



Preview of Oilgae Digest

about

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. The Oilgae team members have been invited to speak and present at numerous international conferences and seminars.

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A Concise and Invaluable Guide to Algae Fuels Industry

The algae energy industry is in its infancy. Everyday, one gets to hear about new technologies and new promises. At the same time, there are a number of reports that claim that algae fuels face tough challenges before they can reach commercial status. Such a large number of statements, some of them conflicting with each other, make it difficult to get a balanced opinion about the algae fuels industry.

Entrepreneurs and would-be investors have a need to get a clearer understanding of the algae fuels industry, in terms of the real prospects for and potential of algae fuels, the critical bottlenecks that are preventing the industry from achieving its potential, aspects to be considered before venturing into this industry and the steps to be taken and costs involved for the same to enter this industry.

The Oilgae Digest was prepared precisely to cater to this need for a clear, balanced and precise guide about the algae fuels industry. The Digest has a special emphasis on providing inputs and insights on questions that are critical to entrepreneurs and investors keen on exploring this industry.

Readers will especially benefit from real world inputs and insights on the following aspects:

- Real World Status of Algae Energy Companies and their Projects
- The Key Challenges Faced by the Algae Fuel Industry
- Details of Capital Costs and Investments
- Venture Capital Investment Trends
- Various Business Models being Adopted by the Companies
- Business Strategies for Success
- Forecasts for Algae Fuel Industry

Concise and written in a language that enables even non-technical businessmen and entrepreneurs to understand the technology, processes and dynamics of this exciting industry, the Oilgae Digest is an invaluable guide to those wishing to learn the fundamentals of the algae fuel industry from experts.

Who will benefit from the Oilgae Digest?

- Entrepreneurs planning to start a venture in the algal energy domain in specific and alternative energy in general.
- Venture capital, Private Equity companies banks, Finance & investment companies exploring investments in this domain.
- Companies in algae-related industries or businesses with synergistic operations exploring oil from algae ventures.
- Corporate Chief Executives and Senior Management
- Management and Strategy Consultants
- Government Departments that Provide Renewable Energy Grants

The Oilgae Digest was developed to provide background and insights on the key parameters driving the **algae fuel business - technical and economic feasibility, real industry status, investments and costs, and business success factors**. This report is a customized edition for those who wish to get a first level understanding of the critical drivers of the algae fuels industry.

The Oilgae Digest was last updated in the 1st week of June 2013, and has 161 pages.

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1 Introduction to Algae Energy

Cultivation of algae for fuels is quite different from cultivating traditional energy crops, for a number of reasons. The environments in which algae grow are diverse; algae require a different method of harvesting than most traditional plants; and the range of energy products that can be derived from algae is quite diverse as well. This chapter introduces to a beginner the key stages and aspects of algae to fuel processes, and the fuel products that can be derived from algae.

Key Sections

- 1.1 Algae & Energy – Background and Concepts
- 1.2 Energy Products from Algae Biomass
 - 1.2.1 Biodiesel
 - Oil Yields from Algae
 - Current Methods of Oil Extraction
 - Converting Algae Oil into Biodiesel
 - 1.2.2 Ethanol
 - 1.2.3 Methane
 - 1.2.4 Hydrogen
 - 1.2.5 Other Hydrocarbons
 - 1.2.6 Prominent Companies & End Products
- 1.3 Algae to Energy Processes
 - 1.3.1 Strain Selection
 - 1.3.2 Algaculture
 - 1.3.3 Harvesting
 - 1.3.4 Oil Extraction
 - 1.3.5 Conversion of Oil to Biodiesel

SAMPLE TOPIC

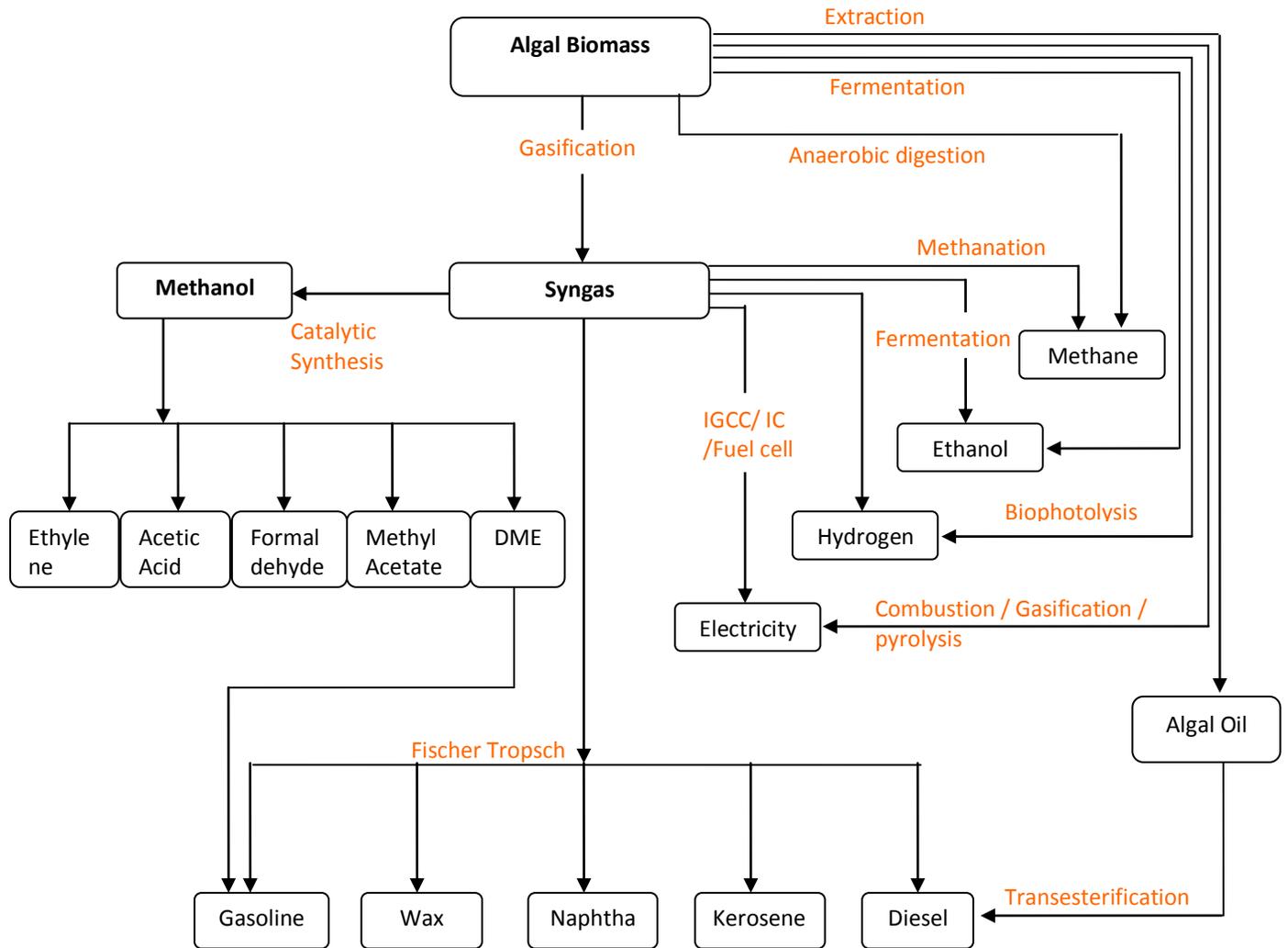
Crop	Oil Content % - Average Values	Crop	Oil Content%- Average Values
Soy	20	Peanuts	50
Canola / Rapeseed	40	Palm Kernel	50
Sunflower	55	Corn	7
Safflower	40	Mustard	40
Castor	45	Flaxseed	45
Hemp	30	Jatropha Seed	40
Dry Coconut	60	Jatropha Kernel	55
Algae		2 to 40	

From the above table, it can be seen that algae have almost 10 times oil & biodiesel yield as palm or Chinese Tallow, and over 50 times the yield as soy. This means that one needs to use 10% of the total land area for algae cultivation for similar oil yields as for palm, and just 2% of land area when compared to soy.

SAMPLE TOPIC

Energy Products from Algae

Paths to the Various Energy Products from Algae



Summary details of key processes are given in the report.

SAMPLE TOPIC

List of Algae Energy Companies and Proposed End-Products

A2BE Carbon Capture	Biodiesel & Ethanol
Algae.Tec	Biodiesel
Algaetech International	Biodiesel
Algenol	Ethanol
Aurora Algae	High value products from algae
Aquaflow Bionomics	Biodiesel, Aviation fuel
BlueMarble Biomaterials	High value chemicals
Carbon Capture Corp	Biodiesel, Butanol, Biomethane, JP-8
Cellana	Biodiesel
CEHMM	Biodiesel
Community Fuels	Biodiesel

SAMPLE TOPIC

Comparison of Open Pond and Photobioreactor

Parameters Showing the Relativity between Open Ponds Vs Closed Bioreactors

Source : NREL

Parameter	Relative
Contamination risk	Ponds > PBRs
Space required	Ponds ~ PBRs
Productivity	Ponds < PBRs
Water losses	Ponds ~ PBRs
CO ₂ losses	Ponds ~ PBRs
O ₂ Inhibition	Ponds < PBRs
Process Control	Ponds < PBRs
Biomass concentration	Ponds < PBRs
Capital/Operating costs ponds	Ponds << PBRs

2 Size & Scope of the Algae Business Opportunity

There are a number of challenges that companies in the algae fuels industry face currently. At the same time, algae being the only feedstock that can possibly replace all our fossil fuels, the potential and payoffs for a successful algae fuel is enormous. This potential is further enhanced when one considers the parallel benefits that algae to fuel efforts bring – in terms of bioremediation of wastewater and CO₂ capture at power plants. This chapter elaborates on the potential and range of business opportunities possible in the context of the algae fuels.

Key Sections

2.1 Energy Industry Payoffs

2.1.1 Global Energy Industry

2.1.2 Oil - Big Challenges & Big Payoffs

2.2 Applications & Uses for Algae

2.2.1 Fuel Applications of Algae

2.2.1.1 Biodiesel

2.2.1.2 Ethanol

2.2.1.3 Hydrogen

2.2.1.4 Methane

2.2.1.5 Hydrocarbons

2.2.2 Non-fuel Applications

2.2.2.1 Bioremediation

- CO₂ Sequestration
- Case Study of Algae-based CO₂ Sequestration
- Algae Bioremediation for Waste Water Treatment
- Case Study of Waste Water Treatment with Algae

2.2.2.2 Other Non-fuel Applications

2.3 Industries with Synergistic Benefits from the Algae Energy Opportunities

- List of Potential Industries

2.4 Wide Range of Business Opportunities

SAMPLE TOPIC

Sample of Products from Microalgae¹

Product	Microalgae	Price (USD)
b-Carotene	<i>Dunaliella</i>	300–3000/kg
Astaxanthin	<i>Haematococcus</i>	10,000/kg
Whole-cell dietary supplements	<i>Spirulina</i> <i>Chlorella</i> <i>Chlamydomonas</i>	50/kg
Fish feed and animal feed	<i>Tetraselmis</i> <i>Nanochloropsis</i> <i>Isochrysis</i> <i>Nitzschia</i>	1-10/Kg
Polyunsaturated fatty acids	<i>Cryptocodinium</i> <i>Schizochytrium</i>	60,000/kg
Pharmaceutical proteins	<i>Chlamydomonas</i>	N/A
Biofuels	<i>Botryococcus</i> <i>Chlamydomonas</i> <i>Chlorella</i> <i>Dunaliella</i> <i>Neochloris</i>	N/A

¹ Source: Department of Chemical & Biomolecular Engineering, The Johns Hopkins University 2008

SAMPLE TOPIC

The global market for carotenoids was \$766 million in 2007. This is expected to increase to \$919 million by 2015, a compound annual growth rate (CAGR) of 2.3%. Beta-carotene has the largest share of the market. Valued at \$247 million in 2007, this segment is expected to be worth \$285 million by 2015, a CAGR of 1.8%.

**Global Carotenoid Market Value by Product 2007 & 2015
(\$ Million)¹**

Product	2007	2015
Beta-carotene	247	285
Astaxanthin	220	252
Canthaxanthin	110	117
Annatto	69	95
Others	120	170
Total	766	919

The scope of applications and potential markets for both fuel and non-fuel uses of algae are explained in this chapter. These insights will help entrepreneurs to identify synergistic business opportunities

3 Real World Status of Algae Energy Projects

News and updates from mainstream media on the algae fuel industry can be often misleading, as many of these updates might have considered only aspect of the industry. On the other hand, it is important for an investor or an entrepreneur to understand the true status of the algae fuels industry from many important angles - in terms of the extent of commercialization and implementation of existing algae fuel projects, level of competition and the real challenges that the industry faces. This chapter provides concise inputs on these, along with answers to critical questions in the Q&A section of the chapter.

Key Sections

- 3.1 Prominent Companies
- 3.2 Status of Algae Fuel in Real World
 - 3.2.1 Industry Concentration
 - 3.2.2. Dominant Designs
 - 3.2.3 Implementation Status of Prominent Companies
 - 3.2.4 Q&A
- 3.3 Bottlenecks & Barriers
 - 3.3.1 Biggest Challenges
 - 3.3.2 Entry Barriers
 - 3.3.3 Q&A

SAMPLE TOPIC

Industry Concentration

Approximate Number of Companies Directly Involved In Producing Fuels from Algae

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
# of companies	1	2	4	5	10	15	25	50	150	200	275	300	325

Source: Oilgae Estimates

List of prominent companies and the status of this emerging industry with regard to the number of companies, existence of standards, key entry barriers and project implementation are provided in this chapter

SAMPLE TOPIC

Heliae

Heliae raised \$15m in funding in May 2012. The investment was made by international conglomerate Salim Group's agribusiness company, PT. PP London Sumatra Indonesia Tbk, through its wholly-owned subsidiary, Agri Investments Pte. Ltd. Since 2008, Heliae has received a total of close to \$50 million in funding.

The Company broke ground on commercial demonstration facility for algae production in May 2012. Heliae is aiming for commercial production in 2014.

Heliae plans to build several additional facilities across the globe in the next few years. With the recent investment from the Salim Group, one of the largest diversified agri-food conglomerates in Southeast Asia, Heliae plans to expand beyond North America and deploy sites throughout the Asia Pacific region. The new facility comprises 20 acres adjacent to Heliae's Gilbert, Ariz. headquarters. The site will be constructed in phases over the next 18 months.

In April 2013, Heliae launched its patent pending microalgae production platform, Volaris. The Volaris platform is a core piece of technology amongst Heliae's diverse intellectual property portfolio, which now includes more than 50 issued patents across the algae value chain. Heliae also entered into a partnership with Evodos to offer its proprietary Spiral Plate Technology.

- ✦ *In April 2013, Heliae launched its patent pending microalgae production platform, Volaris. The Volaris platform is a core piece of technology amongst Heliae's diverse intellectual property portfolio, which now includes more than 50 issued patents across the algae value chain.*
- ✦ *Heliae broke ground on commercial demonstration facility for algae production in May 2012. The Company is aiming for commercial production in 2014.*

4 Investments & Returns

Algae fuels, being at the research and pilot stages of its development, require differing levels of investments for the various stages – lab stage, pilot stage and commercial stage. A critical question for investors is the extent of investments they will need to make for each of these stages. The other important question for those exploring this industry is the cost to make fuel from algae. This chapter provides specific answers to these important questions.

Key Sections

- 4.1 Investments
 - 4.1.1 Lab Stage
 - 4.1.2 Pilot Stage
 - 4.1.3 Commercial Stage
- 4.2 Returns
- 4.3 Costs
- 4.4 Q&A

SAMPLE TOPIC

Cost Components

The total cost of algae fuel = costs for (cultivation + harvesting + oil extraction + transesterification).

Cost Components	Options			
Cultivation	<i>Open ponds</i>	<i>Photobioreactor</i>		
Harvesting	<i>Centrifuge</i>	<i>Flocculation</i>	<i>Flotation</i>	<i>Drum Filtration</i>
Extraction	<i>Expeller Press</i>	<i>Hexane Solvent</i>		
Biodiesel Conversion	<i>Transesterification</i>			

Note: The categories provided in italics are the various options available under each stage

Cost estimates of various options under each stage, total cost of biodiesel production are calculated and presented in the report

5 Profiles of Top Algae Energy Companies

Currently, there are over 100+ companies worldwide with a serious focus on algae fuels. These companies are in various stages of evolution, implementation and success. Many of these companies have unique approaches to deriving fuel from algae. An analysis of the existing algae fuel companies will thus be useful for entrepreneurs who wish to identify processes and technologies that they should be pursuing. This chapter provides profiles and details on the prominent algae fuel companies.

SAMPLE TOPIC

Algenol

Main line of activity: Algae Biofuels Producer

Headquartered at: Indianapolis, USA

Algenol Biofuels is an algae-to-ethanol company. Its Direct to Ethanol™ technology uses fermentation to convert algae directly from culture, to ethanol.

The company believes its seawater-based process can generate up to a billion gallons of algal ethanol per year. Algenol has an algae library in Baltimore, Maryland, to study the organism that can grow in salt or fresh water. The company is targeting to build algae-to-ethanol farms on coasts in the United States.

Since its inception in 2006, the privately funded company has seen \$70 million in investments, with zero venture capital money to its name, according to a company statement.

In Mar 2011, Algenol Biofuels Inc. has announced that its parent company, Algenol LLC, recently acquired Cyano Biofuels GmbH, located in Berlin, Germany. Cyano brings extensive experience in producing hybrid algae to make ethanol and green chemicals, and increases Algenol's research and development capacity while strengthening its access to European expertise in biotechnology and algal research. Cyano Biofuels was founded in 2007 and is located in the Adlershof technology park in Berlin. Cyano Biofuels has strong ties to leading German universities and is a spin-off from Humboldt-University.

In October 2011, Algenol Biofuels started construction of its first pilot scale integrated biorefinery. The facility is located on 36 acres and will be used for the development and deployment of Algenol's technology used for the sustainable production of biofuels and green chemicals. The facility is also said to have a 10,000-square-foot support building, a 4,200-square-foot greenhouse, a 10,000-square-foot water and ethanol processing pavilion, and a saltwater well. The plant has a capacity of producing approximately 100,000 gallons of fuel-grade ethanol per year.

Process & Technology

Algenol chose from a collection of 10,000 strains of algae, and used molecular biology to enhance certain traits. Its engineers enhanced certain algae's ability to make sugar and, through their enzymes, to ferment the sugar and produce ethanol.

The Algenol process occurs in bioreactors that are three-feet by fifty-feet and shaped like soda bottles. During the process, algae consume sunlight and more than 90 percent of the system's CO₂ through photosynthesis, wherein the sugars are converted into ethanol. The ethanol is immediately pumped out and evaporates into the bioreactor which is captured every night. This process overcomes the significant problems other companies face, according to the company.

Highlights

- Algenol is one of the first companies that started focusing deriving ethanol – and not biodiesel - from algae.
- Its announcement of direct fermentation of ethanol – straight from culture – is interesting and could hold good potential if it works out well.
- Algenol completed an approximately \$90 million private financing with a major multinational petroleum corporation that has become a new strategic partner for Algenol. Algenol, in March 2013, announced that the company has demonstrated production rates of more than 9,000 gallons of ethanol per acre per year at its process development unit.
-
- Algenol intends to complete its DOE Biorefinery in 2013. At full scale, the facility will consist of 17 acres filled with photobioreactors, and will produce 100,000 gallons of ethanol per year. The company expects to have a commercial project producing ethanol by the 4th quarter of 2014.

www.algenolbiofuels.com

6 Investments & Venture Capital

For an algae fuel company, seeking venture funding should be an important focus area, given the level of investments required and the risk profile of the industry. Since 2002, interest in investing in algae fuels has been accelerating. In 2008, Sapphire Energy obtained a \$100 million investment from venture firms including Cascade Ventures, owned by Bill Gates. Since then, the VC interest in algae fuels has increased even further. In 2009, ExxonMobil made an investment commitment of \$600 million in Synthetic Genomics, a biotechnology firm, further proving that this is a hot investment domain. This chapter provides details of companies that have been funded, venture capital firms that are active in algae fuel industry investments, and insights and recommendations from top venture capital firms.

Key Sections

- 6.1 Quantum of VC Investments
- 6.2 Companies that have Received VC Funding
- 6.3 Government & Other Public Initiatives
- 6.4 VC Perspectives

SAMPLE TOPIC

Companies that have received VC Funding

Venture capital firms that had made recent investments in algae fuel ventures and the companies they have invested in:

Venture Capital Firms	Algae Firms
Aardvark Investments SA (www.aardvarkinvestments.com)	Cequesta Algae
Access Private Equity	GreenFuel Technologies
Arch Venture Partners (www.archventure.com)	Sapphire Energy
BIRD Foundation (www.birdf.com)	Algatech GreenFuel Blue Marble Biomaterials, Solazyme
BlueCrest (www.bluecrestcapital.com)	Earth2tech
Braemar Energy Ventures (www.braemarenergy.com)	Solazyme

Details are provided for over twenty venture capital investments in algae fuel firms. In addition, inputs are provided for the various government and public initiatives that support algae fuel research.

7 Business Strategies

As in any other business, the winners in the algae fuels industry would have strategized better than the also-rans. The fast-changing and dynamic nature of the algae fuels industry makes it important that entrepreneurs get their strategy right, in such a way that it factors in the uncertainties in the business while at the same time ensures that most of the business actions go towards creating productive, long-term assets. This chapter provides key insights on the various strategic aspects of the algae fuel industry, the steps that needs to be taken by those entering the industry, and clearly points out the key factors for success as well as the mistakes that should be avoided.

Key Sections

- 7.1 Key Success Factors
- 7.2 Niche Focus
- 7.3 Exploring Opportunities in Support Industries
- 7.4 SWOT Analysis
- 7.5 Lab Stage & Pilot Stage
 - Objectives of the Lab Stage & Pilot Stage
 - Examples of Pilot Stage Efforts
- 7.6 Teams & Expertise
 - Team Compositions for Pilot Phase and Full-scale Commercial Phase
- 7.7 Monitoring for Breakthroughs
- 7.8 Things to Avoid
- 7.9 Deciding the End Product
 - 7.9.1 End Products – Q&A
- 7.10 Understanding Your Country / Region’s Regulatory and Incentive Environment Better

SAMPLE TOPIC

The table below provides a list of strengths, weaknesses, opportunities and threats for the algae energy industry.

Strengths	Weaknesses
<ul style="list-style-type: none"> • Present the only possibility for complete replacement of fossil transportation fuels • Very high rewards for success • Large market 	<ul style="list-style-type: none"> • High risk owing to unproven processes • High cost of fuel production • Low margins if produced for fuel • Need for huge R&D investments
Opportunities	Threats
<ul style="list-style-type: none"> • A large number of product possibilities • Early mover advantages available for those entering now • New techniques such as genetic engineering could make the production process cost-effective 	<ul style="list-style-type: none"> • Established players in the energy industry could enter the market and crush the startups • Other alternative energy sources could become more cost competitive • Investors might not be willing to wait for a long time for success

Detailed insights and business strategies are provided for the various aspects mentioned in the list of contents.

8 Future Trends

Knowledge of future possibilities helps entrepreneurs in planning their venture better. This is especially true for an industry that is brimming with so many different possibilities – different possible strains, technologies, processes and products. Based on our acquaintance with the industry since its inception, and based on our interactions with experts and industry participants, we have provided our inputs on the future challenges, highlights and possible surprises for the algae fuels industry.

Key Sections

8.1 Perspectives

8.2 Predictions

Predictions on how the algae energy industry will pan out during the next 15 years - until 2030 – are explained in detail in this chapter. For each of the periods discussed, analyses and predictions are made

SAMPLE TOPIC

Years	Challenges	Highlights	Dark Horses
2013-2017	<ul style="list-style-type: none"> • Optimal strain identification • Devising cost-effective methods for cultivation • Devising cost-effective methods for harvesting 	<ul style="list-style-type: none"> • Ethanol from algae • Many pilot projects • Governments realizing the potential of algae biofuels and devoting higher resources for research • Reduction in costs for biodiesel production processes • Efforts to grow algae next to power plants to use the flue gases for CO₂ 	<ul style="list-style-type: none"> • Growing algae in the dark • Hydrocarbons from algae gasification & catalytic synthesis • Creative sparks coming from garage & backyard inventors
2017-2022	<ul style="list-style-type: none"> • Innovative scientific techniques and out-of-the-box thinking to overcome what looks insurmountable • Innovative business and revenue models that factor in ground realities 	<ul style="list-style-type: none"> • New progress from fields such as genetic engineering & biotech • Low cost photobioreactors • Growing algae next to power plants 	<ul style="list-style-type: none"> • Integrated biorefinery for algae fuel and value added products
2022-2030	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • Hydrogen from algae • Some successful firms starting to dominate the algal fuel landscape 	<ul style="list-style-type: none"> • Ability to produce algal fuel from micro-refineries, making each household a potential producer of algal fuel!

9 Interested? Next Steps

9.3 Ask Oilgae

If you are interested in taking the next steps, you might have the following questions (or other questions related to these):

- Are there consultants I can talk to right away?
- Where do I find the experts who can set up a lab for me?
- Where can I find experts who can set up the pilot phase for me?
- Where can I find experts who can implement the Biodiesel plant for me? Fermentation to ethanol plant?

Q&A

Chapter 3:

- What is the realistic chance of producing fuel from algae?
- Has any company succeeded in producing biofuel from algae?
- Is any company selling biofuel from algae in the commercial market?
- When, according to the top companies in this domain, will they be able to produce biofuels from algae on a commercial scale?
- As algae oil has the potential to replace fossil fuels, what are the big oil companies doing about algae fuels?
- Are the researchers who did the Aquatic Species Program (an extensive research program sponsored by the US government) involved in the current efforts?
- Why did the Aquatic Species Program (1978-1996) fail?
- Why should the current research succeed when the Aquatic Species Program did not?
- Why aren't the governments worldwide investing much more in this?

Chapter 4:

- If algae energy is a medium-high risk business opportunity with a number of uncertainties, why should an entrepreneur invest time and efforts into this domain, instead of other biofuel opportunities?
- Can a small entrepreneur start an algae fuel venture?
- Is it too risky to put in one's own money?
- What are the types of external financing available?

Chapter 7:

- Does hydrogen have a realistic chance of making it big in the short and medium run as a transport fuel?
- Is any company producing or trying to produce hydrogen or methane from algae?
- Can algae biomass or the deoiled algae cake be directly used as fuel for combustion?

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