Industrial production of biodiesel feasible within 15 years

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Within 10 to 15 years, it will be technically possible to produce sustainable and economically viable biodiesel from micro-algae on a large scale. Technological innovations during this period should extend the scale of production by a factor of three, while at the same time reducing production costs by 90%. Two researchers from Wageningen UR (University & Research Centre) believe this to be possible. In their article in Science (published 13 August), they provide a detailed explanation of the route that needs to be taken.

By producing microscopically small algae in bulk in large-scale installations, Europe should be able to become independent of fossil fuels in a sustainable way. Algae could even contribute to the sustainable production of food. To cultivate algae on a large scale, fertilisers (nitrogen and phosphates) could be extracted from manure surpluses and wastewater, with CO2 coming from industrial residues. The energy source for algae is sunlight. Biodiesel and an almost unlimited quantity of protein and oxygen are the sustainable products of this process. The amount of fresh water consumed in algal cultivation is minimal because seawater can be used.

In a nutshell, that is the idea put forward by Professor René Wijffels and Dr Maria Barbosa of Wageningen UR in their perspective article An Outlook on Microalgal Biofuels in *Science*.

Sunlight and wastewater

Both authors demonstrate in their article that, according to calculations on energy consumption in transport in Europe, almost 0.4 billion m3 biodiesel would be needed to replace all transport fuels. The cultivation of micro-algae requires 9.25 million hectares of land - equal to the surface area of Portugal - assuming a yield of 40,000 litres of biodiesel per hectare, to supply the European market.

Algae produce the maximum quantity of oily substances when growing under stress. Such conditions can for instance be induced by a shortage of nutrients such as nitrogen and phosphate.

Algae are much more efficient at converting sunlight and fertilisers into usable oily substances than agricultural crops such as oilseed rape. It is not even necessary to have full sunshine for algal cultivation, which is why it is possible to design reactors that look like vertical plates, on to which the light shines from one side. In this way, it is possible to produce 20-80,000 litres of oil per hectare. In comparison, one hectare of oilseed rape or oil palm yields only 1500 or 6000 litres, respectively.

Financial aspects

The 5000 tonnes of algae (dry matter) now produced annually in the whole world has a value of €250/kg. The price is so high because algae can make rare (and therefore expensive) substances like carotenoids and omega 3 fatty acids that are converted into high-quality products such as food supplements. That is extremely expensive when compared with the palm oil (cost price €0.50 /kg) used as a fuel. However, palm oil and other fuel crops are controversial. To investigate whether the use of algae as biofuels is feasible, a feasibility study was carried out on scale enhancement in algal cultivation. This showed that presently the cost price could be reduced to €4/kg. By making use of residues such as wastewater and CO2 from exhaust gases, by improving the technology and by shifting production to sunnier countries, it would even be possible to reduce the price to one-tenth of that level, namely, €0.40 /kg.

Even then, however, the production of bioenergy from algae would not be financially viable. To achieve that goal, the whole algal biomass would have to be utilised. This consists of roughly 50% oil (40 cents/kg, thus), 40% proteins (yielding 120 cents/kg) and 10% sugars (100 cents/kg). This causes the value to rise to €1.65/kg which is enough to run production on a large scale.

Proteins

Algal proteins offer interesting possibilities. If all transport fuels were to be replaced by algal oil on a European scale, 0.3 billion tonnes of protein would become available as well. That is 40 times more than the amount of protein in the soya that Europe imports each year. Thus, algae would allow us to produce food and feed proteins as well as sufficient quantities of biofuel.

In order to manufacture biofuels from agricultural crops such as oilseed rape, 10,000 litres of fresh water are required to produce each litre of fuel. This is an incredibly large volume. By cultivating algae in seawater, it is possible to achieve the same result with just 1.5 litres of fresh water/kg of product.

With the aid of sunlight, algal growth requires 1.3 billion tonnes of CO2 (Europe produces 4 billion tonnes/year, mainly from fossil fuels) and 25 million tonnes of nitrogen (wastewater and fertilisers contain 8 million). In other words, algal cultivation would not normally compete with food production.

A sustainable pilot-study facility AlgaePARC (Algae Production and Research Centre) will soon be starting up in Wageningen. Here it will be possible to study the scaling up of algal production and to compare various technologies, taking into account energy costs for building, production and logistics during the production of biofuels from algae.

Algae need to be interesting as a food source for fish and shellfish farming within five years. Five years after that, it should be possible to achieve applications such as providing protein sources in foods as well as basic chemicals for the manufacturing industries. Then, in 10-15 years' time, biofuels should be available.

Provided by Wageningen UR

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