Memorandum

Date: Oct 18, 2010

To: Oregon DEQ
JFA (Mike Lawrence, Scott Williams)

From: Jennifer Pont

Subject: LCFS Scenarios Infrastructure Costs

To support DEQ's LCFS analysis, fuel use and vehicle population assumptions were made for business as usual (BAU) and a range of LCFS compliance scenarios using the VISION model. JFA will run the REMI model for the BAU and compliance scenarios to estimate the economic impact of a LCFS on the State of Oregon. This model documents assumed alternative fuel infrastructure cost assumptions that JFA will use to create REMI inputs. We provide cost assumptions for plug-in vehicle charging infrastructure, CNG vehicle refueling infrastructure, biofuel production and handling infrastructure. For compliance scenario and compliance run descriptions, please refer to page 14. Runs 1-4 include gasoline and gasoline substitutes, while runs 6-9 include diesel and diesel substitutes. These runs were combined into a variety of Scenarios, so that each Scenario includes a gasoline run and a diesel run. Run 5 is the One Pool Scenario E, which includes gasoline and diesel and all substitutes.

Plug-in Electric Vehicles

Plug-in electric vehicles require chargers. In the early 1990s, the Electric Power Research Institute defined three different charging levels:

- Level 1: 120 volt AC, 15/20 amp circuit (vehicle charging only to prevent overload)
- Level 2: 240 volt AC, single phase 40 amps
- Level 3: 480 volt AC, three-phase circuit fast charger

For battery electric vehicles (BEVs), a Level 2 home charging system is required. For PHEVs, the charging system depends upon battery size; larger vehicles and electric ranges have larger batteries. The amount of time required to charge a range of PHEV vehicles was estimated in a recent report by Batelle Energy Alliance[1] – the results are provided in Table 1.

Table 1. Estimated Charging Times for Level 1 and Level 2 Systems (Batelle, 2008).

Hours		PHEV-10	PHEV-20	PHEV-40
Level 1	Economy Vehicle	2.7	5.5	10.9
	Mid-size Vehicle	3.6	7.3	14.5
	Light Duty Truck/SUV	4.5	9.1	18.2

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[1] Morrow, Karner, Francfort, "Plug-in Hybrid Electric Vehicle Charging Infrastructure Review", Battelle Energy Alliance, U.S. Department of Energy Idaho National Laboratory. Nov 2008.

Level 2	Economy Vehicle	0.5	1	2
	Mid-size Vehicle	0.7	1.3	2.7
	Light Duty Truck/SUV	0.8	1.7	3.3

For the economic analysis, we assume that one Level 2 charging system is purchased for each EV sold. Based on the estimated charging times above, we further assume that a mix of Level 1 and Level 2 charging systems is purchased for each PHEV as indicated in Table 2. Table 3 provides the total number of Level 1 and Level 2 home chargers purchased between 2012 and 2022.

Table 2. Assumed Shares of Home Charger Type Purchased for Analysis Vehicles.

	Light Duty Auto		Light Duty Truck	
	PHEV	EV	PHEV	EV
Level 1 Charger Share	50%	0%	10%	0%
Level 2 Charger Share	50%	100%	90%	100%

Table 3. Cumulative Home Charger Installations 2012-2022

	BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
PHEV Auto Sales	16,943	169,570	48,408
PHEV Light Truck Sales	3,412	30,839	9,037
EV Sales	18,049	33,036	19,968
Number of Level 1 Chargers	8,813	87,869	25,108
Number of Level 2 Chargers	29,592	145,576	52,305

Estimated costs to install Level 1 and Level 2 home charging systems are provided in Table 4. The Level 1 total cost is from Battelle (2008) with sales tax backed out; it has been divided between labor materials and permit fees according to the Level 2 breakdown. The permit fee was provided by Oregon DOE. The Level 2 costs are provided by eTec and are for the Greater Seattle area but that the cost will be the same for Oregon. We also assume that the chargers are produced outside of Oregon. Table 5 provides cumulative home charger costs from 2012-2022.

Table 4. Plug-in Vehicle Home Charger Installed Costs.

	Level 1	Level 2
Labor	$380	$962
Materials	$412	$1,041
Permit	$14	$14
Total	$807	$2,088

Table 5. Plug-in Vehicle Home Charger Total Costs, $Million

	BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
Level 1, 2012-2022	7.1	70.9	20.2
Level 2, 2012-2022	61.8	304.0	129.5
Total Home Chargers, 2012-2022	68.9	374.9	149.7

In addition to home charging, we need to consider public charging infrastructure. This consists of a number of commercial and public Level 2 charging locations (e.g. work places, shopping malls parking lots) and commercial Level 3 fast charging stations located in the major urban areas and on connecting highways.

We first estimate the number of Level 2 publicly accessible charging stations. There is a wide range of estimated need for Level 2 charging away from home. The emerging consensus seems to be fewer Level 2 charging stations than some of the earlier thinking. This is due to a number of factors including strong indications that EV ranges will increase over the next several years, decreased costs for Level 3 charging stations, and relatively short driving distances between cities in Oregon.

Under the EV Project, eTec may be installing 2050 Level 2 charging stations in Portland, Eugene, Corvalis and Salem. We further assume that there will be a small amount of public and private investment in L2 charging into the future. For our analysis, we make the assumptions indicated in Table 6.

Table 6. Level 2 Charging Station Installation Assumptions

	BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
The EV Project	2050	2050	2050
Additional Locally Funded and Commercial L2 Chargers	2%/yr	5%/yr	2%/yr
Additional by 2022	449	574	449
Total by 2022	2,499	2,624	2,499

Table 7 provides estimated costs for installation of L2 publicly accessible charging stations based on the eTec Infrastructure Deployment report[2]. Note that each station has two charging points. Finally Table 8 provides total cumulative L2 public charging costs.

Table 7. Level 2 Publicly Accessible Charging Station Cost Estimate

	Two Charger L2 Station
Labor	$4,292
Materials	$6,287
Trenching and Repairs	$4,136
Permit	$85
Total	$14,800

Table 8. Level 2 Charging Station Cumulative Costs 2012-2022

	BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
Total, $Million	6.6	8.5	6.6

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[2] "Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Seattle Area", eTec, Jan 2010.

The Level 3 fast charging station network has two components: distributed along major highways for plug in vehicles traveling long distances, and concentrated in city centers. Table 9 shows the estimated number of chargers distributed along major highways for the BAU and LCFS Compliance scenarios. We assume for the BAU the fast charge stations will be located every 25 miles for the Portland to Eugene I-5 corridor due to the EV project and every 40 miles from Eugene to Ashland. For the high EV case, we include charging stations along additional highways as shown in Table 9.

Next, the number of fast charge stations located within city centers is estimated as shown in Table 10. For the BAU and Scenarios 1-5 we assume that one charger will be located every 6 square miles within the major cities located along the I-5 corridor. For the high EV case, we add in cities located along the I-85, U.S. 26, and U.S. 97 corridors.

A total of 52 Level 3 stations are estimated for BAU and all scenarios except Scenario D (High EV scenario). A total of 76 Level 3 stations are estimated for Scenario D.

Table 9. Number of Distributed Fast Charge Stations

Highway	Point to Point	Miles	Number of L3 Charging Stations		
			BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
I-5	Portland to Eugene	110	4.4	4.4	4.4
I-5	Eugene to Ashland	178	4.5	4.5	4.5
I-84	Portland to Pendleton	208		5.2	
U.S. 26	Portland to Bend	160		4.0	
U.S. 97	Bend to Klamath Falls	137		3.4	
	Total Travel Route L3 Chargers		9	22	9

Table 10. Number of Fast Charge Stations Located in City Centers

City	Square Miles	Number of L3 Stations		
		BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
Portland	134.4	22	22	22
Eugene	40.5	7	7	7
Salem	16.4	8	8	8
Corvallis	13.8	2	2	2
Medford	21.7	4	4	4
Bend	32.2		5	
Klamath Falls	18.7		3	
Hood River	2.9		1	
Pendleton	10.1		2	
Total L3 Chargers		43	54	43

Table 11 provides the estimated installed cost for Level 3 Quick Charge Stations[3]. We assume the L3 stations will be installed with public funding. Table 12 provides cumulative Level 3 charging station costs from 2012 through 2022.

Table 11. Level 3 Charging Station Cost Estimate

	Two Charger Station
Labor	$6,452
Materials	$52,264
Trenching and Repairs	$1,379
Concrete Work	$1,379
Permit	$85
Total	$61,558

Table 12. Level 3 Charging Station Cumulative Costs 2012-2022, $MM

	BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
Total	3.20	4.68	3.20

Table 13 summarizes the overall EV Infrastructure assumptions~~.~~

Table 13. Summary of Cumulative EV Infrastructure Installments through 2023

	BAU and Scenarios A-C and F-H	Scenario D	Scenario E: One Pool
Total Home Chargers	38,404	233,444	77,412
Total L2 City Chargers	2,499	2,624	2,499
Total L3 Fast Charge Stations	52	76	52
Home Charger Cost	68.9	374.9	129.5
L2 City Charger Cost	6.6	8.5	6.6
L3 Fast Charge Station Cost	3.20	4.68	3.20
Total Cost, $Million	79.3	388.8	139.9

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[3] "Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Seattle Area", eTec, Jan 2010.

Compressed Natural Gas (CNG)

Table 14 provides our projected CNG vehicle populations for each compliance scenario. Table 15 provides the estimated CNG consumption in 2013 and 2023. The amount of CNG consumed in 2023 is approximately three times the 2013 level.

Table 14. CNG Vehicle Population Forecasts for BAU and Compliance Scenarios

Scenario	Light Duty		Medium Duty		Heavy Duty	
	2012	2022	2012	2022	2012	2022
BAU	367	1,319	407	2,091	206	955
Runs 1-4 [a]	367	1,319	484	2,507	n/a	n/a
Runs 6-8 [b]	n/a	n/a	484	2,507	241	1,144
Run 9 [b]	n/a	n/a	1,570	8,327	743	3,788
Scenario E: One Pool	367	1,319	484	2,507	241	1,144

a. Only includes gasoline share of MD/HD CNG use
b. Only includes diesel share of MD/HD CNG use

Table 15. Scenario CNG Consumption Forecasts, MMBtu/yr

Scenario	Light Duty		Medium & Heavy Duty	
	2013	2023	2013	2023
BAU	34,383	104,028	474,440	2,048,111
Runs 1-4 [a]	34,383	104,028	14,565	65,623
Runs 6-8 [b]	n/a	n/a	546,257	2,389,844
Runs 6-8 [b]	n/a	n/a	1,728,228	8,040,907
Scenario E: One Pool	34,383	104,031	560,823	2,456,432

a. Only includes gasoline share of MD/HD CNG use
b. Only includes diesel share of MD/HD CNG use

For light duty vehicles, we assume that 20% are purchased by individuals and 25% of these will be fueled at home. Therefore, 5% of light duty vehicles will have home charging equipment. The rest of the vehicles will refuel at public/private CNG stations. The installed cost of home CNG fueling equipment is estimated at $5500. This includes $4000 for equipment and $1500 for installation[4]. Table 16 provides our estimated cumulative home charger costs between 2013 and 2023.

Table 16. Estimate of Total Home CNG Refueling Systems Installed by 2023

	Number of Home Refuelers	Total Cost	Labor Cost
BAU	48	$264,000	$72,000
Scenarios A-D and F-H	48	$264,000	$72,000
Scenario E: One Pool	48	$264,000	$72,000

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[4] BRC FuelMaker, pre Gas Equipment Systems, 909-466-6920.

New CNG refueling station sizes range from 6,000 to12,000 gge/day with corresponding installed costs ranging from $1.5 to $2.8 million. For a station to be reasonably profitable, throughput must be a minimum of 15 percent of capacity[5].
We assume for our analysis that the average new station capacity is 8,000 gge/day, with a capacity factor of 30%. This results in annual throughput of 120,000 MMBtu/yr per station. The installed cost per station is $2.15 million. Table 17 provides our estimate of cumulative CNG station installed costs for BAU and LCFS compliance scenarios. We estimate that half of installed cost is labor.

Table 17. Estimated New CNG Refueling Station Cumulative Costs through 2023

	BAU	Runs 1-4 [a.]	Runs 6-8 [b.]	Run 9 [b.]	Scenario E: One Pool
2012 CNG Use, MMBtu/yr	508,823	48,948	546,257	1,728,228	595,206
2022 CNG Use, MMBtu/yr	2,152,140	169,651	2,389,844	8,040,907	2,560,463
CNG Use Increase, MMBtu/yr	1,643,316	120,703	1,843,586	6,312,679	1,965,257
New CNG Station Supply, MMBtu/yr[c]	1,639,834	117,221	1,843,586	6,312,679	1,961,775
Estimated Number of Stations	14	1	15	53	16
Capital Cost, $Million	30.10	2.15	32.25	113.95	34.4
Labor Cost, $Million	15.05	1.08	16.13	56.98	17.20

a. Gasoline pool CNG only
b. Diesel pool CNG only
c. Total less home refueling volumes

For the LCFS diesel and one-pool compliance scenarios, we assume that various amounts of unused biogas are captured, cleaned and introduced to the pipeline. The Scenario 9 quantity is the total landfill, wastewater and dairy gases in Oregon. The installed cost for a landfill gas cleanup system has been estimated at $23.2 per annual MMBtu of capacity[6]. It is assumed that these costs are equivalent to other biogas capture and cleanup systems (dairy and wastewater). Table 18 provides the biogas capture and cleanup costs for the various scenarios.

Table 18. Estimated Biogas Capture and Cleanup System Costs

	Units	Runs 6-8	Run 9	Scenario E: One Pool
Biogas Quantity, 2022	MMBtu/yr	2,150,000	4,300,000	2,150,000
Materials	$	28,407,942	56,815,884	28,407,942
Labor	$	8,227,437	16,454,874	8,227,437
Site Prep	$	1,831,769	3,663,538	1,831,769
Engineering	$	6,597,473	13,194,946	6,597,473
Permitting	$	1,102,166	2,204,332	1,102,166
Contingency	$	3,663,538	7,327,076	3,663,538
Total Installed	$	49,830,325	99,660,650	49,830,325

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[5] Clean Energy Fuels presentation at 2009 Integrated Energy Policy Report workshop.
[6] Cost estimated developed by TIAX under contract to Pacific Gas and Electric Company, 2009.

Ethanol

Under the BAU and LCFS compliance scenarios significant increases in ethanol consumption are anticipated. This is achieved through increasing the blend level in gasoline to 15% (in scenarios 2 and 3) and increased volumes of E85 consumption. The infrastructure costs can be divided into two main categories: ethanol production, handling and storage infrastructure and E85 blending, distribution and refueling infrastructure. Table 19 provides the total ethanol volumes for the BAU and compliance scenarios.

Table 19. Projected 2022 Ethanol Consumption Volumes (million gal/yr)

	Total Ethanol Consumed	Total Ethanol Consumed as E85
BAU	250	107
BAU – High Oil Prices	250	107
BAU – Low Oil Prices	249	107
Run 1 (Cellulosic with ILUC)	307	170
Run 1H (Cellulosic with ILUC, Out-of-State)	308	170
Run 2 (Mixed with ILUC)	403	198
Run 3 (Mixed no ILUC)	331	114
Run 3H (Mixed no ILUC, High Oil Prices)	332	115
Run 3L (Mixed no ILUC, Low Oil Prices)	329	113
Run 4 (EVs, cellulosic)	282	150
Scenario E: One Pool	302	167

Ethanol Production Facility Costs

The BAU and each gasoline pool scenario except Run 1H assume various volumes of in-state cellulosic ethanol production. The total cellulosic ethanol consumption was capped at the RFS2 high ethanol case proportional share volume. Table 20 provides the projected volumes of in-state cellulosic ethanol for each of these scenarios. Also shown is EPA's estimate of average cellulosic production plant size in 2015 and corresponding plant installed cost. The number of in-state cellulosic ethanol plants is expected to range from 0 to 4, at a cost up to $880 million.

Table 20. Estimated Cellulosic Ethanol Production Plant Costs

	Units	Runs						
		BAU[b]	1	1H	2	3[c]	4	One Pool
Existing In-State Capacity	MMGal/yr	1.8	1.8	1.8	1.8	1.8	1.8	1.8
New OR Production, 2022	MM Gal/yr	58	245	0	245	245	193	245
Plant Size[a]	MMGal/yr	69	69	69	69	69	69	69
New OR Plants by 2022		1	4	0	4	4	3	4
Capital Cost per Plant[a]	$MM	220	220	220	220	220	220	220
Total Capital Cost by 2022	$MM	220	880	0	880	880	660	880

a. EPA RFS2 RIA Chapter 4.1, page 754.
b. Same for BAU, high and low oil cases (Scenarios F and G)
c. Same for 3, 3H and 3L high and low oil cases (Scenarios F and G)

Ethanol Transportation & Storage Costs

We assume here that no upgrades are needed at marine terminals to handle increased levels of sugarcane ethanol since these volumes are expected to enter through Seattle for U.S. compliance with RFS2. To transport the increased volumes of ethanol to the petroleum terminals (from rail, marine or production plants), new tanker trucks will be needed. Using the EPA RFS2 assumptions of 8000 gallon capacity and 6 trips per day per tanker truck, we estimate the numbers of new trucks needed by 2022 to transport increased volumes of ethanol to the petroleum terminals shown in Table 21.

Table 21. Estimated Number of Tanker Trucks to Transport Ethanol to Petroleum Terminals

	Units	Runs					
		BAU[b]	1[c]	2	3[d]	4	One Pool
Ethanol Volumes, 2022	MMgal/yr	250	307	403	331	282	302
Volume Increase from 2012	MMgal/yr	84	146	237	165	116	137
Truck Capacity[a]	Gallons	8,000	8,000	8,000	8,000	8,000	8,000
Truck Trips per day[a]		6	6	6	6	6	6
Total New Trucks by 2022		5	8	14	9	7	8
Truck Price	$1000	180	180	180	180	180	180
Total Cost of New Trucks	$MM	0.90	1.44	2.52	1.62	1.26	1.44

a. EPA RFS2 RIA Chapter 4.2
b. BAU high and low oil same as BAU
c. Scenario 1H out of state same as Scenario 1
d. Scenario 3 high and low oil same as 3

To handle the increased volume of ethanol at the petroleum terminals, new storage tanks will need to be constructed (some petroleum tanks can be retrofit). Additional truck unloading, blending and ancillary equipment will also be needed. In the RFS2, EPA estimated these costs for the primary control case at 0.113 $/annual gallon of ethanol. This estimate includes a 15% working inventory and assumes that much of the storage capacity could be accommodated by tanks that had previously stored gasoline. Since ethanol has a lower energy density than gasoline, only 67% of the new ethanol storage capacity can be satisfied by modified existing gasoline storage tanks. The EPA value is utilized directly to estimate the petroleum terminal costs – results are shown in Table 22.

Table 22. Petroleum Terminal Upgrade Costs, cumulative through 2023

	Units	Runs							
		BAU	1, 1H	2	3	3F	3G	4	One Pool
Increased EtOH from 2012	MMgal/yr	84	146	237	165	166	163	116	137
Terminal Upgrade Costs[a]	$/gal/yr	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
Total Terminal Costs, 2022	$Million	9.5	16.5	26.9	18.7	18.8	18.5	13.1	15.5

a. EPA RFS2 RIA Chapter 4.2

E85 Infrastructure

To handle increased E85 consumption, we consider costs associated with transporting E85 from terminals to fueling stations, and the fueling station costs. Modifications to refueling stations are considered here. In the RFS2 RIA, EPA assumes that 25% of gasoline refueling stations will have E85 dispensing equipment. Costs for adding E85 dispensing equipment varies greatly from $12,000 to $100,000. For this analysis it is assumed that installation of E85 dispensing equipment costs $75,000[7]. Table 23 provides the estimated E85 dispensing costs for the BAU and all LCFS scenarios.

Table 23. Estimated E85 Refueling Infrastructure Costs, cumulative through 2023

	Units	
Existing Gasoline Stations		1061
Total Stations with E85 by 2022		265
Existing E85 Stations	MMGal/yr	4
New E85 Retrofits by 2022	%	261
Cost per Retrofit	$	75,000
Total Cost by 2022	$Million	18.7

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[7] Conversation between Cory Ann Wind (OR DEQ) and Northwest Pump and Equipment

Biodiesel

A variety of assumptions have been made about the biodistillates used in the BAU and LCFS scenarios. Table 24 summarizes the projected volumes of biodistillates in 2022. As can be seen, in Runs 6, 7, 9 and the One Pool, the waste oil derived biodiesel consumption increases to 20 million gal/yr. It is assumed that the waste oil BD is all produced in Oregon, so a new biodiesel production plant is required for each of these scenarios. Run 7 and the One Pool Scenario have 8.4 million gal/yr of canola biodiesel above current Oregon production capacity. For these scenarios, it is assumed that the canola is grown in Oregon, but the biodiesel is produced out of state. This assumption is made because investment in such a small biodiesel production plant is unlikely. Finally, the BAU, 6, 9 and One Pool scenarios have in-state production of cellulosic diesel. For these scenarios, it is assumed that a new cellulosic diesel production plant is built in Oregon.

Table 24. Summary of Biodistillate Consumption in 2022, Million gal/yr.

	In-State Cellulosic	Out-of-State Cellulosic	In-State Canola	Out-of-State Canola[1]	Camelina RD[2]	Waste Oil BD[3]
BAU	78.9	0.0	0.3	0.0	0.0	3.5
BAU, High Oil	79.0	0.0	0.3	0.0	0.0	3.5
BAU, Low Oil	78.7	0.0	0.3	0.0	0.0	3.5
6: Cellulosic with ILUC	96.2	0.0	0.3	0.0	0.0	20.0
6H: out-of-state cellulosic	0.0	96.2	0.3	0.0	0.0	20.0
7: Conventional w/ILUC	29.4	0.0	0.3	8.4	50.0	20.0
8: Conventional, no ILUC	0.0	0.0	0.3	0.0	0.0	3.5
8F: High Oil	0.0	0.0	0.3	0.0	0.0	3.5
8G: Low Oil	0.0	0.0	0.3	0.0	0.0	3.5
9: CNG & Cellulosic	61.3	0.0	0.3	0.0	0.0	20.0
One-Pool	34.7	0.0	0.3	8.4	50.0	20.0

1. Canola grown in Oregon, but BD produced out of state
2. Camelina grown outside of Oregon, RD produced outside of Oregon
3. Existing waste oil production capacity ~ 3.5 million gal/yr. All produced in Oregon.

It is assumed that a new plant to produce biodiesel from waste oil costs approximately $0.80 per annual gallon of capacity[8]. Therefore a 20 million gal/yr plant is estimated to cost ~ $16 million. Table 24 summarizes the scenarios that incur this cost.

Table 25. Scenarios Installing Waste Oil Biodiesel Production Capacity

	Waste Oil Biodiesel Plant Expenditure
Run 6	$16 Million
Run 6h	$16 Million
Run 7	$16 Million
Run 9	$16 Million
Scenario E: One Pool	$16 Million

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[8] Imperium Renewables plant in Washington State reported to cost $78 million for 100 million annual gallon capacity. Cnet.com, August 14, 2007.

New plants to produce cellulosic biodiesel will be needed for several of the scenarios. The capital costs for installing cellulosic biodiesel plant capacity are shown in Table 26. The plant size and capital cost are from EPA RFS2 RIA Chapter 4.1.

Table 26. Estimated Cellulosic Diesel Production Plant Costs in Oregon by 2022

	Units	BAU	Run 6	Run 7	Run 9	Scenario E: One Pool
In-State Cellulosic Production, 2022	MMGal/yr	79	96	29	61	35
Cellulosic BD Plant Capital Cost	$MM	346	346	346	346	346
Plant Size	MMGal/yr	33	33	33	33	33
Number of Plants in Oregon		2	3	1	2	1
Installed Cost of Plants	$MM	692	1,038	346	692	346

Additional trucks are needed to transport biodistillate volumes from either the production plant or the rail terminal to the petroleum terminals. Table 27 provides the number of new trucks and associated cost needed by 2022 to transport BD from rail/plant to petroleum terminal using EPA's assumptions from RFS2 RIA.

Table 27. Estimated Cost of New Trucks to Transport BD to the Petroleum Terminals

	Units	Run					
		BAU	Run 6	Run 7	Run 8	Run 9	Scenario E: One Pool
Increase in BD Use by 2022	MMGal/yr	87	97	89	87	84	94
Truck Capacity	Gal	8,000	8,000	8,000	8,000	8,000	8,000
Truck Trips per Day		6	6	6	6	6	6
Number of New Trucks by 2022		5	6	5	5	5	5
Cost per truck*	$1000	180	180	180	180	180	180
Total Cost of New Trucks by 2022	$Million	0.90	1.1	0.90	0.90	0.90	0.90

*EPA RFS2 RIA says 198,000 for heated trucks in colder climates, otherwise same as EtOH.

Upgrades at the petroleum terminals are needed to unload the tanker trucks, store the biodiesel and blend it into conventional diesel. The cost estimate for these upgrades is provided in Table 28, based on EPA's RFS2 RIA Chapter 4.2.

Table 28. Estimated Cost to Upgrade Petroleum Terminals to Unload, Store and Blend BD

	Units	Run					
		BAU	Run 6	Run 7	Run 8	Run 9	Scenario E: One Pool
Increase in BD Use by 2022	MMGal/yr	87	97	89	87	84	94
Terminal Upgrade Cost	$/gal/yr	0.051	0.051	0.051	0.051	0.051	0.051
Cumulative Upgrade Cost by 2022	$Million	4.4	4.9	4.5	4.4	4.3	4.8

Biofuel Distribution to Refueling Stations

From the petroleum terminal, the biofuels are distributed to refueling stations. Table 29 summarizes the fuel volumes in 2012 and 2022 and provides the increase in fuel volumes delivered to refueling stations. The total number of distribution trucks required in 2022 is provided in Table 30.

Table 29. Increase in Fuel Volumes Delivered to Refueling Stations

MMGal/yr	BAU	A & H (1+6)	B (2+7)	C, F, G (3+8)	D (4+9)	E (One Pool)
2012 Volumes						
Gasoline	1,528	1,483	1,527	1,527	1,525	1,526
E85	0	0	0	0	0	0
Diesel	644	643	643	643	635	644
BD	19	19	19	19	19	19
Total	2,191	2,146	2,190	2,190	2,180	2,189
2022 Volumes						
Gasoline	1,334	1,295	1,231	1,279	1,243	1,281
E85	126	200	233	134	176	197
Diesel	681	669	676	679	649	680
BD	106	116	108	106	103	113
Total	2,246	2,280	2,248	2,198	2,172	2,271
Total Increase	56	134	58	8	-8	82

Table 30. Number and Cost of Fuel Distribution Trucks

	Units	BAU	A & H (1+6)	B (2+7)	C, F, G (3+8)	D (4+9)	E (One Pool)
Volume Increase from 2012	MMGal/yr	56	134	58	8	-8	82
Truck Capacity	gal	8000	8000	8000	8000	8000	8000
Trips per day	trips/day	6	6	6	6	6	6
Trips per year	trips/year	2190	2190	2190	2190	2190	2190
Number of trucks		3	8	3	0	0	5
Cost per truck	$	180,000	180,000	180,000	180,000	180,000	180,000
Total Cost	$Million	0.54	1.44	0.54	0.00	0.00	0.90

Compliance Scenario Descriptions

- All Scenarios achieve a 10% reduction in carbon intensity by 2022.
- Where indirect land use change (ILUC) is included, the ILUC number is from California Air Resources Board’s low carbon fuel standard.

Business-as-Usual

- Assumes Oregon receives its proportional share of the federal Renewable Fuel Standard (RFS2) Primary Control Case biofuel volumes (cellulosic ethanol, cellulosic diesel, sugarcane ethanol, soybean ethanol, corn ethanol). Delayed use of cellulosic diesel until 2013.
- An E10 blendwall (a requirement to blend no more than 10% ethanol with gasoline) was assumed for the analysis period.
- E10 blendwall met in 2013, limiting gasoline from absorbing any additional ethanol required by RFS2. After this point E85 consumption begins to increase.
- Biodiesel blend level increases to ~ 13.5% by 2022 due to the federal RFS2.

Gasoline Pool VISION Runs:

In all cases, 26 million gallons per year of Northwest corn ethanol made from Midwest corn plus 1.75 million gallons per year of ethanol from waste berries.

Scenarios

Scenario A – Cellulosic Biofuels with ILUC (Runs 1 + 6)

Run 1 – Cellulosic Ethanol with ILUC (Produced In-State)

- In addition to Northwest corn ethanol and waste berry ethanol, compliance with standard achieved through use of in-state cellulosic ethanol.
- If more ethanol is needed to reach total RFS2 proportional share volumes, it comes from Midwest corn ethanol.

Run 6 – Cellulosic diesel with ILUC (Produced In-State)

- Compliance achieved through the use of new in-state cellulosic diesel and new waste oil biodiesel capacity

Scenario B – Mixed Biofuels with ILUC (Runs 2 + 7)

Run 2 – Mixed Ethanol with ILUC

- In addition to Northwest corn ethanol and waste berry ethanol, compliance achieved through use of sugarcane ethanol, lower carbon intensity Midwest corn ethanol, and cellulosic ethanol
- So much ethanol was required here that the blend wall had to be increased to E12 (12% ethanol blended with gasoline) in 2017 and E15 (15% ethanol blended with gasoline) in 2020

Run 7 – Conventional biodiesel with ILUC

- Compliance achieved through:
    - Moderate amounts of in-state cellulosic diesel production
    - Out of state grown and produced camelina renewable diesel
    - New In-state waste oil biodiesel capacity
    - Existing in-state canola biodiesel
    - New out-of-state canola biodiesel production from Oregon grown canola

Scenario C – Mixed Biofuels without ILUC (Runs 3 + 8)

Run 3 – Mixed Ethanol without ILUC

- In addition to Northwest corn ethanol and waste berry ethanol, compliance achieved through use of sugarcane ethanol, lower carbon intensity Midwest corn ethanol, and cellulosic ethanol
- For comparison with Run 2 in **Scenario B**, we increased the blend wall to E12 in 2017 and E15 in 2020

Run 8 – Conventional Biodiesel without ILUC

- Compliance achieved through
    - Existing canola biodiesel
    - Existing waste oil biodiesel
    - Midwest soybean biodiesel

Scenario D – Electricity, CNG and Cellulosic Biofuels with ILUC (Runs 4 + 9)

Run 4 – High Electric Vehicles with Cellulosic Ethanol with ILUC (Produced In-State)

- In addition to Northwest corn ethanol and waste berry ethanol, compliance achieved through use of Electric Vehicles and Plug-In Hybrid Electric Vehicles plus in-state cellulosic ethanol
- Similar to Run 1 except more plug in vehicles are included, so less ethanol is required

Run 9 – max CNG vehicles and cellulosic diesel with ILUC

- Similar to 6, but more CNG vehicles are included so less biofuels are required

Scenario E – One Pool

- Gasoline pool reductions achieved mainly through the use of in-state produced cellulosic ethanol (on top of existing Northwest corn ethanol and waste berry ethanol production).
- Plug-in vehicle populations double the BAU
- Diesel pool reductions achieved mainly through the use of in-state produced cellulosic diesel, new waste oil biodiesel capacity and imported camelina renewable diesel.
- Light-duty diesel populations increase, CNG populations increase

Scenario F – Mixed Biofuels without ILUC, high oil prices (Runs 3H+8H)

- Similar mix of fuels as Scenario C, but with higher oil prices (A new BAU was run as well)

Scenario G – Mixed Biofuels without ILUC, low oil prices (Runs 3L+8L)

- Similar mix of fuels as Scenario C, but with lower oil prices (A new BAU was run as well)

Scenario H – Cellulosic Biofuels with ILUC, Out-of-State (Runs1H+6H)

Run 1H – Cellulosic Ethanol with ILUC (Produced Out-of-State)

- In addition to Northwest corn ethanol and waste berry ethanol, compliance with standard achieved through use of out-of-state cellulosic ethanol.
- If more ethanol is needed to reach total RFS2 proportional share volumes, it comes from Midwest corn.

Run 6H – Cellulosic biodiesel with ILUC (Produced Out-of-State)

- Compliance achieved through the use of out-of-state cellulosic diesel and new in-state waste oil biodiesel capacity, existing in-state canola biodiesel.