Transforming Kelp Waste Streams into Low-Carbon Ethanol for SAF

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Kelp is one of the most promising non-food feedstocks for ethanol-based sustainable aviation fuels (SAF). It is a zero-input brown macroalgae that requires no land, fresh water, synthetic pesticides or fertilizers to grow. It cycles nutrients and absorbs CO2 when it grows, reducing ocean acidification and improving marine environments. Moreover, farming and processing kelp creates high-quality jobs in rural coastal communities.

In the laboratory, pathways to convert kelp into a variety of biofuels have been demonstrated including methane, ethanol, and butanol. However, technology scale-up remains a key challenge because (i) the feedstock remains relatively expensive and limited in supply; (ii) extraction of fermentable sugars is limited due to kelp's unique carbohydrate composition and (iii) there are few microbial strains that can efficiently convert the available sugars. To date, proven bioconversion pathways remain economically unviable.

Macro Oceans is a California-based kelp bioprocessor. We currently manufacture and sell a high-value bioactive compound from kelp while sending the leftover kelp waste to landfill where it creates significant Greenhouse Gas Emissions (GGEs). In this project, Macro Oceans is partnering with the National Renewable Energy Laboratory to pioneer a kelp-waste-to-ethanol pathway beyond the lab bench. Ethanol is an intermediate product for catalytic conversion to Sustainable Aviation Fuel. We focus on two objectives to make low-carbon, kelp-to-ethanol massively scalable. First, we will develop Macro Oceans's low-carbon and readily available kelp waste stream as a primary feedstock for bioconversion. Second, we will optimize a novel, high-yielding, bioconversion process for transforming kelp waste to ethanol.

We estimate that our novel approach can produce ethanol at 20 g CO2eq MJ, a 63% reduction compared to corn ethanol of 55 g CO2eq MJ. When coupled with high-value bioactive co-products, it is likely to be significantly less expensive as well. We estimate that a single full-scale biorefinery will create more than 50 jobs as well as significant new economic opportunities for coastal communities and historically underserved regions like Alaska.

These innovations will massively expand domestic demand for kelp, reduce U.S. GGEs and help build a scalable pathway to ultra-sustainable, kelp-based Sustainable Aviation Fuels.