Memorandum

To: Bill Peters and Cory Ann Wind | Oregon DEQ

From: Philip Sheehy and Jeff Rosenfeld

Date: January 2017

Re: Task 2: 2014 Illustrative Compliance Scenarios Draft Report

Background

The objective of Task 2 of ICF's contract with Oregon DEQ is to update the 2014 illustrative compliance scenarios, develop new 2017 illustrative compliance scenarios to represent compliance for 2016-2025, and create a Scenario Adjustment Tool (SAT) so DEQ can perform minor periodic update to the scenarios. This memorandum presents the methodology and results for the updated 2014 illustrative compliance scenarios.

Introduction

In 2014, ICF developed four compliance scenarios based on two fuel scenarios (alternative vehicle technologies vs biofuel blending) and two different diesel baselines (B2 vs B5). Table 1 below shows the compliance scenario matrix.

Table 1. 2014 Compliance Scenarios

Compliance Scenarios	Scenario 1 – Advanced Vehicle Technology	Scenario 2 – Higher Biofuel Blending
B2 Diesel Baseline (2010)	1 – B2	2 – B2
B5 Diesel Baseline (2015)	1 – B5	2 – B5

This memorandum outlines the updates of Scenarios 1-B5 and 2-B5. Scenarios 1-B2 and 2-B2 were not updated since the Clean Fuels Program moved forward with a B5 program baseline.

Methodology

Scenario Updates

The November 2016 technical memo identified the following updates to the compliance scenarios

- Update the Oregon VISION model with the 2014 and 2015 calendar year vehicle purchases
- Utilize data from DEQ Clean Fuels Program (CFP) and EIA for biodiesel and ethanol volumes and feedstock types to understand the current use of biofuels and feedstocks
- Update the carbon intensities for conventional and alternative fuels and the compliance schedules

An additional update of consequence is the elimination of off-road diesel from the analysis. This update reduces the diesel pool consumption by 7.2%. In addition, the scenarios have not been updated for actual volumes from 2016 data. This analysis is an update of the 2014 illustrative compliance scenarios to reflect the above updates without looking at the programs current volumetric data.

VISION Updates

Consistent with the previous analysis, the AEO2014 US sales projections for light- (autos and trucks separately), medium-, and heavy-duty vehicles were scaled based on the latest 10 years of Oregon's proportion of US sales. The scaling for the original 2014 analysis was based on 2004-2013 data. The scaling for the updated 2014 illustrative compliance scenarios is based on 2006-2015 data. The table below shows Oregon's portion of US sales from the previous and current analysis.

Table 2. Oregon Portion of US Sales by Vehicle Class

Vehicle Class	2004-2013 Average of Oregon Portion of US Sales	2006-2015 Average of Oregon Portion of US Sales
Light-Duty Autos	1.01%	1.07%
Light-Duty Trucks	0.95%	0.91%
Medium-Duty Trucks (Class 3-6)	1.71%	2.29%
Heavy-Duty Trucks (Class 7-8)	1.04%	1.31%

The increased values for light-duty autos, light-duty trucks and heavy-duty trucks (Class 7-8) from the original 2014 analysis will result in the scenarios projecting higher baseline sales of these vehicles types for 2016 – 2025. The table below shows the approximate number and percent increase in vehicles for each class in 2025 when comparing the original 2014 illustrative compliance scenarios and the updated scenarios.

Table 3. Change in Projected Oregon Vehicle Population

Vehicle Class	Original 2014 Illustrative Compliance Scenarios 2025 Vehicle Population (1000's)	Updated 2014 Illustrative Compliance Scenarios 2025 Vehicle Population (1000's)	Percent Increase
Light-Duty Autos	1,388	1,478	6.5%
Light-Duty Trucks	1,186	1,131	-4.6%
Medium-Duty Trucks (Class 3-6)	87	116	34%
Heavy-Duty Trucks (Class 7-8)	56	66	18%

The VISION model utilizes national data to determine vehicle life expectancy and annual vehicle miles traveled (VMT) that ultimately combine with the Oregon fleet projections to determine fuel consumption. This data may not be consistent with Oregon's vehicle fleet and resulting projections for diesel fuel are consistently low due to high volume of pass through truck traffic. Calibration of the model is required to match historical Oregon fuel consumption with VISION results. The vision model was calibrated utilizing the same methodology as the original 2014 illustrative compliance scenarios. The figure below shows the result from calibrating the heavy-duty diesel consumption with a vehicle miles traveled (VMT) scaling factor of 1.69, an increase over the original 2014 scaling factor of 1.61. The EIA data has been updated since 2014 resulting in the actual data varying from the original 2014 adjusted VISION projections. The light-duty VMT scaling factor decreased from 1.05 to 1.01.

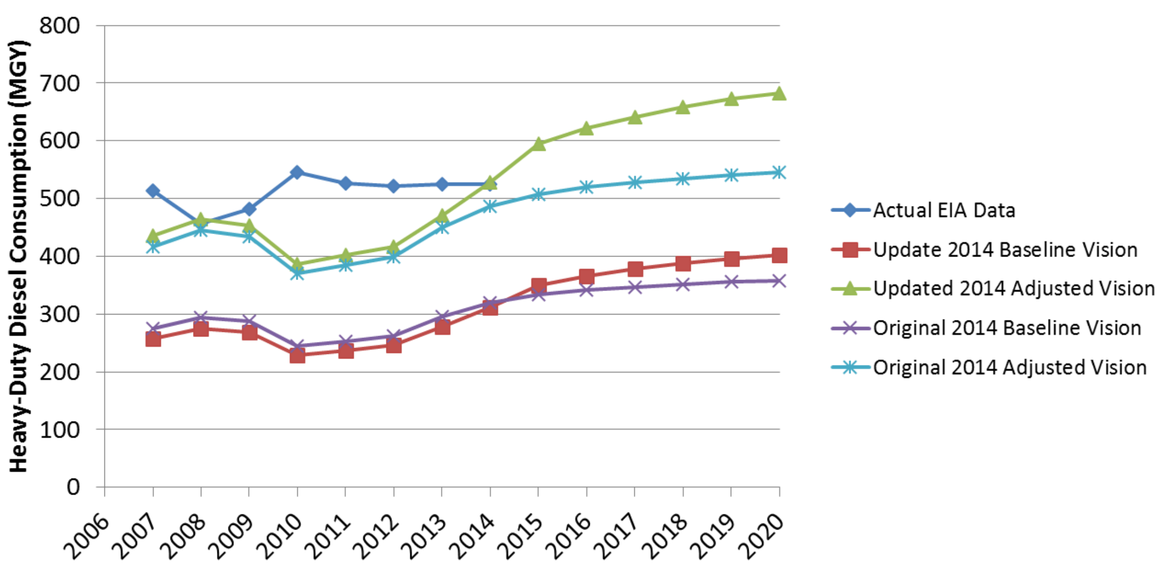

Figure 1 Actual Oregon and VISION Projected Heavy-Duty Diesel Consumption

The updates to the vehicle fleet and the VMT scaling factors result in a projected increase of diesel fuel consumption by 23% and gasoline fuel consumption of less than 1% over the original 2014 analysis in 2025.

Biofuel Feedstocks

DEQ supplied data for the first three quarters (Q1-Q3) of 2016 of biodiesel volumes reported by feedstock. The data shows the feedstock breakdown is currently 77% canola, 12% soy and 11% used cooking oil.

Carbon Intensity and Gasoline and Diesel Fuel Standard Updates

ICF made the carbon intensity updates shown in the table below based on approved pathways in the Clean Fuels Program.

Table 4. Original and Updated Carbon Intensities

Fuel	Original Carbon Intensity (gCO2e/MJ)	Updated Carbon Intensity (gCO2e/MJ)	Reason for Update
Gasoline Blendstock	89.40	100.77	Updated Baseline
ULSD	89.00	101.65	Updated Baseline
NW Corn Ethanol	80.10	53.81	Pathway for Pacific Columbia
MW Corn Ethanol	88.02	69.89	Pathway ETHCOR001
Low CI Corn Ethanol	69.20	57.58	Average of 4 approved NW ethanol pathways
Sugarcane Ethanol	52.94	51.04	Pathway ETHSOR001
MW Soybean BD	50.19	58.25	Pathway BIODOR001
NW Canola BD	68.94	57.84	Pathway BIODOR004
NW Yellow Grease BD	10.28	18.12	Pathway BIODOR002
Waste Oil RD	10.28	19.25	Pathway RNWDOR002
NW Tallow BD	16.85	37.93	Pathway BIODOR003
Tallow RD	16.85	19.25	Pathway RNWDOR003
CNG	71.41	79.93	Pathway ORCNG001
Electricity	154.98	120.27	OR-GREET Model
RNG (CNG)	25.00	40.00	Approved Pathways from California
Corn Oil BD	4.00	36.89	Pathway BIODOR005
Sorghum Ethanol	69.20	75.00	Approved Pathways from California

The gasoline and diesel standards for 2016-2025 were updated to the values shown in the table below.

Table 5. Gasoline and Diesel Standards

Fuel	Gasoline Standard (gCO2e/MJ)	Diesel Standard (gCO2e/MJ)
2016	98.37	99.39
2017	98.13	99.14
2018	97.63	98.64
2019	97.14	98.15
2020	96.15	97.15
2021	95.17	96.15
2022	93.69	94.66
2023	92.21	93.16
2024	90.73	91.67
2025	88.76	89.68

Review of 2014 Assumptions for Fuels that Substitute for Gasoline

The table below presents the assumptions for fuels that substitute for gasoline. These assumptions are consistent with the assumptions outlined in the original 2014 Task 3 report.

Table 6. Fuels That Substitute for Gasoline

Fuel	Assumption
Corn Ethanol, MW	The balance of ethanol consumed in Oregon will be MW corn
Corn Ethanol, NW	At the time of the 2014 report, the Boardman, OR ethanol facility (now Pacific Columbia) produced 26 million gallons of corn ethanol per year
Corn/Sorghum Ethanol, Low Carbon Intensity	Upwards of 100 million gallons per year of sorghum or low carbon intensity corn ethanol will be available to Oregon
Sugarcane Ethanol	Up to 50 million gallons per year of sugarcane ethanol could be consumed in Oregon
Cellulosic Ethanol	Consumption only if necessary to meet the standard
Electricity	For Scenario 1, ICF considered the potential for all PHEVs in the to be PHEV40s and not a split between PHEV10 and PHEV40
Natural Gas	The balance of natural gas consumed, after taking into account renewable natural gas, will be fossil
Renewable Natural Gas	It is assumed that up to 47 million DGE of biogas could be consumed, comparable to the Oregon in-state feedstock potential
Propane	It is assumed that propane consumption will reach a maximum of 1% of total natural gas consumption.

Review of 2014 Assumptions for Fuels that Substitute for Diesel

The table below presents the assumptions for fuels that substitute for diesel. These assumptions are consistent with the assumptions outlined in the original 2014 Task 3 report. There is also one technology, hybrid-electric vehicles (HEVs), in the diesel fleet that is included below.

Table 7. Fuels That Substitute for Diesel

Fuel	Assumption
Soy Biodiesel	Will be the balance biodiesel after accounting for the other feedstocks
Waste Grease/UCO Biodiesel	Will maintain the current waste grease portion of biodiesel consumption of 11% of all biodiesel consumed for as long as possible until more lower CI feedstocks are required
Canola Oil Biodiesel	Will maintain the current canola portion of biodiesel consumption of 77% of all biodiesel consumed for as long as possible until more lower CI feedstocks are required
Corn Oi Biodiesel	Corn oil biodiesel will be used as needed for the compliance scenarios
Renewable Diesel	A conservative assumption was made to remain at a an average statewide 2% blend with a maximum of 10 million gallons per year from tallow and the balance from waste oil
Natural Gas	It is assumed that up to 47 million diesel gallon equivalents of biogas, comparable to Oregon in-state feedstock potential, could be consumed. For Scenario 1, it is assumed that medium and heavy duty CNG vehicle sales increase to the point where 10% of diesel pool fuel consumption in 2025 is a combination of natural gas, biogas and LPG
Propane	It is assumed that propane consumption will reach a maximum of 1% of total natural gas consumption.
HEVs	In Scenario 1, the assumption is made that HEVs achieve 10% sales penetration in the medium- and heavy-duty markets. The business as usual (BAU) case and Scenario 2 do not included medium- and heavy-duty HEVs

Overview of Compliance Scenarios

Based on the updates described above for the alternative fuels available and vehicle populations, ICF developed two updated compliance scenarios that achieve compliance with the Clean Fuels Program by balancing the cumulative deficits and credits over the 10 year compliance period.

Table 8. Overview of Updated 2014 Illustrative Compliance Scenarios

	Updated Scenario 1B5	Updated Scenario 2B5	Assumptions for All Scenarios
Ethanol	Maintained E10 blend rate Maximum of 15 million gallons per year (MGPY) of sugarcane ethanol 100 MGPY of low carbon corn ethanol when needed	Maintained E10 blend rate Maximum of 27 million gallons per year (MGPY) of sugarcane ethanol 100 MGPY of low carbon corn ethanol when needed E85 utilized starting in 2021 increasing from 5% FFV miles on E85 to 25% in 2025	Maximums for achieving compliance: • Ethanol blend is E15 • FFVs 85% of miles on E85 • Sorghum-100 MGPY • Low CI Corn-150 MGPY • Sugarcane- 50 MGPY
Biodiesel (BD) / Renewable Diesel (RD)	Increased BD blend from 5% to 10% from 2019 to 2022 Maintained canola/soy/used oil ratios till 2018 when increased waste oil to 30 MGPY RD maintained at 2% with 10 MGPY from tallow and balance waste oil	Increased BD blend from 5% to 10% from 2017 to 2020 Increased waste oil to 25 MGPY in 2016 up to 50 MGPY in 2022 RD maintained at 2% with 10 MGPY from tallow and balance waste oil till 2020, then increased to 3% blend in 2021 and 4% in 2023	
Natural Gas	Natural gas vehicle market share increased till 10% diesel pool consumption is natural gas (18% market share in 2025) By 2021, 47 MGPY of NG from RNG	By 2019, 100% of natural gas from biogas, 14.5 MGPY in 2025	
Advanced Vehicles (PEVs / MD-HD HEVs)	All PHEVs are PHEV40 MD-HD HEV sales increased to 10% market share by 2025	Same as BAU	Achieves ZEV compliance BAU vehicle populations: 90,000 BEVs in 2025; 61,000 PHEV10 in 2025; 62,000 PHEV40 in 2025 185,000 PEVs in ZEV compliance years

Credits and Deficits

The figures on the following page show the annual credits and deficits generated for Scenarios 1-B5 and 2-B5. Each colored stacked bar represents credits generated from low carbon fuels; the blue line represents the deficits from forecasted gasoline blendstock and ultra-low sulfur diesel (ULSD) consumption. When the bars in years 2016-2021 exceed the blue line, annual credits exceed annual deficits and banked credits are generated for future compliance. When the bars fall short of the blue line in years 2022-2025, banked credits are used to meet annual compliance. The stacked bars are grouped by biofuels for blending at the bottom and advanced vehicle technologies at the top. Tables 8 and Table 9 below show the annual deficits and credits generated and cumulative (banked) credits and the cumulative credits and deficits in last column.

Table 9. Credits and Deficits: Banking in Scenario 1B5

Fuel		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Deficits (Millions)	Gasoline	-0.38	-0.42	-0.49	-0.56	-0.70	-0.84	-1.03	-1.22	-1.39	-1.61	-8.65
	Diesel	-0.24	-0.27	-0.33	-0.39	-0.49	-0.59	-0.74	-0.89	-1.04	-1.23	-6.20
Credits (Millions)	Gasoline subs	0.54	0.55	0.58	0.63	0.68	0.72	0.76	0.80	0.84	0.88	6.98
	Diesel subs	0.41	0.44	0.61	0.76	0.91	0.92	0.98	1.01	0.97	0.92	7.93
Balance		0.33	0.30	0.37	0.45	0.39	0.21	-0.03	-0.31	-0.61	-1.04	
Banked (net)		0.33	0.63	1.00	1.45	1.84	2.05	2.01	1.70	1.09	0.05	

Table 10. Credits and Deficits: Banking in Scenario 2B5

Fuel		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Deficits (Millions)	Gasoline	-0.38	-0.42	-0.49	-0.56	-0.70	-0.83	-1.02	-1.20	-1.37	-1.58	-8.55
	Diesel	-0.24	-0.27	-0.33	-0.39	-0.50	-0.61	-0.78	-0.95	-1.12	-1.36	-6.55
Credits (Millions)	Gasoline subs	0.54	0.55	0.56	0.60	0.63	0.68	0.73	0.79	0.84	0.89	6.81
	Diesel subs	0.51	0.56	0.64	0.71	0.85	0.94	0.98	1.06	1.04	1.02	8.31
Balance		0.43	0.42	0.38	0.36	0.28	0.18	-0.09	-0.31	-0.61	-1.03	
Banked (net)		0.43	0.85	1.23	1.59	1.87	2.05	1.96	1.65	1.05	0.02	

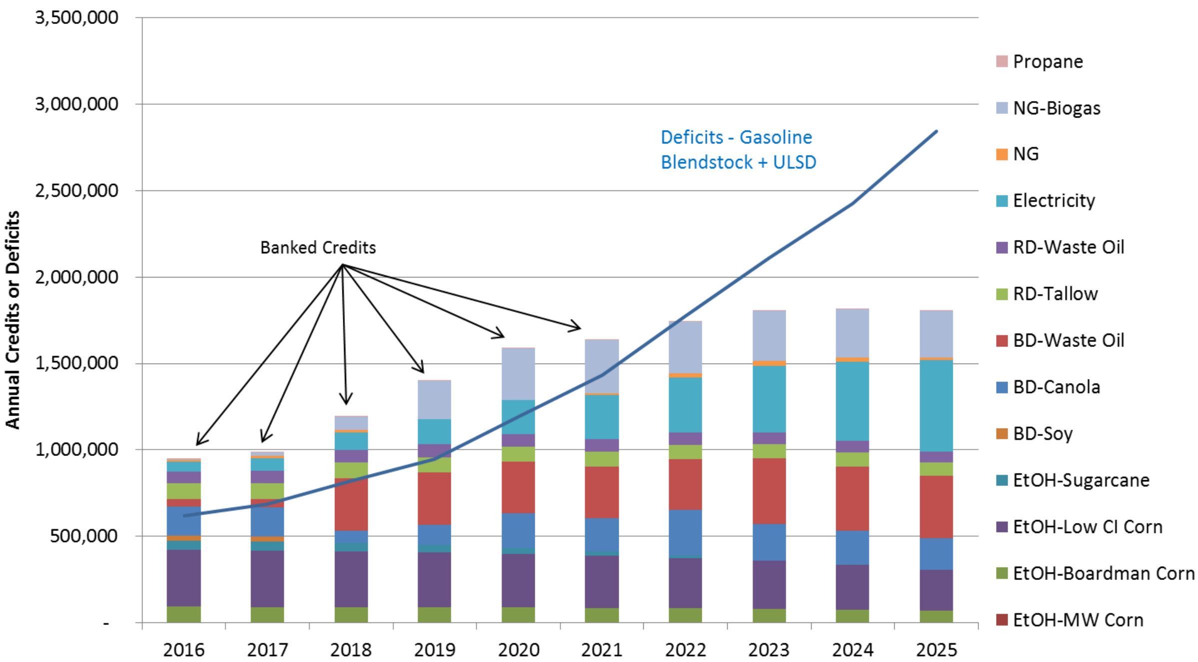

Figure 2. Balance of Credits and Deficits in Scenario 1-B5

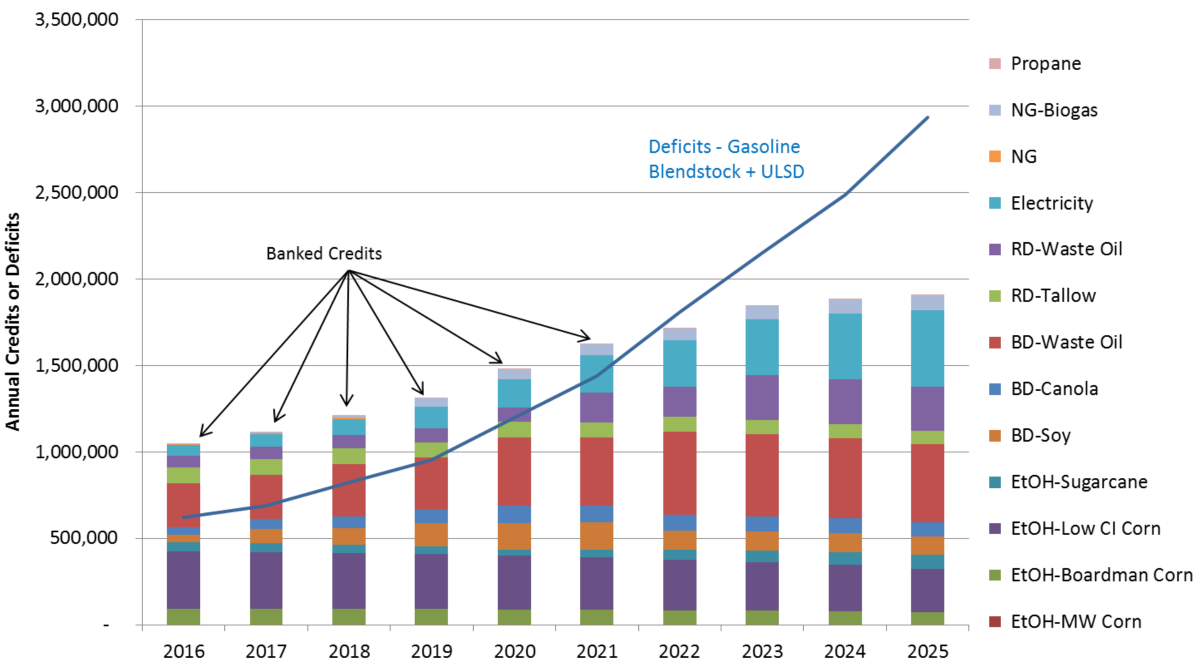

Figure 3. Balance of Credits and Deficits in Scenario 2-B5

Fuel Volumes

Ethanol Volumes

The table below identifies the volumes of ethanol, broken down by feedstock, for both Scenarios 1-B5 and 2-B5.

Table 11. Ethanol Volumes (in millions of Gallons) in Scenario 1-B5

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Corn, MW	0	0	0	0	0	0	0	0	0	0
Corn, NW	26	26	26	26	26	26	26	26	26	26
Corn, Low CI	100	100	100	100	100	100	100	100	97	93
Sugarcane	14	14	13	12	9	7	4	0	0	0
Sorghum	0	0	0	0	0	0	0	0	0	0
Total	140	140	139	138	135	133	130	126	123	119
% EtOH in Gasoline	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
% FFVs VMT on E85	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 12. Ethanol Volumes (in millions of Gallons) in Scenario 2-B5

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Corn, MW	0	0	0	0	0	0	0	0	0	0
Corn, NW	26	26	26	26	26	26	26	26	26	26
Corn, Low CI	100	100	100	100	100	100	100	100	100	100
Sugarcane	14	14	13	11	9	13	17	20	24	27
Sorghum	0	0	0	0	0	0	0	0	0	0
Total	140	140	139	137	135	139	143	146	150	153
% EtOH in Gasoline	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
% FFVs VMT on E85	0%	0%	0%	0%	0%	5%	10%	15%	20%	25%

Biodiesel Volumes

The table below identifies the volumes of biodiesel, broken down by feedstock, for both in Scenarios 1-B5 and 2-B5.

Table 13. Biodiesel Volumes (in millions of Gallons) in Scenario 1-B5

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Soy	5	5	0	0	0	0	0	0	0	0
Canola	32	33	13	22	40	40	58	47	46	45
Waste Oil	5	5	30	30	30	30	30	40	40	40
Total	42	43	43	52	70	70	88	87	86	85
Biodiesel Blend %	5%	5%	5%	6%	8%	8%	10%	10%	10%	10%

Table 14. Biodiesel Volumes (in millions of Gallons) in Scenario 2-B5

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Soy	8	16	19	28	32	33	24	25	26	26
Canola	9	11	13	15	20	20	20	20	20	20
Waste Oil	25	25	30	30	40	40	50	50	50	50
Total	42	52	62	72	92	93	94	95	96	96
Biodiesel Blend %	5%	6%	7%	8%	10%	10%	10%	10%	10%	10%

Renewable Diesel Volumes

The table below identifies the volumes of renewable diesel, broken down by feedstock, for both in Scenarios 1-B5 and 2-B5.

Table 15. Renewable Diesel Volumes (in millions of Gallons) in Scenario 1-B5

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tallow	10	10	10	10	10	10	10	10	10	10
Waste Oil	7	7	7	7	7	7	7	7	7	7
Total	17	17	17	17	17	17	17	17	17	17
RD Blend %	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%

Table 16. Renewable Diesel Volumes (in millions of Gallons) in Scenario 2-B5

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tallow	10	10	10	10	10	10	10	10	10	10
Waste Oil	7	7	8	8	8	18	18	28	28	28
Total	17	17	18	18	18	28	28	38	38	38
RD Blend %	2%	2%	2%	2%	2%	3%	3%	4%	4%	4%

Natural Gas/LPG

The tables below show the natural gas/LPG and biogas consumption in million DGE where market share was increased to achieve 10% diesel pool consumption of natural gas/LPG/biogas in 2025.

Table 17. Natural Gas/LPG Volumes (in millions of DGE) in Scenario 1-B5

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
NG/LPG	6	10	11	0	0	11	24	39	55	73
Biogas	1	3	11	33	45	47	47	47	47	47
Total	7	13	22	33	45	58	71	86	102	120

Table 18. Natural Gas/LPG Volumes (in millions of DGE) in Scenario 2-B5

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
NG/LPG	3	4	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Biogas	0.3	1	1	7	8	9	10	12	13	15
Total	3	4	6	7	8	9	11	12	13	15

Electricity

The table below shows the electricity consumption from BEVs and PHEVs in million GGE for Scenarios 1-B5 and 2-B5.

Table 19. Electricity Consumption (in millions of GGE) in Scenarios 1-B5 and 2-B5

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Scenario 1-B5	2.3	2.7	3.9	5.6	7.7	10.3	13.2	16.3	19.8	23.8
Scenario 2-B5	2.3	2.7	3.6	4.8	6.6	8.6	11.0	13.6	16.6	19.9

GHG Emission Reductions

Table 20 shows the annual full lifecycle GHG emissions in million metric tons from transportation fuels from 2016 to 2025 and cumulatively over the compliance period from 2016 to 2025. These emissions include all stages of the fuel lifecycle that are incorporated in the carbon intensity values. Table 21 shows the actual and percent GHG reductions annually from 2016 to 2025 and cumulatively over the compliance period from 2016 to 2025.

Table 20. Annual GHG Emissions (million metric tons)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
BAU	28.12	28.42	28.61	28.69	28.63	28.51	28.37	28.15	27.89	27.63	283.02
Scenario 1-B5	27.79	28.07	28.08	27.98	27.74	27.59	27.32	27.02	26.71	26.40	274.71
Scenario 2-B5	27.70	27.95	28.05	28.05	27.82	27.57	27.35	26.99	26.69	26.39	274.56

Table 21. GHG Emissions Reductions from the BAU (million metric tons and Percent)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Scenario 1-B5	0.33	0.35	0.53	0.71	0.89	0.92	1.05	1.13	1.18	1.22	8.31
Scenario 1-B5	1.2%	1.2%	1.8%	2.5%	3.1%	3.2%	3.7%	4.0%	4.2%	4.4%	2.9%
Scenario 2-B5	0.43	0.48	0.56	0.64	0.80	0.94	1.02	1.16	1.20	1.23	8.46
Scenario 2-B5	1.5%	1.7%	2.0%	2.2%	2.8%	3.3%	3.6%	4.1%	4.3%	4.5%	3.0%

The reductions in Table 20 are compared to the BAU (which includes the ZEV Program and increased light-duty fuel economy standards) and only represent those reductions that would be directly attributed to the Clean Fuels Program. Both of the baseline scenarios achieved similar cumulative reductions which were expected since the compliance period was looking to achieve the same carbon intensity reductions. The original 2014 scenarios achieved cumulative reductions of 3.1% and 3.0% for Scenarios 1-B5 and 2-B5, respectively.

Conclusions

The following are key highlights from the 2014 Updated Illustrative Compliance Scenarios:

- Over-compliance in the early years of the program reduces the need for new infrastructure (e.g. E85, liquid fuel storage), international biofuels (i.e. imported RD) and reduces compliance costs. Credits can be banked and traded later and do not lose their value. Banking credits when the standard is lower reduces compliance costs and eases compliance in later years. In the scenarios, between 20-40% of the credits are banked annually in years 1-5, which is lower that what was seen in the CA LCFS (35-59% annual credits banked in years 1-5).

- The Clean Fuels Program can be achieved through a diverse fuel supply. All of the scenarios required a combination of ethanol, biodiesel and renewable diesel from various feedstocks, electricity, natural gas, renewable natural gas, and propane for compliance.
- Eight (8) years of overlap between the post-2017 Zero Emission Vehicle (ZEV) Program eases the burden of compliance. The ZEV Program generates between 14-17% of the cumulative credits needed over the compliance period. California only overlaps three (3) years with the post-2017 ZEV Program which limits the contribution ZEVs can have towards compliance in their LCFS.
- Renewable natural gas is a key fuel for Clean Fuels Standard compliance. In the advanced technology scenarios, renewable natural gas generated almost as many credits as electricity. In addition, Oregon has significant in-state potential for renewable natural gas production.
- Without blend limitations and infrastructure requirements, renewable diesel, even in small volumes, is necessary for compliance.