California LCFS Tier 2 fuel pathway application: Renewable diesel produced from co-processed animal fat at the BP Products North America Inc Cherry Point Refinery using natural gas, steam and electricity as process energy

GREET modelling technical support document

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I. Introduction

We are seeking certification for a new Tier 2 pathway under the California Low Carbon Fuel Standard (LCFS) program. This pathway is for co-processing of animal fat, including tallow, and petroleum feedstock in the same hydrotreater. The upstream and downstream emissions are calculated using the Tier 1 BDRD Calculator [1]. Emissions from the co-processing process are calculated based on the modified co-processing calculator published by the California Air Resources Board (CARB) [2].

BP Products North America Inc plans to co-process animal fat with petroleum feedstock to produce RD at the BP Cherry Point Refinery (Cherry Point hereafter) in Blaine, Washington. Cherry Point is owned and operated by BP West Coast Products LLC, a wholly-owned subsidiary of BP Products North America Inc. Animal fat suppliers collect, render and deliver animal fat feedstock to Cherry Point [redacted]. The delivered animal fat is then co-processed and converted to RD with petroleum middle distillate in the same hydrotreater.

This pathway is identical to the default animal fat to RD pathway in the Tier 1 BDRD Calculator except for the points of deviation summarized below:

1) Electricity mix for fuel production is specific to Region 4 - NWPP Mix
2) Feedstock is collected and rendered, then transported [redacted] to Cherry Point. The feedstock is converted at Cherry Point via co-processing in a hydrotreater. The fuel is transported to California for further distribution and consumption
3) Process mass and energy balance
4) Emissions from co-processing process are calculated based on a modified version of the co-processing calculator published by CARB

Based on our modeling, we find that the RD produced with this pathway has a carbon intensity of **27.65 $gCO_2e\ MJ^{-1}$.**

II. Cherry Point Refinery Details

Cherry Point is located at 4519 Grandview Rd, Blaine, WA 98230. This pathway addresses co-processing animal fat in [redacted] diesel hydrodesulfurization (DHDS) reactor. [redacted] DHDS started co-processing in [redacted].

[redacted] DHDS has a design name plate capacity of [redacted] MBD (thousand barrels per day) processing straight run diesel from the crude unit (a combination of VDF [Vacuum Distillate Fractionator] Diesel off the VDF and Straight Run (SR) Diesel off the Crude Tower) and Coker feedstock (Light Coker Gas Oil - LCGO). It can also process Coker Stove Oil (CSO) when [redacted] DHDS unit is down. The nameplate capacity is [redacted] gallons/year for renewable diesel from animal fat produced in [redacted] DHDS.

[redacted] DHDS does not have a H_2 makeup compressor and the makeup gas is supplied directly from the Refinery [redacted]# H_2 system from the [redacted] hydrogen plant. The [redacted] DHDS unit has a single stage - two cylinder recycle compressor. A high-level block flow diagram of the unit process flow is shown below in Figure 1. Figure 2 is the process flow diagram.

Figure 1. Process Flow Diagram

Under US EPA's RFS program, the facility is capable of producing RD under a D code of 5 utilizing waste oils/fats/grease (160).

[redacted], met with the following BP representatives while on-site on [redacted]:

- [redacted] – Feedstock Negotiator & Logistics Specialist
- [redacted] – Operations Coordinator
- [redacted] – Senior Project Manager (Construction)
- [redacted] – Refinery Distillate Planner
- [redacted] – Dock Supervisor
- [redacted] – Operations Specialist (Utilities)

The on-site visit included the following activities:

- Review of plant process information
- Review of the process flow diagram
- Tour of the renewable fuel production, product storage, and product loadout facilities

III. Changes to the Co-processing Calculator inputs for Cherry Point Refinery

Changes made to the co-processing calculator in the "User Input Values" tab are shown in Table 1. "Total Fuel CI" is calculated using the co-processing calculator published by CARB. Other CI calculation results can be found in the "Tier 1 BDRD Calculator".

Table 1. Changes made to the co-processing calculator for the proposed pathway

	Cell Location	**Baseline (100% petroleum)**	**Co-processing**
Feed input			
Middle Distillate (kg/day)	User Input Values! C7, D7	[redacted]	[redacted]
Biogenic feedstock (kg/day)	User Input Values! C8, D8	[redacted]	[redacted]
Hydrogen (kg/day)	User Input Values! C9, D9	[redacted]	[redacted]
		[redacted]	[redacted]
Process energy input		[redacted]	[redacted]
Electricity (kWh/day)	User Input Values! C9, D12	[redacted]	[redacted]
Fuel Gas (kg/day)	User Input Values! C9, D13	[redacted]	[redacted]
Natural gas (btu/day)	User Input Values! C9, D14	[redacted]	[redacted]
Steam (kg/day)	User Input Values! C9, D15	[redacted]	[redacted]
		[redacted]	[redacted]
Output		[redacted]	[redacted]
Total diesel (petroleum + renewable) (kg/day)	User Input Values! C9, D18	[redacted]	[redacted]
Total Fuel Gas (Petroleum + Renewable) (kg/day)	User Input Values! C9, D19	[redacted]	[redacted]
Net Fuel Gas (kg/day)	User Input Values! C9, D20	[redacted]	[redacted]
Total Naphtha (petroleum + renewable) (kg/day)	User Input Values! C9, D21	[redacted]	[redacted]
Total Jet fuel (petroleum+ renewable) (kg/day)	User Input Values! C9, D22	[redacted]	[redacted]
Renewable Diesel produced (kg/day)	Baseline vs Co-processing! C27	[redacted]	[redacted]
Emission factors of hydrogen	Fuel Specs& EF! C78	[redacted]	[redacted]
Emission factors of hydrogen	Fuel Specs& EF! C81	[redacted]	[redacted]

IV. Basis for the Input Values

This pathway is similar to the published Tier 1 BDRD Calculator for animal fat RD, with changes in the following areas as detailed below:

1. Inputs to calculate emissions from RD production (1.0 Changes in CA-GREET model)
2. Process inputs and outputs during RD production (2.0 Mass and Energy Balance)
3. Animal fat and RD transportation modes and distances (3.0 Transportation)

Next to each item in parentheses is the supporting documentation reference in the "BP Animal Fat to RD Original Data File".

The modified CA-GREET spreadsheet, and the modified co-processing calculator are included in the application package.

The default values in the Tier 1 BDRD Calculator for animal fat to RD pathway have been adopted for animal fat rendering [1]. Animal fat is sourced from [redacted]. The distance from rendered animal fat suppliers to Cherry Point [redacted] miles. The [redacted] mile value is used as the Tier 1 BDRD Calculator input. The energy allocation method is used to allocate the upstream emissions from animal fat rendering and transportation. The energy from produced RD and net renewable propane is [redacted]% and [redacted]% respectively.

Natural gas and refinery fuel gas is used for steam methane reforming (SMR) to produce hydrogen. BP completed an analysis for the SMR input over last 5 years, and the average natural gas use is [redacted]% with the rest [redacted]% as fuel gas.

Since co-processing requires an increased demand from the [redacted] Hydrogen Plant, there is an increased use of refinery fuel gas in the [redacted] Hydrogen Plant. Such refinery fuel gas is used to fulfill process heat demand. As a result, an increased amount of natural gas is imported into the refinery fuel system to replace refinery fuel gas.

It is advantageous for the refinery to recover as much refinery fuel gas as possible into the Hydrogen Plant feed for the following reasons:

[redacted]

Gas is purged back to the Hydrogen Plant from the [redacted] DHDS unit. This purged gas contains a high percentage of hydrogen. Hydrogen is recovered in the refinery through the PSA in the Hydrogen Plant at an assumed approximate rate of [redacted]%.
The purged gas is tested bi-weekly for hydrogen (mol%) content using a GC run in the Cherry Point lab on the recycle gas sample (taken in a gas cylinder).

Purge gas hydrogen content (klb/hr) is calculated by determining the average hydrogen mass % in the gas, by accounting for the average methane, ethane and propane content:

[redacted]

Makeup H_2 content is [redacted] wt% when entering the [redacted] DHDS. The net usage of H_2 is calculated by subtracting the amount of H_2 in purge gas from the makeup H_2 stream entering the [redacted] DHDS.

In prior assessments, BP adopted a conservative estimate of [redacted]% natural gas use and [redacted]% fuel gas use in the SMR for H2 produced for [redacted] DHDS. The emission factors of H2 used in SMR from NG is 101.33 g CO_2e/MJ, adopted from the standard value in the Tier 1 BDRD Calculator.

BP staff recognize that the refinery consistently changes the NG and refinery fuel gas allocation to make H_2 for the whole refinery. To ensure accuracy, BP completed an additional assessment to evaluate the sources of H_2 production at the whole BP refinery. It was found that [redacted]% of the H_2 generated at the refinery is derived from natural gas.

Furthermore, for the purposes of this evaluation, the BP refinery is conservatively assumed to use natural gas to produce 100% of the net H_2 used at the refinery. This results in a CI of **8.70 g CO_2e/MJ at the refinery.**

Steam, fuel gas and a small amount of natural gas (UI gas) are used for process heat. Electricity comes from the grid. The steam used for baseline production and co-processing has the same properties in terms of pressure and temperature. Two types of steam are used, [redacted]# steam (with a pressure of ~[redacted] psig) and [redacted]# steam (with a pressure of ~[redacted] psig).

[redacted]

The most recent ASTM D6866 test method is used for all ^{14}C testing. A background correction was conducted, subtracting 0.1% from the initial ^{14}C test result. Total animal fat use was determined by the metered daily animal fat use (See file “[redacted]) and the total days for the time period used in file “[redacted]”. Marginal allocation was used for co-processing in a hydrotreater per CARB guidance.

The RD produced is transported from Cherry Point to CA destinations [redacted] for no more than [redacted] miles. RD is then transported to blending terminals and further distributed in CA [redacted] with default distance values.

V. Model Output

This report has assessed the LCA stages that comprise the new pathway for animal fat RD co-processed in a hydrotreater with petroleum feedstock at Cherry Point, which has a carbon intensity of **27.65 $gCO_2e\ MJ^{-1}$**. Details on the CI of each stage are shown in Table 2.

Table 2. Emissions (gCO_2e/MJ) from animal fat RD produced by Cherry Point, separated by life cycle stage. Figures are rounded.

LCA stage	Cherry Point Animal Fat RD
Animal Fat Collection	0.00
Raw Animal Fat Transportation	0.00
Animal Fat Rendering	16.95
Rendered Oil Transportation	0.14
RD production	8.70
RD Transportation and Distribution	1.10
Total (Well to Tank)	26.89
Total (Tank to Wheel)	0.76
Total (Well to Wheel)	27.65

VI. Discussion of Results

Table 2 shows the emissions from the proposed pathway calculated using the Tier 1 BDRD Calculator and the Co-processing Calculator published by CARB. The ranking for the most greenhouse gas intensive steps is:

1. Animal fat rendering
2. RD production
3. RD and animal fat transportation and distribution

Overall, the animal fat RD produced at Cherry Point has a CI of **27.65 g $CO_2e\ MJ^{-1}$**.

VII. Production Range of Cherry Point Refinery

[redacted]

VIII. Sustainability of Cherry Point

Cherry Point Refinery was designed and constructed using established modern designs and equipment and is managed by professional, qualified staff to ensure that the energy efficiency of and emissions from the facility do not deteriorate over time. Any deterioration in efficiency would result in a less profitable business. Thus, the sustainability of the plant is aligned with the business objectives of the owners.

IX. Impact on Land Use

As the raw material is animal fat, a waste stream from food industry, there is no land use impact.

X. Conclusion

Based on our modeling using the Tier 1 BDRD Calculator and the Co-processing Calculator, we find that RD produced from animal fat through the co-processing process at Cherry Point has a carbon intensity of **27.65 $gCO_2e\ MJ^{-1}$**.

XI. References

1. Tier 1 Simplified CI Calculator for Biodiesel and Renewable Diesel. *Available 02/27/2019, at*

   https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm

2. Excel Template to Illustrate GHG Emissions Estimate for Co-processing in Hydrotreating units, Available 07/24/2017, at http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm.

XII. Data supporting Annual Quantities of Electricity, Natural Gas, Steam, Hydrogen, Feedstock Use, RD Production, and Distance for Feedstock and Fuel Transportation

The data supporting the annual quantities of electricity, natural gas, steam, hydrogen, feedstock use and RD production, distance for feedstock and fuel transportation, as well as the modifications to the Co-Processing Calculator are documented in separate spreadsheets named [redacted]”.