SB 20-038

Legislative Council Staff

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Greenhouse Gas Emissions Report

Drafting Number:	LLS 20-0339	**Date:**	February 10, 2020
Prime Sponsors:	Sen. Fenberg Rep. Jaquez Lewis	**Analyst:**	Christina Van Winkle | 303-866-6289 Christina.VanWinkle@state.co.us
Bill Topic:	**STATEWIDE BIODIESEL BLEND REQUIREMENT DIESEL FUEL SALES**		
Sectors Impacted:	☐ Electric Power ☒ Transportation ☐ Industrial Processes ☐ Waste Management ☐ Agriculture		☐ Natural Gas and Oil Systems ☐ Residential / Commercial / Industrial Fuel Use ☐ Coal Mining and Abandoned Mines ☐ Land Use / Land Use Change / Forestry ☐ Other
Net Change:	☐ Increase ☒ Decrease ☐ Indeterminate ☐ Minimal		
Report Status:	This report reflects the introduced bill. A description of key amendments adopted since introduction is included on page seven.		

Summary

As introduced, this bill requires that all diesel fuel sold or offered for sale between June 1 and September 15 in Colorado be blended with a minimum percentage of biodiesel. Displacing petroleum diesel fuel with biodiesel has the potential to reduce greenhouse gas emissions. This bill requires a minimum 5 percent biodiesel blend by June 1, 2021, resulting in a potential emissions savings of 0.05 million metric tons of carbon dioxide equivalent per year, based on projected diesel fuel sales in the state. Beginning on June 1, 2023, a minimum 10 percent biodiesel blend is required, resulting in a potential greenhouse gas emissions reduction of 0.13 million metric tons of carbon dioxide equivalent per year.

Key Provisions Impacting Greenhouse Gas Emissions

This bill requires that all diesel fuel sold or offered for sale in Colorado between June 1 and September 15 of each year contain a minimum amount of biodiesel. The bill phases in the minimum requirements of biodiesel from no less than 5 percent beginning June 1, 2021, to no less than 10 percent beginning June 1, 2023.

Background

Greenhouse gases trap heat in earth's atmosphere and contribute to global climate change. Greenhouse gases include carbon dioxide, methane, nitrous oxide, and fluorinated gases. As required by House Bill 19-1188, this greenhouse gas emissions report identifies whether a measure is likely to directly cause a net increase or decrease in greenhouse gas pollution within a ten-year period following enactment, and identifies any new sources of greenhouse gas emissions, any increase or decrease in emissions from existing sources, and any impact on sequestration of emissions.

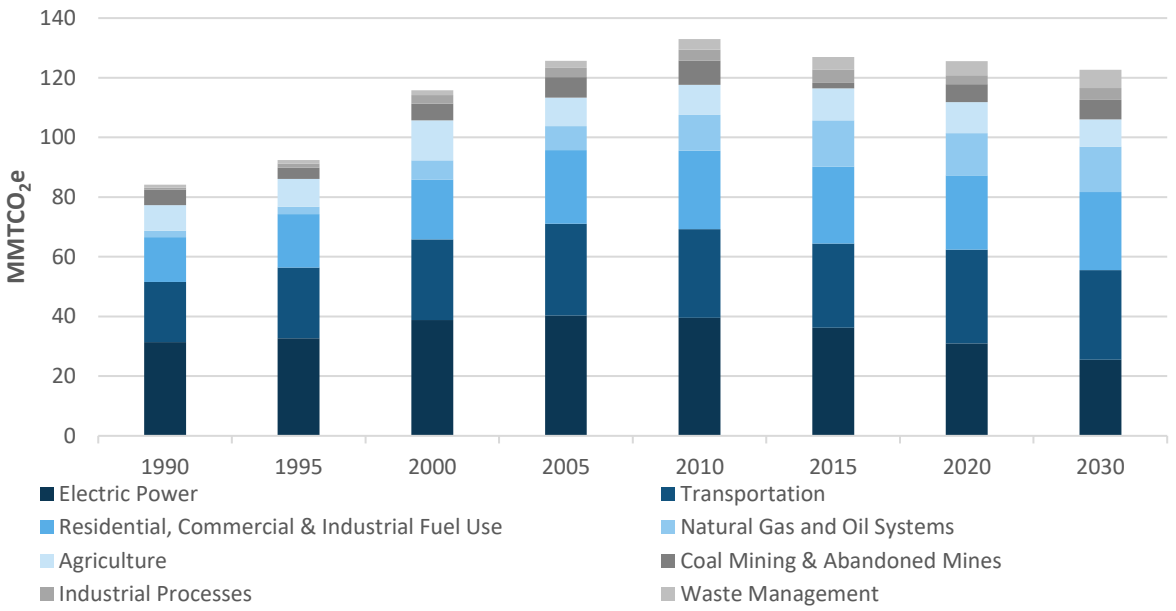
Biodiesel and the renewable fuel standard. Biodiesel is used as a substitute for, or additive to, petroleum distillate fuel oils, thereby displacing fossil-fuel derived fuel consumption and associated greenhouse gas emissions. Biodiesel is a renewable fuel made from biomass feedstocks such as vegetable oils and animal fats. In 2018, soybean oil accounted for 54 percent of the total raw materials used for making biodiesel in the United States, followed by corn oil (15 percent), yellow grease (12 percent), canola oil (9 percent), and animal fats (9 percent).[1] Biodiesel is often blended with petroleum diesel for use as a motor vehicle fuel at low blend levels. Many diesel engine original equipment manufacturers have approved the use of biodiesel blends up to 20 percent (referred to as B20).[2] Engines operating on biodiesel blends up to B20 have similar fuel consumption to engines powered by petroleum diesel, so consumption patterns are not anticipated to increase when converting from petroleum diesel to a biodiesel blend.[3]

Under the federal Renewable Fuel Standard (RFS) program, transportation fuel sold in the United States must contain a minimum volume of renewable fuels. Biomass-based diesel must meet a 50 percent lifecycle greenhouse gas reduction to be eligible under the RFS. The standards are expressed as a volume percentage and are used by refiners and importers of petroleum diesel to determine their renewable fuel volume obligations. Under the current RFS requirements, diesel fuel must contain at least 2.10 percent biomass-based diesel beginning in 2020.[4]

Colorado's transportation-related emissions. In Colorado, transportation-related emissions accounted for approximately 22 percent of total greenhouse gas emissions in 2015, and are projected to grow to 25 percent of emissions in 2020, surpassing electric power as the largest source of greenhouse gas emissions in the state. Transportation-related emissions includes emissions from both on-highway vehicles (e.g., passenger cars, trucks, and heavy duty vehicles) and non-highway vehicles (e.g., boats, locomotives, farm equipment, and aircraft). As discussed below, the use of biodiesel as a petroleum blend in diesel sold in Colorado could reduce greenhouse gas emissions from the transportation sector. A portion of these greenhouse gas emissions savings will be offset by the energy requirements to grow, process, and transport biodiesel.

[1] U.S. Energy Information Administration. Monthly Biodiesel Production Report.
[2] National Biodiesel Board. Available at: https://www.biodiesel.org/using-biodiesel/oem-information
[3] U.S. Energy Information Administration. Biodiesel Blends. Available at: https://afdc.energy.gov/fuels/biodiesel_blends.html. Some studies have shown a slight increase in fuel consumption in heavy-duty engines with higher biodiesel blends, due to the lower energy content of biodiesel. For instance, a study conducted for the California Air Resources Board in 2011 found fuel consumption increased up to 1.8 percent for a 20 percent soy-based biodiesel blend (B20). Another study conducted by the National Renewable Energy Laboratory on biodiesel performance in modern engines found comparable fuel consumption in B20 blends.
[4] This percentage standard represents the ratio of the national applicable renewable fuel volume to the national projected non-renewable diesel volume less any diesel production attributable to small refineries exempted from the standards.

Figure 1
Estimated Colorado Greenhouse Gas Emissions by Sector (1990-2030)
Million Metric Tons of Carbon Dioxide Equivalent



Source: Colorado Department of Public Health and Environment. Colorado Greenhouse Gas Inventory. 2019 Draft.

Assessment

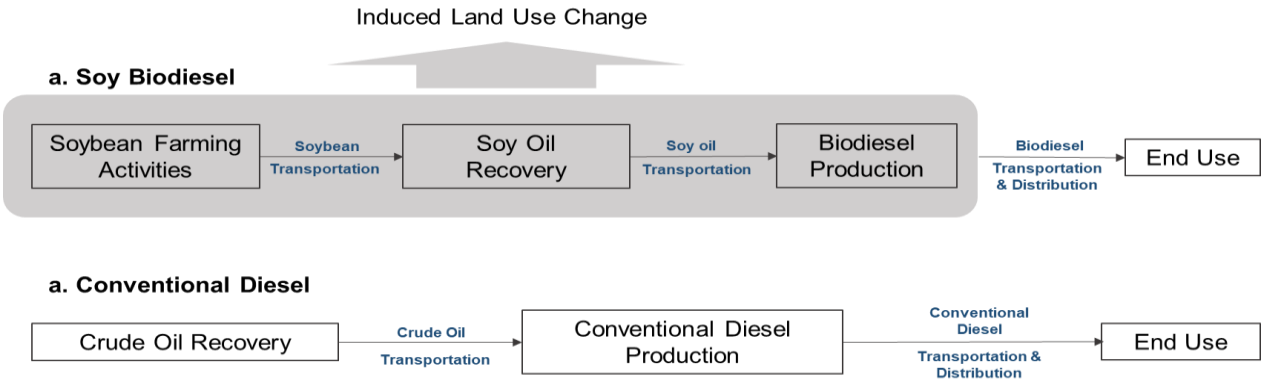
Over the ten-year period following enactment, SB 20-038, as introduced, could reduce greenhouse gas emissions by approximately 1.13 million metric tons of carbon dioxide equivalent. Annual potential greenhouse gas emissions savings amount to approximately 50,000 metric tons of carbon dioxide equivalent under the 5 percent biodiesel blend requirement, and increase to approximately 130,000 metric tons of carbon dioxide equivalent under the 10 percent biodiesel blend requirement. These estimates account for the emissions associated with the feedstock production, transport, distribution and use of biodiesel, compared to the production, distribution and use of baseline petroleum diesel. Additional detail on these estimates is provided below.

Biodiesel production and use. To estimate the greenhouse gas emissions of a specific transportation fuel, all stages of the fuel's production, processing, transportation, and use must be considered. These "well-to-wheel" analyses (e.g., production of the feedstock to combustion of the fuel) account for the use of fossil fuels in the production and transportation stages of biofuels, as well as any induced land use change in the agricultural sector. Although the greenhouse gas emissions from the combustion of biofuels (i.e. tailpipe emissions) are offset by the carbon dioxide fixation while the biomass is growing[5], all emissions associated with agricultural inputs, feedstock transportation and production, as well as their distribution and use must be accounted for to quantify the emissions savings compared to conventional petroleum fuels.

[5] See the definition for carbon sequestration in the glossary of terms.

Sources of greenhouse gas emissions. To quantify the emissions impacts of biodiesel, life-cycle analyses have been conducted by the U.S. Environmental Protection Agency (EPA) that evaluate the environmental impacts throughout its lifetime, from resource extraction to processing, transportation, end use, and disposal. The various stages and material inputs considered in a life cycle analysis are defined within the systems boundary.[6] Figure 2 compares the systems boundary of conventional diesel to soy biodiesel, which also generally corresponds to other feedstocks used to produce biodiesel.[7]

Figure 2
System boundaries for Soy Biodiesel and Conventional Petroleum Diesel Life Cycle Analysis



Source: Adapted from Life Cycle energy and greenhouse gas emission effects of biodiesel in the United States with induced land use change impacts. Bioresource Technology 251 (2018) 249-258.

Greenhouse gas emissions impact of biodiesel. The U.S. EPA life-cycle analyses of biodiesel have quantified the greenhouse gas emissions associated with a number of different feedstocks used in the production of biodiesel. These analyses include the emissions associated with agricultural practices, induced land use changes, feedstock production, transportation, distribution, and use. Table 1 reflects the net emissions associated with biodiesel feedstocks used in 2018, compared to petroleum diesel.

[6] See life cycle analysis in the glossary of terms for a more detailed definition.
[7] It is generally assumed that there are no induced land use change effects caused by animal fats as these are co-products of the meat industry.

Table 1
Lifecycle Greenhouse Gas Emissions by Feedstock and Fuel Type

Feedstock	Net Emissions (kg CO_2e/mmBtu)	Percent Emissions Reduction Compared to Petroleum Diesel
Baseline Petroleum Diesel	97.0	--
Biodiesel Feedstock		
Soybean oil	35.8	63%
Corn oil[1]	41.5	57%
Yellow Grease	13.8	86%
Canola Oil	48.1	50%
Animal Fats[2]	21.8	77%
Other[3]	32.2	67%
Biodiesel Weighted Average[4]	**33.5**	**62%**

Source: EPA Lifecycle Greenhouse Gas Results.
[1] Corn Oil emissions factor calculated from the study: Influence of corn oil recovery on life-cycle greenhouse gas emissions of corn ethanol and corn oil biodiesel (2015). Corn is used by biorefineries to produce a) corn ethanol, b) biodiesel, and c) distiller's grain with solubles. The emissions factor calculated here is the average of three co-product treatment approaches: marginal, hybrid allocation, and process-level energy allocation.
[2] Animal fats emissions factor is based on the beef tallow emissions factor calculated from the study: Life cycle energy and greenhouse gas emissions effects of biodiesel in the United States with induced land use change impacts (2018).
[3] Other emissions factor calculated as an average of all other feedstocks.
[4] Biodiesel weighted average is based on the proportion of biodiesel feedstock inputs used in 2018 (e.g. 54 percent soybean oil, 15 percent corn oil, etc.)

Greenhouse gas emissions impact of biodiesel-blended diesel fuel. SB 20-038, as introduced would require that all diesel sold in Colorado between June 1 and September 15 be blended with at least 5 percent biodiesel (B5) as of June 1, 2021 and 10 percent biodiesel (B10) beginning June 1, 2023. Table 2 below shows the average greenhouse gas emissions from various biodiesel blends in pounds of carbon dioxide equivalent per gallon of fuel consumed, as well as the emissions savings when compared to the current blend requirements under the RFS Program (2.10 percent).

Table 2
Greenhouse Gas Emissions Factors for Diesel and Biodiesel Blends and Percent Emissions Reductions

Fuel	GHG Emission Factor (lbs CO_2e/gallon)	Percent Emissions Reduction from RFS Blend
RFS Blend[1]	27.09	--
B5 Biodiesel	26.55	2.0%
B10 Biodiesel	25.61	5.4%

Source: LCS Calculations, based on EPA Lifecycle Greenhouse Gas Results
[1] RFS Blend represents the 2020 minimum percentage standard for biodiesel (2.10%) according to the current Renewable Fuel Standards. Actual blend percentage may vary.

Greenhouse gas emissions impact of SB20-038. By applying the above emissions factors, the direct greenhouse gas emissions impacts of Senate Bill 20-038 may be estimated based on current diesel consumption patterns and projected future demand. The U.S. Energy Information Agency (EIA) tracks distillate fuel oil consumption by end user by state, and also projects future demand through 2050. Current diesel sales in Colorado averaged 707 million gallons per year between the years 2015 and 2017, including diesel sales to on-highway vehicles, railroad, vessel bunkering, farm, off-highway, and military consumers.

The U.S EIA projects that diesel fuel consumption will decline, on average, 0.68 percent per year between 2021 and 2030.[8] Based on current consumption patterns and future demand, the greenhouse gas emissions savings can be estimated for the biodiesel-blended fuel standards required under SB 20-038. The bill requires only diesel sold from June 1 through September 15 be blended, so annual consumption is prorated to account for this seasonal usage.[9] Baseline emissions are calculated using the current biodiesel percentage standard under the RFS Program, which is 2.10 percent in 2020. This percentage was not adjusted for future years. Table 3 below reflects the baseline emissions and emissions savings under SB 20-038.

Table 3
Baseline Emissions and Emissions Savings under SB 20-038
Million Metric Tons of Carbon Dioxide Equivalent

Year	Baseline Emissions RFS[1]	Emissions Under SB 20-038[2]	Emissions Savings Under SB20-038	Percent Emissions Savings Under SB20-038
2021	2.47	2.42	0.05	2.0%
2022	2.45	2.40	0.05	2.0%
2023	2.43	2.30	0.13	5.4%
2024	2.42	2.29	0.13	5.4%
2025	2.40	2.27	0.13	5.4%
2026	2.38	2.25	0.13	5.4%
2027	2.37	2.24	0.13	5.4%
2028	2.35	2.22	0.13	5.4%
2029	2.34	2.21	0.13	5.4%
2030	2.32	2.19	0.13	5.4%
TOTAL	**23.94**	**22.79**	**1.13**	**5.0%**

[1] LCS calculations using data from the U.S. Energy Information Administration

As shown above, total greenhouse gas emissions savings potential between 2021 and 2030 are anticipated to be between 0.05 and 0.13 million metric tons of carbon dioxide equivalent annually. Over a ten-year period, these emissions reductions represent a combined 5.0 percent greenhouse gas emissions savings potential compared to the baseline emissions between 2021 and 2030. In 2030, transportation-related emissions (on and off-highway) are projected to reach 30 million metric tons of carbon dioxide equivalent. Therefore, SB 20-038 could potentially reduce greenhouse gas emissions in the transportation-related sector by about 0.4 percent in 2030, which represents a 0.1 percent decrease in total projected statewide greenhouse gas emissions in 2030.

[8] U.S. Energy Information Administration. Annual Energy Outlook.
[9] Diesel fuel consumption does not vary significantly from month to month, so it is assumed that 3.5/12 of annual diesel consumption occurs from June 1 through September 15.

Limitations and other considerations

This greenhouse gas emissions assessment does not take into consideration the amount of diesel that would be exempted from the blending requirements under the waiver process. Depending on the amount of diesel sold or offered for sale by exempted distributors and retailers of diesel fuel, the emissions savings calculated here may be reduced. The analysis assumes that there are no disruptions in biodiesel supply, and that prices are not impacted significantly to cause a change in demand for diesel fuel in Colorado. The analysis also assumes the same proportion of biodiesel feedstock (e.g. 54 percent soybean oil, etc.) going forward. Any changes to feedstock inputs to biodiesel may impact the greenhouse gas emissions assessment.

Pursuant to Section 2-2-322.3, C.R.S, this emissions assessment addresses the direct impacts SB20-038 is likely to cause on greenhouse gas emissions. The combustion of biodiesel can also impact emissions of other air pollutants such as particulate matter (PM), carbon monoxide (CO), total hydrocarbons (THC), and oxides of nitrogen (NOx). Studies have generally found that hydrocarbons, particulate matter, and carbon monoxide are reduced in biodiesel, but the impacts on NOx emissions have been less clear. Some studies have found that, under certain circumstances, primarily older, heavy duty engines at higher biodiesel blends, NOx emissions from biodiesel can increase compared to petroleum diesel. NOx, along with volatile organic compounds, is a precursor to ozone, a harmful air pollutant with negative health and environmental effects.

Discussion of amendments to SB20-038

This analysis has been written to the introduced bill. However, as of the date of this report, amendments have been adopted by the Senate that may impact the greenhouse gas emissions in a number of ways. The discussion below addresses two amendments incorporated into the reengrossed bill, specifically L.002 and L.006.

Nonattainment areas (L.002). As amended, diesel fuel in Colorado is only required to contain a minimum percentage of biodiesel if sold or offered for sale within a nonattainment area, limiting the previous statewide requirement. Therefore, the greenhouse gas emissions savings will be reduced depending on the quantity of diesel fuel sold or offered for sale in attainment versus nonattainment areas.

Renewable diesel (L.002). As amended, SB20-038 would also allow diesel fuel to be blended with renewable diesel. Renewable diesel is produced using many of the same feedstocks as used for biodiesel, but production processes vary. Under the RFS, renewable diesel must also meet a 50 percent reduction in greenhouse gas emissions compared to traditional diesel, and therefore the emissions savings of renewable diesel are assumed to be similar to biodiesel.

End user exemptions (L.006). As amended, locomotives and off-road mining equipment are exempted from the biodiesel blending requirements. According to the U.S. EIA, railroad consumers accounted for approximately 9 percent of diesel sales from 2015-2017. Exempting this quantity of diesel fuel from biodiesel-blend requirements would therefore reduce the greenhouse gas emissions by a similar percentage.

Data Sources and Agencies Contacted

U.S. Energy Information Administration
U.S. Environmental Protection Agency
Colorado Department of Public Health and Environment
Colorado Department of Labor and Employment
National Renewable Energy Laboratory

Glossary of Terms

Greenhouse Gas. Greenhouse gases are atmospheric gases that trap heat and contribute to global warming and climate change. The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Less prevalent, but highly potent greenhouse gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These gases are often times aggregated based on the total carbon dioxide equivalent (CO_2e).

Emissions factor. An emissions factor is the average emissions rate of a given greenhouse gas for a given source, relative to units of activity. For example, greenhouse gas emissions from electric power production are based on the fuel-specific (e.g., coal, natural gas, etc.) carbon content per British thermal unit (Btu), a measure of the heat content of fuels. By multiplying fuel consumption (e.g., Btu) by its emissions factor (e.g., pounds of carbon per Btu), greenhouse gas emissions can be quantified.

Emissions sectors. Greenhouse gas emissions reports analyze the impacts on emissions across a number of sectors, as defined in the Colorado Greenhouse Gas Inventory[10]. Each emissions sector is defined in the table below.

Carbon sequestration. Carbon sequestration refers to the removal and long-term storage of carbon dioxide from the atmosphere. Biological carbon sequestration occurs when trees, grasses, and other plants take up carbon dioxide through photosynthesis and store carbon in biomass (e.g., tree trunks, foliage, and roots).

Life-cycle analysis. Life-cycle analyses, or life-cycle assessments (LCA) are tools that can be used to evaluate the potential environmental impacts of a product or activity. LCAs are comprehensive in that they consider the full life cycle of a product or activity, from materials acquisition (e.g. resource extraction) to processing, manufacturing transportation, end-use and disposal. The key materials and processes included in an LCA are defined within a systems boundary, which clearly identifies each stage of the product or activity included in the analysis.

[10] The Colorado Greenhouse Gas Inventory, developed by the Colorado Department of Public Health and Environment, utilizes the U.S. Environmental Protection Agency's State Inventory Tool modules, developed for the individual emissions sectors identified above. These emissions sectors align with the source categories defined in the IPCC Guidelines for National Greenhouse Gas Inventories.

Table 4
Emissions Sectors and Description

Emissions Sector	Description
Electric Power	The electric power sector generates, transmits, and distributes electricity to residential, commercial, and industrial end users.
Transportation	The transportation sector includes combustion emissions from all motorized vehicles for on-highway and off-highway (e.g. boats, aircraft) use of transporting people and/or goods.
Residential, Commercial, and Industrial Fuel Use	Fuel use includes the combustion of fuels in residential, commercial, and industrial sectors for heating and various commercial purposes. Industrial fuel use also includes fossil fuels used for non-combustion purposes, such as in the production of lubricants, solvents, and as feedstocks for asphalt and road oil.
Natural Gas and Oil Systems	The natural gas and oil systems sector includes the extraction, processing, transportation, and distribution of natural gas and oil.
Coal Mining and Abandoned Mines	The mining sector includes active and abandoned surface and underground coal mines, as well as the processing, transportation, and storage of coal.
Agriculture	The agriculture sector includes emissions from livestock and crop production activities, including enteric fermentation, manure management, agricultural soil management, and agricultural residue burning.
Industrial Processes	Industrial processes include the manufacturing of products such as steel, cement, aluminum, lime, soda ash, and nitric acid. Greenhouse gases are emitted as byproducts of non-energy related industrial activities, or due to their use in manufacturing processes or by end-consumers.
Land Use, Land Use Change, and Forestry	This sector accounts for the greenhouse gas fluxes (e.g., net emissions or sequestration of carbon) from land use and land use change within and between all land use types including forest land, cropland, grassland, wetlands, and settlements.
Waste Management	Waste management includes municipal solid waste and industrial waste that is landfilled, as well as the industrial treatment of wastewater.

Source: Compiled by Legislative Council Staff from EPA's State Inventory Tool and CDPHE's Greenhouse Gas Inventory Report.

Additional information. For a full glossary of terms commonly used in greenhouse gas emissions reports, please refer to the Greenhouse Gas Emissions Report Overview memo, available at https://leg.colorado.gov/agencies/legislative-council-staff/greenhouse-gas-emissions-reports.