

**LIFE CYCLE INVENTORY DATA  
SOYBEAN PROCESSING**

Prepared For:

**National Oilseed Processors Association  
1310 L Street, NW #375,  
Washington, DC 20005**

Prepared By

**(S&T)<sup>2</sup> Consultants Inc.**  
11657 Summit Crescent  
Delta, BC  
Canada, V4E 2Z2

Date: September 5, 2024



## EXECUTIVE SUMMARY

The National Oilseed Processors Association (NOPA), is a national trade association, that represents the United States' (U.S.) soybean, canola, flaxseed, safflower seed, and sunflower seed crushing industries.

NOPA's membership includes 15 companies that are engaged in the processing of oilseeds for meal and oil that are further utilized in the manufacture of food, feed, and renewable fuels. NOPA's member companies operate a total of five softseed (canola, flaxseed, sunflower seed and safflower seed or some combination there) and 62 soybean solvent extraction plants across 21 states.

NOPA initiated a survey of its members that operated soybean crushing operations in the summer of 2024. Members provided data on their operations from the calendar year 2023. Only the data from plants employing the solvent extraction process are included in the results presented here.



# TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	I
TABLE OF CONTENTS.....	III
LIST OF TABLES .....	III
1. INTRODUCTION .....	1
1.1 SURVEY .....	1
2. FEEDSTOCK PROCESSED .....	2
2.1 TRANSPORTATION .....	2
2.2 FEEDSTOCK CHARACTERISTICS .....	2
2.3 PRODUCT YIELDS.....	2
3. OIL EXTRACTION.....	3
3.1 ELECTRICITY .....	3
3.2 THERMAL ENERGY .....	3
3.3 WATER CONSUMPTION.....	4
4. OIL REFINING.....	5
4.1 YIELD5 .....	
4.2 ENERGY CONSUMPTION .....	5
4.3 MATERIALS CONSUMPTION.....	6
5. REFERENCES .....	7

## LIST OF TABLES

TABLE 1-1	USDA SOYBEAN CRUSHING DATA .....	1
TABLE 2-1	SOYBEAN TRANSPORTATION .....	2
TABLE 2-2	SOYBEAN CHARACTERISTICS .....	2
TABLE 2-3	SOYBEAN CRUSHING YIELDS .....	2
TABLE 3-1	ELECTRICITY PURCHASES.....	3
TABLE 3-2	THERMAL ENERGY CONSUMPTION (HHV) .....	3
TABLE 3-3	THERMAL ENERGY CONSUMPTION (LHV).....	3
TABLE 3-4	COMPARISON TO GREET 2023.....	4
TABLE 3-5	WATER CONSUMPTION FOR CRUSHING.....	4

TABLE 4-1	OIL REFINING YIELD .....	5
TABLE 4-2	REFINING ENERGY HHV .....	5
TABLE 4-3	REFINING ENERGY LHV .....	6
TABLE 4-4	REFINING MATERIALS .....	6

# 1. INTRODUCTION

The National Oilseed Processors Association (NOPA), is a national trade association, that represents the United States' (U.S.) soybean, canola, flaxseed, safflower seed, and sunflower seed crushing industries.

NOPA's membership for the 2023 calendar year includes 15 companies that are engaged in the processing of oilseeds for meal and oil that are further utilized in the manufacture of food, feed, and renewable fuels. NOPA's member companies operate a total of five softseed (canola, flaxseed, sunflower seed and safflower seed or some combination there) and 62 soybean solvent extraction plants across 21 states.

The USDA reported data on the soybean crushing industry in 2023 is shown in the following table.

**Table 1-1      USDA Soybean Crushing Data**

Parameter	Values
Soybeans crushed	67,536,377 tons
Soy oil produced, Crude	13,285,232 tons
Soy oil produced, Once Refined	10,413,531 tons
Soybean meal	49,869,364 tons

## 1.1 SURVEY

NOPA initiated a survey of its members that operated soybean crushing operations in the summer of 2024. Members provided data on their operations from the calendar year 2023. Only the data from plants employing the solvent extraction process are included in the results presented here.

Survey returns were obtained from 52 plants.

These facilities reported processing 60,073,422 tons of soybeans representing 89% of the USDA reported value.

## 2. FEEDSTOCK PROCESSED

Information was collected on the feedstock received at the crushing facilities. The information is presented below.

### 2.1 TRANSPORTATION

Information on the mass received by transportation mode and an estimate of the transportation distance by that mode was collected. The results are shown in the following table. Information was provided by all but one of the plants.

**Table 2-1 Soybean Transportation**

Mode	Fraction by Mode	Distance, miles
Truck	0.85	53
Rail	0.11	344
Barge	0.04	304
Total	1.00	

### 2.2 FEEDSTOCK CHARACTERISTICS

Information on soybean moisture contents was provided by all but two participants. Information on the lipid content was provided by all but three plants. The information is shown in the following table. The average values are weighted but the standard deviations are based on the unweighted values.

**Table 2-2 Soybean Characteristics**

Parameter	Weighted Average	Standard Deviation
Moisture, kg/kg soybeans	10.75%	0.73%
Lipids, kg/kg soybeans	19.82%	1.59%

### 2.3 PRODUCT YIELDS

The product yields for the soybean crush facilities are shown in the following table. The first column shows the values on an actual moisture content basis and the second column shows the yields on a dry weight basis.

**Table 2-3 Soybean Crushing Yields**

Product	Kg/kg as produced	Kg/kg dry weight basis
Soybean Oil	0.198	0.222
Soybean Meal	0.750	0.738
Soybean Hulls	0.056	0.057
Total	1.004	1.017

Materials added during crushing and refining can be added back to the meal, resulting in the yields greater than 1.00.

### 3. OIL EXTRACTION

The oil extraction process uses energy to separate the soybeans into the individual products. The products produced are crude or degummed soybean oil soybean meal, and soybean hulls.

#### 3.1 ELECTRICITY

There are some facilities that generate some or all of their own electricity through co-generation but most the faculties purchase their electricity from the local utilities. Those facilities that generate some power will have lower electricity purchases but higher fuel consumption. All 52 facilities reported their electricity purchases. The results are shown in several different units.

**Table 3-1 Electricity Purchases**

	Weighted Average Value
kWh/pound soybeans	0.0159
kWh/bushel soybeans	0.9565
kWh/ton soybeans	31.88
kWh/tonne soybeans	35.15

#### 3.2 THERMAL ENERGY

The plants use a variety of different fuels, with natural gas being the dominant fuel. Other fuels used are coal, and landfill gas. Some plants purchase steam, with the steam being produced from natural gas and or coal. The purchase steam has been converted to the fuel assuming 80% thermal efficiency (HHV) and saturated steam. Data was available for 47 facilities. The values are presented in different units and using HHV and LHV basis

**Table 3-2 Thermal Energy Consumption (HHV)**

Fuel	BTU/pound Soybeans	BTU/bushel	BTU/ton	MJ/tonne
Natural gas	349	20,947	698,233	812
Coal	20	1,191	39,693	46
Fuel Oil	0.00	0.23	7.67	0.01
Landfill gas	2	137	4,580	5
Total	371	22,275	742,513	864

**Table 3-3 Thermal Energy Consumption (LHV)**

Fuel	BTU/pound Soybeans	BTU/bushel	BTU/ton	MJ/tonne
Natural gas	315	18,915	630,504	733
Coal	18	1,098	36,597	43
Fuel Oil	0.004	0.215	7	0.008
Landfill gas	2.07	124.06	4,135	4.81
Total	336	20,137	671,244	781

The comparison to GREET 2023 is shown in the following table. Hexane consumption was not surveyed as part of this work. The energy consumption is significantly lower than it is in GREET 2023 and the fuels and the weighted average carbon intensity of the fuels is also lower.

**Table 3-4 Comparison to GREET 2023**

	GREET 2023	NOPA Survey
	BTU/pound Soy oil	
Residual oil	5.8	0.0
Diesel oil	2.9	0.004
Natural Gas	372.6	315
Coal	183.4	18
LPG	0	0
Electricity	80.4	54
Biomass	5.8	0
Landfill Gas	2.9	2.1
Hexane	10.6	10.6
Total	664.4	399.7

### 3.3 WATER CONSUMPTION

Water consumption data was available for 46 facilities. The weighted average value is shown in the following table. The water consumption is about half of the value in GREET 2023.

**Table 3-5 Water Consumption for Crushing**

Units	Value
Gallons/pound soybeans	0.069
Gallons/bushel soybeans	4.14
Gallons/ton soybeans	138
Gallons/tonne soybeans	152

Waste water discharges were reported for 42 facilities. The results are shown in the following table.

**Table 3-6 Waste Water Discharges for Crushing**

Units	Value
Gallons/pound soybeans	0.045
Gallons/bushel soybeans	2.71
Gallons/ton soybeans	90
Gallons/tonne soybeans	99

## 4. OIL REFINING

Some of the plants have additional facilities for refining the crude soybean oil. The product from these facilities is refined bleached and deodorized (RBD) soybean oil. This product has much lower phosphorus levels (5 ppm Max) which is important for renewable diesel production since phosphorus can shorten the catalyst life. Some renewable diesel producers have pretreatment facilities which allow them to purchase the degummed oil and remove the phosphorus at the RD production site.

Twenty-six facilities supplied information on the performance of their refining operations. The reported production was 8.762 million tons, this is 84% of the total once refined value reported by the USDA.

### 4.1 YIELD

Most plants reported the consumption of both degummed and non degummed oil as the feedstock. The yield information is shown in the following table.

**Table 4-1 Oil Refining Yield**

Product	Value
Crude oil (not degummed)	1,625 lbs/ton refined
Crude oil (Degummed)	375 lbs/ton refined
Total input	2,000 lb/ton refined
RBD oil produced	1,929 lbs/ton refined

### 4.2 ENERGY CONSUMPTION

The energy consumption for the refining process is shown in the following table. Not all plants were able to provide energy data as that requires separate meters for the refining section of the facility. The information is shown in the following table.

**Table 4-2 Refining Energy HHV**

Energy Source	Number of Plants	Per ton refined oil produced	Per pound of refined oil produced
Electricity, kWh	26	40.0	0.020
Electricity, BTU	26	136,480	68.2
Natural gas, BTU	25	456,200	233
Coal, BTU	1	86,200	43
Landfill gas, BTU	1	2,000	1
Total, BTU		680,800	345.2

The same information on a LHV basis is shown in the following table.

**Table 4-3 Refining Energy LHV**

Energy Source	Number of Plants	Per ton refined oil produced	Per pound of refined oil produced
Electricity, kWh	26	40.0	0.020
Electricity, BTU	26	136,480	68.2
Natural gas, BTU	25	411,950	206
Coal, BTU	1	79,470	39.7
Landfill gas, BTU	1	1,806	0.9
Total, BTU		629,706	314.8

**4.3 MATERIALS CONSUMPTION**

The main materials reported by refiners were sodium hydroxide and bleaching earth. The information is show in the following table.

**Table 4-4 Refining Materials**

Material	Number of Plants	Pounds/ton refined oil produced	grams pound of refined oil produced
Sodium Hydroxide,	22	3.44	0.78
Bleaching Earth	22	5.22	1.18
Water, gallons	13	72	0.036

## 5. REFERENCES

USDA. 2024. North American Grain and Oilseed Crushings.  
<https://downloads.usda.library.cornell.edu/usda-esmis/files/ks65hk36z/ng4535386/7s75q211k/cairus24.pdf>