Greenhouse gas emissions and energy balance of biodiesel production from microalgae cultivated in photobioreactors in Denmark: a life-cycle modeling - DTU Orbit (08/11/2017)

Greenhouse gas emissions and energy balance of biodiesel production from microalgae cultivated in photobioreactors in Denmark: a life-cycle modeling

The current use of fossil fuels is problematic for both environmental and economic reasons and biofuels are regarded as a potential solution to current energy issues. This study analyzes the energy balances and greenhouse gas emissions of 24 different technology scenarios for the production of algal biodiesel from Nannochloropsis cultivated at industrial scale in photobioreactors in Denmark. Both consolidated and pioneering technologies are analyzed focusing on strengths and weaknesses which influence the performance. Based on literature data, energy balance and greenhouse gas emissions are determined in a comparative 'well-to-tank' Life Cycle Assessment against fossil diesel. Use of by-products from biodiesel production such as glycerol obtained from transesterification and anaerobic digestion of residual biomass are included. Different technologies and methods are considered in cultivation stage (freshwater vs. wastewater; synthetic CO2 vs. waste CO2), harvesting stage (flocculation vs. centrifugation) and oil extraction stage (hexane extraction vs. supercritical CO2 extraction). The choices affecting environmental performance of the scenarios are evaluated. Results show that algal biodiesel produced through current conventional technologies has higher energy demand and greenhouse gas emissions than fossil diesel. However, greenhouse gas emissions of algal biodiesel can be significantly reduced through the use of 'waste' flows (nutrients and CO2) but there are still technical difficulties with both microalgae cultivation in wastewater as well as transportation and injection of waste CO2. In any way, a positive energy balance is still far from being achieved. Considerable improvements must be made to develop an environmentally beneficial microalgae biodiesel production on an industrial scale. In particular, different aspects of cultivation need to be enhanced, such as the use of wastewater and CO2-rich flue gas from industrial power plants.

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