Energy Analysis of Using Macroalgae from Eutrophic Waters as a Bioethanol Feedstock

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ABSTRACT

Eutrophication is an environmental problem in a majority of shallow water basins all over the world. The undesired flowering of macroalgae has been proposed as a biomass resource for bioethanol production and we have analysed the environmental sustainability of two case studies: Orbetello Lagoon (OL), Italy, and Køge Bay (KB), Denmark. Today, macroalgae are collected and stored in landfills to provide a solution for the excess production. An energy assessment revealed that the main environmental support in the growth phase of the macroalgae in both case studies is given by water; in OL, rain represents 51% of the energy use, and runoff from agricultural land constitutes 86% in KB. The environmental support needed for producing one Joule of bioethanol is somewhat more than for a number of other bioethanol feedstocks being $6.5 \times 10^5$ solar equivalent Joules (seJ) for OL and $25.6 \times 10^5$ seJ for KB. However, a high percentage of the environmental support comes from local renewable flows being 40% for OL and 88% for KB. The difference between the two case studies is partly due to the contribution of energy from waves, which plays an important role in carrying macroalgae towards the coast in Køge Bay. Energy-wise, one J of fossil energy is required directly or indirectly to produce 0.28 J of bioethanol for OL or 0.44 J of bioethanol for KB, i.e. the Energy Return On Energy Invested (EROI) is less than 1. Alternative scenarios were developed in order to investigate improvements of system efficiency. They were also analysed with a marginal approach accounting only what the bioethanol production requires of additional processes compared to the present situation, i.e. mainly transportation and conversion of the macroalgae in a biorefinery facility assumed to be situated close to an existing industry producing waste heat. Both energy and EROI analyses show that only a relatively small amount of resources has to be added to the existing system to produce the bioethanol. With the marginal approach for assessment, macroalgae may be appreciated as a resource for bioethanol production instead of considered as an environmental problem.

Citation
