



ALGAE BIOMASS
ORGANIZATION

Algae Biomass Organization
www.algaebiomass.org
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Algae Industry Project Book 2013



Why Algae?



Algae have the power to simultaneously put fuels in our vehicles, recycle CO₂, provide nutrition for animals and people and create jobs for millions of Americans.

Algae Fuels, Feed and More



Algae are a renewable source of drop-in fuels, feed, fertilizer, nutritional oils and pharmaceuticals. They can provide waste water treatment other remediation services. New applications are constantly being discovered.

Algae

Renewable Fuels Sustainable Food and Feed Domestic Jobs Energy Security



The Algae Industry in the United States

Billions of dollars are being invested in the research and development of algae-based technologies. The focus of today's algae industry is on bringing the advances of science and technology for the production of algae products into the marketplace. These efforts are proceeding quickly, primarily driven by those that recognize algae's high per-acre-yield and its suitability for making a variety of different products, from the small volume/high value commodities, like chemicals and nutraceuticals, to the large volume commodities such as fuels and feeds.



The Technology

Algae can be grown commercially in a variety of ways, from open ponds to enclosed photobioreactors, or from hybrid systems that combine various methods. Simply put, there is no one single way to grow algae at commercial scale, and this versatility is one of algae's strengths.

Algae can also grow extremely well on marginal lands using salt water or wastewater, reducing impacts on valuable agricultural lands without competing with other industries for diminishing freshwater supplies.



Fuels and Other Products

Algae contain high levels of oils, carbohydrates, sugars and proteins. These characteristics make them ideal for producing renewable fuel, animal feed and even human food.

Microalgal biomass, which is rich in micronutrients, is already used for dietary supplements to advance human health. Algae has even been used to more economically produce anti-cancer drugs and in other medical applications. They can also be used to beneficially reuse greenhouse gas emissions and treat wastewater.



The Opportunities

Algae-based fuels can be produced domestically, improving America's food and energy security. Algae can also grow in a wide variety of climates by a multitude of production methods, creating a wide variety of jobs throughout the United States. And their ability to grow on marginal lands, absorb CO₂ and treat wastewater means they can have a positive impact on our environment.



Mary Rosenthal
Executive Director

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Industrial-Scale Science

Game-changing energy technologies don't commercialize themselves. In addition to hard work, scientific breakthroughs and engineering feats, new companies need support in the regulatory and policy arenas. Since 2008, the Algae Biomass Organization – the trade association for the US Algae Industry – has helped its 250+ membership accelerate the commercialization of sustainable commodities produced from algae by serving as an advocate and a voice for the industry on Capitol Hill.

The member companies highlighted in this Algae Industry Project Book are just a few of the hundreds of startups, universities, national labs and Fortune 500 companies developing algae's unique ability to drive economic growth, enable food and energy security and reduce harmful greenhouse gas emissions.

Whether it's Green Crude from Sapphire Energy, high value cosmetics and nutritional products from Heliae, ethanol from Algenol, beneficial CO₂ reuse from Duke Energy, or any of the many promising projects listed in this book, you will find the algae industry well positioned to make a significant, triple bottom-line impact on our nation.

This success you see in these pages will continue to be a team effort. It is important to remember that all innovative companies can benefit from partnerships and support when deploying new technologies to scale. Partnerships with, and funding from, agencies like the Departments of Energy and Agriculture and support from state legislatures and Members of Congress have catapulted the industry forward.

With billions of dollars in venture capital, ambitious entrepreneurs, and engagement from large corporations like FedEx, Boeing, Kimberly-Clark, and United Airlines the algae industry is poised to offer a new and sustainable source of products and materials for the global supply chain.

Take a look in the following pages and see for yourself.

Sincerely,

Mary Rosenthal
Executive Director
Algae Biomass Organization



ALGENOL B I O F U E L S

HARNESSING THE SUN TO FUEL THE WORLD™

Algenol Biofuels Inc.

Algenol is an industrial biotechnology company that is commercializing its algae-based technology platform for the production of ethanol and other biofuels. The Company's patented Direct To Ethanol® technology enables the production of ethanol for around \$1.20 per gallon using sunlight, carbon dioxide, marginal land and saltwater at production levels above 10,000 gallons of ethanol per acre per year. Waste algae from the process are utilized in conversion technologies to produce diesel, jet fuel and gasoline. Algenol operates a commercial development campus in Ft. Myers, FL with 60,000ft² of laboratory and office space, a 4-acre outdoor process development unit and a 36-acre pilot scale integrated biorefinery.



Commercial Development Campus Fort Myers, Florida

Investment: \$190 million

Current capacity is 10,000 gallons per acre per year

Employees | **164**

Funds Raised | **\$190 million**

Products |
Ethanol
ULS Diesel
Jet Fuel
Gasoline

Algenol Biofuels Partners

Strategic Partners: Reliance Industries Limited; BioFields S.A.P.I. de C.V.

Federal/State Partners: United States Department of Energy; Lee County, Florida

University Partners: Florida Gulf Coast University; Georgia Institute of Technology's Strategic Energy Institute, with contributions from The University of Colorado

National Lab Partners: National Renewable Energy Laboratory; Pacific Northwest National Laboratory

TIMELINE

2006

Algenol is founded after securing its first round of private financing. Laboratories are established in Baltimore, MD and Berlin, Germany.

2010

Commercial Development Campus in Fort Myers begins operations, consolidating American operations in Florida.

2013

Demonstration of commercial viability at Integrated Biorefinery. Evaluating first commercial sites in Florida, Texas and other States.

2014

Commercial scale production facility with nameplate capacity of 20 million gallons per year broken ground.

2020

Projected 1 billion gallons of annual production utilizing Direct to Ethanol® technology.



Future Commercial Facility

Investment: \geq \$180 million

Projected Capacity by 2015: 20 million gallons per year



Algenol's first commercial facility will include an initial deployment of photobioreactors on 400 acres on a site that will facilitate a future scale-up to 1,500 to 2,000 acres of photobioreactors along with upstream and downstream processing equipment and related infrastructure. It will be located on marginal land with access to salt water and an industrial source of CO₂.

Projected jobs by 2020:

500 permanent jobs per facility

Production in 2020:

1 billion gallons of ethanol per year

Construction jobs:

2,000 per facility



Algenol uses fully closed and sealed photobioreactors for ethanol production directly from enhanced algae. Waste algae are converted into diesel, jet fuel and gasoline using hydrothermal liquefaction and other conversion technologies.



Sapphire Energy

San Diego based Sapphire Energy is pioneering an entirely new industry – Green Crude Oil Production. Green Crude is a renewable, drop-in replacement for petroleum, made from algae, sunlight and CO₂. Green Crude is compatible with existing infrastructure; and is low carbon, renewable, and scalable. Sapphire Energy was the first algae-to-energy company to successfully test their jet fuel in two commercial airline flights in 2009 (Continental and Japan Airlines). The company has an R&D facility in Las Cruces, NM, and is currently operating and producing crude oil daily from the world’s first Integrated Algal BioRefinery (Green Crude Farm) commercial demonstration facility in Columbus, NM.



Research and Development Site Las Cruces, New Mexico

Investment: \$30 million Jobs: 30

Full scale pilot and demonstration of all unit operations from molecular biology to extraction of oil.

Employees | **150**

Funds Raised | **\$350 million**

Products | **Green Crude Oil,
a direct substitute
for fossil crude**

Sapphire Energy’s Partners

Investment Partners: ARCH Venture Partners; The Wellcome Trust; Cascade Investment, LLC; Venrock; Arrowpoint; and Monsanto

Strategic Partners: Monsanto, The Linde Group; Tesoro Refining and Marketing Company, LLC; and the Institute of Systems Biology (ISB)

Federal/State Partners: The US Department of Energy and the US Department of Agriculture

University/Research Partners: The Department of Energy’s Joint Genome Institute; University of California, San Diego; the San Diego Center for Algal Biotechnology; The Scripps Research Institute; University of Tulsa; Sandia National Laboratory; and the Pacific Northwest National Laboratory

TIMELINE

2008

One year after its founding, Sapphire Energy creates the world’s first renewable gasoline from algae.

2009

Sapphire Energy’s algae jet fuel powers the world’s first renewable test flights on two commercial airliners.

2012

On-time and on-budget completion of first phase construction for the Green Crude Farm.

2013

Sapphire Energy announces agreement with Tesoro Refining and Marketing LLC, to purchase barrels of Green Crude oil for refining at its west coast operations.

2018

Anticipated launch of first commercial scale facility with production of 5,000 to 10,000 barrels per day of Green Crude oil.



Green Crude Farm Columbus, NM

Investment: \$135 million Jobs: 30

Full capacity: 100 barrels of green crude per day.



Sapphire Energy's Green Crude Farm features 100 acres of cultivation ponds and all the necessary mechanical and processing equipment needed to harvest and extract algae and recycle water. At full capacity the facility will be 300 acres. The Green Crude Farm was funded by \$85 million in private investment, as well as a USDA loan guarantee and a \$50 million grant from the US DOE, totaling \$135 million.

Continuous operation of all unit processes at the Green Crude Farm since:

2012

Barrels per day of Green Crude at a commercial scale facility:

5,000 - 10,000

Jobs created during the construction of the Green Crude Farm:

634



Sapphire Energy is operating the most advanced, algae crude oil production facility in the world. The company's Green Crude Farm is the world's first commercial demonstration scale algae-to-energy site, integrating the entire value chain of algae-based crude oil production, from cultivation, to harvest, to extraction of ready-to-refine Green Crude.



BioProcess Algae

BioProcess Algae, LLC designs, builds and operates commercial scale bioreactors that enable efficient conversion of light and CO₂ into high value microbial feedstock.

BioProcess Algae is focused on fulfilling feedstock needs in the animal feeds and transportation fuels industries for cost competitive alternatives with favorable carbon balances. BioProcess Algae is based in Portsmouth, RI and is currently running a demonstration plant at the Green Plains Renewable Energy, Inc. ethanol plant in Shenandoah, Iowa. Grower Harvester™ bioreactors installed in Shenandoah are tied directly into the plant's CO₂ exhaust gas and have been operating continuously since inoculation in October 2009.



Company Headquarters Portsmouth, Rhode Island

BPA Portsmouth houses engineering, manufacturing, business development and administration.

Employees | **40**

Investment | **\$50 million**

Products | **Animal Feed
Nutritionals
Fuels**

BioProcess Algae's Partners to date

Investment Partners: Clarcor (NYSE: CLC); BioProcessH2O LLC and Green Plains Renewable Energy, Inc. (NASDAQ: GPRE).

Federal/State Partners: The US Department of Energy

Lab Partners: Bigelow Laboratory for Ocean Sciences

TIMELINE

2008

BioProcess Algae LLC is a joint venture between Green Plains, Clarcor Inc. and Bio-ProcessH2O.

2009

Demonstration plant co-located with a Green Plains' ethanol plant in Shenandoah.

2012

Successful completion of algae-based poultry feed trials, signs commercial agreement for Omega-3 oils with KD-Pharma for nutrition and pharmaceutical applications.

2013

BPA completes its Phase III project, which consists of commercial scale Grower Harvesters. Selected by DOE for Integrated Biorefinery funding.

2020

Projected to have 25 co-locations with 375,000 tons of dry weight biomass per year and 750 full-time employees.



Commercial Demonstration Facility

Shenandoah, Iowa

Full capacity: One metric ton of biomass per day following Phase 4 expansion in 2014



BPA technology enables algae to be produced as a crop, and growing crops is something Americans do phenomenally well. Not only does that give BPA an ideal opportunity to create agricultural jobs, but it also means that the company has no reason to outsource operations. BPA is producing a home-grown and home-processed product that can help achieve our country's most long-term goals: feeding the world and sound financial standing.

Jobs projected in 2020:
750

Tons produced per day in 2020:
375,000

Projected construction jobs:
3700



BioProcess Algae designs, manufactures and operates integrated systems using a unique patented attached growth approach to enhance light penetration, harvest density and gas transfer, overcoming these traditional bottlenecks to low-cost algae cultivation.



Heliae

Heliae® is a platform technology company that uses sunlight and low-cost carbon feedstocks to produce high-value products from algae. Based in Gilbert, Arizona, Heliae is leveraging its core production technology into four target markets: nutrition, therapeutics, health & beauty and agrosiences. With a seasoned management team and world-class science, Heliae is advancing the future of the algae industry by delivering novel algae-based products to dynamic markets around the world.

MARKETS

- **Nutrition**
- **Therapeutics**
- **Health & Beauty**
- **Agrosiences**



Company Headquarters Gilbert, Arizona

Jobs: 104

PARTNERS

Mars Family; Salim Group; Arizona State University; Wageningen University; Clarecastle Group; others not disclosed

TECHNOLOGIES

Heliae algae strains

Algae production systems

Contamination Control

Harvesting

Product Extraction

Heliae is currently building a 20-acre commercial production facility located adjacent to its headquarters and demonstration facility in Gilbert, AZ. The commercial facility is being built in phases, with a target completion of phase 1 in the third quarter of 2013. Heliae's first commercial facility will focus on nutraceutical and cosmetics products with commercial off-takes already in place for the production capacity of the facility.



Since its founding, Heliae has harnessed an innovation culture to develop advanced algae strains, production technology, and downstream processing equipment to optimize algae production for a range of product targets.

TIMELINE

2008

Heliae is founded.

2010

Demonstration facility constructed.

2012

Heliae awarded more than 50 patents.

2013

Construction and completion of first commercial facility; Heliae has been awarded more than 70 patents and has more than 350 patents pending; Company is executing on a global pipeline of project opportunities.

2020

Algae production facilities operating around the world offering innovative algae-based products for a range of industries.



Aurora Algae

Aurora Algae is an innovative bioenergy company that manufactures fuel from optimized algae in a patented production process. Leading technologists at Aurora Algae have engineered a scalable method for fuel generation, using robust and highly productive proprietary algae strains. The Aurora Algae process is carbon-mitigating and non-competitive with agricultural resources, and capable of industrial yields with minimal facility footprints. When produced in conjunction with other high-value products, Aurora Algae's biofuel can be sold at cost-competitive market prices.

PRODUCTS

- **Biofuel**
- **Omega-3 Essential Fatty Acids**
- **Protein and Animal Feed**



R&D and Pilot Processing Facility Hayward, California

Jobs: 70

Corporate Headquarters with R&D laboratory for genetic research and product development.

PARTNERS

Oak Investment Partners, Noventi Ventures, Gabriel Venture Partners

Aurora Algae's proprietary algae strains and production process uses arid land, seawater and captured carbon pollution from industrial emitters, resulting in more capially efficient and more environmentally sustainable algae farming.



Aurora's Pilot-Scale Demonstration

Western Australia

Jobs 50

Six 1-acre production ponds and more than 40 smaller ponds producing 15 tons of biomass per month.

TIMELINE

2007

Aurora Algae founded under original name "Aurora Biofuels."

2009

Completes successful pilot operations in Florida. Biofuel production successfully passes ASTM standards.

2010

Introduces the industry's first platform for the production of products in the pharmaceutical, nutritional supplement, aquaculture and fuels markets.

2011

Completes build out of new US-based headquarters and labs. Completes construction of new plant in Western Australia.

2012

Successfully completes requirements for two million dollar (AUD) Low Emissions Energy Development grant to advance biomass production.



Cellana

Cellana, a leading developer of algae-based bioproducts, uses the most productive plants on earth—marine microalgae—to photosynthetically produce its ReNew™ line of Omega-3 EPA and DHA oils, food and feed, and biofuel feedstocks.

PRODUCTS

- **Omega-3 Nutritional Oils**
- **Food and Feed Supplements**
- **Biocrude Oil**



Kona Demonstration Facility Kailua-Kona, Hawaii

Jobs: 25-50 Investment: \$20 million

PARTNERS

U.S. Department of Energy and the Department of Agriculture

Since 2009, Cellana has operated its Kona Demonstration Facility, a 6-acre, state-of-the-art production and research facility in Hawaii. To date, more than 20 metric tons of whole algae (dry weight) have been produced using Cellana's ALDUO™ process with highly diverse strains, making ALDUO™ one of the most flexible, thoroughly tested, and validated outdoor algae production technologies in the world.



Cellana is in the process of evaluating commercial algae facility locations in Hawaii, the mainland U.S., the Middle East North Africa region, and in Southeast Asia. Cellana's biorefinery business model involves establishing off-take agreements for biofuels, food/feed, and Omega-3 nutritional oils to be produced in algae facilities throughout the world with a total capacity of at least 100,000 metric tons of biomass per year.

TIMELINE

2007

Cellana LLC, a joint venture between Royal Dutch Shell and HR BioPetroleum is formed.

2009

Cellana's Kona Demonstration Facility is commissioned and comes online.

2013

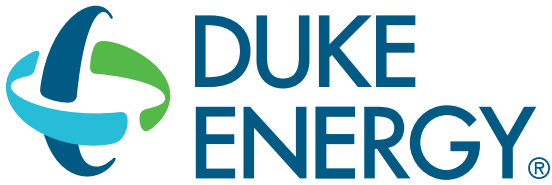
Cellana signs commercial-scale agreement with Neste Oil, the world's largest producer of renewable diesel.

2014

Projected supply agreements for all three algae-derived products: Omega-3 oils, food/feed, and biofuels.

2015/2016

Projected completion of Cellana's first commercial production facility.



Duke Energy and the University of Kentucky

Duke Energy is the largest electric power holding company in the United States with more than \$110 billion in total assets. Its commercial power and international business segments own and operate diverse power generation assets in North America and Latin America, including a growing portfolio of renewable energy assets in the United States.

The University of Kentucky's Center for Applied Energy Research (UK CAER) is an interdisciplinary research center focused on the energy needs of the Commonwealth of Kentucky. The Center, through its technology innovation and service to the community, contributes to improving the lives of Kentuckians by creating jobs and economic opportunities; by sustaining vital industries and public services; and by improving energy efficiency and protecting the environment.



East Bend Demonstration Union, Kentucky

Investment: \$200,000 Capacity: 26,000 Liters

PRODUCTS

- CO₂ Remediation Services
- Algal Biomass
- Fuel and Aquaculture Feeds



PARTNERS

KY Department of Energy Development and Independence; US-China Clean Energy Research Center-Advanced Coal Technology Consortia; ENN Group; Pittsburgh State University.



A demonstration scale photobioreactor is currently being operated and expanded at Duke Energy's East Bend Station located in Union, KY. The PBR converts the CO₂ in flue gas to algal biomass, via photosynthesis. The biomass is then periodically harvested to supply feedstock for upgrading into value added products. The low energy harvesting system recycles water and unused nutrients.

TIMELINE

2008

The University of Kentucky begins its algae project.

2010

ENN performs strain evaluation using flue gas at Duke Energy's East Bend Station.

2012

Algae based CO₂ mitigation demonstration project started at Duke Energy's East Bend Station.

2013

System volume expanded, first periods of sustained operation off of flue gas.

2014

Continue flue gas utilization studies/enhance collaboration with other strategic partners.



Earthrise Nutritionals

Earthrise Nutritionals is the largest producer of Spirulina algae in the world. It is a 30-year pioneer in the field of Spirulina research, biomass production and marketing. Earthrise distributes Spirulina and Spirulina-based products for the food, functional food, dietary supplement, nutraceutical, and animal feed markets in more than 20 countries worldwide. Earthrise is currently engaged in research collaboration with major algae biofuel and bio-product companies worldwide. Earthrise is a wholly-owned subsidiary of DIC Corporation.



Earthrise Calipatria Imperial Valley, California

Jobs: 60

600 tons of Spirulina powder are produced each year in 37 ponds roughly 1.3 acres each.

PRODUCTS

- **Spirulina and Spirulina-based formulated greens products**

In addition to its currently operational ponds the company is testing two 2.5 and 4.5 acre ponds for biomass production, the latter being the largest fully lined outdoor raceway pond ever tested for algae biomass production. The facility has another 80 acres of empty land for future expansion.



Earthrise® operates the world's largest Spirulina farm on a 108-acre site to supply more than 20 countries with the world's best known Spirulina. In the clean, sunny California desert, Earthrise® Spirulina yields more nutrition per acre than any other food.

TIMELINE

1972

The progenitor of Earthrise, Proteus Corporation, is founded to develop Spirulina blue-green algae as a world food resource.

1982

Earthrise develops a partnership with a Japanese company, Dainippon Ink and Chemicals, Inc. (the present DIC corporation).

2005

Earthrise® Nutritionals is wholly owned by Dainippon Ink and Chemicals, Inc. (the present DIC corporation).

2012

Earthrise enters agreement with Sapphire Energy to license a spirulina strain for algae-to-energy production.

2013

Earthrise operates the world's largest Spirulina farm, and together with sister companies' farms, DIC group is the largest Spirulina producer in the world.



Phycal

Phycal develops the biology, processes, and projects for the production of biofuels and bioproducts from high-yield feedstocks such as algae and cassava. Phycal Algae, with the Department of Energy, is designing, building, and operating a pilot algae farm and biorefinery near the Schofield Barracks in Hawaii. Phycal Cassava is using a proprietary strain of high-yield cassava to produce low-cost sugar for algae production and ethanol that qualifies as Advanced Biofuel for the Renewable Fuel Standard.



Pilot Algal Biorefinery Wahiawa, Hawaii

Jobs: 18-36 Investment: \$65 million

PARTNERS

US Department of Energy
National Energy Technology Laboratory

PRODUCTS

- **Algal Oil**
- **Bioproducts**
- **Jet Fuel**

Phycal's Pilot Algal Biorefinery will validate three growth systems at scale: ponds, fermenters and Heteroboost™ – Phycal's proprietary hybrid pond/fermenter system. This pilot is part of a \$65 million research and development project partially funded with a \$51 million R&D contract from the Department of Energy.



Phycal Subpilot Algae Facility

Highland Heights, Ohio

Phycal's Subpilot Algae Facility includes 16,000 square feet of indoor space with ponds, fermenters, and processing, and 5,000 square feet of outdoor pond space.

TIMELINE

2007

Phycal founded, headquarters and main lab established in Cleveland, Ohio

2008

Phycal awarded \$3 million from DOE for Phase I "Innovative Concepts for Beneficial CO₂ Use"

2013

Phycal awarded \$48.5 million from DOE for Phase II "Innovative Concepts for Beneficial CO₂ Use". Begins construction of pilot algae farm and biorefinery.

2015

Pilot to be scaled to demonstration.

2017

Projected commercial production.



Learn more about the algae industry at www.allaboutalgae.com



About the Algae Biomass Organization

The Algae Biomass Organization (ABO) is a 501(c)(6) non-profit whose mission is to promote the development of viable commercial markets for renewable and sustainable commodities derived from algae. Its membership is comprised of people, companies and organizations across the value chain. More information about ABO, including its leadership, membership, costs, benefits and members and their affiliations, is available at the website: www.algaebiomass.org.

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