

Technical note

The energy balance in the Palm Oil-Derived Methyl Ester (PME) life cycle for the cases in Brazil and Colombia

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ABSTRACT

The use of biodiesel produced from the transesterification of vegetable oils with methanol and ethanol is currently seen as an interesting alternative to fossil fuels. The output/input energy relation in the biodiesel production life cycle can be an important indicator of the techno-economic and environmental feasibility evaluation of production of biodiesel from different oleaginous plants. Due to increasing environmental concerns about the emissions from fuel-derived atmospheric pollutants, alternative sources of energy have been receiving greater attention. This work does not look to carry out a complete life cycle assessment (LCA) but rather just to focus on the energy balance in the Palm Oil-Derived Methyl Ester (PME) life cycle, taking into account practices in Brazil and Colombia. This work will show the differences between the results attained for the two cases. The output/input energy relation for the evaluated case studies ranged from 3.8 to 5.7, with an average value of 4.8.

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1. Introduction

The use of biofuels produced through the transesterification of vegetable oils with methanol and ethanol is currently considered to be a feasible energy option. Amongst the advantages that biofuels offer is the potential to reduce emissions of carbon dioxide, carbon monoxide, hydrocarbons and sulfur oxides. From an economic point of view, the continuous increase in the price of oil and the possibility of receiving financial resources through the commercialization of carbon credits – established by the Clean Development Mechanism (CDM) – should be considered. Moreover, strategic questions, such as job and income generation and energy self-sufficiency in rural areas, reinforce the need for biofuel programs.

The LCA methodology is standardized and described under the standards of the International Standard Organization, ISO 14040–14043 [1–4]. LCA is used to evaluate the environmental impacts and other potential factors related to the product's life cycle energy balance, including raw materials, production, consumption, and waste utilization.

The output/input energy relation in biodiesel production can be used as an indicator of techno-economic and environmental feasibility analysis when comparing different oleaginous plants. This will determine the best type of culture for biodiesel production in a specific geographical and economic scenario.

The energy balance for a biofuel production system can be defined as the relation between the energy produced (output per kg biodiesel) and the energy consumed (input per kg biodiesel) for each unit of product.

The LCA energy balance studies for biodiesel production were carried out in Europe by the (ITC) Italian Thermo-Technical Committee [5] for rapeseed and sunflower oleaginous plants, and in the United States by Sheehan [6] for soybean. The output/input energy balance relation ranges from 3.2 to 3.4 for the United States.

The life cycle energy ratios for oil methyl ester from rapeseed in Lithuania [7] have been calculated as a function of rapeseed productivity, oil extraction and the transesterification technologies used. The average values for energy balance output/input relations in this study ranged between 2.41 and 5.23 when rapeseed productivity is 3 ton ha^{−1}.

In Brazil studies considering the methyl and ethyl route related to the castor culture were carried out by Neto [8], attaining an output/input relation ranging between 2 and 2.9. A productivity of 1800 kg ha^{−1} was taken into account.

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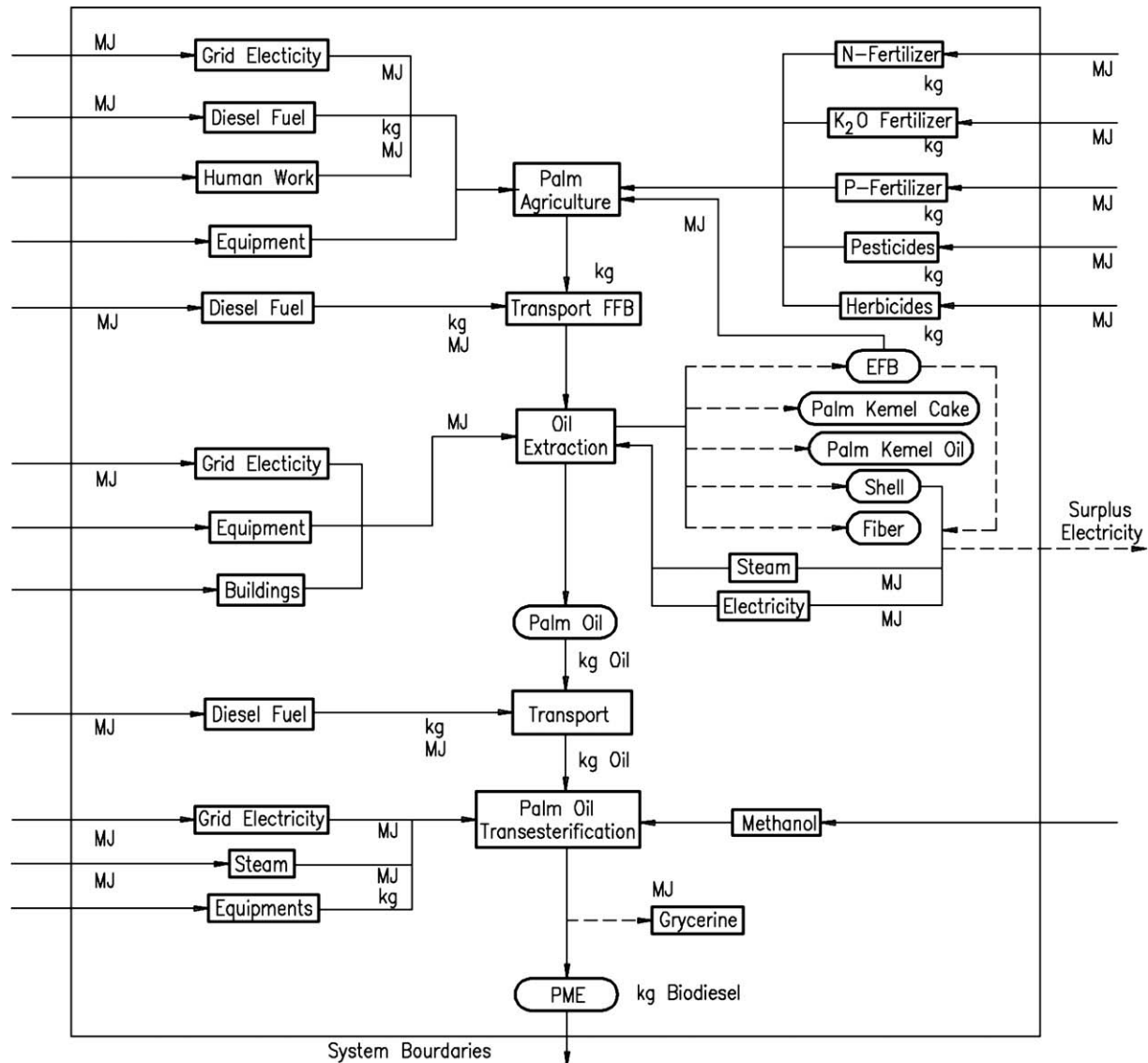


Fig. 1. PME LCA system boundaries.

A study conducted by the Brazilian Foundation for Sustainable Development (FBDS) [9] quotes published data, stating the energy output/input index for palm oil biodiesel is 5.6.

However, care needs to be taken when comparing different life cycle energy balance results, as boundary conditions or the coefficients used during data elaboration may be different.

The objective of this paper is not to carry out a complete LCA, but only the inventory stage to determine the energy balance during the PME life cycle. The output/input energy relation is proposed as an indicator. This allows one to show how many units of renewable energy are obtained when one unit of fossil energy is consumed.

This paper presents the results of this study and a discussion of the differences between the results obtained in both case studies.

2. Methodology

The methodology of this study is based on the ISO 14040 Standard, in so far as it deals with the definition of the objective, function, scope and goal of LCA studies including inventory analysis.

In line with the ISO 14040 methodology, the objective, the function, function unit, scope and goal definition of this work are defined as the following:

- 1 Objective: To evaluate the energy balance of the Palm Oil-Derived Methyl Ester (PME) life cycle, taking into account its use as fuel, for 1 kg of PME and a 20-year useful life period for equipment and buildings.
- 2 Scope of this study: The scope of this study was to generate a basis for discussions on sustainability and renewable nature of biodiesel from palm oil, through the quantification of energy balance.
- 3 Function: Fuel production from crude palm oil through methyl route transesterification.
- 4 Functional Unit: MJ of input energy for each MJ of output energy in the PME life cycle.
- 5 Reference flow: 1 kg of PME
- 6 Product system

The produce units of the PME product system are as follows:

- Unit 1 – Oil palm agriculture;
- Unit 2 – Fresh Fruit Bunches (FFB) transport;
- Unit 3 – Oil extraction;
- Unit 4 – Palm oil transesterification (the plant is assumed to be close to the oil extraction mill).

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