**IEAGHG Information Paper; 2013-IP2: Algal Biofuels**

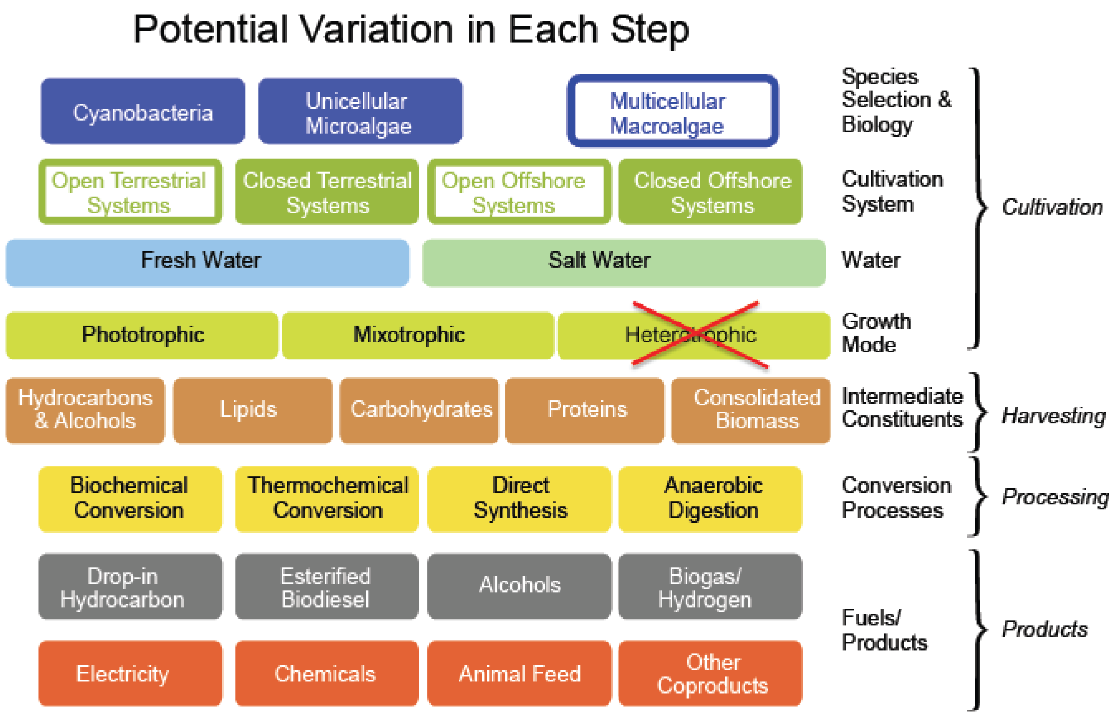
**Background: Sustainable Development of Algal Biofuels (2012)**

A report by the Committee on the Sustainable Development of Algal Biofuels comprising representatives of Board on Agriculture and Natural Resources; Board on Energy and Environmental Systems; Division on Earth and Life Studies; Division on Engineering and Physical Sciences; National Research Council.

Available via: http://www.nap.edu/catalog.php?record_id=13437

Domestic production of algal biofuel from solar energy and $CO_2$, offers the vision of meeting the dual goals of improving energy security and decreasing greenhouse gas (GHG) emissions from the transportation sector. Biofuel produced from algae offers potential advantages over plant-based biofuel, including high biomass productivity and the ability to grow algae in cultivation ponds or photobioreactors on non-arable lands using saline water or wastewater sources. However, along with potential environmental and social benefits, the production of algal biofuel could result in significant resource demands, limited yields and adverse environmental effects.

The topic of algal biofuel is very wide ranging, and in its infancy, with a multitude of species, processes and schemes being investigated. This figure illustrates the pathways for cultivating and processing algae to fuels and other products. Heterotrophic algal growth in the absence of sunlight as a renewable energy input is not considered in this review of energy supply systems.




*From Sustainable Development of Algal Biofuels (2012)*

The Algal Biofuels report identified EROI; GHG emissions; water use; supply of nitrogen, phosphorus, and carbon dioxide; and appropriate land resources as potential sustainability concerns of high importance. The committee does not consider any one of these sustainability concerns a definitive barrier to sustainable development of algal biofuel because mitigation strategies for each of those concerns have been proposed and are being developed. However, all of the key sustainability concerns have to be addressed in an integrated way. The Committee suggests that research, development, and demonstration are needed to test and refine the production systems and the mitigation strategies for sustainability concerns, if the promise of sustainable development of algal biofuel is has any chance of being realized. Definitive economic assessments of potential algal biofuel schemes would be premature at present.

Algae farming schemes fall into 2 broad categories; open ponds (e.g. a shallow raceway with a circulation paddle system) and photobioreactors (e.g. small diameter transparent tubes) with the following general characteristics: -_

| | **Open pond system** | **Photobioreactor** |
|---|---|---|
| Energy source | Natural sunlight | Focussed sunlight |
| $CO_2$ source | Atmosphere or introduced $CO_2$ | $CO_2$ from carbon capture system |
| Nutrients (N and P) | From waste water or introduced | Accurate dosing of nutrients |
| Capital cost | Low cost for simple engineering | High cost for sophisticated system |
| Economics | Generic analysis for energy only schemes is not promising | High value co-products could give economic viability for niche markets |
| Electricity consumption | Modest power demand | High power demand |
| Algal product quality | Variable quality algae product with potential for contamination | High quality mono-culture and secreted co-products possible |
| Potential products | Only suitable as a fuel precursor | Potential for high value products |
| Water use and loss | High water demand and high potential loss by evaporation | High water demand for solution management. Low evaporation loss. |
| Land area requirement | Less than an energy equivalent biomass plantation | Greater than an energy equivalent photovoltaic system |

The harvesting and processing of algae to biodiesel is common to both algae production systems. The extraction of fuel precursors and their subsequent processing can be energy intensive, resulting in a low thermal efficiency of conversion of harvested algae to biodiesel.

There are few complete cradle-to-grave algal biofuel systems defined with adequate certainty for comparative Life-Cycle Analysis (LCA) studies. Open pond algal biofuel systems are comparable on an LCA basis with biomass cultivation and processing to biofuel. The LCA of the engineered photobioreactor route to transport fuels, which essentially starts with solar energy and finishes with motive power could be compared to photovoltaic (PV) generation of electricity for use in electric vehicles (EV) via battery storage. Indicative performance data suggest that the solar energy captured by a photobioreactor might be two or three times less than by the same area of PV panels. Also the energy loss in converting algae to diesel is probably greater than the energy loss associated with battery storage of electricity and a diesel engine efficiency is two to three times less than that of an electric motor. Therefore an overall LCA comparison might indicate that the algal biofuel is several times less effective as a solar powered transport system than a PV-EV combination.

The economic viability of algal biofuel probably needs to focus on niche high value co-products. Thus widespread and large scale deployment of algal biofuel is seen by the Committee to be unlikely.

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