DESIGNED TO WORK:

TECHNICAL ANALYSIS, AND RECOMMENDATIONS FOR MAXIMIZING GHG REDUCTION TARGETS FOR THE GASOLINE AND DIESEL FUEL POOLS WITHIN THE CLEAN FUEL STANDARD.

RICANADA TECHNICAL SUBMISSION

Renewable Industries Canada

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INTRODUCTION

Renewable Industries Canada (formerly the Canadian Renewable Fuels Association) has been proudly representing Canada's renewable fuels producers since 1984. Our members helped build an industry that generates over $3.5 billion in economic benefits every year and has created over 14,000 jobs since 2007. For the last decade, domestic biofuels have been reducing emissions from transportation, combatting pollution, and delivering approximately 4.5 megatonnes of emissions reductions. Much of this resulting from the successful federal Renewable Fuels Standard.

Since its announcement in November 2016, RICanada has supported the Government's plan to develop a Clean Fuel Standard (CFS) to reduce Canada's greenhouse gas (GHG) emissions. We believe the Clean Fuel Standard should be achievable. We also know it is a policy that demands careful and precise regulatory design. As with the original federal RFS, designing a policy that is environmentally ambitious and economically practical is possible. It is not easy, but it is possible – provided regulation can drive the change.

This report is part of RICanada's ongoing comments to the Environment and Climate Change Canada (ECCC) Technical Working Group. It goes farther, offering credible GHG modelling and analysis to show the substantial role of biofuels in delivering tonnage reductions under the CFS. The analysis forecasts potential GHG emissions from the present to 2030 under various scenarios. It also fully leverages our industry's expertise to ensure more technological development and advancements in the transportation sector for years to come.

EXECUTIVE SUMMARY

Consultations on the proposed federal CFS have provided policymakers with considerable data on projected economic impacts and future products that will likely have varying degrees of success once brought to market. What is lacking, however, is a comprehensive technical analysis regarding the GHG reductions available given technologies already widely in use today; and what trends vehicle manufacturers will move towards given future emissions standards (coming into force in 2022).

RICanada believes the transportation sector itself could provide upwards of 20 megatonnes (Mt) of annual GHG reductions by 2030, with liquid fuels providing 25 Mt of reductions. This is without complementary policy beyond the CFS[1].

Ethanol

With respect to ethanol, three different scenarios are considered, and modelled:

(i)

All gasoline contains ethanol with E15 being the most common blend. CFS and carbon pricing increase demand for E85 (i.e. 85% ethanol), CAFE requirements drive demand for E25. This scenario results in an average blend level of 18.7% ethanol by 2030, and GHG emission reductions of 9.2 Mt.

(ii)

CAFE requirements lead to widespread adoption of E25, which is in turn used by flex fuel vehicles (FFVs) instead of E85. This scenario results in an average blend level of 17.5% ethanol by 2030, and GHG emission reductions of 8.5 Mt.

(iii)

Minimal supplemental policy is used: government mandates the production of FFVs, resulting in increased E85 sales and an average blend level of 30.9% ethanol by 2030, and GHG emission reductions of 15.7 Mt.

Biomass-based diesel (BBD)

RICanada has modelled two scenarios, one which shows stronger biodiesel use as compared to renewable diesel, and another which shows the opposite. Fuels containing biodiesel and renewable diesel are common. Assuming a total blend level around 14%, **BBD would yield a reduction of 9.7 to 10.4 Mt of GHG emissions.**

Note that it takes 18-24 months to build a new biofuels facility. CFS will spark a comprehensive build-out of the Canadian industry especially given that our clean power grid provides a CI advantage. However, we expect that supply from the United States will ensure that there is adequate fuel available as the industry here ramps up supply.

[1] Several technologies are incorporated in RICanada's model for calculating GHG reductions from the transportation sector. GHGenius 5.0 was used for lifecycle analysis of various fuels, and projects changes in fuel blends that will be driven in part by the CFS itself, but also due to new engine technologies that will require more high-octane additives like ethanol.

Finally, consideration is given to other low carbon fuels and innovations which will each provide transportation sector GHG abatement. We model EV uptake (3-6 Mt of reductions), natural gas use in trucking (1.1 Mt) and increased refinery efficiencies (2.9 Mt), combined with the 18 Mt that biofuels could provide to arrive at a total target for the CFS of yearly reductions against a 2017 baseline, by 2030.

Timeline and Scope

ECCC plans to publish draft regulations in the Canada Gazette, Part I, in 2018 and final regulations in the Canada Gazette, Part II, in mid-2019. (Clean Fuel Standard regulatory framework). Yet, coordinating considerations from vastly different sectors (transportation, buildings, and industry) is an extremely complicated, laborious undertaking.

Designing transportation-focused Clean Fuel Standard for the immediate and near term. Reduction targets from a partitioned policy are both achievable given the current timeline and will likely lead to more technological development and advancement in the transportation sector than a non-partitioned CFS.

RICanada recommends the CFS partition targets of 12.5 Mt of reductions for the gasoline pool, and 12.5 Mt for the diesel pool. This will provide a total of 25 Mt per year from the transportation sector, by 2030.

While this is less than the 30 Mt per year target, it would send a clear market signal to spur investment and accelerate higher blending of low carbon fuels.

1.0
CONTEXT: RESOLVING GAPS IN TECHNICAL DATA

Several reports followed the government's announcement of the CFS in 2016. Notably, Clean Energy Canada's (CEC) "What a CFS can do for Canada" outlined, among other things, the economic impact that the CFS could have on the renewable fuels sector. CEC concluded that 30 new biofuel plants could be built, supporting 31,000 new jobs. Reports like CEC's provide essential data from an economic modelling perspective. However, in the absence of a comprehensive breakdown of where these GHG emission reductions would come from, problematic gaps still exist. Today it remains unclear how attainable the 30 Mt target is, or from which areas the GHG emission reductions are expected to be achieved.

Against this backdrop, RICanada has worked with third-party engineers to produce a detailed model of where "tonnage" could come from. Specifically, focusing on liquid fuels used in the transportation sector to chart the feasible and realistic role of biofuels. **The results show biofuels can provide between 60 percent to 87 percent of the 30MT of GHG reductions sought by the CFS.** (Results vary depending on the policies selected by the federal government).

Some may think the projections overestimated but analysis confirms that the targets for transportation sector GHG reductions can be achieved using technologies available today and without any required changes to vehicle fleets. (One exception being vehicle engine modifications under new Corporate Average Fuel Efficiency (CAFE) standards).

1.1 METHODOLOGY AND ASSUMPTIONS

Lifecycle Analysis (LCA) model. Calculations presented in this document are based on lifecycle analysis conducted using GHGenius, version 5.0.

Year-by-year analysis. It will be extremely important for the CFS to have meaningful targets for each year between its inception and 2030. Otherwise, too many compliance credits could be banked early in the program absent ambitious action on emissions. For this reason, each scenario explained here in has be mapped with yearly targets for GHG reductions.

Fleet turnover assumptions. Given an average "fleet turnover" period of 12 years, we assume that by 2030, all cars (except some outliers, and infrequently driven vintage cars) will be able to accommodate E15 gasoline.

- Note that the turnover of heavy duty vehicles is much slower than that of light duty cars. However, heavy duty trucks can accommodate up to 20% biodiesel, and up to 100% renewable diesel. For this reason, this analysis does not account for fleet turnover with respect to the diesel fuel pool.

[1] Released in November 2017, and available at: http://cleanenergycanada.org/wp-content/uploads/2017/11/CleanFuelStandardReport-FINAL.pdf

Assumption on energy replacement: In our modelling, 1 MJ of energy from biofuels replaces 1 MJ of energy from fossil fuels. Note that this is a cautious assumption. Ethanol tends to provide an efficiency benefit when burned in cars, so one could assume that 1MJ of energy from ethanol actually replaces 1.2 MJ of energy from gasoline. Due to this efficiency, the GHG reductions realized by burning ethanol are even greater than modelled herein. However, we've chosen to cite conservative estimates.

We assume that by 2030, at least 3% of gasoline sales will be high octane, E25 blends, since ethanol's 114 octane provides a clean and cheap way to boost the overall octane of blended gasoline.

Forthcoming CAFE standards accounted for. Given CAFE standards that will be in place as of 2022, we assume that by 2030, at least 3% of gasoline sales will be high octane, E25 blends, since ethanol's 114 octane provides a clean and cheap way to boost the overall octane of blended gasoline.

- Note: vehicle manufacturers are already testing high compression, lightweight engines to comply with this 2022 requirement. This 3% assumption is therefore conservative.

Flex fuel vehicles (FFVs) will comprise 10% of the vehicle fleet in 2030. Carbon pricing will add at least 11.6 cents per litre to the cost of fossil fuel-based gasoline (conservatively assuming a carbon tax of $50 per tonne of CO2 equivalent in 2030). Ethanol is zero-rated under carbon pricing, so we expect drivers of FFVs will be price conscious and will fill up with E85 as much as possible. Still, in the spirit of providing a conservative estimate, we assume FFVs on the road will be filled with E85 only 50 percent of the time.

Renewable fuels will be one of several solutions. Renewable fuels on their own can tackle a substantial part of the CFS' targets, but it should be clear that this is not the only clean technology that will contribute to transportation sector GHG reduction. Our model includes calculations for GHG emission reductions from electric vehicle use, natural gas use in the heavy transport sector, and CI reductions for gasoline and diesel due to new refinery efficiencies.

EVs to compromise 5% of vehicles on Canada's roads in 2030. Modelling in California has suggested that it is realistic for the state to have 5.8% of its fleet of cars running on electricity by 2030. That said, California on its own is the second largest market for EVs, with China being the largest market. It is unrealistic to assume that Canada – with its cold climate (which hurts battery efficiency and reduces range due to heating needs) – will have the same level of uptake as California. In order to be cautious in our estimates on GHGs reduced by biofuels, we have assumed in our model that EVs will comprise 5% of Canada's fleet in 2030. That said, given that uptake of EVs is unpredictable, we have also included a second scenario that put EVs at only 2.5% of the Canadian fleet of light duty vehicles, in 2030. Other innovations could also present themselves, such as with respect to plug-in hybrid electric vehicles (PHEVs). Toyota, for example, has developed a PHEV that runs on electricity and ethanol as its liquid fuel. This innovation could bring about strong reductions in GHG emissions, while keeping cars affordable.

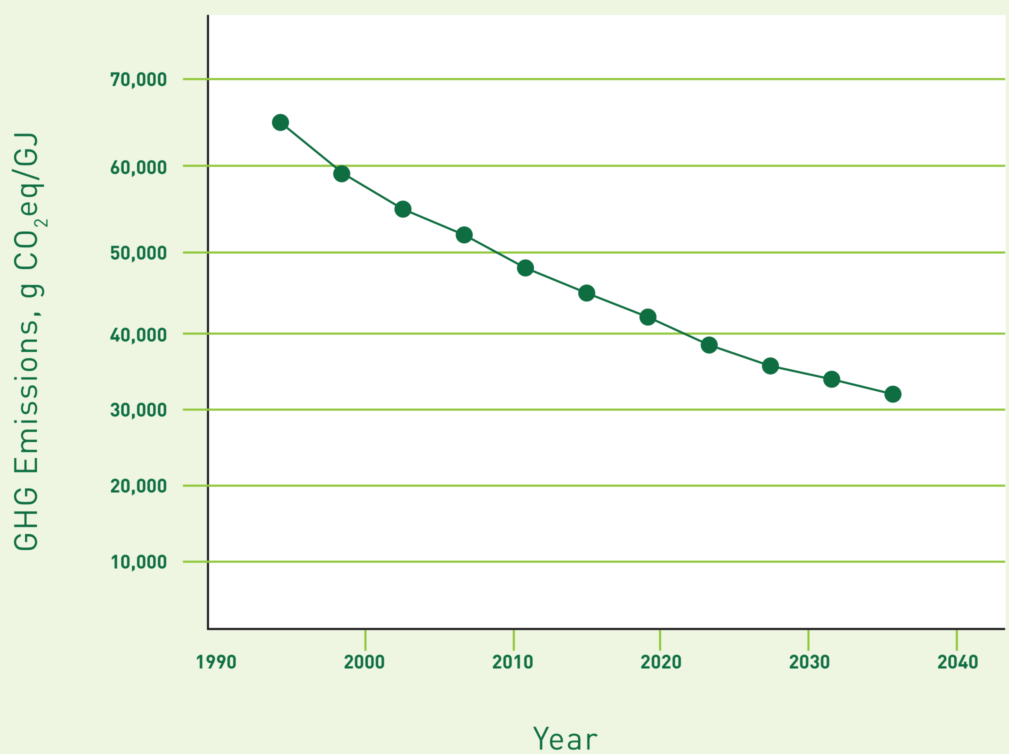
Healthy supply of feedstocks. Under the CFS, demand for biofuels is sure to increase. Increased production to meet this demand is entirely feasible based on the experience of Canadian producers. Even with Renewable Fuel Regulations that were published by the federal government in 2010, there has been a substantial growth in the availability of feedstocks, due largely to increased farm productivity. For example, Canada used to be a net importer of corn, but over the last 10 years, we have become a net exporter.

Upgrades to electrical infrastructure, and availability of green electricity. As EVs gain greater uptake, it will be important to ensure that infrastructure keeps pace. This is not just a question of installing public charging stations, but also ensuring that last mile electricity delivery to residential homes can accommodate the increased load. As well, modelling has shown that by 2025, Ontario will no longer have a surplus of green electricity available at night. This suggests that charging EVs could in the future rely on incremental electricity from gas fired plants. It will therefore be important to reassess the lifecycle analysis of the electricity used for charging EVs.

Improved Carbon Intensity (CI) over time. As history has demonstrated, the average CI of ethanol continues to decline. A corn ethanol plant built 10 years ago would typically have a CI of approximately 44 gCO2e/J. Given ethanol available on the market today that is made from facilities built over the last 25 plus years, we start our model with a CI of 48 gCO2e/J in 2017. However, to reflect that technology has improved, and continues to improve, we model this CI as decreasing to an average of 44 gCO2e/J in 2020, declining gradually to 32.3 gCO2e/J in 2030.

- This assumption is justified by the fact that the CFS will incentivize the production of low-CI ethanol. Tradability of credits within the gasoline pool would "monetize" the CI of ethanol, and thereby make it profitable for companies to invest in cutting edge technologies such as the production of ethanol from inedible plant fibres, and the conversion of municipal waste to biofuels.

Projection: Average Carbon Intensity of Ethanol used in Canada



2.0

SCENARIOS: GHG REDUCTIONS FROM ETHANOL IN GASOLINE

2.1 Ethanol Scenario 1: CFS and carbon pricing increase demand for E85, CAFE requirements drive demand for E25

In 2030, Scenario 1 models gasoline sales as follows:

- 90% of gasoline sales would be E15
- 1.8% of gasoline sales would be E10
- 3.2% of gasoline sales would be E25
- 5% of gasoline sales would be E85
- This represents an overall average blend of **18.7% ethanol** in gasoline, in 2030.
  - **GHG reductions based on a 2017 baseline of 9.2 Mt**

2.2 Ethanol Scenario 2: CAFE requirements lead to widespread adoption of E25

Suggesting E25 would be the fuel of choice for both FFV drivers, and drivers of cars with high compression engines is plausible due to a wide adoption of new cars that require E25's octane. In this scenario, E25 cars alone could represent 20% of the fleet in 2030 given the CAFE requirements that will have been in force as of 2022. Given that these new cars will make E25 almost universally available, this scenario assumes that FFV drivers will use this fuel as well. Combined, the consolidated demand for E25 would represent roughly 22.5% of gasoline sales. With this in mind, Scenario 2 models the following gasoline sales in 2030:

- 75.2% of gasoline sales would be E15
- 1.8% of gasoline sales would be E10
- 22.5% of gasoline sales would be E25
- 0.5% of gasoline sales would be E85
- This represents an overall average blend of **17.5% ethanol** in gasoline, in 2030.
  - **GHG reductions based on a 2017 baseline of 8.5 Mt**

2.3 Scenario 3: Minimal Supplemental Policy – Mandated/ Incented Production of Flex Fuel Vehicles (FFVs)

The federal government could be slightly more prescriptive to encourage even greater adoption of high biofuel blends. Specifically, ECCC could require that all new vehicles with an internal combustion engine must be able to accommodate E85 starting in 2020. On this basis, by 2030 approximately 80% of the cars on the road would be able to use E85. Assuming these vehicles used E25 and E85 each 25 percent of the time, and E15 the rest of the time, gasoline sales would be as follows:

- 57.8% of gasoline sales would be E15
- 1.8% of gasoline sales would be E10
- 20% of gasoline sales would be E25
- 20% of gasoline sales would be E85
- This represents an overall average blend of **30.9% ethanol** in gasoline, in 2030.
  - **GHG reductions based on a 2017 baseline of at least 15.7 Mt**

3.0

GHG REDUCTIONS FROM BIOMASS-BASED DIESEL

Two scenarios are envisioned for BBD. The first assumes a moderate uptake of biodiesel and higher uptake of renewable diesel, and a second assumes the opposite. These two scenarios demonstrate that, to a certain extent, biodiesel and renewable diesel are interchangeable. Use depends on factors such as whether companies are willing to make capital investments to use biodiesel with a lower operating cost than renewable diesel (which does not require specialized blending infrastructure). Other considerations include cloud point in the winter months and the 20% ceiling on the use of biodiesel with the current fleet.

In order to reflect the uncertainty around the choice between biodiesel and renewable diesel, two scenarios have been developed. Scenario 1 assumes that obligated parties will use biodiesel in moderate amounts (5% blend) and then use renewable diesel in a larger quantity. This scenario minimizes capital expenditures for obligated parties.

Scenario 2 assumes that biodiesel will be used as much as possible so that obligated parties can take advantage of the lower ongoing costs of purchasing the fuel. In the summer months, we could expect biodiesel blending to be as high as 20%, with a year-round average of approximately 9%. Renewable diesel would still be included at roughly 5% in order to reflect that the flexibility of the CFS will allow different companies to choose their own compliance solution.

3.1 Biomass-based diesel specific assumptions

BBD is more straightforward than ethanol, in that the current vehicle fleet is able to use a 20% blend of biodiesel, and up to 100% renewable diesel.

Biodiesel blended at 5% year-round (including winter months) has already been tested in Canada leaving room for considerable growth in the use of this fuel.

With regard to biodiesel and renewable diesel, it is important to consider that some obligated parties may favour one over the other. As a drop-in fuel, renewable diesel does not require any special blending infrastructure, but the product is more costly than biodiesel. Since the beginning of 2011, the cost of biodiesel in the U.S. has been on average almost 23 cents (USD) per litre less than renewable diesel.

With current technology, it is possible to make biodiesel with an ultra-low CI, such as zero gCO2e/J or even negative. Such biodiesels are typically made from feedstocks such as used cooking oils, or waste animal fats. Canadian plants are already producing this product, which has developed a strong presence in Ontario where the provincial Greener Diesel Regulation requires a 4% blend of BBD, while stipulating that the biofuel delivers at least a 70% GHG reduction when compared to diesel fuel. We expect the CFS to similarly drive demand for the product.

For the purpose of our modelling, the CI of biodiesel is calculated at 15 gCO2e/J as of 2017, conservatively decreasing to 14.1 gCO2e/J in 2030.

The CI of renewable diesel is calculated at 18 gCO2e/J in 2018, decreasing to 16.9 gCO2e/J in 2030.

3.2 Scenario 1: Moderate biodiesel, strong renewable diesel use

Based on an average blend of 13.25% BBD (5% biodiesel + 8.25% renewable diesel)

- **GHG reductions using a 2017 baseline of 9.7 Mt**

3.3 Scenario 2: Strong biodiesel, moderate renewable diesel use

Based on an average blend of 14% BBD (9% biodiesel + 5% renewable diesel)

- **GHG reductions using a 2017 baseline of 10.4 Mt**

4.0
COST OF ABATEMENT

When measured by volume, Ethanol costs less than gasoline. On a per MJ basis, ethanol costs about the same as gasoline. However, ethanol has an octane rating of 114 which adds substantial value. Both the cost per MJ and octane need to be considered in calculating the abatement cost of ethanol. Modelling has shown that since 2015, the octane value of ethanol has been higher than the actual selling price of ethanol resulting in ethanol's energy cost to refiners being below zero. This will continue to be the case, particularly as octane becomes needed for new high-compression engines.

Abatement obtained through the use of ethanol can therefore cost approximately -$400/tonne, in other words, the use of ethanol could actually save consumers money assuming that some savings are passed on by obligated parties.

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Over the past decade the biodiesel premium has been about 20 cents per litre. Biodiesel will reduce the GHG emissions by about 2.7 kg/litre of biodiesel. The cost of abatement for biodiesel is therefore approximately $75/tonne.

Renewable diesel costs approximately 23 cents per litre more than biodiesel. The cost of abatement for this fuel would be approximately $185/tonne of GHG reductions.

5.0 ADDITIONAL CONSIDERATIONS

Increased use of renewable fuels is one important measure among others that will help Canada meet its Paris Accord objectives. With this in mind, the following considerations are important when calculating the total amount of GHG reductions that can be realized from the transportation sector.

5.1 Reductions in CI for fossil fuels.

Over time, we expect that the respective CIs of gasoline and diesel will decline due to increased upstream efficiencies. These can be calculated for both fuels assuming a 0.1% reduction in CI per year, yielding the following GHG benefits:

- Gasoline: CI starting at 91.54 gCO2e/J in 2017, and declining to 90.4 gCO2e/J in 2030, **yielding an additional 1.65 Mt reduction in GHG emissions.**
- Diesel: CI starting at 92.2 gCO2e/J in 2017 and declining to 91.0 gCO2e/J in 2030, **yielding an additional 1.25 Mt reduction in GHG emissions.**

5.2 Impact of EVs

As noted among the assumptions in this report, the EV scenarios included here are based on projections from California, adapted to the Canadian market. One is more bullish, while the other is more conservative on the market penetration of EVs by 2030.

Scenario 1 for EVs. By 2030, assuming that roughly 5% of light duty vehicles in Canada are EVs, our model projects:

- **6.1 Mt reduction in GHG emissions from EVs**

Scenario 2 for EVs. By 2030, assuming that roughly 2.5% of light duty vehicles in Canada are EVs, our model projects:

- **3 Mt reduction in GHG emissions from EVs**

5.3 Impact of natural gas use in trucking sector.

Assuming a 15% growth in natural gas use per year between now and 2030, this fuel will yield:

- **1.1 Mt reduction of GHG emissions from natural gas**

5.4 Heavy Fuel, and Home Heating Oil

Heavy fuel oil (HFO) is increasingly being displaced by diesel fuel, which is why this report focuses on the latter. (5.2 million cubic metres of HFO were sold in 2010, in 2017 this number shrank to 3 million, a reduction of 2.25 million cubic metres. During this same time period, diesel sales in Canada increased by 2.64 million cubic metres).

With respect to heating oil, this is an application where biodiesel could have a large impact since most oil tanks store the fuel indoors, and inexpensive additives can be used to ensure that the pour point of the fuel remains appropriate for delivery during extreme cold. That said, heating oil is already captured in the figures included here, because it is difficult to parse statistics on this fuel from diesel (due to the fact that they are identical from a chemical point of view). Additional work could be undertaken to ensure that heating oil is delivered at a 20% biodiesel blend, thereby maximizing GHG reductions from the liquid fuel pool.

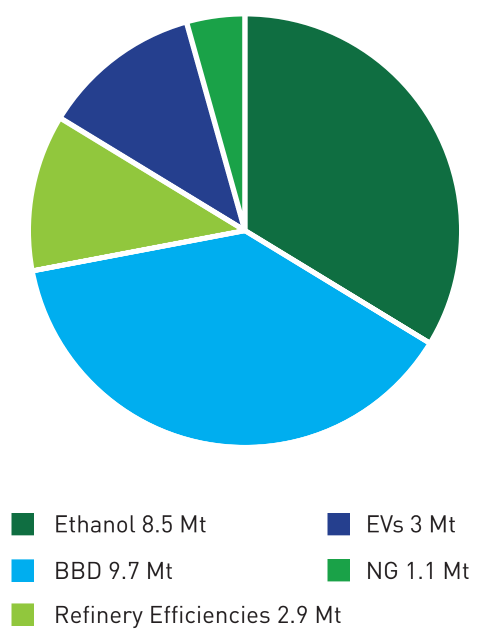
6.0

RICANADA'S RECOMMENDED CFS TARGET FOR TRANSPORTATION SECTOR FUELS

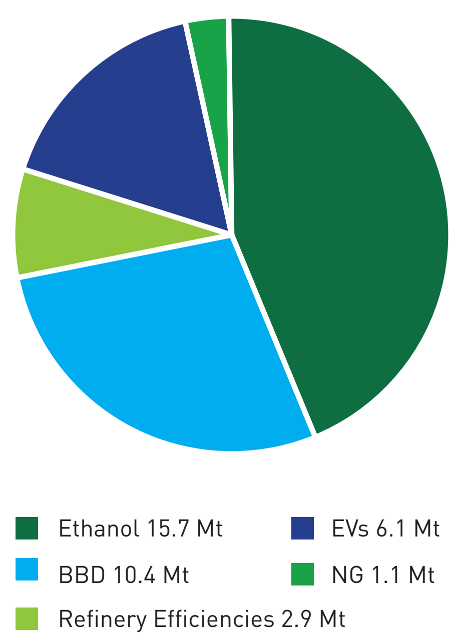
As demonstrated in Ethanol Scenario 3, attaining very substantial GHG emission reductions (15.7 Mt) from ethanol alone is attainable. This scenario surely sounds ambitious though it is not far off from where Brazil is today in its use of ethanol at 27% in gasoline. However, RICanada is aware that one of ECCC's goals is to ensure the CFS is as flexible as possible. With this in mind, recommendations are based on technologies and trends that are already in place or imminent.

The following figures respectively illustrate relatively conservative, and relatively bullish projections on the amount of megatonnes of GHG reductions that could be achieved by the transportation sector, by 2030.

Projected GHG reductions of 25Mt/yr from transportation under the CFS, by 2030



CFS with prescriptive policies on FFVs, and high EV uptake. Projected 36Mt/yr reduction from transportation sector, by 2030



RICanada recommends separate compliance pools for the gasoline and diesel pools, with targets as following:

- **Recommended target for the gasoline fuel pool:** 10-12.5 Mt (assuming roughly 9.5 Mt from ethanol, and the rest coming from other sources)
- **Recommended target for the diesel fuel pool:** 10-12.5 Mt (assuming roughly 9.8 Mt from BBD, and the rest coming from other sources)

7.0 CONCLUSION

Canadian biofuels improve our economy, diversify our fuel supply, create jobs, and improve our nation's environment. Depending on design, the CFS can realize its GHG mitigation targets while incenting the use of a broad range of low carbon fuels, including biofuels.

The CFS is a complex policy best approached in a partitioned manner. Transportation targets have a proven track record at reducing emissions and should be prioritized given the government's timeframe.

RICanada recommends a 20 megatonne target for transportation, and a 25 megatonne target for the liquid fuels pool. Biofuels alone can realistically deliver over 15 megatonnes of these reductions.

Any remaining emissions reductions to meet the 30 Mt CO2eq target can come from building and industrial sectors – both of which are vastly different, unprecedented areas requiring more time to build-out.