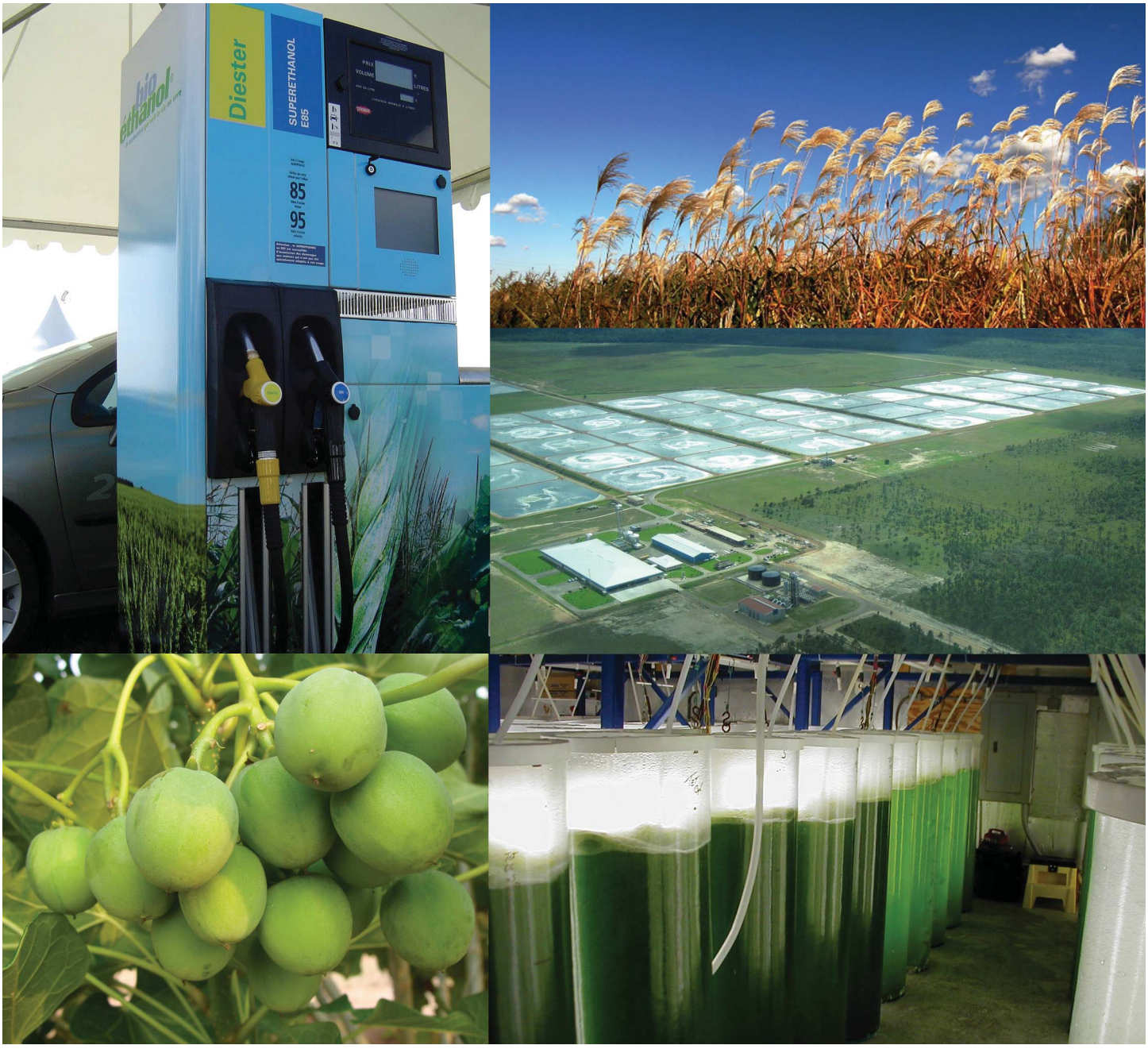
BIOFUELS 2010: SPOTTING THE NEXT WAVE

JOSHUA KAGAN THE PROMETHEUS INSTITUTE | TRAVIS BRADFORD THE PROMETHEUS INSTITUTE



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GTM RESEARCH

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Travis founded the Prometheus Institute in 2003 as a means to connect the vast reach and power of industrial and capital markets with the technologies necessary to sustain and develop long-term economic well-being for people around the world. Travis is currently the Editor-in-Chief of PVNews, the solar energy industry's oldest newsletter, and is the author of Solar Revolution: The Economic Transformation of the Global Energy Industry published by MIT Press. He is also a partner at Atlas Capital, a hedge fund based in Cambridge, MA.

1 EXECUTIVE SUMMARY

Oil is a problematic energy source for reasons other than volatile prices and diminishing supplies. In recent years, the consensus in the scientific community is that climate change is real and is driven largely by carbon emissions that stem from human behaviors. One response to the threat of climate change would be to regulate the use of carbon fossil fuels with an externality tax or some other policy measure. Taxing fossil fuels would drive up the price of petroleum products, making alternative fuels more economically attractive. Yet, can alternative fuels compete without policy initiatives?

This report is an inquiry into the role of biofuels as a legitimate substitute to displace the primacy of petroleum transportation fuels. Our research was guided by the following questions:

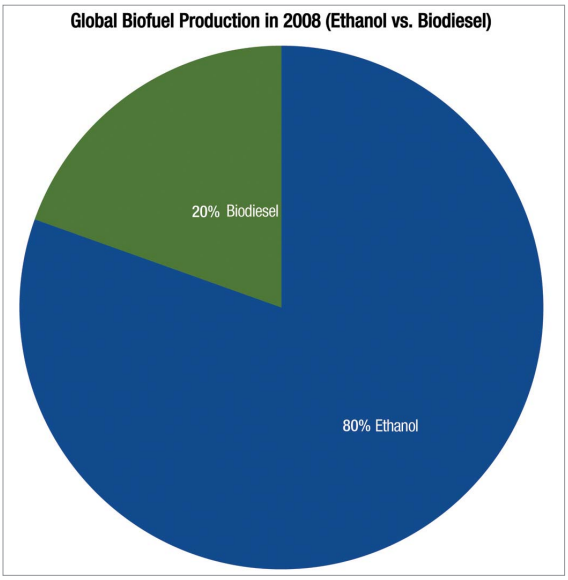
- What are the different types of biofuels and to which of them should more attention be paid?
- Will biofuels ever be price-competitive with fossil fuels without subsidies? If so, when?
- When, if ever, will biofuels displace significant volumes of liquid petroleum products?

The findings of this report are the results of a comprehensive research project, as well as a series of fact-finding interviews of scientists, policymakers, academics, and more than 40 first-, second-, and third-generation biofuel companies. As a result of this extensive research and analysis undertaking, this report provides insights and accurate information on the following biofuel subject areas:

- Regional and global **market dynamics**
- Established and experimental **technology** pathways
- Recent and future biofuel **policies** and their market implications
- The strengths and weaknesses of **feedstock** choices
- The **economics** of each generation of biofuel
- **Profiles** of 40 of the most interesting global biofuel companies

Our research revealed that the global biofuels paradigm is poised to dramatically shift in the coming years. First-generation biofuels (consisting of grain or sucrose-based ethanol and oil seed-based biodiesel) are currently the only commercially viable and available forms of biofuel. Of the 21.5 billion gallons of biofuel produced in 2008, 80% was ethanol (17.3Bgal), while biodiesel accounted for the other 20% (4.1Bgal).

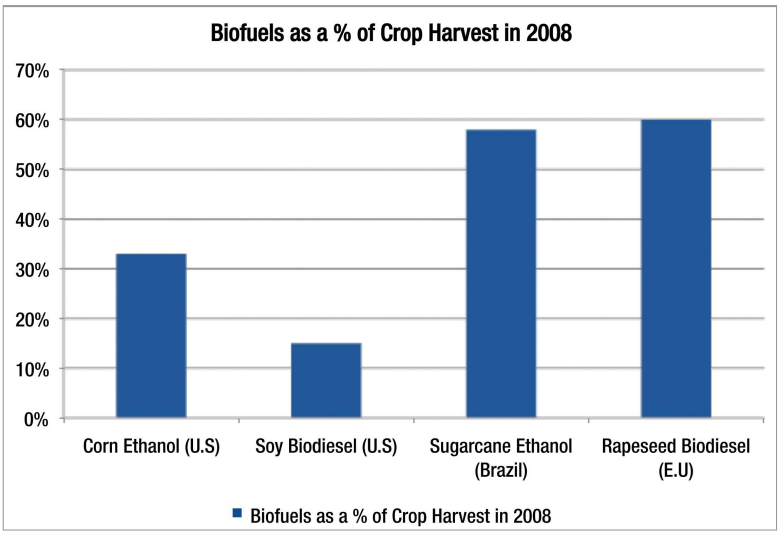
FIGURE 1-1: 2008 GLOBAL BIOFUEL PRODUCTION IN BILLIONS OF GALLONS



Source: The Prometheus Institute

In 2008, ethanol production displaced 3.7% of global gasoline consumption, while biodiesel accounted for 1.5% of the global diesel market (on equivalent Btu levels). When we consider the amount of cropland consumption that was required to displace a relatively minor amount of petroleum, we find that current first-generation biofuels are highly problematic. For example, the United States is the largest corn producer in the world. In 2008, the U.S. allocated approximately 33% of its entire corn crop to displace about 5% of its gasoline needs. Similarly, in 2008, the EU used about 60% of its rapeseed harvest to replace 3% of its diesel consumption.

FIGURE 1-2: 2008 REGIONAL CROP DISPLACEMENT BY BIOFUEL PRODUCTION)



Source: The Prometheus Institute

Given the land-use constraints that face the current generation of biofuels, there is significant enthusiasm from policymakers and entrepreneurs for the commercialization of "advanced" biofuels whose production will not compete with food crops. Based on our analysis of the strengths, weaknesses, and opportunities for advanced biofuels, prospects for the production of significant amounts of biofuel from non-food feedstocks are appealing, but they remain limited by complicated logistics. For example, it is estimated that a cellulosic ethanol plant with a production capacity of 50MGY would require a truckload of biomass to be delivered every six minutes, 24 hours per day and 365 days per year. Furthermore, this biomass will most likely come from unconventional energy crops whose growth, harvest, collection, and transportation methods will differ from the well-established practices of mainstream crops like corn, wheat, soybeans, etc.

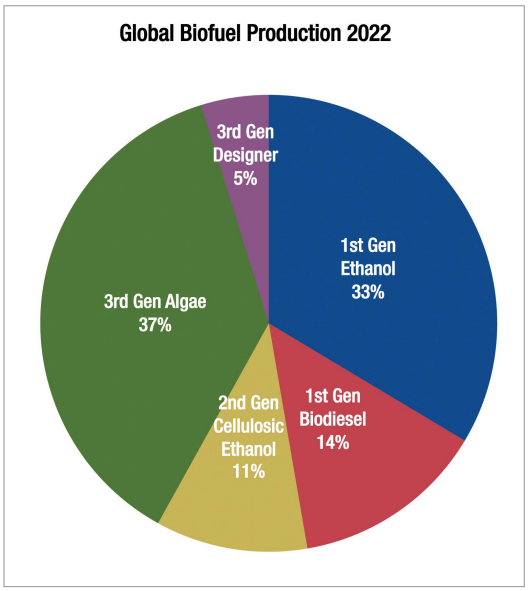
Based on the findings of this report, we forecast that although second-generation cellulosic ethanol will likely achieve commercialization around 2011, its prospects will be limited due to land-use issues, logistical challenges, and fresh-water constraints. Although third-generation technologies such as algae lag behind second-generation cellulosic biofuels by several years, algae biofuels are truly revolutionary and will almost certainly become an unsubsidized economic inevitability around 2016. However, this conclusions will materialize only if algae can achieve the following operational parameters:

- Algae yields reach 5,000-10,000 gallons of diesel per acre per year (compared to corn, which yields 350 gal/acre/year of ethanol, and soybean oil which provides 50gal/acre/year of biodiesel)
- Algae is grown on marginal or desert land using brackish or salt water (thus eliminating the need for scarce agricultural land or freshwater)
- It consumes CO_2 as a feedstock, resulting in the production of algae biofuels being close to carbon neutral
- Using algae for biofuel production does not compete with human or animal food sources

Algae oil can be refined into gasoline, diesel, or jet fuel (as opposed to other biofuels that are limited to a specific transportation application) as well as a number of nutritional and cosmetic supplements, animal feed, and other by products.

We project that by 2022, third-generation biofuels will be the largest global biofuel source, accounting for 37% (40 billion gallons) of total biofuel production (on a volumetric basis).

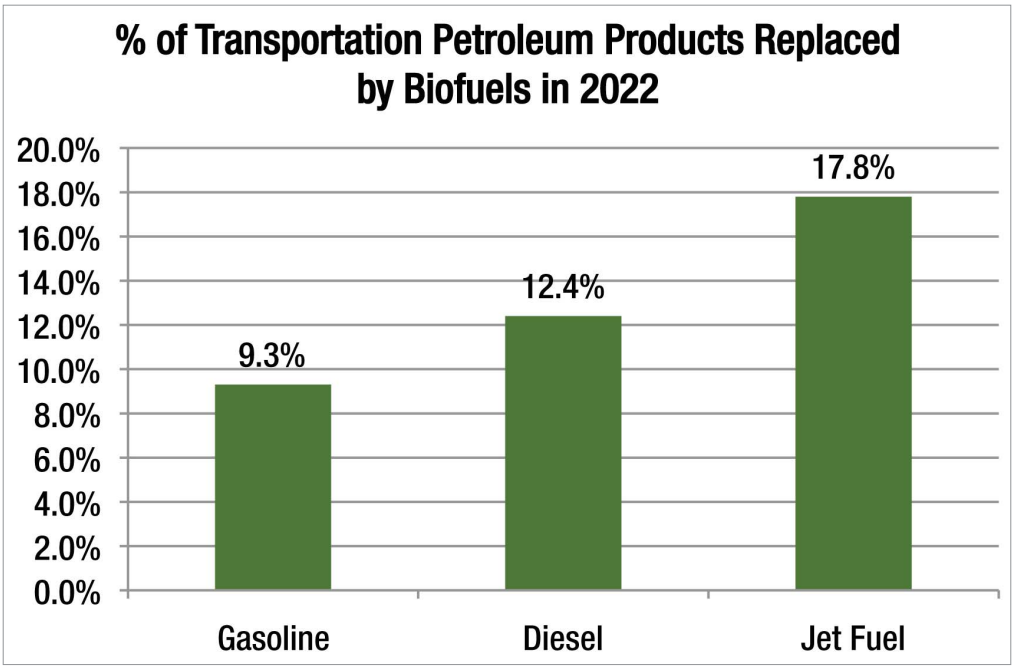
FIGURE 1-3: GLOBAL BIOFUEL PRODUCTION IN 2022, IN BILLIONS OF GALLONS



Source: The Prometheus Institute

In extrapolating our projections in transportation petroleum demand growth in emerging economies throughout the world, we estimate that in 2022, 834 billion gallons of gasoline, diesel, and jet fuel-like products will be consumed globally -- 169 billion gallons more than in 2009. Biofuel production is expected to make up 109 billion gallons of this amount, accounting for 9.3% of the global gasoline market, 12.4% of diesel, and 17.8% of all jet fuel consumed.

FIGURE 1-4: % OF GLOBAL TRANSPORTATION PRODUCTS DISPLACED BY BIOFUELS IN 2022



Source: The Prometheus Institute

This report is intended to be a comprehensive, holistic, and nuanced overview of the global biofuel industry designed for a target audience of investors, entrepreneurs, policymakers, academics, research institutions, and companies with an interest in the field. In the coming years, we believe the global biofuel industry will develop into a market measured in the hundreds of billions of dollars, and a major sector in the cleantech space. Though the near-term prospects of biofuel firms remain uncertain, the industry is full of potential and should be watched closely as its technologies and companies continue to evolve and emerge over the next few years.

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