Washington Department of Ecology

Clean Fuel Standard Cost Benefit Analysis Report

May 12, 2022

BRG | ENERGY & CLIMATE

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Definitions

Fuel	Description
Biodiesel	A motor vehicle fuel consisting of mono-alkyl esters of long chain fatty acids derived from vegetable oils, animal fats, or other nonpetroleum resources, not including palm oil, designated as B100 and complying with ASTM D6751.
Biofuel	A transportation fuel derived from non-petroleum, biogenic renewable sources.
Biomass-Based Diesel	A diesel or diesel blendstock derived from biogenic renewable sources, jointly encompassing biodiesel and renewable diesel.
Consumer Diesel	The diesel mix used by the average Washington consumer in a given year of the analysis, accounting for blended biofuels in that year and scenario.
Consumer Gasoline	The gasoline mix used by the average Washington consumer in a given year of the analysis, accounting for blended biofuels in that year and scenario.
Diesel	Either: (a) A light middle distillate or middle distillate fuel suitable for compression ignition engines blended with not more than 5 volume percent biodiesel and conforming to the specifications of ASTM D975 or; (b) A light middle distillate or middle distillate fuel blended with at least 5 and not more than 20 volume percent biodiesel suitable for compression ignition engines conforming to the specifications of ASTM D7467.
Energy Economy Ratio	The dimensionless value that represents the efficiency of a fuel as used in a powertrain as compared to a reference fuel used in the same powertrain.
Ethanol	Nominally anhydrous ethyl alcohol meeting ASTM D 4806 standards. It is intended to be blended with gasoline for use as a fuel in a spark-ignition internal combustion engine. Before it is blended with gasoline, the denatured fuel ethanol is first made unfit for drinking by the addition of substances approved by the Alcohol and Tobacco Tax and Trade Bureau.
Fossil Diesel	Also referred to as “clear diesel”, means a light middle or middle distillate grade diesel fuel derived from crude oil that has not been blended with a renewable fuel.
Renewable Diesel	Means a diesel fuel that is produced from non-petroleum renewable resources but is not a monoalkylester and which is registered as a motor vehicle fuel or fuel additive under Title 40, part 79 of the Code of Federal Regulations. This includes the renewable portion of a diesel fuel derived from co-processing biomass with a petroleum feedstock.
Sustainable Aviation Fuel	Biofuel used for aircraft operations
Unblended Gasoline	Also known as “clear gasoline”, means gasoline derived from crude oil that has not been blended with a renewable fuel.

Table of Abbreviations

Acronym	Expansion
ACT	Advanced Clean Truck
AEO	Annual Energy Outlook
ATB	Annual Technology Baseline
BBD	Biomass-Based Diesel
BTC	Blender's Tax Credit
CETA	Clean Energy Transportation Act
CFP	Clean Fuels Program
CFS	Clean Fuel Standard
CI	Carbon Intensity
CNG	Compressed Natural Gas
CPP	Clean Power Plan
CSAPR	Cross-State Air Pollution Rule
DOE	Department of Energy
DOL	Department of Labor
EIA	Energy Information Administration
EER	Energy Economy Ratio
EPA	Environmental Protection Agency
EV	Electric Vehicle
GHG	Greenhouse Gas
GGE	Gallon of Gasoline Equivalent
IWG	Interagency Working Group on Social Cost of Greenhouse Gases

JEDI	Jobs and Economic Development Impact
LCFS	Low Carbon Fuel Standard
MJ	Mega Joule
MMT	Million Metric Tons
MSW	Municipal Solid Waste
MTCO2e	Metric Ton of Carbon Dioxide-Equivalent
NAAQS	National Ambient Air Quality Standards
NREL	National Renewable Energy Laboratory
PM	Particulate Matter
PUD	Public Utility Districts
RFS	Renewable Fuel Standard
RIN	Renewable Identification Numbers
RNG	Renewable Natural Gas
RVO	Renewable Volume Obligation
SAF	Sustainable Aviation Fuels
SCC	Social Cost of Carbon
VMT	Vehicle Miles Traveled
ZEV	Zero Emissions Vehicle

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Executive Summary

This report summarizes BRG's findings on the costs and benefits of the Washington Clean Fuel Standard ("CFS"), a policy adopted by the Washington State Legislature to reduce the carbon intensity ("CI") of Washington's transportation fuels 20% by 2038[1], with interim targets beginning in 2023. CI reflects the carbon dioxide emissions per unit of fuel energy consumed. The CFS sets a target CI for transportation sector consumption of gasoline and diesel (and their substitutes) in each year. Providers of fuels with a CI above the target threshold generate deficits and have an obligation to purchase credits from providers of fuels with a CI below the target. Both credit generation and deficit generation are a function of the CI of a given fuel. Credits can be banked and used in future years, and a certain number of non-fuel related credits are also available under certain conditions, as will be discussed in the body of this report.

This analysis makes numerous assumptions, outlined in detail in this report, but generally utilizes price forecasts, models, and data from US government and other public sources. The five most noteworthy policy assumptions driving results are:

1. Washington adopts a Zero Emissions Vehicle ("ZEV") mandate requiring all new cars and light duty trucks sold in the state to be zero-emissions vehicles by 2035, and drivers comply with this requirement.
2. Washington adopts California's Advanced Clean Truck ("ACT") rule, requiring 40-75% of medium and heavy-duty vehicle sales to be zero emissions by 2035, depending on vehicle class.
3. The federal Renewable Fuels Standard ("RFS") remains in place in a form substantially similar in effect to the current policy.
4. Existing state and provincial CFS policies in other jurisdictions do not differ dramatically from their current form, and as such the market for alternative fuels is not substantially disrupted by changes to those markets.
5. Washington achieves a 100% greenhouse gas ("GHG") neutral and 80% clean electricity sector by 2030, as required by the Washington Clean Energy Transformation Act ("CETA").

The impact of each of these assumptions is discussed further in the report. The first two assumptions underpin much of the vehicle electrification and hydrogen vehicle adoption that generates many of the credits to meet compliance with the CFS. The third and fourth assumptions support the economics, market, and prices for many of the biofuels used for compliance. The fifth assumption underpins the carbon intensity for electricity, a key fuel for compliance, falling to zero emissions beginning in 2030.

[1] Transportation fuels covered under the program include on-road gasoline and diesel. Emissions from jet fuel, marine fuel, and ferry boats are not included under the program limits but certain uncovered entities may opt into the program if they desire.

Washington's vehicle fleet changes significantly from 2023-2038 due to the ZEV mandate and ACT rule, resulting in a notable increase in electric vehicles as proportion of the overall statewide vehicle fleet. The increase in ZEV penetration has a significant impact on the compliance pathways and the attributable cost of the CFS program, as ZEV vehicles generate credits under the CFS program in all modeled years.

In each of the compliance scenarios, consumer prices for gasoline and diesel increase while prices for lower-carbon fuels decrease as a result of the policy. Under the *Least Cost* scenario, one of the key policy scenarios studied in this report, consumer gasoline and diesel prices show little impact from the CFS in 2023 and rise by $0.19 (2020$) per gallon of gasoline equivalent ("GGE") for gasoline and $0.17 (2020$) per GGE for diesel by 2031, relative to the baseline fuel price forecast. Price impacts decline in 2034 through the end of the program. These patterns reflect a premium paid by consumers in the early years to substitute lower-CI biofuels and other clean fuels before the ZEV mandate and ACT rule begin to account for a larger share of annual credits generated under the CFS. The cost of electricity (and other low-CI fuels) for consumers is reduced by the CFS, as revenue from the sale of credits to higher-CI fuel suppliers reduce the cost of providing the low carbon fuels needed to achieve compliance. This effect helps to reduce the consumer cost of adoption of the ZEV mandate and ACT rule and provides funding for infrastructure to support these policies.

This report also quantifies the environmental, health, and employment impacts of the policy. While disentangling these effects from those of the ZEV mandate and ACT rule is challenging, these effects are explored in detail in the body below.

1. Introduction

In July 2021, the Washington Legislature adopted the Clean Fuel Standard ("CFS"), implemented by the Transportation Fuel-Clean Fuels Program (E3SHB 1091) in order to reduce carbon pollution from the transportation sector and help achieve the state's greenhouse gas ("GHG") emissions limits. The CFS requires a 20% gradual reduction from 2017 levels in the carbon intensity ("CI") of transportation fuels over a 16-year period (2023-2038). The program requires a 2-year pause in CI percentage reductions in 2032 and 2033 to review the efficacy of the program.[2] After this period, the Department of Ecology ("Ecology) has statutory authority to set the annual carbon intensity reduction standard. Through these measures, Washington looks to cut statewide GHG emissions by 4.3 million metric tons annually ("MMT") by 2038. **Table 1** shows the default annual CI percentage reduction targets modeled in this report. Because Ecology has discretion after 2034 to require emissions reductions on a different cadence, the Accelerated Reduction Scenario considers a faster pace of CI reduction, namely an immediate 10% reduction in the annual target in 2034, with no further incremental reductions from 2035-2038.

Table 1: Annual Carbon Intensity Percentage Reduction Targets

Year	Percent Reduction	Gasoline & Substitutes	Diesel & Substitutes
Baseline	0.0%	98.59	100.02
2023	0.5%	98.10	99.52
2024	1.0%	97.60	99.02
2025	2.0%	96.62	98.02
2026	3.0%	95.63	97.02
2027	4.0%	94.65	96.02
2028	5.5%	93.17	94.52
2029	7.0%	91.69	93.02
2030	8.5%	90.21	91.52
2031	10.0%	88.73	90.02
2032	10.0%	88.73	90.02
2033	10.0%	88.73	90.02
2034	12.0%	86.76	88.02
2035	14.0%	84.79	86.02
2036	16.0%	82.82	84.02
2037	18.0%	80.84	82.02
2038	20.0%	78.87	80.02

[2] Among other measures, the CFS requires a 15% net increase in the production volume of in-state liquid biofuel, and at least 1 new or expanded biofuel production facility representing an increase in production capacity of 60 million gallons of biofuels before reducing the carbon intensity standards beyond 10 percent. For the purpose of this study, it is assumed that these requirements are met by the statutory deadlines.

CFS Credit Rules

Ecology sets carbon intensity reduction standards under the CFS based on the 2017 carbon intensity of gasoline/diesel and their substitutes. Fuels with CI values in excess of the annual standard generate deficits and fuels with CI values below the annual standard generate credits. At the end of each compliance year, deficit holders must retire a number of credits equal to their deficit balance. In addition to satisfying compliance obligations, credits can be traded to other entities to help meet their compliance requirements.

Besides supplying fuels with lower CI, credits may be generated from activities that support the reduction of GHG emissions associated with transportation, including:

1. Carbon capture and storage projects for oil production facilities and refineries
2. Direct air capture projects
3. Investments and activities that support deployment of machinery and equipment used to produce gaseous and liquid fuels from non-fossil feedstocks, and derivatives thereof
4. Fueling of battery or fuel cell electric vehicles (“EVs”)

The following activities can generate up to a maximum of 10% of the total program credits[3]:

1. 5% of total credits can be generated from investments in alternative fuel infrastructure projects (for example building EV charging and building hydrogen fueling stations)
2. 5% of total credits can be state transportation investments funded in an omnibus transportation appropriations act (for example the electrification of the state ferry fleet, alternative fuel vehicle rebate programs, etc.)

Credit-generating activities also include investments in alternative transit, bike and pedestrian programs, and complete streets/safe walking programs.

Credits generated can be traded and/or banked for future compliance periods. For the purpose of this study, it is assumed that state transportation investments generate advance credits when a vehicle or investment is put into service, which must be paid back over nine years.

[3] The law requires Ecology to set limits to the credit generating activities listed here, with state transportation investment funded programs/projects required to be limited to 10%.

Purpose of the Report

The purpose of this report is to:

- Quantify the costs or cost savings per gallon-equivalent of each class of fuel attributable to the Clean Fuel Standard (Section 5)
- Quantify the costs or cost savings per vehicle mile traveled attributable to the Clean Fuel Standard (Section 5)
- Quantify the additional value in greenhouse gas emission reductions (incorporating the social cost of carbon) and the health benefits from reduced criteria pollutants attributable to the Clean Fuel Standard (Section 6)
- Quantify the positive, negative, and transitioned employment impacts attributable to the Clean Fuel standard. (Section 7)

This report also states key assumptions and drivers of uncertainty in the calculations and analysis and potential impacts or implications of changing assumptions on key findings.

Fuel Pathways to be considered

The fuels listed in **Table 2** are considered in this report as the primary vehicle fuels for Washington. For each of these fuels, this report includes a forecast of:

- the cost or cost savings per gallon-equivalent attributable to the Clean Fuel Standard,
- the cost or cost savings per mile traveled for vehicles powered by each of the fuels,
- the overall consumption of the fuel in the state fuel mix, and
- the proportion of vehicles in the state vehicle mix which consume each fuel.

Table 2: Major Potential Vehicle Fuels and their Feedstock

Fuel	Feedstock
Gasoline	Petroleum
Diesel	Petroleum
Propane	Natural Gas Liquids, Petroleum
Ethanol	Corn
Biodiesel	Soybean, Canola, Fats Oils and Grease
Renewable Naphtha	Soybean, Canola, Fats Oils and Grease
Fossil Natural Gas	Natural gas

Renewable Natural Gas	Landfill Gas, Wastewater Treatment Plants, Municipal Solid Waste, Dairy Operations, Food Digesters[4]
Renewable Propane	Soybean, Canola, Fats Oils and Grease
Renewable Diesel	Soybean, Canola, Fats Oils and Grease, Milling and Logging residue
Electricity	Washington grid mix
Hydrogen (Grey and Green)	Natural gas and electricity
Sustainable Aviation Fuel (as Opt-In)	Milling and Logging residue

Summary of the Approach

BRG employed multiple methodologies to model and assess the impact of the CFS program on consumers, fuel prices, environmental benefits, health benefits, and net jobs impacts. Data from multiple sources was used to forecast fuel prices, vehicle fuel economy, fleet turnover, emissions, and pollutant concentration. Many of these different sources and approaches were ultimately utilized in the calculation of the impact of the CFS program on consumers. Wherever possible and appropriate, BRG modified and benchmarked model input assumptions to reflect Washington's transportation sector characteristics. Section 3 includes a detailed discussion of the modeling approach and methodologies used.

[4] Washington State recently passed HB 1663, which sets methane emission capture requirements for solid waste landfills for use of power generation or distribution of RNG. While this law was passed in the 2022 legislative session and may have impacts on the production of RNG, the impacts of the law are still uncertain as it moves through the regulatory process and any assumptions based on the law at this stage would be speculative. Therefore, we consider it outside the scope of this analysis.

2. Baseline Assumptions for the Future of Washington's Transportation Sector

Overview of Baseline Methodology

To assess the value of the CFS, the modeled CFS implementation scenarios are compared to a Baseline case where the CFS program is not in place. Costs, benefits, and other impacts of the policy can be determined after considering the relevant state, federal, and international policies that influence Washington's transportation sector through the program period. Current forecasts for in-place infrastructure costs, technology costs, and fuel costs reflect the best estimates of future costs. This section outlines the major policy, pricing, vehicle fleet, and other assumptions that set the Baseline for evaluating the CFS and discusses key methodological processes used throughout the analysis.

Major Policy Assumptions Relied Upon

State and Provincial Policy

This analysis assumes the CFS programs of California, Oregon, British Columbia, and Canada are in place throughout the lifetime of Washington's CFS program. Their targets are as follows:

- California's Low Carbon Fuel Standard program targets a 20% reduction in CI per unit of fuel by 2030, based on 2010 levels.
- Oregon's Clean Fuels Program targets a 25% reduction in CI per unit of fuel by 2035, based on 2015 levels[5].
- British Columbia's Clean Fuel Standard program targets a 20% reduction in CI per unit of fuel by 2035, based on 2010 levels.
- Canada's Clean Fuel Standard program targets a 13% reduction in CI per unit of fuel by 2030, based on 2016 levels.

CFS programs support consumption of renewable fuels to generate credits and reduce average CI for transportation fuels. Renewable fuels are tradeable across state and provincial borders, leading to competition for fuel and feedstocks and, over time, likely causing a significant degree of convergence in CFS credit prices as marginal fuel sources "choose" which market to serve. The expansion of these programs over time[6] has boosted returns for innovation and technology in fuel decarbonization which can lead to falling fuel costs for consumers as new, cheaper, fuel products become available. While this latter effect is not formally considered in our modeling, it may make deeper decarbonization of the transportation sector possible.

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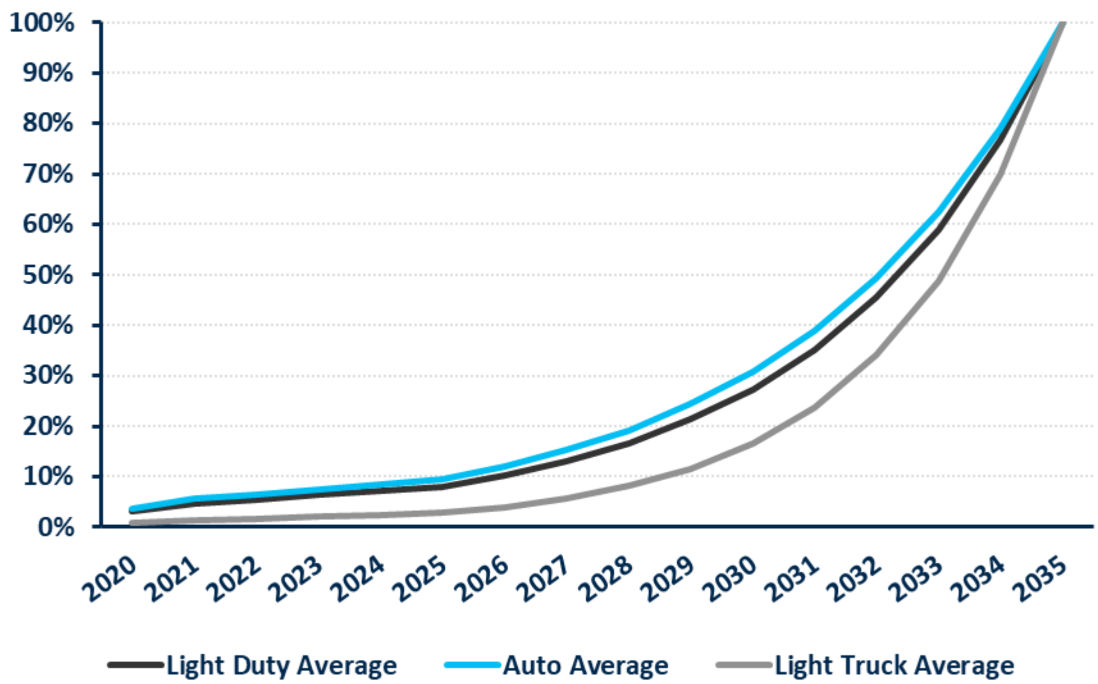
[5] Oregon is considering extending and increasing the CFP targets to 20% below 2015 levels by 2030 and 37% below 2015 levels by 2035.
[6] California's LCFS program, the oldest in the US, took effect in 2011, and Oregon's CFP took effect in 2016.

Several other Washington and federal policies are complementary to the goals of the CFS and will help defray some costs and ensure that certain benefits of the CFS will occur even absent the policy.

In the Baseline case, the analysis assumes that Washington finalizes a Zero Emission Vehicle mandate ("ZEV mandate") reflecting California's ZEV policy[7], which requires 100 percent of new passenger vehicles and light-duty trucks sold in the state to be zero-emissions vehicles (ZEVs) by 2035.[8] While no interim targets are incorporated in this assumption, the analysis assumes a reasonable trajectory to achieve the targets, outlined in **Figure 1**. In an illustrative scenario, the analysis evaluates the impact of pending legislation in Washington to require 100 percent of new passenger vehicles sold to be ZEVs by 2030.

Figure 1: Assumed Interim Targets for ZEV Mandate (Percent of New Vehicle Sales)



Annual ZEV sales targets represent a straight-line growth of ZEV sales in the state from 2021 rates, increasing to 8% on an average basis for light-duty vehicles by 2025. After 2025, new auto and light truck sales grow exponentially until reaching the 100% target in 2035. Light truck sales rates lag auto sales throughout the forecast until 2025, given a lower starting point. The ZEV mandate applies only to sales

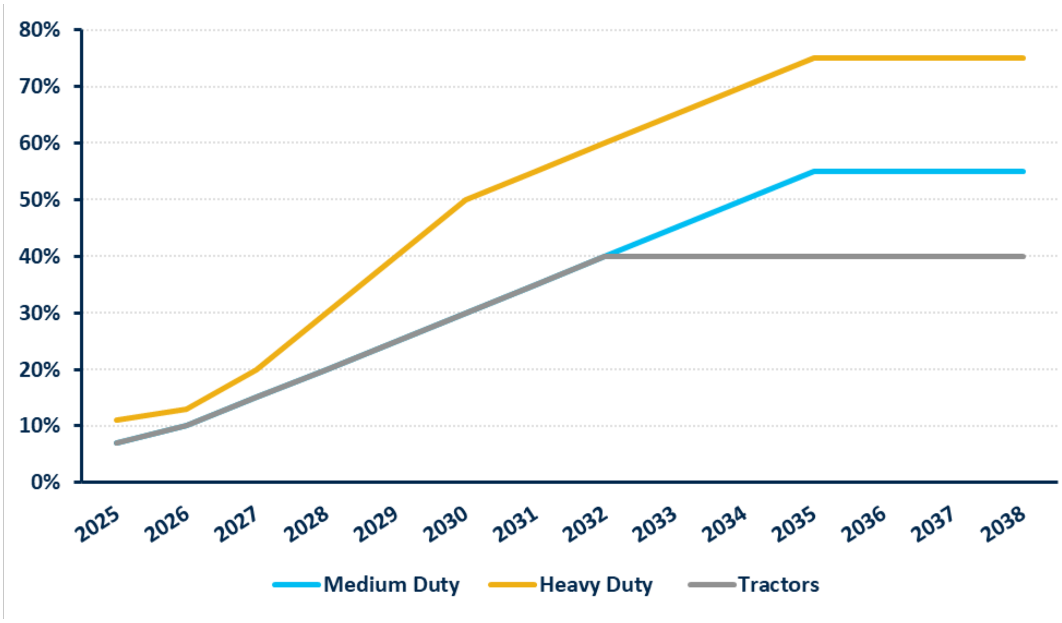
[7] Governor Gavin Newsom, 2020 executive order (N-79-20)

[8] Under RCW 70A.30.010 the Department of Ecology is directed to adopt California's motor vehicle emissions standards, including the Zero Emission Vehicle program.

of new vehicles, and the percentage of ZEV vehicles on the road in any given year over the forecast is therefore lower than the percentage of new vehicles sold in that year.

The state legislature adopted California's Advanced Clean Trucks standard for new medium and heavy duty-vehicle sales starting with model year 2025.[9] Our analysis assumes compliance with this standard in the Baseline case and in all scenarios. The sales percentages are presented in **Figure 2.** For medium-duty trucks, sales for compliance with the policy are assumed to be electric, while heavy duty truck sales are assumed to comprise of half-electric and half green hydrogen trucks in the Baseline and all scenarios. Both electricity and green hydrogen have a CI score of zero after 2030, and as such this difference does not materially impact CFS compliance in the scenarios.

Figure 2: Sales Percentages for Medium and Heavy-Duty Vehicles under California's Advanced Clean Truck Rule



US Federal Policy

The analysis assumes the Environmental Protection Agency will continue to set annual biofuel blending requirements for the Federal Renewable Fuel Standard Policy ("RFS") throughout the CFS program period. The RFS is a federal policy that requires a specific volume of renewable fuel to replace or reduce the amount of petroleum-based transportation fuel. Under the RFS, refiners or importers of gasoline or diesel fuel are required to meet an annual Renewable Volume Obligation ("RVO") by blending renewable fuels into transportation fuel, generating credits ("Renewable Identification Numbers, or RINS"), or by purchasing excess credits from fuel blending entities. Renewable fuels fall into four RIN buckets, D3, D4, D5, and D6, based on the feedstock used, fuel type produced, energy inputs and GHG

[9] RCW 34.05.320

reduction thresholds. Fuel retailers generate RINS by blending the fuels in **Table 3** with either petroleum-based gasoline or diesel.

Table 3: Renewable Fuels Regulated Under RFS

Category # and Type	Example Fuels
D3: Cellulosic Biofuel	Ethanol made from cellulosic material such as corn stover, biogas ("RNG"), wood chips. To be blended with gasoline.
D4: Biomass-based Diesel	Diesel made from Fats, Oils and Grease from soybeans, canola, waste, or animals. To be blended with diesel.
D5: Advanced Biofuel	Ethanol, renewable naphtha, or other biofuels made from sugarcane. To be blended with gasoline.
D6: Renewable Fuel	Ethanol made from corn. To be blended with gasoline.

The EPA sets blending requirements based upon statutory targets and the Agency's estimates of domestic biofuel production capacity. In practice, the EPA characteristically sets blending requirements for non-ethanol biofuels below statutory requirements, in recognition of a domestic productive capacity that cannot achieve the blending targets in the RFS statute.

The four RIN requirements are nested, meaning fuel with a higher GHG threshold can count towards the compliance of fuel with lower GHG reduction thresholds. This increases the value of D3 and D4 RINS due to their fungibility with and application towards less advanced RVO standards (D5 and D6 RVO standards).

For D3 RINS, the EPA provides additional flexibility in the form of waiver credits, which obligated parties can purchase to pair with a D5 RIN in lieu of blending D3 fuel or purchasing D3 RINS. We assume the D3 waiver credits offered by the Environmental Protection Agency ("EPA") remain in place and at a high price level of approximately $1.80/gallon.

The EPA has not sought to use its waiver authority for Biomass-Based Diesel ("BBD"), consistently setting BBD blending volumes at the statutory maximum level, thereby supporting D4 RIN prices. For 2022, EPA has proposed an additional 250 million gallon blending requirement for BBD, noting that productive capacity and blending capacity for the fuel accommodates a higher RVO than is required in statute. Historical and sustained support for BBD blending will likely continue to support D4 RIN prices.

The analysis does not take a position on the extension of the Blender's Tax Credit ("BTC") but assumes that the expiration of the tax credit would be offset by a proportional increase in D4 RIN prices. This is believed to be a reasonable assumption given that renewable volume obligations under the RFS are set based upon the market's capacity to supply biofuels, and that RIN prices fluctuate based upon the economic requirements of biofuel producers.

Subjective Impacts of Assumptions

A summary of the subjective impact of the major policy assumptions is shown in **Table 4** below.

Table 4. Subjective Impact of Major Policy Assumptions[10]

Policy	Qualitative Significance	Nature of Impact
ZEV Mandate	High	This is an alternative clean transportation policy produces significant credit generation and compliance with CFS
ACT Rule	High	This is an alternative clean transportation policy produces significant credit generation and compliance with CFS.
RFS	Moderately High	Alternative remuneration mechanism for biofuel producers that influences the cost of production for marginal price setting fuels like biodiesel and renewable diesel and supports the economic viability of transportation-sector RNG and Baseline ethanol blending.
Neighboring LCFS Policies	Moderate	The analysis assumes that markets are efficient and thus that biofuel producers receive and accept equivalent compensation for fuel in all markets with CFS/LCFS programs, that is that compensation after credits is comparable across the markets.
CETA	Low	The analysis assumes that Washington's relatively low electric sector carbon intensity declines further to reflect the further decarbonization of power supplies. Due to economic factors, age of fossil assets, and other factors, it is likely that Washington's carbon intensity would decline absent CETA goals, though it is not possible to forecast by how much. The low starting point limits the impact of this assumption.

Overview of the VISION Model

VISION is a Microsoft Excel-based model developed by Argonne National Laboratory in conjunction with the U.S. Department of Energy (DOE) to estimate the energy, fuel use, and associated emissions of light-duty, medium-duty, and heavy-duty vehicles. The model offers a variety of alternative fuels and vehicle technologies to forecast the impact of different scenarios on fuel consumption and emissions. VISION uses vehicle survival estimations and age-dependent usage characteristics to calculate energy use by specified vehicle technologies and fuel types. VISION's base case projections rely upon inputs from sources including the Energy Information Administration's (EIA) Annual Energy Outlook (AEO), the U.S. Census Bureau, and the Transportation Energy Databook and other Federal data projections. These sources feed into the model's input parameters.

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[10] Table 4 reflects the opinion of the authors as informed by their expertise. It is not intended to reflect a quantitative assessment of policy impacts, nor is it an exhaustive list of all baseline assumptions and their magnitude of impact to baseline or scenario modeling.

Key parameters include:

- Market penetration of vehicle technologies,
- fuel economy ratios,
- fuel types,
- vehicle miles travelled (VMT), and
- new vehicle sales.

Using these inputs, the model calculates total vehicle stock by type as well as the associated energy use for the fuels utilized by each vehicle type.

Baseline Vehicle Fleet and Fuel Consumption Modeling

To model the impact of the adoption of clean fuels and vehicle technologies, BRG first benchmarks a Baseline case in the VISION model to reflect the characteristics of the Washington vehicle fleet. Washington-specific adjustments for the model include new vehicle sales, vehicle stock, market penetration of vehicle types, as well as vehicle miles traveled and fuel consumption. The benchmarking applies actual Washington 2019 data for these categories[11] to first benchmark the historical data and then relies on the annual percentage change forecast by VISION to project the rate of change in fuel consumption in Washington through 2038.

To calculate the number of new vehicles sold in Washington, BRG applies VISION's default projection of national new vehicle sales and prorates these sales to calculate the number of new vehicle sales within Washington. Sales are then split proportionally across the vehicle types in Washington's vehicle stock to calculate the number of new sales of each vehicle type modeled.

Using the VISION model's calculations of new vehicle sales combined with stock data specific to Washington, BRG estimates new vehicle sales in Washington for each vehicle type modeled. The VISION model calculates the surviving vehicle stock for each year. These calculations account for the vehicle attrition rate as some vehicles leave the statewide fleet at the end of each year due to age, accidents, or other reasons. To correct for variations in VISION's vehicle stock calculations, this analysis applies a vehicle stock correction factor across each of the vehicle technologies to ensure the calculated vehicle stock reflects Washington's existing fleet characteristics.

This analysis updates the market penetration input assumptions for vehicle technology types to reflect the impact of Washington's ZEV mandate and Advanced Clean Trucks rule. These policies result in an

[11] Washington Department of Licensing; U.S. Energy Information Administration: Washington State Energy Profile; U.S. Energy Information Administration: Motor Gasoline Consumption, Price, and Expenditure Estimates; U.S. Energy Information Administration: Distillate Fuel Oil Consumption Estimates; U.S. Department of Energy: Alternative Fuels Data Center

accelerated pace of adoption for electric vehicles. Other vehicle types are proportionally reduced as ZEVs increase to maintain accurate vehicle stock projections.

Furthermore, this analysis adjusts the VISION model's calculation of vehicle miles travelled ("VMT") in Washington to ensure these calculations accurately depict the travel characteristics of Washington's vehicle fleet. BRG first calculates the VMT by vehicle type using available Washington specific data for 2019 and forecasts these values for Washington using the percentage change in the federal rate of VMT growth.[12]

Baseline Fuel Price Assumptions

The Baseline case fuel price forecasts for gasoline, diesel, ethanol, electricity, natural gas, and propane are based on the EIA's 2021 AEO Reference Case projections. The EIA is a statistical and analytical agency within the US Department of Energy which independently collects, monitors, analyzes, and publishes energy statistics. EIA is a widely accepted source of energy data and forecasts in the United States. The EIA publishes its long-term energy forecasts in the AEO, which covers energy usage, supply, and prices, among other metrics. These forecasts include various scenarios based on EIA demographic, technology, and production assumptions.

This analysis uses the AEO Reference case scenario for all AEO-derived forecasts in this study. While the AEO Reference case assumes reasonable improvement in energy production and technologies over the forecast period, it assumes no change in current laws and regulations affecting the energy sector and does not include potential impacts from proposed-but-not-enacted policies. In using the AEO as the basis for the Baseline case, this analysis assumes these prices to be a reasonable starting point from which to compare other scenarios.

Renewable diesel, biodiesel, renewable naphtha, and renewable propane price forecasts were estimated based on a calculated "green adder" to the AEO fossil price for each respective fuel. Green price adders were derived from fuel price data published in the Department of Energy Clean Cities Alternative Fuel Price report from 2016-2021 and using the implied California LCFS price premium based on 2020-2021 California credit volumes, credit prices, and CI benchmarks.

The renewable natural gas price forecast was derived using the AEO compressed natural gas ("CNG") price forecast plus the implied California LCFS price premium. The hydrogen price forecast is based on the VISION forecast which in turn is derived from DOE Alternative Fuel Price Reports.

[12] BRG identified a possible data entry issue in the VISION model for national level VMT data for cars and light trucks in 2018 and 2019, potentially related to changing travel behavior during the COVID-19 pandemic. To correct for this error, BRG applied the percent change of fuel consumption between gasoline and diesel vehicles to approximate the drop in VMT during 2020 and the rebound of VMT in the following year.

Green hydrogen was analyzed using both the VISION model and National Renewable Energy Laboratory ("NREL") Annual Technology Baseline ("ATB") dataset. The NREL ATB is a set of modeling assumptions for producing fuels from various technologies and pathways. This dataset includes capital and operating costs, revenues, fuel price, and productivity for each pathway, which are used to estimate the per-unit cost of production. The ATB and VISION both show that low yield of green hydrogen from high-cost processing render it economically unviable as a transport fuel in the state of Washington with current technology. To illustrate this finding, financial analysis derived from the ATB finds per-unit green hydrogen costs over $22 per GGE, which is generally not cost competitive with other fuels.

All prices in this report (and in **Table 5**) are shown in real 2020 dollars per GGE.

Table 5: Baseline Fuel Price Forecasts (2024-2038)

Fuel Price Forecasts *(2020$/GGE)*	2024	2026	2028	2030	2032	2034	2036	2038
Gasoline	$3.03	$3.21	$3.31	$3.82	$3.94	$3.98	$4.04	$4.10
Ethanol	$3.62	$3.84	$3.97	$4.53	$4.66	$4.72	$4.78	$4.87
Electricity	$5.49	$5.63	$5.64	$5.72	$5.79	$5.79	$5.76	$5.69
Hydrogen	$13.14	$12.36	$11.57	$10.79	$10.40	$10.00	$9.61	$9.22
Renewable Naphtha	$3.27	$3.41	$3.50	$3.89	$3.99	$4.02	$4.07	$4.12
Diesel	$3.12	$3.37	$3.47	$3.89	$4.00	$4.02	$4.04	$4.09
Biodiesel (B100)	$3.65	$3.89	$3.99	$4.41	$4.52	$4.54	$4.56	$4.62
Renewable Diesel	$4.10	$4.35	$4.45	$4.87	$4.98	$5.00	$5.02	$5.08
Natural Gas	$1.79	$1.75	$1.73	$2.07	$2.08	$2.06	$2.04	$2.02
RNG	$2.61	$2.58	$2.56	$2.90	$2.91	$2.89	$2.87	$2.85
Propane	$1.79	$1.87	$1.94	$2.31	$2.41	$2.45	$2.48	$2.52
Renewable Propane	$2.68	$2.76	$2.83	$3.21	$3.31	$3.34	$3.38	$3.41
Crude Oil	$1.27	$1.38	$1.48	$1.53	$1.60	$1.64	$1.68	$1.74

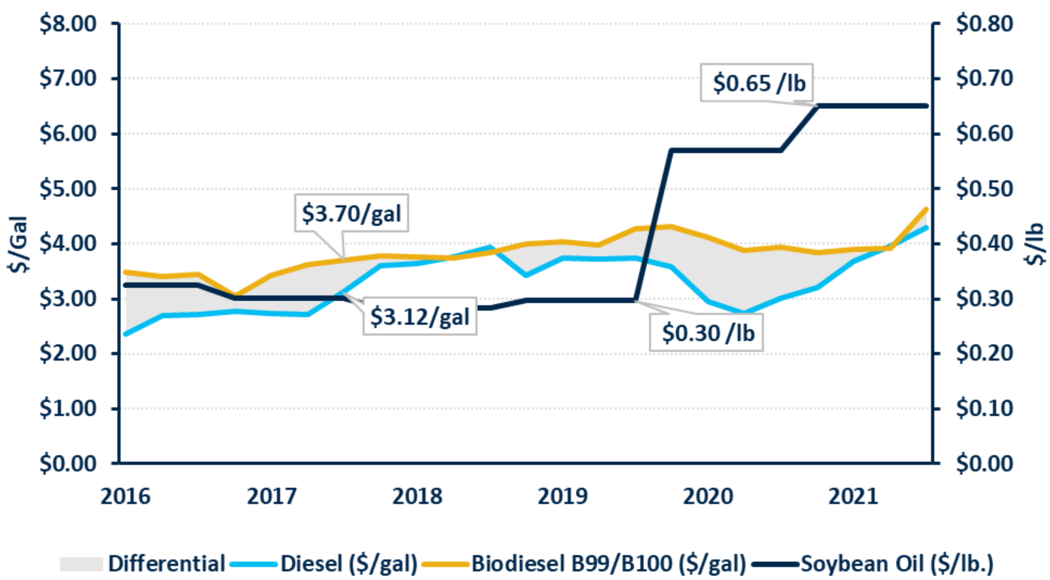
Baseline Biofuels Assumptions

Price forecasts for biodiesel and renewable diesel are estimated by calculating a "green adder" above the forecast price for diesel, using price reports from the US Department of Energy. This is a key assumption that has significant implications our analytical findings. BRG finds that in-state biodiesel and renewable diesel are both cost-competitive and abundant. Resultingly, these fuels are the marginal fuels for meeting CFS targets in many years across our modeled scenarios, thus the major driver of cost and price impacts of the policy for transportation fuels.

There is significant uncertainty surrounding future feedstock costs, particularly for vegetable and soybean oils. Current costs are high due to market volatility and supply limitations resulting from drought conditions and rising biofuel usage. It is likely that supply will equilibrate with demand over the long run, but in the short run, policy compliance costs will be driven by the relationship between feedstock costs and petroleum prices. BRG expects that D4 RINS will be responsive to the differential between feedstock and petroleum prices, partially abating the differential between prices for petroleum and green diesels. The RIN value is closely tied to the cost of producing the associated fuel and typically rises and falls with feedstock prices and other costs of fuel production.

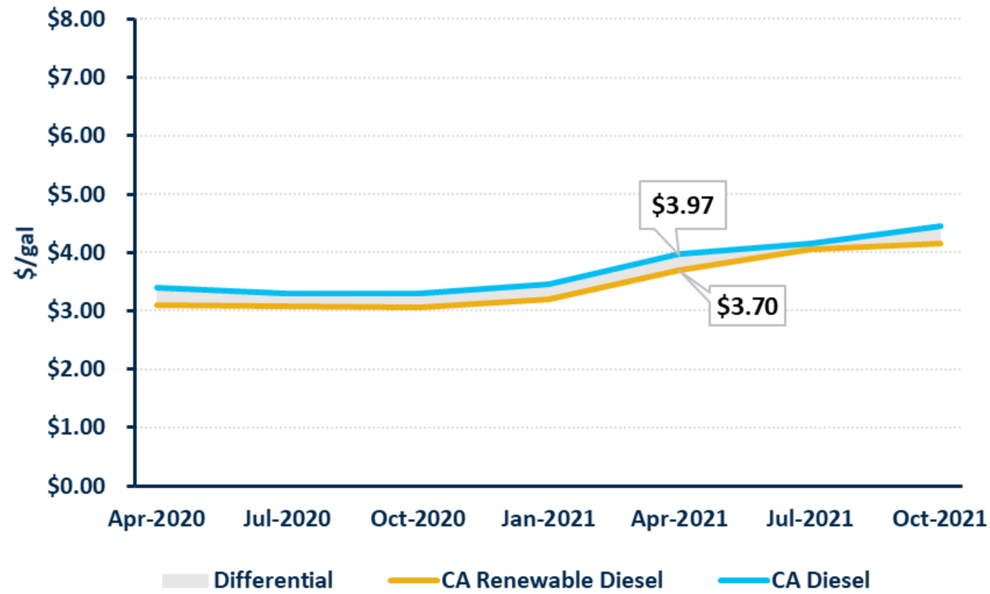
Despite a recent rise in soybean prices, the price differential between biodiesel and diesel has not been as volatile. The green premium is averaged and used as the basis for the biodiesel price adder. BRG believes this is reasonable due to history and the anticipated price behaviors discussed above.

Figure 3: Biodiesel Price Premium



Inflated feedstock prices have affected renewable diesel as well, but compensatory biodiesel price behaviors discussed above also hold true for renewable diesel. Using California market data published in the Alternative Fuel Price reports, BRG uses a similar methodology to calculate a renewable diesel green premium. Although renewable diesel prices have only been included in the report since 2020, the differential between the fuel and diesel has been stable over the reporting period, even as feedstock prices have risen. It is worth noting that renewable diesel prices as seen by consumers in California have consistently been slightly lower than traditional diesel prices, but when accounting for the value of California LCFS credits which are generated, the underlying cost of producing renewable diesel is still higher.

Figure 4: California Renewable Diesel Premium



Current Biofuel Production Capacity

Washington is a major producer of renewable fuels, with 112 million gallons of production capacity for biodiesel currently available.[13] Additionally, BP, a major Washington refiner, has announced that 109.2 million gallons of production capacity for renewable diesel will be available at its Cherry Point refinery in Whatcom County, Washington, in 2022.[14] The Baseline case assumes that this production is exported to neighboring states or provinces with clean fuel credit markets, with only a small proportion remaining to meet Washington's current 2.5% biodiesel blending needs on a volumetric basis.[15]

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[13] https://www.eia.gov/biofuels/biodiesel/production/

[14] https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-investing-almost-270m-to-improve-efficiency-reduce-emissions-and-grow-renewable-diesel-production-at-cherry-point-refinery.html

[15] This 2.5% figure is derived from Life Cycle Associates data, which is in turn derived from EIA data. It is assumed as a minimum biodiesel blend level in the baseline and all assumptions and illustrations.

3. Scenario Overview and Assumptions

Overview of Scenario Design

In addition to the Baseline case (discussed in Section 2), BRG analyzed several compliance scenarios to illustrate paths Washington could take to meet the CFS CI targets. The analysis considers consumer costs and benefits, health and employment impacts, and implications for fuel consumption associated with each compliance scenario.

For each scenario, compliance with the ZEV mandate and the Advanced Clean Truck standard drive a significant share of CFS compliance. This effect gets further support from the Washington Clean Energy Transformation Act (CETA), which requires the carbon intensity of Washington's electricity mix to reach net zero by 2030. Incremental clean fuels blending is required to meet the program targets, but the rate of blending is lower than would be required without the rapid pace of vehicle electrification. In discussion with the Department of Ecology, BRG prepared and analyzed several compliance scenarios. After conducting initial analysis, and in coordination with Ecology, BRG concluded that the collective impact of future transportation policies, including the CFS, and the aggregate market potential for clean fuels, are best modeled through two compliance scenarios and two illustrations. The two compliance scenarios reflect potential pathways for compliance with the CFS statute as it is currently written. The two illustrations reflect the impact of other possible decarbonization pathways under the CFS, but do not reflect the policy as it is currently being developed. The illustrations demonstrate the effect of more ambitious future vehicle electrification policies and explore Washington's maximum "carrying capacity" for clean fuels.

Throughout the scenario analysis it is explicitly assumed that both program costs and program savings are passed through to consumers in the form of higher or lower fuel prices. In other words, while fuel suppliers may have higher or lower profits due to changing patterns of fuel sale volumes, profit margins per unit of fuel sold are identical for producers and suppliers with or without the policy. This reflects conditions in a perfectly competitive market, which the Washington transportation fuels market is assumed to be for the purposes of this analysis.

The analysis also assumes that while Ecology does not adopt a price floor or price ceiling for CFS credits, credit prices naturally do not fall below $2/MT during any periods of long-term credit oversupply. This pattern has been observed in other markets for environmental compliance credits during periods of long-term oversupply, such as the US federal Cross-State Air Pollution Rule ("CSAPR") and reflects both transaction costs and the fact that many entities, even in oversupplied markets, will continue to purchase credits and would have to pay a nominal amount to cover transaction costs and incent holders of excess credits to sell.

All four scenarios assume that in each year 5% of compliance credits are generated by capacity credits, 5% are generated by state transportation investments as advance credits, and that 75 million gallons per year of sustainable aviation fuel are used in the state by 2028[16]. We assume that the providers of these fuels opt into the CFS program to generate credits. The advance credits are assumed to be paid back over a nine-year period reflecting current draft rulemaking for the CFS.

Compliance Scenarios

The first scenario, *Least Cost*, incorporates the utilization of a greater proportion of the in-state biodiesel and renewable diesel already produced in Washington (relative to the Baseline case) and a corresponding reduction in exports of these fuels to neighboring states and provinces. This scenario achieves the CI reduction targets of the policy (i.e. 20% by 2038, as shown in **Table 1**). Aside from the sizable infrastructure investments and vehicle turnover needed to meet the ZEV mandate and Advanced Clean Truck policy, this scenario requires relatively little capital investment or change in statewide vehicle stock to achieve CFS program compliance.

The second scenario, *Accelerated Reduction*, assumes that Ecology immediately reduces the carbon intensity target by 10% in 2034 (i.e. a 20% reduction from 2017 CI levels), and maintains the 20% reduction target for each year from 2034 through 2038 rather than phasing in reduced targets from 2034 to 2038. This represents faster decarbonization targets during the last few years of the standard and involves a higher blending of in-state biofuels for a longer period than the *Least Cost* scenario.

Illustrative Compliance Outcomes

In addition to the two scenarios, BRG prepared two illustrations of other possible compliance outcomes related to the CFS but that are outside Ecology's current regulatory authority. The first, the *Accelerated ZEV* illustration, assumes Washington achieves a legislatively-determined goal that all new passenger cars and light trucks sold in the state be ZEVs by 2030.[17] The pace of adoption (in terms of % of new vehicles sold which are electric) is shown in **Figure 5**.

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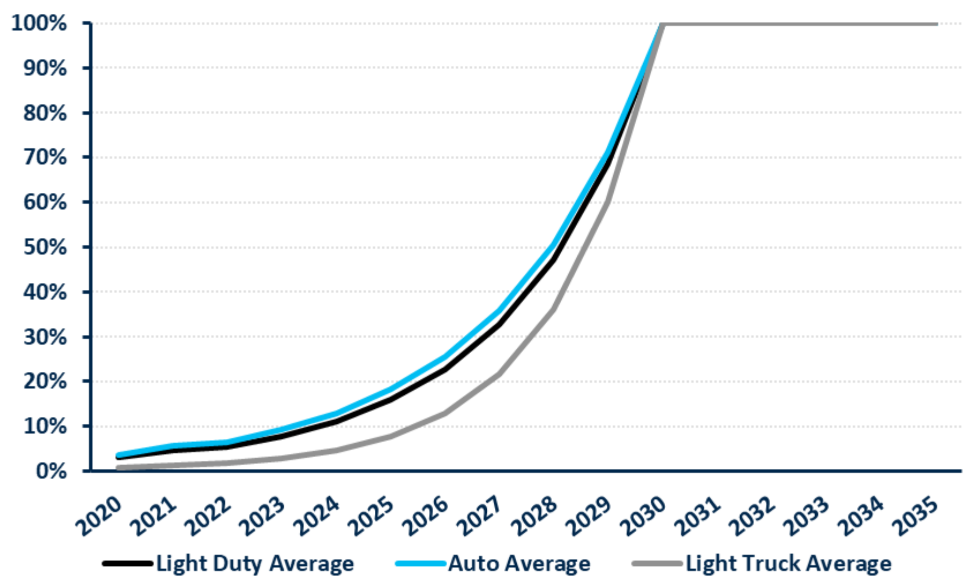
[16] This assumption represents the stated goals of the Port of Seattle Sustainable Aviation Fuel Policy. https://www.portseattle.org/sites/default/files/2020-07/PofSeattleWSU2019_final.pdf, p. 6.
[17] Ch. 182, Laws of 2022, Sec. 415, available at: https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session%20Laws/Senate/5974-S.SL.pdf?q=20220428123147

Figure 5: ZEV Sales as Percent of New Light Duty Vehicles Sold

Scenario: *Accelerated ZEV Illustration*



Finally, BRG prepared a *Max Adoption* illustration, which demonstrates the maximum achievable reduction in carbon intensity for Washington's vehicle fleet. This illustration does not reflect the policy as it is currently being developed, but rather illustrates the maximum economically achievable CI reductions if a more stringent policy were in place. It includes the same ZEV mandate assumptions as in the *Accelerated ZEV* illustration, as well as assuming 17% of new heavy-duty vehicles sold in Washington annually are CNG vehicles burning RNG derived from in-state sources. This illustration also assumes that Washington's current supply of in-state biodiesel and renewable diesel is used for the in-state diesel mix, and that additional imports of renewable diesel come from the US Midwest. The assumed total feedstock availability for renewable diesel is calculated later in this section. Finally, a portion of renewable diesel refining is assumed to produce renewable naphtha and renewable propane as byproducts, which are available for blending with gasoline and as a replacement fuel for fossil propane-powered vehicles, respectively.

Carbon Intensity and Assumptions

This analysis uses CI values in the Washington GREET Model draft prepared by Life Cycle Associates, LLC on March 8, 2022. These assumptions are critical to overall scenario modeling because they model the total emissions reduction from using each type of fuel. As renewable propane and renewable naphtha are not modeled in GREET, the temporary carbon intensities used by the California Air Resources Board for renewable naphtha[18] and renewable propane[19] are used. The electricity CI was assumed to decline linearly from the 2020 CI of Washington electricity down to zero by 2030, which is consistent with CETA, while it is assumed that the statewide CI of hydrogen decreases to zero (i.e. that all hydrogen is green) by 2028. The CIs used in this analysis are shown in **Table 6**.

Table 6: Carbon Intensities used in scenario analysis, by fuel (gCO_2e/MJ)

Fuel	2023 CI	2030 CI	2038 CI
Unblended Gasoline	100.37	100.37	100.37
Ethanol	76.47	76.47	76.47
Renewable Naphtha (Soybean)	65	65	65
Fossil Diesel	101.09	101.09	101.09
Biodiesel (Soybean)	55.82	55.82	55.82
Renewable Diesel (Soybean)	51.71	51.71	51.71
Fossil Natural Gas	80.99	80.99	80.99
Renewable Natural Gas (Landfill)	67.66	67.66	67.66
Fossil Propane	76.42	76.42	76.42
Renewable Propane (Soybean)	65	65	65
Electricity	20.2	0	0
Hydrogen	124.85	0	0
Sustainable Aviation Fuel[20]	47.02	47.02	47.02

The CI values represent conservative estimates for feedstock-limited fuels, most notably for renewable diesel, biodiesel, and RNG, assuming a higher-than-average carbon intensity for fuels sold. Anticipated competition for feedstocks due to the growing market for clean fuels will likely make low-CI pathways more challenging than they have been historically.

In calculating adjusted CI values for electricity, an Energy Economy Ratio ("EER") of 3.4 is used to account for the much higher fuel economy per unit of fuel of electric vehicles due to their electric motor. This is derived from the current EER used in California.[21]

Overview of Cost and Price Assumptions

Washington's share of the North American fuel market is relatively small, and this analysis assumes the program will not have a large effect on out-of-state fuel prices. Within Washington, however, biofuel prices must converge with out-of-state prices both to support imports and/or reduce exports. Given the

[18] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/comments/newtemp_rnaphtha21.pdf
[19] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/comments/newtemp_rpropane21.pdf
[20] https://www.spglobal.com/commodity-insights/en/market-insights/latest-news/coal/110620-safs-california-lcfs-credit-value-tumbles-as-average-carbon-score-climbs
[21] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/lcfsguidance_20-04.pdf

competition for biofuels among CFS jurisdictions, this analysis assumes limitations to Washington's ability to import biofuels and feedstocks which are described below. The analysis also assumes that biofuels produced in-state require sufficient credit pricing under the CFS to make in-state sales attractive relative to exports.

Feedstock Availability for Biofuels

BRG reviewed the in-state feedstock availability analysis done by the consulting firm ICF International ("ICF") for the Puget Sound Clean Air Agency.[22] This review generally agrees with many of ICF's findings, including that there is relatively little realistic potential for in-state feedstocks for biofuels, particularly renewable diesel. BRG disagrees with ICF in that there is likely somewhat greater potential for fats, oils and greases, and canola in the state, but these differences are not sufficient to change the overall character of the findings. Key feedstock availability calculations are summarized in **Table 7**.

Table 7: In-State Produced Feedstocks for Potential Biofuel Production

Fuel	Potential Fuel Produced	Tech Potential (MM GGE)
Canola	Biodiesel, Renewable Diesel	~15-20
Forest Residue	Renewable Natural Gas, Renewable Diesel	~40-45
Fats, Oils, and Greases	Biodiesel, Renewable Diesel	~23
Landfill Gas	Renewable Natural Gas	~130
MSW	Renewable Natural Gas	~230
Whole Trees	Renewable Natural Gas, Renewable Diesel	~210

Limited feedstock availability suggests that the Cherry Point facility will secure much of the commercially available feedstock for renewable diesel, and sustainable aviation fuel production will likely compete for many of the other potential feedstocks. The analysis concludes that no incremental biofuel feedstocks are available from in-state Washington sources except for those available to produce RNG, discussed in detail below. Accordingly, this analysis assumes that all incremental biodiesel and renewable diesel production in Washington will be prepared using soybeans as feedstock, as will any out-of-state production.

In the *Maximum Adoption* scenario, the USDA 2021 national soy production is used to estimate the maximum technical potential for annual fuel production from soybeans in the United States as seen in **Table 8**. The scenario makes a simplifying assumption that the national maximum potential for

[22] ICF, Puget Sound Regional Transportation Fuels Analysis Final Report, September 2019.

renewable diesel is 50% of what would be possible with current US soybean oil production, shown in **Table 8**[23].

The *Max Adoption* illustration assumes that Washington can capture five times its proportion of national heavy duty vehicle miles traveled due to the CFS, which results in approximately 8.4% of national renewable diesel potential being available for in-state use.

Table 8: US Soybean Feedstock Availability

Feedstock	Quantity (billion lbs.)	Tech Potential (M GGE)
Soybean	51.7[24]	6,955[25]

In-State Production of Renewable Natural Gas

Washington currently has in-state RNG production potential at landfill gas and wastewater treatment facilities, supporting statewide production capacity of over 33.2 million GGE/year. A Washington State University study identifies several near-term opportunities for RNG production, including landfill gas, wastewater treatment plants, and dairy facilities.[26] Over a five-year development horizon these facilities could supply over 44 million GGE/year. Medium-term RNG projects identified in the report include landfill gas, wastewater treatment plants, dairies, municipal food waste digesters, and food processing plants that could be developed over the next five to ten years. Combined, these medium-term facilities would add over 47 million GGE/year. In total, current to medium-term projects could cumulatively supply 125.7 million GGE/year of RNG within the next 10 years. The *Maximum Adoption* illustration assumes that Washington can capture this technical potential for in-state transportation use.

[23] This assumption is not intended to imply that half of soybean production could feasibly go to renewable diesel production, but that a blend of factors and feedstocks allow for a simplifying assumption to be made regarding availability of a complex feedstock mix, with increased soybean acreage and yields and contributions from other oilseeds and waste fats also increasing feedstock availability.
[24] The quantity was converted from 4.4 billion bushels, as quoted by the USDA January 12, 2022, using the conversion factor of 11.75 lbs. of soybean oil per bushel on soybean feedstock, as quoted by the USDA December 13, 2021.
[25] ((Quantity * 0.973 lbs. of biodiesel per 1 lb. of soybean oil)/7.71 lbs. per 1 gallon of soybean oil) * 1.066 gallons of biodiesel to 1 M GGE
[26] Washington State University, Promoting Renewable Natural Gas in Washington State; A Report to the Washington State Legislature, December 2018.

Table 9: In-State RNG Capabilities

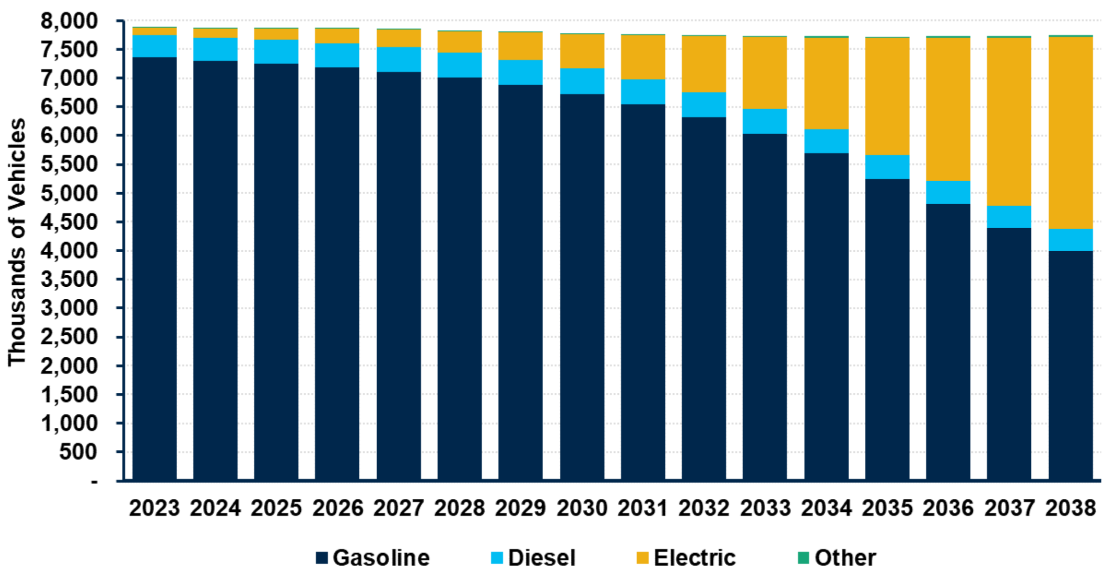
Project Time Horizon	RNG Capabilities (Millions GGE)	Cumulative Capacity (Millions GGE)
Current	33.3	33.3
Near Term	44.8	78.1
Medium Term	47.6	125.7

While there will be many competing applications for this RNG over the study period, D3 RIN credit prices provide a strong financial incentive for the use of RNG as a transportation fuel. In conjunction with the CFS credit prices and the brown value of CNG, this analysis finds that the value of RNG as a transportation fuel exceeds the value for other applications in a maximum adoption setting and supports the full development of these opportunities. In all scenarios besides the *Max Adoption* scenario, it is assumed that in-state RNG is principally exported to other jurisdictions with CFS policies, left undeveloped, or used for non-transportation applications.

4. Scenario Results

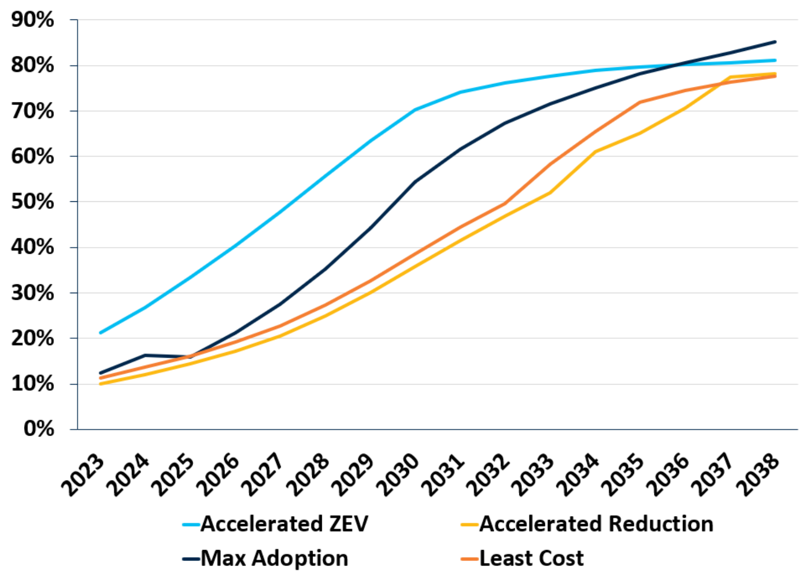
The Baseline case predicts a significant increase in electric vehicles resulting from the ZEV mandate and Advanced Clean Trucks rule, and conventional gasoline and diesel consumption is forecast to decrease by 54% and 19%, respectively, over the modeled time-period in the Baseline case absent the CFS.

Figure 6:
Vehicle Stock by Technology Type



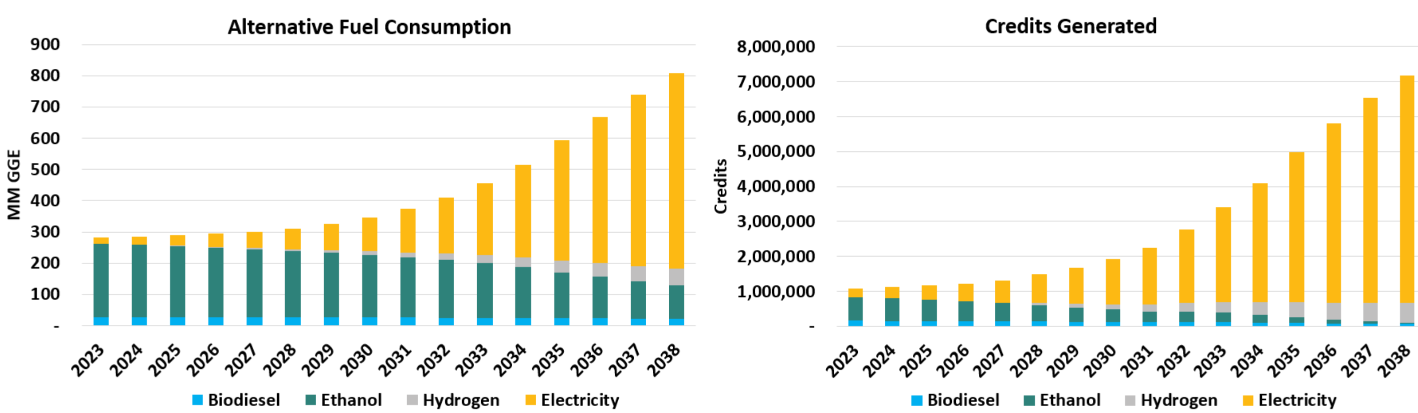
The rapid pace of vehicle electrification significantly supports the 20% reduction in CI required under the CFS, as seen in **Figure 7**; by 2038 approximately 80% of CFS credits are generated by electric vehicles in all scenarios and illustrations. Electric vehicles are much more efficient than internal combustion engines (on a miles per unit of fuel basis), which results in an overall reduction of fuel consumption while vehicle miles traveled remain similar from 2023 to 2038.

Figure 7: Percentage of Credits Generated by EVs by Scenario and Illustration



Incremental fuel blending adjustments are required to accomplish full compliance with the CFS program. The consumption of each fuel between 2023 and 2038 in each compliance scenario is compared to fuel consumption in the Baseline case. **Figure 8** shows both the alternative fuel consumption on the left and the number of CFS credits generated in CFS compliance scenarios due to fuel use assumptions in the Baseline case on the right.

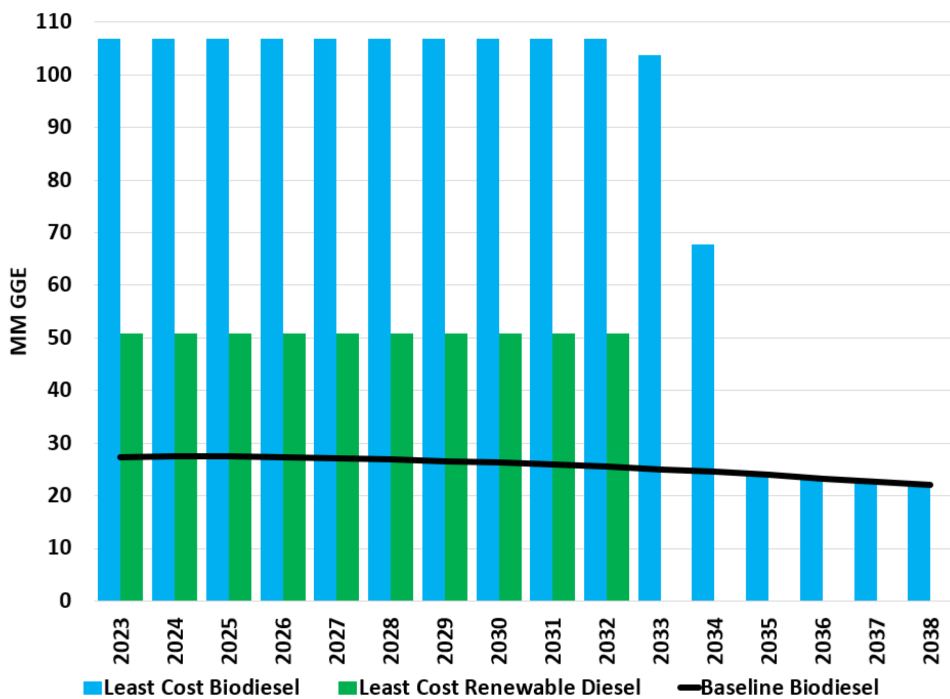
Figure 8: Fuel Consumption and Credits Generated, Baseline Case



Least Cost Scenario Fuel Consumption & Vehicle Fleet

Under the *Least Cost* scenario, it is assumed Washington begins using a greater proportion of available in-state biodiesel and renewable diesel fuels. The analysis assumes that Washington utilizes approximately 90% of in-state biodiesel production capacity from 2023 through 2032 and 51% of in-state renewable diesel production capacity from 2023 through 2032 in its transportation mix, alongside smaller biodiesel and renewable diesel utilization percentages in 2033 and 2034 which still exceed baseline levels.[27] Correspondingly, there is a reduction in exports of these fuels to neighboring states and provinces. Overall consumption of motor fuels remains the same as in the Baseline case, however, the blend of biodiesel and renewable diesel in diesel fuel increases as a percent of total fuel volumes. The increased proportion of biodiesel and renewable diesel from the Baseline case is illustrated in **Figure 9**.

Figure 9: Biodiesel & Renewable Diesel Consumption

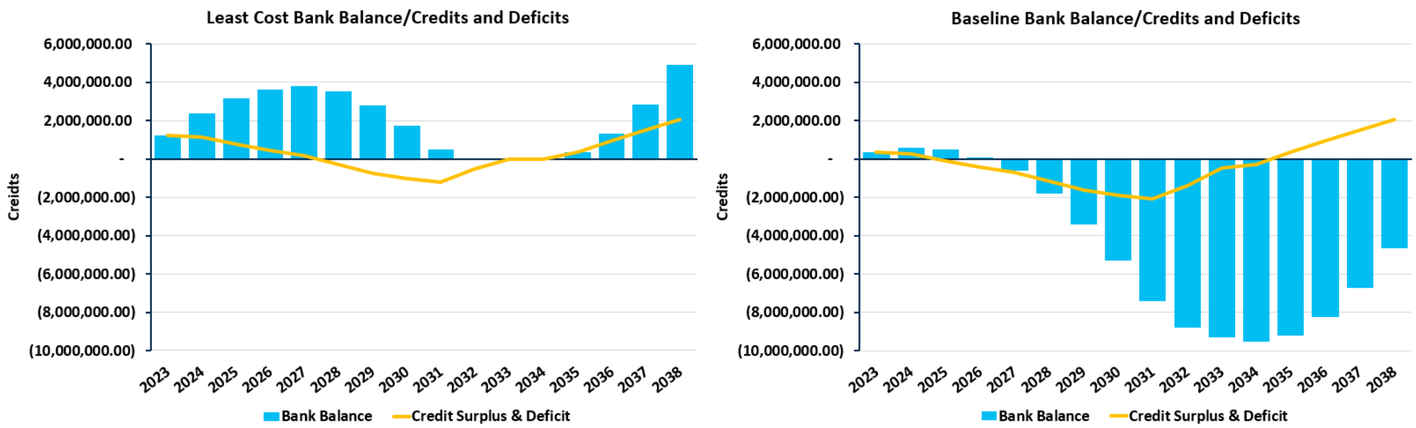


Under the *Least Cost* scenario, total fleet electrification is assumed to be the same as in the Baseline case. Accordingly, total fuel consumption remains the same under both scenarios on a GGE basis. Compliance with the CFS is achieved through increased utilization of lower-CI biofuels. Increased biodiesel and renewable diesel consumption in Washington results in a sufficient increase in credit generation from 2023-2034 to achieve compliance, as shown in **Figure 9**. After 2035, the pace of credit generation from electric and hydrogen vehicles accelerates due to the ZEV mandate and Advanced Clean Trucks standard, as shown in Figure 8, which ensures sufficient credits are available for

27 Results would be similar assuming higher renewable diesel and lower biodiesel

compliance even with a reduction of biodiesel and renewable diesel blending and an increase in exports of these fuels. This causes the bank balance to grow in the last four years in the Least Cost scenario.

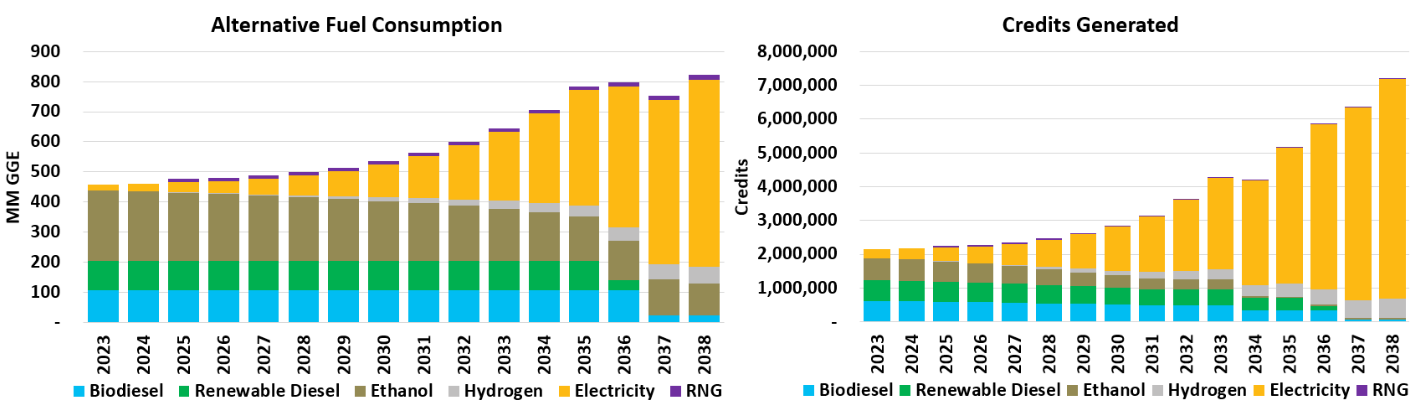
Figure 10: Least Cost vs. Baseline Credit Surpluses and Deficits



Accelerated Reduction Scenario Fuel Consumption & Vehicle Fleet

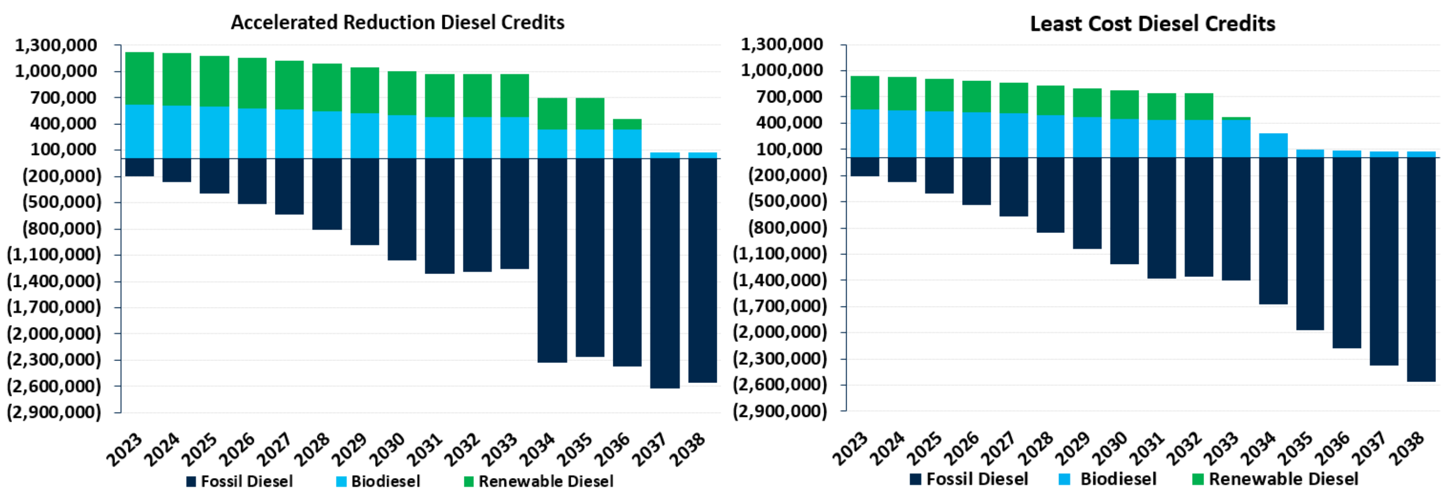
Similar to the *Least Cost* scenario, the *Accelerated Reduction* scenario achieves compliance with the CFS by increasing the consumptions of in-state biodiesel and renewable diesel as a percentage of the total blended diesel fuel consumed in Washington. This scenario assumes that Ecology sets accelerated interim carbon intensity targets requiring the full 20% CI reduction five years early, or by 2034.

Figure 11: Fuel Consumption and Credits Generated, Accelerated Reduction Scenario



Under the *Accelerated Reduction* scenario, it is assumed the state utilizes 90% of in-state biodiesel through 2036. This scenario assumes that 81% of the in-state renewable diesel capacity can be utilized from the Cherry Point refinery, with a smaller percentage in 2036. This results in increased biodiesel and renewable diesel consumption relative to the *Least Cost* scenario, with both earlier and later blending of renewable diesel. **Figure 12** illustrates the increased number of credits generated from biodiesel and renewable diesel in the *Accelerated Reduction* scenario compared to the *Least Cost* scenario.

Figure 12: Biodiesel and Renewable Diesel Credit Generation Comparison

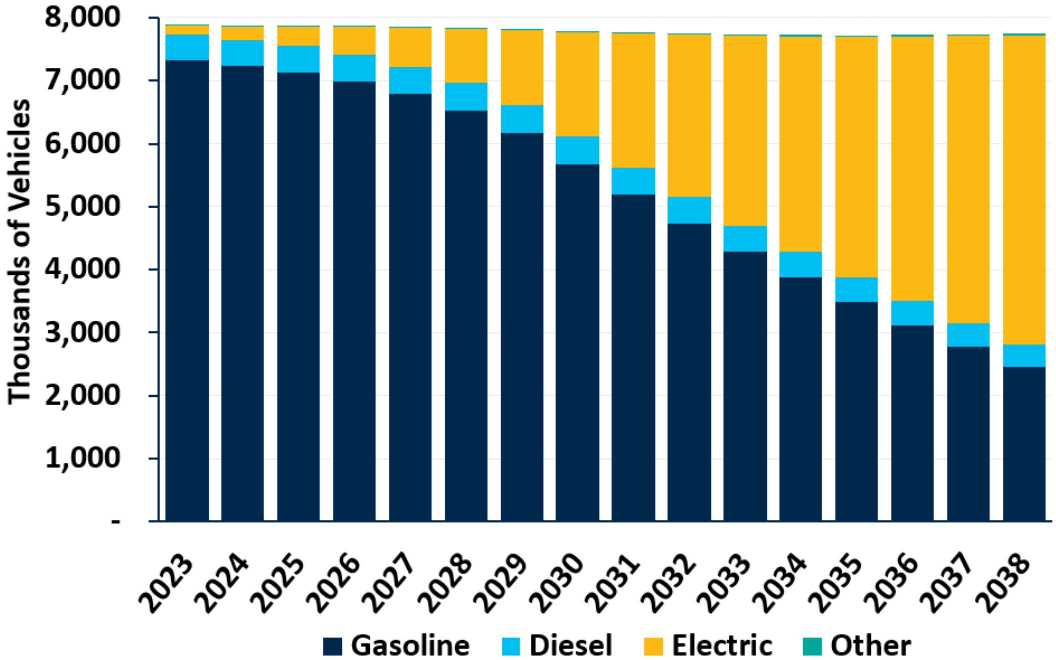


As with the *Least Cost* scenario the change in Washington's vehicle fleet under the *Accelerated Reduction* case is the same as the projected mix under the Baseline case.

Accelerated ZEV Illustration Fuel Consumption & Vehicle Fleet

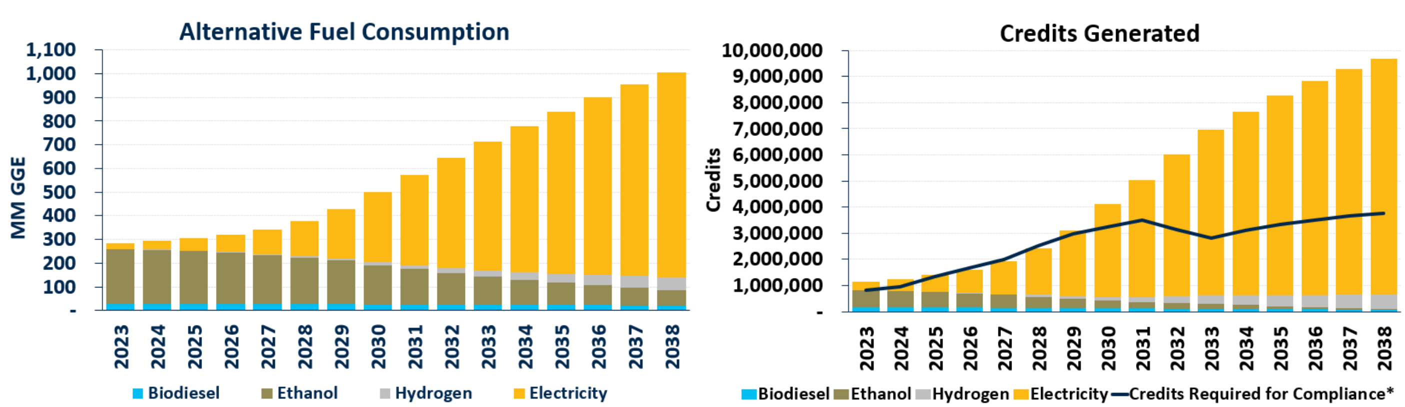
The *Accelerated ZEV* illustration assumes that 100% of new passenger and light truck sales will be ZEVs starting in 2030 rather than by 2035 as in the Baseline case, seen in **Figure 13**.

Figure 13: Accelerated ZEV Vehicle Stock by Technology Type



This accelerated pace of ZEV adoption completely achieves compliance with the CFS with no need for additional clean fuel blending relative to the Baseline case. Fuel efficiency gains due to the higher fuel economy of ZEVs results in considerably less overall fuel consumption in Washington (see **Figure 14**), while vehicle miles traveled by passenger vehicles and light trucks remain comparable to current levels.

Figure 14: Alternative Fuel Consumption & Credits Generated, Accelerated ZEV Illustration



Max Adoption Illustration Fuel Consumption & Vehicle Fleet

The *Max Adoption* illustration assumes that Washington achieves the same accelerated pace of ZEV adoption as in the *Accelerated ZEV* illustration. Additionally, RNG consumption by heavy-duty vehicles is assumed to increase along with greater consumption of biodiesel, renewable diesel, renewable naphtha, and renewable propane. All together this illustration is provided to demonstrate the maximum reduction in carbon intensity possible with current technology and feedstock availability assumptions. The carbon intensity reduction possible under this scenario compared to the Baseline case and other compliance scenarios as well as the assumed vehicle stock changed are illustrated in **Figure 15** and

Figure 16.

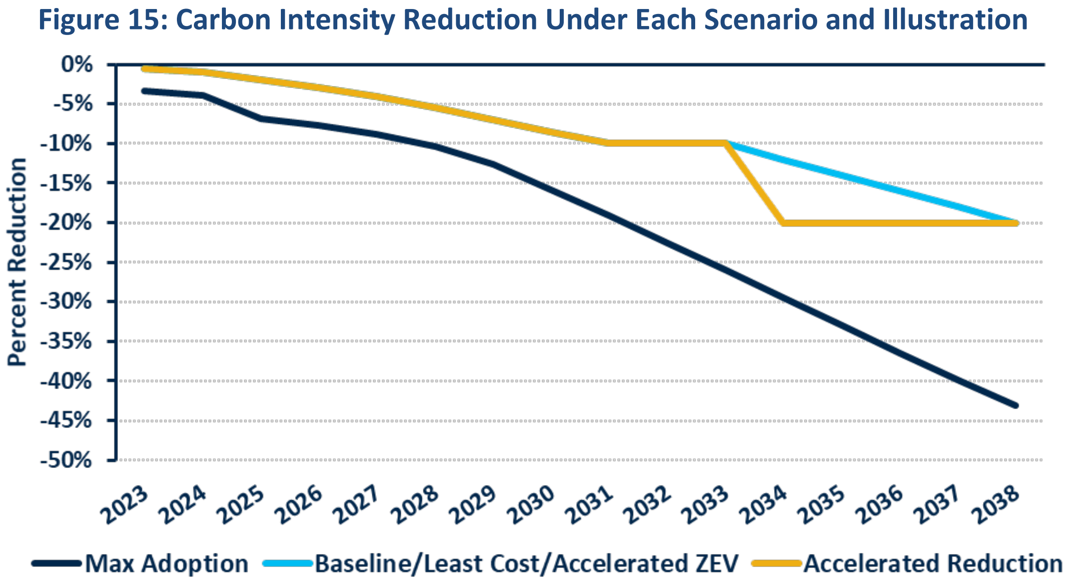
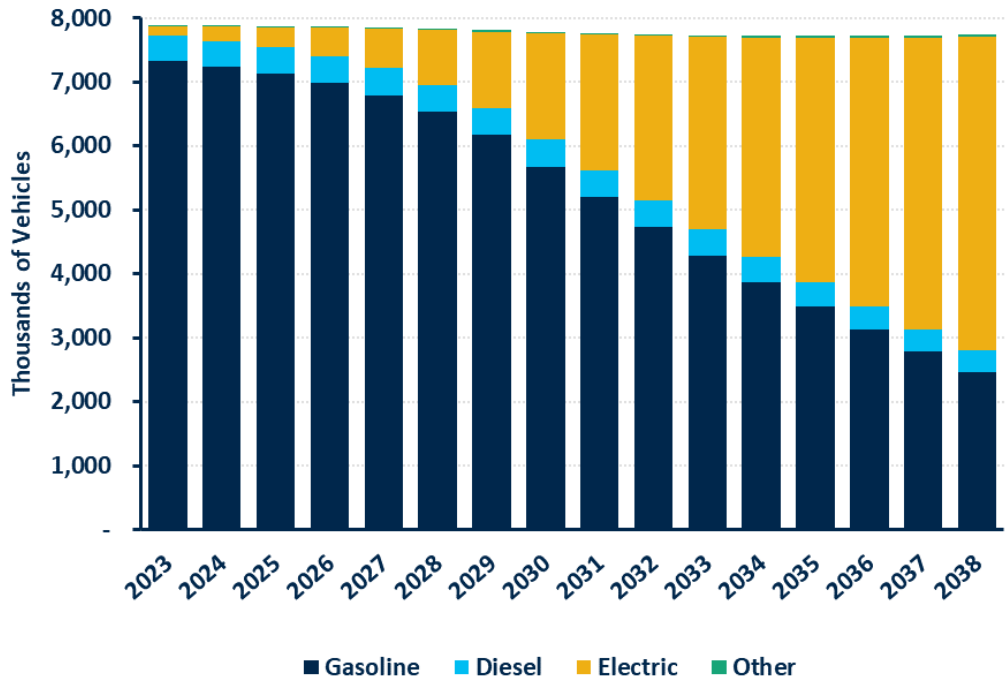


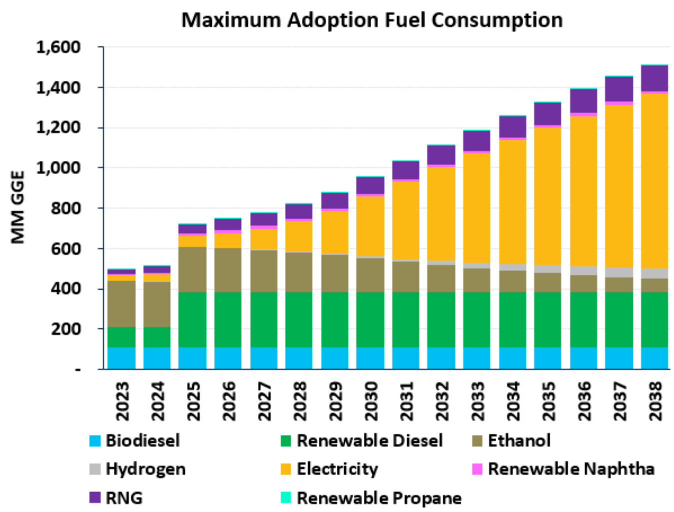
Figure 15: Carbon Intensity Reduction Under Each Scenario and Illustration
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
-40%
-45%
-50%
Percent Reduction
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Max Adoption
Baseline/Least Cost/Accelerated ZEV
Accelerated Reduction

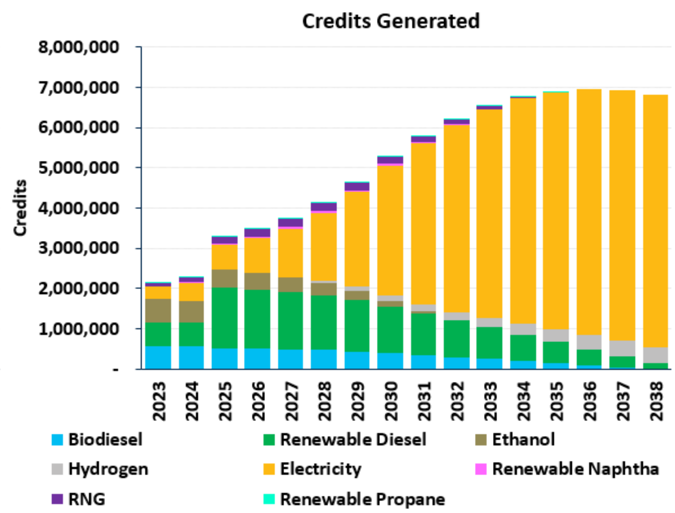
Figure 16: Maximum Adoption Illustration Vehicle Stock



Washington's vehicle fleet and fuel consumption characteristics in the *Max Adoption* scenario are meaningfully different from the Baseline case. Increased ZEV sales and greater clean fuel consumption reduces the average CI value for fuels by 20% and achieves compliance with the CFS by 2031, well ahead of the current deadline in 2038. As such, the *Maximum Adoption* illustration allows for significantly deeper decarbonization of the transportation sector over the modeled period and the statewide CI reaches 44% below the 2017 average gasoline and diesel CI levels by 2038.

Figure 17: Maximum Adoption Illustration Fuel Consumption and Credits Generated





Credit Prices

The credit prices in each scenario are calculated to be the marginal cost of blending sufficient biofuels to reduce life cycle carbon emissions from transportation fuels consumed in Washington by one metric ton of carbon dioxide-equivalent ($MTCO_2e$). For both renewable diesel and biodiesel, this price is calculated by dividing the differential dollar price of the green diesel fuel versus fossil diesel by the differential CI of each green diesel versus the fossil diesel CI.

$$\frac{Price\ of\ biodiesel\ or\ renewable\ diesel\ (in\frac{\$}{MJ}) - price\ of\ fossil\ diesel\ (in\frac{\$}{MJ})}{Carbon\ intensity\ of\ biodiesel\ or\ renewable\ diesel\left(in\ \frac{g}{MJ}\right) - Carbon\ intensity\ of\ fossil\ diesel\ (in\ \frac{g}{MJ})}$$

The outcome of this calculation is converted to dollars per metric ton of carbon emissions and results in a static abatement cost of \$91.16/$MTCO_2e$ for biodiesel (in 2020\$) and \$156.69/$MTCO_2e$ for renewable diesel (in 2020\$).

The marginal fuel varies by scenario and year depending on the adoption targets. In most scenarios, CI targets are aggressive enough to require market participants to purchase renewable diesel as the marginal fuel, which is costlier but has a lower CI value than biodiesel. The *Least Cost* and *Accelerated Reduction* scenarios use biodiesel as the marginal fuel in the early years when CI targets are relatively more modest, which has a lower cost but higher carbon intensity. The marginal fuel in each year illustrates the tradeoff between fuel cost and CI reduction requirements.

The analysis assumes that the interest rate that parties use to hold banked credits is equal to the rate of inflation. This reflects a diverse range of risk preferences and perspectives among compliance entities and other holders of credits. Some entities may view credits as an investment, implying that their own cost of capital reflects their breakeven interest rate on credits. In most cases, an entity's cost of capital will be higher than the rate of inflation. Other entities may view credits simply as a regulatory mechanism and will value banked credits as a means to hedge future regulatory compliance costs. Entities representing either perspective can be observed participating in existing programs. For the purposes of this analysis, the rate of inflation reflects the assumed interest rate to approximate differing risk preferences and reflects a rate somewhat higher than the prevailing federal funds rates.

Table 10: Carbon Abatement Cost by Scenario, 2020$/MT$CO_2$e

Year	Least Cost	Accelerated Reduction
2023	$156.69	$156.69
2024	$156.69	$156.69
2025	$156.69	$156.69
2026	$156.69	$156.69
2027	$156.69	$156.69
2028	$156.69	$156.69
2029	$156.69	$156.69
2030	$156.69	$156.69
2031	$156.69	$156.69
2032	$156.69	$156.69
2033	$156.69	$156.69
2034	$91.16	$156.69
2035	$2.00	$156.69
2036	$2.00	$156.69
2037	$2.00	$2.00
2038	$2.00	$2.00

Policy Impacts on Consumer Fuel Prices

This section presents the costs and cost savings per GGE due to the CFS policy in each scenario.

To calculate the policy cost or benefit for each fuel, the analysis performs the following calculation:

$$Policy\ Impact\left(\frac{\$}{GGE}\right) = (CI\ of\ Fuel - CI\ Target) * Credit\ Price\ (adjusted\ for\ units)$$

Table 11 shows the impacts of the policy on the costs paid by consumers for gasoline, diesel, and electricity. The gasoline and diesel presented in **Table 11** represent the average blended gasoline and diesel consumed by Washington consumers in the scenario, included blends with ethanol, biodiesel, and renewable diesel. A full accounting of cost savings per gallon equivalent for all fuels in each scenario can be found in Appendix 1: Cost of Policy per GGE.

Table 11: Cost or (Cost Savings) per Gallon Equivalent by Scenario, $2020/GGE

Scenario	Least Cost	Least Cost	Least Cost	Accel. Red.	Accel. Red	Accel. Red
Year	**Gasoline**	**Diesel**	**Electricity**	**Gasoline**	**Diesel**	**Electricity**
2023	0.007	(0.016)	(1.833)	0.007	(0.016)	(1.833)
2024	0.017	(0.006)	(1.840)	0.017	(0.006)	(1.840)
2025	0.036	0.014	(1.837)	0.036	0.014	(1.837)
2026	0.056	0.034	(1.835)	0.056	0.034	(1.835)
2027	0.076	0.054	(1.832)	0.076	0.054	(1.832)
2028	0.105	0.083	(1.819)	0.105	0.083	(1.819)
2029	0.134	0.113	(1.806)	0.134	0.113	(1.806)
2030	0.164	0.142	(1.794)	0.164	0.142	(1.794)
2031	0.193	0.171	(1.764)	0.193	0.171	(1.764)
2032	0.193	0.171	(1.764)	0.193	0.171	(1.764)
2033	0.193	0.171	(1.764)	0.193	0.170	(1.764)
2034	0.135	0.139	(1.004)	0.389	0.368	(1.568)
2035	0.003	0.004	(0.022)	0.389	0.367	(1.568)
2036	0.004	0.004	(0.021)	0.389	0.366	(1.568)
2037	0.004	0.005	(0.021)	0.005	0.005	(0.020)
2038	0.005	0.005	(0.020)	0.005	0.005	(0.020)

As can be seen in **Table 11** in the *Least Cost* scenario the policy has minimal effects on consumer gasoline and diesel prices at the start of compliance in 2023 but raises consumer gasoline prices over time by up to $0.19/GGE (2020$) by 2032 and consumer diesel prices by up to $0.17/GGE (2020$) by 2032. The policy also significantly reduces costs to consumers for electricity as a transportation fuel and reduces the compliance cost of the ZEV mandate and Advanced Clean Trucks standard for consumers. Price impacts for gasoline and diesel drop in 2033 and 2034 as renewable diesel blending is no longer needed for compliance and Washington-produced renewable diesel can be fully exported to other markets. Beginning in 2035 these zero emissions vehicle mandates begin to leave the market with a surplus of credits for the remainder of the policy, which causes credit prices to collapse to the assumed transaction cost and holding value and consumer costs relative to the baseline to revert to a few cents at most for all fuels.

As can be seen in **Table 11** the *Accelerated Reduction* scenario has similar consumer impacts through 2032, but results in consumer impacts rising over time and reaching up to $0.39/GGE for gasoline (2020$) and over $0.37/GGE for diesel (2020$) in 2034 through 2036, before the surplus discussed above occurs for this scenario as well. Price impacts are highest in 2034-36 in this scenario as the immediate 10% drop in target CI requires gasoline and diesel sellers to purchase a greater number of credits per unit of fuel than in the *Least Cost* scenario.

Cost of Policy per Vehicle Mile Traveled

Costs per vehicle mile traveled are derived from the miles per gallon of each vehicle type calculated in VISION, divided by the costs shown in the preceding section.

Table 12: Cost of Policy per VMT (¢/Mile)

	Least Cost			Accelerated Reduction		
	Consumer Gasoline	Consumer Diesel	Electricity	Consumer Gasoline	Consumer Diesel	Electricity
	Gasoline ICE & Hybrids	**Diesel ICE**	**EV**	**Gasoline ICE & Hybrids**	**Diesel ICE**	**EV**
Year	¢ per Mile	¢ per Mile	¢ per Mile	¢ per Mile	¢ per Mile	¢ per Mile
2023	0.0	(0.0)	(3.7)	0.0	(0.0)	(3.7)
2024	0.1	(0.0)	(3.7)	0.1	(0.0)	(3.7)
2025	0.2	0.0	(3.6)	0.2	0.0	(3.6)
2026	0.3	0.0	(3.5)	0.3	0.0	(3.5)
2027	0.4	0.1	(3.5)	0.4	0.1	(3.5)
2028	0.5	0.1	(3.4)	0.5	0.1	(3.4)
2029	0.6	0.2	(3.4)	0.6	0.2	(3.4)
2030	0.8	0.3	(3.3)	0.8	0.3	(3.3)
2031	0.9	0.4	(3.3)	0.9	0.4	(3.3)
2032	0.9	0.5	(3.3)	0.9	0.5	(3.3)
2033	0.9	0.5	(3.2)	0.9	0.5	(3.2)
2034	0.6	0.5	(1.8)	1.7	1.3	(2.9)
2035	0.0	0.0	(0.0)	1.7	2.0	(2.9)
2036	0.0	0.0	(0.0)	1.7	3.1	(2.9)
2037	0.0	0.0	(0.0)	0.0	0.0	(0.0)
2038	0.0	0.1	(0.0)	0.0	0.1	(0.0)

5. Environmental Benefits and Cost Savings Results

This section summarizes the environmental and social benefits of the CFS program. The environmental analysis estimates the value of significant health and environmental benefits from the Clean Fuel Standard scenarios. Health impacts represent the economic value of avoided poor health outcomes due to, in part, the CFS and other complementary transportation sector policies. Environmental impacts are quantified by considering the Social Cost of Carbon net benefits after reductions in GHG emissions under the CFS scenarios.

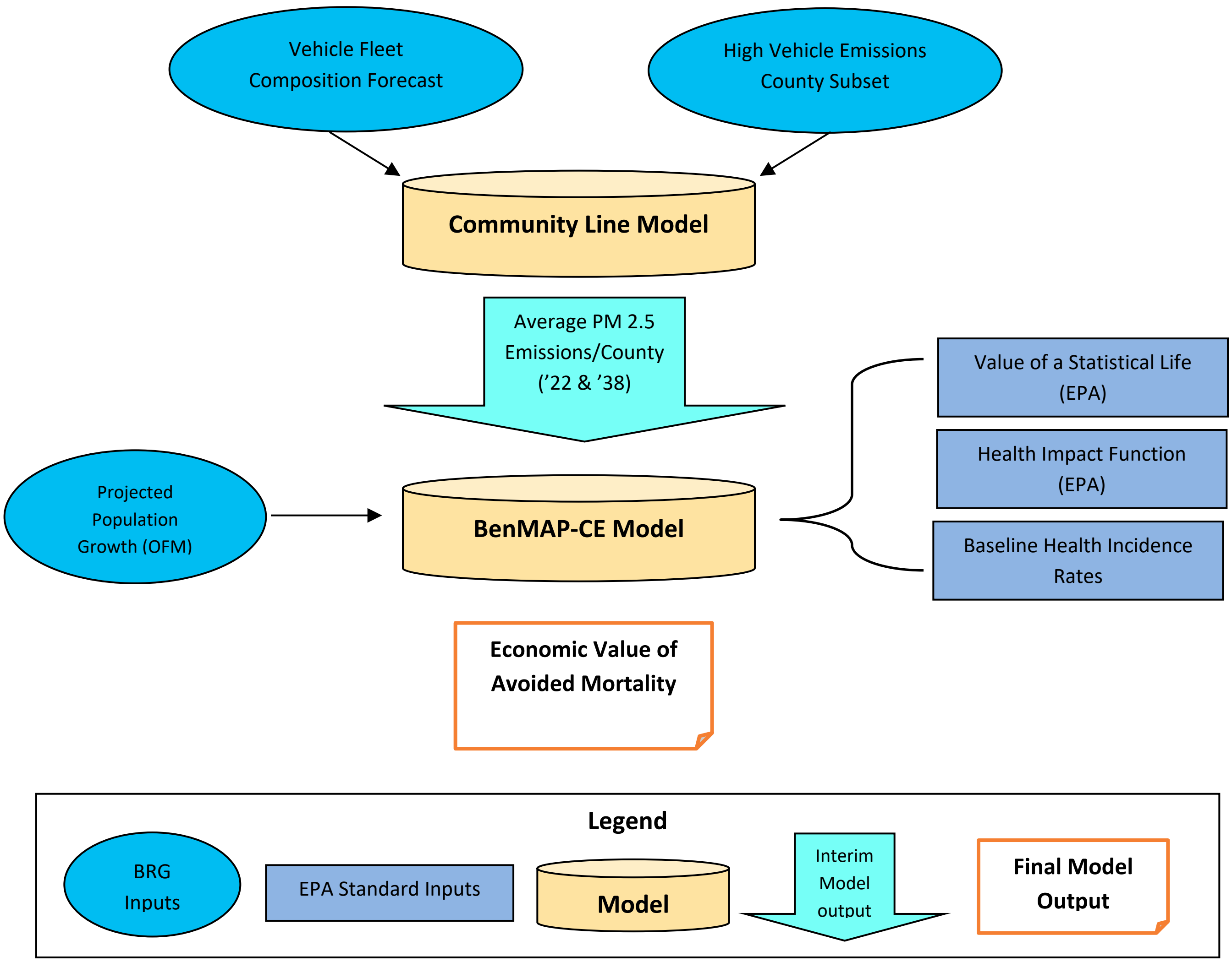
Health Impact Modeling

By 2038, Washingtonians are anticipated to enjoy significant improvements in air quality due to the reduction in criteria pollutants, particularly fine particulate matter. These improvements are due, in part, to the implementation of the CFS, and in part due to other transportation sector policies including the ZEV mandate, the Advanced Clean Trucks rule, and other state and federal policies contributing to improvements in fuel economy and reduced emissions. Health impacts are complex and represent the collective impact of these policies, and as such, benefits from the CFS are not easily distinguishable from other transportation fuel policies.

To illustrate the aggregate health benefits that Washington residents will receive from the CFS and the other transportation fuel policies, BRG modeled total reductions in fine particulate matter (“PM 2.5”) resulting from the change in the vehicle mix from 2022 to 2038 under the *Least Cost Scenario*. Electrification of the passenger vehicle, light, medium, and heavy-duty truck fleet is the primary driver of emissions reductions. Overlapping policies, specifically the ZEV Mandate and the Advanced Clean Trucks rule, narrow the compliance pathways under the CFS to an electrification-heavy compliance approach. While the proliferation of electric vehicles generates substantial health benefits, this change is not entirely attributable to the CFS or severable from other transportation policies. Emissions are further reduced below the *Least Cost Scenario* in the *Accelerated ZEV Illustration* and the *Max Adoption Illustrations*, though because those illustrations go beyond what is required under the CFS, these differentials are not attributable as health benefits of the program.

The analysis estimates the reduction in tailpipe emissions and the impact on avoided mortality using the Environmental Protection Agency’s Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE). Emissions dispersal and concentration related to the change in the vehicle fleet are derived using the EPA’s Community-LINE Source Model (C-LINE). A summary of the modeling approach is set out in **Figure 18** and the model approach and tools are further described in this section.

Figure 18: Summary of Modeling Approach



Calculating Change in Criteria Pollutant Concentrations

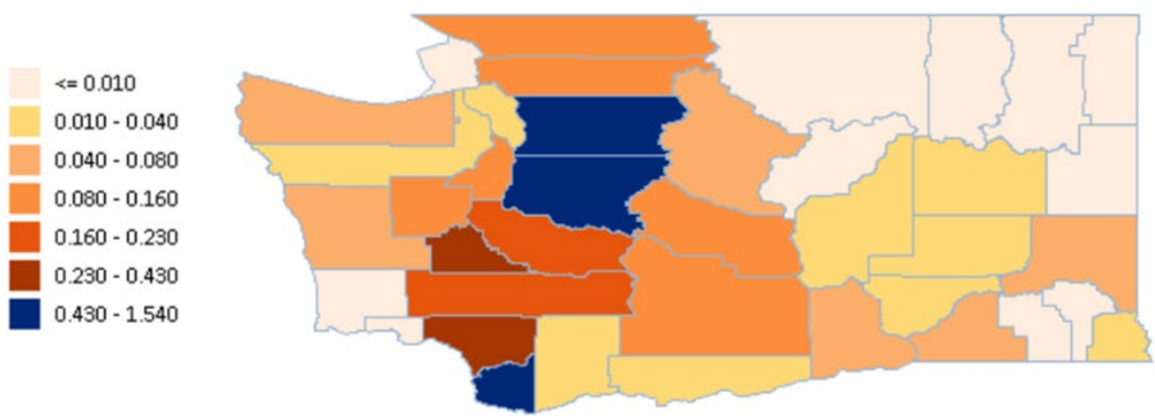
BRG models state-wide reductions in PM 2.5 pollution using the Environmental Protection Agency's Community Line ("C-Line") mapping tool. C-Line estimates the atmospheric concentrations of criteria pollutants over a region under typical weather conditions. C-Line is specifically calibrated to estimate the dispersal of criteria pollutants along roadways attributable to the combustion of gasoline and diesel fuels by cars and trucks.

The analysis estimates pollutant concentrations for C-Line for 24 counties which are indicated by data from the Washington Department of Health to have higher concentrations of residents living near high-traffic roadways. The analysis estimates that the health benefits of reduced pollution to residents of these counties would be most directly attributable to reduced emissions from the combustion of fossil fuels along roadways. This is due to state transportation policies, including the CFS, but as stated above it is not clearly attributable to an individual program.

For the remaining 15 counties which have lower concentrations of residents near roadways, the analysis assumes that pollution levels would be impacted roughly commensurate to state-wide emissions reductions from roadways. The analysis uses data from the Department of Ecology illustrating attributable PM 2.5 concentrations from diesel fuel combustion by census block to calculate PM 2.5 emissions. This approach estimates the impact that a reduction in roadway pollution from outside the county might have on county residents. C-Line estimates PM 2.5 emissions concentrated along roadways but is not calibrated to model background PM 2.5 emissions from roadways outside the area of analysis, and thus may understate the concentration of transportation PM 2.5 in counties with fewer roadways.

The analysis uses C-Line to produce mean annual PM 2.5 pollution concentrations for counties with significant vehicle traffic in 2022 and 2038. **Figure 19** illustrates the magnitude of PM 2.5 reductions by county.

Figure 19: Scale of PM 2.5 Reductions 2022-2038 (µg/m3)



Calculating Changes in Health Impacts

BRG uses EPA's BenMAP-CE health benefits impact tool to estimate the reduction in incidents of mortality and morbidity attributable to statewide reductions in PM 2.5 attributable to the change in composition of the vehicle fleet. The analysis models reductions in mortality due to reduced PM 2.5 exposure.

Health Impact Valuation Analysis

Health benefits are quantified in BenMAP-CE using EPA standard inputs based upon the reduction in morbidity and mortality incidents by 2038 relative to the pre-program year 2022, subject to the following formula:

*Economic value = change in health effect in 2038 from a 2022 baseline * value of health effect*

BenMAP-CE includes a series of academic studies to estimate the impact of reduced PM 2.5 pollution and health effects on adults aged 25-99. Our analysis employs a similar modeling approach as the EPA for the National Ambient Air Quality Standards ("NAAQS") Regulatory Impact Analysis and the Clean Power Plan ("CPP") Final Rule to establish a low- and high-end estimate.

The economic value of the health effect is discounted back to real 2020 dollars using a 3% discount rate, reflecting the 3% inflation rate used by EPA to calculate the future value of health impacts. **Table 13** illustrates the present value of reduced mortality rates by year 2038 attributable to the reduction in PM 2.5 emissions due to the CFS policy and other transportation policies in effect.

Table 13: Economic Value of Reduced Mortality (2020 dollars)

Estimate Range	Study Author	Economic Value of Reduced Mortality
Low-End	Krewski et al (2009)	$1.8 billion
High-End	Lepeule et al (2012)	$3.8 billion

Economic Benefits from GHG Emissions Reductions

BRG uses Washington's Social Cost of Carbon to estimate the value of reductions in GHG emissions across the scenarios. Due to the significant capacity for contemplated policies and/or the Washington transportation sector to significantly exceed the emissions reduction targets under the CFS, the modeled scenarios generate a wide range of economic benefits derived from GHG emissions reductions.

The Social Cost of Carbon

In 2019, the Washington Utilities and Transportation Commission adopted the Social Cost of Carbon ("SCC") metric produced by the Interagency Working Group on Social Cost of Greenhouse Gases ("IWG"). The IWG establishes values for the social cost of emitted carbon ($/emitted ton) for each year. Washington adopted and BRG used the discounted SCC value based upon a 2.5% discount rate[28]. BRG

[28] The 2.5 percent discount rate is most reflected in literature as the correct estimate of the discount rate for IWG-GHG social costs. As IWG writes in their most recent publication (February 2021), ". The low value, 2.5 percent, was included to incorporate the concern that interest rates are highly uncertain over time… Additionally, a rate below the consumption rate of interest would also be justified if the return to investments in climate mitigation are negatively correlated with the overall market rate of return. Use of this lower value was also deemed

calculated the economic value of avoided GHG emissions across each scenario compared to the Baseline case. Avoided GHG emissions are calculated as the total GHG emissions in each scenario, subtracted from the Baseline case, and multiplied by the SCC value for the given year. **Table 14** reflects the annual value of avoided GHG emissions in each scenario. As in Section 5, this table shows incremental carbon benefits of the Clean Fuels Standard above the Baseline. As such, the benefits are higher during periods of higher biofuel blending and are reduced once the standard has a surplus of credits due to the ZEV mandate and Advanced Clean Trucks rule.

Table 14: Social Cost of Carbon and Carbon Emissions Benefits by Year (millions, 2020$)

Year	Social Cost of Carbon (2020$)	Least Cost	Accelerated Reduction	Accelerated ZEV	Max Adoption
2023	$80.34	$21	$28	$12	$108
2024	$81.65	$21	$29	$28	$128
2025	$82.95	$22	$29	$53	$258
2026	$84.26	$22	$30	$91	$302
2027	$85.56	$23	$31	$145	$364
2028	$86.87	$24	$32	$225	$451
2029	$88.18	$25	$33	$344	$578
2030	$89.48	$26	$34	$517	$758
2031	$90.84	$27	$35	$666	$914
2032	$92.21	$4	$36	$783	$1,039
2033	$93.57	$1	$37	$860	$1,123
2034	$94.93	$1	$38	$884	$1,154
2035	$96.30	$0	$40	$840	$1,117
2036	$97.66	$0	$0	$793	$1,076
2037	$99.02	$0	$0	$742	$1,032
2038	$100.39	$0	$0	$691	$987

6. Employment Impacts

This section analyzes the employment impacts of the CFS policy, principally using the Jobs and Economic Development Impact ("JEDI") model, developed by NREL. JEDI estimates the local economic impact of various energy projects. There are three main outputs from the JEDI model: direct labor impacts, indirect impacts, and induced impacts. Direct labor impacts are on-site labor needs, including construction and operating crews. Indirect impacts are the local revenue and supply chain effects of a project, such as the manufacture of project inputs or effects from banking and investment. Induced

responsive to certain judgments based on the prescriptive or normative approach for selecting a discount rate and to related ethical objections that have been raised about rates of 3 percent or higher."

impacts include the household spending from direct and indirect beneficiaries. Each of these outputs are calculated based on project inputs including type, size, location, and expenditures. The JEDI model uses location-specific multipliers in an input-output analysis to estimate total impacts resulting from the project.

In each scenario, the number of jobs supported by infrastructure and investment credits generated by the policy drives some job growth. While jobs may be driven, in part, by the ZEV mandate, the CFS provides direct financial support for these jobs through the sale of CFS credits. A study from the Seattle Jobs Initiative prepared with the City of Seattle Office of Sustainability and Environment established the median hourly wage across EV-related construction jobs in Washington at $34.12, and the cost of labor-adjusted median hourly wage is $29.67.[29] We use the EV industry data from this report to quantify the number of jobs gained from electrification investments in each scenario. In this report, we present electrification jobs attributable to construction driven by the introduction of credits. We exclude annual electrification operation jobs since these are attributable to and supported by the ZEV mandate. Indirect and induced jobs are calculated to be higher for construction than operations jobs.

The *Least Cost* and *Accelerated Reduction* scenarios assume the diversion of in-state biofuel production, which, along with vehicle electrification, will principally result in a reduction in refining jobs and an increase in jobs supported by infrastructure build out under the CFS. It is challenging to estimate employment effects due to lost consumption in the refining sector because refined products can be, to an extent, exported to other markets, resulting in no net job loss, though large reductions can result in step changes due to refinery closures. To accommodate this range of outcomes, the analysis assumes that jobs are lost on a pro-rata basis with the in-state decline in demand for refined products. Lost jobs are assessed relative to the Baseline, which causes the number of lost refining jobs attributable to CFS to decline in the mid to late 2030s as the ZEV mandate and ACT rule become responsible for a greater share of reduced refined product demand.

To quantify the net effects of the CFS, the JEDI petroleum model is used as an indicator of the consequent jobs lost due to reduced demand for gasoline and diesel. The analysis generalizes Washington petroleum refinery economics and estimates the number of jobs sustained by average annual refinery output. This calculation creates a ratio of jobs per gallon of production, which is multiplied by Washington refined product consumption under each scenario and adjusted to assume 16 percent of Washington refined products continue to be imported into the state[30]. The tables below present the non-cumulative job gains or losses in each year relative to the Baseline case and reflect the total net increase in jobs in any given year relative to the Baseline case.

[29] Seattle Jobs Initiative, "Amping Up Electric Vehicle Manufacturing in the PNW." May 2020.
[30] Washington GREET.

Table 15: Employment Impact of Least Cost Scenario

	Petroleum Jobs Lost			Electrification Jobs Gained			Net Job Impact			
Year	Indirect	Induced	Direct	Indirect	Induced	Direct	Indirect	Induced	Direct	Total Net
2023	20	8	13	36	16	11	16	7	-2	21
2024	20	8	13	38	17	12	18	8	-2	24
2025	20	8	13	40	18	12	20	9	-1	28
2026	20	8	13	42	18	13	22	10	-1	31
2027	20	8	13	45	20	13	25	11	0	36
2028	20	8	13	47	20	14	27	12	1	40
2029	20	8	13	49	22	15	30	13	2	45
2030	20	8	13	53	23	16	34	15	3	52
2031	20	8	13	58	26	18	39	17	4	60
2032	20	8	13	67	29	20	47	21	7	75
2033	12	5	8	74	32	22	62	27	14	103
2034	7	3	4	48	21	15	41	18	10	69
2035	0	0	0	1	1	0	1	1	0	2
2036	0	0	0	1	1	0	1	1	0	2
2037	0	0	0	2	1	1	2	1	0	3
2038	0	0	0	2	1	1	2	1	1	4

Table 16: Employment Impact of Accelerated Reduction Scenario

	Petroleum Jobs Lost			Electrification Jobs Gained			Net Job Impact			
Year	Indirect	Induced	Direct	Indirect	Induced	Direct	Indirect	Induced	Direct	Total Net
2023	27	11	18	41	18	12	15	7	-5	17
2024	27	11	18	43	19	13	17	8	-5	20
2025	27	11	18	45	20	14	18	8	-4	22
2026	27	11	18	47	20	14	20	9	-4	25
2027	27	11	18	49	22	15	23	10	-3	30
2028	27	11	18	51	22	16	25	11	-2	34
2029	27	11	18	54	24	16	27	12	-2	37
2030	27	11	18	58	25	17	31	14	-1	44
2031	27	11	18	62	27	19	36	16	1	53
2032	27	11	18	71	31	22	44	20	3	67
2033	27	11	18	82	36	25	56	25	7	88
2034	27	11	18	81	35	24	54	24	6	84
2035	27	11	18	98	43	30	71	31	11	113
2036	17	7	12	110	48	33	92	41	21	154
2037	0	0	0	2	1	1	1	1	0	2
2038	0	0	0	2	1	1	2	1	1	4

In addition to the impacts in the fuels production sector of the state economy and the indirect and induced effects of these changes in investment and economic activity, changing fuel prices could impact consumer purchasing power, which in turn could have secondary effects on employment. The impact of transportation fuel prices on employment is uncertain, and these impacts are harder to quantify in the case of a policy such as the CFS. Generally, the CFS would tend to reduce household spending power available to consumers who own vehicles that consume gasoline and diesel, while increasing the spending power of consumers who drive vehicles that consume electricity or lower-carbon fuels. The net result of these changes to spending power could have employment impacts throughout the service and goods sectors of the economy, though whether the economy-wide impact is positive or negative cannot be ascertained through the models used to conduct this analysis.

7. Regulated Entities

The CFS defines regulated parties as those which produce or import any amount of transportation fuel that is ineligible to generate credits under the program. In practice, producers and importers of conventional gasoline and diesel products would qualify as regulated parties, excluding those used exclusively for exempted activities (for example airline fuel, certain farming activities, and marine bunker fuels). Under current law, Washington requires that all entities which blend, export, import, or supply motor vehicle fuels must register for a fuel tax license. As of February 28, 2022, a total of 275 entities held active fuel tax licenses in Washington.[31] Some of these entities are likely exempt from the CFS, including entities which supply fuels exclusively for exempt activities, operate fuel terminals, or fuel blenders that do not act as distributors. Of all licensed entities, 242 distinct entities operate as fuel distributors/suppliers and likely would qualify as regulated parties under the CFS.

In addition to the regulated parties, the CFS allows for non-regulated parties to participate in the credit market on a voluntary basis. In practice, this voluntary participation by credit generating entities is the means by which the CFS ensures a robust supply of low-carbon fuels for consumers. There are several defined categories of voluntary market participants that are reasonably foreseeable.

Utilities

Electric utilities, including consumer-owned or investor-owned utilities, are specifically contemplated in the CFS as voluntary market participants. Utilities may earn credits by supplying electricity to customers for the purpose of electric vehicle charging. There are currently 6 consumer or investor-owned electric utilities serving Washington retail customers. There are an additional 14 electric cooperatives and 28 not-for-profit community-owned Public Utility Districts ("PUD"). This analysis estimates that, in total, 48 utilities could participate in the CFS on a voluntary basis.

Airline Fuel Retailers

The CFS does not require a reduction in carbon intensity for airline fuels. However, suppliers of lower-carbon aviation fuels, Sustainable Aviation Fuels ("SAF"), can voluntarily participate in the CFP and earn credits for fuel sales. SAF is a rapidly growing industry, and Seattle-Tacoma (SeaTac) Airport has announced its intention to supply a blend of 10% SAF for all flights fueled at the airport by 2028[32]. We assume that SeaTac fuel suppliers will likely participate in the CFS on a voluntary basis.

Clean Fuel Producers, Suppliers, and Retailers

Makers of clean transportation fuels anywhere in the world with the capacity to supply those fuels to Washington can choose to opt into the CFS and earn credits. The universe of clean fuel producers is

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[31] Washington State Department of Licensing, Active Fuel Tax Licenses, February 28, 2022.
[32] Motion of the Port of Seattle to Develop a Comprehensive Port of Seattle Sustainable Aviation Fuels Strategy, Adopted December 19, 2017.

large, and it is difficult to estimate how many producers may elect to participate in Washington's clean fuel market. However, it is possible to review the list of participants in other similar markets and estimate a ceiling of market participants in Washington. California's Low Carbon Fuel Standard program is the most mature and established clean fuel credit market in the US. Fuel suppliers are required to register fuel pathways. As of March 10, 2022, the California Air Resources Board data indicates that 347 unique entities have registered clean fuel pathways.[33] This entity list likely represents an upper estimate of the number of entities that would participate in the Washington credit market, as California's refined products market is roughly 5 times larger than the Washington fuel market and thus the sheer volume of low carbon fuel required to support the California LCFS program targets is significant.

[33] California Air Resources Board, Current Fuel Pathways, Updated March 10, 2022.

8. Conclusion

This analysis shows the principal impacts of the CFS policy. This analysis considers two potential regulatory scenarios, the *Least Cost* and *Accelerated Reduction* scenarios, available to Ecology in implementing the CFS, each of which has relative costs and benefits illustrated in this report. Additionally, this report illustrates that a faster pace of ZEV adoption in the *Accelerated ZEV* illustration would likely drive full compliance with the CFS. Finally, this report analyzes the maximum achievable decarbonization potential of the Washington transportation sector by 2038 in the *Max Adoption* illustration.

Relative to the Baseline, consumer price impacts of the policy in the *Least Cost Scenario* rise from relatively little change in 2023 up to $0.19/GGE for gasoline and $0.17/GGE for diesel (2020$) above Baseline by 2032, while electricity becomes cheaper by up to $1.84/GGE in 2024 and remains significantly cheaper through 2036. Impacts for other fuels are listed in the appendix. In the *Accelerated Reduction Scenario* the consumer price impacts of the policy rise from relatively little change up to $0.39/GGE for gasoline and $0.37/GGE for diesel by 2034-36, while electricity becomes cheaper by up to $1.84/GGE in 2024 and remains significantly cheaper through 2036. Both scenarios show significant environmental benefits from reduced GHG emissions relative to the Baseline case. Under the *Least Cost Scenario*, environmental benefits from reduced emissions cumulatively exceed $215 million by 2030, and benefits from reduced emissions exceed $430 million in the *Accelerated Reduction Scenario* (see **Table 14**). The *Max Adoption* illustration shows an ability to reduce Washington transportation sector emissions intensity by up to 43% below 2017 levels by 2038.

This analysis also highlights the degree to which the ZEV mandate and Advanced Clean Truck standard is intertwined with the CFS. The ZEV mandate and Advanced Clean Truck standard drive the large majority of compliance with the CFS,[34] while CFS credit prices provide cost incentives to switch to ZEVs and provide some financial resources to engage in the infrastructure building needed in part to comply with the ZEV mandate and Advanced Clean Truck standard.

Potential Limitations of Analysis

The analysis relies on several assumptions rooted in strong fundamental analysis which impact the viability and the costs of the scenarios outlined in this report. The analysis uses forecasts of commodity prices (in particular, prices for petroleum and agricultural products) to quantify the costs and benefits of

[34] This analysis assumes that the ZEV mandate results in faster electrification than the CFS would in isolation. That said, BRG notes that Washington already has very high adoption of electric vehicles, and the CFS would significantly improve the economics of ZEV vehicle ownership, including electric vehicles, assuming as this analysis does that credit revenues are passed onto consumers either directly in the form of lower prices or in the form of increased investment in infrastructure. For these reasons it is believed that even absent the mandate electric vehicles would constitute a significant share of going-forward compliance activity. This can be seen in other states such as California which already have CFS policies in place.

the policy. Commodity prices are extremely volatile, and any increase in petroleum prices could reduce the relative costs of this program, while any increase in the cost of agricultural products could increase the costs. Many uncertain events, including climate change, wars, disease, localized weather events, population growth trends, tariffs, and economic activity could have a bearing on these prices. For example, oil prices at the time of publication are higher than assumed in this analysis due to some of these effects.

Changing technology trends can also have significant effects on the future transportation mix of Washington. Many of the technologies contemplated in this report are still early-stage (for example, green hydrogen) or still have room for significant cost reductions with sufficient investment and technological breakthroughs. It is anticipated that many technologies considered in this report will develop rapidly over the life of the program, while others will fail to reach full commercial viability.

The ZEV mandate and Advanced Clean Truck standards offer unprecedented opportunities for decarbonization of the transportation sector but also require unprecedented buildout of infrastructure to support them. While BRG believes that electrification, in particular, and the opportunities for zero emissions vehicles, in general, represent the least-cost way of decarbonizing the transportation sector in most cases, the pace of adoption of electric and low-emissions vehicles due to the standards will have significant implications for the costs and decarbonization opportunities for the policy.

There is also significant uncertainty in future environmental policy which could significantly impact the CFS. As shown in the *Accelerated ZEV* illustration, a strengthening of the ZEV mandate could drive compliance with the policy. Conversely, a weakening of the federal RFS could significantly increase the relative costs of biofuels for Washington consumers and make compliance with the CFS more expensive. Additionally, there is uncertainty about future adoption of CFS policies in other states, and the potential for increased stringency of existing policies, as is currently being considered in other states and provinces. Uncertain future trends in existing regional policies such as those in California, Oregon, and British Columbia could all have significant impacts on the policy outcome in Washington. A wide-scale adoption of CFS policies nationwide could strain the feedstock availability contemplated in the *Maximum Adoption* scenario.

This analysis also assumes that credit prices are derived from the marginal cost of compliance each year. Other factors including expectations of future pricing trends or future policies could cause traded credit prices to deviate from marginal costs in some cases.

This analysis strives to incorporate assumptions from well-respected federal and state sources and utilize models developed by federal agencies and national labs to limit the opportunities for bias. Nevertheless, each of these models and sources makes simplifying assumptions which may not always reflect reality.

Despite these potential limitations, BRG considers this analysis to be the best available representation of the costs, benefits, and compliance pathways associated with the Clean Fuel Standard.

Appendix 1: Cost of Policy per GGE

Note: Consumer gasoline and consumer diesel reflect the blend of gasoline and diesel blendstocks used by the average Washington consumer in each year, and incorporate blended ethanol, biodiesel, and renewable diesel in the annual proportion assumed in each scenario.

Table 17: Policy Impacts of Least Cost Scenario on Consumer Fuel Prices, 2020$/GGE

Year	Consumer Gasoline	Consumer Diesel
2023	0.007	(0.016)
2024	0.017	(0.006)
2025	0.036	0.014
2026	0.056	0.034
2027	0.076	0.054
2028	0.105	0.083
2029	0.134	0.113
2030	0.164	0.142
2031	0.193	0.171
2032	0.193	0.171
2033	0.193	0.171
2034	0.135	0.139
2035	0.003	0.004
2036	0.004	0.004
2037	0.004	0.005
2038	0.005	0.005

Table 18: Policy Impacts of Least Cost Scenario on Non-Consumer Fuel Prices, 2020$/GGE

Year	Unblended Gasoline	Ethanol	Renewable Naphtha	Electricity	Fossil Diesel	Biodiesel	Renewable Diesel	Hydrogen	CNG	RNG	Propane	Renewable Propane
2023	0.045	(0.430)	(0.658)	(1.833)	0.031	(0.869)	(0.951)	0.504	(0.368)	(0.634)	(0.459)	(0.686)
2024	0.055	(0.420)	(0.648)	(1.840)	0.041	(0.859)	(0.941)	(0.728)	(0.359)	(0.624)	(0.449)	(0.676)
2025	0.075	(0.401)	(0.629)	(1.837)	0.061	(0.839)	(0.921)	(0.708)	(0.339)	(0.604)	(0.429)	(0.657)
2026	0.094	(0.381)	(0.609)	(1.835)	0.081	(0.819)	(0.901)	(0.688)	(0.319)	(0.584)	(0.410)	(0.637)
2027	0.114	(0.361)	(0.589)	(1.832)	0.101	(0.799)	(0.881)	(0.668)	(0.299)	(0.564)	(0.390)	(0.617)
2028	0.143	(0.332)	(0.560)	(1.819)	0.131	(0.770)	(0.851)	(1.879)	(0.269)	(0.534)	(0.360)	(0.587)
2029	0.173	(0.303)	(0.531)	(1.806)	0.160	(0.740)	(0.821)	(1.850)	(0.239)	(0.504)	(0.330)	(0.557)
2030	0.202	(0.273)	(0.501)	(1.794)	0.190	(0.710)	(0.791)	(1.820)	(0.209)	(0.474)	(0.300)	(0.527)
2031	0.231	(0.244)	(0.472)	(1.764)	0.220	(0.680)	(0.762)	(1.790)	(0.180)	(0.445)	(0.270)	(0.497)
2032	0.231	(0.244)	(0.472)	(1.764)	0.220	(0.680)	(0.762)	(1.790)	(0.180)	(0.445)	(0.270)	(0.497)
2033	0.231	(0.244)	(0.472)	(1.764)	0.220	(0.680)	(0.762)	(1.790)	(0.180)	(0.445)	(0.270)	(0.497)
2034	0.157	(0.119)	(0.252)	(1.004)	0.151	(0.372)	(0.420)	(1.018)	(0.081)	(0.236)	(0.134)	(0.266)
2035	0.004	(0.002)	(0.005)	(0.022)	0.004	(0.008)	(0.009)	(0.022)	(0.001)	(0.005)	(0.002)	(0.005)
2036	0.004	(0.002)	(0.005)	(0.021)	0.004	(0.007)	(0.008)	(0.021)	(0.001)	(0.004)	(0.002)	(0.005)
2037	0.005	(0.001)	(0.004)	(0.021)	0.005	(0.007)	(0.008)	(0.021)	(0.000)	(0.004)	(0.001)	(0.004)
2038	0.005	(0.001)	(0.004)	(0.020)	0.005	(0.006)	(0.007)	(0.020)	0.000	(0.003)	(0.001)	(0.004)

Table 19: Policy Impacts of Accelerated Reduction Scenario on Consumer Fuel Prices, 2020$/GGE

Year	Consumer Gasoline	Consumer Diesel
2023	0.007	(0.016)
2024	0.017	(0.006)
2025	0.036	0.014
2026	0.056	0.034
2027	0.076	0.054
2028	0.105	0.083
2029	0.134	0.113
2030	0.164	0.142
2031	0.193	0.171
2032	0.193	0.171
2033	0.193	0.170
2034	0.389	0.368
2035	0.389	0.367
2036	0.389	0.366
2037	0.005	0.005
2038	0.005	0.005

Table 20: Policy Impacts of Accelerated Reduction Scenario on Non-Consumer Fuel Prices, 2020$/GGE

Year	Unblended Gasoline	Ethanol	Renewable Naphtha	Electricity	Fossil Diesel	Biodiesel	Renewable Diesel	Hydrogen	CNG	RNG	Propane	Renewable Propane
2023	0.045	(0.430)	(0.658)	(1.833)	0.031	(0.869)	(0.951)	0.504	(0.368)	(0.634)	(0.459)	(0.686)
2024	0.055	(0.420)	(0.648)	(1.840)	0.041	(0.859)	(0.941)	(0.728)	(0.359)	(0.624)	(0.449)	(0.676)
2025	0.075	(0.401)	(0.629)	(1.837)	0.061	(0.839)	(0.921)	(0.708)	(0.339)	(0.604)	(0.429)	(0.657)
2026	0.094	(0.381)	(0.609)	(1.835)	0.081	(0.819)	(0.901)	(0.688)	(0.319)	(0.584)	(0.410)	(0.637)
2027	0.114	(0.361)	(0.589)	(1.832)	0.101	(0.799)	(0.881)	(0.668)	(0.299)	(0.564)	(0.390)	(0.617)
2028	0.143	(0.332)	(0.560)	(1.819)	0.131	(0.770)	(0.851)	(1.879)	(0.269)	(0.534)	(0.360)	(0.587)
2029	0.173	(0.303)	(0.531)	(1.806)	0.160	(0.740)	(0.821)	(1.850)	(0.239)	(0.504)	(0.330)	(0.557)
2030	0.202	(0.273)	(0.501)	(1.794)	0.190	(0.710)	(0.791)	(1.820)	(0.209)	(0.474)	(0.300)	(0.527)
2031	0.231	(0.244)	(0.472)	(1.764)	0.220	(0.680)	(0.762)	(1.790)	(0.180)	(0.445)	(0.270)	(0.497)
2032	0.231	(0.244)	(0.472)	(1.764)	0.220	(0.680)	(0.762)	(1.790)	(0.180)	(0.445)	(0.270)	(0.497)
2033	0.231	(0.244)	(0.472)	(1.764)	0.220	(0.680)	(0.762)	(1.790)	(0.180)	(0.445)	(0.270)	(0.497)
2034	0.427	(0.048)	(0.276)	(1.568)	0.419	(0.481)	(0.563)	(1.591)	0.019	(0.246)	(0.072)	(0.299)
2035	0.427	(0.048)	(0.276)	(1.568)	0.419	(0.481)	(0.563)	(1.591)	0.019	(0.246)	(0.072)	(0.299)
2036	0.427	(0.048)	(0.276)	(1.568)	0.419	(0.481)	(0.563)	(1.591)	0.019	(0.246)	(0.072)	(0.299)
2037	0.005	(0.001)	(0.004)	(0.020)	0.005	(0.006)	(0.007)	(0.020)	0.000	(0.003)	(0.001)	(0.004)
2038	0.005	(0.001)	(0.004)	(0.020)	0.005	(0.006)	(0.007)	(0.020)	0.000	(0.003)	(0.001)	(0.004)

Appendix 2: Cost of Policy per Vehicle Mile Traveled

Table 21: Cost per Vehicle Mile Traveled; Cars in Least Cost Scenario (2020¢/mile)

Year	Consumer Gasoline	Electricity	Consumer Diesel	CNG	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	0.0	(3.7)	(0.0)	(1.9)	1.6
2024	0.1	(3.7)	(0.0)	(1.8)	(2.4)
2025	0.2	(3.6)	0.0	(1.6)	(2.3)
2026	0.3	(3.5)	0.0	(1.5)	(2.3)
2027	0.4	(3.5)	0.1	(1.3)	(2.2)
2028	0.5	(3.4)	0.1	(1.2)	(6.2)
2029	0.6	(3.4)	0.2	(1.0)	(6.1)
2030	0.8	(3.3)	0.3	(0.9)	(6.0)
2031	0.9	(3.3)	0.4	(0.8)	(5.9)
2032	0.9	(3.3)	0.5	(0.7)	(5.9)
2033	0.9	(3.2)	0.5	(0.7)	(5.9)
2034	0.6	(1.8)	0.5	(0.3)	(3.4)
2035	0.0	(0.0)	0.0	(0.0)	(0.1)
2036	0.0	(0.0)	0.0	(0.0)	(0.1)
2037	0.0	(0.0)	0.0	(0.0)	(0.1)
2038	0.0	(0.0)	0.1	0.0	(0.1)

Table 22: Cost per Vehicle Mile Traveled; Light Duty Trucks in Least Cost Scenario (2020¢/mile)

Year	Consumer Gasoline	Electricity	Consumer Diesel	CNG	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	0.0	(3.7)	(0.1)	(2.0)	1.7
2024	0.1	(3.6)	(0.0)	(1.9)	(2.5)
2025	0.2	(3.6)	0.1	(1.8)	(2.5)
2026	0.3	(3.6)	0.1	(1.7)	(2.5)
2027	0.4	(3.6)	0.2	(1.5)	(2.4)
2028	0.5	(3.6)	0.3	(1.4)	(6.9)
2029	0.7	(3.5)	0.5	(1.2)	(6.8)
2030	0.8	(3.4)	0.6	(1.1)	(6.8)
2031	1.0	(3.4)	0.7	(0.9)	(6.7)
2032	1.0	(3.3)	0.7	(0.9)	(6.7)
2033	1.0	(3.3)	0.7	(0.9)	(6.7)
2034	0.7	(1.9)	0.6	(0.4)	(3.8)
2035	0.0	(0.0)	0.0	(0.0)	(0.1)
2036	0.0	(0.0)	0.0	(0.0)	(0.1)
2037	0.0	(0.0)	0.0	(0.0)	(0.1)
2038	0.0	(0.0)	0.0	0.0	(0.1)

Table 23: Cost per Vehicle Mile Traveled; Medium Duty Trucks in Least Cost Scenario (2020¢/mile)

Year	Consumer Gasoline	Consumer Diesel	Propane	Electricity	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	0.1	(0.4)	(4.3)	(8.6)	4.5
2024	0.3	(0.2)	(4.1)	(8.6)	(6.5)
2025	0.6	0.4	(3.9)	(8.3)	(6.3)
2026	1.0	0.9	(3.7)	(8.2)	(6.2)
2027	1.3	1.4	(3.5)	(8.1)	(6.0)
2028	1.8	2.2	(3.2)	(7.9)	(16.8)
2029	2.3	2.9	(2.8)	(7.8)	(16.5)
2030	2.7	3.6	(2.5)	(7.6)	(16.2)
2031	3.2	4.3	(2.2)	(7.4)	(16.0)
2032	3.2	4.2	(2.2)	(7.4)	(16.0)
2033	3.1	4.2	(2.2)	(7.3)	(16.0)
2034	2.2	3.3	(1.1)	(4.2)	(9.1)
2035	0.1	0.1	(0.0)	(0.1)	(0.2)
2036	0.1	0.1	(0.0)	(0.1)	(0.2)
2037	0.1	0.1	(0.0)	(0.1)	(0.2)
2038	0.1	0.1	(0.0)	(0.1)	(0.2)

Table 24: Cost per Vehicle Mile Traveled; Heavy Duty Trucks in Least Cost Scenario (2020¢/mile)

Year	Consumer Gasoline	Consumer Diesel	Propane	Electricity	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	(0.3)	0.2	(9.1)	(6.8)	(19.1)
2024	(0.1)	0.4	(8.7)	(6.5)	(18.9)
2025	0.3	0.8	(8.2)	(6.1)	(18.7)
2026	0.6	1.2	(7.7)	(5.6)	(18.4)
2027	0.9	1.6	(7.2)	(5.2)	(18.1)
2028	1.4	2.1	(6.5)	(4.5)	(17.8)
2029	1.9	2.7	(5.9)	(4.0)	(17.4)
2030	2.4	3.2	(5.3)	(3.4)	(17.2)
2031	2.8	3.8	(4.7)	(2.8)	(16.7)
2032	2.8	3.7	(4.6)	(2.8)	(16.6)
2033	2.8	3.6	(4.5)	(2.7)	(16.5)
2034	2.2	2.5	(2.2)	(1.2)	(9.4)
2035	0.1	0.1	(0.0)	(0.0)	(0.2)
2036	0.1	0.1	(0.0)	(0.0)	(0.2)
2037	0.1	0.1	(0.0)	(0.0)	(0.2)
2038	0.1	0.1	(0.0)	0.0	(0.2)

Table 25: Cost per Vehicle Mile Traveled; Cars in Accelerated Reduction Scenario (2020¢/mile)

Year	Consumer Gasoline	Electricity	Consumer Diesel	CNG	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	0.0	(3.7)	(0.0)	(1.9)	1.6
2024	0.1	(3.7)	(0.0)	(1.8)	(2.4)
2025	0.2	(3.6)	0.0	(1.6)	(2.3)
2026	0.3	(3.5)	0.0	(1.5)	(2.3)
2027	0.4	(3.5)	0.1	(1.3)	(2.2)
2028	0.5	(3.4)	0.1	(1.2)	(6.2)
2029	0.6	(3.4)	0.2	(1.0)	(6.1)
2030	0.8	(3.3)	0.3	(0.9)	(6.0)
2031	0.9	(3.3)	0.4	(0.8)	(5.9)
2032	0.9	(3.3)	0.5	(0.7)	(5.9)
2033	0.9	(3.2)	0.5	(0.7)	(5.9)
2034	1.7	(2.9)	1.3	0.1	(5.3)
2035	1.7	(2.9)	2.0	0.1	(5.3)
2036	1.7	(2.9)	3.1	0.1	(5.3)
2037	0.0	(0.0)	0.0	0.0	(0.1)
2038	0.0	(0.0)	0.1	0.0	(0.1)

Table 26: Cost per Vehicle Mile Traveled; Light Duty Trucks in Accelerated Reduction Scenario (2020¢/mile)

Year	Consumer Gasoline	Electricity	Consumer Diesel	CNG	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	0.0	(3.7)	(0.1)	(2.0)	1.7
2024	0.1	(3.6)	(0.0)	(1.9)	(2.5)
2025	0.2	(3.6)	0.1	(1.8)	(2.5)
2026	0.3	(3.6)	0.1	(1.7)	(2.5)
2027	0.4	(3.6)	0.2	(1.5)	(2.4)
2028	0.5	(3.6)	0.3	(1.4)	(6.9)
2029	0.7	(3.5)	0.5	(1.2)	(6.8)
2030	0.8	(3.4)	0.6	(1.1)	(6.8)
2031	1.0	(3.4)	0.7	(0.9)	(6.7)
2032	1.0	(3.3)	0.7	(0.9)	(6.7)
2033	1.0	(3.3)	0.7	(0.9)	(6.7)
2034	1.9	(2.9)	1.5	0.1	(6.0)
2035	1.9	(2.9)	1.5	0.1	(6.0)
2036	1.9	(2.9)	1.5	0.1	(6.0)
2037	0.0	(0.0)	0.0	0.0	(0.1)
2038	0.0	(0.0)	0.0	0.0	(0.1)

Table 27: Cost per Vehicle Mile Traveled; Medium Duty Trucks in Accelerated Reduction Scenario (2020¢/mile)

Year	Consumer Gasoline	Consumer Diesel	Propane	Electricity	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	0.1	(0.4)	(4.3)	(8.6)	4.5
2024	0.3	(0.2)	(4.1)	(8.6)	(6.5)
2025	0.6	0.4	(3.9)	(8.3)	(6.3)
2026	1.0	0.9	(3.7)	(8.2)	(6.2)
2027	1.3	1.4	(3.5)	(8.1)	(6.0)
2028	1.8	2.2	(3.2)	(7.9)	(16.8)
2029	2.3	2.9	(2.8)	(7.8)	(16.5)
2030	2.7	3.6	(2.5)	(7.6)	(16.2)
2031	3.2	4.3	(2.2)	(7.4)	(16.0)
2032	3.2	4.2	(2.2)	(7.4)	(16.0)
2033	3.1	4.1	(2.2)	(7.3)	(16.0)
2034	6.3	8.9	(0.6)	(6.5)	(14.2)
2035	6.2	8.8	(0.6)	(6.5)	(14.2)
2036	6.2	8.7	(0.6)	(6.5)	(14.2)
2037	0.1	0.1	(0.0)	(0.1)	(0.2)
2038	0.1	0.1	(0.0)	(0.1)	(0.2)

Table 28: Cost per Vehicle Mile Traveled; Heavy Duty Trucks in Accelerated Reduction Scenario (2020¢/mile)

Year	Consumer Diesel	Consumer Gasoline	Propane	CNG	Electricity	Hydrogen
	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile	¢/Mile
2023	(0.3)	0.2	(9.1)	(6.8)	(19.1)	24.4
2024	(0.1)	0.4	(8.7)	(6.5)	(18.9)	(34.6)
2025	0.3	0.8	(8.2)	(6.1)	(18.7)	(33.5)
2026	0.6	1.2	(7.7)	(5.6)	(18.4)	(32.3)
2027	0.9	1.6	(7.2)	(5.2)	(18.1)	(31.1)
2028	1.4	2.1	(6.5)	(4.5)	(17.8)	(86.7)
2029	1.9	2.7	(5.9)	(4.0)	(17.4)	(84.8)
2030	2.4	3.2	(5.3)	(3.4)	(17.2)	(82.9)
2031	2.8	3.8	(4.7)	(2.8)	(16.7)	(80.8)
2032	2.8	3.7	(4.6)	(2.8)	(16.6)	(80.1)
2033	2.8	3.6	(4.5)	(2.7)	(16.5)	(79.3)
2034	5.9	7.2	(1.2)	0.3	(14.6)	(69.7)
2035	5.8	7.1	(1.2)	0.3	(14.6)	(69.0)
2036	5.8	7.0	(1.2)	0.3	(14.5)	(68.3)
2037	0.1	0.1	(0.0)	0.0	(0.2)	(0.9)
2038	0.1	0.1	(0.0)	0.0	(0.2)	(0.9)