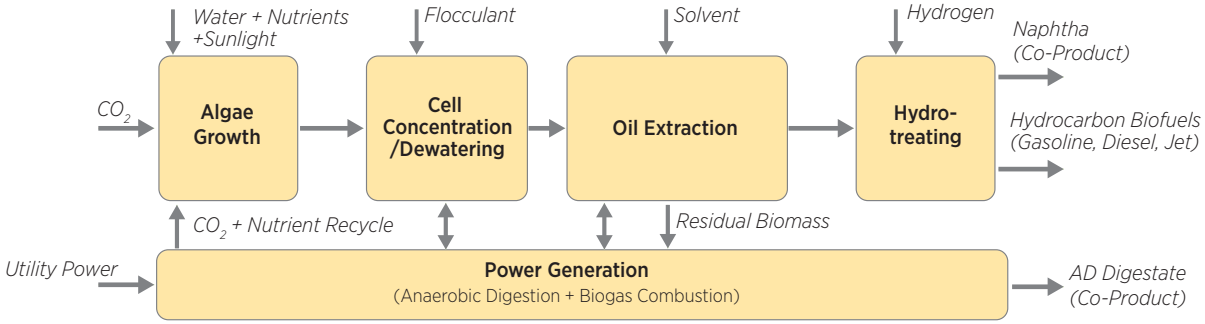
Algal Lipid Upgrading

In the algal lipid upgrading (ALU) pathway, bio-oils are extracted from algal biomass via high-pressure homogenization and a hexane solvent; the algal oil can then be hydrotreated to produce advanced hydrocarbon fuels.

Process Block Diagram



Process Design Details

- Following cultivation, algal cells are harvested and concentrated. Dewatering consists of settling, dissolved air flotation (DAF) assisted by adding a flocculant, and centrifugation. In modeled results of this process, the material achieves a concentration of 10 grams per liter (1% solids) after primary settling, 60 grams per liter (6%) after DAF using an organic polymer flocculant (chitosan), and 200 grams per liter (20%) after centrifugation.
- The algal material is next sent to a wet extraction process, consisting of cell disruption using high-pressure homogenization, followed by solvent extraction with a hexane solvent ratio of 5 kilograms (kg) solvent to 1 kg dry biomass.
- The material is then separated into a light phase and heavy phase in a disk stack centrifuge.
- The solvent is stripped from the oil and recycled using distillation—leaving a relatively pure raw oil stream. The heavy phase containing the algal residue is sent to anaerobic digestion, which breaks down the material into a biogas stream, a nutrient-rich liquid effluent, and a high-solids digestate ("sludge").
- The biogas is burned in a gas turbine for heat and power generation, and the flue gas is recycled back to the ponds to minimize fresh carbon dioxide (CO_2) demands. The nutrients are recycled back to the ponds.
- After separation from the hexane solvent, the extracted raw algal oil is sent to a central hydrotreating unit.

Rationale for Selection

Microalgae grown via autotrophic pathways are attractive due to their superior growth rates and favorable land-use footprints. Nutrient recycling and heat and power integration through anaerobic digestion improve process economics and the sustainability profile of this pathway. It is expected that raw algal oil intermediate will require relatively mild upgrading (hydrotreating) to finished fuels at a marginal cost. Algal biomass can be tailored to produce specific components for fuel and/or product markets—creating the potential for high-value co-products.

Next Steps

To validate current process assumptions, first-hand data on large-scale, outdoor, year-round operation is required. Better characterization of the extracted algal oil will help in the design and understanding of more specific hydrotreating costs and associated potential for improvement. Current techno-economic analyses will be updated as research and development progresses over the next few years.

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