Sustainable Biodiesel Production: A tool for assessing and improving the sustainability of a biodiesel production process

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Background

Biodiesel is a potential low-carbon and sustainable energy source, but the carbon savings and sustainability of biodiesel fuel depend in large part on how the feedstock and the fuel are produced. State, federal, and international renewable fuel policies are increasingly focused on the carbon balance and sustainability of fuels. Renewable fuels are no longer automatically viewed as a solution to global climate change; only those fuels with negative carbon balance and beneficial environmental attributes are regarded as viable tools for greenhouse gas (GHG) emission reductions.

Developing an effective sustainability strategy and implementing the right decision-making tools to improve the sustainability of a renewable fuel while maintaining high productivity and profitability are crucial elements of a successful renewable fuels business.

Sustainability must be viewed in terms of the product's life cycle. Renewable fuel producers who wish to quantify and improve the sustainability of their product should focus not only on the fuel production step, but also on feedstock production and transportation. Feedstock sourcing, logistics, and fuel production all have a large impact on the environmental impacts of renewable fuels.

This paper presents an approach for the development of an effective sustainability strategy for biodiesel companies. The paper outlines a methodology to assess and improve the carbon balance and sustainability of a biodiesel production process based on Life Cycle Assessment (LCA) analysis techniques. Although the principles highlighted here pertain specifically to biodiesel, the principles can be applied to any chemical industry.

Assessing the Footprint of a Biodiesel Production Process

This paper presents a step-by-step methodology to quantify and account for the sustainability of a biodiesel production process across its life cycle ("sustainability accounting") and use this accounting method to identify and evaluate opportunities for improvement. Pareto plots are used as an evaluation and decision-making tool. Multiple sustainability criteria ("Impact Categories") are taken into account, including GHG emissions, but also depletion of natural resources and ecological impacts to air, soil, water, and biodiversity. An example of an ecological impact to water is Acidification.

The paper presents concrete examples and case studies, including the evaluation of chemical vs. non-chemical treatment systems for cooling towers and boilers, the evaluation of different reaction and catalytic methods, and the assessment of different biodiesel purification systems from a sustainability and LCA perspective.

Step 1: Data Gathering

In order to determine the life cycle impacts of the biodiesel production process, all the material and energy streams associated with the process must be quantified. The paper presents a summary of mass and energy streams for each life cycle step of the biodiesel production process, including:

- Raw Materials;
- Production; and
- Transportation.

• Example: x kg soy oil (raw material) used/kg biodiesel produced

Step 2: LCA Emission Factors

Each life cycle step, above, is assigned an emission factor to determine the associated GHG emissions, as well as other impacts, such as resource depletion and impacts to the environment. These emission factors were derived from existing LCA Databases and from published Fuel Well-to-Wheel models.

• Example: x kg CO_2-eq emitted/kg soy oil (GHG impact)
• Example: x kg H_2SO_4-eq emitted /kg soy oil (Acidification impact)

Step 3: Calculate Life Cycle Impacts

The results obtained in Step 1 and Step 2 are multiplied to yield the Impact of each Life Cycle step.

• Example: x kg CO_2-eq emitted/kg biodiesel produced associated with use of soy oil (GHG impact)
• Example: x kg H_2SO_4-eq emitted/kg biodiesel produced associated with use of soy oil (Acidification impact)

Step 4: Identify the Largest Emitters

Once the emission inventory has been created, the Life Cycle Items with the largest impact per unit of production should be identified for each Impact Category, namely GHG emissions, Acidification, etc.

Ranking Life Cycle Items may be accomplished by creating a Pareto plot, which combines a bar chart displaying LCA Impacts in decreasing order with a line graph showing cumulative percentages of the categories. An example of a Pareto plot is presented below for the GHG Emissions Impact Category.

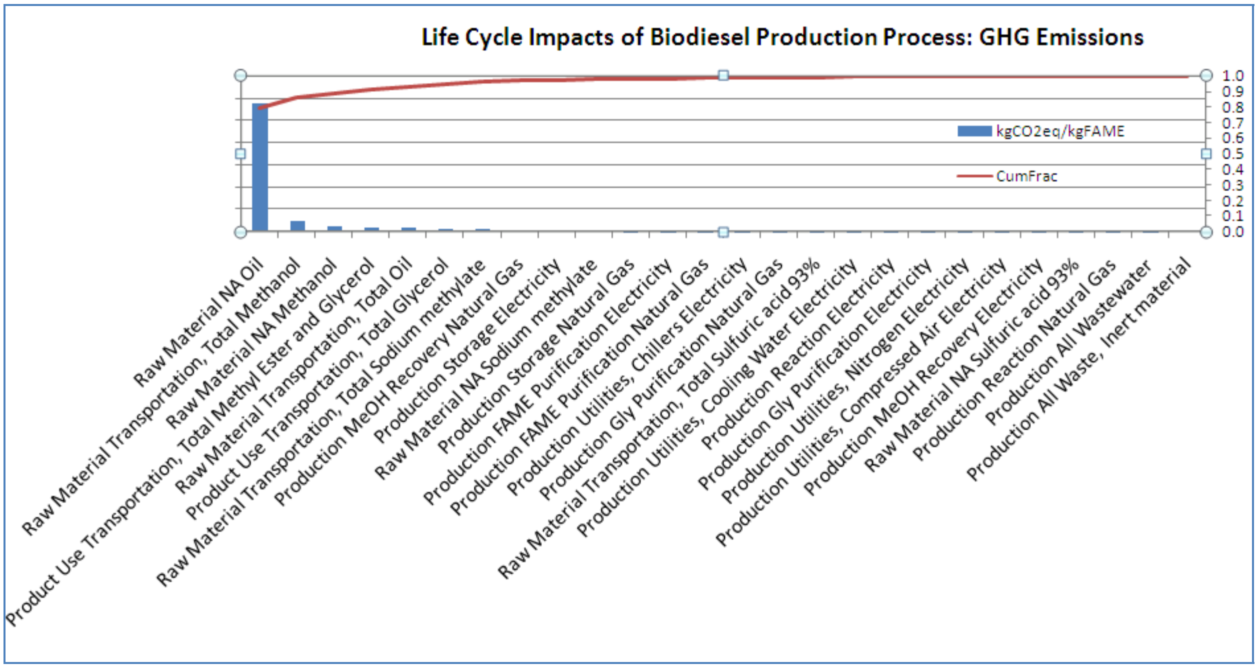

Figure: Example of a Pareto Plot for GHG Life Cycle Impacts from a Biodiesel Production Process (Note: FAME is Fatty Acid Methyl Ester or Biodiesel)

The aim of this exercise is to give a company a place to start devising a sustainability strategy, provide detailed information that may result in insightful notions on the types of processes that contribute to environmental impacts; and more easily identify cost-effective projects with large sustainability improvement potential.

Step 5: Identify Sustainability Improvement Options

The paper discusses potential methods for improving the Sustainability of a biodiesel production process, including energy efficiency projects, emission reduction options, feedstock and raw material sourcing options, and others.

Step 6: Evaluate Sustainability Improvement Options

This section presents a method for the evaluation of sustainability improvement options, including a financial analysis, as well as non-financial considerations, such as implementation timeframe, risk management, and project replicability.

Step 7: Set Targets and Measure Progress

Targets must be clearly defined and measurable. When setting a target a company must also define how progress toward that target will be measured. Sustainability improvement targets are in large part determined by a company’s driver for improved Sustainability performance. Regulations, financial incentives, cost savings, and issues such as social responsibility, response to internal and external pressures, and reputation may move an organization to set internal targets. Each of these drivers is discussed in this section.

Step 8: Communicate Targets and Progress

Goals and progress toward meeting Sustainability goals should be communicated within the company and optionally to stakeholders and other organizations through the company's website, their Annual Reports, advertisements, etc. An improvement of employee morale has been recorded at several firms that have reached goals. This section presents examples of Corporate Sustainability Reports and the current trends in Sustainability Reporting.

Review of Biofuel Initiatives and Economic Implications

The paper also provides a review of various state and federal biofuel policies that incorporate LCA as a key program element, such as the U.S. Renewable Fuel Standard, California's Low Carbon Fuel Standard (LCFS), and the U.K. Renewable Transport Fuel Obligation (UK-RTFO), and discusses how obligated parties can use the tool presented in this study to comply with such policies. The paper also analyzes the potential economic implications of regulations such as LCFS on biodiesel production.