JBS Hyrum Tier 2 Application
Tallow Feedstock Pathway

Date Submitted: June 30 2020

Location of Tallow Production Facility: 410 North 200 West, Hyrum UT 84319

Period of Analysis:

This analysis is based on facility operating data, invoices, and audited reports covering the period [redacted]

Tallow Pathway Information

FEEDSTOCK	PRODUCTION PROCESS	INTENDED LCFS PATHWAY
TALLOW	RENDERING	FEEDSTOCK ONLY

Primary Point of Contact

Name: [redacted]

Phone Number: [redacted]

Email Address: [redacted]

Contents

Feedstock pathway summary

An assessment of Feedstock Production using the Well-To-Tank (WTT) fuel cycle approach of JBS's entire tallow production at the integrated meat packing and rendering facility at Hyrum, Utah. It includes all energy consumption and tallow and meal production data and analysis specifically for the Hyrum rendering facilities.

The purpose of this Feedstock pathway application to is replace the Tier 1 feedstock default with real time CI analysis unique to the Hyrum integrated rendering facility.

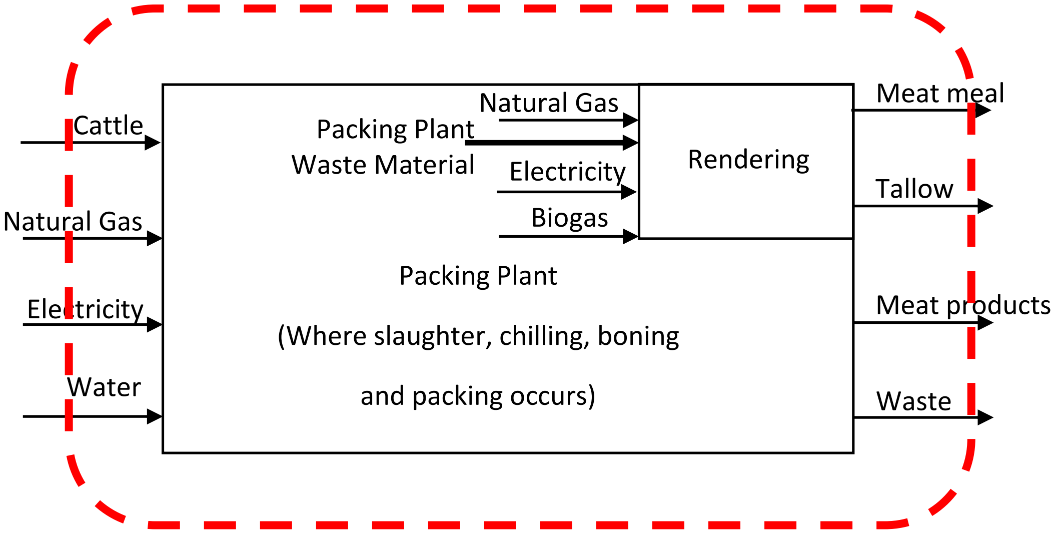

Figure 1: A basic process flow diagram for an integrated meat processing and rendering plant. Note the red dotted line represents the physical and overall system boundary for the facility.

Figure 1 represents the flow of inputs, outputs and consumables within an integrated packing/rendering facility such as Hyrum. The application is submitted as a Tier 2 Feedstock component of a joint pathway. This is required as the LCFS regulation mandates the use of Tier 2 modelling for any innovative process. The process used by JBS Hyrum incorporates real-time monitoring of all major energy and mass flows for the purpose of determining an energy and emissions intensity for tallow produced within the rendering facility.

The sources of energy consumption within the rendering facility are aggregated and allocated to both rendering products (meat meal and tallow).

The Hyrum integrated packing and rendering facility

The packing plant slaughters and processes the beef carcases into saleable products. Those parts of the animal that are waste or unsaleable as human edible-grade products, such as the head, bones, intestines, rumen, hooves, fat, internal organs etc are then passed on to the integrated rendering plant for further processing.

The rendering plant then grinds and cooks this waste in two separate rendering systems from which the resultant products are tallow and meat meal.

The primary advantages of having an integrated rendering plant are:

1. The left-over parts are fresh when processed, which in turn make a better final product.
2. It turns a waste, costing the site money, into valued products.
3. There are significant synergies and energy efficiencies possible, such as no raw material transportation and heat recovery from the rendering plant for preheating process water within the packing plant.
4. 100% traceability of raw material to comply with the most stringent verification processes.

Rendering

Meat rendering plants process animal waste products to produce different qualities and grades of tallow and meat meals. Plants that operate in conjunction with meat packing plants are called integrated rendering plants. Plants that have their raw materials supplied from a range of offsite sources are called independent or toll renderers.

The JBS Hyrum plant is an integrated rendering facility, taking only waste material from the onsite packing plant.

There are two basic types of rendering facilities, ones that produce edible products and those that produce inedible products. All of JBS Hyrum's rendered products are inedible.

Below is an example of a generic and typical cooker/rendering system, similar to what is operated at the Hyrum facility.

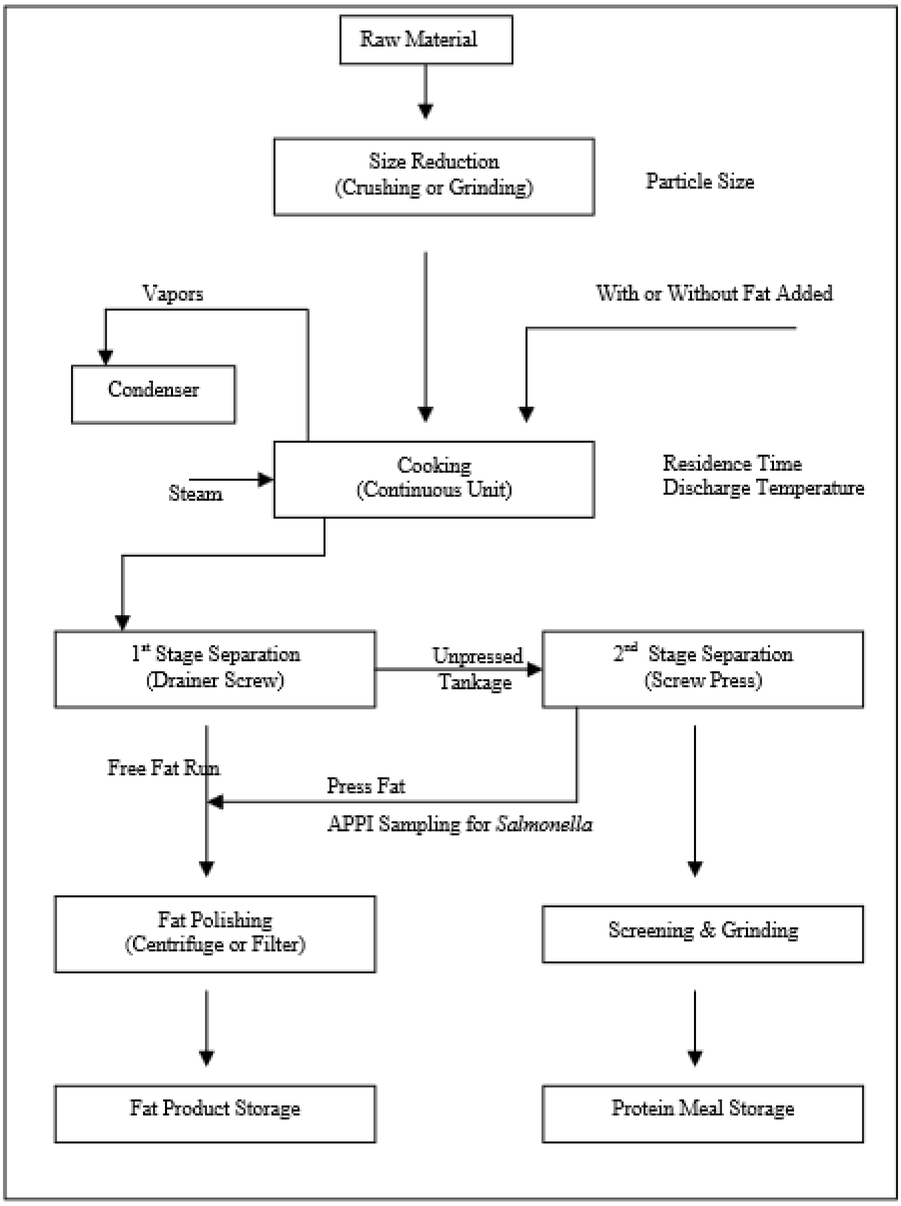

Figure 2: Continuous cooker rendering system. Sourced from 'Essential Rendering - All about the animal by-products industry', pp23, ed. Meeker, National Renderers Association.

The Hyrum Inedible Rendering Facility

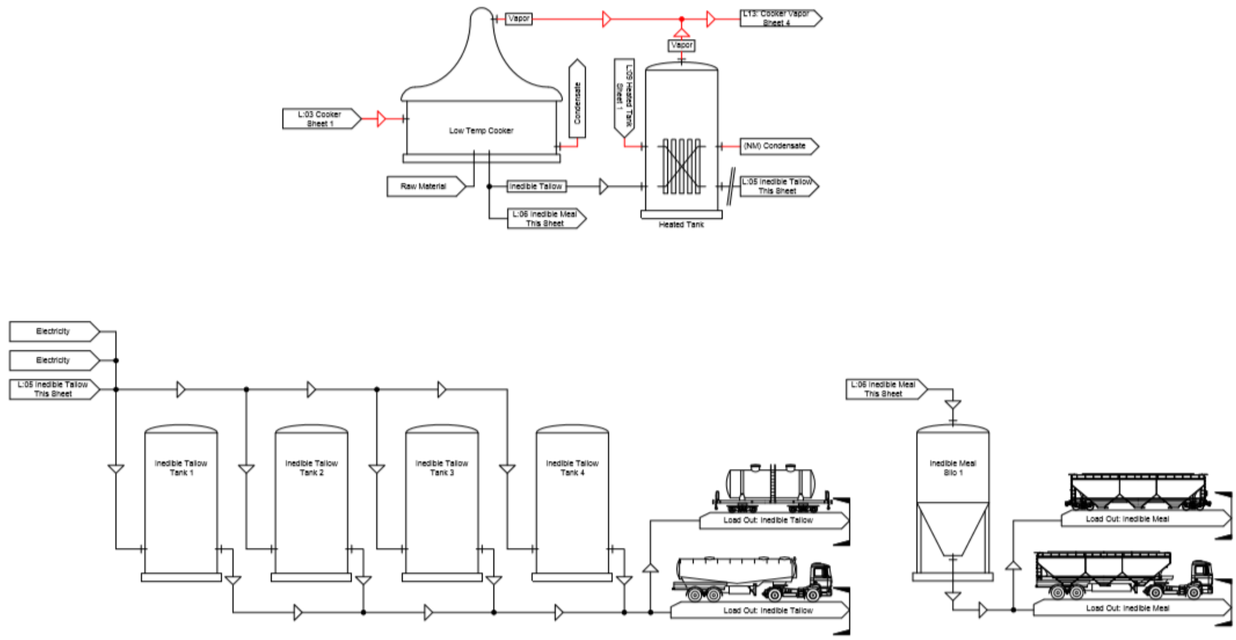

Figure 3: JBS Hyrum inedible tallow process flow diagram. Note the post-screw press processing of meal is not shown and not relevant to the examination of tallow-related energy consumption

Figure 3 represents the Inedible rendering plant at Hyrum. The steam from the boilers is used indirectly to heat the packing plant's waste in the cooker. The degraded/spent steam is then returned to the boilers via one of two condensate return lines, high pressure and low pressure. High pressure condensate return is used in normal operations. The low pressure is typically used as a backup when the high pressure is being serviced.

Once the steam condensate is returned to the boiler it is heated again to the required pressure and temperature for plant operations. There is some boiler makeup water used to overcome losses within the system. This system of energy reuse is not included in the energy and mass balance.

Heat from the Inedible Rendering cooker vapor is recovered through a shell and tube heat exchange system. The recovered heat is used to heat process water for sterilising and cleaning uses in the meat packing facility.

Hyrum's Technical Rendering Facility

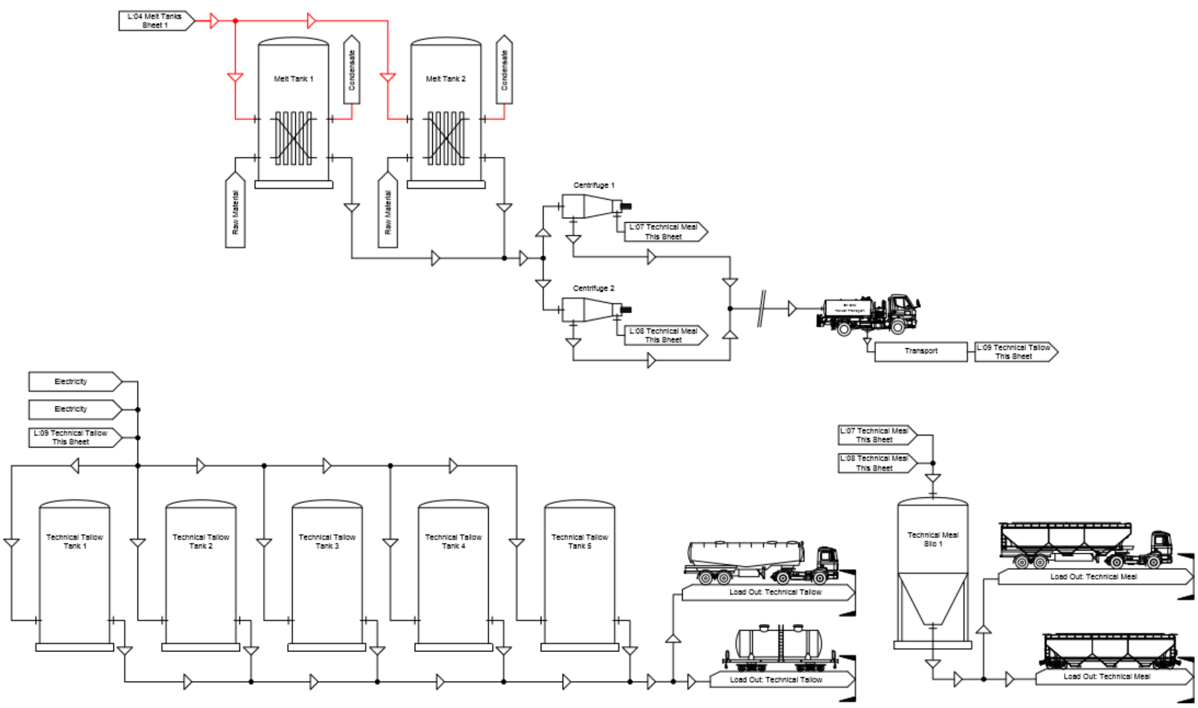

Figure 4: Technical rendering plant process flow diagram.

Figure 4 represents the technical rendering plant at Hyrum. The raw material is conveyed from the fabrication floor to the technical rendering plant. Once in technical rendering, the material flows into the melt tanks where more steam is directly and indirectly applied to liquefy the product. The tallow is further separated and processed to the specification and quality requirement for sale. All energy use is monitored according to the project's Measurement and Data Collection plan.

Tallow Energy and Carbon Intensity analysis

This section reports on:

1. Data monitoring and management
2. Production analysis and calculations methodology
3. Carbon Intensity calculations

As stated previously – the purpose of this Feedstock pathway application to is replace the Tier 1 feedstock default with real time CI analysis unique to the Hyrum integrated rendering facility.

Monitoring and data management

The "Measurement and Data Collection Plan" (M&V plan) outlines monitoring requirements for this project. The additional monitoring points required were installed at the start of the monitoring process.

Data from all monitored meters is [redacted]

[redacted] The data from this database is used to calculate the energy and emissions intensity of tallow produced at the Hyrum integrated rendering facility and conduct the Carbon Intensity analysis.

Energy calculations

The first step is to determine the system boundary. The system encompasses cookers, heat exchanger, melt tanks (as shown in the process flow diagrams) and has the following inputs and outputs;

System Inputs

- Steam from boilers (energy and mass flow rate monitored and calculated)
- Electricity (pro-rata calculations as per M&V plan).
- Process water IN (temperature and flow rate monitored)

System Outputs

- Steam condensate return to boilers. The condensate return to boilers is considered a 100% loss[1] and excluded from calculations.
- Process Water OUT (temperature monitored)
- Finished products - meat meal and tallow (Production reported manually)

Electrical Energy and Gaseous fuels consumption

The approved M&V plan outlines the process of calculating all energy inputs and resultant energy outputs of the Hyrum rendering plant.

Gaseous fuels consumption

There are two sources of gaseous fuels used for combustion in Hyrum's boilers. The first is natural gas supplied via pipeline and consumption is monitored via a daily manual meter read and verified using supplier invoices. The second is the onsite wastewater treatment plant's covered anaerobic lagoon/digestor. Biogas is harvested from the lagoon and sent to the boilers via pipeline. The volume of biogas is monitored via a meter at the wastewater treatment plant.

The boilers feed a single steam header, so energy used in the render plants is a combination of natural gas and biogas generated steam. The total consumption of biogas and natural gas for steam raising is done on a daily average/basis.

[redacted]

Steam condensates

The embedded energy in all steam lines are a function of the mass flow rate and change in enthalpy across the cooker for the steam line used.

The embedded energy of the water which is reused in the boilers via the condensate return lines is not considered in the mass and energy balance.

Heat recovery

Energy is recovered from cooker vapour boiled off in the cooking process via a heat exchange system which preheats process water used for cleaning and sterilisation within the packing plant. This is an energy 'credit' when calculating the net energy required for tallow production.

The flow rate and temperature of process water are monitored at the inlet and outlet of the heat exchanger.

Heat recovered is a function of the process water mass flow rate, heat capacity and temperature differential across the heat exchanger. All energy losses associated with the heat recovery system are allocated to the rendering facility rather than the packing plant's process water. Hence it is only the ***energy recovered*** in the process water that is considered a 'credit' in the rendering facility mass and energy balance.

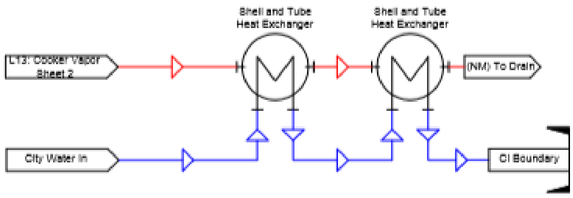

Figure 5: Schematic of the inedible cooker waste heat recovery and heat exchange system

Energy Intensity calculation

A key metric for ARB in the LCFS program is the energy intensity of the entire site's tallow production (i.e. BTU/lb tallow).

Electrical, Natural Gas and Biogas energy are consumed in the rendering plant to produce meat meal and tallow. Both meat meal and tallow go through the same cooking processes. The total energy consumption for the rendering facilities within Hyrum is a summation of the following energy consumptions and reuse unit operations;

1. Cooker steam ([redacted])
2. Rendering electrical energy (e.g. motors, fans etc)
3. Cooker effluent heat recycle for process water (shell and tube heat exchange)

The total calculated energy consumption is then apportioned across the products of the rendering process, meat meal and tallow.

Attribution of total energy consumption to the products of rendering

The monitoring, data acquisition and energy consumption calculations are for the entire rendering system. There is a need to attribute the energy consumption to the production outputs – which are tallow and meat meal.

Product In = packing plant waste

Product Out = tallow and meat meal

Thus it is necessary to proportionally allocate energy consumption to both Hyrum's tallow and meat meal production in order to calculate the energy intensity of these production outputs.

Method of energy allocation to tallow and meat meal

The feedstock pathway for JBS Hyrum's tallow is based on the GREET Tier 2 approach of energy content based allocation of all energy inputs of the rendering process and is allocated proportionally to the tallow and meat meal produced by weight.Below is a worked example of the energy allocation process for the month of [redacted]. The calculation requires the entire production values for both tallow and meat meal and the total energy consumed in the rendering system for that production period.

Table 1: Sources of energy consumption or reuse for the month of [redacted]. Note the heat recovery is a reuse credit.

Energy consumption by source		Units (GJ)
Electricity	Inedible Render	[redacted]
	Technical Render	
Natural Gas/Thermal	Inedible Render	
	Inedible Render heat recovery	
	Technical Render	
Total Energy		

Table 2: Reported production data for both rendering plants for the month of [redacted].

Production by saleable product	Units (tonnes)
Tallow	[redacted]
Meat Meal	
Total production	

Thus to determine the energy intensity of all the products of rendering the following was done;

$$Energy\ Intensity_{total} = \frac{Energy_{total}}{Production_{total}}\ (\frac{BTU}{lb})$$

And for tallow

$$Energy\ Intensity_{tallow} = \frac{Energy_{tallow}}{Production_{tallow}}\ (\frac{BTU}{lb})$$

Where the $Energy_{tallow}$ is the proportional allocation of $Energy_{total}$ for the production tallow. This can be calculated as;

$$Energy_{tallow} = Energy_{total} \times \frac{Production_{tallow}}{Production_{total}}$$

Now $Energy\ Intensity_{tallow}$ can be represented as;

$$Energy\ Intensity_{tallow} = \frac{Energy_{total} \times \frac{Production_{tallow}}{Production_{total}}}{Production_{tallow}}$$

And simplifying this equation we get;

$$Energy\ Intensity_{tallow} = \frac{Energy_{total}}{Production_{total}}$$

Which means

$$Energy\ Intensity_{total} = Energy\ Intensity_{tallow}$$

Thus for the month of April 2020 the $Energy\ Intensity_{tallow}$ is;

$$Energy\ Intensity_{tallow} = \frac{\text{[redacted]}}{\text{[redacted]}} \times \frac{\text{[redacted]}}{\text{[redacted]}} \times \frac{\text{[redacted]}}{\text{[redacted]}} = \text{[redacted]}\ \frac{BTU}{lb}$$

Similarly the $Energy\ Intensity_{meat\ meal}$ is

$$Energy\ Intensity_{meat\ meal} = Energy\ Intensity_{total} = \text{[redacted]}\ \frac{BTU}{lb}$$

ARB Carbon Intensity calculation

JBS's Hyrum's Utah plant Carbon Intensity values are calculated using the California Air Resources Board default emission factors for onsite fuel burn emissions and for electrical energy consumption. The Hyrum plant is supplied with electricity from the Utah (4-NWPP) mix.

The inputs from the JBS analysis are aggregated into the GREET compatible inputs. The reduced form values for total energy intensity and the energy share of electricity and NG are calculated based on monthly JBS data. The inputs are then plugged into CA_GREET3.0 along with the use of 4-NWPP electricity mix for the feedstock region, corresponding to Hyrum, Utah.

Results summary

The energy consumption and emissions for all of the inedible and technical tallow produced at Hyrum are summarised in Table 3 below.

The average over the period reported for JBS Hyrum's rendering facilities tallow energy intensity is [redacted] (Standard Deviation SD = [redacted]). This equates to emissions intensity of [redacted] (SD = [redacted]).

It is important to note this monitoring and analysis system captures all the operating conditions within a rendering facility and the analysed data reflects this normal operational, seasonal variance and pandemic conditions.

Table 3: Summary of Hyrum's tallow energy intensity and emissions.

Hyrum Tallow CI Data		Inedible Tallow		Melt Tank tallow		Summary Values		Units
		Average	SD	Average	SD	Average	SD	
Tallow energy intensity	Total	[redacted]						BTU/lb
	Natural gas							BTU/lb
	Biogas							BTU/lb
	Electricity							BTU/lb
Tallow emissions		[redacted]				25.85	1.51	g CO_2-e/lb

Monthly Averaged Tallow Production Data and Energy and Carbon Intensity Calculations

Description - Date	Rendering Production												
	Inedible Tallow						Melt Tank tallow					Total Tallow production	Total Render production
	Render Electricity	Gas fuel burn	Heat recovery	Tallow Production	Meal Production	Total Inedible	Render Electricity	Gas fuel burn	Tallow Production	Meal Production	Total Melt Tank		
	GJ	GJ	GJ	Tonnes	Tonnes	Tonnes	GJ	GJ	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
March 2020	[redacted]												
April 2020													
May 2020													
June 2020													
Totals	[redacted]												
Weighted Average													
Standard Deviation													

Description - Date	Energy Allocation									CO_2 Allocation							
	Utilities	Inedible Tallow				Melt Tank Tallow				Inedible Tallow				Melt Tank Tallow			
	% Biogas of gas	Electrical energy	Natural gas energy	Biogas energy	Tallow Total	Electrical energy	Natural gas energy	Biogas energy	Tallow Total	Electricity	Natural Gas	Biogas	Tallow emissions	Electricity	Natural Gas	Biogas	Tallow emissions
	%	BTU/lb	BTU/lb	BTU/lb	BTU/lb	BTU/lb	BTU/lb	BTU/lb	BTU/lb	T CO_2-e	T CO_2-e	T CO_2-e	g CO_2-e/lb	T CO_2-e	T CO_2-e	T CO_2-e	g CO_2-e/lb
March 2020	[redacted]																
April 2020																	
May 2020																	
June 2020																	
Totals	[redacted]																
Weighted Average																	
Standard Deviation																	

Description - Date	Summary Values							
	Electricity	Natural Gas	Biogas	Electricity	Natural Gas	Biogas	Tallow energy	Tallow emissions
	T CO_2-e	T CO_2-e	T CO_2-e	BTU/lb	BTU/lb	BTU/lb	BTU/lb	g CO_2-e/lb
March 2020	[redacted]							25.15
April 2020								25.04
May 2020								27.66
June 2020								27.75
Totals	[redacted]							25.85
Weighted Average								25.85
Standard Deviation								1.51

Supporting Data

Hyrum's invoices and verification of energy consumption

As mentioned earlier in this document, rendering is only a proportion of the total operations at the Hyrum integrated meat packing facility. The electrical and natural gas invoices are for the entire site, which covers meat packing and rendering activities. Thus there is no direct link between the invoiced consumption figures and figures reported by direct measurement via the data capture and analysis system.

The whole-of-site energy consumption data was sourced from the site's supplier invoices for natural gas and electricity and both are reported in Table 4

Utility Invoices for Hyrum, whole-of-site								
Description - Date	Natural Gas			Electricity			Tallow	Meal
	Invoice total	4% FFA with heat recovery	0.75%FFA	Invoice total	4% FFA	0.75%FFA	Production	Production
	GJ	% of total	% of total	kWh	% of total	% of total	tonnes	tonnes
March 2020	[redacted]							
April 2020								
May 2020								
June 2020								
Totals	[redacted]							
Reporting Notes								
[redacted]								

Table 4: Energy and production comparisons of what is recorded by the monitoring system and evidenced by invoices. Note: the invoices are for whole-of-site, whereas the energy consumption allocated to tallow is reported as a percent value of the total site consumption. Production values differ from sales values, with the difference being what is in the current inventory or cars on track/in transit. May 2020 report for this application is only for 19 May onwards and hence May totals vary significantly from other months.

Moisture Content of By-Products

The moisture content of Hyrum's tallow and meat and bone meal are of key concern in terms of quality and adherence to overarching industry specifications. Higher moisture content means a lower quality product and the greater the risk of continual degradation of quality post-production. The moisture on by-products produced in Hyrum is managed through the cookers, screw press and then centrifuges and/or polishers for separation of tallow from moisture. The National Renderers Association dictates standard industry specifications for rendered products, of which, moisture is one parameter. These are:

Technical Tallow [redacted] Max

Inedible Tallow [redacted] Max

MBM [redacted] Max

A random selection of COA's from JBS Hyrum's by-product production from 2020, resulted in the below:

JBS Hyrum By-Product Analysis

	Technical Tallow		Inedible Tallow		Meat and Bone Meal	
Date	FFA	Moisture	FFA	Moisture	Protein	Moisture
Mar 2 2020	[redacted]					
Mar 3 2020	[redacted]					
Mar 5 2020	[redacted]					
Mar 6 2020	[redacted]					
Mar 9 2020	[redacted]					
Mar 12 2020	[redacted]					
Mar 13 2020	[redacted]					
Mar 16 2020	[redacted]					
Mar 18 2020	[redacted]					
Mar 19 2020	[redacted]					
Mar 21 2020	[redacted]					
Mar 25 2020	[redacted]					
Mar 27 2020	[redacted]					
Mar 31 2020	[redacted]					
Apr 6 2020	[redacted]					
Apr 9 2020	[redacted]					
Apr 13 2020	[redacted]					
Apr 14 2020	[redacted]					
Apr 16 2020	[redacted]					
Apr 20 2020	[redacted]					
Apr 25 2020	[redacted]					
May 4 2020	[redacted]					
May 6 2020	[redacted]					
May 7 2020	[redacted]					
May 9 2020	[redacted]					
May 11 2020	[redacted]					
May 18 2020	[redacted]					
May 19 2020	[redacted]					
May 21 2020	[redacted]					
May 27 2020	[redacted]					
June 4 2020	[redacted]					

Boiler Efficiency

The boilers average slightly over 80% efficient based on the readings for their real time combustion monitoring system readings. The calculations use the ARB default value of 80% for boiler efficiency.

HYRUM BOILER INFORMATION								
EQUIP ID	Manufacturer	Year	TYPE	Boiler Horsepower	MMBTU/hr	Steam capacity lb. per hour	Location	Fuel Type
Boiler 1	Cleaver Brooks	[redacted]						Natural Gas
Boiler 2	Cleaver Brooks	[redacted]						Bio/Natural Gas
Boiler 3	Cleaver Brooks	[redacted]						Natural Gas
Boiler 4	Cleaver Brooks	[redacted]						Bio/Natural Gas
Boiler 5	Cleaver Brooks	[redacted]						Natural Gas
Boiler 6	Cleaver Brooks	[redacted]						Natural Gas
Boiler 7	Cleaver Brooks	[redacted]						Natural Gas

Note: boiler 7 is in a different location to the 6 boilers involved in this study

AltAir Paramount LLC. GREET Pathway for the Production of Renewable Diesel, Alternative Jet Fuel, and Renewable Naphtha from Animal Tallow from Hyrum, Utah added to Previous Four Tallow Feedstocks

Prepared by Love Goyal and Stefan Unnasch, Life Cycle Associates, LLC

Date Submitted: August 7, 2020

Location of Biofuel Production Facility: 14700 Downey Avenue
Paramount, CA 90723

Period of Analysis
This analysis is based on facility operating data, process invoices, and audited reports covering the 3-month period from March 2020 to May 2020 which is representative of typical reliable plant operations.

Fuel Pathway Information

Fuel	Feedstock	Production Process Technology	LCFS Pathway Requested
Renewable Diesel	• Standard US Tallow (Tallow 1) • JBS Low Energy Tallow (Tallow 2) • Generic Australian Tallow (Tallow 3) • Greeley, CO Tallow (Tallow 5) • Hyrum, UT Tallow (Tallow 6)	Hydrotreating	Renewable Diesel

Primary Point of Contact
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1. Fuel Pathway Summary

A Well-To-Tank (WTT) fuel cycle analysis of the AltAir Paramount Tallow to Renewable Diesel (RD), Renewable Jet Fuel (RJ), and Renewable Naphtha (RN) pathways includes all steps from tallow production to hydrotreating in the AltAir Paramount refinery. Tank-to-Wheel (TTW) analysis includes fuel combustion in a vehicle. Together, WTT and TTW analysis are combined to provide a total Well-to-Wheel (WTW) analysis that determines the fuel cycle greenhouse gas emissions, termed Carbon Intensity (CI), associated with the pathway.

Figure 1 shows the discrete components that form the tallow to RD, RJ, and RN pathways. The pathway inputs correspond to the parameters in the CA_GREET model. The pathway inputs correspond to the parameters in the CA_GREET model. The application is submitted as a Tier 2 using the bdrd-calculator. This is because the LCFS regulation requires the use of Tier 2 model for any innovative process. The process used by AltAir uses liquid hydrogen as an input which is not included in the Tier 1 model RD pathway. Therefore, the Tier 1 model has been used with minor changes as discussed in later sections of this report. Inputs are aggregated and allocated to all refinery products and tallow yield is calculated by energy allocation.

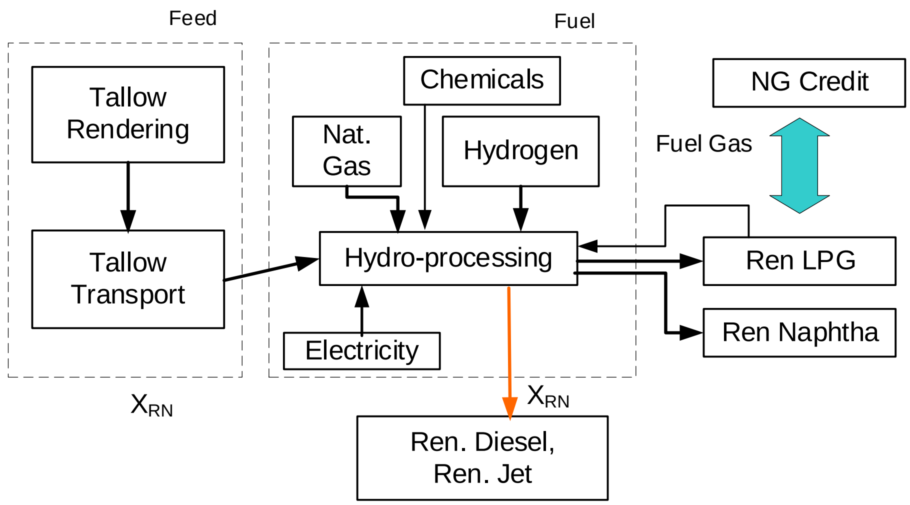


Figure 1. System Boundary Diagram AltAir Paramount Tallow to Renewable Diesel

Tallow is fed into the pretreat reactor (occasionally with small quantities of vegetable oils/fats). After removal of particulates and trace contaminants, oxygen is removed from the feed in the deoxygenation reactor. Light gases are removed from the first stage product in the stripper. The overhead gases removed in the stripper are used as fuel gas. The effluent from the stripper tower is mixed with hydrogen and hydrocracked in the reactor before the distillation stage. Through distillation and fractionation, all the feed is converted and separated into a combination of four products namely, renewable diesel (RD), renewable jet fuel (RJ), renewable naphtha (RN), and renewable LPG (RLPG). Because of the complex nature of the refinery, simple energy-based allocation procedures are used in the analysis following the GREET model. The AltAir Paramount refinery processes approximately XXXX barrels of feed per day and produces about XXX million barrels of renewable fuels per year.

Altair Paramount has previously applied for 4 RD pathways based on different sources of tallow. This new application is a joint pathway with tallow received from the JBS Swift tallow facility in Hyrum, Utah. The fuel pathways for AltAir tallow to RD is based on the GREET approach of energy content based allocation of all the energy inputs to the refinery. This allocation is based on the energy content proportion of RD produced with the total finished products produced. The following principles were applied to the pathway:

- AltAir refinery products include RD, RJ, and RN and LPG from the hydrotreater.
- Natural gas, electric power, and liquid hydrogen are energy inputs to the process.
    - All of the slop co-produced in the process is subsequently re-used as feed
- Allocate inputs to renewable products based on energy proportion of renewable products with all products produced
    - The same approach is used in GREET
    - Treat RN and RJ as co-products
    - Assign natural gas, hydrogen and electricity consumption of the refinery to renewable products based on energy allocation factor.

The above principles of allocation are consistent with the RD pathway in the CA_GREET and ARB's Tier1 bdrd calculator. The energy inputs and emissions analysis are repeatable for future verification.

The analysis is simplified as tallow is the only feedstock. The primary contribution of GHG emissions consists of hydrogen, natural gas, electricity, upstream tallow production, and transportation.

The fuel pathways include tallow collection, rendering, transport, renewable fuel production, renewable fuel transport, distribution, and fuel combustion.
The pathway examined here includes the life cycle stages of:

- Feedstock Production
- Feedstock Transport
- Renewable Fuel Production
- Renewable Fuel Transport

Feedstock

AltAir Paramount uses the mixture of tallow from a variety of sources as feedstocks for the production of its Renewable Fuels. The co-feed may include minor quantities of plant oils such as soy oil, canola oil, tobacco oil, or corn oil and slop which is a byproduct of the process. AltAir Paramount recently received four pathways corresponding to the CA-GREET 3.0 Renewable Diesel pathway that is produced from the following categories of animal tallow:

1. Standard US Tallow

2. JBS low energy tallow from Brooks, Alberta, Canada
3. Generic Australian tallow JBS low energy tallow from Greeley, Colorado.
4. JBS low energy tallow from Greeley, Colorado.

This application adds the following tallow feedstock options:

5. JBS low energy tallow from Hyrum, Utah.

Upstream emissions for standard US tallow rendering are based on the CA_GREET3.0 default in the Tier 1 bdrd calculator. This tallow is delivered by rail to Paramount's refinery located in Paramount, CA. JBS low energy tallow rendering from Greeley, Colorado, Brooks, Alberta and now Hyrum, Utah utilize lower energy than US standard tallow. These values are based on JBS internal analysis following a process level allocation at their rendering facilities. For the generic Australian tallow, standard US rendering inputs are assumed. For the rendering of Australian tallow, the Australian national average grid mix is considered as per (Department of the Environment and Energy, 2018a). The transportation of this tallow included truck transport from beef processing plants in Australia to the ports of Brisbane or Melbourne, an ocean vessel transport from the Australian port to Long Beach port, and truck transport from the Long Beach port to the AltAir Paramount facility (Figure 4). The new JBS low energy tallow from Hyrum, Utah parallels the Greeley, Colorado and Brooks, Alberta pathways. More details on feedstock rendering and transport are included in the feedstock phase section of this report and in the related Hyrum facility rendering information in the AFP.

Renewable Fuel Types

The facility produces renewable diesel fuel (RD) from the AltAir Paramount hydrotreating unit. The unit produces a mixture of RD, which is a CARB diesel compliant fuel, renewable Jet fuel (RJ or sustainable alternative jet fuel (SAJF) as well as renewable Naphtha (RN). This RN is blended to produce CARB compliant gasoline (either with petroleum based octane enhancement or ethanol to make very low petroleum E85. ARB recently approved the Tier 2 provisional pathways RNT002B00430300, RNT002B00440300, RNT002B00450300 for the light naphtha gasoline blending component from AltAir.

Baseline Volume

Tallow is processed over multiple reactors, which process a little more than XXX million barrels of tallow per year to produce about XXX million barrels of renewable diesel. The tallow may be co-processed with small quantities of other vegetable oils as co-feed.

Regional Electricity and Crude Oil Mix

The CA_GREET3.0 analysis uses the region where the tallow is produced and refined. Tallow is sourced from multiple locations across the US and Paramount's facility is located in California. Therefore, the region 1-U.S. Ave electricity for the production of tallow and 3-CAMX for renewable diesel in Table 1 are the regional settings in CA_GREET3.0. The model instructions require the use of the U.S. Ave Crude mix for all fuel pathways except California CARBOB and ULSD. Crude Region has little effect on the CI and the U.S. Ave Crude was used for all of the feedstocks and locations. The regional CI for electric power is used for the user defined tallow pathways.

Table 1. Feedstock and Fuel Regional Mixes for Electric Power

	Feedstock	Fuel
Default Tallow	1-US Ave	3-CAMX
JBS Low Energy Tallow	Alberta GHG Inventory	3-CAMX
Generic Australian Tallow	Queensland GHG Inventory	3-CAMX
Greeley, Colorado Tallow	6-RMPA Mix	3-CAMX
Hyrum, Utah Tallow	4-NWPP Mix	3-CAMX

2. Process Description

The renewable diesel fuel is produced using tallow and non-edible vegetable oils at Paramount's refining facility. The facility also co-produces renewable jet fuel and naphtha from the same feed.

The primary product, renewable diesel fuel, qualifies for the California Air Resources Board (CARB) Low Carbon Fuel Standard LCFS) and the EPA's Renewable Fuel Standard (RFS2) program. This product meets ULSD specifications. The refinery uses a series of reactors to hydrotreat the feed to convert it into the products. These reactors contain catalyst to process the blended feed. The renewable fuel production is monitored on a continuous barrel feed basis. However, for reporting for LCFS, tank "batches" are completed and certified by laboratory results to meet ASTM fuel standards before they are tracked as RD production.

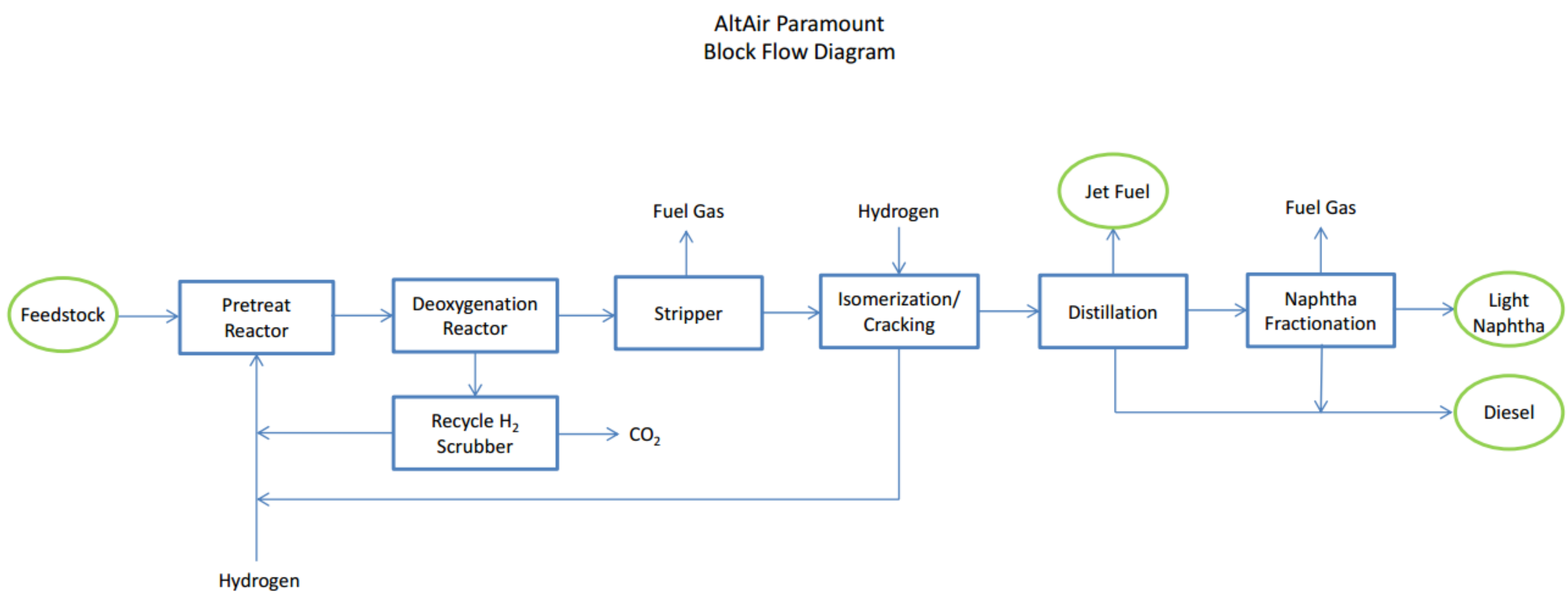
During the renewable fuel co-processing operation, the renewable feedstock passes through multi-stage filters to remove insoluble materials which could cause plugging in the reactor bed. The renewable material is mixed with hydrogen for processing within the hydrotreater unit. The feedstock reacts with the hydrogen over a catalyst bed in the reactor. The purpose of the hydrotreating process is to saturate the fuel products and remove objectionable elements. The elements removed are sulfur, nitrogen, oxygen, and trace metals. The finished renewable diesel is then marketed and can be optionally mixed with other low-sulfur distillate streams or biodiesel before use in vehicles.

Renewable propane fuel mix is produced in the reaction that converts the triglyceride molecule into renewable diesel fuel molecules. Currently, the fuel gas produced is combusted to generate process heat for the AltAir process and some is exported for legacy refinery fuel and therefore does not provide co-product credit. Moreover, its combustion emissions are included in the analysis. To model this, the amount of propane produced was added to the bdrd-calculator as LPG input under the alternative fuel produced and its corresponding upstream emissions for LPG were extracted from CA_GREET3.

Process Flow Diagram

The process flow diagram for the production process is shown in Figure 2.

Figure 2. Paramount Refinery Process Flow Diagram



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3. Result Summary

The WTW results for AltAir Paramount's RD from US standard tallow, JBS Brooks low energy tallow, Generic Australia tallow, JBS Greeley tallow and JBS Hyrum are 37.14, 25.10, 42.93, 23.93 and 19.56 g CO_2e/MJ, respectively. The life cycle carbon intensity includes the WTT and TTW emissions presented in Table 2. TTW emissions include vehicle methane and N_2O emissions. The WTT emissions include the feedstock production and fuel production phases. There are no indirect land use impacts from tallow renewable diesel production because animal tallow is a waste product. No denaturant is used and Indirect Land Use change (LUC) emissions are zero.

Table 2. Total Carbon Intensity for Paramount Refinery Tallow to Renewable Diesel, Alternative Jet Fuel, and Renewable Naphtha (g CO_2e/MJ)

Phase	US Std. Tallow	JBS Brooks Tallow	Generic Aus. Tallow	JBS Greeley Tallow	JBS Hyrum Tallow
Feedstock CI	19.62	7.57	25.40	6.26	2.32
Total Fuel CI	16.75	16.75	16.75	16.91	16.48
Total Tank-to-Wheel	0.76	0.76	0.76	0.76	0.76
Denaturant	0	0	0	0	0
Indirect Land Use	0	0	0	0	0
Total Well-to-Tank CI, g/MJ	37.12	25.08	42.91	23.93	19.56

The following sections describe the fuel pathway inputs, data sources and detailed results for each GHG pollutant.

4. Process Inputs and Yields

Energy inputs to the AltAir Paramount refinery provide the basis for the calculation of GREET inputs. The refinery energy inputs are allocated to products by energy content. The basis for the calculation and source of inputs is described for each key input below.

The AltAir facility tracks the data from sales/purchase receipts as well as inventory control through tank gauging systems and operational flow meters. Data for electricity, natural gas and hydrogen use are based on the respective purchase receipts/reports. A sales/purchase report is the aggregated summary of multiple sales/purchase invoices in monthly periods. Tallow and renewable diesel are based on the combination of operational flow meters and storage tank gauge measurements which are verified at the end of every month. The tallow and RD data are also supported by their purchase/sales report. The data for the fuel gas produced and the portion of it exported to the H-402 heater in the legacy refinery is measured by gas chromatograph composition and flow meter. The data sources for the different material flows are summarized in Table 3. More details about specific material flow are provided in the following sections.

All of the data logger measurements are used in MRR reporting to the ARB for AB32 compliance. Thus, the flow rate measurements have already been reviewed and deemed acceptable by ARB. Each series of data is provided in a separate spreadsheet and summarized in one file.

Table 3. Data sources for material flows

Input	CI Calculator Tab	CI Calculator Field	Data Source	Data File	Data Tab	Cell
Electricity	RD-Production	2.13	Purchase receipts	Electric invoices (pdf, monthly)		
Natural Gas	RD-Production	2.12	Purchase receipts	Natural Gas invoices (pdf, monthly)		
Hydrogen	RD-Production	2.15	Purchase receipts report	XXX (xlsx)	March 2020, April 2020, May 2020	F5010, F5122, E5245
Beginning North American Tallow Inventory	Tallow 1	3.2	Feed Tank 80003 gauging	WE Paramount Fluid MMYY (xlsm, monthly)	MTD	P80
North American Tallow Received	Tallow 1	3.3	Shipping BOLs	AltAir Feedstock Receipts 2016-2020 Update Aug 2 (xlsx)	North American Tallow	B67-B69
Ending North American Tallow Inventory	Tallow 1	3.5	Feed Tank 80003 gauging	WE Paramount Fluid MMYY (xlsm, monthly)	MTD	X80
North American Tallow Transport Distance by Rail	Tallow 1	3.9	Weighted Average Rail Distance	AltAir Feedstock Receipts 2016-2020 Update Aug 2 (xlsx)	North American Tallow	E67-E69
Brooks Low Energy Tallow Received	Tallow 2	3.3	Shipping BOLs	AltAir Feedstock Receipts 2016-2020 Update Aug 2 (xlsx)	Brooks Low Energy Tallow	B46-B48

Generic Australian Tallow Received	Tallow 3	3.3	Shipping BOLs	AltAir Feedstock Receipts 2016-2020 Update Aug 2 (xlsx)	Dinmore Australian Tallow	B36-B37
Greeley, Colorado Tallow Received	Others 2	3.3	Shipping BOLs	AltAir Feedstock Receipts 2016-2020 Update Aug 2 (xlsx)	Greeley, Colorado Tallow	B65-B67
Hyrum, Utah Tallow Received	Others 3	3.3	Shipping BOLs	AltAir Feedstock Receipts 2016-2020 Update Aug 2 (xlsx)	Hyrum, UT	B53-B55
Ren. Diesel	RD-Production	2.8, 2.10, 2.11	Begin Inv., End Inv. and sales report	WE Paramount Fluid MMYY (xlsm, monthly)	MTD	P60, X60, W60
LPG/Fuel gas produced	RD-Production	2.14	Gas chromatograph, flow meter	CARB Fuel Gas Data 2019-20 gwg (xlsx)	Sheet1	AM460, AM490, AM521
Fuel gas export to H-402	RD-Production	2.16	Gas chromatograph, flow meter	CARB Fuel Gas Data 2019-20 gwg (xlsx)	Sheet1	AN460, AN490, AN521
Ren. Jet	RD-Production	2.17	Flow meter, tank gauging	WE Paramount Fluid MMYY (xlsm, monthly)	MTD	T24
Ren. Naphtha	RD-Production	2.19	Flow meter, tank gauging	WE Paramount Fluid MMYY (xlsm, monthly)	MTD	T69

Allocation factor

As the facility co-produces three different products namely renewable diesel (RD), renewable naphtha (RN), and renewable jet fuel (RJ) from the same feed blend, only a part of the energy and material consumption should be allocated to RD to calculate its carbon intensity justifiably. This allocation is done using the respective energy content proportion of the three aforementioned co-products processed at the facility which is the default GREET method.

In the calculation of the carbon intensity of RD pathway, GREET model assumes the production of liquid products with only one co-product, LPG, which generates credits. The allocation of credits to the RD is based on energy. The GREET model assumes the fuel to be composed 100% of RD. However, in practice, the hydrotreating process used to produce RD also produces other co-products, for example renewable naphtha (RN) and renewable jet fuel (RJ).

The fuel yield value, the input in GREET, is calculated as the inverse of feedstock use rate in pounds per pound of fuel produced. With the additional inputs of the co-product yield (lb/lb RD), GREET allocates a percent of system energy inputs to the RD using a calculated allocation factor. The allocation factor is the proportion of the energy content of the fuel produced with the total products produced, which is the sum of fuel and co-products produced. The formulas for fuel yield and allocation factor are as follows:

$$GREET\ Input = Fuel\ Yield\ (lb\ fuel\ /\ lb\ rendered\ fat) = \frac{1}{\frac{Feedstock\ used\ (lb)}{Fuel\ produced\ (lb)}} \quad (1)$$

$$\text{Allocation factor} = \chi = \frac{Fuel\ produced\ (Btu)}{Fuel\ produced\ (Btu) + \sum coproduct\ produced\ (Btu)} \quad (2)$$

$$Where, \quad coproduct\ (Btu) = production\ (lb) \times energy\ density\ (Btu/lb) \quad (3)$$

Depending on the classification of RD, RN and RJ as fuel or co-product, there are multiple methods of accounting of credits. This analysis considers RD to be the only fuel product while RN, and RJ are considered to be co-products. The feedstock use rate calculation uses the energy content of RD as the total fuel energy produced. In the allocation factor, the numerator is equal to the energy content of RD and denominator is equal to the total energy content of RD + RJ+ RN.

The inputs into the GREET are the values before any allocation is done as GREET model applies the allocation factor to the inputs including the yield and energy inputs. The allocation factor calculation is as follows:

$$\chi_N = \frac{RD(MMBtu)}{RN\ (MMBtu)\ +\ RD\ (MMBtu) +\ RJ\ (MMBtu)}$$
$$= \frac{1{,}155{,}460}{21{,}316\ +\ 1{,}155{,}460\ +\ 82{,}094}$$
$$= \mathbf{91.79}\%$$

Effectively, the CI contribution from a given resource is calculated as shown below:

$$GREET\ Emission = \frac{Fuel\ (Btu)}{Fuel\ (Btu) + Co - products\ (Btu)} \times \frac{Resource\ used}{Fuel\ (lb)} \times E_F$$
$$where\ E_F = GREET\ Emission\ Factor$$

The first part of the equation represents the allocation factor, second represents the GREET input (pre-allocation values) and third the emission factor built into GREET model. The allocation factor is based on energy while the GREET input is based on the proportion of resource used to mass of the fuel product. Because of this combination of both mass and energy proportions, the post allocation GREET inputs and subsequently the GREET emissions result in a small variation when comparing the above described methods.

Note that the CI for RN and RJ are the same as that for RD when the above equations are changes such the RN or RJ become the primary products. The allocation factor is different for each product, but the emissions effectively become:

$$E_k = \frac{TotalEmissions\ (g)}{RN\ (MMBtu)\ +\ RD\ (MMBtu) +\ RJ\ (MMBtu)}$$

5. Feedstock Phase

Tallow Collection and Rendering

As previously mentioned, the AltAir Paramount facility processes five categories of animal tallow. The data for the amount of tallow used is based on the net consumption incorporating the change in the inventory (measured by flow meters and tank gauge measurements) as well as the tallow amount purchased/received. This tracking is validated monthly by manual tank gauge verification. The tallow amount received is based on the bills of lading as reflected by the receipts sheet on the AltAir Fluid report.

During the study period, Altair received its tallow via rail and truck from the Port of Long Beach The beginning inventory, ending inventory and tallow received is specified in the monthly WE Paramount Fluids report. The received tallow adjusted by the inventory changes provides the tallow consumed by AitAir facility. Based on the tallow source location as per feedstock receipts, the tallow received is classified as:

- US standard
- JBS Low Energy Brooks, CA,
- Generic Australian,
- JBS Greeley, Colorado tallow, and
- JBS Hyrum, Utah tallow.

For accounting simplification, because of the large volumes, the month ending inventory is assumed to be all US standard tallow and all monthly receipts of other tallow sources are assumed to be converted into products during each month.

6. Source: “Paramount Renewable Fuels Production Report” in WE Paramount Fluid XXXX.xlsm (monthly) and “AltAir Feedstock Receipts 2016-2020 Update Aug 2.xlsx”

US Standard Tallow

Animal tallow is collected from animal processors with on-site rendering facilities. Inputs are based on the CA GREET 3.0 Tier 1 defaults for all aspects of tallow rendering phase inputs. The total energy input for the tallow rendering is 3,944 Btu/lb as per the tier 1 default values. The fuel shares during the tallow rendering phase are also based on the tier 1 values.

All U.S. tallow is sourced and transported by rail cars. Tallow is imported from a weighted average distance of about XXXX miles (by rail cars) which varies from month to month. This monthly weighted calculated distance is used in this analysis.

JBS Brooks, Canada Low Energy Tallow

JBS low energy tallow is rendered by JBS at their beef processing facility in Brooks, Alberta, Canada and imported into the AltAir Paramount facility via rail. The rail distance is 2037 miles. JBS has performed its energy use and CI analysis using internal process-based allocation for its use in the application. The analysis covers the time period from Jan 2018 to May 2019 (17 months) which makes the results more reliable than a 3-month average based on the application period. The analysis calculates the GHG emissions using XXXXX of the facility. The allocation methodology is based on their internal energy intensity study from July 2016 (Please refer to Brooks Tallow CI Calculation Summary spreadsheet). The analysis and supporting documentation are submitted to ARB along with this application.

Generic Australian Tallow

AltAir Paramount facility also imports beef tallow from Australia. The rendering inputs for this tallow are based directly on the standard US tallow rendering inputs as per CA_GREET3.0. The electricity used in the rendering process, however, is modified to use Australia’s specific grid mix.

As the tallow is rendered in various parts of Australia, a country specific electricity grid is considered for rendering. The bdrd-calculator reflects the direct GHG emission factor of 850.80 g CO_2e/kWh for the Australian grid mix as specified by Australian Energy Update 2018 report (Department of the Environment and Energy, 2018a). The electricity mix included in the said report is show below in Figure 3.

	2016–17		*Average annual growth*	
	GWh	share (per cent)	2016–17 (per cent)	10 years (per cent)
Fossil fuels	**217,562**	**84.3**	**-0.8**	**-0.3**
Black coal	118,272	45.8	3.5	-1.0
Brown coal	43,558	16.9	-10.7	-2.5
Gas	50,460	19.6	-0.2	4.2
Oil	5,273	2.0	-6.8	3.0
Renewables	**40,455**	**15.7**	**6.1**	**8.2**
Hydro	16,285	6.3	6.3	3.4
Wind	12,597	4.9	3.3	16.9
Bioenergy	3,501	1.4	-7.6	-3.0
- bagasse	1,435	0.6	-20.7	na
- wood, woodwaste	355	0.1	42.7	na
- municipal, industrial waste	76	0.0	76.9	na
- sulphite lyes, biofuels	442	0.2	6.2	na
- landfill biogas	970	0.4	-8.6	na
- sludge biogas	223	0.1	5.6	na
Solar PV	8,072	3.1	18.0	59.2
- small scale	7,399	2.9	16.0	57.7
- large scale	672	0.3	47.1	na
Geothermal	1	0.0	133.3	na
Total	**258,017**	**100**	**0.2**	**0.7**

Figure 3. Australian National Average Electricity Grid mix for 2017

The electricity mix from the report was plugged in CA_GREET3 and the results of the electricity CI as well as tallow CI (using said electricity mix) were extracted for use in the bdrd-calculator. However, the cell containing the electricity EF value in the bdrd-calculator does not affect the CI of the tallow or the pathway.

The tallow is rendered primarily in Queensland, Australia, with smaller portions from the states of New South Wales and Victoria. Table 4 below shows the electricity emission factors for different regions in Australia from the Australian national emissions report (Department of the Environment and Energy, 2018b)). The table excludes the western Australian region. However, this pathway uses the national average grid mix as described to avoid regional bias in data.

The bdrd-calculator reflects the electricity GHG emission factor of 0.851 kg CO_2e/kWh for the Australian grid mix and tallow CI of 336.27 g CO_2e/lb. However, it should be noted that the cell containing the electricity EF value does not affect any calculation in the spreadsheet, the tallow CI is directly used in RD CI calculations instead.

Table 4. Australia Power Grid Carbon Intensity

	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
State, Territory or grid description	**Emission factors kg CO2-e/kWh**								
New South Wales and Australian Capital Territory	0.89	0.9	0.89	0.87	0.86	0.84	0.84	0.83	0.82
Victoria	1.22	1.23	1.21	1.17	1.18	1.09	1.13	1.08	1.07
Queensland	0.91	0.89	0.88	0.82	0.81	0.78	0.79	0.79	0.8
South Australia	0.84	0.72	0.68	0.62	0.61	0.53	0.56	0.49	0.51
South West Interconnected System in Western Australia	0.87	0.82	0.8	0.78	0.76	0.72	0.76	0.7	0.7
Tasmania	0.12	0.32	0.3	0.2	0.2	0.12	0.12	0.14	0.19
Northern Territory	0.69	0.68	0.67	0.69	0.68	0.67	0.67	0.64	0.64
Average (ex Western Australia)	**0.78**	**0.79**	**0.77**	**0.73**	**0.72**	**0.67**	**0.69**	**0.66**	**0.67**

Information from http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/nger/technical-guidelines

The Australian tallow transport information is detailed in the "STG Sustainability Declaration with Trucking Distances- May 2019.xlsx" included in the application packet. The tallow requires truck transportation from the various rendering facilities in Australia to ports (XXXXXXX) as shown in Table 5 below before a final ocean vessel leg of 11,558 kilometers (7,182 miles) and 13,600 miles (8,451 miles) from XXXX to Long beach port respectively. This trip is followed by a 14-mile truck delivery from the XXXX Terminal at the port of Long Beach to the Paramount refinery.

The Australian tallow sources for a recent May 2019 shipment to Long Beach on the XXXX deadweight ton (DWT) vessel XXXX are listed in Table 5 below. A tanker vessel size of XXXX DTW is used in the application for a conservative number to represent the average vessel size. Australian tallow is also transported in a containerized format, either ISO Tank or Flexi Tank, exported on fixed regular service vessels to the West Coast of the United States. Container vessels loading in XXXX, Australia are typically XXXXX DWT in size, however two recent shipments were onboard the XXXX DWT vessel XXXX. The EF for a XXXX DTW vessel is calculated using the CA_GREET3 as 19.42 g CO_2e/ton-mile. These tallow sources and vessel size are typical and representative of future shipments. The weighted average trucking distance in Australia was XXX miles to port in XXX and XXX miles in XXX. The weighted average of the two is XXX miles, which is then added to the California trucking distance. Combined, this average trucking distance is XXX miles and the weighted average vessel distance is XXXX miles.

Table 5. Typical Generic Australian tallow source information

Name of the point of origin	Location of the point of origin (city, country)	Quantity (mt) and date of delivery	Name and certificate number of the warehouse	Location of the warehouse before shipment (city, country)	Distance (km)	
					Truck	Vessel
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX		XXXX	XXXX			
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Name of the point of origin	Location of the point of origin (city, country)	Quantity (mt) and date of delivery	Name and certificate number of the warehouse	Location of the warehouse before shipment (city, country)	Distance (km)	
					Truck	Vessel
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXXX	XXXX	XXXX	XXXX			

(Source: “STG Sustainability Declaration with Trucking Distances- May 2019.xlsx”)

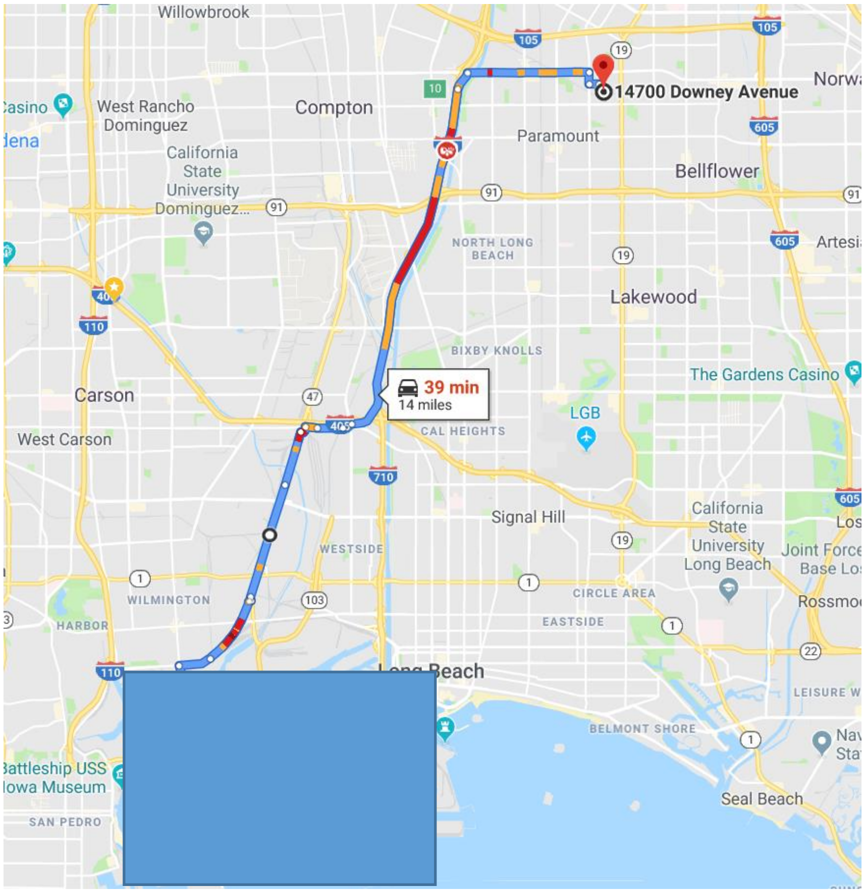

Figure 4. Route of Trucked Tallow from Port of Long Beach to Paramount Refinery

JBS Greeley, Colorado Low Energy Tallow

This tallow is sourced from the rendering facility at the JBS Greeley, Colorado meat packing plant and transported by rail 1308 miles to the Paramount, CA renewable fuel processing facility.

JBS Hyrum, Utah Low Energy Tallow

This tallow is sourced from the rendering facility at the JBS Hyrum, Utah meat packing plant and transported by rail 882 miles to the Paramount, CA renewable fuel processing facility.

The following table summarizes the five tallow categories.

Table 6. Feedstock summary information

Data	US Std.	Brooks, Alberta, CA JBS (Low energy)	Generic Australian JBS	Greeley, Colorado JBS (Low energy)	Hyrum, Utah JBS (Low energy)
Energy inputs	GREET	Invoices	GREET	Invoices	Invoices
Production output	n/a	Invoices	n/a	Invoices	Invoices
Allocation to meal	GREET default	Steam flow for meat processing	GREET default	Steam flow for meat processing	Steam flow for meat processing
Energy Intensity (Btu/lb)	3,944	1,192	3,944	1,095	398
Electricity EF	GREET: US avg	Canada NIR: Alberta	Australia mix	GREET: RMPA Mix	GREET: NWPP Mix
Rendering EF Basis	GREET Default	JBS Analysis	GREET Default	JBS Analysis	JBS Analysis
Rendering EF Value (g CO_2e/lb)	303.82	96.12	336.27	84.68	26.92

6. Fuel Phase

Renewable Diesel Production

The life cycle emissions from the fuel production phase are calculated using the CARB developed Tier 1 bdrd-calculator. The total energy inputs at the fuel production facility as well as the total amount of RD and co-products manufactured at the facility are used as direct inputs for the model.

Tallow Yield

Tallow yield is based on the aggregate feedstock input. The facility achieves a yield of 1.315 lb feed/ lb RD

$$Y_T = \frac{\sum(lb\ Tallow\ )}{(lb\ renewable\ diesel)} = 1.315\ \ lb\ feed\ /\ lb\ fuel$$

The tallow use rate value determines the RD yield (lb fuel/lb fat rendered) in conjunction with the energy-based allocation factor. This value represents the post allocation system input in GREET.

$$RD\ Yield\ (lb\ fuel/rendered\ fat) = \frac{1}{Tallow\ \ Yield} \times \frac{1}{\chi} = \ 0.761\ lb\ RD/lb\ Tallow$$

The tallow to RD yield is consistent with dedicated hydrotreating as well as the refinery operation data. All of the tallow is converted to either RD, RJ, naphtha or propane. A small amount of slop production is also observed, all of which is subsequently fed back as feed. Since no unconverted tallow is observed, the mass yield of 0.761 lb RD/lb tallow (post allocation) is a reasonable GREET input.

Fuel Gas

A number of combustion sources provide process heat at AltAir's bio-refinery. These include natural gas, electricity and hydrogen. Fuel gas (LPG) produced at the facility is also used as a source of process heat for the facility and therefore is also associated with the production of RD. The amount of fuel gas produced is based on the measurement of a real-time flow meter installed at the facility.

The fuel gas produced is fed to two process heaters H-501 and H-502 used by the AltAir facility and a H-402 incinerator used by the legacy refinery. The heater H-402 is operated irrespective of the operation of the AltAir facility and has been in operation for many years. The H-402 incinerator is considered an export of fuel gas since it's operation is a requirement and a result of the legacy refinery operation that left a plume of hydrocarbon contaminated groundwater underneath the refinery property that must be recovered from recovery wells and the hydrocarbons incinerated.

All three of these heaters are also capable of using natural gas along with fuel gas. The use of fuel gas in these heaters substitutes for the natural gas purchased. For the H-501 and H-502, the reduced use of natural gas is represented by the included natural gas purchase data. However, the amount of natural gas substituted in the H-402 is incorporated in the analysis by including a natural gas credit for an equivalent amount of energy on LHV basis. This calculation is already set up in the bdrd-calculator. None of the fuel gas is flared under normal operating conditions.

The fuel gas drum that distributes to the heaters and incinerator has an online Gas Chromatograph with flow meter installed to monitor the composition, flow rate and physical properties of fuel gas produced as well as sent to H-402. The monthly fuel gas exported to H-402 ranges between 291,000 and 303,000 lb per month during normal operation. The volume of fuel gas exported to H-402 as measured by gas chromatograph is converted to lb before use in this analysis. The typical composition of fuel gas as measured by the gas chromatograph is shown below.

Table 7. Typical fuel gas composition

Compound	Formula	MW	Volume %	Mass %	LHV (Btu/lb)
Hydrogen	C0H2	2.02	25.11%	1.94%	51,585

Methane	C1H4	16.04	35.87%	22.06%	21,501
Ethane	C2H6	30.07	4.29%	4.94%	20,426
Propane	C3H8	44.10	21.80%	36.84%	19,918
n-butane	C4H10	58.12	3.08%	6.87%	19,657
isobutane	C4H10	58.12	3.66%	8.16%	19,589
n-pentane	C5H12	72.15	0.77%	2.12%	19,495
isopentane	C5H12	72.15	1.57%	4.34%	19,304
C6	C6H14	86.18	3.86%	12.74%	19,232
Total		**45.68**	100.00%	100.00%	**20,739**

The emissions from the combustion of all of the fuel gas in process heaters are also incorporated in the RD production emissions. The emission factor for the renewable fuel gas was calculated in CA-GREET3.0. For the emissions modelling, the upstream contribution and the contribution of biogenic carbon content (CO, VOC and CO_2) was omitted. The resulting emissions included emissions in the form of N_2O and CH_4.

Natural Gas

Purchased natural gas provides incremental fuel for the fuel gas system. The natural gas is associated with all the refined products. The gas is allocated to the RD product using the previously mentioned allocation factor. Data for the gas use is based on the AltAir facility's monthly invoices supported by flow meters.

Source: Natural Gas Bill Invoices (monthly)

Electric Power

As the purchased electric power is distributed to the entire facility, the power is associated with all the refined products. The amount of electricity allocated to the renewable diesel is based on the allocation factor. Data for power are based on Paramount facility's electricity invoices. The energy inputs for electric power are:

$$E_e = \frac{Electric\ power\ (Btu)}{RD\ (lb)}$$

$$Such\ that, \qquad E_e = \frac{XXX\ \ kWh\ \times\ 3{,}412\ Btu/kWh}{XXX\ lb} = XXX\ Btu/lb\ RD$$

Source: Electricity Invoices (monthly)

The life cycle GHG emissions are then multiplied by the allocation factor for RD. As discussed previously, the CI for each fuel is the same with this approach.

Hydrogen

Liquid hydrogen is purchased from a Praxair facility in Ontario, CA. The amount of Hydrogen used in this analysis is based on the purchase invoices of Hydrogen for each month. Its volume purchased is reported in standard cubic feet (scf) at 70 °F per industry standard. The bdrd-calculator input for hydrogen is at 32 °F. The following formula is used to correct the density in the bdrd-calculator for the temperature difference. The temperature correction factor is calculated on the Fuel_specs sheet in the bdrd-calculator. The calculated value is then used on the RD-productions sheet to correct the raw H_2 inputs at 70F.

$$E_{HC} = Corrected\ H2\ LHV = LHV_{32F} \times \frac{Density_{70}}{Density_{32}}$$
$$= 290 \times \frac{0.0834}{0.0888} = 290 \times 0.9392 = 272\ Btu/ft^3$$

Where, E_{Hc} is the temperature corrected Hydrogen LHV in Btu/scf

The bdrd-calculator is modified to replace the gaseous hydrogen's emission factors with liquid hydrogen specific emission factors including the transport distance of 39 miles as shown below via truck. This emission factor calculation was performed in CA-GREET3.0.

Figure 5. Liquid hydrogen transport from XXX facility in XXX, CA to AltAir

Source: "Delivered Cubic feet Volume" in XXX.xlsx

Chemicals

The production process utilizes small quantities of a few chemiclas including dimethyl disulfide (DMDS). The use rate and its corresponding GHG emissions were calculated as part of the previous iteration of application, under the older LCFS regulation using CA-GREET 2.0. However, under the 2019 regulation, following the simplified bdrd-calculator developed by ARB, the life cycle impact from chemical use has been fixed to a static value and added to all RD pathways, thereby not requiring producer specific chemical inputs. Therefore, the life cycle impact of the chemical use at the facility is not separately incorporated in this lifecycle analysis report.

Data Aggregation

The facility burns natural gas for process heat and draws on grid power for electrical needs. A copy of the process heat fuel supply plan is provided in the RFS2 Engineering report for review. Electricity and natural gas usages are calculated from monthly utility bills. All of the data provided in this analysis is based on Paramount's own data collection and record keeping. The flow rates of natural gas, fuel gas, tallow, vegetable oils, RD, and other refined products are carefully calibrated and tie to an inventory control system. In addition, the same data logger measurement systems are used for Paramount's AB 32 mandatory reporting, which is approved by ARB. All of the flow meters meet accuracy and collaboration requirements that are consistent with this regulation, as demonstrated through positive third-party verification statements by MRR.

The attached bdrd-calculator file contains all the aggregated monthly data used in the analysis. The file represents the 3 months of historical data including March, April, and May 2020 for the Paramount facility.

Co-Products

As previously mentioned, there are two co-products refined along with RD namely, renewable jet fuel, renewable naphtha, and additionally a propane fuel mix. The typical composition of the naphtha produced at the facility is shown below.

Table 8. Typical Naphtha composition

Compound	Formula	Volume %	Mass %	MW	Density (lb/gal)	LHV (Btu/lb)
n-butane	C4H10	0.24%	0.21%	58.12	4.87	19,657
isobutane	C4H10	0.33%	0.28%	58.12	4.69	19,589
n-pentane	C5H12	5.91%	5.54%	72.15	5.26	19,495
isopentane	C5H12	13.88%	12.88%	72.15	5.21	19,304
n-hexane	C6H14	7.47%	7.36%	86.18	5.53	19,232
C6 Iso-paraffins	C6H14	23.12%	22.73%	86.18	5.52	19,201
C6 Naphthenes	C6H12	0.48%	0.54%	84.16	6.41	18,722
n-heptane	C7H16	5.18%	5.29%	100.20	5.74	19,158
C7 Iso-paraffins	C7H16	20.82%	21.35%	100.20	5.76	19,134
C7 Naphthenes	C7H14	0.09%	0.10%	98.19	6.28	18,738
n-octane	C8H18	2.70%	2.84%	114.23	5.89	19,098
C8 Iso-paraffins	C8H18	15.97%	16.83%	114.23	5.92	19,078
C9 Iso-paraffins	C9H20	3.81%	4.06%	128.26	5.99	19,020
Total		100.00%	100.00%	**94.42**	**5.63**	**19,184**

7. Renewable Diesel Transport and Distribution

Paramount's Refinery Facility is equipped with an onsite truck loading terminal. Since the fuel is marketed locally, the transport distance to blending terminals is zero miles. The transportation distance to fuel stations is set at 50 miles which is also the GREET default.

Figure 6. Google Map Image of Paramount Refinery and Fuel Loadout Terminal

8. Life Cycle Results

The life cycle energy and greenhouse gas emission results for Paramount's renewable diesel production are shown below. The calculations were performed using the ARB bdrd-calculator. The complete data set for feedstock, RD production, transport and distribution as well as the total WTW emissions are presented in Table 9.

Table 9. BDRD-Calculator Results for Tallow Based Renewable Diesel (Btu/MMBtu and g/MMBtu)

Standard U.S. Tallow		Brooks, Alberta, Canada Tallow		Generic Australian Tallow	
RD from Tallow 1, gCO_2e/MJ	**37.12**	**RD from Tallow 2, gCO_2e/MJ**	**25.08**	**RD from Tallow 3, gCO_2e/MJ**	**42.91**
Feedstock Production, gCO_2e/MJ	*19.62*	Feedstock Production, gCO_2e/MJ	*7.57*	Feedstock Production, gCO_2e/MJ	*25.40*
Fuel Production, gCO_2e/MJ	*16.75*	Fuel Production, gCO_2e/MJ	*16.75*	Fuel Production, gCO_2e/MJ	*16.75*
Indirect Land Use, gCO_2e/MJ	*0.00*	Indirect Land Use, gCO_2e/MJ	*0.00*	Indirect Land Use, gCO_2e/MJ	*0.00*
Tailpipe Emissions, gCO_2e/MJ	*0.76*	Tailpipe Emissions, gCO_2e/MJ	*0.76*	Tailpipe Emissions, gCO_2e/MJ	*0.76*
JBS Greeley Tallow		**JBS Hyrum Tallow**			
RD from Tallow 5, gCO_2e/MJ	**23.93**	**RD from Tallow 6, gCO_2e/MJ**	**19.56**		
Feedstock Production, gCO_2e/MJ	*6.26*	Feedstock Production, gCO_2e/MJ	2.32		
Fuel Production, gCO_2e/MJ	*16.91*	Fuel Production, gCO_2e/MJ	16.48		
Indirect Land Use, gCO_2e/MJ	*0.00*	Indirect Land Use, gCO_2e/MJ	0.00		
Tailpipe Emissions, gCO_2e/MJ	*0.76*	Tailpipe Emissions, gCO_2e/MJ	0.76		

9. References

ARB (2009) Default LCFS pathway for Tallow Based Renewable Diesel

Department of the Environment and Energy. (2018a). Australian Energy Update 2018, (August), 32. Retrieved from https://www.energy.gov.au/sites/default/files/australian_energy_update_2018.pdf

Department of the Environment and Energy. (2018b). *Australian National Greenhouse Accounts Factors*. Retrieved from https://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-july-2018

JBS. (2018). Co-Product Credit Documentation for Low Carbon Tallow Rendering in the California ARB Low Carbon Fuel Standard Program.

10. Acronyms

Btu:	British thermal units
CO_2e:	Carbon dioxide-equivalent
HHV:	Higher heating value
kWh:	kilowatt-hour
LHV	Lower heating Value
MMBtu:	Million British thermal units
scf:	Standard cubic feet (natural gas)
DMDS:	Dimethyl disulfide
RD:	Renewable diesel
RJ:	Renewable Jet
LPG:	Liquid petroleum gas

11. Supporting Documents

- "Air Quality Permit"

Air quality permits are available for the entire Paramount refinery.

- "Electricity, Hydrogen and Natural Gas Invoices"

3-month invoices for electricity and natural gas are provided. Invoiced power provides the basis for power consumption.

- "Praxair -1.xlsx"

An aggregated report presenting the Hydrogen purchased and received by AltAir. Each individual shipment is represented by an individual row populated with all the shipment related details including the date and amount received.

- "WE Paramount Fluids MMYY.xlsm (monthly)"

A monthly report prepared by Alt Air tracking the flow meter, tank gauge measurements and shipments of all of its fluid feedstock and products including tallow, RD, RJ and RN. The report includes the daily production data including the amount of feedstock used and the products produced. The report also includes the details of all the tallow and RD shipment records with each receipt represented in an individual row.

- "CARB Fuel Gas Data 2019-20 gwg.xslx"

An aggregated report prepared by Alt Air daily tracking the production, flow, composition and distribution of the propane fuel mix measured by gas chromatograph and flow meter. The report includes the daily amount (lb) of propane fuel mix produced as well as the amount (lb) sent to the H-402 heater offsetting NG use in H-402.

- "AltAir Feedstock Receipts 2016-2020 Update Aug 2.xslx"

An aggregated report prepared by Alt Air summarizing all the tallow purchase transactions over the application period. The details include the source of tallow allowing the separation of the types of tallow in the total tallow received.

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