Asphalt Plant - Renewable Diesel and Biofuels

Asphalt concrete pavement (ACP), as with all highway construction material production, requires a considerable amount of energy to produce. The asphalt binder needs to be heated to reduce viscosity and adequately bind to aggregate. And the particles making up the aggregate also need to be heated to dry out moisture. This info sheet focuses on the fuel used at production plants in Oregon to make ACP and discusses opportunities for alternative fuels that could lower greenhouse gas (GHG) emissions.

Best Practice

The alternative practices discussed below support mobile asphalt plants to make the switch from recycled fuel oil (RFO) to renewable diesel or renewable propane, and support fixed plants in making the switch from natural gas to renewable natural gas and/or renewable hydrogen. Depending on plant operations and current fuel and energy use, the following fuels may represent GHG emission reductions.

Renewable Diesel (or Biodiesel) for Portable Plants to Replace RFO

Renewable diesel is considered a drop-in fuel, meaning it can replace fossil fuels with virtually no capital upgrades and operational change for engine use. Renewable diesel is the preferred fossil diesel substitute that can be used at higher blend rates (99% renewable) without additional maintenance or warranty issues that some experience with biodiesel. That said, these fuels will likely require initial testing in diesel equipment used in asphalt production to fully evaluate operational viability. Renewable diesel can also operate at the same cold temperatures as petroleum diesel, without the gelling problems experienced with biodiesel. Substitution of lower-lifecycle climate impact fuels (specifically renewable diesel and biodiesel products) for fossil diesel or RFO, represents a significant opportunity to reduce the climate impact of diesel equipment without negatively impacting operations or the quality of services provided.

Renewable diesel and biodiesel reduce tailpipe GHG emissions by using plant-based feedstocks to produce the fuel instead of fossil petroleum. The carbon contained in these materials is part of the living carbon cycle and therefore has a much lower climate impact than fuels produced with fossil carbon that has been stored in the earth for millions of years. Further, if it is made from waste oils (such as used cooking oils), the production GHG emissions are further reduced.

Switching fuel is likely to only require the cleaning of equipment, replacement of burner tips and modification of flow controls to get the heat rate to perform according to the need. Note any fuel switch may require these updates. Even with these minor upgrades, using biodiesel or renewable diesel is a commercially viable way to reduce GHG emissions.

Renewable Propane for Portable Plants and Fixed Plants

Renewable propane offers a drop-in fuel solution for fossil-fuel propane and is a byproduct of renewable diesel production. Like renewable diesel, renewable propane can be produced with a variety of feedstock materials (used cooking oil and/or animal fats). Renewable propane can substitute 100% of fossil propane where and when there is adequate supply.

Renewable Natural Gas for Fixed Plants

Renewable natural gas (RNG) is produced during the decomposition of organic waste materials in landfills, wastewater treatment plants, and dairy operations. It is similar to typical fossil-fuel based natural gas and can be used as a drop-in fuel replacement. Acquiring a supply of RNG requires that a facility is located near a source of RNG. Alternatively, Oregon natural gas utilities, specifically Northwest Natural Gas (NWN), is planning to offer a 4% RNG retail product beginning in 2022. Subject matter experts anticipate RNG will ultimately replace 15-20% of total natural gas sold in Oregon, if every source is captured and injected to the existing natural gas pipeline.

Renewable Hydrogen for Fixed Plants

Hydrogen is an excellent heat-producing fuel that produces only water as the byproduct of combustion. Hydrogen is the original fuel for gas lamp districts and was later replaced with methane – "natural gas." Hydrogen can be made in low-carbon ways by using electrolysis of water to separate hydrogen atoms from oxygen atoms. This process can be powered by renewable electricity - "green hydrogen" - and could be developed to scale to meet all the thermal needs of industry. However, progress for the infrastructure for hydrogen production is in early stages. While the technology exists and performs as needed, a massive scaling of technology is required to deliver the fuel needed for the current load of natural gas.

In the future, hydrogen could be produced at an end-user facility where electricity and water connections allow the local plant to produce its own fuel onsite for immediate use. Or, more likely in the near term, production of hydrogen would occur at a standalone facility and injected into a natural gas pipeline. When injected into a pipeline, hydrogen is generally thought to be usable up to 15% in traditional natural gas systems. At some point, the entire gas delivery system will need to be upgraded for hydrogen to completely replace natural gas. Further, operating plants will need to replace their burners and commission their systems to deliver the right amount of heat.

Real World Examples

- Malarkey Roofing Company uses bio-digester gas from Portland Bureau of Environmental Services Columbia Boulevard wastewater treatment plant.[1] The private business is able to utilize up to 25% of the biogas fuel produced at the wastewater facility, which powers a historical average of 67% of the roofing manufacturing facility.

Other/Complimentary Alternatives

- Participation in EnergyStar for Industry Challenge to reduce total fuel needs. (See "Stockpile Moisture Management & Other Plant Energy Efficiency Measures" Info Sheet.)
- Onsite moisture management or other actions to increase energy efficiency. (See "Stockpile Moisture Management & Other Plant Energy Efficiency Measures" Info Sheet.)
- Renewable hydrogen produced with 100% renewable electricity. Use of this fuel may well become best practice in the mid- to long-term (5-15 years) for industrial combustion needs, but does not offer an immediate, commercially available solution like the other renewable fuels and renewable electricity, without developing onsite hydrogen production to serve onsite consumption.

[1] For details visit https://www.portlandoregon.gov/bes/article/500421

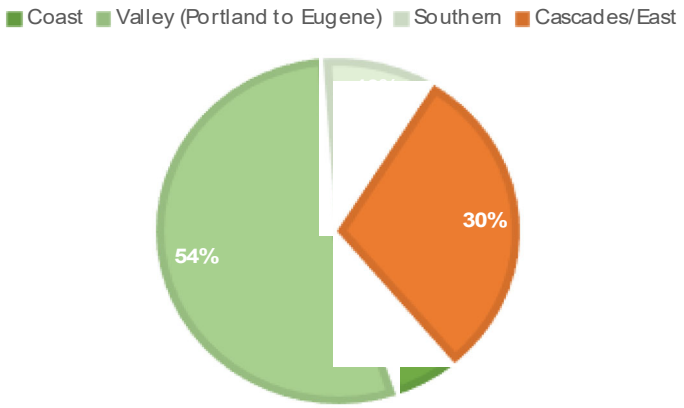
Current Conditions & GHG Inventory Results

Current Conditions

ODOT purchases between 1 million and 1.9 million short tons of asphalt concrete pavement (ACP) annually for use in construction and maintenance projects. Between Fiscal Years (FY) 2016 – 2019 construction projects used an average of 900,000 short tons annually, while maintenance used an average of 400,000 short tons. ODOT reports using between 20 – 30% reclaimed asphalt pavement (RAP) in all mixes.

Within Oregon, total ACP tonnage produced is estimated at an average of 3.4 million tons annually (2018 – 2020). The majority (85 – 90%) is produced at stationary plants fueled by natural gas, while the remainder (10 – 15%) is produced at portable plants fueled by RFO. Production by portable plants is highly variable between years, as is use of ACP by regions in Oregon. A rough breakdown of use by region is shown in Figure 1, to the right.

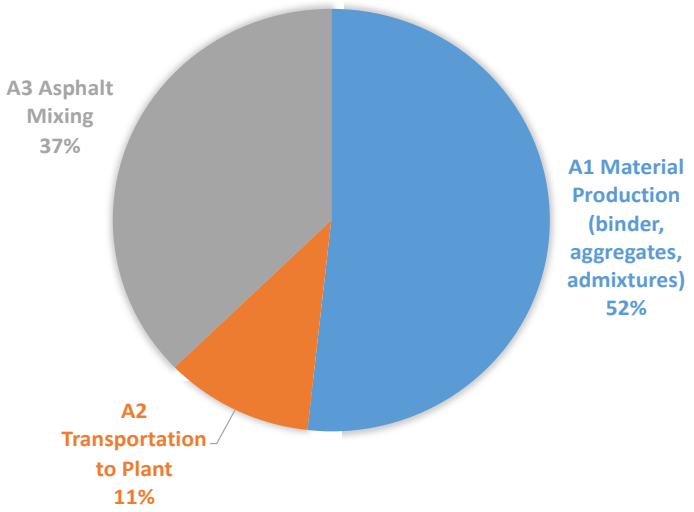
Figure 1 - ACP Use by Region



GHG Inventory Results

Estimated GHG emissions from the production of asphalt pavement used in ODOT projects ranged between 54,000 and 72,000 MT CO_2e annually during FY 2016 – 2019. The four-year average was 65,000 MT CO2e. This estimate is more accurate than other states due to Oregon vendors currently leading the nation in public environmental product declarations (EPDs) for ACPs. Computing averages of available EPDs results in an average emission factor of 47.5 kg CO_2e/short ton (with a range of 43.6 – 51.4). Available EPDs provide emissions intensities for three "upstream" stages of production, presented in Figure 2. Asphalt *mixing* plant emissions are predominately from fuel combustion for heating, which represent 37% of the total production GHGs, or between 20,000 – 26,000 MT CO2e for ODOT projects.

Figure 2 - Emissions from Stages of ACP Production



Practice Alternative(s): Market Study

Availability and Access

Renewable Diesel

The near-term barrier to increasing renewable diesel use is limited production capacity domestically and therefore limited supply volumes. It is understood that additional supply of renewable diesel will be available in the market over time, but it will likely take another two to five years to see additional supply come to fruition. A second related challenge is that renewable diesel is not consistently available throughout Oregon and, specifically, is not available at card lock fuel stations. Many card lock stations are franchised but individually owned and will likely need to install new tanks to regularly provide other fuels like renewable diesel.

To improve distribution, a minimum annual purchase volume (100,000 gallons annually) is typically required to support card lock operators investing in the addition capital infrastructure. Supplying this fuel via card locks would allow for greater access to smaller jurisdictions and other small-scale private business uses. During project interviews, representatives from smaller jurisdictions noted it would be helpful and appreciated if the State of Oregon would lead the charge to supply renewable diesel throughout the state.[2] This could happen through a new price agreement or through the Greater Oregon Fleet Cooperative. Distributing renewable diesel at retail stations is not without precedent:

- California's Propel Fuels operates 32 public fueling stations that offer renewable diesel at a competitive price to conventional diesel.
- VP Racing Fuels recently began selling renewable diesel in Bend, Oregon.[3]

Renewable Propane

Blue Star Gas reached out to ODOT during this project informing the agency they have renewable propane available for use. Their supply comes from Renewable Energy Group (REG) in Louisiana and is transported via rail to Blue Star Gas terminals in Oregon and California. Blue Star Gas reports no minimum purchase amount required to provide renewable propane as a transportation fuel. Blue Star's renewable propane is currently available at locations in western Oregon and the supplier is open to discussing eastern Oregon locations as needed. As of this writing, it is unclear if renewable propane supply is available to serve stationary needs, or only the transportation market.

Renewable Natural Gas

Available supply of RNG has typically gone toward the mobile fuel market to capture the significant financial incentives available as part of Oregon's Clean Fuels Program and California's Low-Carbon Fuel Standard. However, as part of interviews conducted for this project, NWN shared that as early as 2022 they anticipate offering a 4% renewable natural gas product option for stationary applications. Dairies, landfills, or wastewater treatment facilities represent existing RNG production options that provide other contract options for RNG in the marketplace, provided facilities are co-located with these sources.

[2] For details visit https://greateroregonfleetcooperative.org

[3] https://www.bendbulletin.com/business/renewable-disel-pump-added-at-the-quickway-market-in-bend/article_122eacae-2dee-11ec-93a2-878ea9cab6f9.html

Renewable Hydrogen

A few producers are organizing to make hydrogen available for public sale. Douglas County Public Utility District in Washington State is the farthest along toward that goal. Eugene Water and Electric Board (EWEB) has also expressed interest in making renewable hydrogen from their hydroelectric dams. At this time, no renewable hydrogen is available from local sources in the Pacific Northwest, but supply is anticipated to be available within five to fifteen years.

Renewable Electricity

Oregon investor-owned utilities, Portland General Electric and Pacific Power, offer a variety of renewable electricity programs for their customers. Some of these programs offer anytime enrollment and no contracts, while others – like community solar programs – have limited, open enrollment periods and require minimum contract periods. Third-party brokers also offer RECs from renewable electricity typically generated from more distant, often out-of-state projects.

Costs

During industry interviews conducted for this project, costs referenced included the following:

Renewable Diesel

- The fuel itself is cost neutral for locations near Portland and the Willamette Valley (utilizing Oregon Clean Fuel Program credits). Additional distribution charges apply east of the Cascades. At present, distribution charges range from $0.20 per gallon (truck and trailer delivery) to $0.39 per gallon (tank wagon delivery). These charges are anticipated to decline as the renewable diesel distribution system expands in 2022 or as the fuel becomes the default diesel used in Oregon.
- Additional fuel tanks ($10 - $15k per 1,000 gallon tank)
- Replacement burner tip ($1k per replacement)

Renewable Propane

- Pricing is reported to be close to the cost of traditional propane (utilizing Oregon Clean Fuel Program credits). Prices reported at the time of this report are $1.90 per gallon equivalent.[4] Renewable propane pricing is reported as volume-dependent; to provide an accurate price quote, a better understanding of annual fuel use is required. At this time, it is unclear how per gallon prices may change for use in portable asphalt plants and whether that fuel use falls under the Clean Fuels Program. Without the CFP credit, market prices for propane (as of January 2021) are $2.85 per gallon.

Renewable Natural Gas

- Renewable natural gas is not yet readily available in the stationary fuels market-place and therefore pricing information is not publicly available. Fossil natural gas prices (as of January 2021) are $2.19 per gallon of diesel equivalent.[5]

[4] Price provided by an Oregon fuel supplier with available supply of renewable diesel.
[5] Clean Cities Alternative Fuel Report (Jan 2021). Online at https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_january_2021.pdf

Renewable Electricity

- Renewable electricity price premiums vary with utility and program option and range between a $0.001 and $0.008 cents per kilo-watt hour (kWh) over average grid electricity.

Making the Transition

- The largest GHG reduction opportunity related to mobile ACP plant fuel switching, as determined by this project's advisory group, is use of biodiesel or renewable diesel as a substitute for RFO. RFO represents the most carbon-intense fuel currently in use by Oregon asphalt producers.
- Higher biodiesel blends are an option, but there are concerns about cold weather use.
- Stationary asphalt plants in Oregon operate using natural gas. Infrastructure investments have already been made and will be difficult to leave stranded. Plants using natural gas should focus on energy efficiency and reevaluate renewable fuel supply options as RNG and renewable hydrogen become available in the Oregon marketplace. These plants should also consider buying verified carbon offsets to reduce the emissions from the fuel until that supply becomes available.

Practice Alternative(s): Mitigation & Cost Scaling

Life Cycle Considerations

GHG pollution from tailpipes is often the focus when considering climate impacts from fuel combustion. However, there are also GHG emissions from the production of fuels (i.e., embodied carbon). Biofuels offer significant GHG reductions at the tailpipe, but commonly have greater impacts than fossil fuels during production. This is because the most common feedstock for biofuels are agricultural crops, such as soybeans in renewable diesel. Ideally, biofuels are produced to the largest extent possible with "waste" materials such as used cooking oil or tallow. Use of waste material feedstock for renewable diesel offers some of the lowest impact fuels available on the market. Unfortunately, waste materials are not available in the quantities required to produce the volumes of diesel fuels currently consumed, which is why crop feedstocks are used for production.

GHG Impacts

Figure 3 - Tailpipe GHG Emissions

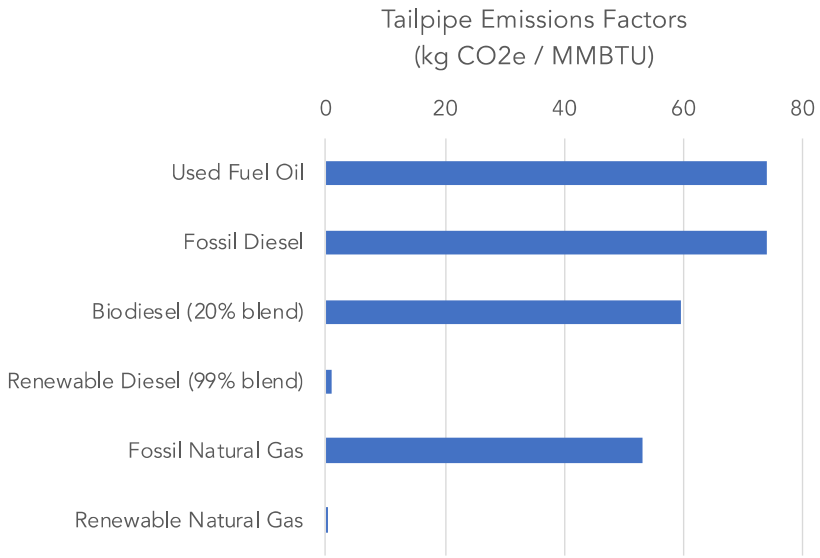


Figure 3, to the right, compares tailpipe GHG emissions (kg CO_2e / MMBTU) for natural gas, RFO, biodiesel (20% blend) and renewable diesel (99% blend).[6] RFO is the most GHG intense fuel of the group per unit of heat. If Oregon ACP producers were to replace 100% of fossil fuel use with 100% renewable fuels, reductions are estimated between 20,000 – 26,000 MT CO_2e per year. The range represents unknowns related to the precise types of fuels being used (natural gas vs. RFO) and the annual fluctuation inherent with ODOT's procurement of ACP (i.e., increased program funding means more ACP is used). If portable ACP producers were to switch from RFO to biodiesel (B20 blend), emissions would be reduced by 1,000 MT CO_2e annually. If these producers were to switch to a 100% biodiesel or renewable diesel product, emissions reductions are estimated to be about 5,000 MT CO_2e per year.

Cost Impacts

The following table summarizes fuel costs, estimated GHG reductions, and provides cost impacts per unit of GHG reductions, using a marginal cost difference[7] between RFO and various biofuel blends. Note the costs per gallon are assumed to be at market prices and do not receive the Clean Fuels Program financial incentives for use of biofuels. Recycled fuel oil prices are not readily available; therefore, residual fuel oil is used as a proxy to represent low value petroleum products for illustration purposes. Cost impacts below focus on a substitution of bio or renewable diesel for RFO. Prices for renewable natural gas for stationary uses is currently unavailable and therefore that substitution is not included.

Note: Prices do not include Clean Fuel Program credits, and, without such a financial incentive, renewable fuel substitution for plant operators will be expensive. Table 1, on the next page, shows market prices for biofuel (without CFP credits) are significantly higher than low-value petroleum-based fuels in the marketplace and therefore would represent high cost mitigation for asphalt plant operators compared to their current operations and fuel use.

[6] Values on the graphic are from EPA Greenhouse Gas Emissions Factors for Greenhouse Gas Inventories (April 2021). Biogenic CO_2 from renewable fuels excluded from reporting.

[7] The marginal cost difference is equal to alternative fuel ($ / gallon) – baseline RFO ($ / gallon) = additional cost required to procure alternative fuel and realize GHG reductions. In other words it is the additional cost required to purchase alternative fuels beyond what is currently paid for RFO.

Table 1

Fuel Type	U.S. Average Cost per Gallon or Equivalent (prices as of Jan 2021)	Cost per Million BTU ($ / MMBTU)	Cost Increase vs RFO per Million BTU	GHG Reduced vs RFO (kg CO2e / MMBTU)	Cost per MT CO2e Reduced ($ / MT)
Residual Fuel Oil (#5/6)	$1.40	$9.65	N/A (Baseline)	N/A (Baseline)	N/A (Baseline)
Biodiesel (20% blend)	$2.47	$17.25	$7.60	-14.7	$520
Biodiesel (100% blend)	$3.49	$26.56	$16.91	-73.4	$230
Renewable Diesel (R100)	$3.20	$24.61	$14.96	-73.4	$200

Residual Fuel Oil Price: https://www.eia.gov/dnav/pet/pet_pri_refoth_a_EPPR_PWG_dpgal_a.htm
Biofuels Prices: Clean Cities Alternative Fuel Price Report (Jan 2021).
https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_january_2021.pdf

Recommendations

- Partner with industry and Oregon Department of Environmental Quality to develop an incentive program tailored to the asphalt pavement production industry that fairly incentivizes fuels that result in fewer GHG emissions.
- Partner with trade associations to better understand (e.g., survey) which plants use fossil fuels and who might consider switching to renewable fuels.
- Create a working group of plant operators and fuel providers to discuss transitioning fuels on a managed schedule and procurement of carbon offsets. Develop a pilot program as appropriate.
- Consider incorporating the increased cost of renewable fuels into ODOT contracts to support fuel switching.
- Substitute RNG and or renewable hydrogen for fossil natural gas, as it becomes available. (NWN anticipates a product offering as early as 2022.)