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Diamond Green Diesel, LLC
Diamond Green Diesel – Port Arthur
CARB LCFS Fuel Pathway Report



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Date: November 15, 2023

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Executive summary

This report outlines the life cycle analysis (LCA) and carbon intensity (CI) calculations pertaining to renewable fuel produced by Diamond Green Diesel LLC (DGD)'s newly constructed renewable diesel production plant in Port Arthur, Texas, for the consideration of provisional fuel pathways under the California Low Carbon Fuel Standard and granted by the California Air Resources Board.

Diamond Green Diesel LLC is a joint venture between subsidiaries of Valero Energy Corporation and Darling Ingredients Inc. and is the largest renewable diesel producer in North America. The DGD-Port Arthur plant (DGD-PA) began operations in late 2022, adding to DGD's existing operations in Norco, Louisiana. DGD-PA has expanded DGD's production capacity by 470 million gallons of renewable diesel per year to a total of 1.2 billion gallons per year.

The sections below describe how DGD-PA sources feedstocks, the process by which feedstocks are converted into renewable fuels, how DGD-PA's fuel products are transported to California for end use, and the life cycle boundaries that apply to each of these areas. This LCA provides fuel-cycle carbon intensity (CI) values for DGD-PA's renewable diesel and renewable naphtha pathways for each of the feedstocks covered by this application. The results are shown in the following table.

Table 1: Lifecycle GHG Emissions – DGD Renewable Diesel and Renewable Naphtha from Multiple Feedstocks

Proposed Carbon Intensity, gCO ₂ e/MJ	
Feedstock	CI
Soybean Oil	58.00
Canola Oil	54.20
Corn Oil	28.60
Used Cooking Oil	20.70
Tallow	33.20

Renewable Diesel and Renewable Naphtha will receive the same carbon intensity by feedstock.

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Introduction

Diamond Green Diesel LLC (DGD) is a joint venture between subsidiaries of Valero Energy Corporation and Darling Ingredients Inc. and is the largest renewable diesel producer in North America. A newly completed renewable diesel plant near Valero's Port Arthur, Texas refinery has expanded DGD's production capacity by 470 million gallons per year to a total of 1.2 billion gallons per year. The DGD-Port Arthur plant (DGD-PA) began operations in late 2022.

The renewable diesel sold by DGD-PA is produced from sustainable low-carbon feedstocks such as used cooking oil, inedible animal fats, and vegetable oils. DGD-PA uses several processes to convert raw feedstock into drop-in renewable diesel fuel, namely:

- Feedstock pretreatment (impurities removal)
- Hydrotreating (oxygen removal and hydrogenation)
- Isomerization (fuel properties improvement)
- Fractionation (separation of hydrocarbons into fuel products)

These processes are further described in sections below. The DGD-PA plant is shown in the following figure:

Figure 1 **Diamond Green Diesel – Port Arthur Facility**



LCA Model

The Tier1 Simplified CI Calculator for Biodiesel and Renewable Diesel based on CA-GREET3.0 is used as the basis for the CI calculations presented in this report. The general model settings used are:

1. The Regional Electricity mix for the renewable diesel plant is 13-SRMV Mix.
2. The regional crude oil mix is US Average Crude
3. The regional natural gas source is US Average NG.

There are two adjustments made to the Tier 1 calculator with respect to hydrogen. The first relates to the energy content on the Fuel Specs sheet, which is reported as 290 BTU/Ft³. This is the energy density at 32F, not at 60F. This has been corrected by changing the values in cells B and C24 on the Fuel Specs sheet to the correct energy density at 60F of 274 BTU/Ft³. The second adjustment relates to the emission factor for hydrogen in the calculator, which accounts for [CBI] miles of hydrogen transportation by pipeline. Removing this additional step reduces the hydrogen emission factor to [CBI] CO₂eq/MM BTU. This change is made in cell C37 on the EF Table sheet.

At the guidance of CARB, user-defined emission factors for used cooking oil and tallow rendering have been developed in order to account for partial feedstock sourcing from Mexico. These emission factors have been incorporated into the Tier 1 calculator as appropriate. All other pathways use standard values for feedstock production emissions.

Feedstocks

DGD-PA sources and processes the following feedstocks sourced from North America into renewable diesel, which correspond to the following pathways found in CARB's Tier1 Simplified BDRD CI Calculator:

- Soybean Oil (Soy Oil)
- Canola Oil (Canola)
- Corn Oil (CornSorghum Oil)
- Used Cooking Oil (UCO1)
- Tallow and Grease Residues (Tallow1)

CI calculations for the production of soybean oil, canola oil, and corn oil are based on the standard emission factors and life-cycle analysis as provided in the LCFS Tier1 Simplified RD Calculator and CA-GREET3.0 model. Used cooking oil and tallow have user-defined rendering emission factors incorporated into the CI calculations for these pathways. Shipping distances and modes of transport from feedstock suppliers to DGD-PA are tracked for all feedstocks, and are included in the LCA.

Feedstock is transported to DGD-PA and is offloaded at a [CBI] facility owned and operated by [CBI]. This facility, called [CBI], then transfers feedstock to DGD-PA via [CBI] for processing. Feedstock mass balances are maintained around DGD-PA and [CBI] in order to accurately track feedstock consumption and transportation distances.

All feedstock is tested for moisture content when received and must meet the specification of less than [CBI] moisture content. A conservative moisture content value of 0% is used for modelling (the lower the moisture content, the higher the CI). Certificate of Analysis documents from feedstock suppliers are available.

Renewable Diesel Production

The renewable diesel production process at DGD-PA starts with a Pretreatment Unit, which removes [CBI] from [CBI] feedstock and prepares it for conversion into diesel fuel. The Pretreatment Unit treats [CBI] feedstock primarily by the use of [CBI] and a [CBI] process, which [CBI] [CBI] out of [CBI]. Waste products from the Pretreatment process are disposed offsite or treated for reuse.

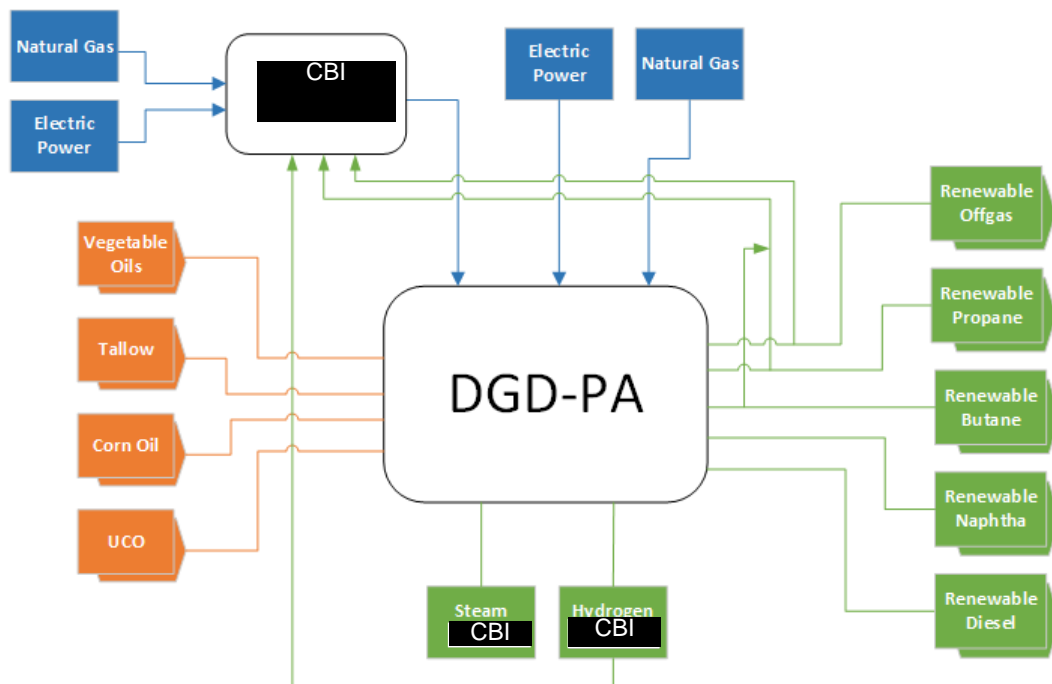
DGD-PA then uses the [CBI], which includes hydrotreating and isomerization, to convert feedstocks into renewable hydrocarbons. The hydrotreating section converts triglycerides and fatty acids present in feedstocks into paraffin hydrocarbons through the use of heat, pressure, and hydrogen in the presence of a catalyst. These resultant paraffin molecules are then structurally rearranged by isomerization to improve fuel properties of the final product.

The last step of the process involves the fractionation of renewable hydrocarbons into renewable fuel products. The primary product is renewable diesel, and renewable co-products include naphtha, butane, propane, and offgas. Fractionation occurs in the [CBI] of the [CBI], as well as in a [CBI] [CBI] and [CBI] unit called the [CBI].

Renewable propane, butane, and offgas can all be routed via [CBI] to the [CBI] plant to supplement [CBI] production. This [CBI] is then used by DGD-PA during the [CBI] process for the production of renewable diesel. [CBI] purity within the [CBI] is maintained through the use of a [CBI] stream, which sends [CBI] back to the [CBI] for recovery and purification.

Figure 2 shows the simplified process diagram for DGD.

Figure 2 Diamond Green Diesel – Port Arthur Simplified Process



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Mass Inputs and Outputs

The amount of feedstock processed by DGD-PA is automatically computed by the Tier1 calculator based on feedstock receipts and changes in feedstock inventory levels. Process chemicals are a standard value in the new model (0.03 gCO₂e/MJ).

The production of renewable diesel is determined using opening and closing inventory measurements and measurements of renewable diesel sales. Feedstock information is reported in pounds on the DGD component inventory report (mass) and RD production is reported in gallons on the DGD tank inventory report (volume).

Energy Requirements

The energy required for both the DGD-PA and [CBI] facilities, such as purchased electricity and natural gas, as well as other utilities needed by DGD-PA, are maintained under utility contracts and are tracked through monthly invoices. These energy and utility consumptions are included in the DGD-PA LCA model and use the standard emission factors presented in CA-GREET3.0, with the exception of hydrogen.

Co-Products

Co-products of the renewable diesel production process at DGD-PA include naphtha, butane, propane, and offgas. All of these streams are created from the same renewable feedstocks as is the renewable diesel. Co-products are either sold, used as [CBI] at the [CBI], and/or used in the production of [CBI] at the [CBI]. Any co-products used for [CBI] production are counted as displacement credit against natural gas consumption at DGD-PA.

Co-product production rates are individually measured, and each have calculated energy content. The energy content of each stream is determined using laboratory compositional analysis and reference heating values for each component. The sum of individual component heating values makes up the energy content of the bulk streams.

Renewable Diesel Transport

DGD-PA distributes its renewable diesel by [CBI] or by [CBI] from the plant to customers in California. For [CBI] shipments, the route taken is via the [CBI] using vessels with a DWT of [CBI] tons, which when entered into the CA-GREET3.0 model results in a user defined emission factor of [CBI] CO₂eq/gallon mile. All possible transportation routes, along with their mileages and associated carbon intensity contributions, are tracked and documented for each customer. To be conservative and allow for flexibility of transportation options for DGD's customers, the route with the highest emissions is used in the calculator.

Tailpipe Emissions

Tailpipe emissions are the same for all renewable diesel fuels. This emission category calculates the methane and nitrous oxide emissions associated with the combustion of renewable diesel in vehicles. The value in CA-GREET3.0 is 0.76 g CO₂eq/MJ.

Indirect Land Use Change

Soybean oil and canola oil both have indirect land use change factors built into the Tier 1 Calculator of 29.10 gCO₂e/MJ and 14.50 gCO₂e/MJ, respectively. These default values are used in the calculations. There are no indirect land use emissions associated with any of the remaining feedstocks.

Summary

The emissions calculated for the individual stages mentioned above are summed to determine the fuel-cycle CI. The results for DGD-PA's renewable diesel and renewable naphtha pathways are shown in the following table. Renewable diesel and renewable naphtha from the same feedstock receive the same CI.

Table 4: Lifecycle GHG Emissions – DGD Renewable Diesel

Proposed Carbon Intensity, gCO ₂ e/MJ	
Feedstock	CI
Soybean Oil	58.00
Canola Oil	54.20
Corn Oil	28.60
Used Cooking Oil	20.70
Tallow	33.20

Where:

- All of the above feedstocks are sourced [CBI] within [CBI]