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Comprehensive Survey on Energy Use for Biodiesel Production

The National Biodiesel Board (NBB) has conducted the most comprehensive survey of the actual energy used by commercial biodiesel production plants in the world and is releasing the data for public use. These numbers represent the most accurate depiction of the energy used to produce biodiesel. This data should replace all existing data in lifecycle energy and greenhouse gas models for better simulating the lifecycle analysis of biodiesel, including those used by the US Environmental Protection Agency and the California Air Resources Board for the recently released rulemakings. These numbers represent total energy used at biodiesel production plants. No subtraction from total energy use has been made for co-product generation, such as glycerin.

The average energy used to produce a gallon of biodiesel from virgin vegetable oils is 3,184 BTUs. Energy use among plants that use blends of virgin oil and recycled or reclaimed fats and oils varies, as does the composition of these feedstocks. Taking into account all of these variations, the overall industry average for all feedstocks and all production technologies is 4,192 BTUs per gallon of biodiesel.

	Virgin Oils	**Industry Average**	
	(Soy & Canola)	(including all feedstocks)	
Inputs per gal biodiesel			Units
Electricity	0.12	0.19	KWh (3,413 BTU/KWh)
Natural Gas	2.69	3.45	SCF (1,027 BTU/SCF)
total energy	**3,184**	**4,192**	**BTU/gal**

The NBB is the trade association for the US biodiesel industry. Responding to requests for this data from academic institutions and government agencies, such as the US Department of Agriculture, NBB developed a survey that was sent to NBB's entire membership, including 230 biodiesel producing companies. To design a survey instrument capable of accurately capturing the most relevant data, NBB sought input from organizations such as Argonne National Laboratories, developer of the GREET lifecycle analysis model.

The survey form used to collect this data is provided at the end of this document. Survey data was returned to NBB on the attached form via email. Each survey was reviewed by NBB's Professional Engineer. When necessary, clarifying questions were asked of the producers via phone or email to verify that all the data was reported consistently, and that the data accurately represent the actual energy used to produce the reported volume for each plant.

The data reported here were weighted against actual 2008 production volumes. Maximum plant capacity remains larger than current production rates. When weighted against plant capacity rather than actual production, the weighted averages were not statistically different. Weighting by actual plant production provides the most accurate representation of real-world production and provides a realistic estimate of energy use that can be expected as existing plants increase production volume. New plants and new technology implemented at existing plants can be expected to improve energy efficiency, just as has been demonstrated in recent years. No estimates for future energy improvements are included in this analysis.

2008 was a record year for the volume of biodiesel production in the US, reaching nearly 700 million gallons. The survey data returned by US producers represents 37% of that record volume. This is the

first survey of actual data ever representing such a substantial volume of biodiesel production. This data represent an excellent cross section of biodiesel plant size, biodiesel production technologies, and biodiesel feedstocks. Equal portions of the survey pool use multi-feedstocks as the number of plants dedicated to virgin oil or recycled oil and animal fat.

Data was analyzed within the general categories reported here to determine whether correlations could be made between individual feedstock types and energy use. Very little variation was found between plants that used virgin oils. Canola and soybean oil required similar energy inputs. Only slight differences in overall averages were noted between crude, degummed, or refined vegetable oils. More variation was noted among producers using animal fats and recycled oils.

Most biodiesel producers use a combination of electricity and natural gas. Some small producers use only electricity, and several producers reported using alternative sources of energy such as used motor oil or biodiesel. When converted to common units of energy, such a British Thermal Units (BTU), these producers using alternate sources consumed similar amounts of total energy as the industry average. Electricity use for blended feedstocks reached as high as 0.9 kilowatt-hours per gallon of biodiesel for a single producer. Natural gas usage for recycled oil reached as high as 12 standard cubic feet per gallon of biodiesel for a single producer. These extreme examples represent the maximum energy use reported in the survey, and do not represent typical production.

One obstacle to acquiring this type of process-specific data is the reluctance of private companies to reveal trade secrets in a highly competitive market. Previous estimates of the energy used during biodiesel production had to rely on process modeling and data from a very small number of plants using older technology. The results reported from this survey include no modeling. The results provided here represent actual energy consumption measured at operating biodiesel facilities.

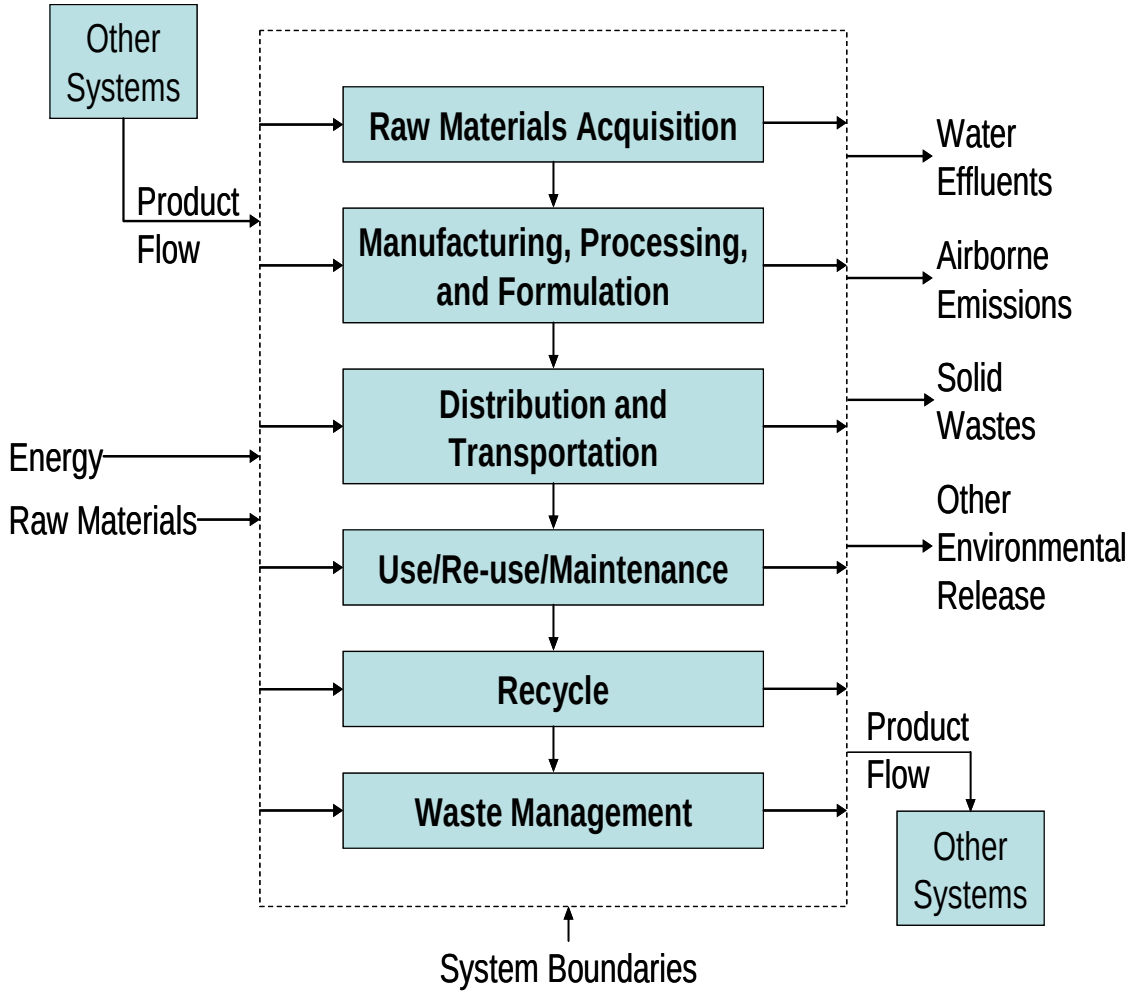
In addition to raw energy consumption data, NBB requested information on the quantity of material inputs and outputs, so that data would be available for complete lifecycle analysis. The table below summarizes the industry averages per gallon of biodiesel.

	Virgin Oils	**Industry Average**	
Inputs per gal biodiesel	(Soy & Canola)	(including all feedstocks)	
			Units
Feedstock	7.3285	7.7834	Lbs
Methanol	0.6735	0.7208	Lbs
Sodium Methylate	0.1712	0.1832	Lbs
Sodium Hydroxide	0.0072	0.0073	Lbs
Potassium Hydroxide	0.0000	0.0005	Lbs
Hydrochloric Acid	0.3214	0.2088	Lbs
Sulfuric Acid	0.0000	0.0010	Lbs
Phosphoric Acid	0.0047	0.0025	Lbs
Citric Acid	0.0054	0.0027	Lbs
Outputs			
Glycerin	0.8881	0.9075	Lbs
Fatty Acids	0.0153	0.0340	Lbs

Sample Survey Sent to NBB Members

A life cycle assessment addresses the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life-treatment, recycling and disposal. A life cycle assessment is also often referred to as a cradle-to-grave analysis. It is a process by which the greenhouse gas potential, emissions and energy consumption of product inputs and production processes are weighed against the greenhouse gas, emissions and energy consumption benefits of the finished products.

Life Cycle Stages



			Notes
Total Production Quantity		**Gallons/Year**	**This will be used to arrive at weighted average**
			Indicate the feedstock this information is based upon. If different feedstocks have different input/output flows, please complete a worksheet for each feedstock.
Feedstock			
Inputs	**Quantity Used/Gallon of Biodiesel**	**Units**	
Feedstock		**Pounds**	
Methanol		**Pounds**	**Please Specify: Denatured or Undenatured**
Ethanol		**Pounds**	
Sodium Methylate		**Pounds**	
Other:		**Pounds**	
Other:		**Pounds**	
Sodium Hydroxide		**Pounds**	
Potassium Hydroxide		**Pounds**	
Other:		**Pounds**	
Other:		**Pounds**	
Hydrochloric Acid		**Pounds**	
Sulfuric Acid		**Pounds**	
Phosphoric Acid		**Pounds**	
Citric Acid		**Pounds**	
Other:		**Pounds**	
Other:		**Pounds**	
Purchased Energy			
Electricity		**Kwh**	
Coal		**Pounds**	**Please Specify Type of Coal**
Natural gas		**SCF**	
Diesel		**Gallons**	
Fuel Oil		**Gallons**	
Other:			
Other:			
Water Usage		**Gallons**	**Total Freshwater Input; Source of Water (City Water, Ground Water, etc.):**

Other Outputs			
Glycerin	**Quantity Produced/Gallon of Biodiesel**	**Units**	**Please Specify Glycerin Quality**
Fatty Acids		**Pounds**	
Other:		**Pounds**	
Other:			
Waste water discharge			**Please Specify: Discharge to WWTP or River**
		Gallons	