanol technology development and commercial demonstration are proceeding at a very measured pace in Canada. Much of the current activity is funded by reinvestment of earnings generated by first-generation plants. In addition to the projects listed, Greenfield Specialty Alcohols operates a technology Centre of Excellence at its Chatham, Ontario facility. This Centre undertakes technology research for both first- and second-generation ethanol technologies and is internally funded.

The link between advanced technologies and the blend mandate is also simple. A future in which ethanol sales are less certain, or in which new facilities cannot be financed (or are financed at a higher risk premium), places additional pressure on the funding that can be committed to technology development. Given the current, very low, level of government participation in these efforts, removal of the blend mandate would make the RFS objectives more uncertain.

A Broader Range of Considerations

As the role of ethanol continues to evolve, several other issues deserve consideration in the broader context of a clean fuel standard. The proposed CFS focuses almost exclusively on reducing life cycle GHG emissions from fuels. Whereas, while ethanol contributes significantly to this reduction of GHG emissions, it also contributes to lessening other harmful airborne emissions and contributes to Canada's agricultural economy. These factors should not be ignored, and can be considered valid arguments for maintaining Canada's current renewable fuels strategy.

A More Complete View of Government Support

Although Canadian government support for ethanol has served several objectives, numerous studies have focused on GHG emissions as though they were the primary objectives. Oddly, Canada's renewable fuels strategy does not mention GHG abatement directly, although it can be assumed to be a driving force behind making renewable fuels more available to markets.

Some studies have suggested high GHG abatement costs in support of arguments against continued biofuels support. For example, Canada's Ecofiscal Commission's *Course Correction* report estimates the abatement cost for ethanol policies at $180–$185/tonne.[12] This estimate is based on the Commission's own work, plus a previous study by the International Institute for Sustainable Development. Notwithstanding the different purposes and methodologies between the analyses, the contrast in these findings is striking. Ethanol has unique properties, like octane, which add value to the fuel it is blended with. Ecofiscal's decision to leave out these values—focusing exclusively on GHG reductions—inflates the abatement cost estimates. Further, most analyses focus on government program expenditures during the program period, ignoring both the return to government in tax revenues from ethanol producers and the emissions reductions that continue after the programs have ended. Additionally, Ecofiscal's methodology was considered

12 Ecofiscal Commission, *Course Correction*, iii.

The abatement cost calculations all assume that the government received only GHG reductions in return for its financial support. This is simply not the case.

controversial; it included biofuel industry subsidies in abatement cost calculations, but did not assess subsides to gasoline. Abatement costs are a comparative concept, and require the use of the comparable base system boundary conditions if accuracy is sought.

What Is the Net Cost to Government?

The typical approach—taken in quantifying the abatement cost or the cost of government programs overall—has been to consider the total amount spent by government over a given period compared to the resulting emissions reduction. For example, *Course Correction* estimates the fiscal cost at $1.87 billion over the period of 2006 to 2015.[13] The cost after 2015 can be considered small, because government financial support programs were winding down and have now been completely phased out. The estimated fiscal cost allocates the entire amount spent by government to the goal of reducing GHG emissions. And, it makes no attempt to account for the other objectives of the renewable fuels strategy. This is perhaps an understandable oversimplification because there is no way to objectively estimate the impact that not having biofuels programs would have had on agricultural or rural community expenditures by government.

Another factor must be considered. The critics of government support for ethanol production facilities argue that without the support, ethanol production facilities would not have been built or expanded. This view is at least partially corroborated by the timing of production capacity growth. Most, if not all, of the investment decisions were influenced by available government funding. However, the abatement cost calculations all assume that the government received only GHG reductions in return for its financial support. This is simply not the case. A somewhat dated report from Doyletech quantifies the government revenue from both the capital and operating phases of the 1.775 million litres of ethanol capacity and 471 million litres of biodiesel capacity that existed in 2010 when Doyletech completed its study.[14] Doyletech found that the installed biofuels capacity generated $492.1 million of provincial government

13 Ibid., tables 7 and 8. The estimate from 2006–12 is based on IISD low case, and the remainder of the period is estimated by the *Course Correction* authors.

14 Doyletech Corporation, *Total Economic Impact Assessment*.

revenues and $679.9 million of federal government revenues during the construction phase. As well, a further $151.5 million in annual provincial government revenues and $145.4 million in annual federal government revenues were generated.

These government returns occur primarily through direct and indirect taxes. Allocating the tax revenues between ethanol and biodiesel on the basis of production capacity suggests that during the construction phase, the ethanol capacity generated $926 million for government, and an additional $235 million per year during the operations phase. Over the ten years examined by *Course Correction*, this would amount to more than $2 billion in government revenue.[15]

A Life Cycle Perspective

There is one further analytical extension that must be made to the estimated costs and GHG impacts of Canada's ethanol policies. A large portion of the government funding was provided in the form of capital contributions to construct the ethanol plants. A standard approach to financial analysis would be to consider the net cost to government over the useful life of the plants it supported. Because the capital contributions are made early in the life of the plants and their return in the form of tax payments happens later, it is appropriate to discount. Using a social discount rate of 6 per cent, and scaling the government revenues to match the projected capacity as plants begin to retire, the net present value (NPV) of the government payment/revenue stream is estimated at $2.1 billion. When considered over the useful life of the production capacity of the plants supported by government, and taking into account the tax revenues generated over that same period, the NPV of government revenues from ethanol production will exceed the NPV of the financial support offered.

15 Not all of the production capacity was in place for the entire 2006–15 period, so the operating phase revenues must be adjusted to match capacity.

Looking to the future, Canada's objective is to reduce GHG emissions from transport—and ethanol contributes to that objective.

Conclusion

The two primary arguments in support of retaining a blend mandate in a low-carbon fuel standard are to support a stable investment environment for future ethanol production and to maintain an adequate volume of low-carbon/high-octane blending components for the gasoline pool. Gasoline blending is a complex matter. Removal of the blend mandate would give gasoline producers more scope to minimize costs by considering all sources of octane within their efforts to optimize refinery production and costs. However, the discussion is about transitioning to a low-carbon future. Because it is biomass-based, ethanol's life cycle impact qualifies it as a low-carbon fuel. A low-carbon fuel standard intends to reduce the carbon intensity of gasoline and other fuels. The blend mandate is a straightforward, necessary approach to ensuring that gasoline includes a low-carbon component. The approach also guarantees that infrastructure investments will be made to enable CFS targets to be met through mid- to high-level ethanol blends, as well as E5 and E10. Relying entirely on an upper bound on the carbon content of gasoline is unlikely to achieve the same result, given the market structure of fuels distribution. However, the upper bound does take on a critical role in supporting the adoption of other alternatives.

The matter of a stable investment environment for future ethanol investments is critical. As the industry has developed historically, commodity prices have been volatile and have greatly influenced industry economics. Looking to the future, Canada's objective is to reduce GHG emissions from transport—and ethanol contributes to that objective. Advanced biofuels technologies are moving toward commercial status, and are at a critical stage. A blend mandate is a low-cost way for government to improve the market certainty that the industry requires. This ensures continued access to affordable capital so that companies can make the required investments to contribute to Canada's low-carbon future.

The questions of environmental and climate impacts of ethanol have also been surveyed. Blending ethanol demonstrates benefits in each of these areas. Given these benefits, one of the key considerations in a low-carbon fuel discussion ought to be structuring the standard to ensure that the role of ethanol is strengthened and its benefits extended.

Finally, two key points arise from the recent debate surrounding government support for ethanol production:

1. Government financial support is currently in the rear-view mirror. The money has been spent, and existing capacity will continue to produce as a low-carbon standard is designed and implemented. The wisdom is in extracting value from past investments.
2. Evaluations of government support typically focus on the money spent by government compared to the GHG emissions abated. The evaluations fail to consider the taxes returned to government as the plants are built and operated. These revenue streams have been estimated to exceed direct expenditures, even on an NPV basis.

Achieving Canada's low-carbon future for transportation will be challenging. Previous research demonstrates that deep reductions in GHG emissions will require Canada to act in many directions at once. Every technology currently available must play a role. Additionally, a carbon price must be imposed, properly structured, and applied to fuels to support decarbonization; and consumers must change their behaviour—and be induced to change their behaviour—to make an 80 per cent reduction possible. Ethanol has an expanded role to play, and emerging low-carbon fuel standards should be designed to support that role as well as encourage broader measures to reduce GHG emissions.

APPENDIX A
Octane

Table 1 compares the key properties of octane and vapour pressures for ethanol to the main petroleum blending components of gasoline. As shown in the table, ethanol makes a strong contribution to the octane performance of blended gasoline. One of the challenges in gasoline blending is to add enough blending components to raise the octane number to the retail octane rating of 87 for regular gasoline, 89 for mid-grade gasoline, or 91–93 for premium gasoline. Based on the data presented, mid-cut reformate provides both the second-highest octane rating and the lowest contribution to vapour pressure. The higher Reid Vapour Pressure of ethanol—relative to both reformate and iso-octane—is a greater consideration in summer than in winter.

Table 1
Attributes of Octane-Enhancing or Reducing Hydrocarbons and Ethanol

	Octane Rating (RON*)	Reid Vapour Pressure (psi**)	Gravity (degrees API***)
Iso-octane	100	1.8	72.8
Ethanol	115.9	2	48
Mid-range reformate	109.3	1	32.8
Light alkylate	93.2	4.6	72.3
Isomerate	78.6	8	83
Catalytic cracked naphtha	92.9	4.5	52
Light straight-run naphtha	63.7	10.8	81.8
n-butane	91	46	104.1

Notes: Reid Vapour Pressure measured at 100 degrees F when in contact with air at volume ration 1:4.
For iso-octane and n-butane, values are converted from estimated densities.
The RON of ethanol/gasoline blends is typically higher than 115.9.
*RON = research octane number
**psi = pounds per square inch
***API = American Petroleum Institute gravity
Source: The Conference Board of Canada.

Refinery Sources of Octane

Refineries produce several blend stocks that can be blended into finished gasoline. The exact process, volumes, and costs depend on the individual refinery.

Reformate: Reformate is produced via a catalytic reformer using medium to heavy naphtha streams from the distillation tower. It contains octanes and aromatic compounds, such as benzene and toluene, and generally has an octane rating in the higher end of the 85 to 100 range. Increasing the severity of the reforming process to produce higher octane reformate increases the unit cost. But, it reduces the yield and increases the Reid Vapour Pressure.

Alkylate: This second-largest source of octane for the gasoline pool combines light olefins (butylene and propylene) with iso-butane to produce alkylate. The light olefins, and possibly some of the iso-butane, come from the refinery fluidized catalytic cracking (FCC) unit. Iso-butane is also an output from refinery hydrocrackers. It is also produced at gas processing plants, NGL fractionation plants, or by converting normal butane in an isomerization unit.

Butylene or propylene and iso-butane are fed into an alkylation reactor, where they combine to form a mixture of heavier hydrocarbons. The liquid fractionate of this mixture of compounds is called alkylate—a high-octane RON (research octane number of 90 to 97) gasoline-blending feedstock. Because alkylation takes two low-density feedstocks and produces a higher density product, the feed volume is reduced by about 30 per cent. Alkylate contains no aromatics and no sulphur. Increasing the isooctane content in alkylate by increasing the severity of the production process can result in a significant (up to 20 per cent) drop in output volumes.

Isomerate: Isomerization rearranges the low-octane C5 and C6 normal-paraffin molecules in light crude oil distillate or light straight-run naphtha to produce higher-octane C5 and C6 isoparaffins. This significantly increases the octane of the resulting naphtha stream (isomerate) and makes it a valuable gasoline blendstock. Isomerate is beneficial not only because of its higher octane, but also because it contains essentially no sulphur and no benzene.

Poly Gasoline: Polymerization combines two or three light olefin molecules (such as ethylene and propylene) from the gas plant to produce a high-octane, olefinic gasoline blendstock component known as poly gasoline. Although a fairly inexpensive process, poly gasoline is not often used because it is a relatively undesirable gasoline blendstock. Its high olefins, which are unstable in gasoline, can create gum in the product when in storage.

Iso-Octane Production ex Crude Oil Refineries: Most iso-octane is produced by oil refineries via catalytic reforming and alkylation, and is mixed with the reformate and alkylate that is available to a refiner's gasoline pool. However, some iso-octane is also being produced by natural gas processing techniques utilizing isomerization technology. For example, Keyera Inc. owns a plant near Edmonton (Alberta EnviroFuels) that is producing 13,600 barrels of iso-octane per day from butane. Alberta EnviroFuels is shipping iso-octane to refineries in Canada and the U.S. Gulf by rail and truck.

APPENDIX B

Ethanol's Role as an Octane Enhancer

What Is Octane and Where Does It Come From?

The octane rating of a fuel refers to its ability to reduce the tendency of gasoline to ignite prematurely during the compression stage rather than when a spark is applied. The octane rating or number of a fuel is a measure of its knock resistance when combusted under high compression in engines. Engine efficiency can be improved when the compression ratio is increased, but this requires the use of high-octane fuel to prevent knock, or uncontrolled auto-ignition.

Higher octane blendstock can be produced by the refinery, it can be purchased from other refineries, or octane ratings can be improved by blending ethanol into the gasoline. The exact pathway for any refinery is determined through optimization analysis.

In addition to the factors described above, there are infrastructure considerations that relate to ethanol blending. Ethanol is typically blended at wholesale distribution terminals and requires storage at the point of blending. To the extent that storage capacity is limited or expensive, the gasoline blender must make decisions regarding how to optimize available capacity. Under current regulations, each gasoline supplier must ensure a minimum 5 per cent ethanol, on average, in the gasoline it supplies to consumers. This means that ethanol storage capacity is mandatory as well. Removing the blend mandate would place the decisions of storage and blending capacity allocation in the hands of the blender.

The economics of ethanol blending, as compared to other sources of octane, are challenging to assess directly. The decision is based on the full range of blending options available, including the options for producing or purchasing as optimized by the refinery and blender. The optimization analysis depends on information that is proprietary and specific to individual facilities. However, two observations can be made. First, the current blend level in Canada exceeds the minimum requirement. Second, a clean fuel standard that does not include a blend mandate puts the decision to blend or not blend ethanol entirely in the hands of the market. If GHG emissions targets are not set high enough then obligated parties may be able to comply by blending less ethanol. Or, if the GHG performance of ethanol improves, the volumes required for compliance can be smaller without increasing GHGs.

On balance, ethanol is currently providing gasoline blenders with a cost-effective source of low-carbon, high-octane blendstock. In fact, ethanol is currently the only low-carbon octane available in large volumes for blending.[16] Canada's governments have invested significant capital to encourage ethanol production over the past two decades with a purpose of promoting clean fuels. The supporting analysis indicated a net benefit to Canada over a long-term future. Apart from the blend mandate, very few of the historical support measures are still active. This suggests that continued ethanol production would harvest the financial seeds sown in the past.

A policy shift toward a clean fuel standard that does not include the current renewable fuels standard is not recommended. The broad assertion is that providing the market with the choice of selecting the best available option among clean or low-carbon sources must be based on analysis. This suggests there are alternatives that promote the low-carbon objective. To date, the low-carbon alternatives to ethanol as an octane source have not been commercialized. This implies that retaining the blend mandate is necessary. Further, the critics of a blend mandate should be required to demonstrate that the net benefits identified when the RFS was implemented would no longer exist under the CFS.

16 Renewable iso-butanol is also being produced, but at only one location to date and in small quantities relative to Canada's fuel market.

APPENDIX C

Bibliography

Doyletech Corporation. *Total Economic Impact Assessment of Biofuels Plants in Canada*. May 2010 (updated for 2013). http://ricanada.org/resource/total-economic-impact-assessment-biofuels-plants-canada/ (accessed April 21, 2017).

Ecofiscal Commission*. Course Correction: It's Time to Rethink Canadian Biofuels Policies*. October 2016. https://ecofiscal.ca/reports/course-correction-time-rethink-canadian-biofuel-policies/ (accessed April 21, 2017).

Environment and Climate Change Canada, *Clean Fuel Standard*: *Discussion Paper*. 2017. http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=D7C913BB-1 (accessed April 21, 2017).

—. *Federal Renewable Fuels Regulations: Overview*. 2017. https://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=828C9342-1 (accessed April 21, 2017).

—. *Renewable Fuels Regulations*. 2017. http://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=0AA71ED2-1 (accessed April 21, 2017).

Government of Canada. *The Pan-Canadian Framework on Clean Growth and Climate Change*. 2017. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html.

Government of Ontario. *Ontario's Regulatory Register: Developing a Modern Renewable Fuel Standard for Gasoline in Ontario*. 2017. http://www.ontariocanada.com/registry/view.do?postingId=23583&language=en (accessed April 21, 2017).

ICF. *About ICF*. 2017. https://www.icf.com/company/about.

IGPC Ethanol Inc. *Assessing Major Investment at Its Operation in Aylmer, ON: Proposed Investment Would Double IGPC's Annual Ethanol Production Capacity*. Press release, Aylmer ON: IGPC, October 18, 2016. http://ww2.igpc.ca/reports/IGPC%20Ethanol%20Inc%20%20to%20Increase%20Aylmer%20Ontario%20Facility%20-%20October%2018%202016.pdf (accessed April 21, 2017).

McIntosh, Matt. *Fuelling Innovation: Ethanol Producer Uses Technology to Augment Business.* AgInnovation Ontario, 2017. https://www.aginnovationontario.ca/en/fuelling-innovation/ (accessed April 21, 2017).

Robins, Allison, James Knowles, and Len Coad. *A Long Hard Road*. November 2015. http://www.conferenceboard.ca/e-library/abstract.aspx?did=7491 (accessed April 21, 2017).

Scott, Irwin, and Darrel Good. *On the Value of Ethanol in the Gasoline Blend.* 2017. http://farmdocdaily.illinois.edu/2017/03/on-the-value-of-ethanol-in-the-gasoline-blend.html (accessed April 21, 2017).

United States Environmental Protection Agency (EPA). *Renewable Fuel Standard Program*. 2017. https://www.epa.gov/renewable-fuel-standard-program/renewable-fuel-standard-rfs2-final-rule (accessed April 21, 2017).

About The Conference Board of Canada

We are:

- The foremost independent, not-for-profit, applied research organization in Canada.
- Objective and non-partisan. We do not lobby for specific interests.
- Funded exclusively through the fees we charge for services to the private and public sectors.
- Experts in running conferences but also at conducting, publishing, and disseminating research; helping people network; developing individual leadership skills; and building organizational capacity.
- Specialists in economic trends, as well as organizational performance and public policy issues.
- Not a government department or agency, although we are often hired to provide services for all levels of government.
- Independent from, but affiliated with, The Conference Board, Inc. of New York, which serves nearly 2,000 companies in 60 nations and has offices in Brussels and Hong Kong.

Insights. Understanding. Impact.

Renewable Fuel Standards Within a Low-Carbon Fuel Strategy
Gerry Angevine and Len Coad

To cite this briefing: Angevine, Gerry, and Len Coad. *Renewable Fuel Standards Within a Low-Carbon Fuel Strategy*. Ottawa: The Conference Board of Canada, 2017.

An accessible version of this document for the visually impaired is available upon request.
Accessibility Officer, The Conference Board of Canada
Tel.: 613-526-3280 or 1-866-711-2262 E-mail: accessibility@conferenceboard.ca

The Conference Board of Canada

255 Smyth Road, Ottawa ON
K1H 8M7 Canada
Tel. 613-526-3280
Fax 613-526-4857
Inquiries 1-866-711-2262
conferenceboard.ca

PUBLICATION 9015 | 9016
PRICE: Complimentary