Task 2 – Illustrative Compliance Scenarios

Final Report

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Submitted to:
Oregon Department of Environmental Quality

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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 the available compliance options from 2016-2025, and create a Scenario Adjustment Tool (SAT) so DEQ can perform minor periodic update to the scenarios. This report presents the methodology and results for the 2017 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.

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

Table 1. 2014 Compliance Scenarios

The 2017 Illustrative Compliance Scenarios build on the 2014 scenarios. Since DEQ moved forward with a B5 baseline, for the rest of the report we will remove the B2 and B5 nomenclature and call the scenarios – Scenario 1 and Scenario 2. The underlying premise of each scenario remains the same where Scenario 1 relies on advanced vehicle technologies (e.g. plug-in electric vehicles (PEVs), natural gas vehicles (NGVs), and heavy-duty hybrid electric vehicles (HEVs)) and Scenario 2 relies on a higher blending of biofuels.

Also added to this analysis is Scenario 3. Unlike Scenarios 1 and 2 which look at the minimal avenues to compliance (total credits balancing total deficits) over the ten year compliance period, Scenario 3 looks past 2025 to 2026 and 2027 where a 10% carbon intensity reduction is maintained. Scenario 3 also limits credit banking in the early and uses a hybridized approach towards the potential across alternative fuels to contribute to carbon intensity reductions and generation of credits.

VISION Modeling

ICF updated the Oregon VISION model with the AEO2016 Base Case VISION model projections for values including annual vehicle sales and new vehicle fuel economy. This updated model was used for the 2017 Illustrative Compliance scenarios. Consistent with the previous analysis, US sales projections for light- (autos and trucks separately), medium-, and heavy-duty vehicles were scaled based on the latest 10 years (2006-2015) of Oregon's proportion of US sales. Table 2 below shows Oregon's portion of US sales based on the updated AEO2016 projections.

Vehicle Class	10yr Average of Oregon Portion of AEO2016 US Sales
Light-Duty Autos	1.08%
Light-Duty Trucks	0.93%
Medium-Duty Trucks (Class 3-6)	2.35%
Heavy-Duty Trucks (Class 7-8)	1.36%

Table 2. Oregon Portion of US Sales by Vehicle Class

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 the 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 by scaling it to actual VMT so that approximate historical fuel consumption match as closely as possible.

The figures below show the results from calibrating the light-duty gasoline consumption and heavy-duty diesel consumption with a vehicle miles traveled (VMT) scaling factors of 1.01 and 1.66, respectively. The figures also includes the adjusted fuel consumption projections from the updated 2014 illustrative compliance scenarios for comparison.

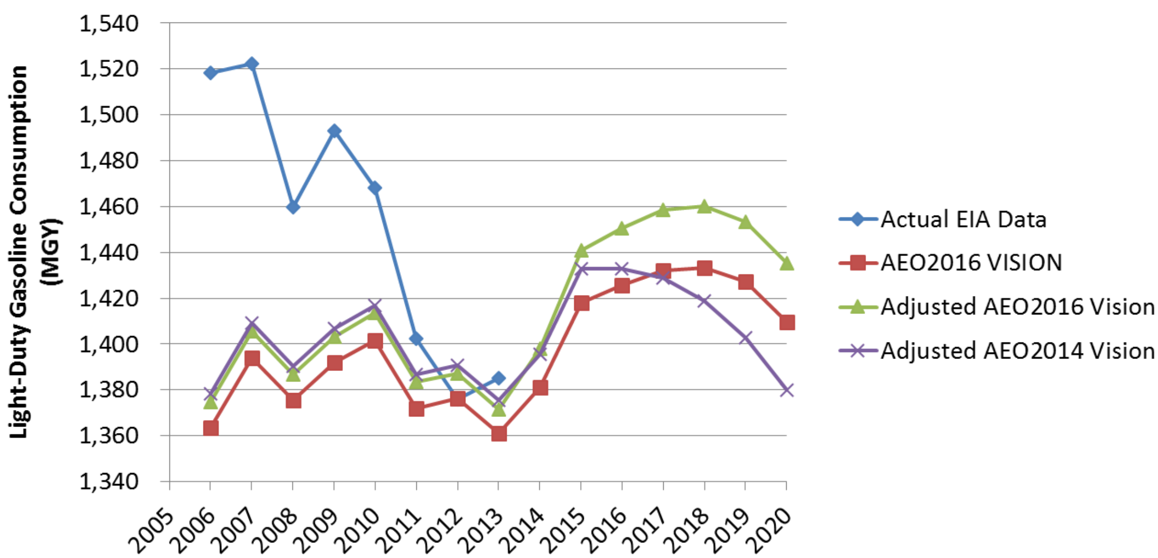

Figure 1 Actual Oregon and VISION Projected Light-Duty Gasoline Consumption

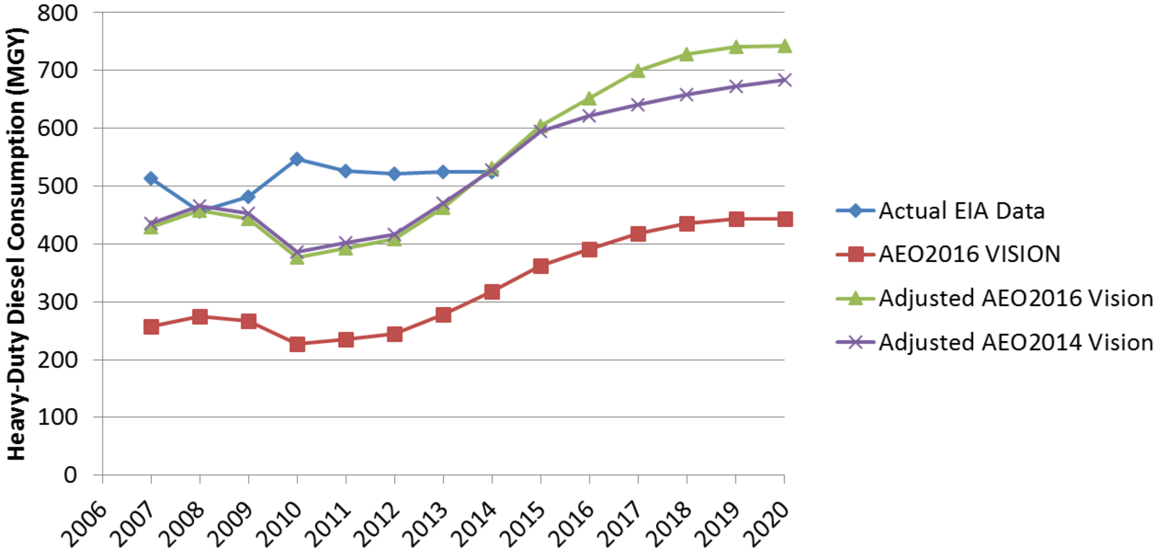

Figure 2 Actual Oregon and VISION Projected Heavy-Duty Diesel Consumption

Figures 1 and 2 above show that AEO2016 has more aggressive sales projections for light, medium and heavy duty vehicles than AEO2014 resulting in increased projected fuel consumption.

Clean Fuels Standards

The gasoline and diesel standards for 2016-2025 are shown in the table below.

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
2026[1]	*88.76*	*89.68*
2027	*88.76*	*89.68*

Table 3. Gasoline and Diesel Standards

Vehicle Populations

PEV Vehicle Populations – Zero Emission Vehicle (ZEV) Mandate

The California Air Resources Board recently published an Advanced Clean Cars Midterm Review[2]. In this review ARB developed three compliance scenarios for California and for Section 177 (S177) ZEV States, states that are administering the California ZEV requirements pursuant to section 177 of the federal Clean Air Act. There are currently nine (9) S177 states: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont.

Table 4 compares the total plug-in electric vehicle (PEV), battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) sales from 2011-2016 as tracked by ZEV Fact sales dashboard[3].

[1] For Scenario 3, it is assumed that the 2025 standard of a 10% carbon intensity reduction remains in place.
[2] https://www.arb.ca.gov/msprog/acc/acc-mtr.htm
[3] http://www.zevfacts.com/sales-dashboard.html

State	Total PEV Sales	BEV Sales	PHEV Sales
CT	4,903	1,832	3,070
ME	1,134	203	931
MD	7,863	2,892	4,971
MA	8,467	3,262	5,205
NJ	10,946	3,991	6,955
NY	19,274	5,497	13,777
OR	10,825	6,600	4,225
RI	841	236	605
VT	1,521	305	1,216
OR % of S177 States	16.5%	26.6%	10.3%

Table 4. 2011-2016 ZEV Sales from ZEV Facts for S177 States

The results from the three scenarios developed by ARB for the S177 States are shown in Table 5 below. The names of the scenarios are Mid Range, Low Tech and High Tech.

Year	Mid Range Scenario		Low Tech Scenario		High Tech Scenario	
	BEV Sales	PHEV Sales	BEV Sales	PHEV Sales	BEV Sales	PHEV Sales
2018	9,863	58,654	3,075	27,860	8,703	45,498
2019	18,743	72,614	7,375	36,767	17,712	59,598
2020	29,505	92,374	13,702	65,734	29,320	72,356
2021	39,078	105,304	9,962	73,569	41,810	81,066
2022	42,699	109,491	14,391	88,042	44,891	90,212
2023	48,698	119,000	16,862	98,286	52,327	97,958
2024	54,081	127,766	19,208	108,163	60,452	105,116
2025	59,200	136,668	21,548	118,308	68,891	112,311

Table 5. ARB Forecasted Annual PEVs Sales for S177 States

The Low Tech Scenario assumes a lower percentage of auto makers are making only ZEVs than the High Tech Scenario resulting the Low Tech Scenario relying heavily on PHEVs and increased used of banked credits. Since over 16% of total S177 PEV sales have occurred in Oregon but over 26% of BEV sales have been in Oregon, ICF made the assumption to apply Oregon's share of current PEV sales to the High Tech Scenario to forecast Oregon's PEV sales from the ZEV Mandate.

Table 6 below shows Oregon forecasted PEV sales and their percentage of forecast light-duty vehicle sales. For Scenario 3, ICF forecasted 2026 and 2027 sales assuming a similar increase in annual sales as from 2024 to 2025.

Year	Oregon PEV Forecast		% of Light-Duty Vehicle Sales
	BEV Sales	PHEV Sales	
2018	1,432	7,488	5%
2019	2,915	9,809	7%
2020	4,825	11,908	10%
2021	6,881	13,342	12%
2022	7,388	14,847	13%
2023	8,612	16,122	15%
2024	9,949	17,300	16%
2025	11,338	18,484	17%
2026[4]	*12,921*	*19,749*	*19%*
2027	*14,724*	*21,101*	*21%*

Table 6. Oregon Forecasted Annual PEVs Sales Resulting from the ZEV Mandate

ICF assumed that there will be a 50/50 split between PHEV10 and PHEV40. An important update from AEO2016 that will have an effect on the scenarios is an update to the percent vehicle miles traveled (VMT) that PHEV40 operate in all electric mode. In AEO2014 the all-electric mile VMT was 54% but AEO2016 has an updated value of 62%. Each PHEV40 will now consume 15% more electricity and 17% less gasoline.

Medium- and Heavy-Duty Vehicle Populations

In Scenario 1, the assumption is made that HEVs achieve 10% sales penetration and natural gas 6.5% sales penetration in the medium- and heavy-duty markets by 2025. The business as usual (BAU) case and Scenario 2 do not included medium- and heavy-duty HEVs. Scenario 3 increases the sales penetration of HEVs from 10 to 12% and natural gas vehicles from 6.5% to 8% in the medium- and heavy-duty markets from 2025 to 2027.

Additional Electric Vehicles

Credits from other sources of electricity including transit buses, forklifts and fixed guideway were also included in the scenarios. The credits included were using a similar methodology to the Task 3 Additional Electrification report, but instead of a 2015 baseline, the credits were calculated using a 2012 baseline for technologies using a fuel displacement credit calculation methodology for forklifts and fixed guideway.

For Scenarios 1 and 2, the conservative assumption was made of 100 electric transit buses in Oregon in 2025 and linear interpolation from 5 transit buses this year and an estimated 15 total electric transit buses in 2018. For Scenario 3, a more aggressive assumption was made of 150

[4] ICF forecasted values for 2026 and 2027. Values 2018 – 2025 are based on the Advanced Clean Cars Midterm Review.

electric transit buses by 2022 and continuing that growth till 2027 where there would be 320 total electric transit buses.

Table 7 below includes the credits generated from transit buses starting in 2017 (using an EER of 2.7 in 2017 and 4.2 from 2018+), credits from fixed guideway starting in 2018 and credits from forklifts in 2019.

Year	Transit Buses – Scenarios 1/2	Transit Buses – Scenario 3	Forklifts	Fixed Guideway	Scenario 1/2 Total	Scenario 3 Total
2017	265	265			265	265
2018	1,583	1,583		18,741	20,324	20,324
2019	2,829	5,134	81,196	18,847	102,872	105,177
2020	4,028	8,572	90,311	18,792	113,131	117,675
2021	5,190	11,907	91,922	18,732	115,844	122,561
2022	6,270	14,928	92,813	18,509	117,591	126,250
2023	7,295	17,896	93,639	18,272	119,205	129,807
2024	8,266	20,713	94,438	18,028	120,732	133,179
2025	9,201	23,188	94,374	17,605	121,181	135,167
2026	N/A	26,316	99,224	17,845	N/A	143,386
2027	N/A	29,445	104,289	18,088	N/A	151,821

Table 7. Annual and Total Credit Generation Potential from Fixed Additional Electricity

Fuel Availability

Carbon Intensity

Table 8 on the following page shows the carbon intensities and gasoline and diesel fuel standards utilized for the 2017 illustrative compliance scenarios which are consistent with the carbon intensities utilized for the updated 2014 illustrative compliance scenarios.

Fuel	Carbon Intensity (gCO2e/MJ)
Gasoline Blendstock	100.77
ULSD	101.65
NW Corn Ethanol	53.81
MW Corn Ethanol	69.89
Low CI Corn Ethanol	57.58
Sugarcane Ethanol	51.04
MW Soybean BD	58.25
NW Canola BD	57.84
NW Yellow Grease BD	18.12
Waste Oil RD	19.25
NW Tallow BD	37.93
Tallow RD	19.25
CNG	79.93
Electricity	120.27
RNG (CNG)	40.00
Corn Oil BD	36.89
Sorghum Ethanol	75.00

Table 8. Oregon Clean Fuel Program Carbon Intensities

Assumptions for Fuels that Substitute for Gasoline

For ethanol, there is corn ethanol production capacity of over 200 million gallons per year within the Pacific Northwest Region consisting of Oregon, Washington and Idaho. These producers fall into the category of NW corn ethanol with carbon intensities ranging from 53.81-54.00 g/MJ. In the scenarios below, the total volume of NW corn ethanol consumed never exceeds 103 MGY so there is ample supply in the region.

For renewable natural gas (RNG), the limitation for consumption in Oregon is dependent on demand and not supply. There is sufficient supply from landfills, wastewater treatment plants and other sources like waste feedstock digesters in the U.S. to achieve demand. In 2016, RNG generated over 188 million D3 RINs[5] which are equivalent to approximately 114 million diesel gallon equivalents (DGE). California consumed 87 million DGEs of that volume leaving almost 30 million DGEs available to generate CFP credits in Oregon.

Table 9 below presents the assumptions for fuels that substitute for gasoline.

[5] https://www.epa.gov/fuels-registration-reporting-and-compliance-help/2016-renewable-fuel-standard-data

Fuel	Assumption
Corn Ethanol, NW	Pacific Ethanol Columbia has a production capacity of 40 MGPY and all of it would stay in Oregon.
Corn/Sorghum Ethanol, Low CI	An additional 160 MGPY of capacity exists in the Pacific NW region in addition to the Pacific Ethanol Columbia facility and up to 150 MGPY of low CI corn ethanol would be available to Oregon.
Corn Ethanol, MW	The balance of ethanol needed will be MW corn.
Sugarcane Ethanol	Up to 50 million gallons per year of sugarcane ethanol would be available to Oregon.
Cellulosic Ethanol	Will be consumed if necessary to meet the standard.
Electricity	For Scenario 1, all PHEVs to be PHEV40s.
Renewable Natural Gas (RNG)	For Scenario 1, up to 90% of natural gas consumption could be from RNG. For Scenario 2, up to 99% could be from RNG.
Natural Gas	The balance of natural gas consumed will be fossil.
Propane	Maximum of 1% of total natural gas consumption.

Table 3. Fuels That Substitute for Gasoline

Assumptions for Fuels that Substitute for Diesel

For biodiesel, the national biodiesel production capacity is in excess of 2.3 billion gallons per year[6]. In 2016, 1.568 billion gallons of biodiesel were produced, with approximately 10% from canola oil, 10% from corn oil, 10% from animal fat or tallow and 12.6% from waste grease or used cooking oil[7].

Table 10 presents the assumptions for fuels that substitute for diesel.

[6] https://www.eia.gov/biofuels/biodiesel/production/biodiesel.pdf
[7] https://www.eia.gov/biofuels/biodiesel/production/table3.pdf

Fuel	Assumption
Canola Oil Biodiesel	Maintain the current canola portion of biodiesel consumption of 77%.
Waste Grease/UCO Biodiesel	Maintain the current waste grease/used cooking oil portion of biodiesel consumption of 11%.
Soy Biodiesel	Will be the balance biodiesel after accounting for the other feedstocks.
Corn Oil Biodiesel	Will be consumed if necessary to meet the standard.
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
Renewable Natural Gas (RNG)	Up to 90% of natural gas consumption could be from RNG.
Natural Gas	The balance of natural gas consumed will be fossil.
Propane	Maximum of 1% of total natural gas consumption.

Table 4. Fuels That Substitute for Diesel

Overview of Compliance Scenarios

Based on the assumptions described above for the fuels available and vehicle populations, ICF developed two compliance scenarios that achieve compliance with the Clean Fuels Program by balancing the cumulative deficits and credits over the 10 year compliance period. Scenario 3 is a hybrid of Scenario 1 (advanced technology) and Scenario 2 (high biofuels) that minimizes early banking of credits while looking at the compliance requirements for 2026 and 2027 and looks at the potential of all technologies and fuels to contribute without the constraint of balancing total deficits and total credits at the end of 2025.

Table 11 summarizes the assumptions for each scenario.

Maximums for Scenario Assumptions	2017 Scenario 1 (Advanced Technology)	2017 Scenario 2 (High Biofuels)	2017 Scenario 3 (Hybrid)
Ethanol: • Max ethanol blend is E15 • NW Corn - 40 MGPY max • Low CI Corn - 150 MGPY max • Sugarcane - 50 MGPY max • Max 85% of FFV miles on E85	• Maintained E10 blend rate • 40 MGPY of NW corn • Balance from low CI corn ethanol (max 102 MGPY) • No sugarcane ethanol	• Maintained E10 blend rate • 40 MGPY of NW Corn • Low CI corn ethanol when needed • No sugarcane ethanol	• Maintained E10 blend rate • 40 MGPY of NW corn • Balance from low CI corn ethanol (max 102 MGPY) • Starting in 2024, 50 MGY of sugarcane ethanol • Ramped up E85 consumption by 5% per year starting in 2023, ending with 25% FFV VMT from E85 in 2027
Biodiesel (BD): • Max BD blend is B10 • Waste Oil BD – 50 MGPY max Renewable Diesel (RD): • Max RD blend is R5 • Tallow RD - 10 MGPY max • Waste Oil RD - 50 MGPY max	• Increased BD blend from 5% to 9% from 2017 to 2025 • Maintained canola/soy/used oil ratios until 2018 • Increase waste oil BD to 15 MGPY in 2018, max 30 MGPY in 2025 • RD maintained at 2% • 10 MGPY from tallow and balance waste oil	• Increased BD blend from 5% to 10% from 2017 to 2020 • Increased waste oil BD to 25 MGPY in 2017 up to 50 MGPY in 2022 • RD maintained at 2% then increased to 3% blend till 2025 • 10 MGPY from tallow and balance waste oil till 2021	• Increased BD blend from 5% to 10% from 2019 to 2025 • Increased waste oil BD to 25 MGY in 2021 up to 50 MGY in 2027 • RD increased from 2% to 5% of diesel pool from 2020 to 2025 • 10 MGY from tallow and balance from waste oil
Natural Gas (NG):	• The NG MD and HD new vehicle market share was increased steadily from 2017 (1%) till 2022 (6.5%) and staying constant resulting in 5% of diesel pool consumption being NG in 2025 • By 2019, 90% of NG from biogas	• BAU vehicle market share • By 2019, 100% of NG from biogas, 11.1 MGPY in 2025	• The NG MD and HD new vehicle market share was increased steadily from 2017 (1%) till 2027 (8%) resulting in 6% of diesel pool consumption being NG in 2027 • By 2019, 90% of NG from biogas

Advanced Vehicles:
• Achieves ZEV compliance
• BAU vehicle populations in 2025:
  ▪ 70,000 BEVs
  ▪ 62,000 PHEV10
• 62,000 PHEV40 163,000 PEVs in ZEV compliance years
	• All PHEVs are PHEV40
	• MD-HD HEV sales increased to 10% market share by 2025
		Same as BAU	• All PHEVs are PHEV40
			• MD-HD HEV sales increased to 10% market share by 2025 and 12% by 2027

Table 5. Overview of 2017 Illustrative Compliance Scenarios

2016 Clean Fuels Program Data

ICF used actual information reported to DEQ for 2016 for the following:

- The biodiesel feedstock breakdown is currently 77% canola, 12% soy and 11% used cooking oil. This information was used to establish the assumptions of what carbon intensities were used to calculate compliance with the standards.
- The percentage of fuel being imported as B5 or E10 was 12.5% and 1.8%, respectively, in 2016. Since DEQ established default B5 and E10 carbon intensities, there is a slight difference in credit generation due to the use of different carbon intensities of the ethanol and biodiesel portions of the finished fuels. For the ethanol portion of the default E10, the carbon intensity is 69.89 versus 58.58 for a typical low CI corn. Similarly, for the biodiesel portion of the default B5, the carbon intensity is 58.25 versus 57.84 for a typical

NW canola biodiesel. Using the B5/E10 carbon intensities typically results in less credits than by specifying the actual biodiesel/ethanol used.

To test the potential impact of this, ICF ran Scenario 2 (higher biofuels) using the current volume of finished B5/E10 as reported to DEQ in 2016 and another run if the B5/E10 were reported with their typical biodiesel/ethanol. This resulted in less than a 0.2% difference in the generation of credits so it is not a critical issue impacting credit generation.

Results

Credits and Deficits

For each scenario, a table and a figure are presented. The tables show the annual credits and deficits generated and cumulative (banked) credits and the cumulative credits and deficits in last column. The figures show the same information but in a stacked bar chart. Each colored stacked bar represents credits generated from low carbon fuels; the stacked bars are grouped by biofuels for blending at the bottom and advanced vehicle technologies at the top. 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 black credit bank line was added to Scenario 3 to highlight the size of the credit bank.

Scenario 1: Advanced Technologies

	Fuel	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Deficits (Millions)	Gasoline	-0.39	-0.42	-0.51	-0.58	-0.73	-0.87	-1.08	-1.28	-1.46	-1.70	-9.01
	Diesel	-0.21	-0.30	-0.37	-0.43	-0.56	-0.68	-0.86	-1.04	-1.21	-1.42	-7.15
Credits (Millions)	Gasoline subs	0.51	0.59	0.64	0.70	0.76	0.83	0.89	0.95	1.01	1.06	7.98
	Diesel subs	0.27	0.53	0.65	0.85	0.89	0.94	1.00	1.03	1.03	1.05	8.21
Balance		0.18	0.40	0.41	0.53	0.35	0.21	-0.05	-0.33	-0.63	-1.02	
Banked (net)		0.18	0.58	0.99	1.52	1.88	2.09	2.04	1.70	1.07	0.05	

Table 6. Credits and Deficits: Banking in Scenario 1

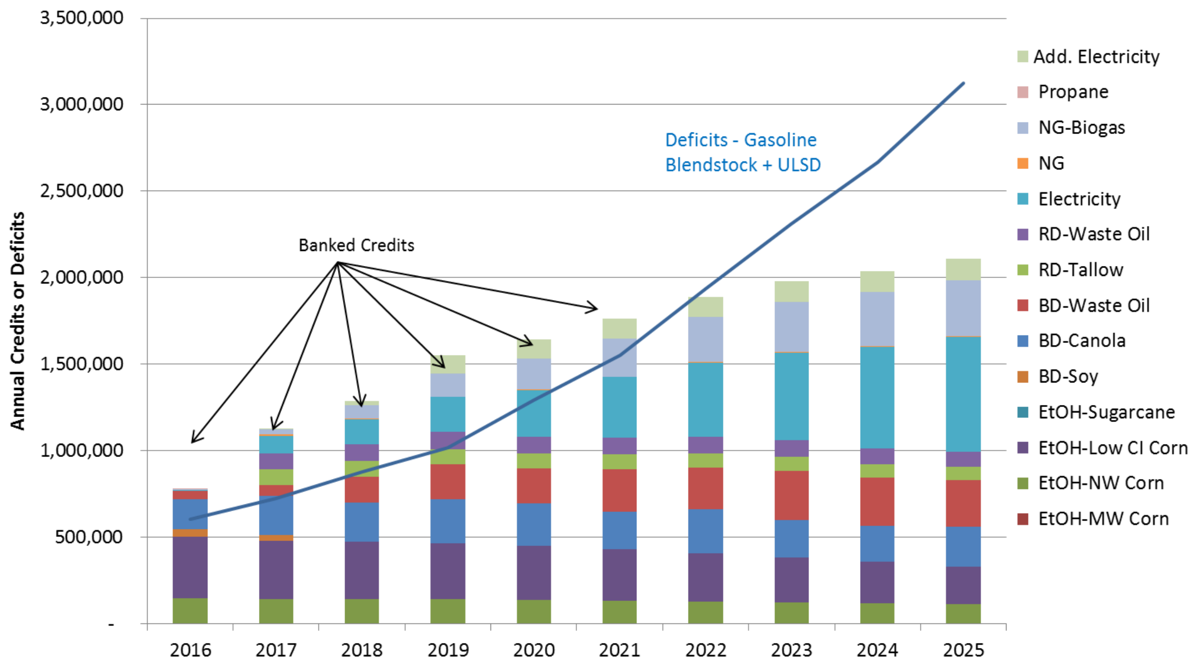

Figure 3. Balance of Credits and Deficits in Scenario 1

Scenario 2: High Biofuels

	Fuel	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Deficits (Millions)	Gasoline	-0.39	-0.43	-0.51	-0.58	-0.73	-0.87	-1.08	-1.28	-1.47	-1.71	-9.06
	Diesel	-0.21	-0.30	-0.37	-0.44	-0.57	-0.69	-0.87	-1.04	-1.22	-1.47	-7.18
Credits (Millions)	Gasoline subs	0.51	0.62	0.65	0.69	0.73	0.78	0.83	0.87	0.91	0.94	7.52
	Diesel subs	0.27	0.62	0.73	0.85	0.93	0.95	1.11	1.13	1.11	1.07	8.76
Balance		0.18	0.51	0.50	0.52	0.36	0.16	-0.02	-0.33	-0.68	-1.17	
Banked (net)		0.18	0.69	1.19	1.71	2.07	2.24	2.22	1.89	1.22	0.05	

Table 7. Credits and Deficits: Banking in Scenario 2

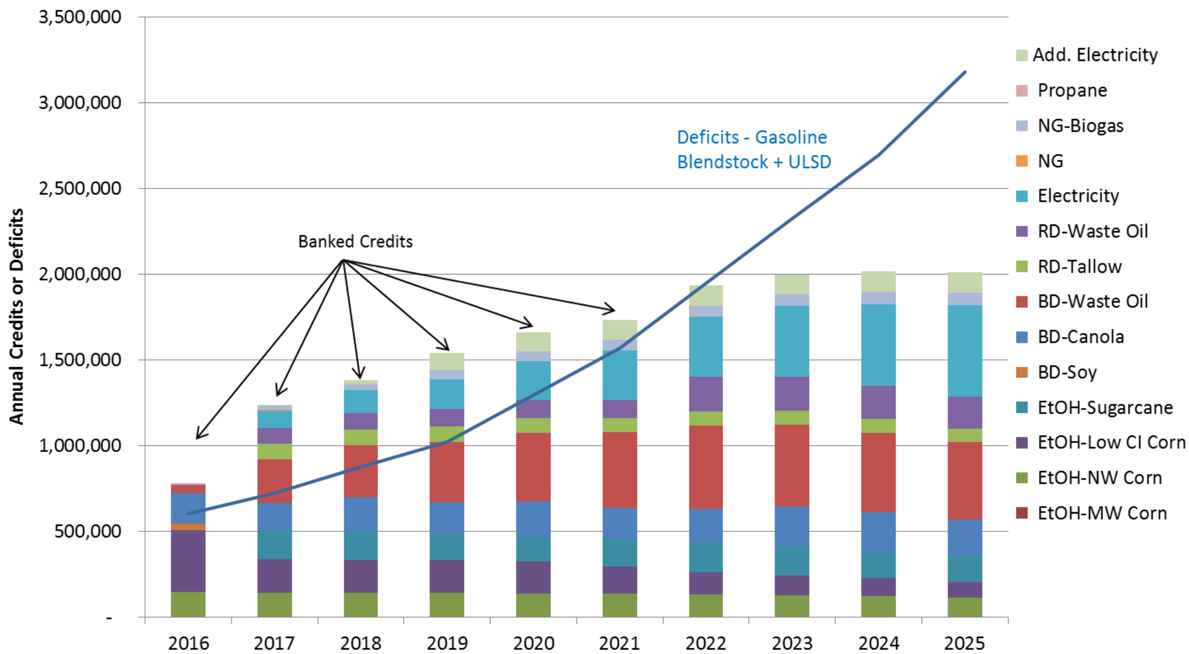

Figure 4. Balance of Credits and Deficits in Scenario 2

Scenario 3: Hybrid

	Fuel	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025	2026	2027
Deficits (Millions)	Gasoline	-0.39	-0.42	-0.51	-0.58	-0.73	-0.87	-1.08	-1.27	-1.45	-1.68	-8.98	-1.63	-1.57
	Diesel	-0.21	-0.30	-0.37	-0.44	-0.56	-0.68	-0.84	-1.00	-1.17	-1.36	-6.94	-1.36	-1.35
Credits (Millions)	Gasoline subs	0.51	0.59	0.63	0.70	0.76	0.83	0.89	0.97	1.07	1.14	8.07	1.25	1.37
	Diesel subs	0.27	0.47	0.53	0.72	0.87	1.04	1.21	1.28	1.29	1.42	9.10	1.47	1.52
	Balance	0.18	0.33	0.28	0.39	0.34	0.32	0.17	-0.03	-0.26	-0.49		-0.27	-0.04
	Banked (net)	0.18	0.51	0.79	1.19	1.53	1.85	2.03	1.99	1.74	1.25		0.98	0.95

Table 8. Credits and Deficits: Banking in Scenario 3

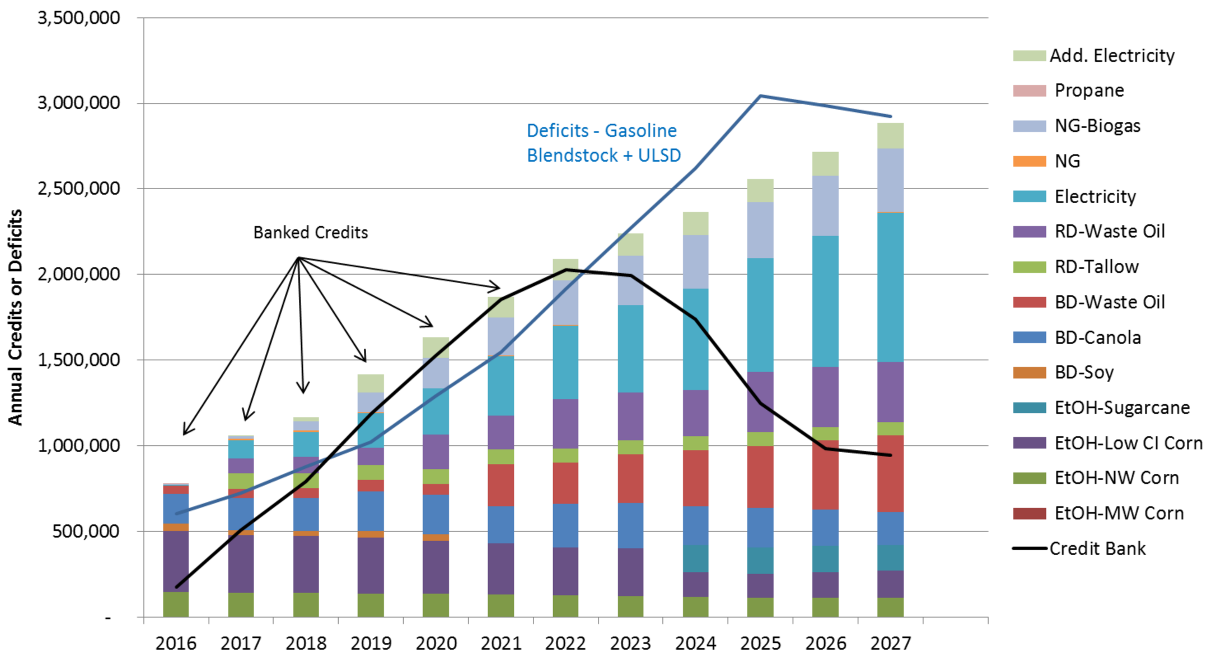

Figure 5. Balance of Credits and Deficits in Scenario 3

Fuel Volumes

Ethanol Volumes

Tables 15, 16 and 17 below identify the volumes of ethanol, broken down by feedstock, for Scenarios 1, 2, and 3.

Ethanol – Scenario 1										
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	40	40	40	40	40	40	40	40	40	40
Corn, Low CI	102	103	103	102	100	98	95	92	89	86
Sugarcane	0	0	0	0	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0	0	0	0	0
Total	142	143	143	142	140	138	135	132	129	126
% 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 9. Ethanol Volumes (in millions of Gallons) in Scenario 1

Ethanol – Scenario 2										
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	40	40	40	40	40	40	40	40	40	40
Corn, Low CI	102	60	60	60	60	53	46	43	40	37
Sugarcane	0	43	43	42	41	45	49	50	50	50
Sorghum	0	0	0	0	0	0	0	0	0	0
Total	142	143	143	142	141	138	136	133	130	127
% 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 10. Ethanol Volumes (in millions of Gallons) in Scenario 2

Ethanol – Scenario 3												
Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Corn, MW	0	0	0	0	0	0	0	0	0	0	0	0
Corn, NW	40	40	40	40	40	40	40	40	40	40	40	40
Corn, Low CI	102	103	103	102	100	98	95	99	53	57	60	63
Sugarcane	0	0	0	0	0	0	0	0	50	50	50	50
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0
Total	142	143	143	142	140	138	135	139	143	147	150	153
% EtOH in Gasoline	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
% FFVs VMT on E85	0%	0%	0%	0%	0%	0%	0%	5%	10%	15%	20%	25%
Volume of E85								8.8	18	26	35	44

Table 11. Ethanol Volumes (in millions of Gallons) in Scenario 3

Each gasoline refueling station dispenses approximately 1.5 million gallons of gasoline per year. If an E85 pump were added to an existing station and it dispenses 0.5 million gallons per year, 18 E85 pumps would be needed in 2023, 35 in 2024, 53 in 2025, 71 in 2026 and 88 in 2027. Currently there are five (5) E85 stations in Oregon[8].

Biodiesel Volumes

Tables 18, 19 and 20 below identify the volumes of biodiesel, broken down by feedstock, for Scenarios 1, 2, and 3.

Biodiesel - Scenario 1										
Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Soy	5	7	0	0	0	0	0	0	0	0
Canola	34	43	44	50	50	45	55	49	49	58
Waste Oil	5	6	15	20	20	25	25	30	30	30
Total	44	56	59	70	70	70	80	79	79	88
Biodiesel Blend %	5%	6%	6%	7%	7%	7%	8%	8%	8%	9%

Table 12. Biodiesel Volumes (in millions of Gallons) in Scenario 1

[8] http://www.afdc.energy.gov/locator/stations/

Biodiesel – Scenario 2										
Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Soy	5	0	0	0	0	0	0	0	0	0
Canola	34	32	39	36	42	37	43	53	53	53
Waste Oil	5	25	30	35	40	45	50	50	50	50
Total	44	57	69	71	82	82	93	103	103	103
Biodiesel Blend %	5%	6%	7%	7%	8%	8%	9%	10%	10%	10%

Table 13. Biodiesel Volumes (in millions of Gallons) in Scenario 2

Biodiesel – Scenario 3												
Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Soy	5	6	6	7	7	0	0	0	0	0	0	0
Canola	34	36	38	46	46	45	55	59	54	58	53	47
Waste Oil	5	5	5	7	7	25	25	30	35	40	45	50
Total	44	47	49	60	60	70	80	89	89	98	98	97
Biodiesel Blend %	5%	5%	5%	6%	6%	7%	8%	9%	9%	10%	10%	10%

Table 14. Biodiesel Volumes (in millions of Gallons) in Scenario 3

Renewable Diesel Volumes

Tables 21, 22 and 23 below identify the volumes of renewable diesel, broken down by feedstock, for Scenarios 1, 2, and 3.

Renewable Diesel – Scenario 1										
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	9	9	10	10	10	10	10	9	9
Total	17	19	19	20	20	20	20	20	19	19
RD Blend %	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%

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

Renewable Diesel – Scenario 2										
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	9	10	10	10	10	21	21	21	21
Total	17	19	20	20	20	20	31	31	31	31
RD Blend %	2%	2%	2%	2%	2%	2%	3%	3%	3%	3%

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

Renewable Diesel – Scenario 3												
Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Tallow	10	10	10	10	10	10	10	10	10	10	10	10
Waste Oil	7	9	9	10	20	20	30	29	29	38	38	38
Total	17	19	19	20	30	30	40	39	39	48	48	48
RD Blend %	2%	2%	2%	2%	3%	3%	4%	4%	4%	5%	5%	5%

Table 17. Renewable Diesel Volumes (in millions of Gallons) in Scenario 3

Natural Gas/LPG

Tables 24, 25 and 26 below show the natural gas/LPG and biogas consumption in million DGE where market share was increased to achieve 5% diesel pool consumption of natural gas/LPG/biogas in 2025.

Natural Gas – Scenario 1										
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
NG/LPG	4	5	4	2	3	4	5	5	6	6
Biogas	0	5	11	20	26	34	41	47	52	57
Total	4	9	15	22	29	37	45	52	58	63

Table 18. Natural Gas/LPG Volumes (in millions of DGE) in Scenario 1

Natural Gas – Scenario 2										
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
NG/LPG	2	2	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Biogas	2	2	4	7	8	8	9	10	11	11
Total	3	4	6	7	8	9	9	10	11	11

Table 19. Natural Gas/LPG Volumes (in millions of DGE) in Scenario 2

Natural Gas – Scenario 3												
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
NG/LPG	4	7	8	5	3	4	5	5	6	6	7	7
Biogas	0	2	8	16	26	34	41	47	52	57	60	65
Total	4	9	15	22	29	37	45	52	58	63	67	72

Table 20. Natural Gas/LPG Volumes (in millions of DGE) in Scenario 3

Electricity

Table 27 below shows the electricity consumption from BEVs and PHEVs in million GGE for Scenarios 1, 2, and 3.

Electricity												
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Scenario 1	3.1	4.0	5.6	7.8	10.6	14.0	17.6	21.4	25.6	29.9		
Scenario 2	3.1	4.0	5.1	6.8	9.0	11.7	14.5	17.5	20.7	24.0		
Scenario 3	3.1	4.0	5.6	7.8	10.6	14.0	17.6	21.4	25.6	29.9	34.5	39.3

Table 21. Electricity Consumption (in millions of GGE) in Scenarios 1 and 2

GHG Emission Reductions

Table 28 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.

GHG Emissions											
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
BAU	28.87	29.85	30.48	30.75	30.71	30.56	30.38	30.09	29.76	29.42	300.87
Scenario 1	28.59	29.47	30.00	30.12	30.04	29.80	29.50	29.14	28.76	28.32	293.73
Scenario 2	28.58	29.36	29.89	30.12	29.99	29.80	29.42	29.07	28.73	28.39	293.34
Scenario 3	28.59	29.54	30.12	30.27	30.05	29.69	29.29	28.85	28.39	27.80	292.59

Table 22. Annual GHG Emissions (million metric tons)

Table 29 shows the actual and percent GHG reductions annually from 2016 to 2025 and cumulatively over the compliance period from 2016 to 2025.

GHG Reductions from the BAU											
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Scenario 1	0.28	0.38	0.48	0.62	0.68	0.76	0.87	0.95	1.01	1.11	7.14
Scenario 1	1.0%	1.3%	1.6%	2.0%	2.2%	2.5%	2.9%	3.2%	3.4%	3.8%	2.4%
Scenario 2	0.29	0.49	0.59	0.63	0.72	0.76	0.96	1.03	1.03	1.03	7.53
Scenario 2	1.0%	1.6%	1.9%	2.1%	2.4%	2.5%	3.2%	3.4%	3.5%	3.5%	2.5%
Scenario 3	0.28	0.31	0.36	0.48	0.66	0.87	1.09	1.24	1.37	1.62	8.28
Scenario 3	1.0%	1.0%	1.2%	1.6%	2.1%	2.8%	3.6%	4.1%	4.6%	5.5%	2.8%

Table 23. GHG Emissions Reductions from the BAU (million metric tons and Percent)

The reductions in Table 29 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 updated 2014 illustrative compliance scenarios achieved cumulative reductions of 2.9% and 3.0 for Scenarios 1-B5 and 2-B5, respectively. The reduction in cumulative emissions (Scenarios 1 and 2) attributable to the Clean Fuels Program is due to the increased contribution of the ZEV Mandate (mainly from the AEO2016 increase of PHEV eVMT) towards compliance which is also included in the BAU case and the inclusion of additional electricity credit generation.

Conclusions

The following are key highlights from the 2017 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 used later and do not lose their compliance value. Banking credits when the standard is lower reduces compliance costs and eases compliance in later years. In the scenarios, between 20-42% 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). 13-15% of total credits required for compliance in the Oregon program were banked in these scenarios.
- 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 17-21% of the cumulative credits (an increase from 14-17% in the updated 2014 illustrative compliance scenarios) needed over the compliance period.
- Renewable natural gas is a key fuel for Clean Fuels Standard compliance. In the advanced technology scenarios, renewable natural gas generated 11% of the credits necessary for compliance.
- Without blend limitations and infrastructure requirements, renewable diesel, even in small volumes, is necessary for compliance, but Scenario 2 only moderately strayed from a 2% renewable diesel blend reaching a maximum of 31 MGPY. Scenario 3 reaches a 5% blend rate, but only in 2025.
- The results of Scenario 3 show that through a combined approach of Scenarios 1 and 2 there is potential for meeting the 2016 – 2025 CFP requirements without exhausting the bank of credits and to nearly reach annual credit generation and deficit generation parity in 2027.