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A Sustainability Perspective of Microalgal Biofuel Production through Biorefineries

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Microalgae is a third-generation biomass feedstock considered sustainable in addressing some concerns of the first- and second-generation biomass feedstocks. It comprises lipids, carbohydrates, and proteins that can be converted into various bioproducts through biorefineries. A biorefinery is a system of technologies that converts biomass feedstocks into multiple bioproducts. Biorefineries consist of four conversion platforms such as thermochemical, mechanical, chemical, and biological. Each of these biorefinery platforms corresponds to many biorefinery conversion processes that enable the production of primary and secondary bioproducts. Microalgal biorefinery is assessed through the triple bottom line assessment tools such as the environmental, economic, and social aspects. The environmental aspect is evaluated using a life cycle assessment. The economic components are assessed through techno-economic analysis. The social aspect is determined using social-economic studies. While the holistic sustainability of the microalgal biorefinery is assessed using multi-criteria decision analysis. Although the complexity of the process network of microalgal biorefineries is challenging to understand, it can be designed to generate sustainable bioproducts using process integration and optimization techniques. Case studies are presented along with the challenges in microalgal biorefineries. Overcoming the challenges in microalgal biorefinery will enable the commercialization of these conversion platforms and generate sustainable microalgal biofuels.