TALLOW BIODIESEL INFORMATION FOR CARB
REVISION 2

Prepared For:

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EXECUTIVE SUMMARY

The production of biodiesel from animal tallow is a commercial process in California. In order for the fuel to be used in the California Low Carbon Fuel Standard program it needs an approved carbon intensity. CARB has developed CI values for several biodiesel products made from different feedstocks. They have also developed a CI for renewable diesel produced from tallow. All of the information is therefore already available for calculating a CI.

As part of the work in developing the tallow RD CI, CARB developed a tallow biodiesel pathway in the GREET model. This was a working model at ARB and was not released to the public. ARB made this model available to the NBB for the development of this pathway. That pathway has been used to develop the CI for tallow biodiesel.

Two production scenarios are investigated. In the first production system tallow is produced in the Midwest and transported to California for biodiesel production. This is the same assumption used in the renewable diesel pathway.

The well to wheel emissions calculated are shown in the following table.

Table ES- 1 Lifecycle CI Results for Tallow Biodiesel – California Production

Stage	Emissions, g CO_2eq/MJ
Rendering	28.11
Tallow Transport	1.52
Biodiesel Production	4.89
Biodiesel Transport	0.76
Total Tank to Wheel	35.28
Vehicle Operation	4.45
Total	39.73

It is concluded that tallow biodiesel produced in California should have a CI of 39.73. This is very close to the 39.33 g/MJ value for the tallow renewable diesel pathway. This is expected as the soybean biodiesel and soybean renewable diesel pathways are also very close.

In the second production scenario investigated the biodiesel production is outside of California. The primary difference in this pathway is the carbon intensity of the electricity production for the biodiesel production stage, which would be the US average instead of the California marginal mix. There are also small differences in the transportation emissions. The well to wheel emissions calculated are shown in the following table.

Table ES- 2 Lifecycle CI Results for Tallow Biodiesel – US Production

Stage	Emissions, g CO_2eq/MJ
Rendering	28.11
Tallow Transport	0.47
Biodiesel Production	5.20
Biodiesel Transport	1.95
Total Tank to Wheel	35.73
Vehicle Operation	4.45
Total	40.18

It is concluded that tallow biodiesel produced outside of California should have a CI of 40.18 g CO_2eq/MJ.

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1. INTRODUCTION

The California Air Resources Board has developed carbon intensity factors for a number of renewable fuel production pathways for their Low Carbon Fuel Standard program. These pathways include several biodiesel pathways (soybean oil, canola oil, used cooking oil) and several renewable diesel pathways (soybean oil, tallow). One commercial pathway that is not included in the current look-up table is tallow biodiesel.

The National Biodiesel Board has filed a 2B application with CARB for the recognition of this pathway. This document provides information on the process and GREET modelling results for a tallow biodiesel pathway. CARB has developed a tallow to biodiesel pathway in a working version of the GREET model but that model has not been released to the public. CARB did make that model available to the NBB for the purpose of completing this application.

The specific approach taken for this work to use the following CA GREET inputs data:

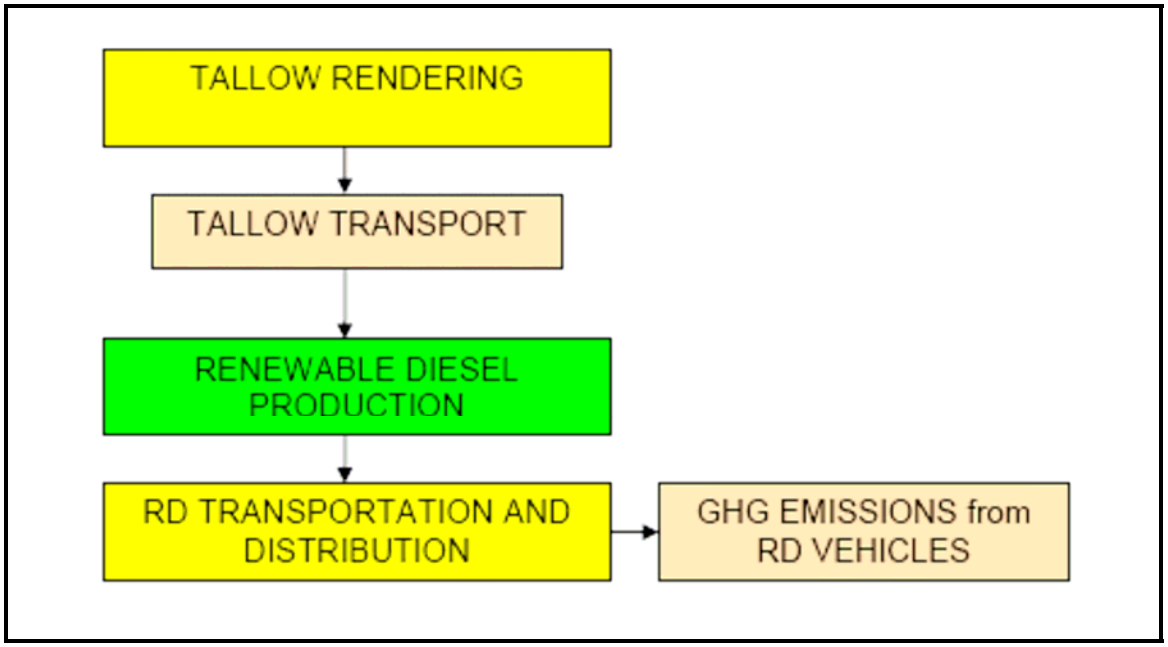
Table 1-1 CA-GREET Input Data

Activity	Value	Units or comments
Tallow rendering	6,026	(Btu/lb. of tallow)
Tallow transesterification	2,116	(Btu/lb. of biodiesel)
Tallow use:	1.04	lbs. tallow/lb. biodiesel
Glycerine production	0.105	Lb/lb Biodiesel
	Energy content	Market value
Biodiesel	16,149	BTU/lb
Glycerine	7,979	BTU/lb
Tallow Transportation	10	Miles by MDT to rail yard
	1400	Rail to California
Biodiesel Transportation	50	Miles by HDDT to blending stations
	90	Miles by HDDT to refuelling stations
	20%	Biodiesel goes direct to refuelling stations

2. TALLOW BIODIESEL PROCESS

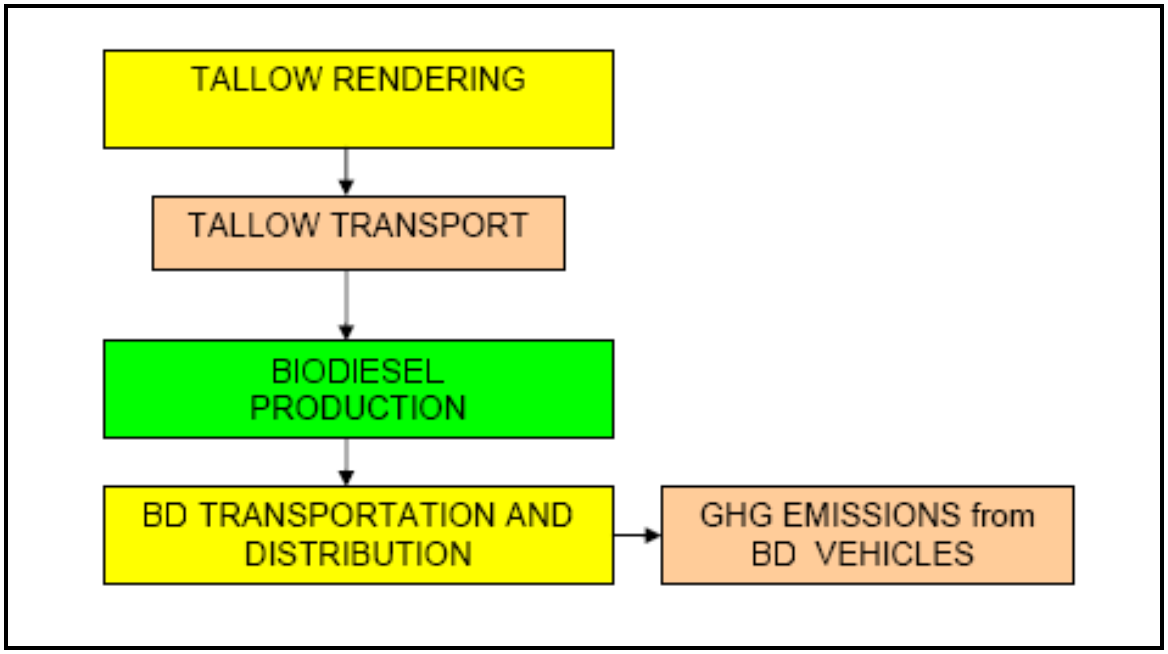
The tallow renewable diesel pathway that CARB has developed and approved includes the discrete components shown in the following figure.

Figure 2-1 Tallow Renewable Diesel Discrete Components



It is proposed that the figure for the tallow biodiesel be essentially the same as shown in the following figure.

Figure 2-2 Tallow Biodiesel Discrete Components



It can be seen that the systems are very similar with the only real difference being the fuel production process.

2.1 Regional Assumptions

Tallow is produced throughout the United States. There are approximately 250 rendering plants in the United States. The plants process a variety of raw materials from whole animals to wastes from slaughter facilities. The composition of the input material can vary from plant to plant as some plants specialize in certain species and others will process a mixture of animals.

It is proposed that the CI for tallow biodiesel be generic, with transportation distances of the tallow or the produced biodiesel being representative of the distances used in the Midwest soybean biodiesel pathway. This will be conservative for California tallow biodiesel producers processing local tallow but it will provide operators with the maximum flexibility.

3. RENDERING

In the Tallow Renewable Diesel documents, CARB obtained data for several rendering operations to determine the energy used by the process and allocated the energy to the fat and the meat and bone meal by energy allocation. The table with the data is reproduced below.

Table 3-1 Rendering Energy for Production of Tallow

Rendering Energy Data Source	Thermal Energy	Electrical Energy	Notes
	Btu/gal	kWh/gal	
Survey of U.S. Rendering Plants			
Plant 1	43,622	1.534	
Plant 2	45,628	1.414	
Average used for higher energy pathway	44,625	1.474	
Nelson and Schrock, 2006	14,420	NR	Thermal energy includes energy used to generate electricity
Nelson and Schrock, undated	42,857	0.900	Appears to allocate all rendering energy to fat and none to meat and bone meal
National Renderers Association, 2009	16,170	NR	Assuming 50% moisture in raw material, 126,900 Btu/gallon for fat consumed
Natural Resources Canada, 2005	18,836	0.736	For typical Canadian renderers; energy allocated based on mass of products
Fats Proteins Research Foundation, 2005	15,247	0.278	Electricity based on soybean processing; thermal energy based on evaporation of 50% moisture in raw material.

In preparation for this work an attempt was made to find additional information on the energy consumed in the rendering process. One of the objectives was to try and find information by specie. While information was obtained for a plant that processed mostly poultry, a plant that processed a mixture of species and used cooking oil, and a plant that processed mostly beef the energy contents were quite different for each plant, even after adjusting for the fat content of the input material. The findings are summarized in the following table.

Table 3-2 Rendering Data Obtained

Plant	Feedstock	Power Use (MM BTU)	Thermal Energy (MM BTU)	Tallow (1,000 Pounds)	BTU/Pound
Plant A	Poultry	71,812	195,537	28,950	9,235
Plant B	Mixed Species	5,000	17,000	8,431	2,609
Plant C	Beef	19,200	131,094	10,104	14,875
Total		96,012	343,632	47,485	9,258

In discussions with the plant operator to try and better understand the results it became apparent that while the data might be representative of California plants, it was not representative of US plants. For example, beef plants can process mostly whole dairy cattle, waste from a meat packer (bones, trimmings, and offal) or some combination of both. Three times as much fat is recovered from the material from a meat packer compared to whole carcass. In California, beef plants process about 70% whole carcass and 30% packer waste, whereas in other parts of the country, the ratios would be reversed.

The weighted average energy consumption from the three rendering facilities was 9,528 BTU/pound of tallow before any allocation. After energy allocation between the tallow and the meal this energy was reduced to 7,260 BTU/pound of tallow (HHV). This is not significantly different than the 6,621 BTU/pound (HHV) used by CARB in the tallow renewable diesel pathway document.

It is therefore proposed that the existing energy consumption for the rendering process used in the Tallow to Renewable Diesel pathway be used in the Tallow to Biodiesel pathway. This represents plants that process mixed tallow, as most rendering plants fall into this category.

CARB's existing pathway has two CI values, one for low-energy and one for high-energy rendering, this new pathway assumes that high-energy rendering is used.

The modelling assumptions are:

- Rendering uses 6,026 Btu/lb tallow.
- The same distribution of the energy between thermal and power is assumed as was used for the tallow to renewable diesel pathway.

The emissions for rendering are shown in the following table. These are derived from the GREET model identified as processed.ca_greet1.8b_dec09-RD.xls. The model was obtained from CARB, the "processed" is from an operation to reduce the number of formats in the file so that it could be opened. The emissions are obtained by zeroing the production of glycerine and then the model is run again with the glycerine included to obtain the "Total Adjusted Emissions". This is done because while no glycerine is produced during rendering, a portion of the rendering emissions will be allocated to glycerine once the biodiesel is produced. The electric power is set to US average. The g/lb of tallow results in this table are essentially identical to Table 1.03 in the Tallow to RD document.

Table 3-3 GHG Emissions from Energy Used in Rendering of Tallow

Emission Species	Total Emissions (g/lb Tallow)	Total Emissions (g/mmBtu BD)
VOC	0.054	3.500
CO	0.300	19.290
CH_4	0.828	53.350
N_2O	0.003	0.210
CO_2	462	29,757
GHG Emissions	485	31,194
Total Emissions (gCO_2e/MJ tallow)		29.57
Total Adjusted Emissions (gCO_2e/MJ) (after glycerine allocation)		28.11

4. TALLOW TRANSPORT

Two tallow distribution scenarios are modelled. In the first, the tallow distribution scenario is essentially the same as the tallow to renewable diesel pathway.

Tallow from Midwest is transport 10 miles by HHD trucks to rail yard and 1,400 miles by rail to biodiesel facilities in CA. The emission factors used for the truck and train are the CA GREET default values and they are the same as used in other biodiesel and renewable diesel pathways.

The emissions for the first tallow transport are shown in the following table. The "Total Emissions" are without adjustment for glycerine and the adjusted emissions include the allocation of a portion of the emissions to the glycerine based on energy content, as is the standard practice in the CARB analyses.

Table 4-1 GHG Emissions from Transportation of Tallow to California

Emission Species	Total Emissions (g/lb Tallow)	Total Emissions (g/mmBtu Tallow)
VOC	0.018	1.18
CO	0.063	4.03
CH_4	0.028	1.81
N_2O	0.001	0.04
CO_2	25	1,617
GHG Emissions	26	1,684
Total Emissions (gCO_2e/MJ)		1.60
Total Adjusted Emissions (gCO_2e/MJ)		1.52

In the second scenario, the tallow is assumed to be transported 50 miles by HHD truck to the biodiesel plant. The biodiesel is produced outside of California and then transported to California for blending and use there.

The emissions for the second tallow transport are shown in the following table. The "Total Emissions" are without adjustment for glycerine and the adjusted emissions include the allocation of a portion of the emissions to the glycerine based on energy content, as is the standard practice in the CARB analyses.

Table 4-2 GHG Emissions from Transportation of Tallow to US Biodiesel Plant

Emission Species	Total Emissions (g/lb Tallow)	Total Emissions (g/mmBtu Tallow)
VOC	0.004	0.24
CO	0.011	0.73
CH_4	0.009	0.55
N_2O	0.000	0.02
CO_2	8	503
GHG Emissions	8	523
Total Emissions (gCO_2e/MJ)		0.50
Total Adjusted Emissions (gCO_2e/MJ)		0.47

5. BIODIESEL PRODUCTION

The biodiesel energy consumption is 2,116 BTU/lb of biodiesel, a CA GREET default. All of the input values are CA GREET default values. The process yields biodiesel and glycerine, the glycerine energy is 4.9% of the biodiesel energy. The glycerine is a co-product and the ARB allocates 4.9% of the total production energy to glycerine. It is assumed that the biodiesel is produced in California so the GREET model is adjusted to California marginal power.

The model results are shown in the following table.

Table 5-1 GHG Emissions from Biodiesel Production - California

Emission Species	Total Emissions (g/lb Tallow)	Total Emissions (g/mmBtu BD)
VOC	0.052	1.78
CO	0.208	3.65
CH_4	0.791	17.17
N_2O	0.004	0.04
CO_2	384	4,704
GHG Emissions	405	5,155
Total Adjusted Emissions (gCO_2e/MJ)		4.89

For biodiesel produced outside of California the US average mix for power is used. These results are shown in the following table.

Table 5-2 GHG Emissions from Biodiesel Production - US

Emission Species	Total Emissions (g/lb Tallow)	Total Emissions (g/mmBtu BD)
VOC	0.054	1.79
CO	0.300	4.03
CH_4	0.828	17.30
N_2O	0.003	0.03
CO_2	462	5,034
GHG Emissions	484	5,489
Total Adjusted Emissions (gCO_2e/MJ)		5.20

The emissions are 0.05 gCO_2e/MJ higher with this scenario.

6. BIODIESEL TRANSPORT

There are two biodiesel transport scenarios modeled. In the first scenario (California biodiesel production), biodiesel is transported 50 miles by HDDT (80%, the rest 20% go directly to close by stations) to blending stations, then 90 miles by HDDT (100%) to refueling stations. These are the same assumptions used in other biodiesel pathways.

No allocation of these emissions is required since these are downstream of the process that produces glycerine.

Table 6-1 GHG Emissions from Biodiesel Transport

Emission Species	Total Emissions (g/mmBtu)
VOC	0.33
CO	1.48
CH_4	0.95
N_2O	0.02
CO_2	770
GHG Emissions	802
Total Emissions (gCO_2e/MJ)	0.76

In the second scenario (US biodiesel production), biodiesel is transported 1,400 miles by rail to blending stations, then 90 miles by HDDT (100%) to refueling stations.

No allocation of these emissions is required since these are downstream of the process that produces glycerine.

Table 6-2 GHG Emissions from Biodiesel Transport

Emission Species	Total Emissions (g/mmBtu)
VOC	1.31
CO	4.71
CH_4	2.21
N_2O	0.05
CO_2	1,980
GHG Emissions	2,060
Total Emissions (gCO_2e/MJ)	1.95

7. LIFECYCLE RESULTS

The full lifecycle results are obtained from the addition of the various stages. The results are shown in the following table. The vehicle operation emissions are the same as used in other biodiesel pathways.

Table 7-1 Lifecycle CI Results for Tallow Biodiesel- California Production

Stage	Emissions, g CO_2eq/MJ
Rendering	28.11
Tallow Transport	1.52
Biodiesel Production	4.89
Biodiesel Transport	0.76
Total Tank to Wheel	35.28
Vehicle Operation	4.45
Total	39.73

It is concluded that tallow biodiesel should have a CI of 39.73. This is very close to the 39.33 g/MJ value for the tallow renewable diesel pathway. This is expected as the soybean biodiesel and soybean renewable diesel pathways are also very close.

For biodiesel produced outside of California the results are only slightly higher as shown in the following table. The differences are caused by the different electricity carbon intensity for the biodiesel production and the slightly different transportation assumptions.

Table 7-2 Lifecycle CI Results for Tallow Biodiesel- US Production

Stage	Emissions, g CO_2eq/MJ
Rendering	28.11
Tallow Transport	0.47
Biodiesel Production	5.20
Biodiesel Transport	1.95
Total Tank to Wheel	35.73
Vehicle Operation	4.45
Total	40.18

8. REFERENCES

CARB. 2009. Detailed California-Modified GREET Pathway for Co-Proceed Renewable Diesel Produced from Tallow (U.S. Sourced). http://www.arb.ca.gov/fuels/lcfs/092309lcfs_tallow_rd.pdf

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