Memorandum

To: Bill Peters and Cory Ann Wind | Oregon DEQ

From: Philip Sheehy and Jeff Rosenfeld

Date: February 2017

Re: Task 2: 2017 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 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.

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 2017 Illustrative Compliance Scenarios that 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 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 looks at the potential across alternative fuels to contribute towards the carbon intensity reductions and generation of credits.

Methodology

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. The table below shows Oregon's portion of US sales based on the updated AEO2016 projections.

Table 2. Oregon Portion of US Sales by Vehicle Class

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%

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 by scaling the VMT so the VISION approximate historical fuel consumption 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.

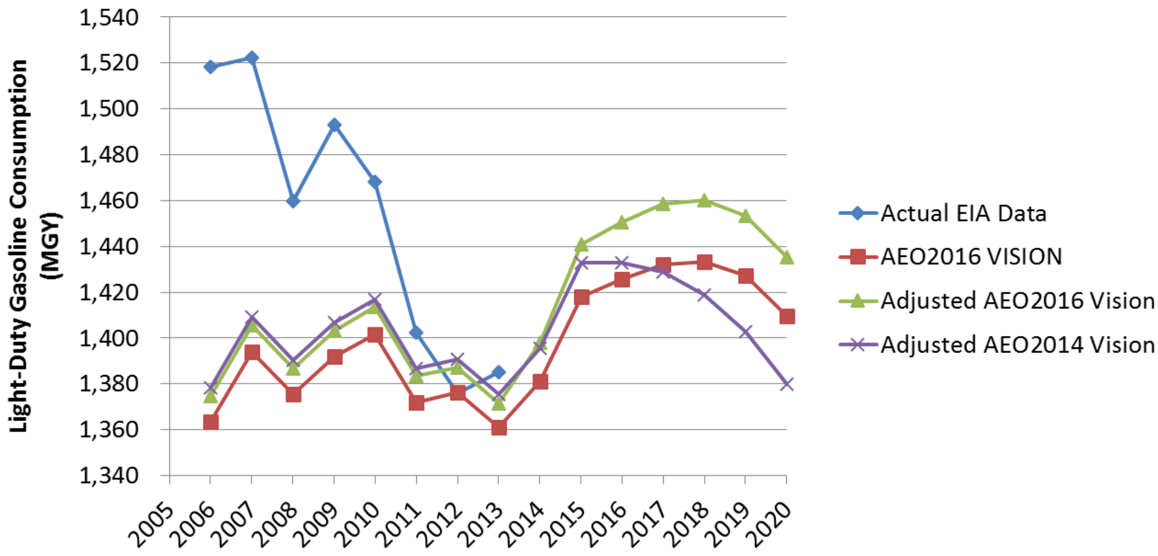

Figure 1 Actual Oregon and VISION Projected Light-Duty Gasoline Consumption

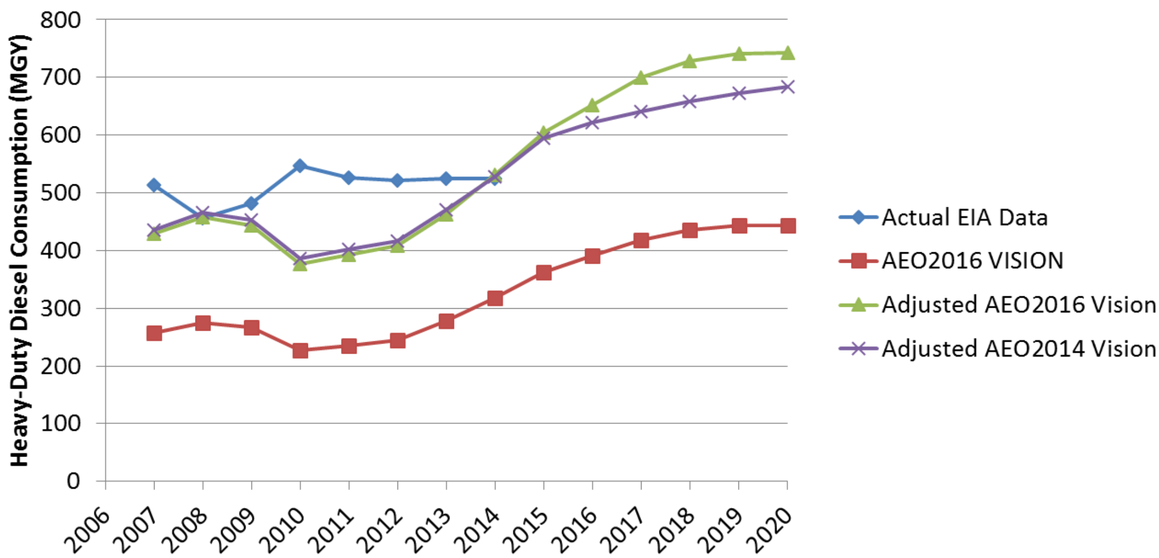

Figure 2 Actual Oregon and VISION Projected Heavy-Duty Diesel Consumption

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.

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.

PEV Vehicle Populations - ZEV Mandate

The California Air Resources Board recently published an Advanced Clean Cars Midterm Review[1]. In this review ARB developed three compliance scenarios for California and for Section 177 (S177) ZEV States. A S177 ZEV State is a state that is administering the California ZEV requirements pursuant to section 177 of the federal Clean Air Act. There are currently 9 S177 states: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. The following table compares the total PEV, BEV and PHEV sales from 2011-2016 as tracked by ZEV Fact sales dashboard[2].

Table 3. 2011-2016 ZEV Sales from ZEV Facts for S177 States

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%

The results from the three scenarios developed by ARB for the S177 States are shown in the table below. The names of the scenarios are Mid Range (Scenario 1), Low Tech (Scenario 2) and High Tech (Scenario 3).

[1] https://www.arb.ca.gov/msprog/acc/acc-mtr.htm
[2] http://www.zevfacts.com/sales-dashboard.html

Table 4. ARB Forecasted Annual PEVs Sales for S177 States

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

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. The table below shows Oregon forecasted PEV sales. For Scenario 3, ICF forecasted 2026 and 2027 sales assuming a similar increase in annual sales as from 2024 to 2025.

Table 5. Oregon Forecasted Annual PEVs Sales Resulting from the ZEV Mandate

Year	Oregon PEV Forecast	
	BEV Sales	PHEV Sales
2018	1,432	7,488
2019	2,915	9,809
2020	4,825	11,908
2021	6,881	13,342
2022	7,388	14,847
2023	8,612	16,122
2024	9,949	17,300
2025	11,338	18,484
2026[3]	*12,921*	*19,749*
2027	*14,724*	*21,101*

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.

Additional Electricity

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

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

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

Table 6. Annual and Total Credit Generation Potential from Fixed Guideway

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	72,016	18,741	92,340	92,340
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

Carbon Intensity and Gasoline and Diesel Fuel Standard

The following tables 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.

Table 7. Oregon Clean Fuel Program Carbon Intensities

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

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

Table 8. 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
2026[4]	*88.76*	*89.68*
2027	*88.76*	*89.68*

Assumptions for Fuels that Substitute for Gasoline

The table below presents the assumptions for fuels that substitute for gasoline.

[4] For Scenario 3, it is assumed that the 2025 standard of a 10% carbon intensity reduction stays in place.

Table 9. Fuels That Substitute for Gasoline

Fuel	Assumption
Corn Ethanol, MW	The balance of ethanol consumed in Oregon will be MW corn
Corn Ethanol, NW	Pacific Ethanol Columbia has a production capacity of 40 MGPY, assume up to 40 MGPY stay in Oregon
Corn/Sorghum Ethanol, Low Carbon Intensity	An additional 302 MGPY of capacity exists in the Oregon NW region in addition to the Pacific Ethanol Columbia facility, another 150 MGPY of low CI corn ethanol could be consumed
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 90% of natural gas consumption in Scenario 1 and 99% in Scenario 2 (since the volumes are much smaller) could be from biogas
Propane	It is assumed that propane consumption will reach a maximum of 1% of total natural gas consumption.

Assumptions for Fuels that Substitute for Diesel

The table below presents the assumptions for fuels that substitute for diesel. There is also one technology, hybrid-electric vehicles (HEVs), in the diesel fleet that is included below.

Table 10. 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 Oil 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 90% of natural gas could come from biogas. For Scenario 1, it is assumed that medium and heavy duty CNG vehicle sales increase to the point where 5% of diesel pool fuel consumption in 2025 is a combination of natural gas, biogas and LPG; updated to 5% from 10% based on the California
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 assumptions described above for the alternative 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 combination 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. Scenario 3 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. Overview of 2017 Illustrative Compliance Scenarios

	2017 Scenario 1	2017 Scenario 2	2017 Scenario 3
Ethanol: Maximums for achieving compliance: • Ethanol blend is E15 • FFVs 85% of miles on E85 • NW Corn-40 MGPY • Low CI Corn-150 MGPY Sugarcane- 50 MGPY	Maintained E10 blend rate No sugarcane ethanol required 40 MGPY of NW corn with the balance from low CI corn ethanol (maximum 102 MGPY)	Maintained E10 blend rate Maximum of 50 million gallons per year (MGPY) of sugarcane ethanol 40 MGPY of NW Corn and low carbon corn ethanol when needed	Maintained E10 blend rate 40 MGPY of NW corn with the balance from low CI corn ethanol (maximum 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
Biodiesel (BD) / Renewable Diesel (RD)	Increased BD blend from 5% to 9% from 2018 to 2025 Maintained canola/soy/used oil ratios till 2018 when increased waste oil to 15 MGPY, maximum 30 MGPY in 2025 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 2017 up to 50 MGPY in 2022 RD maintained at 2% with 10 MGPY from tallow and balance waste oil till 2021, then increased to 3% blend till 2025	Increased BD blend from 5% to 10% from 2019 to 2025 Increased waste oil to 25 MGY in 2021 up to 50 MGY in 2027 RD increased from 2% to 5% of diesel pool from 2020 to 2025 with 10 MGY from tallow and balance from waste oil
Natural Gas	Natural gas vehicle market share increased till 5% diesel pool consumption is natural gas (6.5% market share in 2025) By 2019, 90%of NG from RNG	By 2019, 100% of natural gas from biogas, 11.1 MGPY in 2025	Natural gas vehicle market share increased till 5% diesel pool by consumption is natural gas by 2025 and up to 6% in 2027 (6.5% market share in 2025, 8% in 2027) By 2010, 90%of NG from RNG
Advanced Vehicles (PEVs / MD-HD HEVs): Achieves ZEV compliance BAU vehicle populations: 70,000 BEVs in 2025; 62,000 PHEV10 in 2025; 62,000 PHEV40 in 2025 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

Credits and Deficits

The figures on the following page show the annual credits and deficits generated for Scenarios 1, 2, and 3. 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. The black credit bank line was added to Figure 5 to highlight the size of the credit bank. Tables 12, 13, and 14 below show the annual deficits and credits generated and cumulative (banked) credits and the cumulative credits and deficits in last column.

Table 12. Credits and Deficits: Banking in Scenario 1

Fuel		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Deficits (Millions)	Gasoline	-0.38	-0.42	-0.51	-0.58	-0.73	-0.87	-1.08	-1.28	-1.46	-1.70	-9.01
	Diesel	-0.25	-0.30	-0.37	-0.44	-0.57	-0.68	-0.87	-1.04	-1.21	-1.42	-7.15
Credits (Millions)	Gasoline subs	0.56	0.59	0.64	0.70	0.76	0.83	0.89	0.95	1.01	1.06	7.98
	Diesel subs	0.43	0.48	0.67	0.80	0.84	0.94	0.96	1.03	1.03	1.05	8.21
	Balance	0.35	0.35	0.43	0.48	0.30	0.21	-0.10	-0.33	-0.63	-1.02	
	Banked (net)	0.35	0.70	1.13	1.60	1.90	2.11	2.01	1.68	1.04	0.03	

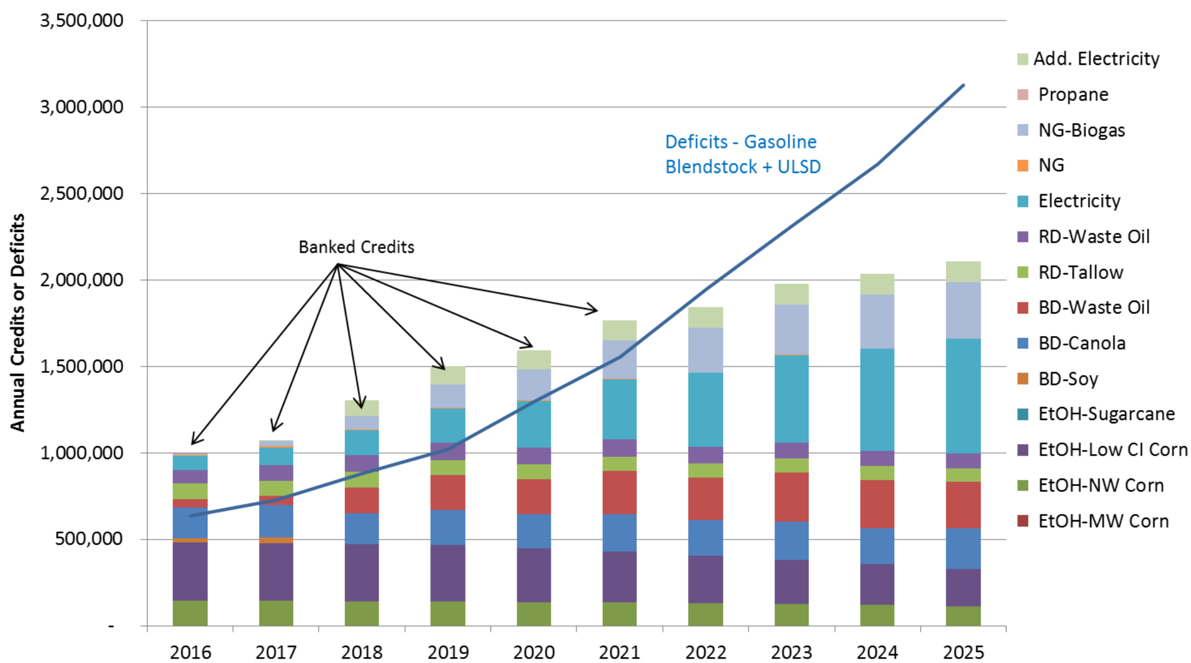

Figure 3. Balance of Credits and Deficits in Scenario 1

Table 13. Credits and Deficits: Banking in Scenario 2

Fuel		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025
Deficits (Millions)	Gasoline	-0.38	-0.43	-0.51	-0.58	-0.73	-0.87	-1.08	-1.28	-1.47	-1.71	-9.05
	Diesel	-0.25	-0.30	-0.37	-0.44	-0.57	-0.69	-0.88	-1.05	-1.22	-1.47	-7.25
Credits (Millions)	Gasoline subs	0.57	0.62	0.65	0.69	0.73	0.78	0.83	0.87	0.91	0.94	7.58
	Diesel subs	0.43	0.61	0.75	0.85	0.88	0.95	1.06	1.09	1.11	1.07	8.79
	Balance	0.36	0.50	0.52	0.52	0.31	0.16	-0.08	-0.38	-0.68	-1.17	
	Banked (net)	0.36	0.86	1.38	1.90	2.20	2.37	2.29	1.91	1.23	0.06	

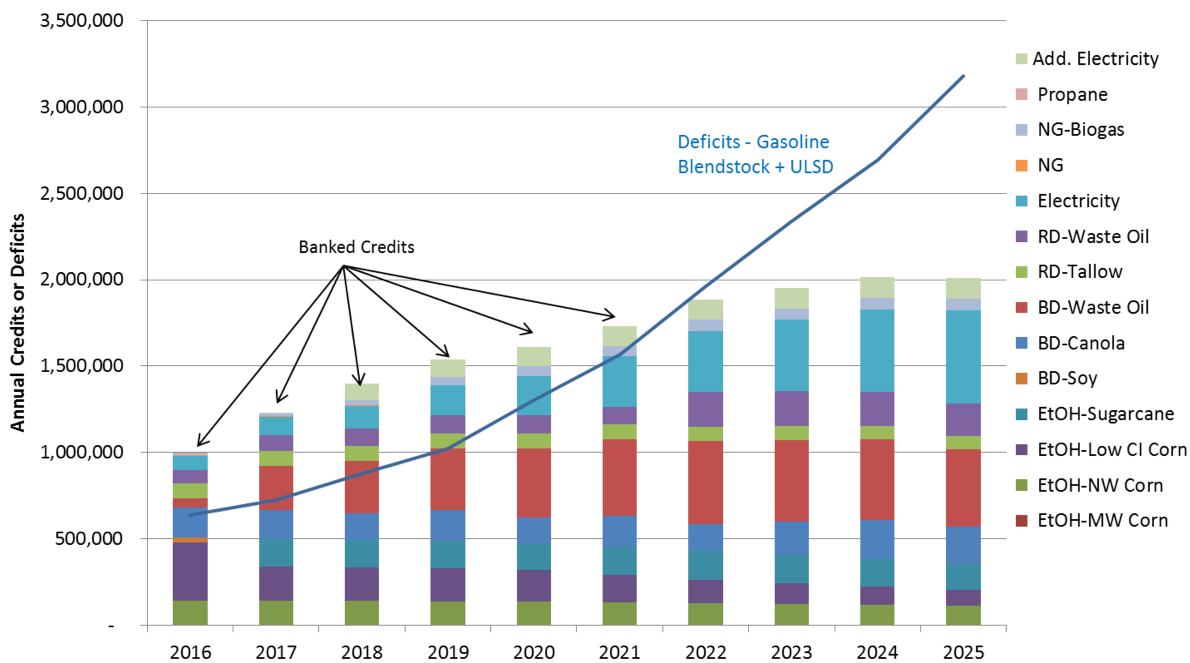

Figure 4. Balance of Credits and Deficits in Scenario 2

Table 14. Credits and Deficits: Banking in Scenario 3

Fuel		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2016-2025	2026	2027
Deficits (Millions)	Gasoline	-0.38	-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	-0.25	-0.30	-0.37	-0.44	-0.56	-0.68	-0.84	-1.00	-1.17	-1.36	-6.98	-1.36	-1.35
Credits (Millions)	Gasoline subs	0.56	0.59	0.63	0.70	0.76	0.83	0.89	0.97	1.07	1.14	8.13	1.25	1.37
	Diesel subs	0.43	0.47	0.60	0.72	0.87	1.04	1.21	1.28	1.29	1.42	9.33	1.47	1.52
	Balance	0.35	0.33	0.36	0.39	0.34	0.32	0.17	-0.03	-0.26	-0.49		-0.27	-0.04
	Banked (net)	0.35	0.69	1.04	1.44	1.78	2.10	2.28	2.24	1.99	1.50		1.23	1.20

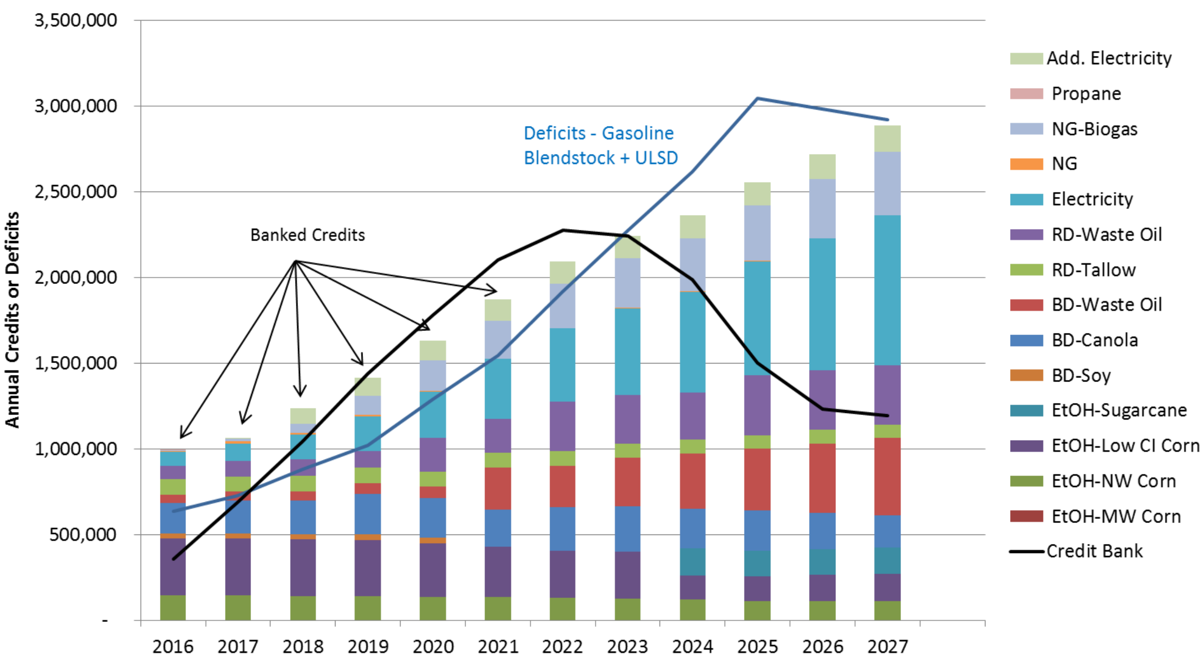

Figure 5. Balance of Credits and Deficits in Scenario 3

Fuel Volumes

Ethanol Volumes

The table below identifies the volumes of ethanol, broken down by feedstock, for Scenarios 1, 2, and 3.

Table 15. Ethanol Volumes (in millions of Gallons) in 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 16. Ethanol Volumes (in millions of Gallons) in 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 17. Ethanol Volumes (in millions of Gallons) in 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%

Biodiesel Volumes

The table below identifies the volumes of biodiesel, broken down by feedstock, for Scenarios 1, 2, and 3.

Table 18. Biodiesel Volumes (in millions of Gallons) in Scenario 1

Feedstocks	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Soy	5	6	0	0	0	0	0	0	0	0
Canola	34	36	34	40	40	45	45	49	49	58
Waste Oil	5	5	15	20	20	25	25	30	30	30
Total	44	47	49	60	60	70	70	79	79	88
Biodiesel Blend %	5%	5%	5%	6%	6%	7%	7%	8%	8%	9%

Table 19. Biodiesel Volumes (in millions of Gallons) in 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	29	36	31	37	33	43	53	53
Waste Oil	5	25	30	35	40	45	50	50	50	50
Total	44	57	59	71	71	82	83	93	103	103
Biodiesel Blend %	5%	6%	6%	7%	7%	8%	8%	9%	10%	10%

Table 20. Biodiesel Volumes (in millions of Gallons) in 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%

Renewable Diesel Volumes

The table below identifies the volumes of renewable diesel, broken down by feedstock, for Scenarios 1, 2, and 3.

Table 21. Renewable Diesel Volumes (in millions of Gallons) in 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 22. Renewable Diesel Volumes (in millions of Gallons) in 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 23. Renewable Diesel Volumes (in millions of Gallons) in 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%

Natural Gas/LPG

The tables 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.

Table 24. Natural Gas/LPG Volumes (in millions of DGE) in 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 25. Natural Gas/LPG Volumes (in millions of DGE) in 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 26. Natural Gas/LPG Volumes (in millions of DGE) in 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

Electricity

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

Table 27. Electricity Consumption (in millions of GGE) in Scenarios 1 and 2

	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

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 28. Annual GHG Emissions (million metric tons)

	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	29.53	30.05	30.18	30.09	29.80	29.56	29.14	28.76	28.32	294.01
Scenario 2	28.58	29.37	29.95	30.12	30.05	29.80	29.47	29.13	28.73	28.39	293.58
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 29. 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	0.28	0.32	0.43	0.57	0.62	0.76	0.82	0.95	1.01	1.11	6.86
Scenario 1	1.0%	1.1%	1.4%	1.8%	2.0%	2.5%	2.7%	3.2%	3.4%	3.8%	2.3%
Scenario 2	0.29	0.48	0.53	0.63	0.67	0.76	0.90	0.97	1.03	1.03	7.29
Scenario 2	1.0%	1.6%	1.7%	2.1%	2.2%	2.5%	3.0%	3.2%	3.5%	3.5%	2.4%
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%

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 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.