Task 2 – Updated Business As Usual Scenario

Final Report

July 2014

Prepared for
Oregon Department of Environmental Quality
811 SW 6th Avenue
Portland, OR 97204-1390

Prepared by
ICF International
75 E. Santa Clara St. Suite 300
San Jose, CA 95113
408.216.2800

ICF conducted this work under contract with the Oregon Department of Environmental Quality. ICF developed the scenario in a manner consistent with our scope of work with Oregon DEQ, and as we do in all of our work, we strive to provide information and projections consistent with standard practices in a professional manner. This scenario, however, should not be confused with ICF market forecasts. ICF makes no warranties express or implied (including without limitation any warranties or merchantability or fitness for a particular purpose), as to this material. Specifically but without limitation, ICF makes no warranty or guarantee regarding the accuracy of this scenario or that such work products will be accepted by any legal or regulatory body.

Table of Contents

1 Introduction 3

2 Oregon VISION Model Updates 5

2.1 Vehicle Fleet 5

2.2 Calibrating Fuel Consumption 8

3 Fuel Consumption and Carbon Intensity Results 11

3.1 Fuel Consumption 11

3.2 Carbon Intensity 13

List of Tables

Table 1. Assumptions for Updated Business As Usual Scenario 4

Table 2. Oregon Portion of US Sales by Vehicle Class 5

Table 3. Scaling Factors for VMT 9

Table 4. BAU Biofuel Assumptions 11

Table 5. Oregon Carbon Intensity Values 13

List of Figures

Figure 1. Oregon Light-Duty Auto HEV and PEV Market Shares Compared to AEO2014 6

Figure 2. Light-Duty Vehicle Fleet by Fuel and Technology 7

Figure 3. Medium- and Heavy-Duty Vehicle Fleet by Class and Technology Type 8

Figure 4. Actual Oregon and VISION Projected Light-Duty Gasoline Consumption 10

Figure 5. Actual Oregon and VISION Projected Heavy-Duty Diesel Consumption 10

Figure 6. Projected Oregon Statewide Fuel Consumption 11

Figure 7. Breakdown of Ethanol Consumed in the BAU Scenario by Feedstock and Production Location 12

Figure 8. Breakdown of BD and RD Consumed in the BAU by Feedstock and Production Location 12

Figure 9. Average Oregon BAU Transportation Fuel Carbon Intensity 14

Abbreviations and Acronyms

AEO	Department of Energy Annual Energy Outlook
B5	5% by volume blend of biodiesel with diesel
B10	10% by volume blend of biodiesel with diesel
BAU	Business As Usual
BEV	Battery Electric Vehicle
CAFE	Corporate average fuel economy
CARB	California Air Resources Board
CNG	Compressed Natural Gas
DGE	Diesel Gallon Equivalent
E85	85% by volume ethanol blend with gasoline
E10	10% by volume ethanol blend with gasoline
EIA	Energy Information Administration
EPA	US Environmental Protection Agency
FCV	Fuel cell vehicle
FFV	Flex-fuel vehicle
GGE	Gasoline Gallon Equivalent
HEV	Hybrid Electric Vehicle
HDV	Heavy-duty vehicle
ICE	Internal combustion engine
ILUC	Indirect Land Use Change
LCFS	Low Carbon Fuel Standard
LDV	Light-duty vehicle
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MDV	Medium-duty vehicle
NGV	Natural gas vehicle
NHTSA	National Highway Traffic Safety Administration
ODOT	Oregon Depart of Transportation
PEV	Plug-In Electric Vehicles
PHEV	Plug-In Hybrid Electric Vehicles
PHEV10	PHEV with 10 miles equivalent all electric range
PHEV40	PHEV with 40 miles equivalent all electric range
US DOE	United States Department of Energy
VMT	Vehicle Miles Traveled
ZEV	Zero Emission Vehicle

1 Introduction

The clean fuel standard in Oregon, implemented by the Clean Fuels Program, requires a 10% reduction in carbon intensity from the gasoline and diesel baselines over a ten year period. In addition to carbon intensity reduction, the Clean Fuels Program helps Oregon reduce its consumption of traditional petroleum fuels. Potential fuels that could be used to achieve the standards are ethanol, biodiesel, hydrogen, electricity, natural gas, propane, and biogas. Task 2 updates the business as usual (BAU) scenario, where the BAU includes the vehicle and infrastructure cost and fuel consumption without a Clean Fuels Standard in place. Compliance scenarios (to be developed in Task 3) for the Clean Fuels Standard will be compared against the updated BAU to determine incremental costs and fuels required to achieve the scenarios.

As part of Oregon DEQ's original rulemaking and advisory committee process in 2010, technical analysis was performed by TIAX LLC to develop an Oregon specific BAU and compliance scenarios for a Clean Fuels Standard. The VISION model was used to quantify the amount of fuels, infrastructure, and investment required for the BAU scenario. VISION is a fleet sales and turnover model developed by Argonne National Laboratory that can be used to quantify future energy consumption and GHG emissions based on overall fleet characteristics and composition. It is important to understand the fleet composition when considering alternative fuel consumption. Many alternative fuels including E85 (blended ethanol and gasoline with 85% by volume ethanol), electricity and natural gas require new vehicles to be purchased or converted and maximum consumption of these fuels is constrained by the population of these vehicles within the fleet.

As part of the previous analysis, assumptions were made around the composition of the vehicle fleet, carbon intensities, and availability of low carbon fuels for compliance both in Oregon and out-of-state. Four years later there is a greater understanding of the vehicles and fuels that could be available and new regulations and developments that will affect Oregon's fleet composition and fuel consumption. The latest available version of the VISION model, "VISION 2013 AEO Base Case,"[1] was used to develop the updated BAU scenario. ICF and DEQ agreed on the assumptions to update the BAU shown in Table 1 below during Task 1 and are presented in more detail in the Task 1 Memorandum.[2] Task 2 created an updated BAU case based on the agreed upon assumptions to compare the compliance scenarios (to be developed in Task 3) against. The updated BAU scenario includes significantly less biofuels and more plug-in electric vehicles than the previous BAU resulting is lower carbon intensity reductions from the BAU alone.

[1] http://www.transportation.anl.gov/modeling_simulation/VISION/

[2] ICF Task 1 Memorandum – Final_v2; Original June 25, 2014; Updated July 8, 2014.

Table 1. Assumptions for Updated Business As Usual Scenario

Assumption to Update	Update
Vehicle Fleet Sales and Market Shares	• Previous analysis included sales data through 2009; Oregon Department of Transportation (ODOT) is now able to supply data through 2013 • BAU projections will be based on US sales projections from AEO2014
Light-Duty Fuel Economy Standards	EPA and NHTSA passed new light-duty fuel economy standards that are included in AEO2013 and 2014
Zero Emission Vehicle (ZEV) Program	ZEV was updated in 2012 and requires an increase in sales from the previous analysis
Ratio of Battery Electric Vehicles (BEVs) to Plug-in Hybrid Electric Vehicles (PHEVs)	• Previous analysis includes a 1:6 Ratio of BEV:PHEV • Currently ratio is 50:50 nationwide and this ration will be used prior to the new ZEV requirements starting in 2018
Compressed Natural Gas (CNG) and Propane	• Small amounts of natural gas were included in the previous analysis. • The updated BAU will include consumption to match/cover newly funded CNG facilities in OR. • CNG is used as a surrogate for compressed and liquefied natural gas (LNG). • Propane was not included in the previous analysis; small amounts have been included in this analysis based on recent sales in Oregon
Availability of Cellulosic Fuels	• The previous BAU included RFS2 proportional shares of cellulosic biofuels • National cellulosic volumes have been off-target and the pull from the California Low Carbon Fuel Standard (LCFS) will draw existing and future volumes of cellulosic fuels to California
Availability of Low Carbon Fuels to Oregon	In absence a Clean Fuel Standard, Oregon will only draw existing volumes of low carbon fuels consumed in Oregon; the California LCFS will pull all new low carbon fuels.
Biofuel Blends	• Updated BAU will only include required volumes and blends: E10 and biodiesel blend to cover statewide B5 requirement and Portland B5 requirement; composite state biodiesel blend of 5.0%; Portland has opted to not enforce B10 requirement • Only currently consumed low carbon biodiesel as part of the statewide and Portland requirements will be maintained in the updated BAU
Indirect Land Use Change (ILUC)	The updated BAU will include the proposed California Air Resources Board (CARB) values for ILUC; previous analysis included current values

2 Oregon VISION Model Updates

2.1 Vehicle Fleet

It is important to understand the fleet composition when considering alternative fuel consumption. Many alternative fuels including E85 (blended ethanol and gasoline with 85% by volume ethanol), electricity and natural gas require new vehicles to be purchased or converted and consumption is constrained by the population of alternative fuel vehicles within the fleet.

AEO2013 Base Case VISION model was updated using AEO2014 vehicle sales and market shares for light- (auto and truck), medium- (Class 3-6) and heavy-duty (Class 7-8) vehicle classes. ODOT 2013 vehicle registration data was used to estimate vehicle sales for 2010-2013 and combined with Oregon fleet sales from 1970-2009 from the previous analysis. The AEO2014 US sales projections for light- (autos and trucks separately), medium-, and heavy-duty vehicles was scaled based on the previous 10 years of Oregon's proportion of US sales (2004-2013). Table 1 below shows Oregon's portion of US sales for the 10 year period.

Table 2. Oregon Portion of US Sales by Vehicle Class

Vehicle Class	10 Year Average of Oregon Portion of US Sales
Light-Duty Autos	1.01%
Light-Duty Trucks	0.95%
Medium-Duty Trucks (Class 3-6)	1.71%
Heavy-Duty Trucks (Class 7-8)	1.04%

Light-Duty Vehicles

For technologically mature vehicles and fuels including ethanol (FFV), diesel and natural gas, the simplifying assumption was made that the Oregon market share for these vehicles would be consistent with the AEO2014 US market share. For hybrid electric (HEV) and plug-in electric vehicles (PEVS), which includes BEVs and PHEVs, Oregon sales data was compared against the AEO2014 US market shares and two times (2x) the AEO2014 US market shares for HEVs and PEVs. ICF chose to compare Oregon sales data against AEO2014 and 2x AEO2014 based on the previous analysis in 2010 where Oregon data was consistent with 2x AEO2009 for HEVs. Figure 1 below shows the comparison of Oregon data with AEO2014 and 2x AEO2014.

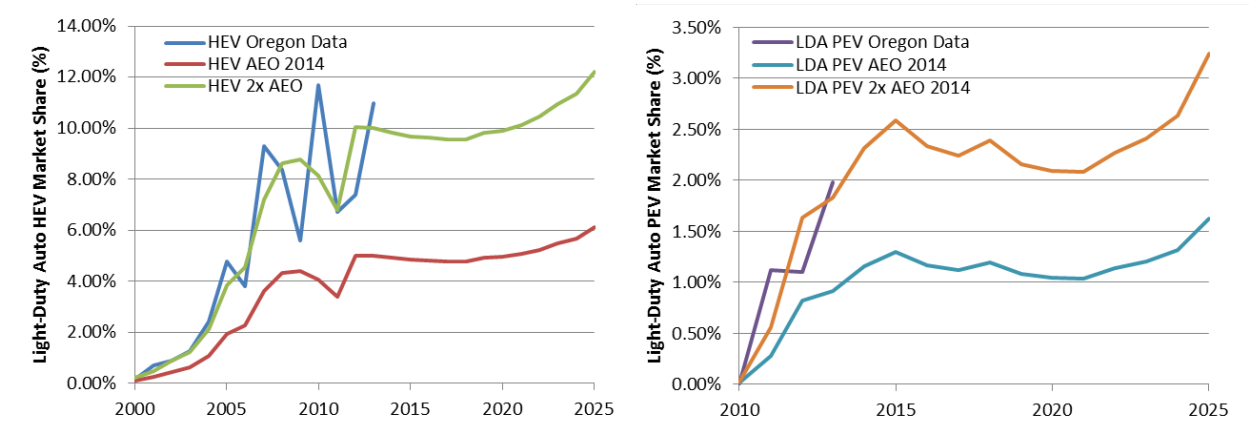

Figure 1. Oregon Light-Duty Auto HEV and PEV Market Shares Compared to AEO2014

Figure 1 shows that 2x AEO2014 is similar to the Oregon historic market share data and a good surrogate for future projections. This is consistent with the previous analysis from 2010. For PEVs, the split between BEV/PHEV was adjusted from AEO2014 to be a 50/50 split which is consistent with future data. The PHEV market share is further divided into two categories: PHEVs with 10 mile equivalent all electric range (PHEV10) and PHEVs with 40 mile equivalent all electric range (PHEV40). The PHEV split between PHEV10/PHEV40 is 50/50 and the overall BEV/PHEV10/PHEV40 split of 50/25/25 is consistent with vehicle models being developed for auto manufacturers.

For years 2014-2017, the 2x AEO2014 market share was utilized in the updated BAU for PEVs. For years 2018-2025, the BAU was updated to include the new ZEV program requirements. The California Air Resources Board (CARB) most likely compliance scenario with no fuel cell vehicles (FCVs) and the above PEV breakdown were used to project BEV and PHEV markets shares. The resulting PEV market share is 5.9% in 2018 to 22% in 2025.

Figure 2 shows the resulting Light-Duty fleet from 2010 to 2025. There is a significant increase in the proportion of the fleet consisting of HEVs and PEVs by 2025 which is driven by the ZEV program. Approximately 14% of the fleet will be HEV and PEV with 6% HEV and 8% PEV. The resulting PEV fleet is much larger by the tenth year of the compliance period compared to the 2010 analysis due to a more stringent ZEV program and three additional years (2023-2025) of PEV sales under the ZEV program. In the updated analysis, the 2022 Oregon fleet consists of approximately 109,000 PEVs while the 2010 analysis only had approximately 52,000 PEVs in the 2022 Oregon fleet.

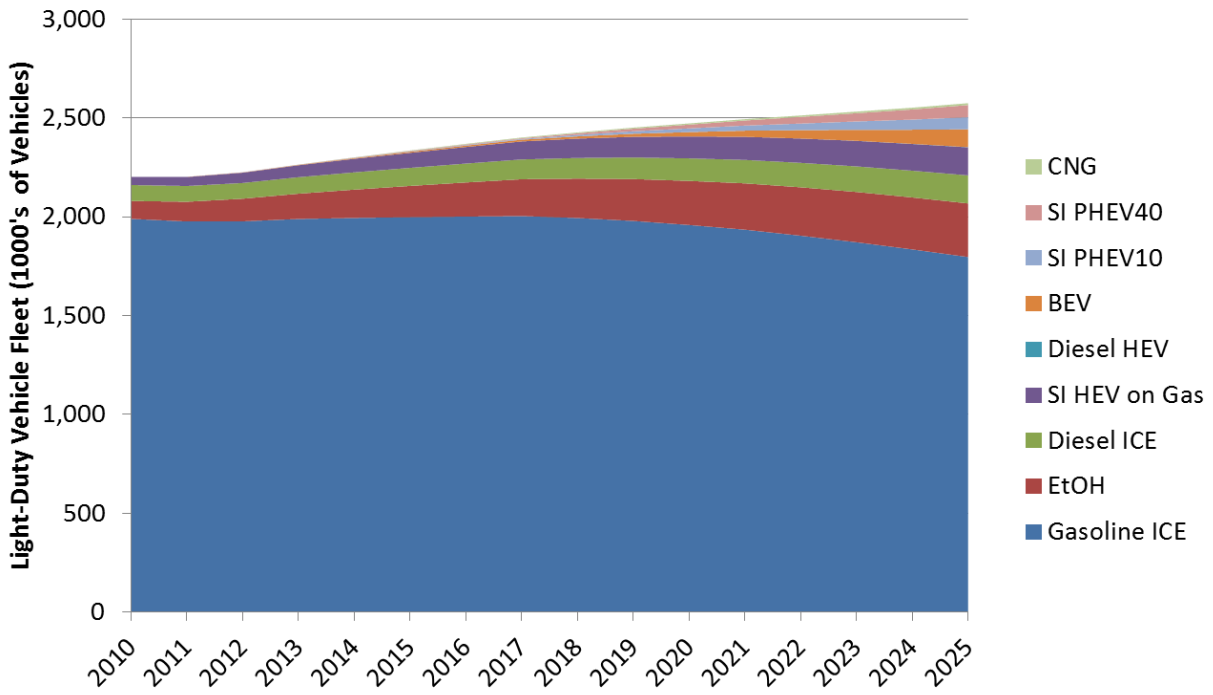

Figure 2. Light-Duty Vehicle Fleet by Fuel and Technology

Medium and Heavy Duty Vehicles

For medium- and heavy-duty vehicles, the gasoline, diesel and CNG/liquefied propane gas (LPG) market shares were assumed to be the same as the US sales which is consistent with the previous analysis. Figure 3 below shows the resulting medium- and heavy-duty by technology and class. There is an increase in both the medium- and heavy-duty diesel fleet which is consistent with AEO2014 US sales. The Oregon portion of heavy-duty US sales is 24% higher than the previous analysis (0.84% vs 1.04%). In addition, the trajectory of US sales of medium and heavy duty vehicles in AEO2014 is steeper than AEO2009 resulting in a 20% larger medium and heavy-duty vehicle fleet in 2022 compared to the 2010 analysis.

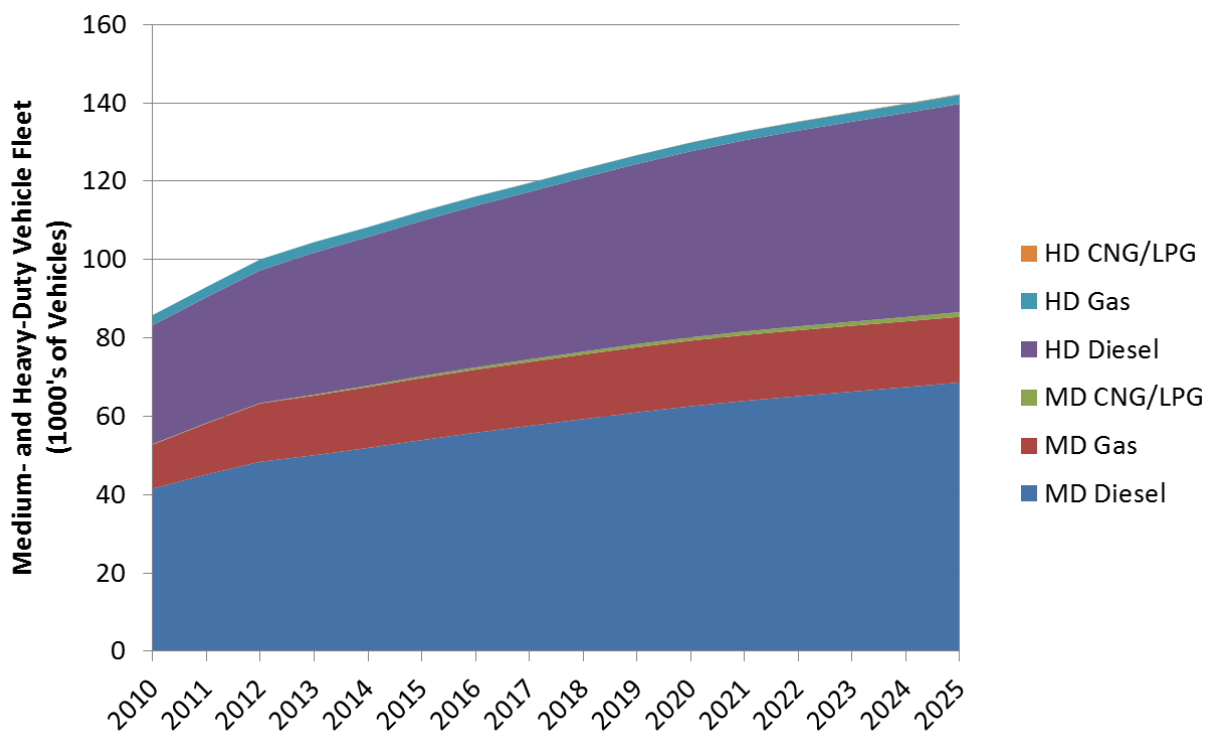

Figure 3. Medium- and Heavy-Duty Vehicle Fleet by Class and Technology Type

2.2 Calibrating Fuel Consumption

The VISION model utilizes national data to determine vehicle life expectancy and annual miles travel that ultimately combine with the Oregon fleet projections to determine fuel consumption. This data may not be consistent with Oregon's vehicle fleet and calibration of the model is required to match historical Oregon fuel consumption with VISION results. The VISION model was calibrated to account for consistent fuel consumption between historic data for light-duty gasoline and heavy-duty diesel from the Energy Information Administration (EIA)[3]. Medium-duty fuel consumption was excluded since the previous analysis in 2010 showed that medium-duty VISION projections and actual consumption were consistent.

For the gasoline, medium- and heavy-duty gasoline projections from VISION were subtracted from the EIA data to make sure only light-duty gasoline consumption was being compared. The same was done for diesel where VISION projected light- and medium-duty diesel consumption was subtracted from EIA data. The calibration was completed by applying a scaling factor to light-duty and heavy-duty VMT to produce the same fuel consumption. Table 3 shows the resulting scaling factors.

[3] http://www.eia.gov/dnav/pet/pet_cons_prim_dcu_SOR_a.htm

Table 3. Scaling Factors for VMT

Vehicle Class	VMT Scaling Factor
Light-Duty	1.05
Medium-Duty	None
Heavy-Duty	1.61

The higher heavy-duty scaling factor is due to a significant amount of pass-through traffic of heavy-duty trucks consuming diesel that are not registered in Oregon and accounted for the in ODOT registration data. After introducing the scaling factors, CNG fuel consumption was compared with the estimated CNG consumption from the CNG station funding applications and the consumption levels were found to be consistent. Figure 4 and Figure 5 show the comparison between the actual Oregon data from the EIA, the original VISION projected fuel consumption, and the VISION adjusted fuel consumption.

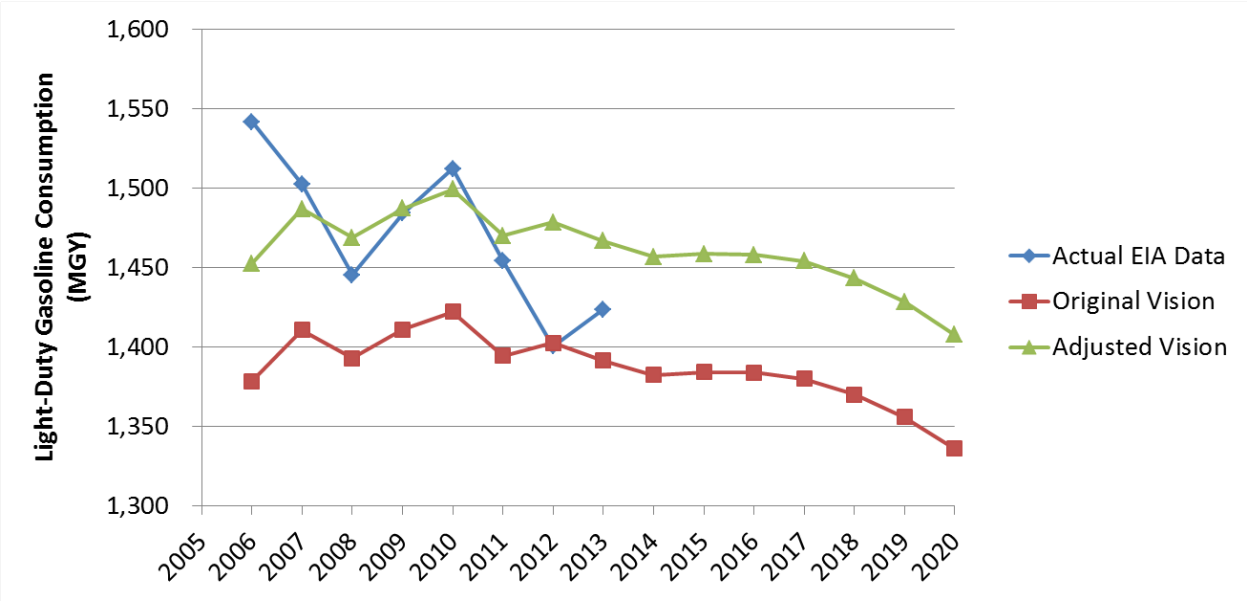

Figure 4. Actual Oregon and VISION Projected Light-Duty Gasoline Consumption

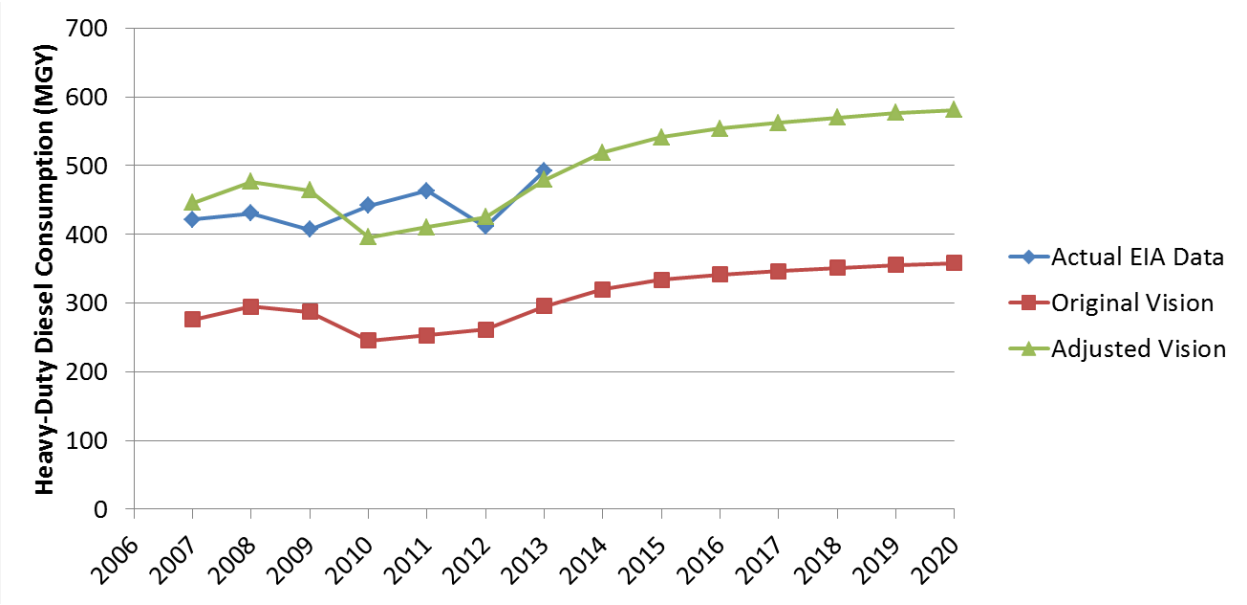

Figure 5. Actual Oregon and VISION Projected Heavy-Duty Diesel Consumption

3 Fuel Consumption and Carbon Intensity Results

3.1 Fuel Consumption

The updated VISION model with calibrated VMT projected the Oregon fuel consumption for 2010 to 2025 shown in Figure 6. The unit of fuel consumed is millions of gasoline gallon equivalents (GGE) per year. Gasoline and diesel make up 88-92% of the total fuel consumption in Oregon between 2010 and 2025. Biofuels are 8-10% of the fuel consumption and the remaining fuels (natural gas, LPG, and electricity) only contribute 1.7% by 2025.

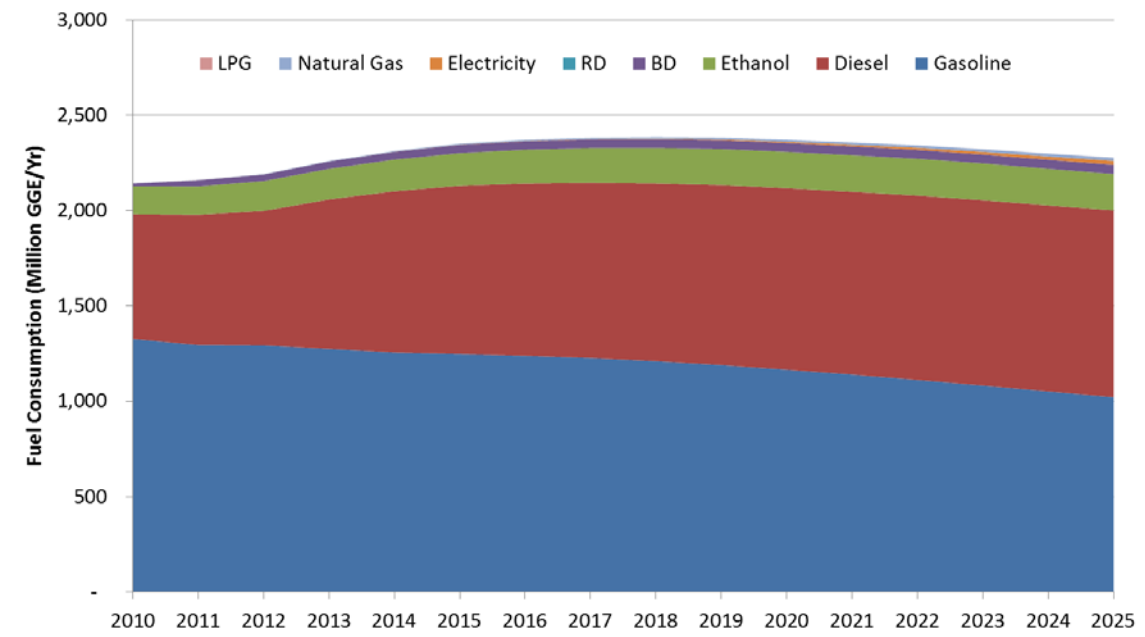

Figure 6. Projected Oregon Statewide Fuel Consumption

The assumptions shown below in Table 4 were used to breakdown the biofuels shown in Figure 6 to determine the carbon intensity of BAU scenario. Figure 7 and Figure 8 show the volumes of each type of biofuel consumed.

Table 4. BAU Biofuel Assumptions

Biofuels	BAU Biofuel Assumption
Ethanol	Maintain an E10 blend level and only include the Boardman ethanol plant (26 MGY) with the balance from Midwest corn ethanol
Biodiesel (BD)	Maintain current levels of low carbon biodiesel from the 2013 Summary Reports for Oregon fuel consumption and statewide blend of 5.0%
Renewable Diesel (RD)	No renewable diesel is consumed in the BAU since there is currently no renewable diesel consumed in Oregon and no regulation requiring it

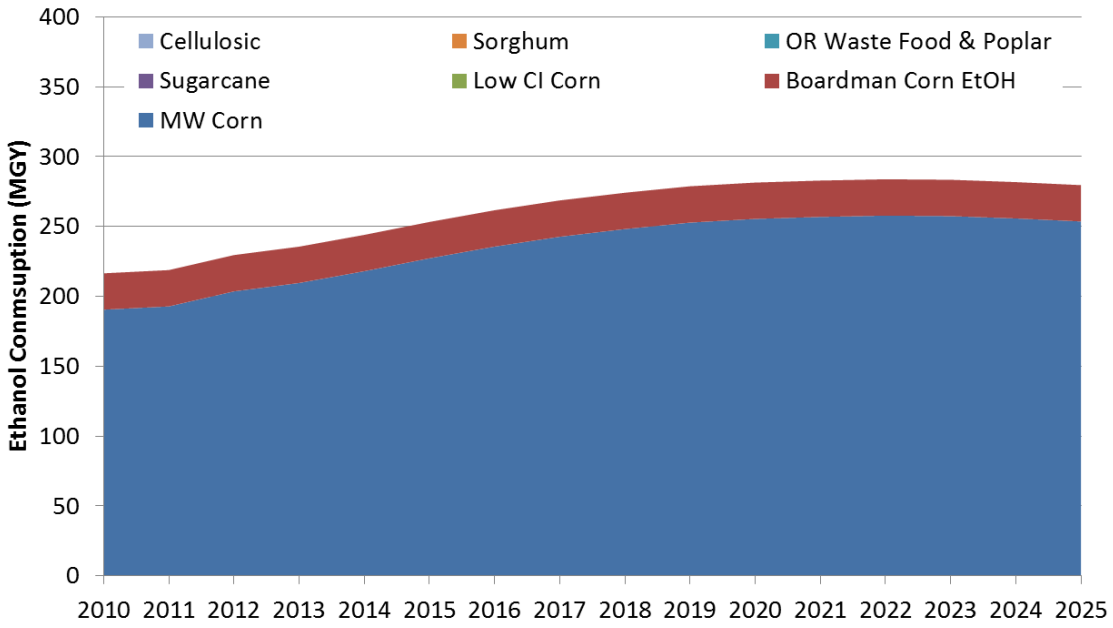

Figure 7. Breakdown of Ethanol Consumed in the BAU Scenario by Feedstock and Production Location

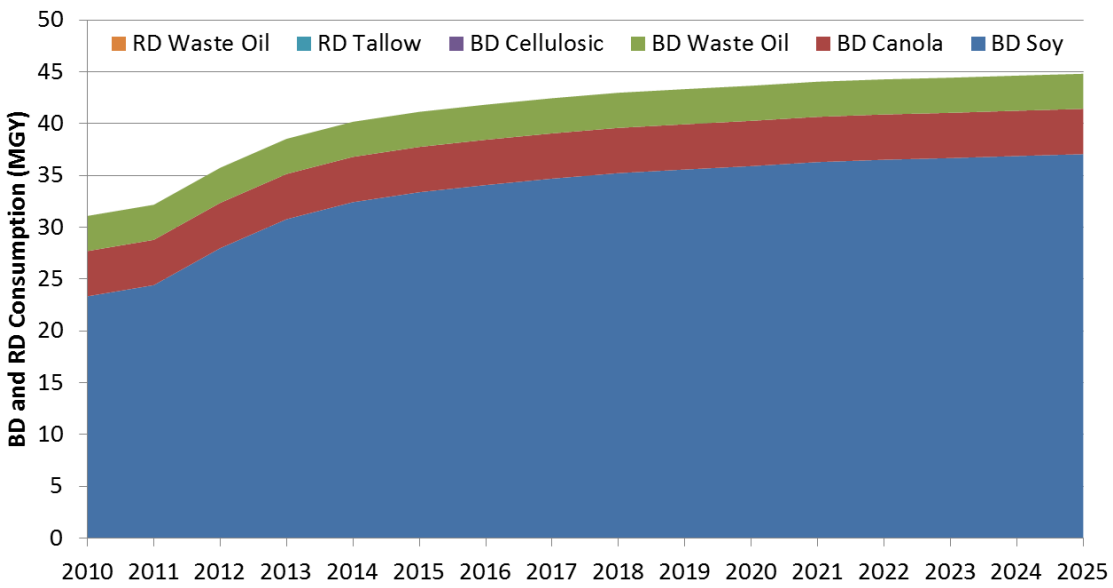

Figure 8. Breakdown of BD and RD Consumed in the BAU Scenario by Feedstock and Production Location

3.2 Carbon Intensity (BAU Scenario)

The carbon intensity values from the 2010 analysis were updated with the proposed CARB ILUC values[4] and updated gasoline blendstock and diesel values. The 2010 gasoline blendstock and diesel carbon intensities were updated by Oregon DEQ based on 2010 electricity sources and Canadian 2010 crude exports to PADD IV and PADD V. Table 5 below shows the updated carbon intensity values in grams of carbon dioxide equivalent per megajoule of fuel (gCO2e/MJ). The energy equivalency ratio (EER) adjusted values for electricity (EER = 3.4) and diesel pool natural gas (EER = 0.9) take into account the increased or decreased fuel efficiency compared to the conventional fuel. Diesel pool natural gas is considered natural gas consumed in the heavy-duty sector that displaces diesel. For example, the EER of 3.4 for electricity means that a vehicle fueled on electricity would travel 3.4 times farther than a comparable conventional fueled vehicle with the same amount of fuel.

Table 5. Oregon Carbon Intensity Values

Fuel	Pathway CI (gCO2e/MJ)	ILUC (gCO2e/MJ)	Updated CI (gCO2e/MJ)
Gasoline Blendstock	89.4	-	89.40
Ultra Low Sulfur Diesel	89.0	-	89.00
Midwest Corn Ethanol	64.82	23.20	88.02
Boardman Corn Ethanol	56.99	23.20	80.10
Midwest Soy Biodiesel	19.99	30.20	50.19
Northwest Canola Biodiesel	27.31	41.60	68.91
Northwest Waste Grease Biodiesel	10.28	-	10.28
Electricity	154.98	-	154.98 (EER adjusted – 45.58)
Natural Gas and LPG	71.41	-	71.41 (Diesel Pool EER adjusted – 79.34)

Table 5 above lists the fuels included in the BAU scenario and does not included the multitude of potential fuels that could be used for compliance. CARB has approved over 100 LCFS pathways to generate credits including: ethanol from sugarcane, sorghum and molasses; biodiesel and renewable diesel from tallow, waste grease, corn oil and other virgin oils; and biomethane to CNG and LNG from dozens of different biomethane production facilities.

Based on the fuel consumption shown in Figure 6, Figure 7, and Figure 8 and the carbon intensities in Table 5, Figure 9 below shows the small reduction in the average Oregon BAU transportation fuel carbon intensity from 2011 to 2025. The increased electricity consumption in the gasoline pool from the ZEV program is the main driver for the reduction in carbon intensity. The diesel pool carbon intensity

[4] http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/iluc_presentation_handouts_031014.pdf

remains relatively the consistent since the statewide average biodiesel blend is held at 5.0%. The slight decrease is due to increased levels of CNG consumption.

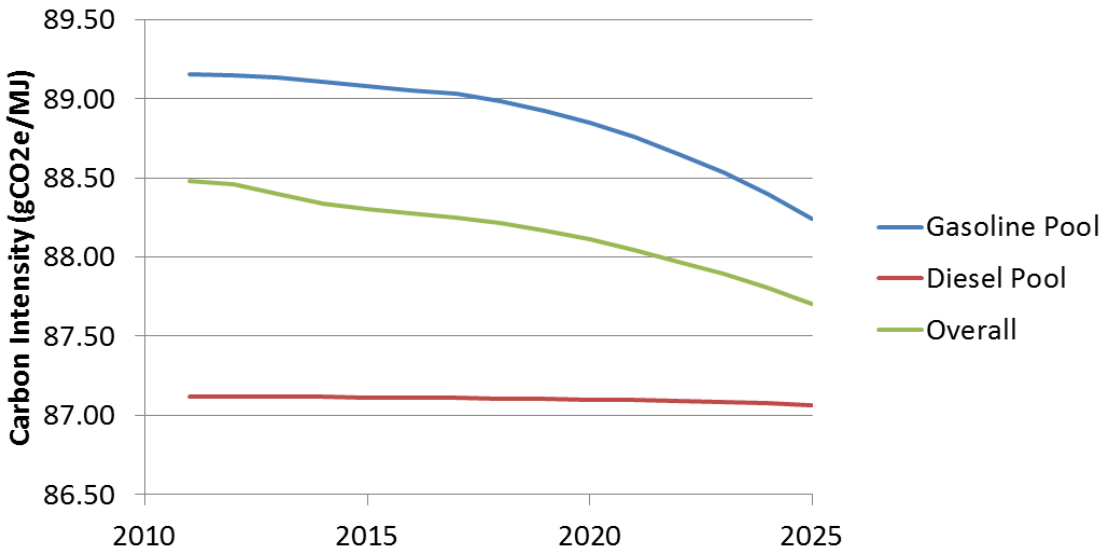

Figure 9. Average Oregon BAU Transportation Fuel Carbon Intensity