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# Algae Status Report

# How Far are we from Commercialization?

# Introduction

Algae, ranging from single-celled microalgae to large seaweeds, are the simplest and most abundant form of plant life, responsible for more than half of the world's primary production of oxygen. They form the base of the food chain with many living things depending upon them. With the recent research and interest into using algae for producing biofuels, they have the potential to become even more important. This paper explores the real world status of algae to energy research and commercialization efforts.

**Algae & Energy – Background & Concepts**

Algae can be broadly categorized into two: microalgae and macroalgae. The chief physical distinguishing factor between the two is the size. Microalgae are very small (+/- 1 to 50 μm) while macroalgae can reach sizes of up to 60 m in length (Mc Hugh, 2003).

Microalgae, because of their growth rate and yields, are capable of producing a lot more oil than other energy crops. Some estimates suggest that microalgae are capable of producing up to 50,000 litres of oil per hectare a year. This could be converted into biodiesel by conventional processes and be used to fuel vehicles from jets to tractors.

Microalgae, specifically, posses several attractive characteristics in the context of energy and biofuels:

* They can be grown in non - arable lands.
* Oil yields from algae are much higher than those from other biodiesel crops.
* They are capable of fixing CO2 in the atmosphere, thus facilitating the reduction of increasing atmospheric CO2 levels.
* Algae biofuel is non-toxic, contains no sulfur, and is highly biodegradable.

While microalgae strains that are rich in oil content can be used for producing biodiesel, other strains of microalgae and macroalgae can also be used as energy feedstock. Fuels such as ethanol, methane, hydrogen and other hydrocarbon fuels can be derived from these, through a variety of processes.

**Energy Products from Algae Biomass**

***Biodiesel from Algae***

Biodiesel refers to any diesel-equivalent biofuel made from renewable biological materials such as vegetable oils, animal fats or from other biomass such as algae.

Algae have lipid content varying from 2%-40%, based on the strain. On this dimension (% oil content), there is nothing extra-ordinary about algae – in fact, algae’s oil content by weight on average is not much higher than that for many other oil crops.

One of the key reasons algae are considered as feedstock for oil is their high yields. Put simply, algae are the only bio-feedstock that can theoretically replace all of our current and future petro-fuel consumption. It will be very difficult for the first generation biodiesel feedstock such as soy or palm to produce enough oil to replace even a small fraction of petro-oil needs without displacing large percentages of arable land meant for food crops.

*Typical yields in US gallons of biodiesel per acre*

|  |  |
| --- | --- |
| Plant | Biodiesel Yield (Gal per acre) |
| Algae | 5000 and higher |
| Chinese Tallow | 500-1000 |
| Palm Oil | 500 |
| Coconut | 230 |
| Rapeseed | 100 |
| Soy | 60-100 |
| Peanut | 90 |
| Sunflower | 80-100 |

*Source: The Department of Energy (DoE), USA*

According to the Department of Energy, USA, the world’s use of gasoline and diesel is about 1300 billion gallons per year. Studies reveal that algae have the ability to produce about 5000 gallons of biodiesel/ acre. Moreover, about 1.5 billion hectares[[1]](#footnote-1) of non-forested land is available worldwide that is not being used for agriculture. A simple calculation shows that in order for algae biodiesel to completely replace all transportation fuels, it will require about 80 million hectares of land (less than 5%), which sounds achievable. Crops such as palm would require close to a billion hectares for the same result, a daunting and almost impossible task.

***Ethanol from Algae*** - Ethanol is a clean-burning, high-octane fuel that is produced from renewable sources. Ethanol is a replacement for gasoline. Algae could be an ideal source for second generation bio-ethanol because some species are high in carbohydrates/polysaccharides and have thin cellulose walls.

***Methane*** ***-*** Compared to other hydrocarbon fuels, burning methane produces less carbon dioxide for each unit of heat released. Algae can be a feedstock for methane. In some ways, it can be said that the simplest approach to produce energy from algae is by producing methane gas.

***Hydrogen*** ***-*** Hydrogen is not an energy source, but is a carrier of energy. Hydrogen currently finds applications in specific industry segments, though none of these is directly for energy use. Hydrogen can be produced from algae through a variety of processes.

***Other Hydrocarbons*** ***-*** Algae biomass comprises hydrocarbons which can theoretically be transformed into a number of hydrocarbon fuels of varying compositions and properties. Research is in its nascent stages regarding the different types of hydrocarbon fractions (other than diesel) that can be derived from algal biomass in an economically sustainable way.

Transesterification

Methanation

Fischer Tropsch

Fermentation

Biophotolysis

Combustion / Gasification /

pyrolysis

**Algal Biomass**

Gasoline

Wax

Naphtha

Kerosene

Diesel

Electricity

Hydrogen

Ethanol

Ethylene

Acetic

Acid

Formaldehyde

Methyl Acetate

DME

Fermentation

IGCC/ IC /Fuel cell

Methane

Gasification

Catalytic Synthesis

**Syngas**

**Methanol**

Algal Oil

Anaerobic digestion

Extraction

*Paths to the Various Energy Products from Algae*

# Real World Status of Algae Energy Projects

Algae, being a third generation biofuel feedstock, have been in the limelight since 2005. This section explains the status of this new industry in terms of the number of companies, existence or emergence of standards and project implementation.

****Industry Concentration****

While precise estimates of the number of companies are not available at this stage, the total number of companies that have made significant commitments and investments in the algae fuel field is approximately 75, according to our estimates (as of Sep 2010), even though there are about 200 companies pursuing efforts at various levels.

In terms of size, most companies are very small or small, with most of them having fewer than 50 employees. A small percentage of the companies are established companies that are over 10 years old.

The few large companies one sees in this field today are the companies that have been formed with joint ventures with Big Oil companies – for instance, Shell has a joint venture with HR Biopetroleum and together they have formed the company Cellana.

*Approximate Number of Companies Directly Involved In Producing Fuels from Algae*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Early 2009 | Mid 2009 | End 2009 | Mid 2010 |
| # of companies | 1 | 2 | 4 | 5 | 10 | 15 | 25 | 50 | 75 | 100 | 150 | 200 |

*Source: Oilgae Estimates*

*Age of Algae Energy Companies – 2010*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Age of Company\* (Years) | >5 | 2-5 | 1-2 | Less than 1 year |
| % of companies | *5* | *35* | *35* | *25* |

*Source: Oilgae Estimates*

*\*: Number of years in operation specifically with a focus on algae energy*

**Dominant Designs**

Dominant design is a concept that refers to technological/process designs that have become de-facto standards in their corresponding market places. If a design that represents a core technology or process becomes dominant and gets accepted as the accepted industry standard, many services and products – including new products or services - in the industry might need to depend on the dominant design for their success. Dominant designs, in some instances, could hence be construed as a disincentive for completely original ideas.

As of September 2010, for the algae energy industry, there is no dominant design – be it in terms of end products, technology, or processes.

**Prominent Companies**

As of 2010, the algae energy industry is less than ten years old, but there are a few companies that have already achieved prominence. The following is the list of companies that have been able to make some progress so far.

* Aquaflow Bionomic
* Cellana
* Exxon-Mobil / Synthetic Genomics
* OriginOil
* PetroAlgae
* Sapphire Energy
* Seambiotic
* Solazyme
* Valcent

Implementation Status of Prominent Companies

We provide a brief report on the current status of efforts for the prominent companies in this industry.

***Aquaflow Bionomic***

A New Zealand-based company, Aquaflow has achieved commercial scale continuous harvesting of wild algae from oxidation ponds. In December 2008, the company announced that it has been successfully produced the world’s first sample of synthetic paraffinic kerosene (SPK) converted from compounds derived from wild algae.

The company has been running a pilot plant of its algae harvester at the Blenheim district sewage ponds in New Zealand, where it has stockpiled 40 tonnes of algae, some of which has already been used to produce jet fuel.

In July 2009, Aquaflow Bionomics and Solray Energy teamed up to overcome the challenges that have kept algae biofuels from commercial production. Since March 2010, Aquaflow has been working with Honeywell’s UOP on the U.S. Department of Energy algal projectto demonstrate technology to capture CO2 and cultivate algae for biofuel production.

***Cellana - Shell & HR Biopetroleum***

**As algae oil has the potential to replace fossil fuels, what are the big oil companies doing about algae fuels?**

The large oil companies have recognized that algae could be a very important future biofuel feedstock and some have publicly acknowledged this recognition. Some prominent companies have also started exploring algae fuels.

Here are some examples and updates:

* *Exxon Mobil* – In Jul 2009, Exxon Mobil announced it was investing a potential $ 600 million into research on algae-based fuels, through a partnership with Synthetic Genomics, a company that has been a pioneer in commercializing genomic-driven technologies. This has been by far the single largest investment into algae-fuels ever, by any type of business or research entity. Exxon announced that the investment will enable Synthetic Genomics to obtain biofuels from algae using its knowledge of and expertise in genetic engineering tools and techniques.
* *Royal Dutch/Shell* - Royal Dutch/Shell has a joint venture with HR Biopetroleum and the venture is exploring algae fuels in a plant at Hawaii.
* *Chevron* - Chevron has a working relationship with prominent algae fuels company Solazyme.
* *ConocoPhillips* - ConocoPhillips announced in July 2008 that the company had signed a multi-year research agreement with the Colorado Center for Biorefining and Biofuels (C2B2), a Colorado Renewable Energy Collaboratory research center. The first part of the project will center on creating renewable fuel from algae.
* *BP* - Since the beginning of 2008, BP has been exploring algae along with other feedstocks such as Jatropha. In Aug 2009, BP announced it was making a $10 million investment in Martek Biosciences. The two companies will work together to use Martek's algae-based technologies for the creation of sustainable and affordable technology for microbial biofuel production.

Cellana is a joint venture between HR BioPetroleum and Royal Dutch Shell that designs, tests, and operates technologies to produce renewable oil and animal feed from marine algae at very large scale.

Cellana plans to initially build a small research plant but hopes to move to a full-scale commercial plant of 20,000 hectares. Cellana hopes to have its first commercial plant operating within 2011. The company also plans to set up five more algae to fuel plants by the end of 2015.

***OriginOil***

OriginOil’s patent-pending technology, Quantum Fracturing for algae oil production, has been one of the company’s highlights so far. The heart of the OriginOil system is the Helix BioReactor™, an advanced algae growth system that can grow multiple layers of algae biomass around-the-clock with daily harvests. The company also mentioned an interesting harvesting technique in July 2008. It has a cascading production strategy in place to harvest 90% of matured algae, and it uses the remaining 10 percent for the production of more algae.

In September 2009, the company announced an innovative production system called “Attached Growth System” which uses a type of algae that attaches itself to growth surfaces. In January 2010, the company announced that ongoing industrial algae experiments in the company had uncovered a constant daily rate of algae production, which the company termed the Daily Harvest Constant.

***PetroAlgae***

PetroAlgae is commercializing environment-friendly algae developed by a research team at Arizona State University. The company also stated that they have developed a new system for extracting oil from algae.

In December 2009, PetroAlgae signed a Memorandum of Understanding with Foster Wheeler AG’s Global Engineering and Construction Group for engineering services to be performed in conjunction with PetroAlgae’s micro-crop technology.

According to the company, they are closest to commercialization in feedstock and algal oil production. The company plans to complete a working demonstration of its micro-crop farm in Florida by the end of 2010.

***Sapphire Energy***

Sapphire Energy’s collaborations include The Scripps Research Institute; University of California, San Diego; the University of Tulsa, and the Department of Energy’s Joint Genome Project for scientific support.

In 2008, the company claimed it had succeeded in refining a high-octane gasoline from algae that is chemically identical to crude oil. In January 2009, Japan Airlines & Continental Airlines used algae biofuels from Sapphire Energy to fuel their flights powered by biofuel blends.

In September 2009, Sapphire Energy unveiled its plug-in hybrid electric vehicle, combining several promising technologies aimed at slashing carbon emissions. In October 2009, the company, with the cooperation of a number of partners, built a 300-acre demonstration Integrated Algal Biorefinery designed to produce renewable gasoline, diesel and jet economically from an algal feedstock.

In December 2009, Sapphire Energy was awarded a $50 million grant from the U.S. Department of Energy as well as a loan guarantee of $54.5 million from the U.S. Department of Agriculture.

Sapphire Energy is currently ramping up production of its algae biofuel and is looking to produce 1 million gallons of algae biofuel per year by 2011, and 100 million gallons per year by 2018.

***Seambiotic***

In June 2008, Seambiotic entered into a joint venture with Inventure Chemical to construct a pilot commercial biofuel plant in Israel, using algae created from CO2 emissions as feedstock. The plant will utilize high-yield oil-rich algae strains that Seambiotic has developed and grown in its open pond system coupled with Inventure's patent-pending conversion processes to produce ethanol, biodiesel and other value-added chemicals.

In Jan 2009, Seambiotic announced that it was in transition from the pilot plant stage to large scale industrial algae cultivation and production. It also announced that the company planned to establish a 5 hectare algae farm in collaboration with the Israeli Electric Corporation.

In July 2009, Seambiotic announced that its U.S. subsidiary, Seambiotic USA, has entered into an agreement with NASA Glenn Research Center to develop an on-going collaborative R&D program for optimization of open-pond microalgae growth processes. Under the Agreement, NASA Glenn and Seambiotic USA will work together to improve production processes and to study and qualify algae oil from alternative species and production processes as candidate aviation fuel at NASA's test facilities.

***Solazyme***

The company has developed a new way to convert biomass into fuel using algae, and claims the method could lead to less expensive biofuels. Solazyme powered a Mercedes with algal-based biodiesel at the Sundance Film Festival in Park City, Utah in January 2008.

Solazyme was awarded a separate Navy contract to provide R&D and delivery of over 20,000 gallons of renewable algae derived F-76 Naval distillate fuel for use in Navy ships in September 2009. In fulfillment of the jet fuel contract, Solazyme has combined its algal renewable oil production process with Honeywell UOP’s Ecofining process to provide renewable jet fuel for testing and fuel certification to confirm it meets all military specifications and functional requirements.

In July 2010, Solazyme delivered 1,500 gallons of algal jet fuel to the U.S. Navy for testing and certification. In September 2010, they supplied 20,000 gallons of algal-derived shipboard fuel.

***Valcent***

Valcent Products has developed a high density vertical bio-reactor for the mass production of algae.

In March 2008, Valcent announced that data from its fully operational field test plant had confirmed commercial production potential with several companies expressing interest to build out commercial plants on a joint venture basis. It also stated that the research and development team had completed twelve months of the algae vertical bioreactor development program.

Real World Status – Summary

Significant efforts towards commercialization have been employed in the algae to fuel domain in the past few years. A number of startups are in the pilot or pre-commercial stages, and are expected to commercialize their technologies in a timeframe of about five years.

**Bottlenecks & Barriers**

This section discusses the key barriers to algae fuels, under the following topics:

* Key Challenges
* Algae Fuel Production Cost
* Entry Barriers

Key Challenges

The real challenge facing the algae industry is the high cost of fuel production from algae. The high cost is owing to the following difficulties:

* **Difficulty in optimal strain selection -** Strain- selection is a resource intensive exercise. For instance, if the end-product is biodiesel, it is crucial that you identify algal strains that are capable of producing high levels of algae oil as well as being resistant to contamination, adaptable to temperature extremes, tolerant of high oxygen levels and suited to local water conditions in growth ponds. This is a high-cost step requiring significant resources.
* **Contamination management in open cultivation environments and in waste water/sewage -** Contamination with bacteria, protozoa or another species of algae is a serious problem for monospecific/axenic cultures of micro-algae.
* **High capital and operating costs of photobioreactors –** Photobioreactors are controlled algae culture systems that promise reliable, high yields.The high capital costs for these are associated with the construction materials, circulation pumps, and nutrient-loading systems of photobioreactors. The operating costs are high owing to maintenance of equipments, labour, nutrients, and power.
* **High cost of harvesting -** Harvesting microalgae is very energy intensive. This is mainly because the conventional harvesting methods used for harvesting microalgae such as centrifuges, filtration and flotation equipments are energy-intensive as they are fully automated. However, the manual and the semi-automated methods are relatively less energy intensive but require more manpower.
* **High capital cost of biomass gasification -** Although significant progress has been achieved and new improved technologies are being demonstrated, the process of biomass gasification costs higher compared to combustion.
* **Difficulty in getting high quality scientific talent -** The real challenges facing the industry are scientific in nature; hence, fundamental and applied research expertises are important ingredients a start up should bring with it. However, it is very difficult to obtain high –quality scientific talent.

***Algae Fuel Production Cost***

The biggest bottleneck today for algae to become a mainstream biofuel feedstock is the cost of producing fuel from algae. The processes and methods that are used to make biodiesel and other energy fuels from algae are quite well-established; however, the total cost of fuel production using any of these methods today is significantly higher than comparative costs for fossil fuels, or for biofuels produced from other feedstock.

|  |  |
| --- | --- |
| Cost range for fossil gasoline/diesel ($ / gal) | 2.0\* |
| Cost range for non-algal biofuels ($ / gal) | 2.25-2.75\*\* |
| Cost range for algae Biodiesel ($ / gal) | 6-18\*\*\* |

*Source: Oilgae Estimates*

*\* Based on prices between June and Sep 2010.*

*\*\*cost of gasoline or diesel equivalent gallon (in terms of energy content); costs vary depending on whether the fuel is biodiesel or bio-ethanol.*

*\*\*\*: The lower costs are possible today only with the use of open ponds. However, very large-scale algae cultivation for fuel in open ponds pose significant challenges and are not yet fully proven to be a working model.*

*All costs above are for the equivalent cost when oil leaves the place of extraction. The prices at the pump will be significantly higher than these, taking into account shipping, taxes, distribution costs and channel margins. If price at pump is X, crude is 0.75X, refining about 0.1X, distribution & marketing about 0.05 X and taxes about 0.1X. Cost calculated with price of crude at US$75 / barrel*

As one can observe from the above table, algae oil prices, based on some data available from the market from pilot scale experiments, cost between two to nine times as much as its competitors.

***Entry Barriers***

Being an industry with few large companies and in which there is no dominant design, the entry barriers for new firms are few.

But there are other, more important aspects new entrants should consider:

* **Cost of Talent** - Success in this industry in the short and medium term depends on the ability to achieve breakthroughs in scientific and engineering related domains. Hence, very high quality scientific and engineering talents are a must for new entrants wishing to make a mark. Acquiring such high-quality talent could be both time-consuming and expensive.
* **Necessity of Scale** *–* The end-products are essentially energy products, and hence any company entering this domain needs to be in a position to scale its operations to operate at national or international levels. Startup companies that are not able to convincingly show that they have the appetite to grow into large or very large companies might not be taken seriously by prospective investors.
* **External Factors** *–* There are significant external factors at play in the energy industry. The price of fossil fuels is one of them. The fossil fuel price is in fact the biggest competition that companies in this industry might face, though it technically doesn’t qualify as competition! The other externality that deserves mention is government policies and incentives. It is well understood that the alternative energy industry needs the support of the government in the short and medium term, in terms of subsidies and favourable tax policies. Adverse changes in these policies could have a dramatic impact on new companies trying to enter this industry.
* **Distribution Channels** *–* While there is no dominant design for the algae oil/fuel domain, there is a dominant design for the fossil oil domain – the Big Oil companies, both international and local. Not only are these companies exceptionally cash rich, they also completely control the current distribution channels for fossil fuel distribution. New entrants will either have to creatively disrupt these existing channels or will have no other choice but to enter into business agreements with the giant oil companies.

# Future Trends

**Perspectives**

While in theory algae have an excellent potential to be a significant feedstock for our transportation fuels, at the same time it has to be admitted that we are only in the beginning stages of exploiting algae for fuel.

During the period 2004-2009, when the first group of the algae fuel companies started cropping up, most companies were solely looking at producing biodiesel from algae. Since 2009, industry observers could see a shift in business strategy where many of these companies have started looking at other fuel opportunities (ethanol, jet fuel etc.). Further, having realized that it could take longer to sustainably produce fuel from algae, many companies have started looking at other short-term options such as producing non-fuel products from algae, and wastewater remediation using algae. Such experiments are expected to continue for the next 2-3 years.

The following assessments can be made:

* Producing energy products such as biodiesel and ethanol from algae is not rocket science. In fact, even a backyard inventor can make oil and biodiesel right from his home, right now. The bottleneck is really the high cost of the processes.

“At the end of the day, no one single solution will address our domestic energy demands, but focus on feedstock such as algae could be a vital component of creating a renewable fuel economy.”

* **Doug Henton, CEO of Solix Biofuels**
* There are two types of challenges to be overcome with respect to processes: (1) Engineering challenges such as making photobioreactors, raceway ponds and centrifuges more efficient and (2) Biological challenges such as increasing oil yields from algae, genetic engineering of algal strains and facilitating specific strains of algae to survive in habitats that are not natural to them.
* It is expected that many engineering challenges could be solved within the next 2-3 years. It is more difficult to predict when the biological challenges will be overcome, though good progress is being made on aspects such as genetic engineering of algae strains. Experts predict that experiments on overcoming the biological challenges could take more than 5 years (beyond 2015).

**Some Interesting Perspectives**

**What is the realistic chance of producing fuel from algae?**

In itself, there is no difficulty in making fuel from algae. In fact, you could make algae fuel at home – all you need is to just grow the microalgae in a pond or fish tank, filter the algae using some basic filters (even ordinary filter cloth would do!), dry the biomass and squeeze it using a basic oil press, and you get algae oil which can be turned into biodiesel using a process called transesterification. It really isn’t rocket science. The total cost for getting this fuel done at home could even be competitive with the diesel you get at the gas station.

The difficulty lies in making such fuel in a cost-effective and sustainable manner when done on a large scale.

The reason why it costs less when done on a small scale at home is because many crude and inexpensive processes (especially for cultivation and harvesting) are enough for the small amounts of oil required, and also because many hidden costs (cost of electricity and labour costs for example) are not usually taken into account.

When done on a large-scale, however, the processes for culturing, harvesting and extraction need to be far more sophisticated. Some of these processes, especially for culturing and harvesting, are quite expensive today.

While algae fuels are currently not cost-effective when produced on a large scale, a number of efforts – both engineering and biological – are ongoing. Some vital breakthroughs are expected by end of 2010, especially in photobioreactor design and cost, and in harvesting methods. These breakthroughs could result in algae fuels being produced at much lower costs.

* **Long waiting period** - It has also been admitted by many prominent companies that producing algae fuel at a cost that is competitive with that of fossil fuel will take years. The general consensus is that it will take at least until 2015 for the world to see a company produce algae fuels at large scales and at competitive costs.
* **Algae fuels are not the silver bullet** - A prevalent thought is voiced by Doug Henton, CEO of Solix Biofuels, who commented that “at the end of the day, no one single solution will address our domestic energy demands", but that focus on feedstock such as algae could be a vital component of creating a renewable fuel economy.
* **Bioremediation potential** - Another recurrent theme among top executives in the industry is the prospect of CO2 abatement and wastewater remediation by algae.
* **Distributed production** - Riggs Eckelberry, the CEO of OriginOil in Mar 2010 opined that algae fuels could see a more distributed production infrastructure quite different from the current centralised fossil fuel production set up.
* **Benefitting local economies worldwide** - A top executive from the company Live Fuels felt that the algae fuel industry could benefit local economies by creating more local jobs, as against the current fossil fuel economy in which significant number of jobs are present in only those countries that have large oil deposits.
* **Potential for non-fuel products** - Here's a different perspective from Prof. Charles Trick, the Beryl Ivey chair for ecosystem health at the University of Western Ontario and a specialist in aquatic sciences and microbial ecology, has to say: "Even if biofuel production by algae is not considered commercially viable, these cells could be selected to produce unique biomolecules, converting sunlight energy into specialty products that might normally be created through traditional petrochemical techniques.”

Analysis of predictions from many other experts shows a similarly cautious forecast.

**Predictions**

Predicting specific developments in the algae energy field – such as the cost of algal oil, the best strains, or the most cost efficient harvesting process – is difficult. It could be far more useful if one were to attempt predicting the broad trends that could shape the industry in the next 5-10 years. This is what we attempt to do in this section.

While the above predictions are somewhat general in nature, we attempt a more specific set of predictions. It must be pointed out that predicting specific developments in the algae energy field is very difficult. Hence, these inputs should be considered as more of intelligent guesses.

Based on all the facts and happenings, the following are what we predict: (Aug 2010)

In the next 2-3 years (by the end of 2013), one or more companies will be able to prove that they can indeed produce fuel from algae in a cost-effective manner in laboratory conditions.

In the next 4-5 years (by the end of 2015), one or more companies will be able to start supplying fuel from algae commercially, though possibly not on a nationwide basis.

In 8-10 years from now (by 2020), fuel from algae could start meeting a significant part of our energy needs.

The following table provides our predictions on how the algae energy industry will pan out during the next 10 years, until about 2020. For each of the periods discussed, analyses and predictions are made on the following aspects:

Challenges – The key challenges that could be overcome during this period

Highlights – Ideas/concepts most likely to flourish

Dark Horses – Possible surprise winners

|  |  |  |  |
| --- | --- | --- | --- |
| Period | Challenges | Highlights | Dark Horses |
| **2010-2013** | * Optimal strain identification * Devising cost-effective methods for harvesting | * Growing algae in sewage & wastewater * Ethanol from algae * Governments realizing the potential of algae biofuels and devoting higher resources for research | * Growing algae in the dark * Creative sparks coming from garage & backyard inventors |
| **2013-2015** | * Devising cost-effective methods for cultivation * Innovative scientific techniques and out-of-the-box thinking to overcome what looks insurmountable * Innovative business and revenue models that factor in ground realities | * Growing algae next to power plants * Low cost photobioreactors * Lower costs for biodiesel production processes * A large number of companies venturing into the algal fuel field, trying to “strike gold” | * Hydrocarbons from algae gasification & catalytic synthesis * Methane from algae |
| **2015-2020** | * Making algae fuels cost competitive * Taking algal fuel from being a small player to being a significant contributor to global energy consumption * Mature management to ensure that companies evolve into competitive businesses. | * New progress from fields such as genetic engineering & biotech * Hydrogen from algae * Some successful firms starting to dominate the algal fuel landscape | * Ability to produce algal fuel from micro-refineries, making each household a potential producer of algal fuel! |

Oilgae is the definitive resource for algae energy. In addition to being an online hub for all aspects of algae fuels, the Oilgae team is also a regular contributor to various online and offline forums. Oilgae is currently looking for networking with algae-enthusiasts in the conference for joint-ventures.

about Oilgae

1. *Source: Food and Agriculture Organization (FAO)* [↑](#footnote-ref-1)