Food and fuel from microalgae: Integration of photosynthesis and photovoltaics allows to achieve a positive energy balance of algae biomass production

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In spite of the potential of microalgae, no company seems to possess a mature technology able to produce algae biomass at low cost and compete with traditional sources of food, feed and fuel. The high capital and operating costs of microalgae farming, the non-sufficiently positive energy balance and the not yet established sustainability still prevent the development of this technology to commercial scale. But new designs are emerging, which may contribute to closing the gap between algae feedstock and current alternatives.

Among the barriers that need to be cleared before fuel, feed and food from algae may become a reality, there is the sustainable cultivation of selected strains at large scale and the low EROI (Energy Return on Investment) of the process. The main reasons for the preference of photobioreactors (PBR) over ponds for algae cultivation is that they provide a close and more controllable environment, thus limiting the risk of contamination and ensuring a higher and more sustainable production. However, no PBR design has been developed and tested at the (large) scale necessary for a complete economic and energetic evaluation of the process, and at pilot scale PBR show a lower EROI compared to ponds.

The Green Wall Panel (GWP), a low-cost, flat PBR developed at the University of Florence and commercialized by Fotosintetica & Microbiologia S.r.l. (Italy), needs about 350 KJ m^{-2} d^{-1} to operate (mostly for mixing and cooling). In the summer, with an average productivity of 20–25 g m^{-2} d^{-1} (equivalent to an energy output of about 400 KJ m^{-2} d^{-1}), the biomass production process in this system achieves an EROI near unity, while an EROI of more than three would be necessary. An integrated GWP has been recently developed to reduce energy costs and enhance the EROI. Called SOLO, this stand-alone system uses part of the impinging photons for photovoltaic generation of about 1 MJ m^{-2} d^{-1} of electric energy, which are sufficient to cover all the needs of the process (including cultivation, harvesting and drying). In a particular application of the SOLO tested outdoors, it has been shown that a significant fraction (30–50%) of the impinging photons can be diverted to the photovoltaic elements without reducing algal productivity.

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