Life Cycle Performance of Biofuels from Microalgae

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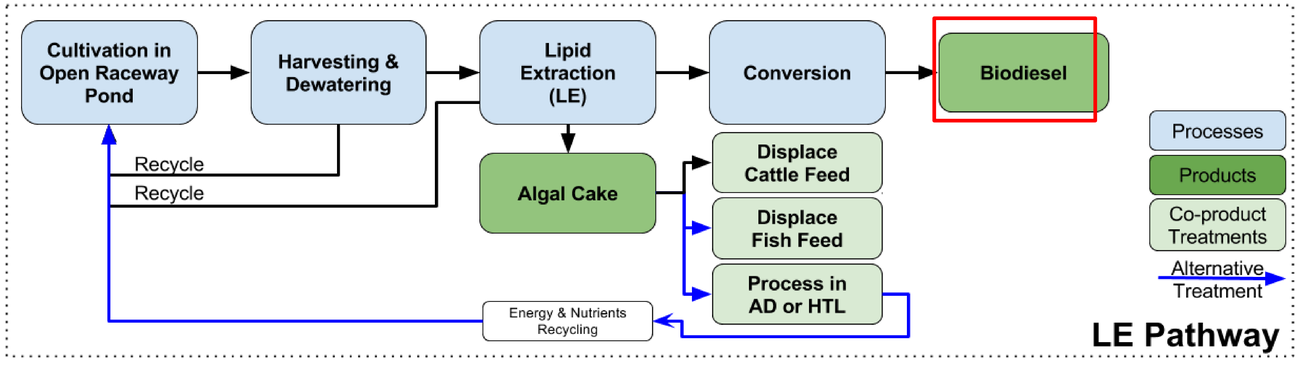
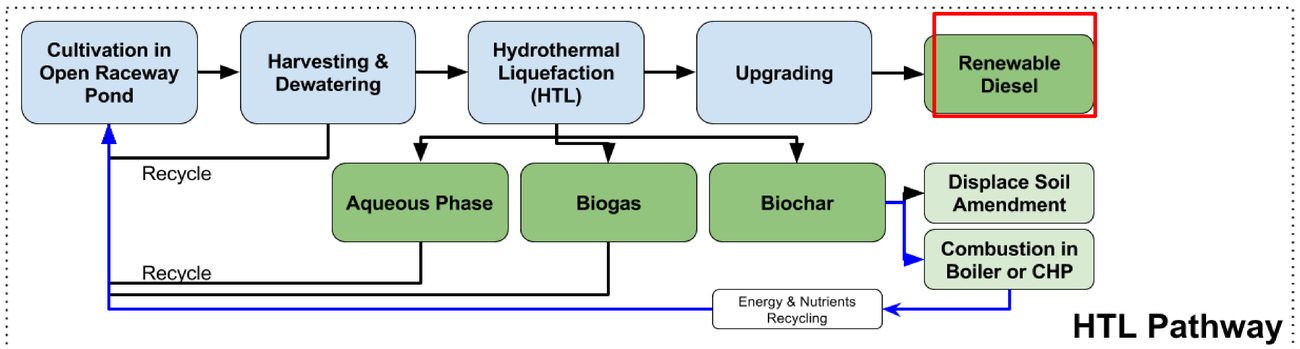
System Description





Introduction

Interest in biofuels derived from microalgae is growing because microalgae have high productivity and high oil content comparing to terrestrial energy crops, and the growth of microalgae requires significantly less land area and do not require fertile cropland. However, the intensive fertilizer and energy inputs during cultivation, harvesting and dewatering of biomass may result in high environmental impacts for algae-derived fuel production.

This study aims to evaluate and compare the GHGs and energy consumption from the most two popular oil conversion technologies for algal biofuel production using a process-based, prospective life cycle assessment (LCA) approach, and focuses on the effects of co-product treatment strategies and allocation approaches.

--Lipid Extraction (LE): transesterification process, considered as conventional biodiesel production technology extracting crude lipids from biomass using hexane.

--Hydrothermal Liquefaction (HTL): a thermochemical process involving the reaction of biomass in water at subcritical temperatures (below 374 ° C) and high pressure (10–25 MPa) for a certain reaction time.

	Economic Allocation	Energy Allocation	Mass Allocation	Displacement	Recycling for Energy and Nutrient
LE Pathway	Cattle Feed Price	NA	NA	1. Cattle Feed 2. Fishmeal	1. Process in Anaerobic Digester 2. Process in Hydrothermal Liquefaction
HTL Pathway	Soil Amendment Price	Energy Content of Biochar	Weight of Biochar	Soil Amendment	1. Combusted in CHP to produce Heat and Electricity 2. Combusted in Boiler to produce Heat

Recommendations

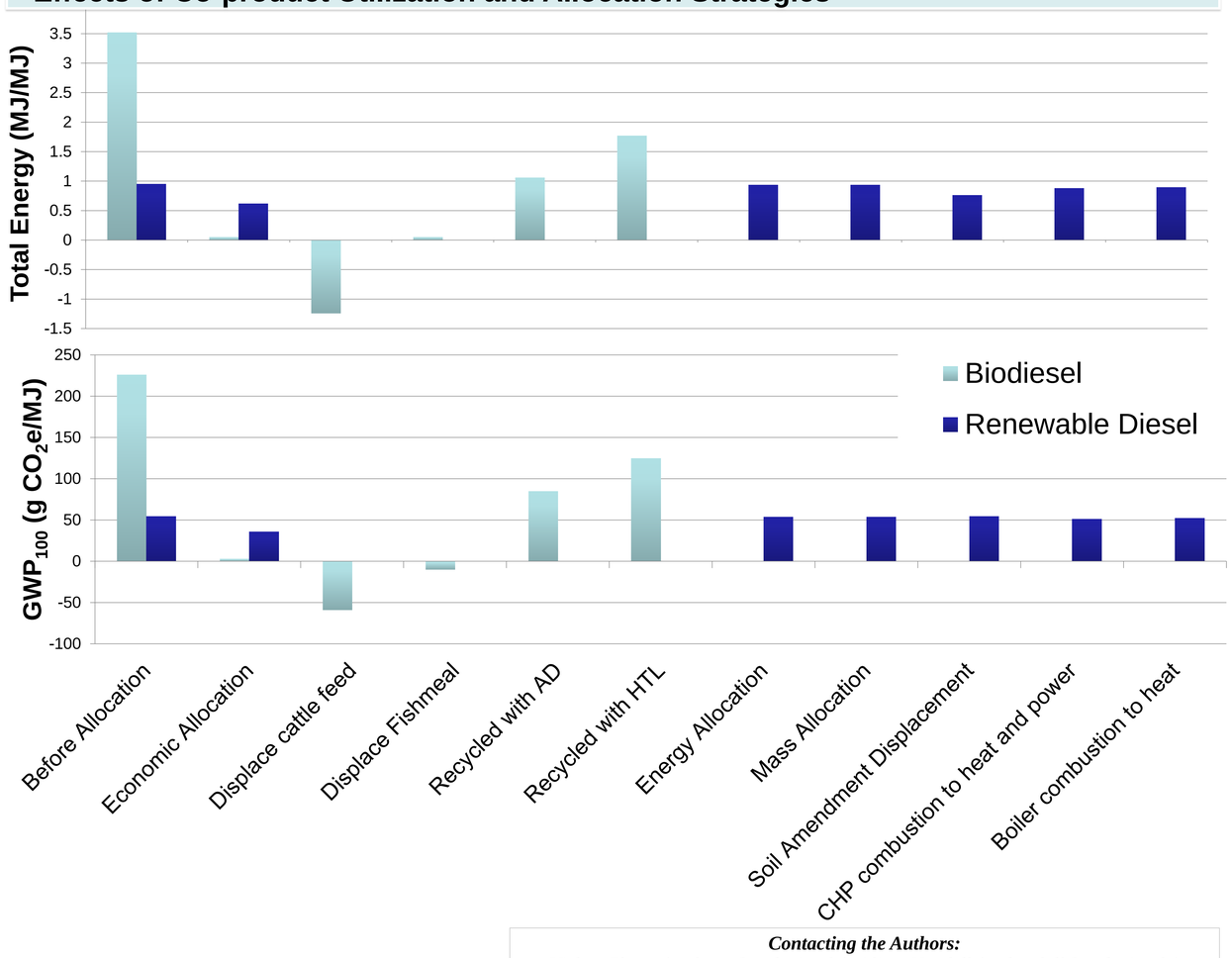
HTL is recommended for algae-based biofuel production compared to LE pathways due to low energy consumption and GHG emissions and little to no dependency on co-products for this result. The different utilization of co-product (algal cake) in the LE pathway has significant effects on the environmental performance of biodiesel. Thus renewable diesel provides more robust results than biodiesel because it does not depend on methodological choices or market conditions. Furthermore, the renewable diesel produced from the HTL pathway can be directly used as petroleum-derived diesel substitute, while biodiesel has lower energy content and may require additional handling for distribution and blending.

In general, biodiesel has higher GHG emissions than renewable diesel does, but when algal cake is used for animal feed (cattle feed or fish feed), and accounted for using the displacement method, it reduces the system emissions to a negative level. Therefore, using algal cake as animal feed is recommended instead of using it for energy generation or nutrient recycling due to its high nutritional value.

Results

Before Allocation of Co-products	Biodiesel (LE Pathway)	Renewable Diesel (HTL Pathway)
GWP_{100} (g CO_2e/MJ)	**225**	**55**
Total Primary Energy (MJ/MJ)	**3.52**	**0.95**

Effects of Co-product Utilization and Allocation Strategies



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