Scientists assess environmental impacts of bioenergy for transport

Converting algae into bioenergy is one option being considered to meet future demand for transport energy. However, a recent study suggests that some combinations of cultivation processes and conversion technologies for algae-derived energy consume more energy than is produced, although water use and greenhouse gas emissions are lower for the most promising options compared with bioenergy sourced from switchgrass and canola.

Bioenergy (biodiesel and bioelectricity) produced from large-scale cultivation of algae could potentially provide a sustainable alternative to fossil fuels for transport. Nevertheless, algae-to-energy systems will have environmental impacts, including those associated with algae cultivation and the technologies used to process the algae into biofuel. This study used life cycle assessment (LCA) to estimate the environmental impact of a number of combinations of production methods and conversion technologies for producing transport energy from algae grown in open ponds. The environmental impacts of the most promising combinations of methods and technologies were then compared with the environmental impacts associated with bioenergy production from two crops: switchgrass and canola.

The results suggest that production and conversion processes have an important impact on overall energy return. In addition, not all of the combinations produced more energy than was consumed in the cultivation and conversion processes. For example, despite uncertainties associated with using the energy return on energy invested (EROEI) (the amount of energy produced per energy consumed to deliver one functional unit of energy), the EROEI ranged from 0.65 to 4.10 depending on the combination of cultivation and conversion processes for the algae systems. Values over 1 imply net energy production, but a value of 3 is regarded as the minimum sustainable level of EROEI. Both biodiesel production with conversion of residual matter into bioelectricity and bioelectricity generation from direct combustion were considered to be the most promising combinations for energy efficient production of bioenergy from algae.

In addition, direct combustion conversion processes (combustion of algae to produce bioelectricity) appear to be more efficient than anaerobic digestion conversion processes (that produce methane-derived bioelectricity), irrespective of whether oils in algae are first extracted to produce biodiesel. There could be three reasons for this: the amount of algae digested is relatively low with less nitrogen and phosphorus available for recycling as input nutrients; methane and ammonia recovery is not as high as the theoretical maximum recovery; and a substantial amount of the bioelectricity generated from methane is required for digestion operations, reducing the amount available for transport needs.

Compared with producing biodiesel from canola (with conversion of residual matter into bioelectricity) and generation of bioelectricity from switchgrass, both algae systems (biodiesel production with conversion of residual matter into bioelectricity and bioelectricity generation from direct combustion) produce more usable transportation energy per unit area of land (measured in terms of vehicle kilometers travelled (VKT) production per hectare). Algae generates, on average 4.2 and 15.7 times more VKT production per hectare than the canola and switchgrass systems respectively. This implies that the cultivation phase of algae bioenergy systems use land more efficiently than terrestrial crops used for bioenergy feedstock (when compared on a raw biomass energy basis).

When other environmental impacts were considered, algae-derived transport energy had mixed results compared with switchgrass and canola derived energy. Net energy use for cultivating and producing transport energy of the two most promising algae-to-energy systems was higher than net energy use in the canola and switchgrass systems (on a per km travelled basis). However, water use and greenhouse gas emissions were lower than the canola and switchgrass systems. This study suggests that, although cultivation of algae requires less land than switchgrass and canola, algae-to-energy systems can produce other environmental burdens, particularly in the net energy used to produce transportation energy.


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