

Lifecycle Analysis Approach of Transportation Fuels

In 2009, the Oregon Legislature authorized the Environmental Quality Commission to develop low carbon fuel standards for Oregon. The goal is to reduce the average **carbon intensity** of Oregon's transportation fuels by ten percent over a ten-year period based on a lifecycle assessment. This factsheet describes how to calculate carbon intensity using a lifecycle analysis approach.

Measurement of carbon intensity

Carbon intensity is expressed in grams of greenhouse gases (measured in carbon dioxide equivalent) emitted per million joules of energy produced. The mathematical equation looks like this: g CO₂e/MJ. Gallons of liquid fuels, cubic feet of gaseous fuels, and watts of electricity must be converted to a common measure of energy. This conversion allows for equal comparison between all types of fuels.

Calculating carbon intensity

Carbon intensity encompasses emissions from the extraction or growth, refinement, distribution, storage, and combustion of a fuel. The sum of each step in a fuel's lifecycle produces an overall lifecycle value. The carbon intensity of an individual fuel can also be adjusted to account for:

- production of co-products,
- indirect effects such as land use change, and
- efficiency of alternative fuel vehicles.

A more detailed description of this calculation can be found in the [final report](#).

Fuel made from petroleum

The lifecycle of petroleum-based fuels begins at the point of extraction from a well and ends when the fuel is burned. Since petroleum-based gasoline and diesel fuels are used the most, DEQ calculated the statewide average carbon intensity based on the known source of crudes, conventional and oil sands extraction and refining technology, and typical paths that fuels take to get to Oregon.

Fuel made from petroleum waste

For fuel made from waste products like plastics, the lifecycle analysis begins when the use of the product for its original intent ends. This means that the emissions from producing the original product do not count as part of the lifecycle of the fuel. The lifecycle begins with the collection of the waste that becomes the feedstock for the fuel and again ends when that fuel is burned in a vehicle.

Fuel made from biomass

Biomass is a fancy name for plants and other types of cellulosic and organic material. As biomass grows, it removes carbon dioxide from the atmosphere during

photosynthesis. When biomass-based fuel is combusted, carbon dioxide is returned to the atmosphere. This results in a net zero balance of carbon dioxide emissions. However the intensity value is still not zero for this fuel because other greenhouse gases are also emitted during combustion.

Fuel made from biomass waste

For fuel made from biomass waste like cooking oil, wheat, grass straw or corn stover, the lifecycle analysis begins at the collection of the waste from the field. As with all fuel from biomass, the carbon dioxide emissions from the combustion of a biomass waste fuel is also a net zero.

Co-Products

Production of some biofuels can produce co-products that have other benefits. For example, refining ethanol produces distiller's grains and solubles that can replace animal feed while biodiesel refining produces glycerin for use in industrial applications. A credit is included when calculating carbon intensity to represent emissions that are being displaced.

Land use change

Growing a feedstock to produce more biofuels might cause unproductive land to be converted into cropland. In the conversion process, carbon dioxide is released that may have remained otherwise sequestered in the soil or vegetation. The current science presents a great deal of variation and uncertainty in quantifying this effect. At this time, DEQ is proposing to not adjust the carbon intensity for land use change, but intends to do so once the science becomes more certain. A review of this issue is included in future program reviews.

Other indirect effects

Other indirect effects may also occur when producing and utilizing fuels. For example, greenhouse gases are released during the clean-up of oil spills. The current science on these issues is very immature and at this time, DEQ is proposing to not adjust the carbon intensity to account for other indirect effects. A review of this issue is included in future program reviews.

Efficiency of alternative fuel vehicles

DEQ uses an "energy economy ratio" to establish the relative greenhouse gas contribution of various vehicles. DEQ has calculated values through 2022 to reflect existing federal standards for fuel economy. In the future, these standards are likely to change as the technology of alternative fuel vehicles improves. What won't likely change is that most alternative types of vehicles will continue to utilize fuel far more efficiently than vehicles with conventional gas and diesel combustion engines DEQ will continue to review this ratio to ensure that it remains accurate in future program reviews.



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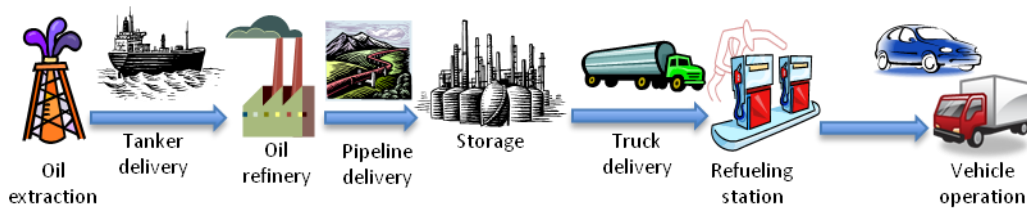
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Table of selected carbon intensity values

DEQ has calculated the carbon intensity of several of Oregon’s fuels. This table is a portion of those calculations:

Gasoline and Gasoline Substitutes	Carbon Intensity Value (gCO ₂ e/MJ)	Diesel and Diesel Substitutes	Carbon Intensity Value (gCO ₂ e/MJ)
Gasoline	92.34	Ultra low sulfur diesel	91.53
Ethanol - Midwest production and corn	64.82	Biodiesel - Midwest production and soybeans	21.66
Ethanol - Northwest production and Midwest Corn	53.79	Biodiesel - Northwest production and Midwest soybeans	19.99
Sugarcane Ethanol	26.44	Biodiesel - Northwest Canola	27.31
Cellulosic Ethanol - Farmed Trees	15.54	Biodiesel - Yellow Grease	10.28
Cellulosic Ethanol - Wheat Straw	20.90	Biodiesel - Tallow Average	16.85
Pipeline natural gas in Oregon	70.22	Pipeline natural gas in Oregon	74.70
Electricity average - 2012	37.80	Electricity average - 2012	57.40

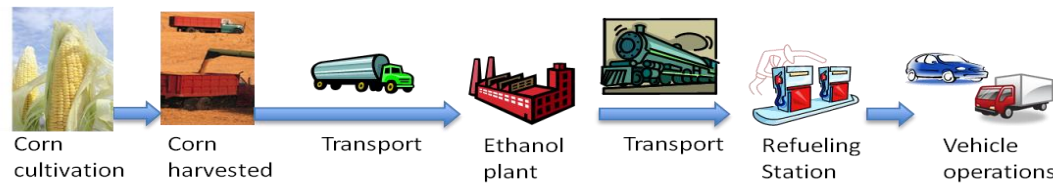
Example: Petroleum lifecycle analysis



For petroleum, the following are some of the elements included in the model:

- Oil extraction, flaring and venting rates of natural gas;
- Transportation including marine tankers, pipelines, and tanker trucks;
- Oil refining process;
- Terminal, storage, and dispensing operations; and
- Combustion in vehicles.

Example: Corn ethanol lifecycle analysis



For corn ethanol, the following are some of the elements included in the model:

- Farming practices including fertilization, equipment used;
- Crop yield;
- Transported using a variety of modes including rail cars and tanker trucks;
- Fuel production process, including the type of fuel used;
- Production of co-products;
- Terminal, storage, and dispensing operations; and
- Combustion in vehicles.

Model used for Life Cycle Analysis: GREET Model (Greenhouse gases, Regulated Emissions, and Energy use in Transportation model)

GREET is a computer model developed and maintained by the Argonne National Laboratory. DEQ modified GREET to reflect Oregon conditions. If GREET is unable to generate an accurate carbon intensity (as in the case of a fuel made from an industrial waste), then a DEQ-approved method can be used.

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