



Oregon LCFS Compliance Scenario Analysis

Oregon Department of Environmental Quality
Advisory Committee Meeting

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Reference: D0530

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Agenda

- 1 Analysis Overview
- 2 Oregon LCFS Structure
- 3 Define Business as Usual (BAU)
- 4 Proposed LCFS Compliance Scenarios



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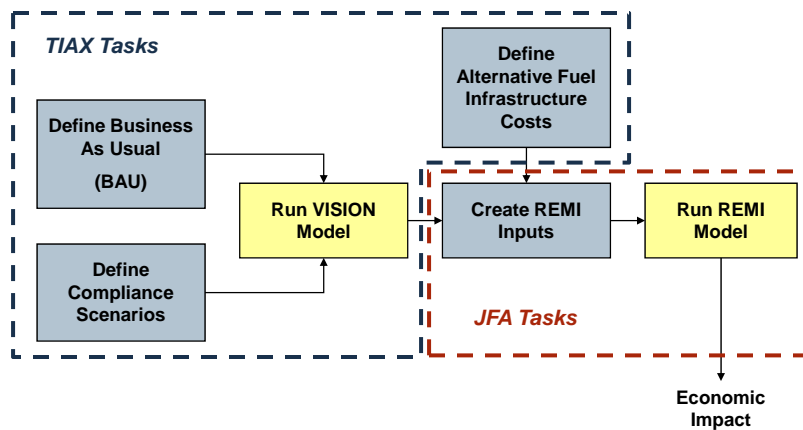
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Analysis Overview

Tasks

Objective: Estimate LCFS Impact on State Economy

Approach: Evaluate a Range of Possible Compliance Scenarios and compare them to BAU



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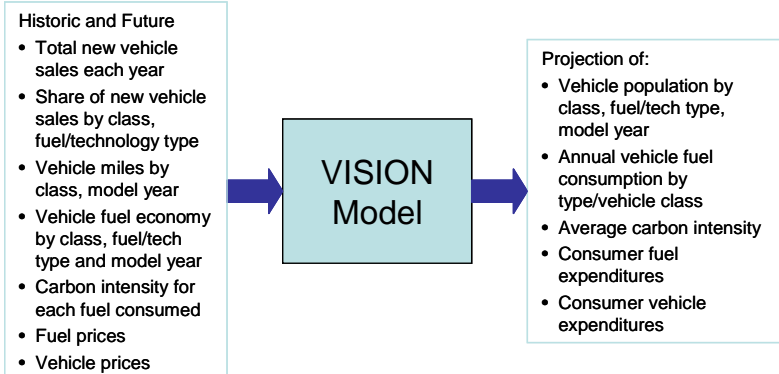
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Defining the Business-As-Usual Case

- The BAU is a forecast of transportation fuel use and associated costs through 2022
- The LCFS compliance scenario costs are compared to the BAU costs to determine LCFS cost
- Key Assumption: Projected consumption of Biofuels
 - Ethanol volumes, types
 - Biodiesel volumes, types
- Key Assumption: Alternative Fuel Vehicle market shares
 - EV market share
 - PHEV market share
 - E85 FFV market share
- Other Assumptions
 - Base and Alt Fuel vehicle fuel economy
 - Base and Alt Fuel carbon intensity
 - Vehicle and fuel prices



VISION Model Inputs and Outputs



$$\text{Fuel Consumption} \propto \frac{\text{Vehicle population, VMT/vehicle}}{\text{Fuel Economy}}$$

$$\text{Fuel Cost} = \text{Fuel Consumption} \times \text{Fuel Price}$$



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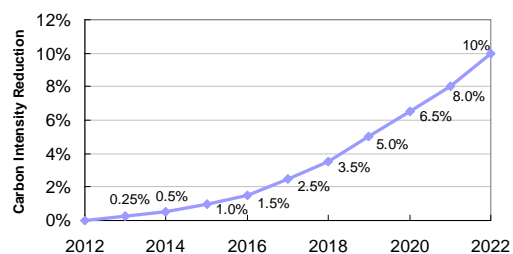
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LCFS Structure

Timing

LCFS Time Frame

- Baseline year
 - 2010
 - Measure CI reductions from 2010
- LCFS Initial Year
 - 2012
 - Reporting only
- Target Year
 - 2022
 - 10% Reduction achieved
- Shape of compliance curve
 - Gradual start
 - Same as California



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Baseline Carbon Intensity Values

	Units	Baseline Year (2010)
Gasoline Baseline Carbon Intensity		
Blendstock Carbon Intensity	g CO2e/MJ	92.3
Neat Ethanol Carbon Intensity ¹	gCO2e/MJ	92.8
Ethanol Blend Level ²	% vol	10%
Neat Ethanol Blend Level	% energy	6.7%
Gasoline Baseline Carbon Intensity	gCO2e/MJ	92.3
2022 Target	gCO2e/MJ	83.1
Diesel Baseline Carbon Intensity		
ULSD Carbon Intensity	gCO2e/MJ	91.5
Biodiesel Carbon Intensity ³	gCO2e/MJ	51.3
BD Blend Level	% energy	2.1%
Diesel Baseline Carbon Intensity	gCO2e/MJ	90.7
2022 Target	gCO2e/MJ	81.6

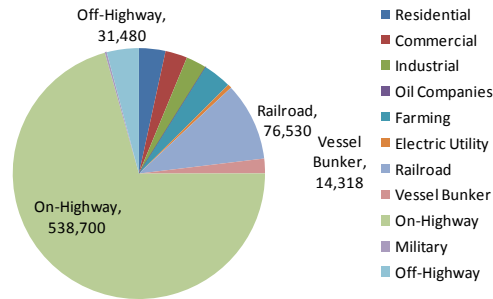
1. Assumes 26 Mgal/yr Boardman corn ethanol, 0.36 Mgal/yr waste berry ethanol, balance MW corn ethanol
2. Denatured ethanol - assumed to be 2% by vol gasoline blendstock
3. Assumes 8.4 Mgal/yr MW soybean BD, 3.5 Mgal/yr waste oil BD, and 0.3 Mgal/yr canola BD



Quantify Off-Road Diesel Consumption Included in LCFS

- Off-Highway
 - Construction, Mining
 - Assume 90% of this category
- Railroad
 - Intrastate estimated at 6,385 thousand gal/yr*
 - Corresponds to 8% of category
- Vessel Bunkering
 - All commercial and private boats
 - Assume 50% of this category
- Assumptions result in
 - 538.7 Million gal/yr on-road
 - 41.9 Million gal/yr non-road

Oregon Distillate Use, 1000 gal/yr (2004-2008 avg)



Source: EIA Oregon Distillate Use Data

*From Oregon DEQ RR Activity Data Average of 2002, 2005, 2008 usage.



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Analysis Overview

Define BAU

Business-As-Usual (BAU) Assumptions

- **Key Assumptions**
 - **Vehicle Populations**
 - BAU Alternative Fuel Volumes
- Secondary Assumptions
 - Vehicle Fuel Economy
 - Fuel Retail Prices
 - Alternative Fuel Vehicle Incremental Prices



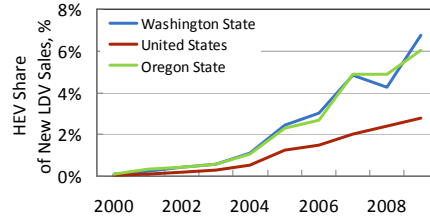
Scale VISION (U.S.) Vehicle Populations to Oregon

- VISION uses annual vehicle sales to estimate populations, and vehicle expenditures
- Vehicle Categories in VISION
 - Class: LDA, LDT, MDV (class 3-6), HDV (class 7-8)
 - Fuel/Technology type: FFV, HEV, PHEV, EV, CNG, diesel, gasoline
- Legacy Fleet – Oregon DOT database
 - DOT database classifies vehicles as light duty or truck
 - Light Duty
 - Not all records indicate LDA vs LDT
 - Using WA split for LDA/LDT
 - Fuel types are specified
 - Medium & Heavy Duty
 - Database has ~35,000 trucks
 - Not clear if this is MDV only or MDV and some HDV
 - Motor Vehicle Carrier Data also available for Heavy Duty
 - Many heavy duty trucks drive through Oregon, but not registered
- Future Annual Vehicle Sales (2010+)
 - Use EIA’s Annual Energy Outlook (AEO) U.S. vehicle sales projections
 - Scale with 5 yr avg ratio of Oregon new car sales to U.S. new car sales
 - LDA ratio is 0.93% of U.S. sales
 - LDT share is 1.03% of U.S. sales



Adjusted Light Duty Plug-in Vehicle Sales

- Oregon HEV market share is 2X National sales rate
- Assume PHEV/EV sales are 2X National sales rate
- Add 1000 EVs in 2010 due to Oregon participation in The EV Project
- Increased Ratio of EV:PHEV from 1:99 to 1:6



2022 Forecast (Preliminary)	Light Duty Auto	Light Duty Truck	Total Light Duty
PHEV Market Share	25.1%	21.5%	23.6%
PHEV Population	28,830	5,974	34,804
EV Market Share	0.6%	0.16%	0.42%
EV Population	5,668	938	6,607
Total LDV Population	1,399,968	1,259,549	2,659,417
PHEV Fleet Share	2.1%	0.5%	1.3%
EV Fleet Share	0.4%	0.1%	0.2%



Added Medium and Heavy Duty CNG Vehicles

- VISION does not include medium and heavy duty vehicles
- Using AEO2009 market share values for medium & heavy duty CNG vehicles

	Light Duty	Medium Duty	Heavy Duty
2022 Market Share	0.06%	6.1%	1.9%
2022 Population	1,320	1,792	2,392

**Verify VISION VMT and Fuel Consumption Results**

- Once vehicle populations are defined, VISION calculates
 - Vehicle Miles Traveled (VMT)
 - For each vehicle class and fuel type
 - Use VISION default VMT values function of model year and vehicle class
 - Fuel consumption
 - For each vehicle class and fuel type
 - Function of population, VMT and fuel economy
- Calibrate Model
 - Compare VISION VMT to Oregon historic VMT
 - Compare VISION predicted fuel consumption to historic fuel consumption
- For Light Duty vehicles, predicted VMT is too low
 - Increased VMT by a factor of 1.23
 - Fuel consumption for 2006-2008 within 5% of actual
- Medium & Heavy duty pops still in flux – for now forcing fuel consumption to match actual and applied this factor to future fuel consumption



Business-As-Usual (BAU) Assumptions

- **Key Assumptions**
 - **Vehicle Populations**
 - **BAU Alternative Fuel Volumes**
- Secondary Assumptions
 - Vehicle Fuel Economy
 - Fuel Retail Prices
 - Alternative Fuel Vehicle Incremental Prices



Estimate BAU Alternative Fuel Volumes

- Consider Oregon biofuel mandates
 - Portland biodiesel requirement – 5% now, will increase to 10% by ??
 - Statewide biodiesel requirement – 2% now, likely won't increase to 5% in LCFS timeframe
- RFS2 Biofuel volumes

RFS2 Volume Requirements	% GHG Reduction	Billion Gallons/yr (2022)			
		Minimum Volume Requirement		EPA Analysis Primary Control Case	
		Ethanol Equivalent	Actual Volumes	Ethanol Equivalent	Actual Volumes
Total Renewable Fuel		36		36	34.5
Total Advanced Biofuel		21		21	15
Cellulosic Biofuel	60%	16		16	11
Cellulosic Ethanol				4.9	4.9
Cellulosic Diesel				11.1	6.5
Biomass-based Diesel	50%		1	1.5	1.0
Biodiesel (fame)				1.28	0.85
Renewable Diesel				0.26	0.15
Other Advanced Biofuel	50%			3.47	3.06
Brazilian Sugarcane				2.24	2.24
Other Biodiesel				1.23	0.82
Renewable Fuel	20%	15		15	15
Total Ethanol				22.1	22.1
Total Biodiesel				13.9	8.3



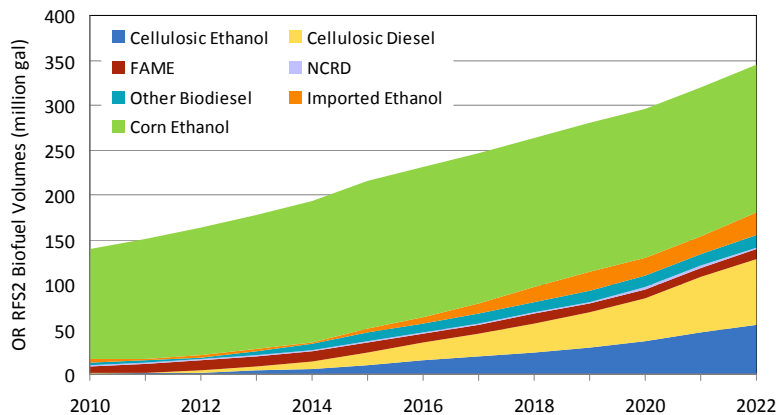
RFS2 Biofuels: Oregon's Proportionate Share

- Proportionate share of RFS2 Primary Control Case
- Ratio of projected OR gasoline and diesel consumption in 2022 relative to U.S. consumption

Oregon Proportionate Share of RFS2 Volumes	% GHG Reduction	Million Gallons/yr (2022)			
		Minimum Volume Requirement		EPA Analysis Primary Control Case	
		Ethanol Equivalent	Actual Volumes	Ethanol Equivalent	Actual Volumes
Total Renewable Fuel		410		410	345
Total Advanced Biofuel		245		245	180
Cellulosic Biofuel	60%	181		181	129
Cellulosic Ethanol				55	55
Cellulosic Diesel				125	73
Biomass-based Diesel	50%		12	18	12
Biodiesel (fame)				16	10
Renewable Diesel				3	2
Other Advanced Biofuel	50%			46	39
Brazilian Sugarcane				25	25
Other Biodiesel				22	14
Renewable Fuel	20%	165		165	165
Total Ethanol				245	245
Total Biodiesel				165	100



RFS2 Biofuels: Oregon's Proportionate Share of Primary Control Case



Biofuels Currently Consumed

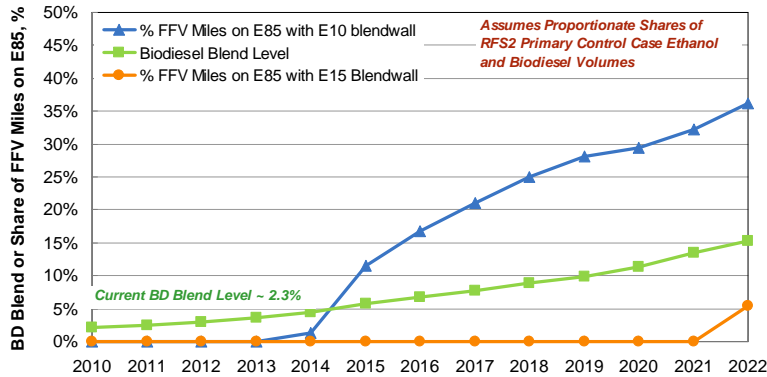
- Biodiesel
 - Waste Oil: 3.2-3.5 million gal/yr
 - Canola: 0.3 million gal/yr
 - Balance MW Soybean BD
 - 2010 BD consumption ~ 12.2 million gallons
- Ethanol
 - 2/3 of Boardman corn ethanol production (26 million gal/yr)
 - Summit Energy production (360,000 gal/yr)
 - Balance MW Corn Ethanol
 - 2010 Ethanol Consumption ~ 127 million gal/yr

Company	Fuel	Feedstock(s)	Plant Capacity (MGY)
K&S Madison Farm	Biodiesel	Canola	0.02
SeQuential-Pacific Biodiesel	Biodiesel	Waste oil & Canola	5.0
Pendleton Grain Growers Biodiesel	Biodiesel	Canola	0.01
Beaver Biodiesel	Biodiesel	Waste Oil	0.5
Evergreen Fuels	Biodiesel	Canola & Waste Oil	0.04
Portland Biodiesel	Biodiesel	Waste Oil	1.0
Lookout Mountain	Biodiesel	Waste Oil	0.05
Total Biodiesel Capacity			6.62
Pacific Ethanol, Boardman	Ethanol	MW Corn	40.0
Summit Energy	Ethanol	Waste Berries	1.5
Total Ethanol Capacity			41.5

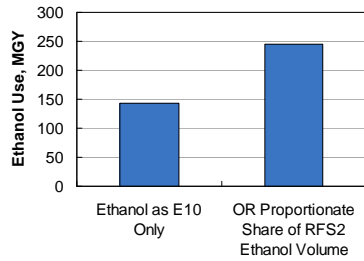


Oregon's Proportionate Share of RFS2 Volumes

- Impact on E85 Consumption
 - With E10 blendwall, 35% of FFV VMT on E85 by 2022
 - With E15 blendwall, 5% of FFV VMT on E85 by 2022
- BD blend level increases to 15% (state mandate ~5%)



BAU Ethanol Volume Decisions...



- Ceiling: Proportionate shares
 - CARB and NESCAUM using proportionate shares as BAU in scenario analysis
 - In OR, requires FFVs to use E85 for 35% of VMT
 - Compliance in "aggregate": No requirement that each state receive its proportionate share
 - What is incentive for investment in E85 infrastructure at terminals, stations?
 - Places cost of E85 investment in BAU, not LCFS

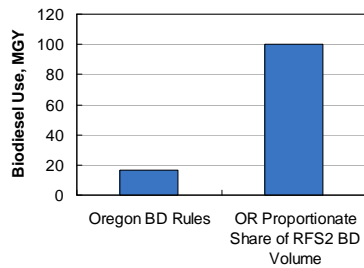
Floor: Oregon rules

- Assume no E85, only E10
- All of E85 infrastructure costs assigned to LCFS

- **Seek input on BAU Ethanol Volumes**



BAU Biodiesel Volume Decisions...



- Ceiling: Proportionate shares
 - CARB and NESCAUM using proportionate shares as BAU in scenario analysis
 - In OR, results in a 15% BD blend by 2022
 - Compliance in "aggregate": No requirement that each state receive its proportionate share
 - What is incentive to import more soybean BD?
 - What is incentive to invest in OR BD production?
 - Results in higher BAU fuel costs

Floor: Oregon rules

- Assume no additional BD only up to 2.7% (assumes 10% in PDX, 2% rest of state)
- Assigns all bulk of BD fuel costs to LCFS

- **Seek input on BAU Biodiesel Volumes**



Business-As-Usual (BAU) Assumptions

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 - **Vehicle Fuel Economy**
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**Vehicle Fuel Economy**

- VISION model has baseline vehicle fuel economy values over time
 - Light duty baseline vehicle is mid-size gasoline
 - Includes CAFE improvements
 - Similar to Pavley tailpipe GHG standard
 - Medium & Heavy duty baseline vehicles are diesel
- Fuel economy for alternative vehicles are scaled from baseline vehicle with Energy Economy Ratio (EER)
 - Ratio of baseline vehicle MJ/mi to alt vehicle MJ/mi
 - Also used to scale carbon intensity values
- Propose modifying selected VISION EERs
 - EVs
 - PHEVs (electric portion)
 - Light duty diesel
 - Light duty CNG
 - HD CNG (added)



PHEV and EV EERs

- TIAX adjusted the VISION default EER for EVs and the electric portion of PHEVs
 - Increased 2010 EV fuel economy to CARB value
 - Assume no EV fuel economy improvement through 2022

Light Duty Vehicles	Units	VISION Default	CARB	Assumption for Oregon
Gasoline Vehicle				
2010	mi/gal	30.0	29	30.0
2020	mi/gal	38.8	38	38.8
2022	mi/gal	38.9	X	38.9
PHEV/EV				
2010	MJ/mi		1.0	1.0
2010	mi/gal	83	119 ^a	122 ^b
2020/2022	mi/gal	108	119 ^a	122 ^b
PHEV/EV EER				
2010		2.8	4.2	4.1
2022		2.8	3	3.1

a. Converted to mi/gal using GREET default LHV for CARFG of 113,927 Btu/gal
 b. Converted to mi/gal using GREET default LHV for conventional gasoline of 116,090 Btu/gal



PHEV Fuel Economy Assumptions

- The electric portion of the PHEV fuel economy was adjusted as shown in the previous slide
- The gasoline portion of the PHEV fuel economy uses an EER of
 - 1.46 in 2010
 - 1.39 in 2020
 - Same EER values as HEV
- The electricity share of PHEV VMT is
 - 17.4% in 2010
 - 32% in 2020

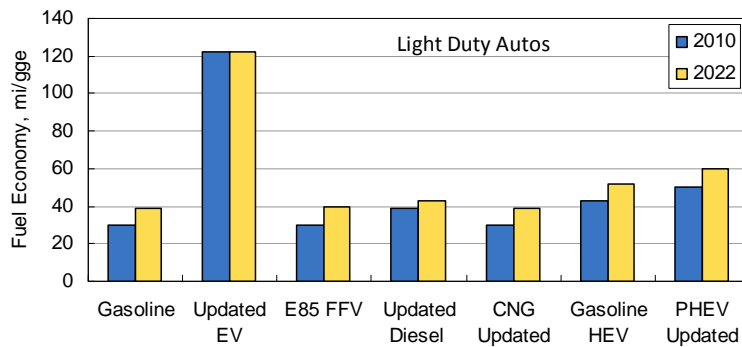


Other EER Adjustments

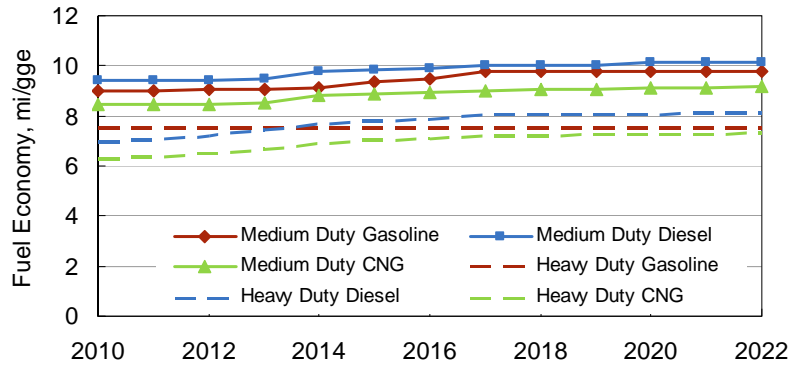
- Light Duty Diesel
 - The VISION default EER for light duty diesel vehicles is constant over time at 1.3, resulting in a fuel economy of over 50 mpg in 2025.
 - TIAX adjusted the EER to reflect improvements to the gasoline vehicle through 2018 that will not translate to diesel vehicles
 - Use the default value of 1.3 in 2010
 - Decrease to 1.1 by 2018
 - Because Oregon is separating diesel LCFS compliance from gasoline compliance, the light duty diesel EER is not applied to the diesel carbon intensity value
- Light Duty CNG
 - The default EER was 0.96.
 - TIAX revised to 1.0 reflect the Honda civic GLX
 - Consistent with CARB LCFS analysis
- Medium/Heavy duty CNG EER
 - This category was not included in VISION
 - TIAX utilized an EER of 0.90 based on the Cummins Westport ISLG engine
 - Consistent with CARB LCFS analysis



Light Duty Fuel Economy Summary



Medium and Heavy Duty Fuel Economy Summary



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Fuel Prices

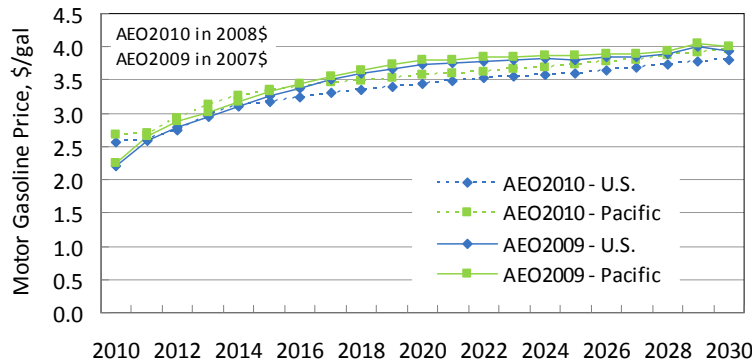
- Fuel Retail Prices
 - Motor Gasoline
 - Diesel
 - CNG
 - E85
 - Electricity (use OR specific prices)
 - Biodiesel (updated VISION estimate)
- Alternative Fuel Vehicle Prices
 - Increments relative to base vehicles
 - Use VISION defaults

Update VISION
with AEO2010
from AEO2009



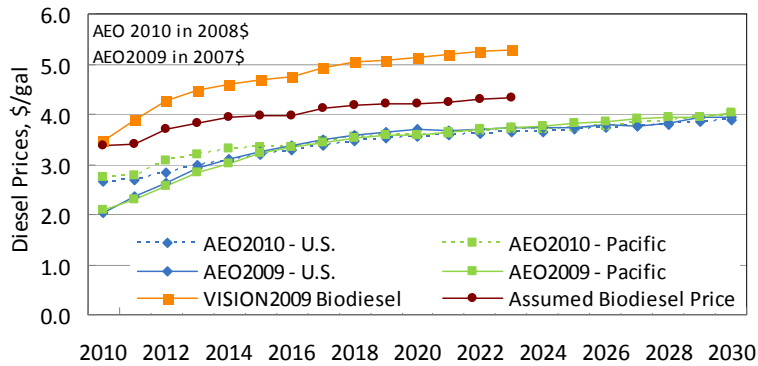
Gasoline Prices

- Using AEO2010 Pacific Forecasts



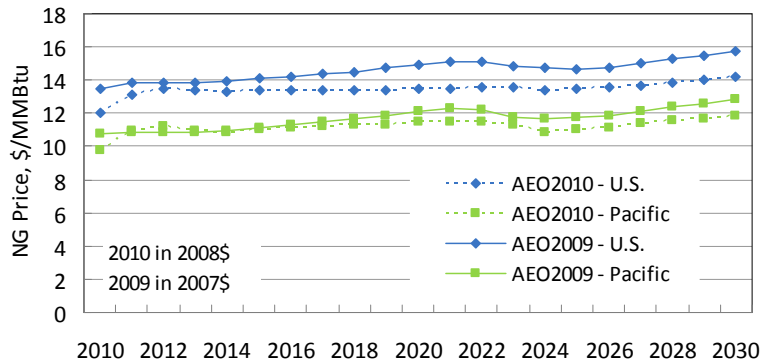
Diesel and Biodiesel Prices

- For Diesel, using AEO2010 Pacific forecast
- For Biodiesel, using diesel price + \$0.63
 - EIA does not forecast BD prices
 - U.S. DOE EERE data indicate a 5 year average price differential of \$0.63



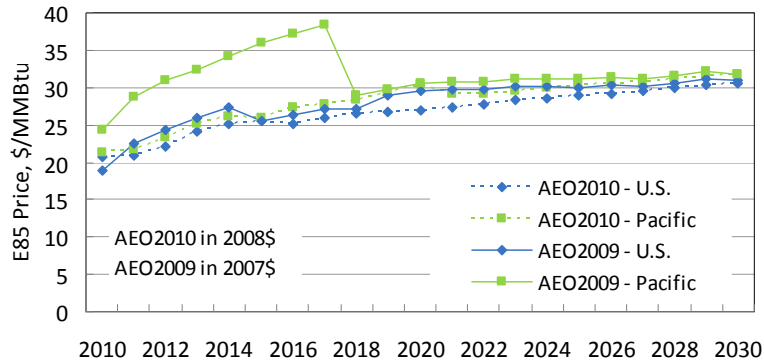
CNG Prices

- Using AEO2010 Pacific Forecast



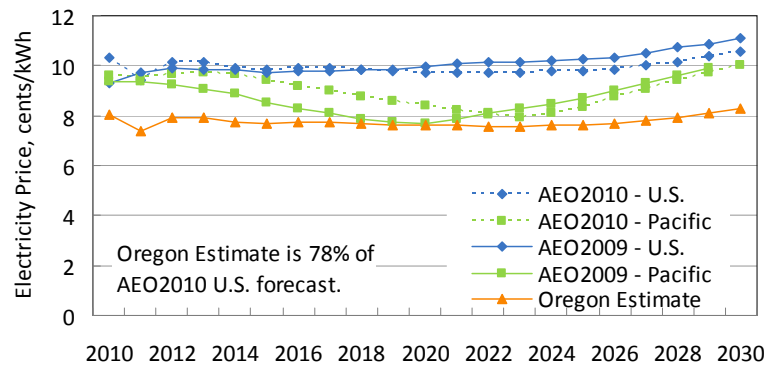
E85 Prices

- Using AEO2010 Pacific Forecast



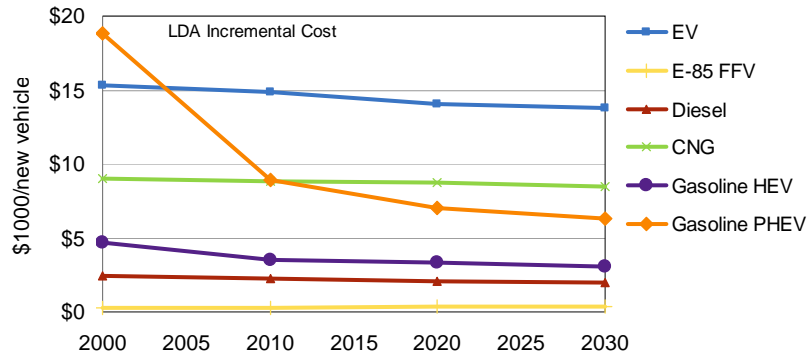
Electricity Prices

- Compared Oregon retail electricity prices to U.S. average prices.
- Seven year average of ratio of OR to U.S. prices is 78%
- Applied 78% factor to AEO2010 U.S. price



Alternative Fuel Vehicle Prices

- Increments relative to base vehicles
- Using VISION defaults



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Proposed Compliance Scenarios

Gasoline Pool

	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		Cellulosic (with ILUC)	Mixed Ethanol (with ILUC)	Mixed Ethanol (no ILUC)	Max EV + Cellulosic (with ILUC)
Ethanol volume	MGY	At least BAU	At least BAU	At least BAU	At least BAU
OR Corn	MGY	26	26	26	26
OR Berries	MGY	1.5	1.5	1.5	1.5
Avg MW Corn	MGY	Balance to achieve E10	Balance to achieve E10	Balance to achieve E10	Balance to achieve E10
Low CI MW Corn	MGY	0	Up to RFS2 Share	Up to RFS2 Share	Only if needed for CI goal
Brazil Sugarcane	MGY	0	Up to RFS2 Share	Up to RFS2 Share	Only if needed for CI goal
Cellulosic	MGY	Balance to achieve CI goal	Low to Moderate (up to 189)	Low to Moderate (up to 189)	Low to Moderate (up to 189)
Vehicle Population					
E85 FFV	1000's	BAU	Increase if % E85 VMT is high	Increase if % E85 VMT is high	BAU
EVs & PHEVs	1000's	BAU	BAU	BAU	240-288
Light Duty CNG	1000's	BAU	BAU	BAU	BAU
Med Duty CNG	1000's	1.2*BAU	1.2*BAU	1.2*BAU	1.2*BAU
E85 Use	% VMT	Float as needed to consume ethanol	Float as needed to consume ethanol	Float as needed to consume ethanol	Float as needed to consume ethanol



Proposed Compliance Scenarios

Diesel Pool

	Units	Scenario 5	Scenario 6	Scenario 7	Scenario 8
		Cellulosic (with ILUC)	Max Conventional (with ILUC)	Max Natural Gas (with ILUC)	
Biodiesel Blend Level	%	At least BAU	At least BAU	At least BAU	
OR Waste Oil	MGY	Max Capacity	Max Capacity	Max Capacity	
OR Cellulosic	MGY	Medium: up to 110	Low: up to 77	Low: up to 77	
NW Canola	MGY	As needed to achieve reduction	High: up to max available	As needed to achieve reduction	
NW Renewable Diesel	MGY	Assume goes to aviation industry			
MW Soybeans	MGY	Balance	Balance	Balance	
CNG Consumption					
Biogas Derived	MMBtu	Low to Moderate: up to ½ of unused	Low to Moderate: up to ½ of unused	High: All of unused	
Pipeline NG	MMBtu	Balance	Balance	Balance	
Vehicle Populations					
Light Duty CNG		1.2 * BAU	1.2 * BAU	More – 1.5X?	
Med Duty CNG		1.2 * BAU	1.2 * BAU	More – 1.5X?	
Hvy Duty CNG		1.2 * BAU	1.2 * BAU	More – 1.5X?	

