Water Usage in Biodiesel Production

Tom O’Connor, PE
National Biodiesel Board
National Biodiesel Board

• Trade association representing the biodiesel industry in the US

• NBB is “feedstock neutral”
What is Biodiesel?

- Renewable fuel for diesel engines derived from vegetable oils or animal fats (ASTM D 6751)

- Produced by a reaction of an oil or fat with an alcohol to yield mono-alkyl esters and glycerin (which are separated)
Energy Balance

Output: Input

- 3.2:1 in 1998
- Grew to 4.56 due to improved farming
- May reach 5.44 by 2015

Shrestha, University of Idaho
We make biodiesel from:

- soybean oil
- inedible tallow, grease
- lard
- edible tallow
- other

Canola, palm, jatropha, jojoba, mustard, sunflower, coconut, flax, hemp, coconut, waste vegetable oil, spent coffee grounds, pennycress, algae...
Water Usage Associated with Biodiesel

1. Oil-to-Biodiesel Conversion Process
2. Water Use Associated with Feedstock
Water Usage Associated with Biodiesel

1. Oil-to-Biodiesel Conversion Process

Estimates range from 0.32 to ~ 1 gallon of water used for each gallon of biodiesel produced.

(EPA, Sandia Labs, NBB producers’ survey)
Production of 1 gallon of Biodiesel Uses 0.3 - 1 gallon of Water

Entire Biodiesel Industry in US Uses 700 MG/year of Water (max.)

Golf Courses in Jefferson County, CO Use 1,840 MG/year of Water

Estimated Colorado golf course irrigation water use, 2005: USGS
2. Water Use Associated with Feedstock

- Variables, feedstocks, regional issues
- More difficult to develop numbers
- 57% of feedstocks are soy--let’s start there
Water Use Associated with Soybeans

Often-Cited Numbers

- 6,500 gallons of water per gallon biodiesel
- 13,800 - 60,000 gallons water per MMBtu
(14,000 - 75,000 gal/ MMBtu)
Call for Further Review

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ENERGY DEMANDS ON WATER RESOURCES

REPORT TO CONGRESS ON THE INTERDEPENDENCY OF ENERGY AND WATER

U.S. DEPARTMENT OF ENERGY

DECEMBER 2006
“Currently, the most water-intensive aspect of biofuel production is growing the feedstock. When that feedstock is corn or soy... and the feedstock is grown on irrigated land, the water consumption is quite high, as shown in Fig. V-4.”
Figure V-4. Water Consumption Per-Unit-Energy and Current Water Use for Fuel Extraction and Processing
See Appendix B for Data References
“On the other hand, biofuel feedstock produced … from feedstocks grown without irrigation, or from feedstocks grown with nontraditional water, will have minimal freshwater use intensity associated with production.

This could provide significant volumes of bioenergy and biofuels in the future with low water use intensity (Perlak et al., 2005).”
Energy Demands on Water Resources

“Water use for irrigated soy production in the U.S. varies... with a national average of 0.8 acre-feet of water (USDA, 2004a). The average water use was 6,200 gallons of water per bushel of soy...”

U.S. Department of Energy

December 2006
Big Factor: Irrigated or Not?

If irrigated, is it:

- efficient
- responsible
- productive
- sustainable?
Efficient Irrigation

- appropriate, renewable source water
- minimize evaporation (drip, subsurface)
- scheduling, monitoring and control
7.5% of Soybean Acres are Irrigated
(5.5 of 72.4 million acres)

Planted Soybean Acres

QuickTime™ and a decompressor are needed to see this picture.

Irrigated Soybean Acres
Water Use Associated with Soybeans

soybean:

20% oil,

80% meal

Allocate Inputs to Outputs
Water Use Associated with Soybeans

soybean:
20% oil,
80% meal

soybean oil:
90% biodiesel,
10% glycerin
Water Use Associated with Soybeans: Aggregate of Irrigated and Non-, with Coproducts

6,200 gallons water per gallon biodiesel, adjusted estimate:

$$6,200 \times 7.5\% \times 20\% \times 90\%$$

(acres, oil, biodiesel)

= 84
Water Use Associated with Soybeans: Aggregate of Irrigated and Non-, with Coproducts

84 gallons water per gallon biodiesel = 

84 gallons per 130,000 Btu = 

646 gallons per MMBtu

Just an estimate...
Figure V-4. Water Consumption Per-Unit-Energy and Current Water Use for Fuel Extraction and Processing
See Appendix B for Data References
Aggregate Soybeans

- Ethanol Processing
- Corn Irrigation
- Hydrogen Electrolysis
- Hydrogen Reforming
- Uranium Processing
- Uranium Mining
- Oil Storage in Salt Cavern**
- Oil Sands
- Oil Shale In-Situ*
- Oil Shale Surface Retort
- Refining
- Enhanced Oil Recovery
- Petroleum Extraction
- Gas Storage in Salt Cavern**
- Natural Gas Pipeline Operations
- Natural Gas Extraction & Processing
- Coal Gasification
- Coal Slurry
- Coal Liquefaction
- Coal Washing
- Coal Mining

Petroleum Refining
Consumes 1-2 Billion Gallons per Day

Figure V-4. Water Consumption Per-Unit-Energy and Current Water Use for Fuel Extraction and Processing
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Soybean Agriculture & Water Quality

- Low Fertilizer Requirements
  (Soy fixes atmospheric nitrogen)
- Low Pesticide Requirements
- Low Irrigation Requirements
“Compared with ethanol, biodiesel releases just 1.0%, 8.3%, and 13% of the agricultural nitrogen, phosphorus, and pesticide pollutants, respectively, per net energy gain.”
Fertilizers and Pesticides
Soybean Biodiesel Compared with Corn Ethanol

(Hill, et al, 2006)
Water and Biodiesel

- Biodiesel comes from multiple feedstocks
- Conversion process uses minimal water
- Soybean irrigation inputs are allocated over all outputs (protein meal, oil, biodiesel, glycerin)
Water and Biodiesel

- Biodiesel is a young, changing industry
- Important part of our energy future
- Needs to develop in a responsible, sustainable way
**NBB Sustainability Principles**

1. Biodiesel production shall follow all applicable laws of the jurisdiction in which it is produced.
2. Biodiesel projects shall be developed and operated under appropriate, transparent, and participatory processes that involve all relevant stakeholders.
3. Biodiesel shall contribute to climate change mitigation by significantly reducing lifecycle greenhouse gas emissions as compared to fossil fuels. Producers shall strive to continuously improve that reduction.
4. Biodiesel production shall support human rights and labor rights, and shall ensure safe and decent working conditions.
5. Biodiesel production shall contribute to the social and economic development of local communities.
6. Biodiesel production shall strive to improve food security.
7. Throughout the supply chain, the biodiesel industry shall implement management systems that maintain and strive to improve biodiversity, areas of High Conservation Value, and the quality of natural resources such as soil, air, and water.
8. Biodiesel production shall respect natural resource rights, such as land and water rights.
9. All participants throughout biodiesel supply chain shall be dedicated to the ideal of continuous improvement. Members shall, through ongoing efforts, make advancements in the economic, social and environmental performance of the industry.
Biodiesel Sustainability Principles

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