The Influence of Algae Cultivation on the Selection of Jet Fuel or Biodiesel

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Abstract

The aim would be to discover the impact of conflicting factors in the application of algae in CO_2 sequestration for the benefit of sustainable biofuels. Based on the LCA approach, the model and quantitative AI assessment approach were established by coupling the upstream CO_2 source and the downstream algal product at the uniform level of Nannochloropsis oceanica algae, benefiting the selection of algal biofuel suppliers would come. The AI model examined the impact of interacting factors on energy consumption, including transport distances coupled with cleaning modes coupled with flue gas CO_2 concentration, lipid content coupled with specific productivity with the supply of nutrients, and the refining process with the end products. The computational framework of the AI model is divided into three sub-models, including the CO_2 capture and purification model, the algae cultivation and harvesting model, the refining process, and the biofuel product model. Consistent with the uncertainty analysis of the KI model, positive energy gains were realized over a wide range of lipid levels despite the use of biofuel or biodiesel that couples solar energy and nutrient byproduct effects. Wet biodiesel and HTLHRJ jet biofuel had the energy consumption priorities in three jet biofuel tracks and three biodiesel tracks. The allocation analysis confirmed that algal biofuel has promise in the direction of cultivating algae suitable for the target requirements of biofuel products and improving by-product recovery. The results would increase interest in both LCA and CO_2 sequestration for the benefit of sustainable biofuels.

Introduction

Climate change, mainly due to the emission of flue gases from the coal-fired power plant industry, is a critical environmental issue today. Taking into account power demand and downstream emissions, CO^2 fixation with algae becomes an attractive approach for CO^2 capture and additional benefits in downstream algae use due to environmental permit priorities and sustainable potential. Coal-fired power plant flue gas is an ideal carbon source for large-scale algae cultivation due to stable and centralized emission characteristics, which have been qualified as carriers of bioenergy with benefits of bio-nutrients along with CO^2 abatement. However, the algae chain must reconcile economic, energetic, and ecological aspects to be able to make a specific product selection.

The improvement of flue gas cleaning technology for edible bio-nutrients has achieved certain economic benefits, but the energy consumption is very high. The ideal species of algae should be qualified with the characteristics of rapid growth and high lipid content, but the growth rate of algae decreases with increasing lipid content. However, the increase in algal growth benefits CO_2 fixation, while the increase in lipid content in algae benefits biofuel quality and quantity. Most reviews provide the most promising microalgae species for different types of biofuels. Nanochloropsis oceanica is considered the ideal species of algae, characterized by rapid growth and high lipid content. The challenge of tolerance to high CO_2 concentrations was overcome by gradually increasing the CO_2 concentration to even purified CO_2 by combining pH control and aeration control. Pollutants in flue gas have been shown to have a tolerance to SO^X less than 60 ppm, NO_2 less than, 300 ppm and NO less than 60 ppm, but an aggregation of specific trace metals in algal cells has been studied. For edible algae, as an edible source of CO_2, the flue gas needs to be further cleaned to remove trace metals to inhibit trace metals in bio-nutrients. Consequently, the need for edible CO_2 increases energy consumption but benefits economics, while the general algal feedstock without the benefit of edible bio-nutrients loses advantage despite improved CO_2 sequestration. Algae farming for target suitable algae products must also find a balance between energy consumption and economics in terms of quality and quantity of algae products.

Currently, the algae industry pursues a wide range of products, from bio-nutrients and animal feed to biofuels for aeroplanes and biodiesel. However, it is difficult to reasonably derive the available algal end product with an upstream flue gas source and appropriate algal cultivation due to the long and complex value chains and the uncertainty in upstream algal feedstocks for downstream bioenergy conversion systems. LCAs were performed products and processes based on available models and approaches. The current evaluation results are complex, as a complicated system of relevance from the upstream CO_2 source to the product of the downstream consequences is insufficiently discussed.

In this study, a quantitative assessment model was established and uncertainty analysis was performed, and conflicting factors in the application of algae for CO^2 capture were balanced in favour of sustainable biofuel. In particular, mass allocation and energy allocation were included in the dimensionless value-based model for IA assessment. The results would increase interest in both the AI assessment of LCA and CO_2 sequestration for the benefit of sustainable biofuels.

Conclusion

Combining transport distances and cleaning modes with flue gas concentrations, low CO^2 flue gases are suitable for on-site use within 10 km, while more than 95% of CO_2 flue gases are flexible in terms of transport distance and cleaning modes.

Specific productivities and CO_2 fixation meet negative logarithmic relationships with lipid levels, while lipid levels and profile define biofuel delivery outcomes. HTLHRJ, BiodieselRD, and Biodieselwet achieved positive energy gains in the lipid range of 35% -45% from general algae with glycerol by-products. Negative energy gains in the wide range of edible seaweed cultures despite the addition of by-products (bio-nutrients and glycerol).

By combining solar energy harvesting and by-product effects, positive energy gains have been achieved at 15% to 45% lipid content for both general and edible algae. The algal CO2 fixation can be further modified with the AI model towards algal cultivation corresponding to the available target biofueL product and the connection of upstream flue gas sources.

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