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Status Review of Oregon's Clean Fuels Program 2016–2018 Q3

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(REVISED VERSION)

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Status Review of Oregon's Clean Fuels Program, 2016–2018 Q3 (Revised Version)[1]

Highlights

- As part of the state's overall strategy to reduce greenhouse gas (GHG) emissions, Oregon's Clean Fuels Program (CFP) aims to reduce transportation sector emissions by incentivizing innovation, technological development, and deployment of low-emission alternative fuels and vehicles. It is designed as a performance standard, rather than a prescriptive approach to emissions reduction. It sets an annual declining target in fuel carbon intensity (CI) with a goal of 10% reduction by 2025 relative to 2015 levels.
- The CFP has been in effect for three years, with relatively small but growing CI reduction targets of 0.25% in 2016, 0.5% in 2017, and 1.0% in 2018, with a 2019 CI target of 1.5%. The CFP had 163 registered parties and 283 transportation fuel pathways available for use as of the end of 2018.
- From 2016 through 2018 Q3, total emissions reduction requirements were 2.4 million metric tons (MMT) CO_2e and reported emissions reductions were 2.0 MMT CO_2e, representing overcompliance of over 421,000 tons CO_2e and creating a systemwide "bank" of program credits (each representing 1 MT CO_2e) that can be used to meet future targets. Data for 2018 lacked residential electricity credits at the time of writing.
- The program generated excess credits relative to deficits in every quarter through 2017. With 2018 electricity credits not yet reported, 2018 deficits through Q3 exceeded credits by under 1,700, well below the 30,000 credits generated by residential electricity in 2017 Q1–Q3, and the about 29,000 credits for the same category that would be generated under 2018 standards given the same energy.
- Aggregate alternative fuel energy consumption remained approximately stable over the program period—the program's operation thus far. Ethanol contributed the largest share of alternative fuel and remained between 10% and 11% by volume of blended gasoline, at or just above the "blendwall" of 10% blends, through the period. Between 2016 and 2017, the only two years of complete data, transport energy from fossil natural gas, biogas, propane, and non-residential electricity each grew by over 50%, and from biodiesel grew by over 7%.
- The average annual CI rating for most reported alternative fuels declined between 2016 and 2018 through Q3, including the biggest volume contributors, ethanol (just under 1.5% decline) and biodiesel (just over 17% decline).
- Prices of CFP compliance credits (each representing 1 MT CO_2e) remained in the $40–$50 range through 2016 and 2017. The yearly average increased to $84 in 2018 as volumes traded also rose. Data through March 2019 indicate an average price around $145.
- Oregon's CFP shares some design similarities with California's Low Carbon Fuel Standard (LCFS), but also has some differences in terms of program targets and baseline fuel blends, treatment of indirect land use change, residential electricity for electric-vehicle (EV) charging, and other credit generation and credit market elements. The programs, along with a similar policy in British Columbia, are part of the Pacific Coast Collaborative commitment to low carbon fuels and economies among these jurisdictions. Washington state is currently considering a similar clean fuel standard as part of its legislative process.

[1] This revision corrects an error in a highlight that appeared in the initial release of this report that misaligned timeframe and credit and deficit accounting. It alters text in the highlights and Section 1 on CFP credits and deficits to accord with the correction. We apologize for the error.

Introduction

Oregon's Clean Fuels Program (CFP) constitutes part of the state's overall strategy to reduce greenhouse gas (GHG) emissions. The CFP aims to reduce transportation sector GHG emissions by incentivizing innovation, technological development, and deployment of low-emission alternative fuels and vehicles. It is designed as a performance standard: it sets an emissions target for fuels under the program and establishes rules to govern the behavior of participants but is otherwise a non-prescriptive approach to emissions reduction. Obligated parties determine the best method of compliance for their circumstances. The CFP is, to a large extent, based on California's Low Carbon Fuel Standard (LCFS), operational since 2011. Like the LCFS, the CFP sets an average carbon intensity (CI) standard, measured in grams carbon dioxide equivalent per megajoule of fuel energy (gCO_2e/MJ), that all regulated parties must achieve across all fuels they provide for use in the jurisdiction. To comply, regulated parties may combine strategies such as: (i) producing low carbon fuels; (ii) purchasing low carbon fuels from other producers; (iii) purchasing credits generated by producers of low carbon fuels; or (iv) banking credits across compliance years for future use. The program does not mandate any particular fuel or technology. British Columbia has a similarly designed program [1]; Canada and Brazil are also developing fuel CI standards largely modeled after the LCFS [2, 3]; Washington state's legislature is currently deliberating on a similar policy [4].

The CFP targets a 10% reduction in CI rating for the statewide fuel pool in 2025 from 2015 levels. In 2019, the program requires a reduction of 1.5% in the average CI rating for transportation fuels in the state. In 2015, when the CFP began, biofuels were already blended into retail gasoline and diesel due to existing federal and state policies. Oregon has state-level requirements for 10% ethanol by volume (known as E10) and 5% biodiesel by volume (B5). The Federal Renewable Fuel Standard requires a specified volume of biofuels to be blended into the national fuel supply. As a result, almost all retail gasoline in Oregon is E10, and almost all retail diesel is B5 [5], and these levels are included in the CI rating of the 2015 baseline reference fuels.

This report is modeled after our California LCFS Status Review series [6]. It summarizes data and reports trends based on public CFP program data from Oregon's Department of Environmental Quality (DEQ), the administering agency, supplemented by other public data sources. It examines CFP compliance metrics from 2016 through 2018 Q3, the last quarter for which data are available, and addresses: CFP credits and deficits and transport energy (Section 1), carbon intensity of fuels (Section 2), credit trading and prices (Section 3). It also provides a brief summary of principal program design differences between the CFP and California's LCFS.

1. CFP Credits and Deficits and Transport Fuel Energy

Under Oregon's CFP, the average CI rating of regulated transportation fuels must decline by a specified percentage each year relative to the 2015 level. The required decline is referred to as the annual standard. All fuel volumes receive a CI rating assigned by DEQ based on a lifecycle analysis of the fuel's GHG emissions (from production to on-road combustion). Fuels with a CI rating lower than the standard generate program credits; those with a rating higher than the standard (higher carbon) accrue deficits. Obligated parties generate credits or deficits by multiplying the total energy content of fuel they supplied by the CI rating for that fuel, adjusting for relative efficiency of the fuel-vehicle combination compared to reference fuels used in an internal combustion engine, to yield a total amount of emissions relative to that year's target. Each credit or deficit represents one metric ton of carbon dioxide equivalent (MT

CO_2e) of that emissions savings or overage, respectively. Regulated parties responsible for deficits must obtain at least that many credits to achieve compliance. The standard is assessed separately for gasoline and diesel fuel "pools" (a pool is each fossil reference fuel and its alternative fuel substitutes). Credits are wholly fungible, can be used for compliance against either fuel pool standard and may be banked for future use without limit. For more about transportation fuel CI standard policy design, see [7] and [8]. Oregon's CFP regulation is on Oregon Secretary of State's website [9].

The CFP standard declines over time. In 2016 and 2017, CI rating reduction requirements were 0.25% and 0.5% relative to the 2015 baseline, respectively. Through 2017 (the last year for which complete program data has been reported), the program had generated 1,755,906 credits and 1,332,589 deficits. The credit surplus of 423,317 MT CO_2e illustrated that regulated parties exceeded requirements to that point, creating a systemwide "bank" of credits available for future use (under more stringent reduction requirements) that can accumulate or be drawn down over time. Through 2018 Q3, reported credits under the CFP totaled 2.4 MMT CO2e and total program emissions reduction requirements were 2.0 million metric tons (MMT). The reported total does not include 2018 residential electricity credits [10]. Credits exceeded deficits in every quarter for 2016 and 2017 (Figure 1). In 2018 through Q3, under an annual standard of 1%, 676,951 credits and 678,633 deficits were generated, drawing down the systemwide credit bank by 1,682 for the year to that point, without, however, residential electricity credits yet counted. Residential electricity credits totaled over 40,000 in 2017 and over 30,000 in 2017 through Q3,[i] indicating that 2018 data through Q3 will likely show a net credits surplus once 2018 residential electricity credits are counted.

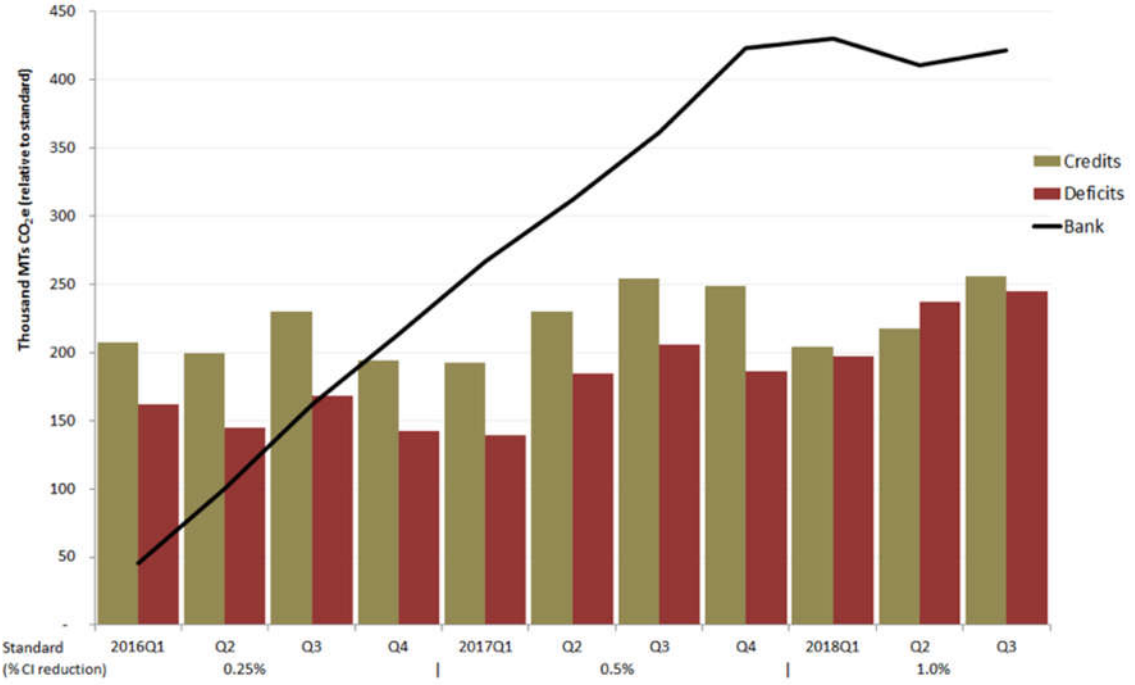

Figure 1. Oregon CFP carbon credits and deficits. Also shown are cumulative net credit "bank" (black line) and annual standard (data table). Annual data 2016–2017; 2018 through Q3 only. In 2018, the program expanded to generate credits from off-road electricity use displacing transport fuels, such as aerial trams, streetcars, and light rail. Data for 2018 does not include residential electricity credits. Data source: [10].

Liquid biofuels were responsible for most credit generation under the program from 2016 through 2018 Q3; ethanol generated 58% of credits, followed by biodiesel, which generated 36% of credits. Renewable diesel, a hydrotreated biofuel that can be blended with diesel without restriction, was not initially covered by the CFP and did not generate any credits until 2017 Q4. Electricity generated about 4% of credits to date. This total does not include 2018 residential electricity use (not available until later this spring), but does include 2018 credits from off-road electricity use in fixed guideways, e.g. aerial trams, light rails, and streetcars, after the program expanded to cover these sources in that year).[ii,iii] Credits from biogas, fossil natural gas, and propane each contributed a less than 1% share over the period, but increased from 2016 to 2017 by 77%, 49%, and 99%, respectively.

Ethanol generated over half the credits in every quarter, but credit generation diversified, especially towards biodiesel (Figure 2). In 2016 Q1, ethanol generated 67% of credits and biodiesel generated 28% of credits. In 2018 Q3, the credit shares of ethanol and biodiesel were 55% and 41%, respectively. No public data are available on relative credit contributions of liquid biofuels from particular feedstocks, e.g., ethanol from corn or molasses, or biodiesel from soybean, canola, or used cooking oil, beyond CI ratings of available fuel pathways and of reported fuels (discussed below).

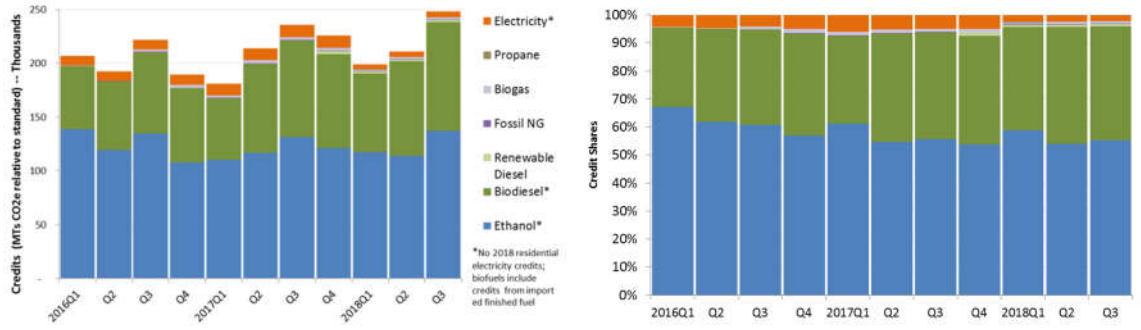

Figure 2. Alternative fuel net CFP credits (left) and credit shares (right). Calculations exclude residential electricity credits in 2018, not reported until 2019 (see Endnote i). Annual data 2016–2017, 2018 through Q3 only. Data source: [10].

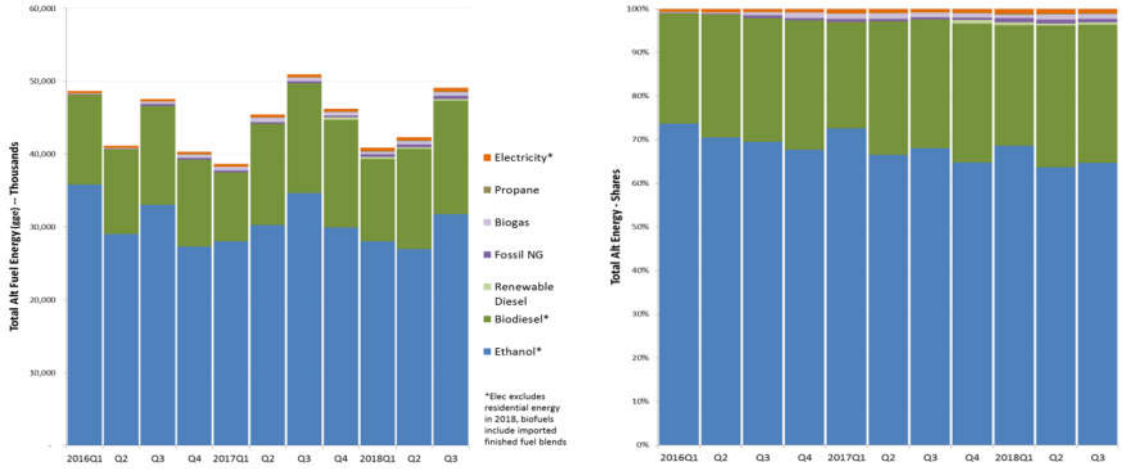

Figure 3. CFP alternative fuel energy by fuel type, 2016–2018 Q3. Source: [10].

Energy reported under Oregon's CFP remained level over the period. The gasoline pool contributed around 65% of total reported energy (Table 1). Alternative fuels contributed close to 7% of total transport energy reported in Oregon's CFP from 2016 through 2018 Q3. Liquid biofuels were 99% of alternative fuel energy in 2016 and 97% in 2018 through Q3 (Figure 3, Table 1).

Ethanol provided the most alternative fuel energy, close to 70% in 2016 and just under 66% in 2018 through Q3. Ethanol volumes were at or above levels to satisfy the state requirement for E10 in gasoline, also known as a "blendwall" level (requiring no alternative infrastructure for distribution and use).[iv] The average blend rate of biomass-based (diesel and renewable diesel) in diesel fuel by volume similarly stayed above the state B5 requirement. Average blend levels for ethanol in gasoline and biodiesel in diesel were 11.1% and 5.7%, respectively, in 2016 and 10.1% and 6.1% (also respectively) in 2018 Q3. Between 2016 and 2017—the first two full program years for which data are available—total energy supplied by ethanol decreased by 1.8% and total energy supplied by biomass-based diesel increased by 8.3%. The relatively small energy contributions from the non-liquid alternative fuels also grew in the first two years (Table 1). Providers of the gaseous fuels can opt-in to the program to generate credits, but are not obligated to report, as their CI rating has been assessed as meeting the 10% CI reduction program target for 2025.

Table 1. Total transportation energy use reported in Oregon's CFP (million gge*, unless otherwise noted).

	2016	2017	2018 thru Q3	% change 2016–2017
Clear gasoline	1,432	1,451	1,165	1.3%
Clear diesel	801.0	772.1	620.5	-3.6%
Ethanol	125.2	122.9	86.8	-1.8%
Biodiesel	49.4	53.2	40.6	7.6%
Renewable diesel**	--	0.38	0.73	NA
Fossil natural gas	0.66	1.02	1.22	52.9%
Biogas	1.02	2.08	1.30	103.5%
Propane (LPG)	0.05	0.11	0.33	97.2%
Electricity (non-residential)**	0.05	0.08	1.37	68.7%
Electricity (residential)*	1.28	1.56	--*	22.2%
Total fuel	2,411	2,404	1,918*	-0.28%
Ethanol by volume in gasoline blend	11.1%	10.8%	10.1%	
Biomass-based diesel by volume in diesel blend	5.7%	6.3%	6.1%	
Gasoline pool (percent of total energy)	64.9%	65.8	65.3%	
Total alt fuel	169.8	173.2	132.3*	2.00%
Total alt fuel (percent of total energy)	7.1%	7.3%	6.9%*	
Non-biofuel portion of alt fuel	1.0%	1.9%	3.2%*	

*gge = Oregon Clear Gasoline (blendstock) gasoline gallon equivalents. Credited energy from residential electricity used as a transportation fuel for 2016 and 2017 were obtained from DEQ; it is not yet available for 2018 (affecting asterisked categories).

** Renewable diesel was not mandated as a covered fuel in the program in 2016 but may have been used in the state. In 2018, the program expanded to include off-road electricity used in, for example, fixed guideway applications such as light rail, aerial tram, and streetcars. Source: [10].

Biogas credits can be generated through a book-and-claim system for biogas entering the pipeline anywhere in North America and contracted towards natural gas transport fuel dispensed in-state. For these reasons, it is difficult to assess the portion of gaseous fuel energy growth reported in the program that represents changes in fueling patterns in Oregon. Other state and federal policies incentivized Oregon low-carbon fuel use. The federal Renewable Fuel Standard (RFS) promotes biomass-based diesel, biogas, and ethanol nationwide. Oregon and the U.S. subsidize transport electricity through EV rebates [v] and other policies. In September 2018, Oregon reported 17,759 electric passenger vehicles [12]. There is less publicly available information on the breakdown of off-road electricity energy generating credits.

2. Carbon Intensity Ratings of Fuels

The CFP provides incentives to support the deployment of low-carbon alternative fuels in Oregon. Figure 4 depicts CI rating targets,

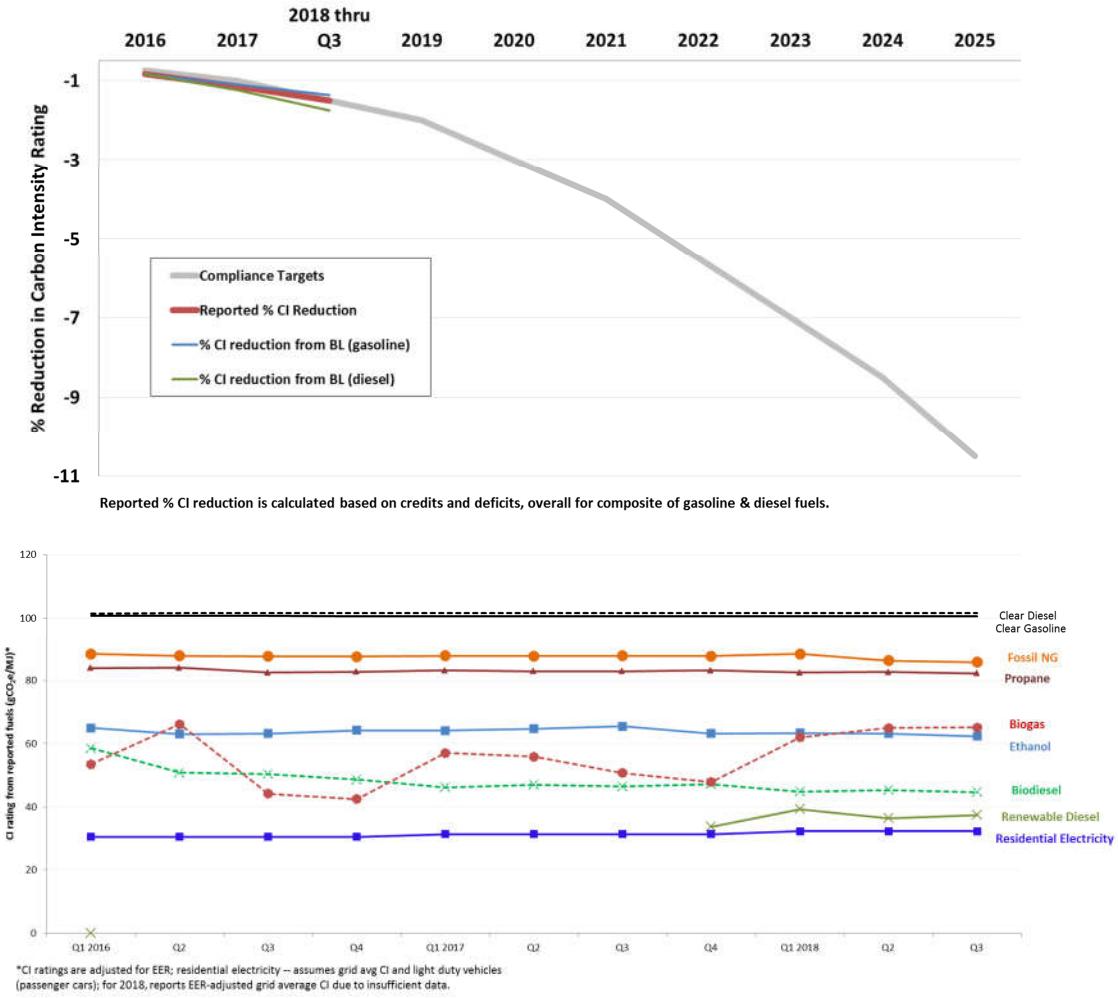

Figure 4. Annual average% CI rating reduction of reported fuels and compliance targets of gasoline and diesel fuel pools, CFP (top). Quarterly CI rating by fuel category, CFP (bottom). For both, reported data for 2016 and in 2018 through Q3. Reported ratings are adjusted for Energy Economy Ratio (EER),[vi] using the program value of 0.9 for natural gas in spark-ignition engines and 3.4 for residential electricity, which assumes all light-duty vehicles, or passenger cars). Reported CI ratings for all on-road electricity vehicles, and for off-road electricity use once covered by the program starting in 2018, were not calculated due to insufficient data and a data reporting error.[vii] Data source: [10].

reductions to date overall and by fuel pool, and compliance targets to 2025. CI ratings of Oregon fuels reported under the program in 2016, 2017, and 2018 through Q3 were lower than the 2015 baseline by 0.34%, 0.65%, and 1.0%, respectively, from program data (without residential electricity credits in 2018). Ratings declines were more pronounced in the diesel pool than in the gasoline pool in 2017 and 2018 through Q3.[viii] The reported CI ratings of the dominant compliance fuels, ethanol and biodiesel, were lower in 2018 through Q3 than in 2016 (Figure 4, bottom). Reported ethanol CI rating declined 1.4% (from 63.9 to 63.0 gCO_2e/MJ); for biodiesel, the CI rating decline was 17.2% (from 54.36 to 44.9 gCO_2e/MJ). The CI rating reductions for reported fuels could represent shifts in production processes to lower carbon intensity (e.g., efficiency gains or feedstock switching), use of lower-carbon blends for shipment to the Oregon market, or some combination thereof. Higher-CI rated alternative fuels such as fossil natural gas and propane declined 1.4% and 0.7% respectively from 2016 to 2018 through Q3, to 86.9 and 80.7 gCO_2e/MJ, respectively. Biogas had a lower CI rating than fossil natural gas throughout the reporting period: it was 48.2 gCO_2e/MJ in 2016 and 64.4 gCO_2e/MJ in 2018 through Q3, though this was on relatively small volumes of fuel. Renewable diesel had an average CI rating of 33.7 gCO_2e/MJ in 2017, the first year of required reporting for the fuel, and 37.8 gCO_2e/MJ in 2018 through Q3, an increase of 12.1%. The CFP had 163 registered parties and 283 transportation fuel pathways at the end of 2018 (Table 2). Each pathway receives a CI rating under the program. Liquid biofuels accounted for most pathways; ethanol accounted for 51% of pathways (145), and biomass-based diesel contributed an additional 25% (72 pathways, 16 of them renewable diesel). There were several pathways for electricity. Some pathways use the recent annual Oregon grid average CI rating as a default. Others comprise similar average CI ratings for specific utilities, and solar or wind EV charging.[ix] There were also several pathways for program reference fuels, the petroleum-based gasoline and diesel fuels used to calculate a baseline (and which receive a CI rating based on a statewide average), and for imported blends without a particular biofuel identified (Table 3).[x]

Table 2. DEQ fuel pathways, 2018. Source: [10].

Fuel	# of pathways
Compressed natural gas	24
Liquefied natural gas	14
Ethanol	145
Biodiesel	56
Renewable diesel	16
Electricity	15
Gasoline, Diesel	3 each
E10 Gasoline, Liquefied Petroleum Gas, B5 Diesel, B20 Diesel	2 each

Table 3. CI scores for reference fuels in Oregon's CFP. Source: [10].

Fuel	2018 value (gCO_2e/MJ)
Clear gasoline	100.77
Clear diesel	101.65
E10 gasoline	98.64
B5 diesel	99.61
B20 diesel	93.41

Note: Reference fuels comprise the fuels used in determining the program 2015 baseline. Default CI scores for the blends apply to imported finished fuels without an identified/program certified CI score associated with the biofuel portion.

Figure 5 shows CI rating ranges for available CFP pathways by alternative fuel type in 2018. It shows considerable variation of CI rating within fuel types, and overlap of potential CI ratings across fuel types, belying a simple rank ordering of fuel type by CI rating.

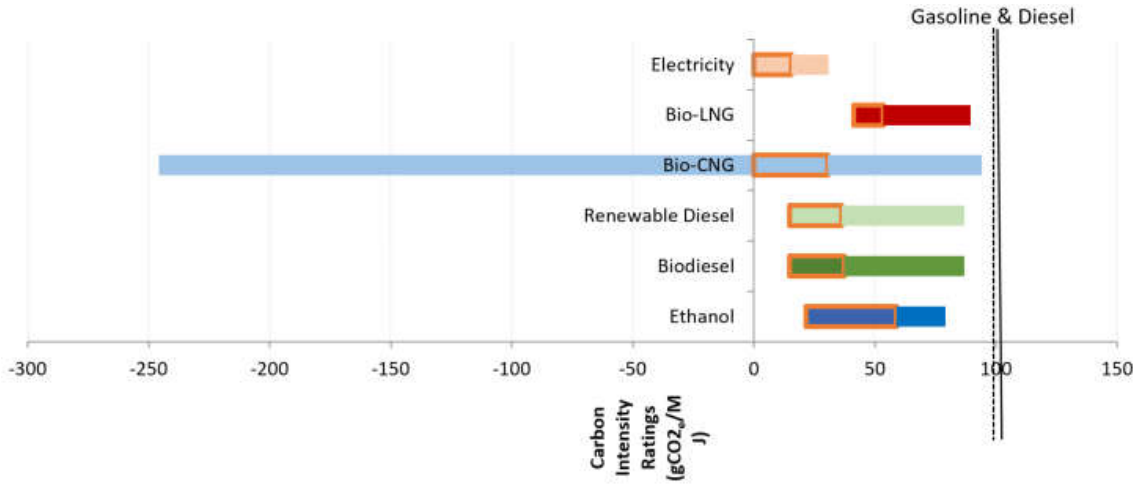

Figure 5. CI rating ranges for alternative fuel pathways in Oregon's CFP, 2018. Colored bars represent CI rating ranges for pathways certified in the program and available for use, adjusted for energy efficiency ratio (assumed electricity EER is 3.35, the average of the 3.4 EER for on-road passenger EVs and 3.3 EER for light rail, the majority of off-road electricity end use for transportation in Oregon, according to federal data). In 2016 and 2017, only the on-road passenger EV EER was in effect, from 2018, off-road electricity use was also covered. Sources: [10], [13].

3. CFP Credit Trading and Prices

As fossil fuel retailers sell fuels, they accumulate deficits based on the amount of lifecycle GHG emissions above the target for that year. Low-carbon fuel providers generate credits based off the amount of GHG emissions their fuels emit relative to the target; lower CI fuels generate more credits per unit. Compliance is demonstrated through retirement of adequate credits to cover deficits. The demand and supply of credits creates a market in which prices fluctuate to reflect current conditions. The program design of CFP, particularly the market mechanism, encourages lowest cost compliance. Credit prices can be affected by market and policy uncertainty, availability and cost of emissions-reducing projects or lower emission fuels, expectations about future market performance, and about policy (the CFP and other policies, for example the U.S. RFS, which shapes domestic use of alternative transportation fuels) [14].

In Oregon's CFP, regulated parties may carry a net deficit balance of up to 5% of the total deficits that entity generated in the compliance period to the next year, without penalty. In 2017, Oregon's HB 2017 instituted a "credit clearance market" for the CFP, based on a similar mechanism in California's LCFS. The credit clearance market requires entities with unmet compliance obligations at the end of a compliance year, beyond the allowed 5% deficit carryover, to purchase credits pledged into a pool by other parties at a set price, capped initially at $200, and adjusted for inflation in later years. This sets a "soft" credit price cap for the program, and can target certain potential market failures, such

as counterparties not locating each other or obligated parties not engaging in trading when obligations have not fully been met and credits are available for sale. Obligations on remaining deficits after the clearance market clearinghouse can be deferred until the next year with a 5% annual interest penalty. The regulation mandates an analysis by DEQ if multiple parties defer their obligations or a single party defers for multiple years. The aim of the provision is to handle short-term credit supply shortfalls and allow more time for producers to generate additional credits, by bringing additional low-carbon fuel supplies to market.

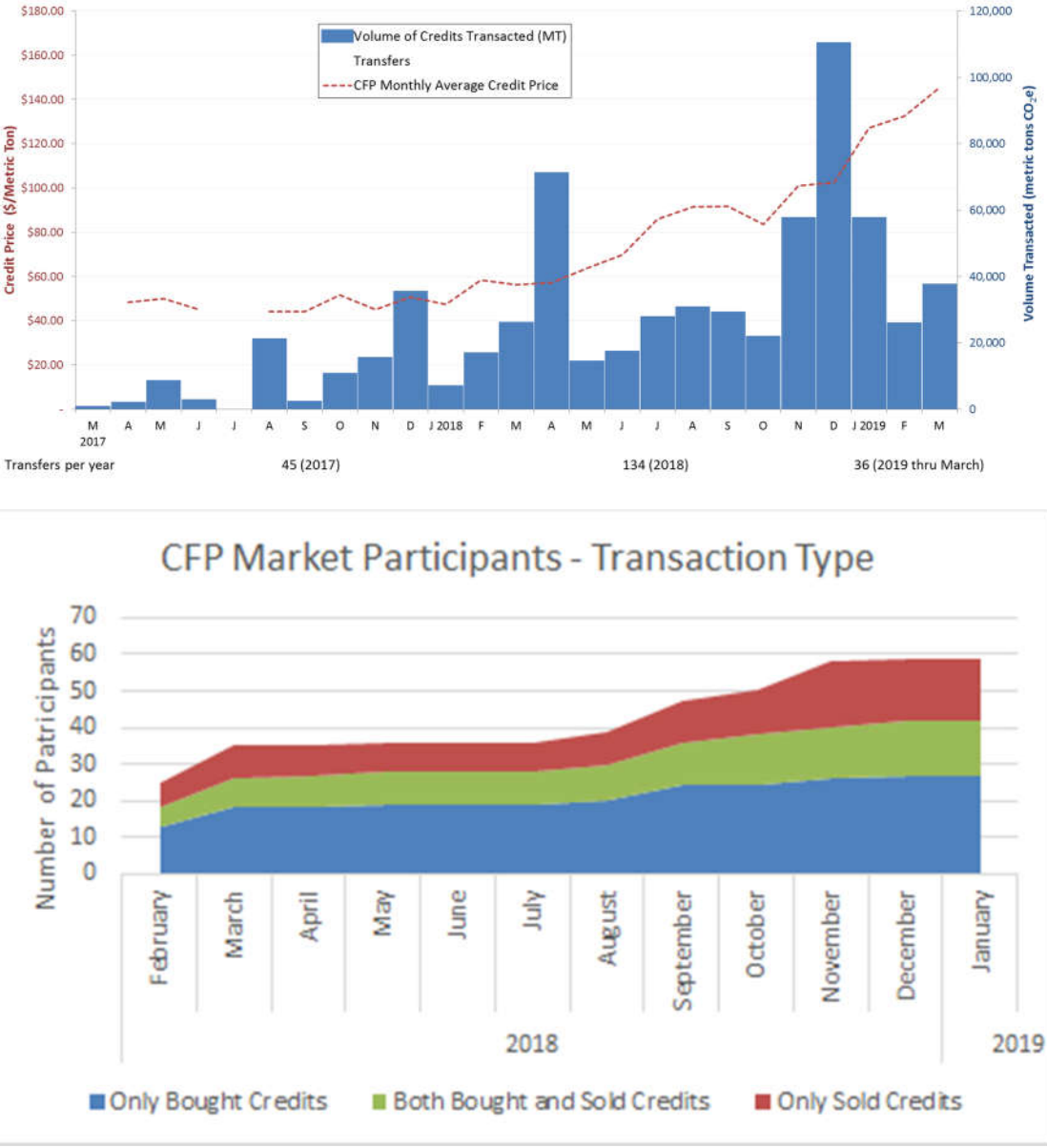

Figure 6. Average monthly CFP credit prices, transaction volumes, and number of transfers reported to DEQ 2017 through March 2018 (top); credit buying and selling participation for 2018 and 2019 (bottom). Data source: [15].

The CFP includes additional cost containment mechanisms including DEQ authority to defer or suspend aspects of the program on the basis of a projected potential shortfall in adequate fuel supply (from an annual forecast by the Oregon Department of Administrative Services), as well as emergency deferrals due to unexpected fuel shortages, credit market disruption, or abnormal credit market behavior. DEQ reports on credit trades every month. Trading for the first program year and 2017 Q1 involved a handful of trades for a small number of credits. Credit prices averaged about $48 for slightly more than 90,000 credits traded in 2017 at a 0.5% CI reduction target. In 2018, the volume of credits traded increased to more than 420,000; credit prices climbed to a volume-weighted average of about $84. Credit prices for 2019Q1 averaged about $134, but on an upward trajectory for an average $145 in March (Figure 6, top). Roughly 37% of registered parties, or 61 entities, had participated in the credit market by March 2019, up from 24 entities through February 2018. Entities in all trading categories (only sold, only bought, and did both) more than doubled over that period (Figure 6, bottom).

CFP incentives' direct net cost impact per unit of fuel can be calculated using fuel CI rating, credit price, and CI rating targets.[xi] Table 4 shows the direct impact on cost for E10 and B5 fuel components (summed to net for the blended fuel) for 2017, 2018, and 2019.[xii] At a $134 average credit price thus far in 2019, an E10 gallon would have a $0.05 charge from deficits accruing to the petroleum portion of the gallon, and a $0.04 per gallon subsidy on ethanol portion of that same gallon, summing to under a $0.02 net cost (includes rounding). The calculation assumes a biofuel CI rating at the 2018 average through Q3. Under the same assumptions, a B5 gallon in 2019 would incur a charge of $0.06 on the petroleum fraction, and the biodiesel portion would receive an incentive of about $0.04, for a less than $0.02 net cost. Data for 2018 and 2017 show lower charges on the petroleum fuel fractions of an E10 gallon and a B5 gallon, lower incentives on the biofuel portions of each fuel, and lower summed (net) direct cost impacts.[xiii]

Table 4. CFP policy incentives for fuels in E10 and B5. Assumes (a) reported average annual CFP credit prices and CI ratings for ethanol and biodiesel, (b) program values for fuel energy densities and petroleum fuel CI ratings, and (c) E10 and B5 as 10% ethanol by volume in blended gasoline and 5% biodiesel by volume in blended diesel, respectively. Reported sums may differ from arithmetic due to rounding. *2019 calculations use average credit prices through March and 2018 average ethanol and biodiesel CI ratings through Q3. Source: [10, 15].

Fuel	Blend components	2019*	2018	2017
E10 (gallon)	Clear gasoline	$0.052	$0.029	$0.013
	Ethanol	-$0.037	-$0.024	-$0.013
	Sum	*$0.016*	*$0.005*	*$0.00*
B5 (gallon)	Clear diesel	$0.060	$0.033	$0.015
	Biodiesel	-$0.044	-$0.028	-$0.015
	Sum	*$0.015*	*$0.004*	*$0.00*

4. Oregon's CFP and California's LCFS

Oregon and California have substantially different fuel markets, Oregon's is about one-eighth the size of California's and the CFP has only been in operation for three years, compared to eight for the LCFS. The diesel pool constitutes roughly 35% of Oregon's transportation energy, whereas in California, it represents less than 25% of the state's transportation energy. California has considerable in-state petroleum fuel

production—both oil production and refining—while Oregon has none and is thus more reliant on imported fuels. However, the program design of Oregon's CFP closely resembles California's LCFS. Both programs use the GREET model (The Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model, California regulatory agency overseeing the LCFS, to make fuel pathways certified in the California program available under the CFP, adjusted for the Oregon destination, with a minimal amount of duplicated work. Oregon DEQ's rulemaking in cost containment followed California's with a similar program. Both programs allowed opt-in crediting for alternative jet fuel starting in 2019, and expanded crediting to cover off-road electricity. Each state retains discretion over the design of its program, however, and there are several differences between the two, including:

- *indirect land use change (iLUC)*. The CFP uses a different value (from a different modeling system) for iLUC emissions for fuels that use corn as a feedstock. As a result these fuels have a lower CI rating (and gasoline standard baseline, based on E10 fuel with Midwest corn ethanol) under the CFP than the LCFS. Other iLUC values (and modeling) are the same in both programs.

- *electricity credits*. Oregon instituted a system to ensure all residential electricity charging is credited in the CFP. This system provides a backstop aggregator to claim any credits served by an electric utility not registered in the program. California's LCFS assigns credits to the electrical distribution utility or its designee. The CFP also allows electric utilities the annual choice to earn credits based on the recent average CI rating of electricity sourced by the utility or the state grid average. The measure provides an incentive for the utility to lower its own CI rating, although the crediting does not fully reflect the interchangeability of power supplied by the grid. California electric distributing utilities do not have a similar choice under the LCFS. California's LCFS recently adopted additional changes to allow crediting based on marginal electricity emissions that vary with the time-of-charging; the CFP has no similar provision.

- *credit market monitoring and design*. Oregon's CFP requires an annual low carbon fuel supply forecast to foresee potential low carbon fuel supply issues. DEQ has the authority to defer program aspects and must perform "root cause analysis" in the event of a forecast supply shortage or actual credit or fuel market disruptions. CFP allows a 5% net deficit carryover for regulated parties into the following compliance year without penalty ("small deficit" provision). California's LCFS has none of these provisions.

- *sources of credits and deficits and pathway validation*. California's LCFS allows crediting for carbon savings due to innovations in crude production and refining and assigns additional deficits for substantive increases in state average fossil fuel CI rating over time; Oregon's CFP does not.[xiv] Finally, the LCFS adopted several design elements in 2019 that Oregon's CFP does not have, such as third-party independent validation of information used in CI rating calculation, a protocol for crediting carbon capture and sequestration, and limited crediting for hydrogen and electric vehicle fueling infrastructure [16].

California and Oregon cooperate as part of the Pacific Coast Collaborative (PCC), an agreement between California, Oregon, Washington, and British Columbia to take action on climate change, including creating a regional low carbon fuel market. California and British Columbia were the first two PCC jurisdictions to adopt clean fuel policies in 2010. Oregon followed in 2016. Washington 2015 legislation sponsored by the US Department of Energy and developed at the Argonne National Laboratory) as the as the basis for life cycle carbon intensity assessments, though each uses a version localized to its respective jurisdiction. Oregon DEQ works closely with the California Air Resources Board, the

effectively barred an LCFS there until 2023; a bill being considered in the 2018 legislative session would lift that barrier and institute a similarly designed fuel carbon intensity standard.

The PCC commitment involves working together to align programs toward "an integrated West Coast market for low carbon fuels." [17]. This could involve a regional program spanning multiple jurisdictions or a formal linkage that would allow credit trading across jurisdictions. Such an approach would face several significant technical and design challenges to harmonize CI accounting methods, program CI targets and stringency, and cost containment mechanisms [18]. Absent a formal linkage agreement, the low carbon fuel programs in California, Oregon, and British Columbia have an aggregate impact on fuel markets that means credit price movements in each jurisdiction may not be independent from the others, especially if sources of low carbon fuel supply overlap and are limited. Fuel producers can be expected to balance a range of economic, contractual and technical factors when choosing into which market to sell their product. In theory, markets with high credit prices would typically attract more of the available fuel supply, which would exert downward pressure on those market prices, while the converse would be expected in markets with a low credit price. The adjustment would be expected to continue until producers either are indifferent between jurisdictions when considering where to send the next unit of fuel, given the market and policy conditions in each, or hit some other barrier to selling more fuel. How this and any other interaction mechanisms play out is for future research to identify and characterize; assessment of the precise interaction is challenging due to the limited history of these programs, few comparable programs globally, the dynamic nature of the interaction, and the other market conditions at play within and across jurisdictions. In general, the presence of multiple jurisdictions with similar policies to support low carbon fuels would tend to strengthen the signal to invest in low carbon fuel production capacity, at the same time as creating potential competition across jurisdictions for a limited fuel supply at any given time, depending on the stringency of the policies [18].

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Endnotes

[i] DEQ estimates residential electricity transport credits based on information about the state electric vehicle fleet, metered residential charging behavior, and other available data sources, and reports the associated credits in spring of the year following the charging event. Assuming no change in charging from 2017 credited levels and electricity grid average carbon intensity levels, residential EV charging in 2018 through Q3 would result in about 29,800 credits.

[ii] Electricity crediting adjusts for improved efficiency of electricity compared to reference fuels–by a factor of 3.4 for passenger vehicles, 3.3 for light rail, and 2.1 for streetcars. Pre-existing light rail and streetcar electric energy in 2018 do not receive the credit for displaced fossil fuels that most alternative fuels do; new fixed guideway sources do.

[iii] Our analysis indicated a mismatch between reported on-road, non-residential electricity credits issued and the amount of energy dispensed through these pathways. Credits were over-reported, or the amount of electricity dispensed through this pathway was under-reported, or both, for 2016 and 2017 (but not 2018), based on the implied CI rating of electricity back-calculated from the reported figures compared to the Oregon grid average. The category, as reported, represents about 5% of electricity credits and energy, and less than 0.5% of alternative energy and credits, and the issue did not affect results reported here for other calculations that involve electricity. We return to this topic in the section on CI ratings, below.

[iv] E15, a 15% ethanol by volume blend, has been approved for passenger vehicles of model year 2001 or newer, and E85 can be used in flex-fuel vehicles. E15 use is restricted seasonally due to volatility properties (Reid Vapor Pressure); the EPA has proposed regulations that would waive that restriction similar to the waiver for E10.

[v] The state policy for EV rebates was delayed until fall 2018 due to a lawsuit; implementation is proceeding following a decision by the Oregon Supreme Court [11].

[vi] EER is used in the program to account for relative on-road efficiency of fuel/vehicle combinations compared to reference fuels.

[vii] Residential charging electricity CI rating was calculated for 2016 and 2017 based on residential energy obtained by DEQ for this calculation, but not yet available in its quarterly summary. Residential electricity data for 2018 are not yet available. Back-calculation of on-road, nonresidential electricity based on program data yielded CI ratings for 2016 and 2017 between -17 and -6gCO_2e/MJ; while values can deviate from the grid electricity value due to differing CI ratings by utility areas and possibilities for zero emission charging from solar or wind electricity, the negative figures indicate an error in reported energy, associated credits, or both. DEQ is aware of the issue, which pertains only to on-road, non-residential electricity, which accounted for between 90 and 96% of on-road electricity credits, and between 94 and 98% of on-road electricity energy in the first eight quarters of the program. For off-road electricity, first covered by the program in 2018, insufficient information about allocating energy across utility areas, transport modes, and timing of deployment (which impacts crediting for displaced reference fuels), was available to calculate CI ratings. EERs for off-road electricity vary between 2.1 (fixed guideway streetcar), and 3.3 (light rail).

[viii] Relative to the program baselines, CI rating reductions for 2017 and 2018 through Q3 were 0.74% and 1.2%, respectively for the gasoline pool and 0.60% 0.87% for the diesel pool.

[ix] The CFP allows utilities to decide on an annual basis whether to use a utility-specific CI rating or the national grid average for generation of electricity credits.

[x] The multiple pathways for gasoline and diesel comprise 2018 CI values, revised CI values for 2019 forward due to changes in CI rating modeling, and CI values equivalent to gasoline and diesel for unidentified fuels entering the state. Imported finished blends for E10, B5, and B20—used to describe biodiesel blends by volume in diesel fuel between 6% and 20%, and a 20% blend under Oregon's CFP—are calculated using a Midwest corn (for ethanol) or soybean (for biodiesel) in the blend.

[xi] Net policy impacts may not translate directly into retail price changes. Retail prices reflect a variety of cost and market conditions. Calculated changes in net cost would be reflected in prices to the extent that producers and retailers pass CFP incentives through to consumers, a decision influenced by factors such as fuel market structure and production and delivery costs.

[xii] The method used here reflects direct program incentives to fuel components based on all reported program data on ethanol and biodiesel used. It differs from DEQ's posted formula on fuel cost, which calculates added cost for imported B5 and E10 blends that do not have identified biofuel components (and are assigned Midwestern ethanol and biodiesel CI ratings), and assesses blended fuels rather than blending components. [15],[Peters, personal communication]

[xiii] For 2017, E10 had a slight calculated net cost of $0.0001 per gallon, and B5 had a slight calculated net incentive of $0.0002.

[xiv] For context, California has in-state oil production and refining; Oregon does not.