Biofuels in Canada: Tracking progress in tackling greenhouse gas emissions from transportation fuels

Canadian biofuel mandates, volumes, feedstocks and avoided greenhouse gas emissions

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CLEAN ENERGY CANADA

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About Clean Energy Canada

Clean Energy Canada is a program of Simon Fraser University's Centre for Dialogue. We work to accelerate Canada's transition to a clean and renewable energy system. We build awareness of and support for solutions that address climate disruption and foster an energy efficient, environmentally responsible and prosperous economy. We do so in collaboration with civil society, governments, and the private sector.

About Navius Research

Navius Research is a private consulting firm, specializing in the analysis of policies designed to meet environmental goals, with a focus on energy and greenhouse gas emission policy. We are Canada's leading experts in forecasting the environmental and economic impacts of energy and emissions policy initiatives.

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This report aims to provide the most accurate representation possible of biofuel volumes, feedstocks and avoided greenhouse gas emissions in Canada, given publicly available data.

Contents

Summary

Jurisdictions across Canada – and the world – are designing policies to drive down greenhouse gas emissions. Efforts to address climate change will include the use of biofuels as analysis at the provincial[1], federal[2] and international level demonstrates[3]. It is clear that low-carbon, renewable fuels are a critical component of any strategy to reduce emissions from the transportation sector, complementing electrification, transit, smarter urban design planning, and active transportation strategies.

Canada has used renewable fuel standards and low-carbon fuel standards to promote the adoption of renewable fuels, at both the provincial and federal level. However, little public information is available documenting the performance of these policies.

This study's quantitative assessment of the regulations will inform actions that governments could take to enhance existing measures, or adopt new measures in current and future climate action commitments. This study seeks to provide concrete data on the performance of Canadian regulations and reflect on best practices in other jurisdictions to inform the development of policy to reduce greenhouse gas emissions from the transportation sector in line with short-term (2020), medium-term (2030) and long-term (2050) targets.

We explored two questions:

1. What have existing renewable fuel standards and low-carbon fuel standards achieved in Canada, as measured by biofuel volumes, feedstocks and avoided greenhouse gas emissions?
2. What principles should be the basis for future biofuel policies?

We answered the first question by estimating biofuel volumes and feedstocks from available public sources, and sought interviews with industry and governments from each Canadian jurisdiction that has a renewable fuel standard or low-carbon fuel standard in place. We then combined this data with the lifecycle analysis tool GHGenius to estimate the quantity of greenhouse gas emissions avoided by displacing high-carbon gasoline and diesel fuels with lower-carbon renewable fuels.

We answered the second question by reviewing literature analyzing the best practices for renewable and low-carbon fuels in Canada, the United States, and Europe.

Our analysis finds that government policy is clearly driving biofuel adoption. Renewable fuel standards and low-carbon fuel standards have reduced annual carbon pollution in 2014 by 4.3 megatonnes (MT) CO_{2eq}, equivalent to taking one million cars off the road, and grown biofuel use to 3.9 million m^3, equivalent to 5% of all gasoline and diesel use in Canada.

However, most provincial and federal renewable fuel standards have been met – with the exception of B.C.'s low-carbon fuel standard and Ontario's Greener Diesel requirement. Additional government policy is required to increase biofuel use and achieve associated emissions reductions.

[1] Wolinetz, M. (2015) *A Plan for Climate Leadership in British Columbia*, *Navius Research Inc*
[2] Bataille, C. et al.(2015). *Pathways to deep decarbonization in Canada, SDSN – IDDRI.*.
[3] International Energy Agency (2015) *World Energy Outlook 2015*.

Regardless of the specific mechanism such as a strengthened renewable fuel standard or low-carbon fuel standard, the policy should:

1. Drive greenhouse gas avoidance
2. Support investment in low-carbon fuel production, use and innovation
3. Support sustainability criteria for renewable fuels
4. Ensure affordability of fuel supplies
5. Improve compliance data reporting and transparency

Introduction

Several jurisdictions across Canada — particularly Quebec, Ontario, Alberta and British Columbia — are poised to finalize and implement new climate and energy policies. These will likely include a mix of carbon pricing, regulation and voluntary measures designed to reduce emissions in a timely manner and in all sectors.

Updating renewable fuel standard (RFS) and low-carbon fuel standard (LCFS) regulations will help reduce emissions in the transportation sector. Jurisdictions updating these policies need concrete performance data on the results of existing policies to learn from the strengths, and improve upon the weaknesses, of existing Canadian policies and regulations.

Starting in 2010, Canada's federal and provincial governments implemented a number of renewable and low-carbon fuel standards, with the aim of reducing greenhouse gas (GHG) emissions in the transportation sector while achieving other policy goals, such as rural and economic development. A renewable fuel standard (RFS) defines a minimum amount (by volume) of biofuel that must be added to petroleum fuels in a calendar year, while a low-carbon fuel standard (LCFS) requires the average GHG emissions per unit of transportation fuel to decline over a defined period (e.g. by 2020). Some RFS regulations have adopted threshold GHG intensities to ensure the renewable fuels eligible under the regulation achieve minimum GHG reductions (e.g. in AB, renewable fuels must have lifecycle GHG emissions at least 25% lower than gasoline and diesel). All provinces from British Columbia east to Ontario have introduced a RFS for both gasoline and diesel fuels. To date, British Columbia is the only province to have adopted an LCFS. The federal government also enacted a RFS for gasoline (2010) and diesel fuel (2011) under the *Canadian Environmental Protection Act*.

Although these regulations have been in place for up to 10 years in some jurisdictions, information regarding the impact of RFS and LCFS has been limited. British Columbia is the only jurisdiction with readily available data on biofuel volumes, feedstocks and avoided GHG emissions resulting from these policies. Alberta and Manitoba have directly reported compliance results to the end of 2013, and Saskatchewan and Ontario have results on only the gasoline portion of their RFS, as their diesel RFS standards are relatively new. The federal government is expected to release compliance data on renewable fuel use in both gasoline and diesel for the periods ending December 2012 in the near future.

Objectives

This work aims to evaluate the performance of the Canadian renewable fuel regulations and to recommend how they could be improved to meet future climate commitments. The regulations are evaluated using available data, from 2010 to 2014, which describes biofuel consumption in terms of:

- Volumes
- Characteristics (e.g. product types, feedstocks, country of origin)
- Estimated GHG emissions (e.g. based on product, feedstock, full lifecycle assessment (LCA) of emissions from biomass production, refining and transportation to market)

Based on the performance of the Canadian market fuel regulations and an analysis of similar policies in other jurisdictions, we also recommend policy design principles to improve renewable fuel and low-carbon fuel regulations. The results can be used by governments, industry, and other

stakeholders to develop and advance the next phase of effective regulatory tools to decarbonize transportation fuels in Canada.

The following sections provide more detail on the current policy and regulatory context, our analysis methodology, the results, and our policy design principals. The appendix provides more detail on the results of our analysis by province, fuel and feedstock.

Policy Context

Between 2010 and 2014, provincial governments and the federal government implemented RFS regulations — and a LCFS in British Columbia — to drive biofuel adoption. On the surface, the RFS regulations are similar: each requires a certain blending volume of ethanol or renewable distillate by a certain date. All regulations base compliance on aggregate renewable fuel use over a period of time. This allows fuel suppliers to select renewable fuel products, markets and blend levels that are best suited to their particular business. However, the details of each regulation differ depending on the specific policy objectives of each jurisdiction. Some of the key design details include who the regulated party is, GHG intensity requirements, fuel exemptions and the regulated biofuel volume.

The federal RFS applies to fuel refiners and importers, while the provincial RFS regulations apply to fuel suppliers based on fuels that are sold into the provincial market.

From an emissions perspective, Alberta's RFS requires that the GHG intensity of renewable fuels be 25% lower than baseline fossil fuels. Ontario's *Greener Diesel* regulations is similar because it stipulates average carbon intensity reductions for renewable distillate fuels over the first three compliance periods from 2014 to 2017. The British Columbia LCFS differs from both; it requires the life-cycle GHG intensity of all transportation fuels to be reduced by 10% by 2020 (starting in mid-2013). Under the British Columbia LCFS, renewable fuels are just one option among many – including natural gas, hydrogen and electricity – to reduce transportation GHG emissions. Most other RFS regulations in Canada, including the federal standards, do not specify GHG requirements for renewable fuels eligible for use in the regulations.

Each RFS or LCFS regulation specifies how to measure compliance. Fuel pool volumes — the defined type of fuel that renewable fuel should form a portion of — are different in each region. For example, in some regions heating fuel may be exempt from the regulation. In other cases, a regulation may require a certain type of renewable fuel, such as ethanol, or allow the blender to decide on the renewable fuel they prefer.

Table 1 summarizes the policy requirements for ethanol blending with gasoline fuels across Canada from 2010 to 2014. British Columbia, Alberta, Saskatchewan, Manitoba and Ontario have had RFS regulations applied to gasoline since 2010 or earlier, with requirements currently ranging from 5% to 8.5% by volume. The gasoline fuel RFS regulations generally apply to automotive gasoline (e.g. aviation fuel volumes are exempt). The federal regulation covers the remainder of the country, requiring 5% ethanol by volume. The federal regulation exempts fuels used in Newfoundland and Labrador and regions north of 60° latitude. There are similar exemptions in provincial regulations for fuels used in Northern Ontario and Manitoba.

Table 1: Provincial and federal policies for ethanol blended into gasoline

Ethanol						
	2010	2011	2012	2013	2014	Regulation and Notes
British Columbia	5.0%	5.0%	5.0%	5.0%	5.0%	The Renewable and Low Carbon Fuel Requirements Regulation
Alberta		5.0%	5.0%	5.0%	5.0%	Renewable Fuels Standard Regulation under the Climate Change and Emissions Management Act
Saskatchewan	7.5%	7.5%	7.5%	7.5%	7.5%	The Ethanol Fuel Act and Ethanol Fuel (General) Regulations
Manitoba	8.5%	8.5%	8.5%	8.5%	8.5%	The Ethanol General Regulation
Ontario	5.0%	5.0%	5.0%	5.0%	5.0%	Ethanol General Regulation
Quebec						
New Brunswick						
Nova Scotia						
PEI						
Newfoundland						
Yukon						
Northwest Territories						
Federal Policy[1]		5.0%	5.0%	5.0%	5.0%	Renewable Fuels Regulation

1) Exempt from federal gasoline policy: Newfoundland & Labrador, all Territories and Quebec north of 60 degrees

Table 2 summarizes the regulated requirements for renewable distillate blending with diesel fuel across Canada from 2010 to 2014. All Canadian regulations now specify that 'renewable diesel' fuels are eligible pursuant to the regulations. Common products available in the market are biodiesel (a fatty acid methyl ester fuel) and hydrogenation-derived renewable diesel (HDRD). In the United States, HDRD is referred to as 'renewable diesel', which confuses use of this term in Canadian regulations. For this report, we use renewable distillate in the Canadian regulatory context, which encompasses both biodiesel and HDRD.

Alberta, Saskatchewan and Manitoba have set provincial blending requirements at 2% by volume. British Columbia initially established a 3% blend requirement in 2010, which increased to 4% by volume in 2011. Midway through 2013, the province also implemented carbon intensity requirements for its LCFS with a 10% GHG intensity reduction requirement by 2020. The Ontario diesel RFS notionally requires 2% by volume in 2014-2015, increasing to 3% in 2016 and 4% in 2017; however, the GHG averaging mechanism pro-rates eligible volumes, which will reduce the actual volumetric blending levels.

The remainder of the country is covered by the federal mandate for 2% renewable distillate, with exemptions for aircraft, competition vehicles, heating oil, military use and scientific use. Prior to 2013, heating oil and diesel fuel volumes in Quebec and the Maritimes were exempt from the federal regulation; the diesel RFS was amended in 2013 to permanently exclude all heating oil volumes, relieve the Maritimes from compliance for an additional six months, and extend the second compliance period to the end of 2014. Diesel fuel used in Newfoundland and Labrador and Northern Canada remains exempt.

Under provincial diesel RFS regulations, jet fuel volumes for aircraft are exempted. Locomotive fuel volumes were excluded in Alberta and Manitoba prior to 2013. Alberta's RFS does not apply to fuel

produced and consumed within industrial operations, such as volumes of diesel fuels used in oilsands operations (known as 'behind-the-fence' diesel use). All other provincial regulations apply to both on-road and off-road diesel volumes.

Table 2: Provincial and federal policies for renewable distillate blended into diesel

Jurisdiction[1]	Renewable Distillate Volume Required					Regulation and Notes
	2010	2011	2012	2013	2014	
British Columbia	3.0%	4.0%	4.0%	4.0%	4.0%	The Renewable and Low Carbon Fuel Requirements Regulation
Alberta		2.0%	2.0%	2.0%	2.0%	Renewable Fuels Standard Regulation under the Climate Change and Emissions Management Act
Saskatchewan			2.0%	2.0%	2.0%	The Renewable Diesel Act
Manitoba	2.0%	2.0%	2.0%	2.0%	2.0%	Biodiesel Mandate for Diesel Fuel Regulation
Ontario					1.0%[1]	Greener Diesel Regulation
Quebec						
New Brunswick						
Nova Scotia						
PEI						
Newfoundland						
Yukon						
Northwest Territories						
Federal Policy[2]		1.0%[3]	2.0%	2.0%	2.0%	Renewable Fuels Regulation

1) The Ontario *Greener Diesel Regulation* came into force in April 1, 2014 with a 2% pro-rated requirement. Given that it did not apply to the entire year, and it utilizes a GHG averaging formula which reduces renewable diesel volumes, we have approximated the requirement at 1%.
2) Maritimes exempt until mid-2013 only. Newfoundland & Labrador, all Territories and Quebec north of 60 are exempt.
3) The federal policy came into force on July 1, 2011 with a 2% requirement. Given that it did not apply to the entire year, we have approximated the requirement at 1%.

Methodology

This work is the first public, comprehensive baseline study of renewable fuel use in Canada. The analysis period is for the 5-year period from January 1, 2010 to December 31, 2014. This period aligns with the first implementation of renewable fuel standards in Canada for both gasoline and diesel fuels, although legacy provincial ethanol blending standards have existed for much longer.

The methodology used in this analysis has four primary steps:

1. Tabulate renewable fuel use, under provincial and federal RFS/LCFS regulations
   a) Use provincial and federal RFS/LCFS compliance data (published, direct communication)
   b) Complement this with other data sources and make assumptions as necessary
2. Characterize biofuel product use (ethanol, biodiesel, HDRD) and biomass feedstocks
   a) Use provincial and federal compliance data, as above
   b) Complement this with other data sources and make assumptions as necessary
3. Estimate the GHG reductions associated with federal and provincial biofuel mandates using GHGenius 4.03a

4. Identify best practices from the analysis and conduct a literature review to recommend the characteristics of future RFS/LCFS regulations

Table 3 outlines the data sources and major assumptions we used to estimate fuel volume and feedstock in this analysis.

Table 3: Data and assumptions by jurisdiction

Province	Data and Assumptions
British Columbia	Fuel volumes for gasoline, diesel and renewable fuels and their feedstocks are from provincial compliance data to the end of 2012, and personal communication with policy director regarding the trend in 2013 and 2014. British Columbia is the only jurisdiction which publishes detailed product and feedstock information.
Alberta	We used provincial compliance data for gasoline, diesel, and biofuel volumes to the end of 2013. We assumed the same blending rate as 2013 for 2014. Statistics Canada data[4] was used to inform gasoline and diesel volume from 2010 and 2014, assuming the reported volume includes blended biofuel (i.e. gasoline volume is actually the blended gasoline volume). Ethanol feedstock is assumed to be half wheat and half corn.[5] Wheat is sourced domestically, while corn is from U.S. imports. Biodiesel feedstock is assumed to be an equal split between canola and soy.[6] Canola-based biodiesel is assumed to come from domestic production and soy from the United States. We assumed no HDRD, however, lacking blending data, we cannot be certain.
Saskatchewan	We used Statistics Canada data to inform gasoline and diesel volume from 2010 to 2014, assuming the volume includes blended biofuel. Ethanol blend and feedstock to 2012 is based on Government of Saskatchewan data.[7] We assumed the same (2012) feedstock and blend rate in 2013 and 2014. We assumed a portion of the national renewable distillate consumption noted by the U.S. Department of Agriculture,[8] is consumed in Saskatchewan to comply with the provincial policy. We assumed the same feedstocks and blend ratio for renewable distillate, as per the information provided for Manitoba.
Manitoba	Fuel volumes are based on personal correspondence with the government of Manitoba. They estimate 5% of renewable distillate volume is HDRD. We assumed ethanol feedstock is primarily corn, and biodiesel feedstock is primarily canola.[9]
Ontario	Gasoline and ethanol volumes are based on personal correspondence with the Government of Ontario. Diesel blend volumes are from Statistics Canada, with missing values interpolated. We assumed the diesel volume includes blended biofuel. Renewable distillate volume is estimated based on domestic production[10] minus exports plus imports. Following this approach, Ontario uses relatively little biodiesel.

[4] StatsCanada (2015). *Supply and disposition of refined petroleum products.* CANSIM Table 134-0004.

[5] Personal correspondence with Don O'Connor and Dussureault, 2014. Global Agricultural Information Network: Canada, Biofuels Annual. United States Department of Agriculture (USDA) Foreign Agricultural Services.

[6] Ibid.

[7] Government of Saskatchewan, 2013. Saskatchewan Ethanol Act and Regulations Review.

[8] Dussureault, (2014). Global Agricultural Information Network: Canada, Biofuels Annual. United States Department of Agriculture (USDA) Foreign Agricultural Services.

[9] Based on personal correspondence with Don O'Connor and Doug Hooper, 2015.

[10] Bloomberg New Energy Finance (2016) Biofuels Assets Database

Province	Data and Assumptions
Quebec, Maritimes	The total gasoline and diesel fuel use volumes are from Statistics Canada, with missing values interpolated. We assume the gasoline and diesel volumes include blended biofuel. Ethanol volume was inferred based on national totals and domestic production, less consumption in other provinces, then allocated to Quebec and the Maritimes, weighted by total gasoline consumption. For biodiesel, we followed the approach in Ontario by adding domestic production and imports and then subtracting exports. Since provincial compliance volumes count toward federal obligations, fuel suppliers may over-blend in some provincial markets and reduce blending in markets without provincial RFS and LCFS standards. Accordingly, the approach we've taken here provides only a rough estimate of what actual renewable fuel use may have been. To reduce blending, distribution costs, or to meet regional fuel performance specifications (e.g. winter operability standards), markets may have utilized renewable fuels at significantly different levels.

Results

Figure 1 summarizes the avoided GHG emissions and renewable fuel consumption and content across Canada from 2010 to 2014. Nationally, renewable fuel consumption has nearly doubled over that five-year period, rising from 2.1 million cubic metres (m^3) to 3.9 million m^3. This change coincides with a growing number of RFS regulations implemented across Canada.

Over that same period, renewable fuel consumption avoided GHG emissions from fossil gasoline and diesel fuel use. Annual lifecycle GHG emissions from transportation fuels would have been 2.3 Mt CO_{2eq} higher in 2010. The avoided lifecycle GHG emissions rose to 4.3 Mt CO_{2eq} in 2014, accounting for a 2% reduction in lifecycle transportation emissions.[11] Figure 1 summarizes avoided lifecycle GHG emissions per province between 2010 and 2014.

[11] Based on gasoline and diesel use in Canada and lifecycle emissions from GHGenius v4.03a.

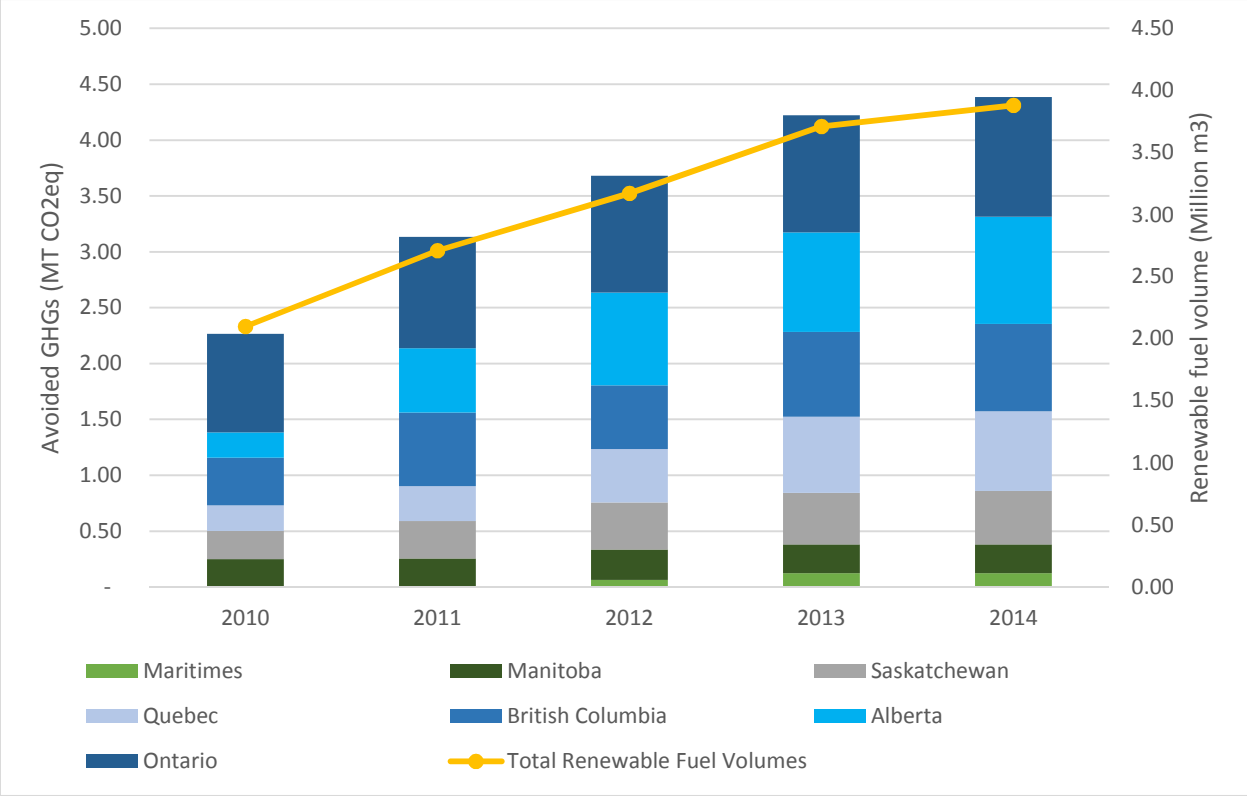

Figure 1: Provincial avoided GHG emissions and total renewable fuel volumes by year

Renewable Gasoline (Ethanol)

As of 2011, the federal RFS required gasoline to contain 5% ethanol by volume. However, the requirement was surpassed in 2012 as fuel suppliers blended ethanol beyond the federal mandate. Ethanol content, by volume, averaged 7% in 2014. There is little evidence as to why this occurred.

Ethanol consumption increased in all provinces from 2010 to 2014 (Table 4). The growth is especially noticeable in jurisdictions that implemented a RFS or LCFS regulation during the study period, indicating that the policies changed biofuel use. For example, ethanol consumption in Alberta rose by a factor of 34 from 2010 to 2012, from 8,200 m^3/yr to 278,200 m^3/yr.

Table 5 shows the ethanol content in the gasoline pool within each province. Compliance was achieved in all provinces with fuel regulations during the study period. The one possible exception to this result is Manitoba over the period from 2012 to 2013 (noted in orange), but the shortfall is relatively small, ranging from 0.2 to 1.0% of the gasoline pool volume and may be due to discrepancies in gasoline use estimates at the provincial and federal level. Our analysis uses Statistics Canada data for gasoline fuel use, while the Manitoba government provided the ethanol estimates.

Table 4: Ethanol consumption estimates, by province (1000's m^3)

Province	2010	2011	2012	2013	2014
British Columbia	240	260	250	318	332
Alberta	10	280	410	420	480
Saskatchewan	230	230	240	250	260
Manitoba	150	160	150	150	150
Ontario	1080	1230	1240	1260	1310
Quebec	180	180	220	400	430
Maritimes	0	0	140	260	260
Total	**1880**	**2330**	**2650**	**3070**	**3240**

Table 5: Ethanol blend estimates, by province (% of gasoline pool)

Province	2010	2011	2012	2013	2014
British Columbia	5.0%	5.7%	5.8%	6.3%	6.3%
Alberta	0.1%	6.1%	6.5%	6.5%	6.3%
Saskatchewan	8.9%	9.2%	9.1%	9.0%	9.0%
Manitoba	9.4%	9.8%	8.3%	7.5%	8.0%
Ontario	6.7%	7.6%	7.6%	7.6%	7.8%
Quebec	2.0%	1.9%	2.4%	4.7%	4.8%
Maritimes	0.0%	0.0%	2.4%	4.7%	4.8%

Renewable Diesel

Fuel suppliers have likely met the national renewable distillate fuel requirement of 2% after July 1, 2011. However, the result is somewhat less clear than for ethanol because the data for total regulated diesel consumption (i.e. fuels not exempt from the policy) includes more assumptions than does the data for total gasoline consumption. For example, data for diesel fuel consumption in Newfoundland and Labrador (which is exempt) is especially poor, so it is difficult to calculate the total volume of regulated diesel. This estimate shows that, at worst, the federal diesel fuel requirement was achieved in 2013 and 2014 and possibly narrowly missed in 2012.

Growth in renewable distillate consumption was even more rapid during the study period, increasing six-fold from 2010 to 2014. However, because blending requirements are lower than for ethanol, less renewable distillate was consumed than ethanol (Table 6). As with the ethanol blending requirement, the renewable distillate requirement was achieved in all provinces that had a policy in place (Table 7). These include Alberta, Saskatchewan and Manitoba (all 2% as of 2012), and British Columbia (currently 4%, implemented in 2010).

Table 6: Renewable distillate consumption estimates, by province (1000's m^3)

Province	2010	2011	2012	2013	2014
British Columbia	90	160	160	230	240
Alberta	70	100	140	160	170
Saskatchewan	0	20	50	60	60
Manitoba	20	20	30	30	30
Ontario	0	0	20	10	0
Quebec	40	80	120	140	140
Maritimes	0	0	0	0	0
Total	**220**	**380**	**520**	**630**	**640**

Table 7: Renewable distillate blend estimates, by province (% of diesel pool)

Province	2010	2011	2012	2013	2014
British Columbia	3.0%	4.3%	4.5%	5.6%	5.6%
Alberta	1.0%	2.0%	2.0%	2.2%	2.1%
Saskatchewan	0.0%	1.0%	2.0%	2.0%	2.0%
Manitoba	2.0%	1.7%	2.2%	2.3%	2.0%
Ontario	0.0%	0.0%	0.2%	0.2%	0.0%
Quebec	0.8%	1.4%	2.4%	3.0%	3.0%
Maritimes	0.0%	0.0%	0.0%	0.0%	0.0%

Feedstocks

Figure 2 shows national ethanol consumption, listed by feedstock. Approximately 80% of the ethanol is produced from corn, while the remainder is produced from wheat.

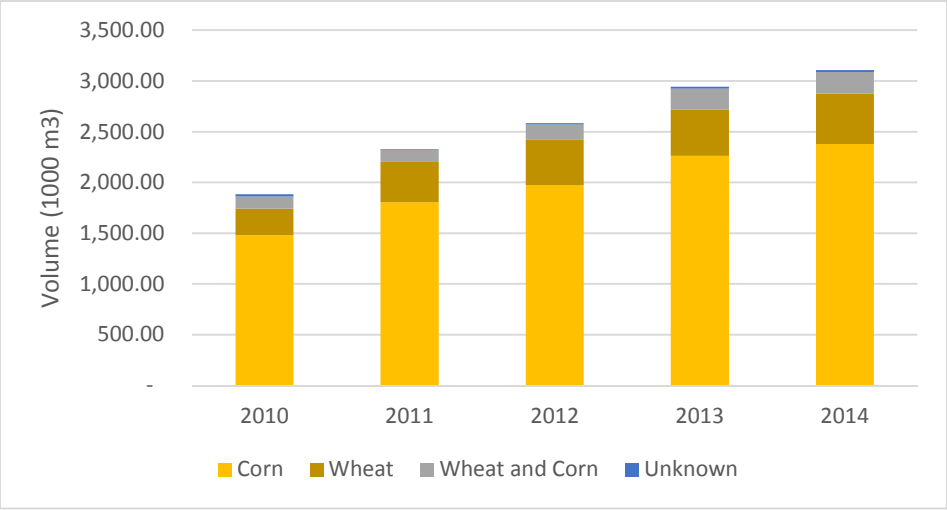

Figure 2: Ethanol volumes by feedstock

Figure 3 shows the same data for renewable distillate consumption. Canola grown in North America is used to produce 30% of the renewable distillate consumed in Canada. Palm oil used in imported HDRD fuels accounts for 30%, and the remaining 40% is from a mix of yellow grease, soy and other blends.

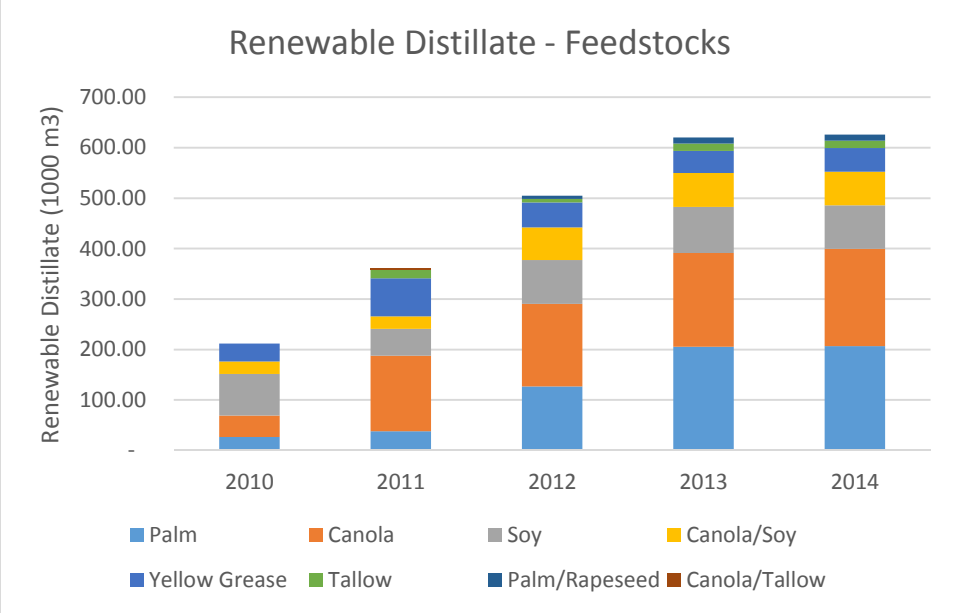

Figure 3: Renewable distillate volumes by feedstock

Recommendations for Future Policy Development

The following five principles should help guide the future development of renewable fuel and low-carbon fuel policy:

1. Drive greenhouse gas avoidance
2. Support investment in low-carbon fuel production, use and innovation
3. Support sustainability criteria for renewable fuels
4. Ensure affordability of fuel supplies
5. Improve compliance data reporting and transparency

We developed these five principles based on a review of existing policies and available literature. In some instances, the Canadian policies outlined in this report are achieving these goals in part. The recommendations aim to make existing and future policies more effective by ensuring they meet GHG, or other policy objectives set by governments.

Drive greenhouse gas avoidance

GHG targets should form the basis of biofuel policies since biofuels have the potential to significantly reduce transportation GHG emissions. Other policy objectives such rural and economic development can complement this objective. To maximize GHG reductions, policies should specify the GHG requirements of fuels eligible under the regulation, commit to steadily increasing policy stringency, and seek cross-jurisdictional partnerships.

Drive Greenhouse Gas Avoidance: For example, policies that require the volumetric consumption of a specific fuel alone, such as ethanol, are only indirectly reducing GHG emissions and may reduce the incentive to improve the GHG performance of ethanol fuel options, or develop alternative fuels. The U.S. National Low-Carbon Fuel Standard program suggests targeting GHG emissions directly by modifying RFS regulations to include life cycle emissions intensity targets for each fuel pool (i.e. gasoline, diesel), or to replace the regulations outright with a LCFS.[12]

Canada's fuel regulations, notably British Columbia's LCFS, already compare favorably with the U.S. National Low-Carbon Fuel Standard program's recommendations to reduce GHG intensity, which include:

- Regulating fuel producers, importers and suppliers
- Separating the diesel and gasoline pools
- Using a consistent lifecycle analysis to determine GHG impacts for all fuel types (fossil, renewable, alternative)

Commit to steadily increasing policy stringency: There are likely sufficient biofuel volumes to achieve more stringent GHG standards in the near to medium term (2020, 2030), but producers require a consistent policy signal to build production capacity and market the fuels:

- An analysis of low-carbon fuel supply for the west coast regions of North America showed sufficient supply to reach beyond proposed and legislated targets in British Columbia,

[12] Yeh, Sonia, Daniel Sperling, M. Griffin, Madhu Khanna, Paul Leiby, Siwa Msangi, James Rhodes, and Jonathan Rubin. 2012. National Low Carbon Fuel Standard: Policy Design Recommendations. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-12-10.

Washington, Oregon, and California. The scenarios showed the potential to reduce the lifecycle carbon intensity of all transportation energy in the region by 15–21% by 2030.[13]

- A recent study of deep GHG reductions pathways in Canada identified low-carbon fuels, including biofuels, as a crucial GHG abatement action.[14] In particular, the study highlighted the need for policy signals to drive innovations in energy-dense and near-zero GHG fuels that are suitable for long-distance travel and freight transportation — in other words renewable diesel fuels, such as biodiesel and HDRD, that can reduce emissions in heavy-duty trucks, trains, ships, and planes.

Seek cross jurisdictional partnerships. Broader coverage and greater consistency among fuel policies will reduce "carbon leakage" — when GHG reductions in one region increase emissions in another by driving higher-emission activities there. One criticism of renewable fuel regulations, for example, is that they create fuel shuffling, where a fuel with a low GHG-intensity is sent to a regulated region while the high-GHG fuel is sent to an unregulated region. The result of fuel shuffling can be no net reduction of GHG emissions. Consistent policies, compliance tracking, and enforcement across jurisdictions can prevent this outcome.

Support Investment in Low-carbon Fuel Production, use and Innovation

Reducing transportation emissions will require a mix of fuels and technologies, some of which are not yet at commercial production stage. For example, significantly expanding biofuel use will likely require a shift to advanced biofuels.[15] Since the final solution or mix of solutions are unknown, policies should be designed to provide a long-term greenhouse gas reduction signal, complemented by targeted policies for specific approaches to develop sustainable biomass supplies, high-quality fuel production technologies, and efficient production and distribution systems.

Set long-term measures to increase policy certainty. Biofuel producers and capital market investors view policy uncertainty as the biggest investment risk.[16] Similarly, the International Energy Agency reduced their medium-term forecast of biofuel production in regions where policy is vague or has stalled.[17] Long-term policy targets should be reinforced by compulsory regulatory requirements to manage and reduce risk, encouraging investment in new biomass supplies and biofuel technologies.

Complement standards with other policies. Research, development and commercialization strategies can bolster successful compliance with fuel standards by addressing other barriers to deployment of biofuels. For example, The Pathways to Deep Decarbonization report calls for a "national research and development and deployment support for bulk non-food crop biofuels" to complement renewable fuel standards regulations.[18] The Council of Canadian Academies comes to similar conclusions. They call for "stringent, compulsory, economy-wide policies" to drive down greenhouse gas emissions supported by enabling policies that include direct government investment, enabling

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[13] Malins, C., Lutsey, N., Galarza, S.,Shao, Z., Searle, S., Chudziak, C., &van den Berg, M., 2015. Potential low-carbon fuel supply to the Pacific Coast region of North America. The International Council on Clean Transportation. Washington, D.C

[14] Bataille, C. et al., 2015. Pathways to deep decarbonization in Canada, SDSN - IDDRI

[15] IBID

[16] See PwC's Cleantech Practice, 2014, 2014 Biofuels Market Insights Survey at www.pwc.com/en_US/us/technology/publications/assets/2014-biofuels-market-insights-survey.pdf

[17] International Energy Agency, 2014, Renewable Energy Medium-Term Market Report 2014: Market Analysis and Forecasts to 2020

[18] Bataille, C. et al.(2015). *Pathways to deep decarbonization in Canada, SDSN – IDDRI*

infrastructure and innovation support.[19] For biofuels, this could mean adopting a systematic approach as California has done to identifying specific technologies, barriers to adoption and the tools to minimizing those barriers.[20]

Support Sustainability Criteria for Renewable Fuels

Globally, the increased use of renewable fuels has raised concerns around food security and conversion of lands to support increased agricultural production. To date, it does not appear that RFS and LCFS policies in Canada have negatively impacted other sustainability goals such as food security, maintaining biodiversity, or reducing carbon emissions from the biosphere. In Canada, land use for crop production has remained relatively stable since 2007.[21] At a global scale economic models of biofuel production, and lands converted from forest or grassland to farmland, showed that increased global farm production, between 2004 and 2012, generally resulted from using existing farmland more intensively, rather than through new lands.[22]

Nonetheless, concerns remain about biofuel demand impacts. To mitigate the potential for biofuels to cause or contribute to food insecurity, or other negative environmental or social impacts, sustainability criteria can be implemented in renewable fuel standards to assure biomass is sustainably produced for biofuel use. For example, The Energy Independence and Security Act of 2007 in the United States includes specific requirements for renewable biomass.[23] Another example is that under the European Union's Renewable Energy Directive, compliant fuels cannot be produced on land with high biodiversity value and must have a verifiable chain of custody from the farm to fuel that requires reporting on issues such as food security, land conversion and labour practices.[24] Alberta also requires that specific biofuel sources like Palm, not result in deforestation.[25]

Ensure Affordability of Fuel Supplies

Analysis of the California LCFS suggests that avoiding extreme compliance costs, which would translate into high fuel costs for consumers, should be a critical policy goal.[26] Yeh et al. (2012) made several recommendations in this regard:

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[19] Council of Canadian Academies, 2015. Technology and Policy Options for A Low-Emission Energy System in Canada – Expert Panel on Energy Use and Climate Change. http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/magna/energyuse_fullreport_en.pdf

[20] California Air Resources Board, 2015. DRAFT Heavy-Duty Technology and Fuels Assessment: Overview. http://www.arb.ca.gov/msprog/tech/techreport/ta_overview_v_4_3_2015_final_pdf.pdf

[21] Agriculture Canada, 2015. Changes to the Renewable Fuel Standard Program Aggregate Compliance for Canadian Crops and Crops Residues: Data Analysis and Justification for 2015.

[22] Babcock, B.A., Iqbal, Z., 2014. Using Recent Land Use Changes to Validate Land Use Change Models. Staff Report 14-SR 109, Center for Agricultural and Rural Development, Iowa State University

[23] U.S. Government, 2007. Energy and Independence Act of 2007. https://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

[24] See Articles 17, 18, and 19 of the Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources, http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm

[25] Alberta Energy (2011) Renewable Fuel Greenhouse Gas Emissions Eligibility Standard. http://www.energy.alberta.ca/BioEnergy/pdfs/GHGEmissionStandardApp1.pdf

26 Lade, Gabriel E. and C.-Y. Cynthia Lin Lawell, 2013. A Report on the Economics of California's Low Carbon Fuel Standard and Cost Containment Mechanisms. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-13-23

Use market mechanisms to minimize total GHG abatement costs. These mechanisms already exist in the structure of the British Columbia LCFS, which offers a flexible set of compliance options, and credit trading and banking, which allows the least costly abatement actions to be used first. A cap on the cost of compliance by having unlimited compliance credits available for set price (e.g. $200/t CO2eq) is proposed to mirror a similar mechanism in place in the California LCFS.

Finally, broad geographical and market coverage will help reduce compliance costs, in addition to preventing carbon leakage.

Improve Compliance data Reporting and Transparency

To measure policy effectiveness, current and future RFS and LCFS regulations should require enhanced fuel and GHG emissions reporting on a transparent and frequent basis. Compliance reports vary across jurisdictions, and many important fuel use data characteristics (like feedstocks and estimated avoided GHG emissions) do not exist. In fact, this report was developed in response to this lack of data. We made many assumptions to estimate biofuel volumes and feedstocks in order to estimate avoided GHG emissions.

In this case, the British Columbia regulation serves as a model of best practice in Canada; British Columbia publishes the renewable fuel volume, feedstock and GHG intensity based on the GHGenius model. This approach allows for public review and easy verification of avoided emissions and feedstocks. At the international level, the United States and the United Kingdom provide even more comprehensive data.

Ideally, RFS and LCFS compliance should be reported quarterly with all fuel volumes, feedstocks, carbon intensities, and greenhouse gas estimates per fuel type. This recommendation applies to fossil fuels and other fuels, such as electricity and hydrogen.

Conclusion

Biofuels have and will continue to play a role in reducing transportation-related emissions — complementing other strategies. The Pathways to deep decarbonization in Canada report for example finds that biofuels will likely need to account for 20% of liquid fuels by 2030 and 90% by 2050 in addition to widespread electrification, transit, smarter urban planning and active transportation strategies to meet Canada's long-term climate targets.[27]

Our analysis finds that government policy is clearly driving biofuel adoption. Renewable fuel standards and low-carbon fuel standards have reduced annual carbon pollution in 2014 by 4.3 MT CO_{2eq}, equivalent to taking one million cars off the road, and grown biofuel use to 3.9 million m^3, equivalent to 5% of all gasoline and diesel use in Canada.

However, most provincial and federal renewable fuel standards have been met – with the exception of B.C.'s low-carbon fuel standard and Ontario's Greener Diesel requirement. Additional government policy is required to increase biofuel use and achieve associated emissions reductions.

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[27] Bataille, C. et al.(2015). *Pathways to deep decarbonization in Canada, SDSN – IDDRI*

Regardless of the specific mechanism such as a strengthened renewable fuel standard or low-carbon fuel standard, the policy should:

1. Drive greenhouse gas avoidance
2. Support investment in low-carbon fuel production, use and innovation
3. Support sustainability criteria for renewable fuels
4. Ensure affordability of fuel supplies
5. Improve compliance data reporting and transparency

Biofuels are an important component of any strategy to reduce greenhouse gas emissions, and compulsory use renewable fuel regulations complement other transportation and climate action policies.

APPENDIX

Review by Don O'Connor:

In December, 2015 Don O'Connor reviewed an early draft of this data and analysis. He did not review the recommendations for future policy development. He found small discrepancies in the analysis and text, but generally the total biofuel volumes and avoided greenhouse gas emission estimates align with results presented at the 2015 Canadian Renewable Fuels Association Conference in 2015.

Data Tables

Figure 4 compares greenhouse gas avoidance with the percentage of renewable fuels used in Canada in 2014. This graph illustrates, that different fuels and renewable fuel processes have different greenhouse gas benefits. While ethanol accounted for 84% of renewable fuel use it only accounted for 65% of greenhouse gas avoidance. Conversely, biodiesel accounted for just 10% of fuel use but accounted for 30% of greenhouse gas avoidance. HDRD, a type of renewable distillate, accounted for approximately the same.

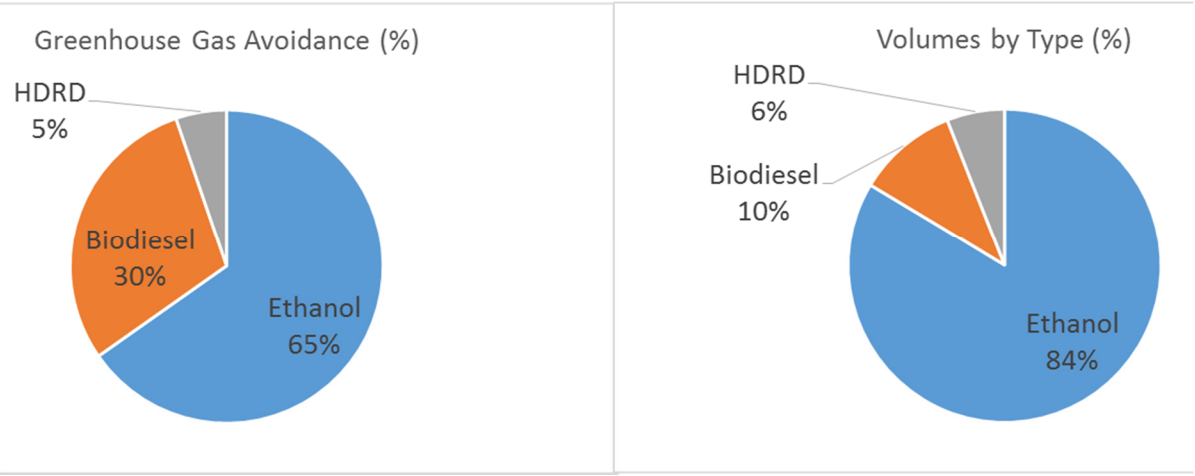

Figure 4: Comparison of GHG avoidance and volume of renewable fuels used

Table 8: British Columbia Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	4459	4311	4069	4689	4921	86.86
Ethanol (1000 m^3)						
Wheat	25	28	0	0	0	28.66
Wheat and Corn	122	120	151	190	200	49.85
Corn	67	108	87	110	115	49.85
Unknown	21	7	13	16	17	49.85
TOTAL	**235**	**263**	**251**	**316**	**332**	
Renewable %	5.0%	5.7%	5.8%	6.3%	6.3%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	2977	3462	3372	3968	4028	95.61
Biodiesel (1000 m^3)						
Canola	42	74	44	49	50	4.18
Canola/Soy	3	3	36	40	41	17.39
Canola/Tallow	0	3	0	0	0	-8.00
Soy	11	3	0	0	0	17.39
Unknown	4	13	9	10	10	17.39
TOTAL	**60**	**96**	**89**	**100**	**102**	
Renewable %	2.0%	2.7%	2.5%	2.4%	2.4%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	27.00	38.00	55.00	105.08	106.67	75.26
Palm/rapeseed	0.00	0.00	6.00	11.46	11.64	75.26
tallow	0.00	17.00	7.00	13.37	13.58	-20.18
unknown	4.00	5.00	2.00	3.82	3.88	75.26
TOTAL	31.00	60.00	70.00	133.74	135.76	
Renewable %	1.0%	1.7%	2.0%	3.2%	3.2%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.43**	**0.65**	**0.56**	**0.72**	**0.74**	

Table 9: Alberta Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	5735	4588	6315	6431	7575	88.53
Ethanol (1000 m^3)						
Wheat	8	139	207	208	238	44.60
Wheat and Corn	0	0	0	0	0	48.56
Corn	0	139	207	208	238	52.52
Unknown	0	0	0	0	0	48.56
TOTAL	**8**	**278**	**413**	**417**	**476**	
Renewable %	0.1%	6.1%	6.5%	6.5%	6.3%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	7211	4980	6974	7405	7778	97.33
Biodiesel (1000 m^3)						
Canola	0	51	71	80	83	7.41
Canola/Soy	0	0	0	0	0	12.46
Canola/Tallow	0	0	0	0	0	12.46
Soy	72	51	71	80	83	11.89
Unknown	0	0	0	0	0	17.50
TOTAL	72	101	143	161	165	
Renewable %	1.0%	2.0%	2.0%	2.2%	2.1%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	0.0	0.0	0.0	0.0	0.0	77.36
Palm/Rapeseed	0.0	0.0	0.0	0.0	0.0	77.36
Tallow	0.0	0.0	0.0	0.0	0.0	17.50
Unknown	0.0	0.0	0.0	0.0	0.0	0.00
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
Renewable %	0.00%	0.00%	0.00%	0.00%	0.00%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.23**	**0.58**	**0.83**	**0.89**	**0.96**	

Table 10: Saskatchewan Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	2560	2506	2667	2772	2843	86.86
Ethanol (1000 m^3)						
Wheat	228.4	229.4	241.9	249.5	255.9	39.83
Wheat and Corn	0.0	0.0	0.0	0.0	0.0	52.30
Corn	0.0	0.0	0.0	0.0	0.0	52.30
Unknown	0.0	0.0	0.0	0.0	0.0	52.30
TOTAL	**228.4**	**229.4**	**241.9**	**249.5**	**255.9**	
Renewable %	8.92%	9.15%	9.07%	9.00%	9.00%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	2447	2630	2527	2962	3159	97.69
Biodiesel (1000 m^3)						
Canola	0.0	25.0	48.0	56.3	60.0	5.07
Canola/Soy	0.0	0.0	0.0	0.0	0.0	9.00
Canola/Tallow	0.0	0.0	0.0	0.0	0.0	10.52
Soy	0.0	0.0	0.0	0.0	0.0	12.94
Unknown	0.0	0.0	0.0	0.0	0.0	0.00
TOTAL	**0.0**	**25.0**	**48.0**	**56.3**	**60.0**	
Renewable %	0.00%	0.95%	1.90%	1.90%	1.90%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	0.0	0.0	0.0	0.0	0.0	77.29
Palm/Rapeseed	0.0	0.0	0.0	0.0	0.0	77.29
Tallow	0.0	0.0	0.0	0.0	0.0	15.98
Unknown	0.0	0.0	1.3	3.0	3.2	77.29
TOTAL	**0.0**	**0.0**	**1.3**	**3.0**	**3.2**	
Renewable %	0.00%	0.00%	0.05%	0.10%	0.10%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.25**	**0.33**	**0.42**	**0.46**	**0.48**	

Table 11: Manitoba Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	1636	1627	1849	1966	1869	88.28
Ethanol (1000 m^3)						
Wheat	0	0	0	0	0	46.47
Wheat and Corn	0	0	0	0	0	41.90
Corn	154	159	154	148	150	37.33
Unknown	0	0	0	0	0	46.47
TOTAL	154	159	154	148	150	
Renewable %	9.4%	9.8%	8.3%	7.5%	8.0%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	1079	1286	1329	1221	1324	97.05
Biodiesel (1000 m^3)						
Canola	0.0	0.0	0.0	0.0	0.0	8.45
Canola/Soy	22.0	22.0	28.7	26.8	25.6	6.23
Canola/Tallow	0.0	0.0	0.0	0.0	0.0	12.30
Soy	0.0	0.0	0.0	0.0	0.0	4.01
Unknown	0.0	0.0	0.0	0.0	0.0	16.45
TOTAL	**22.0**	**22.0**	**28.7**	**26.8**	**25.6**	
Renewable %	2.0%	1.7%	2.2%	2.2%	1.9%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	0.0	0.0	0.0	0.0	0.0	76.38
Palm/Rapeseed	0.0	0.0	0.0	0.0	0.0	76.38
Tallow	0.0	0.0	0.0	0.0	0.0	16.15
Unknown	0.0	0.0	0.0	1.4	1.3	76.38
TOTAL	**0.0**	**0.0**	**0.0**	**1.4**	**1.3**	
Renewable %	0.00%	0.00%	0.00%	0.12%	0.10%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.25**	**0.26**	**0.27**	**0.26**	**0.26**	

Table 12: Ontario Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	16230	16172	16290	16595	16750	84.26
Ethanol (1000 m^3)						
Wheat	0	0	0	0	0	70.78
Wheat and Corn	0	0	0	0	0	60.28
Corn	1084	1225	1240	1256	1308	49.77
Unknown	0	0	0	0	0	70.78
TOTAL	1084	1225	1240	1256	1308	
Renewable %	6.7%	7.6%	7.6%	7.6%	7.8%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	7233	7143	7020	7329	7372	92.87
Biodiesel (1000 m^3)						
Canola	0.00	0.00	0.00	0.00	0.00	28.30
Canola/Soy	0.00	0.00	0.00	0.00	0.00	21.93
Canola/Tallow	0.00	0.00	0.00	0.00	0.00	0.00
Soy	0.00	0.00	15.50	11.16	3.57	15.55
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**0.0**	**0.0**	**15.50**	**11.16**	**3.57**	
Renewable %	0.0%	0.0%	0.2%	0.2%	0.0%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	0.00	0.00	0.00	0.00	0.00	75.14
Palm/Rapeseed	0.00	0.00	0.00	0.00	0.00	75.14
Tallow	0.00	0.00	0.00	0.00	0.00	-16.60
Unknown	0.00	0.00	0.00	0.00	0.00	75.14
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
Renewable %	0.0%	0.0%	0.0%	0.0%	0.0%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.88**	**1.00**	**1.04**	**1.05**	**1.07**	

Table 13: Quebec Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	8850	9205	8890	8575	8895	83.96
Ethanol (1000 m^3)						
Wheat	0.00	0.00	0.00	0.00	0.00	79.45
Wheat and Corn	0.00	0.00	0.00	0.00	0.00	64.65
Corn	175.00	175.00	217.53	402.42	429.20	49.86
Unknown	0.00	0.00	0.00	0.00	0.00	79.45
TOTAL	**175.00**	**175.00**	**217.53**	**402.42**	**429.20**	
Renewable %	2.0%	1.9%	2.4%	4.7%	4.8%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	4665	5278	5021	4679	4742	92.55
Biodiesel (1000 m^3)						
Canola	0.00	0.00	0.00	0.00	0.00	35.28
Canola/Soy	0.00	0.00	0.00	0.00	0.00	27.29
Canola/Tallow	0.00	0.00	0.00	0.00	0.00	N/A
Soy	0.00	0.00	0.00	0.00	0.00	19.30
Yellow Grease	35.00	75.00	49.97	43.75	47.37	3.03
TOTAL	**35.00**	**75.00**	**49.97**	**43.75**	**47.37**	
Renewable %	0.8%	1.4%	1.0%	0.9%	1.0%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	0.00	0.00	71.96	94.69	94.26	74.57
Palm/Rapeseed	0.00	0.00	0.00	0.00	0.00	74.57
Tallow	0.00	0.00	0.00	0.00	0.00	-31.63
Unknown	0.00	0.00	0.00	0.00	0.00	74.57
TOTAL	**0.00**	**0.00**	**71.96**	**94.69**	**94.26**	
Renewable %	0.0%	0.0%	1.4%	2.0%	2.0%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.27**	**0.40**	**0.41**	**0.57**	**0.60**	

Table 14: Maritimes Fuel Consumption and Renewable Blend

	2010	2011	2012	2013	2014	gCO_2e/MJ
Gasoline (1000 m^3)	2431	2770	2758	2771	2690	83.85
Ethanol (1000 m^3)						
Wheat	0.00	0.00	0.00	0.00	0.00	82.89
Wheat and Corn	0.00	0.00	0.00	0.00	0.00	64.64
Corn	0.00	0.00	67.50	130.06	129.83	46.39
Unknown	0.00	0.00	0.00	0.00	0.00	N/A
TOTAL	**0.00**	**0.00**	**67.50**	**130.06**	**129.83**	
Renewable %	0.0%	0.0%	2.4%	4.7%	4.8%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Diesel (1000 m^3)	1804	2210	1659	2109	1557	92.42
Biodiesel (1000 m^3)						
Canola	0.0	0.0	0.0	0.0	0.0	31.49
Canola/Soy	0.0	0.0	0.0	0.0	0.0	20.56
Canola/Tallow	0.0	0.0	0.0	0.0	0.0	N/A
Soy	0.0	0.0	0.0	0.0	0.0	9.64
Unknown	0.0	0.0	0.0	0.0	0.0	N/A
TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
Renewable %	0.00%	0.00%	0.00%	0.00%	0.00%	
	2010	**2011**	**2012**	**2013**	**2014**	**gCO_2e/MJ**
Renewable Diesel (1000 m^3)						
Palm	0.0	0.0	0.0	0.0	0.0	75.51
Palm/Rapeseed	0.0	0.0	0.0	0.0	0.0	76.38
Tallow	0.0	0.0	0.0	0.0	0.0	4.83
Unknown	0.0	0.0	0.0	13.1	14.3	75.51
TOTAL	**0.0**	**0.0**	**0.0**	**13.1**	**14.3**	
Renewable %	0.00%	0.00%	0.00%	0.62%	0.92%	
Avoided GHG Emissions (Mt CO_{2eq})	**0.00**	**0.00**	**0.06**	**0.12**	**0.12**	