

Five key strategies for algae biofuels commercialisation:

A new study Algae 2020 (June 2009), has identified five key strategies: fatter, faster, cheaper, easier, and fractionation marketing approaches to help producers to reduce costs and accelerate the commercialisation of algae biodiesel, biocrude, and drop in fuels

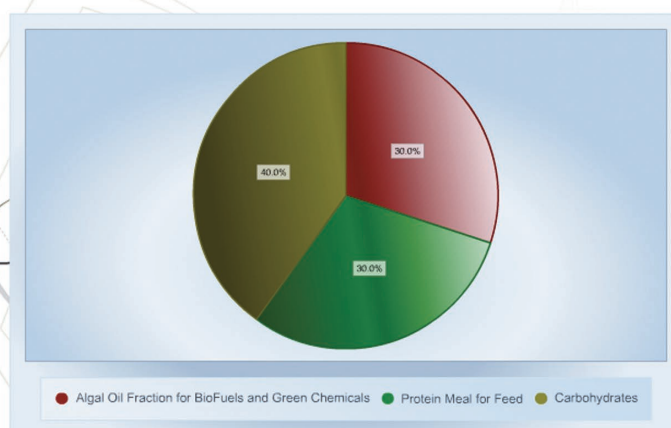
1 Faster – A primary strategy for most algae biofuels producers is to identify algae species that have a high oil content that will also grow quickly to produce biodiesel, biocrude and drop-in fuels.

It is largely agreed among seasoned practitioners, phycologists, producers, and subject matter experts that algae with high oil content such as *Botryococcus braunii* (Bb) grows slowly and can be harvested only a few times a week, whereas algae with lower oil content such as *Dunaliella* or *Nannocloropsis* (in the 20-40% range) will grow more quickly and can be harvested daily or a few times a day. For this reason, most algae R&D projects and pre-commercial projects are using algal strains with 20-40% content.

2 Fatter - Algae producers are especially interested in using algal species with a high triglyceride (TAG) oil content for biodiesel and biocrude production. Compared to most algae used today with 25% oil content, several scientists and producers are working on identifying species and methods to increase oil content.

Algal biomass fractions, products and markets

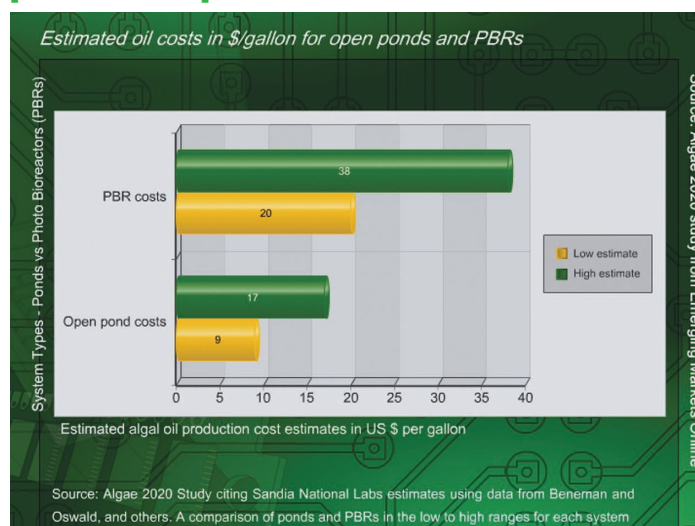
One feedstock - a diversified portfolio of products



Source: Algae 2020 study, Emerging Markets Online

Algae products are and will be used to manufacture: fuel, feed, food, fertilizer, plastics and green chemicals. Algae meal will be a protein supplement for aquatic and livestock/poultry feeds.

Algal oil production costs in open ponds and photo bioreactors



Source: Algae 2020 Study citing Sandia National Labs estimates using data from Beneman and Oswald, and others. A comparison of ponds and PBRs in the low to high ranges for each system

Most algae systems today can generate from 2,500 gallons up to 5,000 gallons of oil per surface acre in raceway ponds acre using 30% oil content. If algae producers can use fatter algae with 60% oil content, they can reduce the size and footprint of algae biofuels production systems by as much as half, resulting in significant capital and operating costs reductions and savings for systems twice their size using species with lower oil content. This presents a significant innovation and a welcome improvement for algae producers eager to lower costs to enter biofuels markets.

3 Cheaper – Based on the examination of several algae business and economic models, the Algae 2020 study finds the estimated costs to produce algae oils and algae biodiesel today range from \$9 (€6.5) to \$25 per gallon in ponds, and from \$15 to \$40 in photobioreactors (PBRs).

An outstanding, significant economic challenge for algae producers is identifying low cost oil extraction and harvesting methods. These costs are likely to come down significantly in the next few years and reducing these costs are critical to

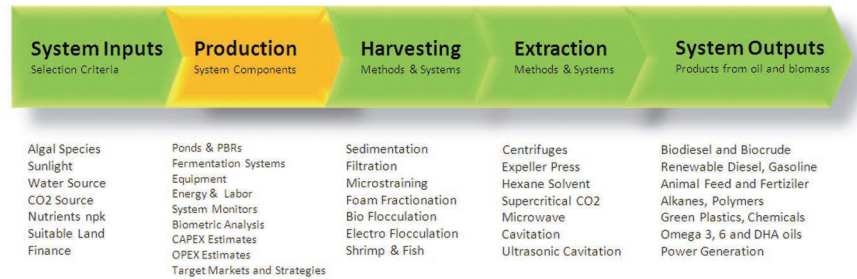
algae biofuels companies for commercial success.

Extraction systems can be expensive with estimates up to \$15 per gallon of oil produced depending on the extraction method. One company, Algae to Energy uses a patented system from Missing Link Technology that can extract algae oil from \$.08 up to \$.29 per gallon (depending on the species used) compared to other algae extraction methods ranging from \$2 a gallon up to \$12 per gallon.

Another example is a harvesting technology from Algae Venture Systems that costs less than \$.30 per gallon of oil harvested compared to traditional centrifuge technologies which can cost up to \$1 or more per gallon. Cost reductions in algae production systems are essential for algae producers to establish economically sustainable and profitable enterprises.

4 Easier/Better – Since algae production systems are a complex composite of several sub-sets of systems (i.e. production, harvesting, extraction, drying systems), reducing the number of steps in algae biofuels production is essential to providing easier, better, and lower-cost systems.

Algal biomass production systems



Source: Algae 2020, Emerging Markets Online Consulting Services

For example, Origin Oil has developed a technology to combine harvesting and extraction systems into a single process that is designed to reduce system complexity and costs for algae producers. Another example is to employ a method that uses algae cells as mini-processors and refineries in a process referred to as 'milking the algae' that will consume carbon dioxide and excrete hydrocarbon fuels directly. Examples of this include Arizona State's blue-green algae that excretes a kerosene type of jet fuel and Algenol's blue-green algae that excretes ethanol fuel directly.

There are also a few species of algae that will naturally excrete oils from the cells. By milking the algae, these algal micro-refineries help to bypass the harvesting, extraction and refining systems all together by

excreting forms of biofuels directly from the cells. These methods have the capability to significantly reduce production costs, and help to simplify complex processes for emerging algae producers and customers of new algae biofuels production systems.

5 Co-product fraction marketing strategies

– are critical to success. Even with algae species with up to 50% oil content, the additional 50% of the biomass remains. This biomass fraction contains valuable proteins for livestock, poultry and fish feed additives valued from \$800 up to \$2500 per tonne.

Part of the oil fraction, the Free Fatty Acids can produce DHA (fish oil equivalents), Omega 3 and Omega 6 heart healthy oils, as well as valuable products such

as Beta Carotene and other nutraceutical and pharmaceutical supplements from carotenoids.

Other fractions of the algae contain valuable chemicals or molecular compounds that can be used to produce green plastics, green detergents, cleaners, and polymers that are bio-degradable, non-toxic, and can be sold at a premium price over traditional petroleum based products. These biomass co-product marketing strategies will be critical to the success of aspiring algae biodiesel, biocrude, renewable diesel, aviation fuel and drop-in fuel producers. ●

For more information:

This article was written by Will Thurmond, president of biofuels consulting firm Emerging Markets Online, and author of Algae 2020: Advanced Biofuels and Commercialisation Outlook (460 pages, June 2009). For more info, visit www.emerging-markets.com