# RESEARCH SUMMARY:
# PROSPECTS FOR RENEWABLE, LOW-CARBON FUELS IN PORTLAND

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OVERVIEW

This document summarizes research conducted in mid-2020 on the prospects for renewable and low-carbon fuel use in Portland. The work was performed by Efficiency for Everyone to support the Bureau of Planning and Sustainability in updating Portland’s Renewable Fuel Standard.

This document contains three sections:

1) **Key findings and the relevant policy implications** for seven renewable and low-carbon fuels: ethanol, electricity, biodiesel, renewable diesel, renewable natural gas, renewable propane, and renewable hydrogen.

2) **Detailed discussion** of each of the seven renewable and low-carbon fuels with a focus on the potential use and supply of each fuel to 2030 and policy opportunities.

3) **Research activities and sources consulted** during the development of this report.

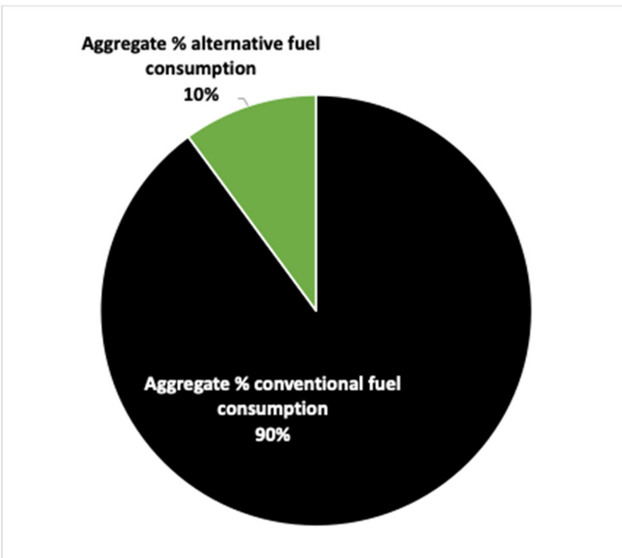
SECTION 1: KEY FINDINGS AND RELEVANT POLICY IMPLICATIONS

This section describes Portland's fuels landscape in 2019, the growth trajectories of alternative fuels, and suggests six policy opportunities to use Portland's Renewable Fuel Standard (RFS) to decrease the use of conventional fuels.

**Key findings on fuel use in Portland**

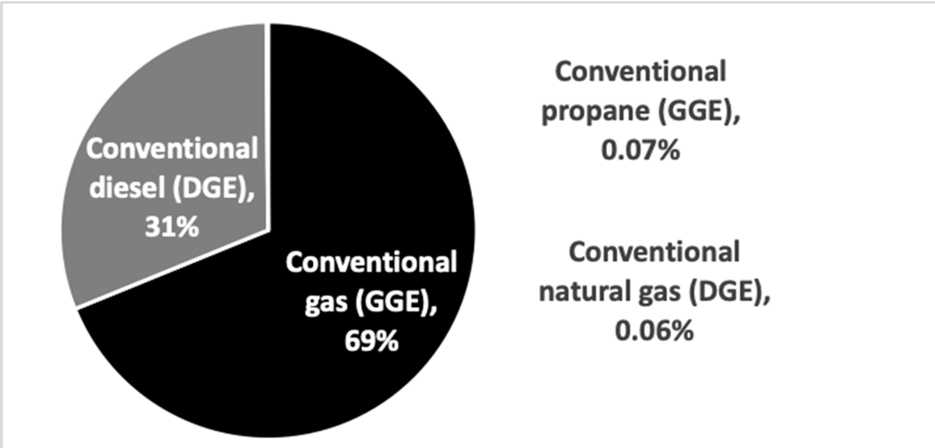
In Portland in 2019, conventional fuels made up 90% of transportation fuel use and alternative fuels made up 10%.

*Conventional vs. alternative fuel use in Portland, 2019*



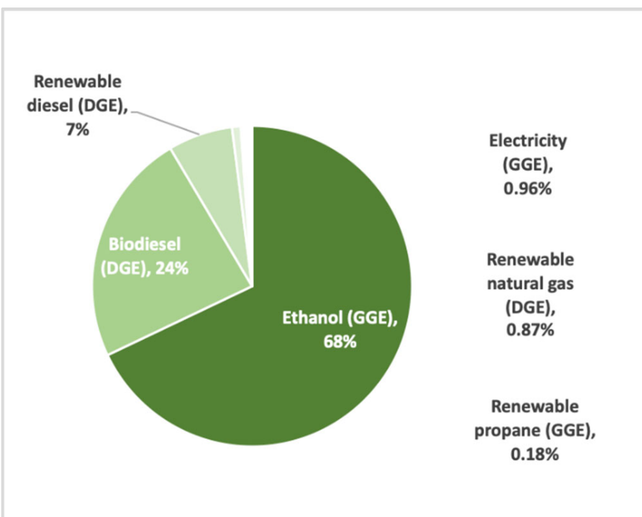

Gasoline and diesel together accounted for more than 99% of conventional fuel use. Gasoline made up 69% of conventional fuel use and diesel 31%. Natural gas and propane together made up 0.13% of conventional fuel use.

*Conventional fuel use in Portland, 2019*




The use of each alternative fuel mirrored the conventional fuel for which it is a substitute. Ethanol (blended into gasoline) and biodiesel and renewable diesel (blended into diesel) together accounted for 98% of alternative fuel use, with ethanol making up 68%, biodiesel 24%, and renewable diesel 7%. Renewable natural gas, renewable propane, and electricity comprised 2% of alternative fuel use.

*Alternative fuel use in Portland, 2019*

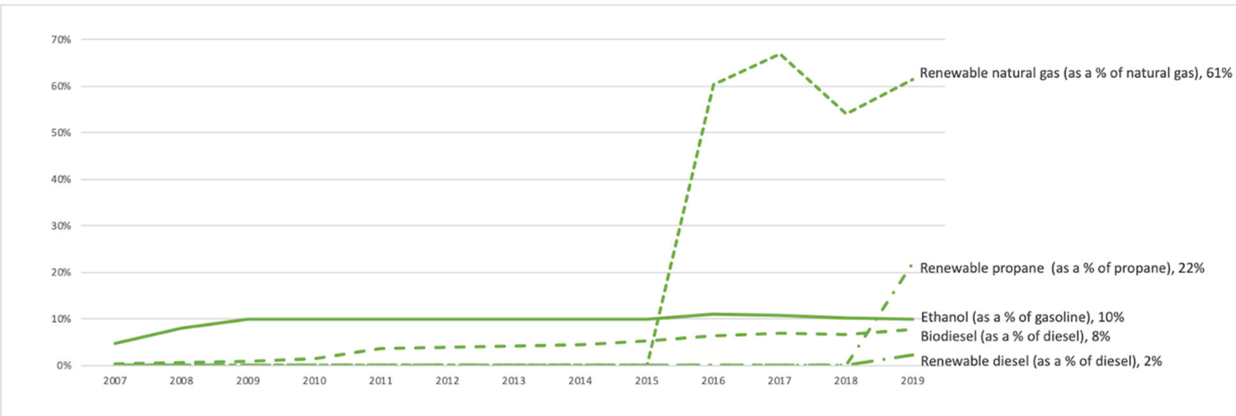



Since 2007 and the passage of the first Federal Renewable Fuel standard and Portland's RFS, each alternative fuel has followed a different use trajectory. Volumes of ethanol and biodiesel, the only two fuels subject to the RFS's volumetric mandates, have tracked the volumes of the fuels to which they are tied by the RFS. However, while ethanol has remained constant at 10% of gasoline volume since 2009, biodiesel had an uptick in market share among all diesel fuels, rising from its mandated minimum of 5% in 2015 to 8% in 2019.

Since its launch in 2016, Oregon's Clean Fuels Program (CFP) has provided data on alternative fuel use in Oregon. There are no data on the consumption of renewable natural gas prior to the initiation of the CFP, and in its first year of reporting (2016), renewable natural gas already accounted for 60% of all natural gas used in transportation and has remained in that range since, with some annual fluctuation.

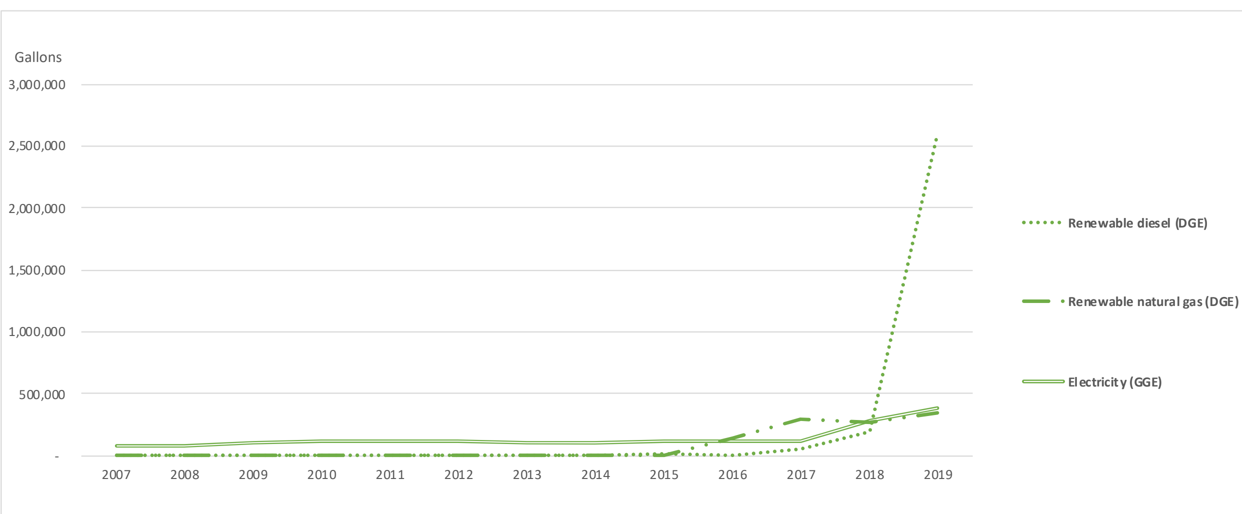
The CFP first recorded use of renewable diesel in 2017 and its co-product, renewable propane, in 2019. In 2019, renewable diesel had a 2% market share of all diesel fuel and renewable propane had a 22% market share of all propane use. One expert described renewable diesel's sudden appearance and climbing use (in California) by saying it "came out of nowhere."

*Ethanol, biodiesel, renewable diesel, and renewable natural gas as a percentage of total fuel use of its type, by volume, in Portland, 2007-2019*



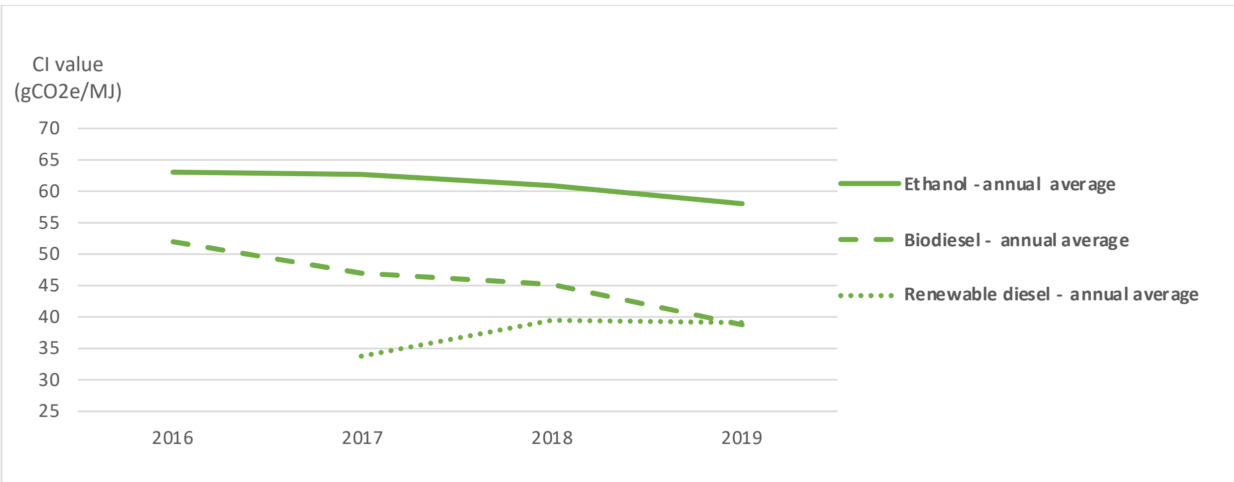

The sharp upward trajectory of renewable diesel is more clearly visible in its volumetric history, especially when compared to renewable natural gas and electricity, both of which have seen increases in use but neither as dramatic as that of renewable diesel.

*Use of renewable diesel, renewable natural gas, and electricity in Portland, 2007-2019 (gallons)*



Another significant change in the alternative fuels landscape since the initiation of the CFP is the decline in carbon intensity of ethanol and biodiesel. All experts attribute this to the market incentives created by the CFP, which rewards suppliers for bringing low-carbon fuels into the state. From 2016, the first year of the CFP, to 2019, the most recent full reporting year, the average CI value of ethanol (measured on an annual basis) declined 8% and the average CI value of biodiesel declined 25%.

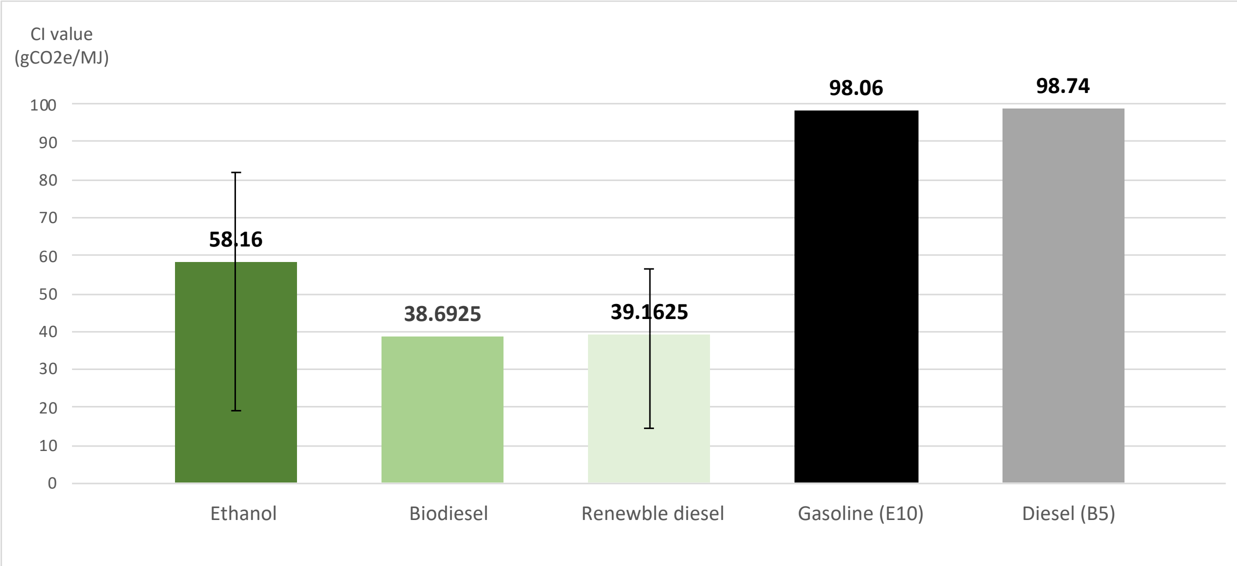
*Average annual carbon intensity values of ethanol, biodiesel and renewable diesel in Oregon, 2016-2019*




Despite the overall decline in carbon intensity of ethanol and biodiesel since 2016, the CI values of the fuels still range widely, with the lowest values between 10 and 20 and the highest values over 50 (biodiesel) and over 80 (ethanol). Even the fuel pathways with the highest CI values compare favorably to their conventional counterparts, which have CI values of approximately 100.

Renewable diesel has a similarly broad range in CI values, with low and high values comparable to biodiesel. The variation in carbon intensity together with the gap between average annual values and lowest recorded values suggests there is ample opportunity to decrease the average CI values of all three fuels over time.

*Carbon intensity range and annual average values for ethanol, biodiesel, renewable diesel, gasoline (E10) and diesel (B5) fuels in Oregon, 2019*




**Six low-carbon transportation fuel substitutes with low to moderate barriers**

The following table presents a rank order of policy opportunities to increase use of alternative fuels using Portland's RFS. All six policy opportunities are judged to have low to moderate barriers to implementation based on experts' description of their infrastructure costs, education/communication requirements, and fuel price impacts. The table shows the technical potential of each policy opportunity on three metrics:

- Volume of conventional fuel replaced
- Percent increase in volume of substitution fuel
- Volume of conventional fuel remaining

Even if all six policy opportunities are implemented to their technical potential, 60% of Portland's transportation fuel will still be conventional and all of it will derive from a single source: gasoline.

*Six policy opportunities to increase use of alternative fuels in Portland*

| Rank<br>Lowest barriers to highest barriers | Opportunity | Facilitating factors | Barriers | Technical potential | | |
|---|---|---|---|---|---|---|
| | | | | Proportion of conventional fuel replaced (volume in million gallons, 2019) | Percent increase in volume of substitution fuel over 2019 consumption | Remaining volume of conventional fuel use (based on 2019 consumption) |
| 1 | Increase biodiesel mandate from B5 to B20 and require biodiesel to meet a low CI value | Ready supply; no infrastructure changes required | Opposition from fossil diesel suppliers; potential price impacts based on speed of phase-in and CI values required | 15% (16.44) | 175% | 93.16 million gallons conventional diesel |
| 2 | Require 100% of diesel to come from alternative sources or meet a low CI value | Supply of renewable diesel is currently limited but growing quickly; no infrastructure changes required; no blend wall if at least 80% of fuel by volume is replaced with renewable diesel | Uncertain opposition from fossil diesel suppliers; potential price impacts based on speed of phase-in and CI values required | 100% (109.60) | 4220% | eliminates conventional diesel and replaces is with either 100% renewable diesel or a blend of up to 20% biodiesel |
| 3 | Require a low CI value for ethanol | No infrastructure changes required; unlikely to face supply constraints due to small volumes | May increase prices slightly at the pump, depending on speed of phase-in and CI values required | no impact | no impact | no impact |
| 4 | Require 100% of natural gas to come from renewable sources or meet a low CI value | Ready supply; no infrastructure changes required | Uncertain impact on prices | 100% (0.22) | 63% | eliminates conventional natural gas as a transportation fuel |
| 5 | Require 100% of propane to come from renewable sources or meet a low CI value | No infrastructure changes required | Uncertain supply; uncertain impact on prices | 100% (0.25) | 354% | eliminates conventional propane |
| 6 | Increase ethanol mandate from E10 to E15 | Ready supply | Requires infrastructure upgrades, pump labeling, and education; potential cross-fueling risk for vehicles 2001 and older | 5% (12.12) | 145% | 231.12 million gallons conventional gasoline |

**Pathways to low-carbon fuel for gasoline vehicles**

In order to reduce GHG emissions beyond what can be obtained from the six policies described above, Portland will need to support the transition of gasoline vehicles (nearly all of which are privately owned light duty/passenger vehicles) to one of three low-carbon fuels: E85, biodiesel/renewable diesel, or electricity. The table below describes three pathways discussed by experts, each of which requires massive infrastructure investments (either in vehicles or fuel distribution or both). Experts did not have suggestions about how to use the RFS to support these pathways. However one possibility is clear: if 100% of gasoline was mandated at E85, either through a volumetric or CI standard, vehicle owners would be required to take one of the three pathways below.

*Three low-carbon pathways for privately owned (non-fleet) gasoline vehicles**

| Pathway | Alternative fuel | Facilitating factors | Barriers | Technical potential | | |
|---|---|---|---|---|---|---|
| | | | | Proportion of conventional fuel replaced (volume in million gallons, 2019) | Percent increase in volume of substitution fuel over 2019 consumption | Remaining volume of conventional fuel use (based on 2019 consumption) |
| Replace/retrofit gasoline engines vehicles to accommodate E85 ("Flex Fuel") | Ethanol | Abundant supply of ethanol | Retrofit cost $500-600 for existing vehicles and uncertain technical expertise to perform retrofits; low supply of OEM Flex Fuel vehicles in the U.S.; costs to upgrade gas station pumps/tanks; consumer education; risk of cross-fueling; emissions impact diminished if owners do not fuel up with E85 | 85% (202.79) | 750% | 40.57 million gallons conventional gasoline |
| Replace gasoline vehicles with electric vehicles | Electricity | Growing number of OEMs making EVs, strong advocacy, positive perception of technology | Nascent charging infrastructure that is more difficult for MF residents to access, higher vehicle cost | 243.35 | 2,123,184% | eliminates conventional gasoline |
| Replace gasoline vehicles with diesel vehicles | Biodiesel or renewable diesel | Market-ready vehicles and fueling infrastructure | Small vehicle selection, possibly negative perceptions resulting from VW emissions scandal; requires co-implementation with a low-carbon standard for diesel | 243.35 | 2,033% | eliminates conventional gasoline |

**The future for a low-carbon gasoline alternative fuel: isobutanol and isooctane**

Some small producers are in the early stages of developing isobutanol as a low-carbon alternative fuel to blend with conventional gasoline and isooctane as a low-carbon drop-in substitute for gasoline. Isobutanol is an alcohol-based fuel that, like ethanol, is produced from plant-based sources. One expert suggested the blend wall for isobutanol is 16%, however the City of Seattle conducted a pilot in which isobutanol was blended with gasoline in select City fleets at 20%.[1]

Isooctane is produced from isobutanol. Experts note that, in their privately-conducted studies, isooctane has fewer particulates and comparable NOx and SOx emissions than conventional gasoline.

Today, both isobutanol and isooctane are produced in very small quantities and have a higher cost than conventional gasoline or ethanol. Nearly all production is sold to buyers in Europe, where isooctane is used in high-performance vehicles like race cars, and to airlines like Delta, that are experimenting with isooctane as a lower-carbon jet fuel.

Isobutanol and isooctane can be produced in refineries that today produce ethanol, suggesting that developing new refinery capacity may not represent a substantial barrier to future increases in supply. As is the case with other alternative fuels, finding a buyer to guarantee future demand for the fuel through an offtake agreement is the biggest barrier to financing new production capacity.

The City can continue to monitor the production and use of isobutanol and isooctane so that at a future point, if/when the market attains sufficient supply and competitive cost, these fuels could be included in the RFS.

[1] Thi Dao. August 12, 2019. "Seattle Lowers Emissions by 33% with Renewable Gasoline Blend." *Government Fleet*. https://www.government-fleet.com/338017/seattle-lowers-emissions-with-renewable-gasoline-blend

## SECTION 2: ALTERNATIVE FUEL POLICY OPPORTUNITIES

This section reviews policy opportunities and important considerations for updating Portland's RFS with regard to seven alternative fuels: ethanol, electricity, biodiesel, renewable diesel, renewable natural gas, renewable propane, and renewable hydrogen.

### Important considerations for setting fuel policy

In addition to the fuel-specific considerations below, experts noted general guidelines for regulating transportation fuels that are relevant regardless of the fuel type:

*An important advantage of a low-carbon fuel standard, in contrast to a volumetric standard, is that it remains fuel neutral*

Experts point to California's Low Carbon Fuel Standard, which informed the development of Oregon's Clean Fuels Program, as a leading example of a fuel-neutral policy. As one expert explained, an LCFS "sets up all fuels as competitors, it's technology-neutral and allows the market to value the fuels and determine which come into the state. The regulator sets a performance standard and the market determines the fuel mix that meets it based on the credit prices." When the California standard was in development in 2014-2015, regulators expected suppliers would use cellulosic ethanol to meet requirements. That technology did not materialize and what did occur was a striking rise in the volume of renewable diesel. Experts pointed to the fuel-neutral quality of the LCFS as allowing it to accommodate rapidly evolving fuel technology: had the California standard been written as a volumetric mandate requiring set volumes of low-CI ethanol it would not have been able to adapt.

*Portland needs to evaluate what, if any, additional benefits can be derived from applying a low-carbon standard in the City's RFS, given the aggressive goals of Oregon's CFP*

Experts had a variety of opinions on whether Portland should seek to add a carbon intensity standard to its RFS. They noted the following considerations for policy makers in evaluating this question:

- Is Portland uniquely "situated" to hit a more stringent CI standard than the state as a whole because of its stakeholders, local interest, or local fuel supply or demand? For example, is there a ready supply of renewable natural gas or vehicles that need it? If so, Portland would be in a position to drive emissions down farther and faster.
- What are the local benefits of a more stringent CI standard? While carbon emissions reductions are a benefit of global scale, co-benefits like improved air quality have a local benefit and may be a reason to set a lower CI standard at the City level.
- How would a more stringent standard in Portland change the distribution of fuels in the rest of the state? Could the Portland RFS disadvantage other localities by attracting a higher proportion of alternative fuels? Some experts suggested a CI standard in Portland could have the opposite impact – that of decreasing CI levels statewide – arguing that fuel suppliers would not bring in fuels with multiple CI values to the state and thus Portland's CI standard would become the default State standard.

- What are the consequences of setting a local carbon intensity standard that differs from the State standard (in the CFP)? Differing standards may create confusion in the market.

*The City will need to attend to the communications of any changes in the RFS, both to Council and the public.*
Experts suggested the City emphasize the "big picture" goals that the RFS addresses. They also suggested the City "lead by example" and take a tiered approach: first making the changes to its own fueling and vehicle infrastructure, then requiring those changes of its contractors, and finally requiring those changes in the City at large.

As of October 2020, the City of Portland had already begun the transition to alternative, low-carbon fuels for City-owned fleets. Diesel fuel used by City vehicles exceeded the RFS mandated minimum of 5% biodiesel as early as 2007, when the City's first RFS policy was adopted. By 2020, the City had replaced 100% of fossil diesel with renewable diesel, amounting to more than 400,000 gallons annually. The City was also nearing completion of a project to generate low-carbon renewable natural gas at the City's Columbia Boulevard Wastewater Treatment Plant. The project was expected to generate more than one million gallons of fossil fuel-equivalent biogas annually. The City had also begun extending low-carbon fueling requirements to its contractors, including franchised garbage haulers working in Portland and was considering expanding requirements to construction contractors and other suppliers.

*It will be critical to assess and track the financial or cost implications of any change in fuel policy.*
Experts note any policy that changes the distribution of fuel use will incur a cost. In a program like California's LCFS or Oregon's CFP, increased cost comes as a transfer of credits/dollars from high carbon fuels to low carbon fuels, with a larger transfer as the carbon intensity standard becomes more stringent. A Portland standard more stringent than the State's could produce pricing disparities between fuels sold in Portland and elsewhere. Experts said higher costs are usually passed on to users at the pump, but that because the added cost per gallon is usually small (typically pennies) and demand is inelastic, there has been little impact on fuel use.

This report makes no attempt to estimate the cost impacts of the policy options described below. Although the City could choose to commission such a study, the California experience shows fuel markets can move in unpredictable ways, making it difficult for policy makers and experts to predict how they will react. If the City does conduct a systematic evaluation of cost implications, experts had some recommendations:

- In evaluating the potential cost implications of a policy, fuel suppliers are an important source of information, however experts cautioned that suppliers will nearly always say a new policy will increase prices. Experts recommended Portland push suppliers for evidence to support this claim and carefully evaluate that evidence.
- Experts suggested looking to California's experience as another data source for projecting price impacts. California's LCSF has been in effect longer than Oregon's CFP

and experts believed price impacts in California could be a model for possible price outcomes in Portland.

An alternative approach to attempting to predict cost impacts would be to design a policy that increases requirements slowly in areas where supply and cost impacts are uncertain and will be responsive to market conditions, enabling the City to slow implementation where unsustainable cost impacts arise or speed implementation where supply increases quickly and costs decline. Regardless of the approach the City takes, experts recommend the City closely monitor fuel prices after the policy takes effect.

**Ethanol**

Ethanol is the only renewable fuel that can be blended with gasoline. At present, there are no market-ready drop-in[2] renewable fuel substitutes for conventional gasoline and thus ethanol is the only low(er)-carbon substitute for Portland's highest volume transportation fuel (69% of all transportation fuel in 2019).

As a result of the Federal Renewable Fuel Standard (RFS), nearly all gasoline sold in the U.S. contains a minimum of 10% ethanol, making ethanol the most widely used renewable fuel in Oregon and the U.S. In 2019 in Portland, ethanol accounted for 7% of all fuel and 68% of all renewable fuel. Ethanol's share of total gasoline volume has remained constant at about 10% (the mandated minimum blend rate) since the adoption of the Federal and City Renewable Fuel Standards took full effect state-wide by 2009.

Ethanol is manufactured at multiple facilities around the U.S., including two operational facilities in Oregon. In 2019, ethanol imported to Oregon had an average carbon intensity (CI) of 58.16, substantially higher than the average CI of biodiesel (38.69) and renewable diesel (39.16). However, the lowest CI ethanol, at 21.85, was in range of the lowest CI diesels, both with values between 14 and 15. And, the average annual CI of ethanol imported to Oregon has declined 8% since the initiation of the CFP in 2016.

Ethanol's impact on air quality is much debated. In March, 2020 the U.S. EPA completed a study comparing air quality in the U.S. "pre-RFS" (2005) and "post-RFS" (2016). The study had several limitations, primarily that the pre/post differences in air quality cannot be directly attributed to the changes in renewable fuel use. The study found post-RFS increases in concentrations of ozone, NOx, and acetaldehyde. Concentrations of particulate matter varied but were generally unchanged. The study found decreases in concentrations of CO, benzene, and 1,3-butadiene.[3] The results of this study have been challenged by ethanol industry groups. In contrast, a 2016 review of the scientific literature by the Energy Future Coalition and the United Nations Foundation found that ethanol reduces emissions of most compounds of interest.[4]

*Policy opportunity: Increase the ethanol blend mandate from E10 to E15*

There are multiple technical and infrastructure barriers to increasing ethanol use. Increasing the ethanol mandate in conventional gasoline from the current 10% (E10) to 15% (E15) is the

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[2] A "drop-in" fuel is one that is completely interchangeable with its conventional fuel counterpart, meaning it can be distributed through the existing infrastructure and used by existing vehicles without modification. Most drop-in fuels referenced in this report, including renewable diesel, renewable natural gas, and renewable propane, have similar or identical molecular structures as their conventional counterparts. Isobutenal is another alternative fuel that can be blended with gasoline, but it is currently produced only in very small sufficient volumes by a small number of suppliers.

[3] U.S. EPA. 2020. *Clean Air Act Section 211(v)1: Anti-backsliding Study.* EPA-420-R-20-008. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZBY1.pdf

[4] Sadaf Sobhani. 2016. *Air Polution from Gasoline Powered Vehicles and the Potential Benefits of Ethanol Blending.* Energy Future Coalition, United Nations Foundation. http://energyfuturecoalition.org/wp-content/uploads/2016/12/final_clean-fuelsBOOK.pdf

opportunity with the lowest (although still substantial) barriers to implementation. The U.S. EPA approved the use of E15 in 2011 for vehicles newer than 2001, and experts agree that E15 contains the maximum proportion of ethanol that can be safely used in standard gasoline engines in newer vehicles. Nearly all vehicles on the road today are capable of using E15. As of 2019, one expert estimated 93% of all passenger vehicles in the U.S. are model year 2001 and newer. Data obtained from the Oregon Department of Motor Vehicles (DMV) shows that, as of October 2020, 85% of gasoline-powered passenger vehicles registered in Multnomah County were model year 2001 and newer.[5] Vehicles not approved by the EPA to use E15 include motorcycles, off-road vehicles including boats, heavy-duty vehicles like busses, and machines with smaller engines like yard equipment and power tools.

Implementing this policy would increase ethanol's share of all fuels from 7% to 10% and increase total renewable fuels from to 10% to 13%, all other fuel uses held constant at 2019 levels. Ethanol consumption in Portland would be expected to increase 12.2 million gallons over 2019 levels (a volumetric increase of 45%) for a total consumption of 39.2 million gallons.

This policy would be expected to face substantial challenges:

- Resistance from conventional gas suppliers, who will see a 5% decrease in demand for their fuel.
- Added expense for gas stations, which may need to maintain two pumps, E15 for most vehicles and E10 for vehicles older than 2001. An ethanol industry source estimated the retrofit cost starts at approximately $1,000 per pump.[6]
- Education and labelling needs at the pump to ensure vehicles are fueled with the correct blend based on vehicle age.
- Concerns from vehicle owners and marine and small engine users.
- Slight increase in NOx emissions.

Important considerations:

- While the Clean Fuels Program (CFP) has already led to a reduction in ethanol CI values since 2016, Portland could consider additional measures to encourage/require low-CI ethanol.
- There are no supply constraints on ethanol in general, but there may be supply constraints on ethanol with the lowest CI values.
- While the EPA says E15 is viable for vehicles 2001 and newer, some experts suggest older vehicles with less sophisticated engine computers may be less well equipped to handle higher ethanol blends.
- Experts think even a 50% increase in ethanol use would be unlikely to impact prices at the pump because of the large U.S. ethanol supply, however a CI requirement could impact prices if there is an insufficient supply of low-CI ethanol to meet the demand.

[5] Oregon Department of Motor Vehicles. Data report on vehicles in Multnomah County by vehicle type, year, and fuel type. Provided to BPS by DMV. 2020.
[6] Fuel Freedom Foundation. https://www.fuelfreedom.org/get-ethanol-blends/.

*Policy opportunity: Increase the use of E85 gasoline in Portland*

Gasoline that contains between 51% and 85% ethanol (E85) can only be used by specially equipped engines ("Flex Fuel" vehicles) and thus the volume of E85 gasoline consumed in Portland is a function of two things: the number of Flex Fuel vehicles on the road and the proportion of Flex Fuel vehicle owners who fuel up with E85.

Because ethanol has 25% less energy by volume than gasoline, engines running on E85 must be equipped to sense the gasoline/ethanol blend and inject a larger volume of fuel into the engine when the proportion of ethanol is higher. In the U.S. in 2016, Flex Fuel vehicles made up only about 7% of all on-road light-duty (i.e. passenger) vehicles.[7] In Multnomah County in 2019, Flex Fuel vehicles made up 8% of all gasoline vehicles in fleets of 20 vehicles or more, nearly all of which were passenger vehicles. The six largest fleet owners of Flex Fuel vehicles were PV Holdings, a rental car company (682 vehicles), the City of Portland (321 vehicles), Multnomah County (88 vehicles), Penske Leasing (87 vehicles), Qwest Corporation (81 vehicles), Broadway Cab (70 vehicles).[8] Oregon DMV data shows, as of October 2020, 3% of gasoline-powered passenger vehicles in Multnomah County were registered as Flex Fuel vehicles.

Experts note the cost to retrofit a standard gasoline engine to accommodate E85 is about $500-600 aftermarket (and about $100 if done by the OEM during manufacture).[9] There has been little to no demand for Flex Fuel retrofits in Portland to date. The City could consider raising awareness of the possibility and providing funding to offset the cost. Flex Fuel vehicles can still operate on standard gasoline, however, so any emissions reductions from these conversions would require vehicle owners to fuel up at the two gas stations in Portland that currently offer E85.

A second challenge to increasing use of E85 is the infrastructure costs required for gas station upgrades. One source suggested 30-60% of E85 installations require a new underground storage tank (the others do not require a new tank) – with the average gas station having 3.3 tanks, one for each grade of gasoline. The cost for a new tank can range from $50,000 to $200,000 and averages $74,000.[10] One expert estimated the cost of retrofitting a gas station to accommodate the E85-specific underground tank and pumps to be $100,000 or more. Given these costs, it seems unlikely gas station owners would make the required changes unless there is a substantial increase in demand for E85 and/or funding to cover their costs.

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[7] U.S. Energy Information Administration. 2016. "Almost all U.S. gasoline is blended with 10% ethanol." https://www.eia.gov/todayinenergy/detail.php?id=26092

[8] Oregon Department of Motor Vehicles. Data report on vehicles in Multnomah County fleets larger than 20 vehicles. Provided to BPS by DMV. 2020.

[9] National Research Council. 2011. Renewable Fuel Standard: Potential economic and environmental effects of U.S. biofuel policy. The National Academies Press: Washington, D.C. https://www.nap.edu/read/13105/chapter/8.

[10] Fuel Freedom Foundation. https://www.fuelfreedom.org/get-ethanol-blends/; NREL. 2015. E15 and Infrastructure. https://afdc.energy.gov/files/u/publication/e15_infrastructure.pdf; "Trump Push for Corn-heavy Fuel isn't Reaching the Pump." 2019. Transport Topics. https://www.ttnews.com/articles/trump-push-corn-heavy-fuel-isnt-reaching-pump

*Policy opportunity: Increase the use of E85 in existing Flex Fuel vehicles*

Some experts believe most Flex Fuel vehicle owners are unaware that their vehicles can be fueled with gasoline that is up to 85% ethanol (E85). In 2007-2008 Clean Cities ran a campaign to educate these owners and saw a small increase in E85 consumption. A similar campaign could be operated by the City. This policy would likely have limited impact due to the small number of Flex Fuel vehicles on the road (3% of gasoline vehicles) and the scarcity of gas stations (perhaps two) selling E85 in Portland. If the campaign achieved its technical potential, and all Flex Fuel vehicles in Multnomah County switched from E10 to E85, ethanol would increase in market share from 7% to 8%, all other fuel uses held constant at 2019 levels.

**Electricity**

While some electric vehicle (EV) advocates say we must “electrify everything,” transport experts agree that for the foreseeable future Portland will require a mix of fuels to reach emissions targets. Experts also agree that while electricity may eventually make up the largest share of Portland’s transportation fuel mix, it is likely to be one of the slower fuels to reach its technical potential due to substantial barriers to adoption and its starting point as the least common alternative fuel. In Portland in 2019, electricity made up 0.10% of all transportation fuel and 0.96% of alternative fuels.

The barrier to electricity as a transportation fuel is exactly opposite the challenge facing most other alternative fuels. Supply is not at issue: renewable, low-carbon electricity is abundant, inexpensive, and available everywhere. What the City lacks is widespread adoption of electric vehicles. In Multnomah County as of October 2020, there were 6,326 registered EVs (excluding hybrid vehicles), which made up 1.2% of Portland’s registered passenger vehicles.

Any policy to increase adoption of EVs will need to consider impacts on two elements of the EV infrastructure: fast charging and vehicle maintenance. Adoption of EVs requires access to charging, ideally fast charging. While homeowners can install fast chargers, this is more difficult for renters and multi-family residents (HB 2510 in 2017 addressed this but has not solved the problem). Experts suggested expanding access to fast charging at workplaces and stores that are already part of people’s weekly routine (e.g. grocery, pharmacy, library) as one solution. The ability of vehicle owners to find trained mechanics who can service their vehicles is another consideration, although experts note this may be more pertinent to fleet owners than individuals.

*Policy opportunity: Increase adoption of privately-owned EVs by reducing their cost*

One expert noted that approximately 90% of vehicles in Oregon are privately owned, and given this estimate, privately owned gasoline vehicles account for 62% of the conventional fuel used in Oregon - by far the largest fuel wedge in the City’s transportation pie. The State has already set a goal of 50,000 EVs on the road by the end of 2020. On May 1, 2020 there were approximately 32,000 EVs registered in the State. Oregon thus needs a 56% increase in EV adoption in seven months to meet the 2020 goal - an unlikely outcome.

Experts point to four barriers to greater EV adoption among the general public: limited selection of EVs, higher cost of EVs compared to gasoline vehicles, lower awareness of EVs and their benefits, and a lack of charging infrastructure. None of the interviewees suggested the City address the former barrier, noting that car makers are quickly moving to innovate in this space and all expect vast increases in availability of electric passenger vehicles in the next few years.

Both academic researchers and respected publications in the popular press have document that EVs have lower annual fueling costs and a lower lifecycle cost than reasonably priced conventional fuel vehicles.[11] However, an EV's "first cost" or retail price is still typically higher than a comparable conventional fuel vehicle. Experts believe the first cost of passenger EVs will reach price parity with conventional fuel vehicles by 2025 and may be less expensive by 2030. There are several efforts underway to accelerate the move toward price parity. The City can consider how it could leverage, replicate, or contribute to the following efforts in the short term and even after parity is achieved, to further increase EV adoption:

- A Federal tax credit of up to $7,500 for purchase of an EV.
- A State of Oregon "standard" rebate of $2,500 for purchase of a new EV.
- A State of Oregon "Charge Ahead" rebate (income-qualified, below 120% median) of $2,500 for a new EV (can be combined with the "standard" rebate) or $2,500 for purchase of a used EV.
- An additional point-of-sale discount/rebate for EV purchases. Funding for an EV rebate could come from:
    - Credits obtained by electricity suppliers or users under Oregon's Clean Fuels Program; California is developing a program that will direct about 80% of credits obtained by utilities under the State's LCFS to point-of-sale rebates;
    - Grants or the Portland Clean Energy Fund
    - A new tax measure

The City is already working to address the awareness and charging infrastructure barriers and has more than 30 actions it is taking as part of its EV strategy. These include working with community partners to increase availability to charging and addressing equity issues in electric transportation, for example focusing efforts to expand EV ownership and use in geographic areas where public transport is less available and/or where air quality is poor.

Important considerations:

- Equity: As with any innovative technology, the higher cost of EVs is likely resulting in disparities in adoption, with lower rates of uptake among low and moderate income households and people of color. Two elements of the existing State incentive program may disadvantage lower income households:
    - If they do not pay Federal taxes they cannot benefit from the tax credit (although some portion of it may be provided as a tax refund - this needs to be investigated with a tax expert).

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[11] Michael Sivak and Brandon Schoettle. January 2018. *Relative Costs of Driving Electric and Gasoline Vehicles in the Individual U.S. States. Report No. SWT-2018-1*. The University of Michigan: Sustainable Worldwide Transportation. Richard Raustad. 2017. *Electric Vehicle Life Cycle Cost Analysis: Final Research Project Report. EVTC Project 6 – Electric Vehicle Life Cycle Cost Analysis*. University of Central Florida. Harto, Chris. October 2020. "Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers." Consumer Reports. https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

    - If they buy a used vehicle they qualify for only 50% of the EV incentive available for new vehicles.
- Used vehicle sales: Any plan to replace conventional vehicles with EVs will need to address used car sales for two reasons:
    - Used cars make up 70% of annual car sales in the U.S.,12 and one expert suggested used cars may account for an even higher percentage in Oregon. At present, EVs make up only a small proportion of used car sales (one expert suggested 2%).
    - Current Oregon State rebates do not support used EV purchases: the "standard" rebate is not available for used purchases and the "Charge Ahead" income-come qualified rebate is 50% of the amount offered for new EV purchases.
- Any additional rebates for EV purchases are likely to be popular and funding may be quickly exhausted. 2009's "Cash for Clunkers" Federal rebate program provided $3,500-$4,500 per vehicle and was deemed wildly successful. The program exhausted its first $1 billion in eight days (~222,222 rebates) and a total of $3 billion overall (~666,666 rebates and ~26,666 rebates in Oregon, by share of the U.S. population).[13]
- Utility programs have two decades of experience implementing consumer rebate programs and Go Electric Oregon notes on its website that it is working with utilities to encourage EV adoption.[14]

*Policy opportunity: Limit the CI value of electricity used as a transportation fuel*

Under the Clean Fuels Program, a utility, at its own discretion, selects one of two values to be used for its CI value under the CFP: the CI value for its utility-specific electricity mix or the CI value for the statewide electricity mix. For 2020, the CI value for the statewide electricity mix was 107.92.[15]

In 2020, the two electric utilities serving Portland customers, Portland General Electric (PGE) and Pacific Power (PP), chose to use the CI value of the statewide electricity mix rather than their utility-specific CI values. Although the CFP did not publish the CI values of PGE's and PP's utility-specific mixes, the approximate value can be calculated using the CFP's published CI values for the public utility districts and cooperatives in Oregon, their estimated proportion of total electricity in the state, and the CI value of the statewide mix. Using a weighted average and assuming PGE and PP account for 75% of electric demand in the state, and that the remaining

[12] "Number of new and used light vehicle sales in the United States from 2000 to 2018." Statista.com. Accessed June 3, 2020. https://www.statista.com/statistics/183713/value-of-us-passenger-cas-sales-and-leases-since-1990/
[13] "Car Allowance Rebate System." Wikipedia. Accessed June 3, 2020. https://en.wikipedia.org/wiki/Car_Allowance_Rebate_System
[14] Go Electric Oregon. Accessed June 3, 2020. https://goelectric.oregon.gov/2020-goal
[15] The CI values for the statewide mix and for all utilities except Portland General Electric and Pacific Power are provided in the Clean Fuels Program document, "Calculating the Carbon Intensity of Electricity used in the CFP 2014-2018, effective for the 2020 compliance period." https://www.oregon.gov/deq/aq/Documents/cfp-carbcalc.pdf

utilities have an average CI value of 5, the estimated CI value of PGE and PP utility-specific mixes is in the mid-140s.

Because electric motors are more efficient than internal combustion engines, it is necessary to calculate an "effective" CI value for electricity when comparing it to the CI value of fuels used for non-electric vehicles. Using the example of a light-duty passenger vehicle, dividing the estimated CI value for electricity from PGE and PP by the CFP's published energy economy ratio of 3.4 yields an effective CI for transportation electricity from PGE and PP in the low 40s.[16]

Whether Portland could set its own CI limits on electricity as a transportation fuel is a question that could not be answered by the experts interviewed, although they found it "intriguing" and raised the following considerations:

- Under an LCFS, electricity should generate more credits as the grid becomes cleaner; experts believe there is a question around whether the CFP should/could provide higher credit values for cleaner electricity.
- Experts think the Oregon Public Utilities Commission (OPUC) may pre-empt the City if a City policy attempts to influence an electric utility's fuel mix using the RFS to mandate CI levels for electricity. The OPUC may argue that the City statute conflicts with the State's Renewable Portfolio Standard.
- Electric utilities may oppose a City policy that attempts to regulate their fuel mix through a CI standard within the RFS.
- An updated RFS that sets the CI value of electricity at a level already agreed to by electric utilities (for example, at limits mandated by SB 1547) may be unlikely to engender opposition from utilities and would be a mechanism to enforce the 100% Renewable by 2050 resolution adopted by Multnomah County on June 1, 2017 and crafted jointly with the City of Portland.

*Policy opportunity: Provide additional advantages to private EV drivers to encourage adoption*

One expert noted that cities in France and England have made internal combustion engines illegal in city centers. The City could consider what other policy levers it has at its disposal to provide advantages to drivers and add value to EV ownership. For example, reduced parking costs or increased parking availability for EVs.

*Policy opportunity: Increase adoption of electric transit and school busses*

Electric busses are available but expensive. One expert noted an electric type C bus is more than two times the cost of a comparable conventional fuel bus. Public entities will require grant funding as well as public support for investing in these vehicles. Financing from the CFP has already been granted to five school districts in Oregon to purchase electric busses, and one expert suggested the remaining funds in the VW settlement could be used for this purpose.

[16] The energy economy ratio is published in Oregon Rule 340-253-8010, Table 7. https://oregon.public.law/rules/oar_340-253-8010

Considerations for electric busses include ensuring service technicians are property trained and education for drivers to maximize operational efficiency of the electric drive train.

*Policy opportunity: Increase adoption of small electric vehicles*

Numerous types of small vehicles are already or will soon be available with electric motors, including forklifts, drayage, street sweepers, smaller construction equipment. Experts say there has not been widespread adoption to date and a significant advantage for converting these vehicles to electricity is improved air quality, especially for vehicles like forklifts that are used in warehouses. This report did not assess current use of these small vehicles nor the costs or availability of electric vehicle alternatives.

*Mid- to long-term policy opportunities: Increase adoption of medium- and heavy-duty EVs*

Medium and heavy-duty electric vehicles are both in development. Experts believe medium-duty vehicles will begin increasing in adoption after 2025 as their prices decrease. Like electric busses, they are currently two to three times more expensive than their conventional fuel counterparts. Examples of medium-duty formats include flatbed trucks, box trucks (e.g. a U-haul), or a utility truck with a boom.

Experts think heavier duty trucks will not get to price parity with conventional vehicles until after 2025 and that it is still uncertain whether electricity will ultimately be the dominant fuel in this weight class, with hydrogen, natural gas, and diesel as competitors. However, for vehicles with stop-start duty cycles, predominantly waste haulers and transit vehicles, the higher first cost of an EV may be overcome by lower life cycle costs as a result of reduced maintenance needs.

*Mid- to long-term policy opportunity: Ban the sale of vehicles with internal combustion engines*

This is a policy being put forward by Britain, which will ban internal combustion vehicle sales in 2035, as well as other European and Asian countries. A bill currently in committee in the Washington State legislature would ban registration of new gasoline powered passenger vehicles and light-duty trucks starting in 2030. In Portland this policy would be more symbolic than impactful given the ease with which Portlanders could purchase vehicles outside the City. In the near term, this policy may engender opposition from large car dealerships including Subaru, Toyota, Lexus, Tonkin, and Dick Hannah. However, by the time the policy goes into effect it is likely that EVs will already have attained a much larger market share than today and thus the effect of the policy may be akin to a minimum performance standard in that it will primarily address the “late majority” and the “laggards.”

**Biodiesel**

Biodiesel is one of the two fuels mandated by Portland's current RFS, which requires all diesel fuel contain 5% biodiesel (B5). In 2019, biodiesel was the second highest-volume alternative fuel in Portland, making up 24% of renewable fuels and 2% of all fuels.

Biodiesel has a compelling narrative (turn deep fryer waste oil into fuel!) and a prominent local producer (SeQuential Biofuels, based in Eugene). Its market share in Portland has increased moderately since 2016, when the Clean Fuels Program began, growing from 6% of all diesel fuel to 8% in 2019, a 21% increase. One expert noted that in 2019, biodiesel was less expensive in Oregon than diesel as a result of the CFP, leading Safeway to blend all diesel at its pumps with 20% biodiesel (B20) in order to lower prices. The CI value of biodiesel in Oregon has declined substantially since 2015, dropping from an annual average of 51.89 in 2016 to 38.69 in 2019.

Oregon Department of Environmental Quality states that use of B20 leads to a decline in particulate matter (-12%), sulfates (-20%), and CO (-12%), and leads to an increase in NO (+2-4%).[17] One expert noted that the air quality impacts of biodiesel compared to conventional and renewable diesel is a "live" conversation at the California Air Resources Board (CARB).

*Policy opportunity: Increase the biodiesel blend mandate from B5 to B20 (or maybe B25?)*

Experts agree biodiesel can be blended into conventional diesel at a rate of up to 20% (B20) without concern for problems that occur at higher blends, like gelling at low temperatures and microbial growth. One expert suggested a 25% biodiesel blend (B25) would be feasible. A B20 mandate would displace 16.44 million gallons of conventional diesel annually, increase biodiesel's share of all fuels from 2% to 7%, and increase total renewable fuel market share from 10% to 14%, all other fuel uses held constant at 2019 levels. Biodiesel consumption in Portland would be expected to increase by 175% to a total expected consumption of 25.81 million gallons.

A B20 volumetric mandate would be expected to face moderate challenges, primarily from conventional diesel suppliers, who would see a 15% decrease in demand for their fuel. Advocates, particularly those promoting electricity, view all alternative liquid fuels as "transitional" or as "bridge" fuels to reduce emissions in the short term while zero-carbon fuels ramp up. These parties may be resistant to language that treats an increase in the biodiesel mandate as a permanent solution to transportation emissions.

Important considerations:

- While the Clean Fuels Program (CFP) has already led to a reduction in biodiesel CI values since 2016, Portland could consider additional measures to encourage/require

[17] Oregon DEQ. "Reducing air pollution with biodiesel." Accessed June 15, 2020. https://www.oregon.gov/deq/aq/programs/Pages/Diesel-Reducing-air-pollution.aspx.

low-CI biodiesel. The lowest CI biodiesel is made from waste oils, which are in shorter supply worldwide as their use for transportation fuel increases.

- There are no supply constraints on biodiesel at present and there are at least 15 facilities that produce biodiesel in the U.S., as well as Canada and Korea. Major international producers include REG and World Energy Resources. Oregon has one biodiesel producer, SeQuential Biofuels of Eugene.
- This policy would result in a substantial increase in biodiesel demand, tripling consumption in Portland and increasing state-wide biodiesel use by 25%. The expected increase in consumption in Portland of 16.44 million gallons is approximately equal to SeQuential's annual nameplate biodiesel capacity of 17 million gallons. All experts agreed that there is sufficient supply to meet this increased demand – if not in Oregon than in the US and internationally.
- Experts suggested a B20 requirement in Portland would introduce little to no increase in cost at the pump given an abundant biodiesel supply. Some experts suggested a B20 requirement could potentially *decrease* diesel costs because of the value of the credits accorded to biodiesel under the CFP, noting that some blenders have voluntarily gone to B20 in the recent past in order to capitalize on these credits.
- Experts were uncertain about the cost impact of a CI requirement for biodiesel and noted cost would respond to the level at which the CI requirement was set and the supply of biodiesel that would meet that CI requirement. If the CI requirement is set at a value such that limits only a small volume of currently available fuel meets the requirement, cost would be expected to increase until additional supply becomes available. The CFP reported CI values for biodiesel included in the program in 2019 ranging from 11 to 59.99 and an average value in 2019 of 38.69. The CFP does not publish the volume of biodiesel at each CI value, however the City would be advised to work with the program if setting a CI value to ensure there would be a sufficient supply to minimize cost impacts.
- Experts suggested an increased use of biodiesel could result in a slight increase in NOx emissions but also in reduced particulates. As noted elsewhere in this report, the air quality impacts of alternative fuels is still a very active area of research and thought to vary based on the feedstocks and production methods of the fuels and the characteristics of the engines that burn them.
- B20 is currently available at fewer than 10 gas stations in Portland, out of approximately 80 gas stations in the City[18]. Anecdotal research shows these stations serve B20 to all diesel customers, suggesting a move from B5 to B20 will have little to no impact on diesel customers.

Experts noted that properly managed fleets can run on 100% biodiesel (B99) and the Clean Cities program has been educating fleet managers about biodiesel for several years. Although early biodiesel did suffer from quality control issues the educational efforts are expected to have counteracted these earlier negative perceptions. The six largest fleet owners of diesel vehicles in Multnomah County, who together account for 47% of all diesel vehicles in fleets of 20 or more vehicles, are: TriMet (1,778 busses, 120 cars), the City of Portland (576 trucks, 266 cars), First

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[18] Yelp.com, accessed June 6, 2020.

Student (167 busses), the largest users of biodiesel may be fleets owned by government (including transit), Ryder and Penske rental companies (286 trucks), and FedEx (113 trucks).

**Renewable diesel**

Renewable diesel is a drop-in substitute for conventional diesel. Unlike biodiesel, there are no complications with high-percentage blends and renewable diesel can be substituted for diesel in any proportion. As one expert explained, renewable diesel "*is* diesel." Although made from biomass, it has the same chemical composition as fossil diesel. Like diesel, renewable diesel can be blended with biodiesel and users may benefit from a blend of biodiesel and renewable diesel because of the increased lubricity of the fuel and thus the reduced wear on the engine.

Worldwide, but in particular in California and Oregon, interest in and use of renewable diesel has increased exponentially since 2017. As one expert explained, renewable diesel seemed to "come out of nowhere." In Portland, renewable diesel has had the steepest increase in consumption of any fuel, jumping from 1% of renewable fuels in 2018 to 7% in 2019. In just two years, from 2017 (the first year the Clean Fuels Program recorded any renewable diesel use in Oregon) to 2019, the amount of renewable diesel in Oregon increased 4,401%.

Experts expect to see a sharp increase in renewable diesel demand in the near term. Major producers Neste and REG currently bring renewable diesel into Oregon from Singapore and Louisiana, respectively, and there are at least six renewable diesel refineries operating in the U.S., with several more planned. Some facilities produce both conventional and renewable diesel, like BP's Cherry Point refinery, which has been co-processing about 5% renewable diesel since 2018. One expert predicted substantially increases in RNG production by 2022 with sufficient capacity to meet 100% of Portland's 2019 diesel consumption.

There are still no renewable diesel refineries in the Pacific Northwest, however NEXT is in the permitting phase for a large refinery in Port Westward, Oregon scheduled to open in 2021. One expert suggested the bottleneck in producing renewable diesel will not be feedstocks but rather a shortage of refinery capacity - although conventional diesel refineries can be converted to produce renewable diesel and the two diesel types (conventional and renewable) can be co-produced in the same facility. As is the case with renewable natural gas, producers' biggest barrier to increasing supply is obtaining financing for new renewable diesel production facilities, which in turn rests on the producer's ability to demonstrate future demand for their product. The preferred path to "certainty and clarity" in this regard, for producers and their financial backers, is through offtake agreements in which buyers agree, in advance, to purchase a given quantity of fuel at a specific price. A secondary means to providing certainty is through regulatory programs like the LCFS and the CFP.

As a result of the CFP, renewable diesel is currently priced lower than biodiesel in Oregon and much lower than in Seattle. One expert estimated public fleets buy renewable diesel for $0.24 more per gallon than regular diesel and another expert noted that a large private fleet now pays $0.30-$0.40 more for renewable than conventional diesel.

None of the experts interviewed were aware of negative perceptions of renewable diesel, however there are concerns about indirect land use impacts as production ramps up. In addition, experts noted that any policy on renewable diesel should explicitly prohibit the use of palm oil, cultivation of which is relatively inexpensive and responsible for a substantial amount of the deforestation of the world's tropical rainforests. The City may also want to consider excluding recycled palm oil from being used to meet an updated RFS. Renewable diesel can be made from a variety of feedstocks, including waste oils, and has CI values nearly identical to those of biodiesel, ranging in 2019 from 14.78 to 58.57 with an average of 39.16.

*Policy opportunity: Increase use of renewable diesel*

Renewable diesel use is already on a sharp upward trajectory in Oregon because of its competitive pricing and ease of substitution for conventional diesel. Said one expert, "renewable diesel is the future." The City has two options to support a further increase in use of renewable diesel. Both may be opposed by the fossil fuel industry and conventional diesel suppliers, who will see demand for their product decline or be eliminated.

- A volumetric mandate for renewable diesel. Given renewable diesel's ease of substitution, this could be set at any blend ratio.
- A CI mandate. Because renewable diesel is currently in the same CI range as biodiesel, a CI mandate would regulate diesel fuel based on emissions reductions targets without privileging one alternative diesel fuel over the other.

Considerations:

- Education would be needed for the general public and fleets. Clean Cities has done some of this work and the City could look to that program as an example.
- Any standard that includes a volumetric mandate for renewable diesel only and excludes a mandate for biodiesel runs the risk of alienating and engendering opposition from biodiesel suppliers. In addition, including both fuels in any volumetric mandate is advisable because of the benefits of including biodiesel in a renewable diesel blend, including the add lubricity that biodiesel provides. As a fuel supply chain player (whose business includes both renewable and biodiesel) noted, "We think R99 blended with biodiesel is a better product because of its performance enhancement, emissions reductions, lower CI value, and lower cost."
- Regulatory measures like a strong CFP or RFS signal to suppliers that the market for a renewable fuel is stable and enduring. One expert suggested including renewable diesel in Portland's RFS is likely to help ensure new refineries get built and argued that Washington State's failure to pass a low carbon fuel standard for the 4th time may have been one reason REG and Phillips shelved plans for a new renewable diesel refinery at Ferndale, Washington.
- Experts emphasized that lowering the price of renewable diesel is key and that once the price hits parity with conventional fuels the demand will grow, especially among fleets.

**Renewable natural gas**

Renewable natural gas (RNG) is a drop-in substitute for conventional natural gas, a niche fuel in Oregon that makes up just 0.14% of all transportation fuels. Renewable natural gas can have an extremely low CI value when produced using dairy farm manure. The Clean Fuels Program reports one California dairy biogas supplier's product has a CI of -272.92. Renewable natural gas sourced from landfills ranges widely in its CI values, from a low end of 17.41, in range of the lowest alternative fuels, to 86.88, higher than any ethanol or alternative diesel. Renewable natural gas to be generated at Portland's wastewater treatment plant starting in Q4 2020 will be the first facility in Oregon to create renewable natural gas and inject it into the conventional natural gas pipeline. The Portland plant's RNG is expected to have a CI value between 20 and 30.

Experts say Oregon has a scant 500 natural gas vehicles and, as of October 2020, Multnomah County had 163 registered natural gas vehicles: 121 busses, 24 passenger vehicles, 16 trucks, and two motorcycles. Although in California natural gas vehicles have attained a larger market share (scaled to population, California has four times more natural gas vehicles), experts believe natural gas in Oregon is unlikely to ever gain a substantial market share because of the "astronomically expensive" infrastructure costs: the vehicles, tanks, and pumps required to distribute and use it. One exception may be vehicles in municipal or regional government fleets, which could take advantage of the renewable natural gas to be produced by Portland's wastewater treatment project and the reduced infrastructure costs allowed by a return-to-base fleet that can reliably fuel up at the same location.

Among the small number of Oregon vehicles currently powered by natural gas, renewable natural gas has already attained predominance. In 2019, renewable natural gas accounted for 61% of all natural gas used in transportation, the highest market share in its fuel category of any alternative fuel. Experts noted that most if not all waste haulers in Portland are already buying renewable natural gas, including Waste Management, Republic, and Heiberg as well as Kroger's delivery vehicles, although this report did not independently verify this information.

The advanced state of the transition from conventional to renewable natural gas in the transportation sector in Oregon has likely been aided by the ability to make the conversion using a paper transaction, similar to purchasing "green power" from an electric utility. These paper transactions are sometimes called "book-and-claim accounting" and the renewable natural gas credits can be referred to as RNG certificates, Thermal RECs, green gas certificates, and RNG credits. Like renewable electricity, the molecules of renewable natural gas cannot be distinguished from conventional gas once the two are comingled in a pipeline. The use of certificates allows buyers to claim the environmental benefits of renewable natural gas even though the actual molecules they burn may not have been generated using renewable means.

Fuel experts expect a "tsunami" of renewable natural gas producting in the coming years, much of which is expected to be sold to utilities that are looking to offset emissions from conventional electricity and natural gas.

Important considerations:

- Any policy that expands the use of natural gas as a transportation fuel will face opposition from advocates, who strongly oppose investment in natural gas infrastructure out of concern the investment will subsidize the continued development and use of conventional natural gas. As one journalist put it, “Much of what consumers use natural gas for already has excellent electrification alternatives, making utility RNG programs more about the survival of natural gas companies than about a path to meet climate goals.”[19]
- Advocates for electrification, in particular, argue that the emissions reduction benefit of natural gas, like all fuels, is a function not only of the fuel itself but what it replaces and that natural gas may not be the only or the lowest carbon option. Some experts suggest there may be more benefit to using excess renewable natural gas (beyond what is needed for existing vehicles) in buildings to displace conventional natural gas used for space heating, water heating, or cooking.
- Renewable natural gas has lower CI values than conventional natural gas (which California rates at a CI of 80). Because RNG has the same molecular structure as conventional natural gas it has approximately the same emissions of other toxic chemicals like CO and Nox.[20]
- A 2018 report from the Oregon Department of Energy to the Oregon State Legislature estimated the potential to produce renewable natural gas in Oregon. The report estimated the State has the potential to meet 4.5% of current natural gas consumption (including not only transportation but also “stationary” uses like home heating and cooking) using anaerobic digestion, which creates renewable natural gas from municipal and animal waste streams. This market-ready technology is already employed at 49 facilities where it is used to produce biogas, a first-stage product that, with further cleaning, results in renewable natural gas. Although as of 2018, none of the 49 biogas facilities were producing renewable natural gas. The report found that a second technology, thermal gasification, which produces renewable natural gas from forest and agricultural waste products, could meet up to 17.5% of current natural gas consumption. This pathway is still in development and is not currently employed at commercial scale in the U.S.[21]

*Policy opportunity: Mandate low-CI renewable natural gas*

There are no compelling reasons *not* to require all of Portland’s transportation sector natural gas to come from renewable sources. Experts suggest there is an adequate supply of renewable natural gas in the U.S. market to meet all of Oregon’s current transportation natural gas needs. While displacing the small proportion of conventional natural gas in use for transportation seems

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[19] Sarah Golden. July 19, 2019. “Let’s talk about Renewable Energy Certificates for . . . natural gas.” *GreenBiz*. https://www.greenbiz.com/article/lets-talk-about-renewable-energy-certificates-natural-gas
[20] Oregon Department of Energy. 2018. *Biogas and Renewable Natural Gas Inventory SB 334 (2017) 2018 Report to the Oregon Legislature*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2018-RNG-Inventory-Report.pdf
[21] *Ibid.*

unlikely to stir much opposition from natural gas suppliers, the emissions reduction potential from this policy would also be minimal. One positive co-benefit of this policy would be to add certainty, for renewable natural gas producers, of a continued market for their product. All alternative biogas producers noted they are only able to obtain financing for new production facilities when they can document demand for the product, either through regulatory requirements or through off-take agreements.

**Renewable propane**

Propane is one of the least-used transportation fuels in Portland at 0.08% of all fuels. Nearly all vehicles in Multnomah County that run on propane are school busses – they account for 93% of propane vehicles in fleets of 20 vehicles or more.

Renewable propane is a byproduct of the production of renewable diesel and has already attained a strong foothold in Portland, making up 22% of all propane used in 2019. The market share of renewable propane, within its fuel category, is second only to renewable natural gas and twice the market share of ethanol (10%).

Renewable propane has air quality benefits, when compared to conventional propane, which will be of particular importance when it displaces conventional propane used in school busses. Experts did not indicate supply issues at present, and because renewable propane is a co-product of renewable diesel, as production of the latter ramps up, so will the former. When there is no demand for renewable propane as a stand-alone fuel it is returned to the refining process. When there is a market for it, renewable propane is transported by truck to the end user, just like conventional propane.

*Policy opportunity: Increase use of renewable propane*

Similar to the opportunity in renewable natural gas, experts suggested no compelling reasons *not* to require all of Portland's propane to come from renewable sources. This could be accomplished through either a volumetric mandate or a CI standard.

**Renewable hydrogen**

Renewable hydrogen is a gaseous fuel with remarkably high infrastructure costs. A hydrogen-powered passenger vehicle currently costs approximately $1 million and, according to experts, there are no hydrogen passenger vehicles currently on the market. The fueling and service infrastructure for hydrogen vehicles is also novel, limited in supply, and expensive, in large part due to the requirements of a fuel of this nature. For example, hydrogen must be stored at 10,000 pounds, requiring specialized tanks that must be replaced every year.

Hydrogen has some benefits compared to existing alternative fuels: it has no tailpipe emissions at all, it has a faster refueling time than today's EVs, and vehicles have a long range. Hydrodgen vehicles are essentially EVs (they have an electric drive train).

Due it these limitations, no experts believe hydrogen will be a market-ready fuel before 2030, and then only for heavy-duty vehicles and perhaps return-to-base fleets.

SECTION 3: RESEARCH ACTIVITES AND SOURCES

This section describes the research activities undertaken and sources consulted in developing this report.

### Expert interviews

A total of 15 telephone interviews were conducted with experts in government and the private sector. Interviews ranged from 30 minutes to more than two hours and covered each of the seven renewable fuels as well as policy and equity implications for volumetric and carbon intensity fuel standards.

Eight interviews were completed with fuel policy experts in City, State, and Federal government and seven interviews were completed with experts at companies producing conventional and/or alternative fuels as well as fuel distributors.

### Literature review

The following sources were consulted during the literature review. The fuel data workbook that accompanies this report references the sources using their source number and reference code.

| Source number | Reference code | Citation |
|---|---|---|
| 1 | CFF 2020 | Oregon Office of Economic Analysis. *2020 Clean Fuels Forecast*. https://www.oregon.gov/deq/aq/Documents/CFP-Forecast2020.pdf |
| 2 | CFF 2019 | Oregon Office of Economic Analysis. *2019 Fuel Supply Forecast*. https://www.oregon.gov/deq/aq/Documents/CFP-Forecast2019.pdf |
| 3 | ODEQ 2018 | Oregon Department of Environmental Quality. *2018 Fuel Supply Forecast*. https://www.oregon.gov/deq/aq/Documents/CFP-Forecast2018.pdf |
| 4 | ICF 2018 | ICF. *Memorandum re: Task 1: 2017 Forecast*. Oregon Department of Environmental Quality. https://www.oregon.gov/deq/aq/Documents/CFP-Forecast2017.pdf |
| 5 | EIA 2019 | U.S. Energy Information Administration. *State Energy Consumption Estimates: 1960-2017*. June 2019. DOE/EIA-0214(2017). https://www.eia.gov/state/seds/sep_use/notes/use_print.pdf |
| 6 | DOE Alt Fuels Data | U.S. Department of Energy Alternative Fuels Data Center. *Oregon Transportation Data for Alternative Fuels and Vehicles*. https://afdc.energy.gov/states/or |
| 7 | ODEQ 2019 | Oregon Department of Environmental Quality. *Electric Vehicles in Oregon – End of December 2019*. https://www.oregon.gov/deq/FilterDocs/CFP-electicvehicles.pdf |
| 8 | ODOE 2018 | Oregon Department of Energy. *2018 Biennial Energy Report*. https://www.oregon.gov/energy/Data-and-Reports/Pages/Biennial-Energy-Report.aspx |

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| 9 | RFA 2019 | Renewable Fuels Association. 2019. *2019 Ethanol Industry Outlook*. https://ethanolrfa.org/wp-content/uploads/2019/02/RFA2019Outlook.pdf |
| 10 | RFA 2020 | Renewable Fuels Association. 2020. *2020 Ethanol Industry Outlook*. https://ethanolrfa.org/wp-content/uploads/2020/02/2020-Outlook-Final-for-Website.pdf |
| 11 | EIA 2020 | U.S. Energy Information Administration. March 2020. Monthly Biodiesel Production Report, with data for January 2020. https://www.eia.gov/biofuels/biodiesel/production/biodiesel.pdf |
| 12 | SEQ 2019 | SeQuential Biofuels. November 5, 2019. Press release. https://choosesq.com/press/sequential-finalizes-plant-expansion-increases-biodiesel-production-up-to-12-million-gallons-annually/ |
| 13 | EIA Fuel Stocks DB | U.S. Energy Information Administration. Fuel Stocks by Type database. https://www.eia.gov/dnav/peT/pet_stoc_typ_c_r50_EPOORD_mbbl_a.htm (to download data: select monthly, click on year range) |
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| 15 | Neste website | Neste. https://www.neste.us/about-neste/who-we-are/production |
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