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# Advanced Biofuel Market Report 2013

## Capacity through 2016

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## Executive Summary

This report catalogs the growth and challenges of the advanced biofuel industry and provides updates on developments since the publication of last year's report in 2012. The scope of this work includes active advanced biofuel projects in the United States and Canada. Each project included in this report achieves at least a 50% reduction in carbon intensity relative to a petroleum baseline, using the direct and indirect effects as measured by the California Air Resources Board.

E2 developed a low-end and high-end methodology to estimate future capacities. For low-end estimates, our figures include facilities that have demonstrated progress towards production. For high-end estimates, we examined all active companies we could identify, but discounted some capacity projections. We also used Cleantech Group's industry investment data, as well as input from companies, to understand the probability of completion and develop estimates of investment in the industry.

For these fuel capacities to be achieved, each project would need to be completed on the schedule we have projected. Comparisons of our reports over the last three years show that some projects are complete on schedule, some projects are deferred, others are canceled due to market conditions, and some that we did not identify are successful.

### Key Figures

- Capacity for 2013 is 1.0 billion gallons gasoline equivalent
- Capacity for 2015 is between 1.4 and 1.6 billion gallons gasoline equivalent. This equates to 0.7% of total U.S. transportation fuel use.
- 160 commercial scale facilities planned, under construction, or complete from 159 companies
- 13 demonstration facilities in existence
- Private investment in the advanced biofuel industry totals over \$4.85 billion since 2007
- Public grants exceed \$600 million since 2008. Currently 20 biorefinery projects are public grantees.
- Federal loan guarantees exceed \$940 million since 2008. Nine of the current biorefinery projects have received these loan guarantees.

After completing our analysis, a number of trends emerged. The capacity projections are sufficient to meet the federal Renewable Fuel Standard (RFS) and California's Low Carbon Fuel Standard (LCFS) targets through 2016, given the other fuels and technologies that can be used in each program. Capacity in the industry continues to grow, and biodiesel remains the dominant advanced biofuel today and through 2016. Drop-in renewable hydrocarbons, which may be blended directly into standard gasoline, diesel, or jet fuel, show significant progress and we expect them to contribute more substantially to overall advanced biofuel capacity over time. Industry growth is driven primarily by federal and state policies, specifically the RFS and the LCFS. The substantial public investment in the advanced biofuel industry comes primarily from the Department of Agriculture, the Department of Energy, and the Department of Defense.

Regulatory certainty, including the continued existence of renewable fuel policies, the permitting of pathways, non-compliance fees paid by oil and gas companies, and agency reaction to market conditions, remains unstable and is a barrier to commercialization for many projects. Capital and operating expenses also continue to be a significant challenge for many advanced biofuel developers. While some companies are retrofitting existing refineries for biofuel production, others will need to construct new facilities, which requires substantial investment.

Looking towards 2016, there is real potential for advanced biofuels to scale up. Today, numerous facilities are on track towards commercialization, and the industry is moving steadily forward. New investments and regulatory certainty will help ensure the successful commercialization of these projects.



*INEOS Bio's commercial-scale facility converting municipal solid waste into ethanol in Vero Beach, FL. Began operations in 2013. Photo courtesy of INEOS Bio.*

## I. Glossary of Terms

advanced biofuel	Liquid fuels made from non-petroleum sources that achieve a 50% reduction in carbon intensity compared to a petroleum fuel baseline according to the California Air Resources Board.
biodiesel	Fatty acid methyl ester fuel, derived from vegetable oils, animal fats, or other waste oils. Can be used in place of diesel and is commercially available. In this report, considered advanced only if made with non-virgin oils.
butanol	Energy dense alcohol formed through fermentation of biomass. May be blended into gasoline at higher percentages than ethanol.
carbon intensity	An indicator of the emissions associated with a particular fuel pathway. Measured in grams of carbon dioxide equivalent (CO <sub>2</sub> e) per megajoule.
cellulose	Non-food based form of biomass.
commercial facility	Operated with the intention of selling the product at a profit. Product is readily available and facility is operated continuously.
conventional biofuel	Also called first-generation biofuel. Encompasses starch-based ethanol and virgin-oil-based biodiesel. Reduces carbon intensity by 5-30% from a gasoline baseline. Feedstocks used for conventional biofuels, like corn, wheat, sugar, soybean and palm oil, often displace agricultural production.
crude oil	Petroleum before it is processed and refined into fuel and other derivatives. Known as biocrude when processed from biomass, which may be refined into renewable (or drop-in) gasoline, diesel, or jet fuel.
demonstration facility	Facility used to demonstrate technology and full commercial process at a small scale. May not be operated continuously or at a profit.
dimethyl ether (DME)	Similar to propane. May be blended into diesel to boost butane levels.
drop-in fuel	Renewable hydrocarbons that can be refined into gasoline, diesel, or jet fuel. Can be used in existing vehicles and pipelines with no modifications to vehicle technology or infrastructure.
enzymatic hydrolysis (EH)	Biochemical process to convert cellulose to sugar with enzymes. Used to produce ethanol.

ethanol	Alcohol that can be blended into gasoline. In U.S., blended at 10% to enhance octane levels. This report focuses on cellulosic ethanol.
ethanol equivalent	Liquid fuel measured from an ethanol energy content basis. Ethanol has two-thirds the energy content of gasoline. RFS uses ethanol equivalencies.
feedstock	An input that is processed or otherwise converted to biofuel. In this report, most feedstocks are biomass-based.
gasification	Frequently-used process to heat biomass for conversion into liquid fuels. Can be used to produce a variety of fuel types.
gasoline gallon equivalent (gge)	The amount of alternative fuel equivalent to one liquid gallon of gasoline. Volumes are often measured in gge for straightforward comparisons across fuels.
hydrocarbon	Chemical compound made of carbon and hydrogen. Found in petroleum products.
jet fuel	A liquid hydrocarbon suitable for use in airplanes. Refined from biocrude and renewable feedstocks.
pilot facility	Smaller lab-based facility, designed for research purposes.
pyrolysis	Thermochemical process similar to gasification, but performed in the absence of oxygen. Used to produce a variety of fuels. Includes catalytic cracking of carbon bonds.
renewable diesel	Also called advanced diesel. Made by hydroprocessing of vegetable oils, algal oils, or animal fats. As a liquid hydrocarbon, has very similar properties to petroleum diesel. Functions as a “drop-in” fuel.
renewable gasoline	Also called advanced gasoline. May be refined from a gasification or pyrolysis process. Is chemically similar to petroleum gasoline. Functions as a “drop-in” fuel.
transesterification	Process used to produce biodiesel from fats, oils, or greases.

## II. Introduction

This is E2’s third annual market report, which seeks to catalog the growth and challenges of advanced biofuels. Advanced biofuels present an opportunity to replace petroleum fuels with domestic and renewable fuel products, and are just becoming commercially available in the United States. However, the industry still faces challenges to reach significant market penetration.

Our purpose is to document advanced biofuel activities so that policymakers have additional information to understand the ability of the market to meet (or exceed) state and federal fuel standards, like the Renewable Fuel Standard (RFS) and California’s Low Carbon Fuel Standard (LCFS). We also survey the challenges of rapid growth that the industry faces.

### Scope of report

Advanced biofuels are those fuels that have less than half the carbon intensity of fossil fuels and minimize their impact on food production. As shown in Table 1, E2 tracks advanced biofuels that achieve this threshold according to the California Air Resources Board (ARB), which assesses a broad scope of direct and indirect effects. There are a number of fuel pathways that the Environmental Protection Agency (EPA) has not yet approved that E2 considers advanced. There are also a few fuel pathways that EPA considers advanced that do not meet E2’s criteria. Fuel pathways marked as “E2 Advanced Biofuel” are the only ones considered in this report, unless otherwise noted. While some advanced biofuel will

be imported, we consider only domestic capacity in our estimates.

This report assesses only active advanced biofuel projects. We do not include projects that have been canceled or otherwise deferred. This is particularly important when comparing reports across years, since projects included in one year may be removed the next.



*Virent’s demonstration-scale facility in Madison, Wisconsin. Virent is testing a variety of feedstocks for conversion to renewable gasoline, diesel, and jet fuel. Photo credit Virent.*

### Main findings and conclusions

Many advanced biofuel technologies have been proven at a demonstration level. Companies now must access significant capital to build commercial scale biorefineries and improve the economics of their production processes.

U.S. and Canadian production capacity expanded again this year, from 490 million gallons (gge) in 2012 to one billion gallons. We identified 159 companies active in the production of advanced biofuels, as well as 93 companies providing products and services to the supply chain.

Regulatory certainty significantly affects access to sufficient capital, as noted in previous market reports. Regulations control the permitting of new pathways, non-compliance fees, and mandated volumes of various fuel types. The instability surrounding renewable fuel policies, including uncertainty about whether they will continue, remains an industry challenge. As some companies plan and build commercial plants, permitting and commissioning challenges have delayed plans for full production. The RFS and LCFS are discussed in more detail in section V.

A number of new strategies have emerged to ease the need for new capital as individual companies find unique approaches to overcoming the challenges of biofuel development. Some companies have secured investments from large oil companies. Others are converting idled petroleum refineries, which significantly reduces the fi-

SCOPE OF REPORT		
Fuel/Pathway Type	E2 Advanced Biofuel	EPA Approved Advanced Biofuel
corn ethanol or butanol		
sugarcane ethanol		✓
biodiesel (non-virgin oil)	✓	✓
biodiesel (virgin oil)		✓
cellulosic ethanol	✓	✓
cellulosic butanol	✓	
drop-ins from non-food sources	✓	✓
new technologies awaiting EPA approval (e.g. algae, planted trees)	✓	

**Table 1.** The scope of E2’s report versus types of fuels EPA has approved as advanced.



financial requirements for developing capacity. Strategic partnerships or co-locating with feedstock producers have helped to solidify the supply chain and bring stability to commercialization plans.

Despite continued regulatory and financial challenges, the advanced biofuel industry has emerged with new production and announcements of major new projects not counted in previous projections. We believe the U.S. and California policy goals are technically achievable, but we are concerned about the availability of sufficient capital investment for scaling up. Even considering these barriers, evidence over the last three years demonstrates steady improvement.

### III. Advanced Biofuel Industry Overview

This report examines liquid transportation fuels that reduce greenhouse gas emissions by 50% or more on a lifecycle basis according to ARB.

#### Methodology

E2 assessed all companies we could identify that are currently working to produce advanced biofuels in the United States and Canada. We captured data on investment, technology, feedstocks, and commercialization plans. We examined all active companies, including financing status and project milestones, and discounted some capacity projections to arrive at our high-end assessment of capacity.

To develop our low-end production capacity numbers, we include projections only from those facility plans that have demonstrated progress toward completion. These projects have significant disclosed details such as financing, location, feedstock partnerships, permitting, and more.



*KiOR's commercial-scale facility produces drop-in gasoline and diesel in Columbus, MS. Began operating in 2013. Photo credit Ken Childress Photography for KiOR.*

#### Active Companies

There are 159 companies working to produce advanced biofuel in the U.S. and Canada. This number remains nearly constant from 2011 and 2012. Some companies have shifted to fuel production from fossil-based natural gas, and a few others have otherwise left the biofuel market (and are therefore outside the scope of our study). Most companies, however, continue to assess ways to enter the advanced biofuel market and scale up production, although they may pursue other revenue streams for short-term growth.

These 159 companies have at least 160 commercial scale projects completed, under construction, or in advanced planning stages. 138 of these facilities are complete. The majority can produce biodiesel from multiple feedstocks; five completed commercial facilities produce ethanol and drop-in fuels. There are 13 demonstration facilities in the U.S. and Canada.

In addition to the companies and projects we have identified that are specifically dedicated to developing second-generation biofuels from renewable feedstocks, we expect technological progress in the first-generation biofuel sector will allow some companies to surpass the 50% reduction threshold and qualify as advanced. Corn ethanol producers such as Pacific Ethanol and Aemetis are exploring methods to reduce the carbon intensity of their process. Other companies, like Gevo, are exploring cellulosic production techniques for butanol. We expect that some of these projects will ultimately achieve advanced status, and may contribute significantly to future capacity estimates. They are not, however, included in our current estimates.

In addition to advanced biofuel production, 93 companies are providing the feedstocks, catalysts, enzymes and technology services to support advanced biofuel production. These companies as tracked by E2 are listed in Appendices E-G.

No significant mergers or acquisitions occurred in the past year for fuel producers, but dozens of partnerships resulted in increased capital and knowledge flow. It is likely there will be greater market consolidation in the coming years. A complete list of all active companies is available in Appendices B and C.

ADVANCED BIOFUEL CAPACITY 2013-2016										
IN MILLIONS OF GALLONS/YEAR										
	# Companies		2013 Capacity		2014 Capacity		2015 Capacity		2016 Capacity	
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Biodiesel	116	134	718.0	753.8	747.0	784.4	829.5	871.0	954.0	1,001.7
Drop-ins	16	33	229.0	229.7	320.6	321.4	382.3	528.7	417.3	622.6
Ethanol	26	28	12.1	12.2	118.2	118.3	162.8	224.9	207.8	531.8
Other (DME, Butanol)	1	3	1.6	1.7	1.6	20.0	20.0	60.0	20.0	140.0
TOTAL (volume)	159	198	960.7	997.4	1,187.4	1,244.0	1,394.7	1,684.6	1,599.2	2,296.1
<b>TOTAL (gge)</b>			<b>1,021.8</b>	<b>1,058.3</b>	<b>1,227.7</b>	<b>1,276.9</b>	<b>1,425.2</b>	<b>1,688.9</b>	<b>1,625.6</b>	<b>2,186.5</b>

**Table 2:** E2's advanced biofuel capacity projections from 2013-2016.

## 2013 Fuel Capacity

This year advanced biofuel production capacity was at 1.0 billion gallons of gasoline equivalent, as summarized in Table 2. Within the 1.0 billion gallons, we show biodiesel production, and not capacity. Full biodiesel capacity is much higher, at about 2.1 billion gallons per year (Appendix C). Total biodiesel production is about 1.6 billion gallons this year and comprises the vast majority of advanced biofuel in the country by EPA standards. Of this total, the non-virgin oil biodiesel production that E2 tracks is at 718 million gallons (volumetric). At a distant second, capacity for drop-in fuels has jumped substantially. We expect 229 million gallons of renewable diesel and gasoline capacity to be online by end of the year, including recent startup at KiOR and Diamond Green's new facilities. These fuels have fewer blend or pipeline restrictions than ethanol or biodiesel.

Cellulosic ethanol progress continues to be slow but steady. The INEOS plant in Florida began production in July, after a few months of mechanical delays. We expect



*Crimson Renewable Energy, LP – Bakersfield Biodiesel and Glycerin Plant. Photo courtesy of Crimson Renewable.*

subsequent cellulosic ethanol plants to require similar commissioning periods before startup. Although not tracked here, Beta Renewables' 20 million gallon cellulosic ethanol facility in Italy began production in June of 2013. Other plants that were originally scheduled for completion this year have been delayed until 2014 or 2015.

## 2015 Fuel Capacity

Our analysis shows that the advanced biofuel industry will have between 1.4 - 1.6 billion gge of capacity by 2015.

Since our first report in 2011, we have been tracking 2015 closely, as this is the first year in which RFS and LCFS targets start to ramp up more aggressively, and advanced biofuel production may reach a point of inflection.<sup>1</sup> As reference, U.S. Energy Information Administration projects 214 billion gallons of total transportation fuel use in 2015,<sup>2</sup> so this would represent approximately a 0.7% replacement. Further, 2015 may be the first year with sufficient advanced biofuel production to allow an accurate assessment of the eventual success of the two programs. Last year E2 projected 2015 capacity at 1.6 - 2.6 billion gallons. Our updated number is just below last year's estimate, primarily due to the delay of some projects and cessation of others. Still, our lowered estimate could provide adequate fuel to meet U.S. fuel standards, as discussed on page nine.

<sup>1</sup> Some define significant as replacing one percent of U.S. fuel demand with advanced biofuel. We will consider market penetration significant when risk capital falls and allows greater capital investment- which will likely be after the first set of biorefineries are in production.

<sup>2</sup> Energy Information Administration. Transportation Sector Key Indicators. Online at: <<http://www.eia.gov/analysis/projection-data.cfm#annualproj>>

## 2016 Fuel Capacity

We assessed 2016 for the first time, as these forward projections are now tangible enough to measure. We counted between 1.6 and 2.1 billion gallons of capacity (gge) scheduled to be built by 2016. The biggest spread in this projection is between the low and high numbers for cellulosic ethanol. Converting cellulose to any fuel type remains a challenge. We are tracking 14 cellulosic ethanol plants, of which 11 are new construction. After the successful launch of this crop of facilities, we anticipate less new construction, and instead the retrofit of existing corn ethanol facilities to accept cellulosic feedstocks. Companies like Sweetwater and Edeniq are providing low-capital ways to add capability at existing ethanol refineries to utilize cellulosic feedstocks like corn stover. Also, POET's Project LIBERTY will be a bolt-on facility to allow cellulose processing at its corn facilities.

Aside from the existing 133 biodiesel facilities, last year we reported 27 commercial facilities and eight demonstration projects that were likely to come online by 2015. There are still 27 facilities of interest, but a few of the previous projects have dropped, and a few new projects were announced. Our low-end list tracks the current 27 commercial and 13 demonstration projects slated for completion by 2016. This complete list is available in Appendix A.

## 2020 Potential

Considering the growth trends in Table 3 between 2011 and 2016, we expect the fastest growth to occur in drop-in fuels, given their expected volumes in 2016 versus cellulosic ethanol. Part of this growth can be attributed to the petroleum industry's preference for drop-ins versus ethanol, since drop-in products are more aligned with petroleum refinement. However, oil companies and the biofuels industry have had a tense relationship over the past decade.<sup>3</sup> Oil companies could become major investors in advanced biofuel, but cultural shifts and reductions in biofuel production costs must occur. As global policy moves towards assigning costs to carbon emissions, the oil industry might have more interest in investing in advanced biofuel production. The greater the cost of carbon emissions, the more appealing advanced biofuels will be. Until these cultural changes occur, political skirmishes and regulatory uncertainty will continue.

ADVANCED BIOFUEL CAPACITY 2011-2016						
IN MILLIONS OF GALLONS/YEAR						
	2011	2012	2013	2014	2015	2016
	Actual		Projected (Low-End)			
Biodiesel	350.0	369.9	718.0	747.0	829.5	954.0
Drop-ins	75.2	88.5	229.0	320.6	382.4	417.4
Ethanol	1.0	3.8	12.1	118.2	162.8	207.8
Other	1.0	1.6	1.6	1.6	20.0	20.0
<b>TOTAL (volume)</b>	<b>427.2</b>	<b>463.8</b>	<b>960.7</b>	<b>1,187.4</b>	<b>1,394.7</b>	<b>1,599.2</b>

**Table 3:** Actual domestic advanced biofuel capacity in 2011 and 2012, and E2's low-end projections for capacity through 2016.

Biodiesel will continue to be the dominant advanced biofuel through this decade, but by 2020 there will be increasing market share from low-carbon corn ethanol facility conversion or drop-in fuels.

After completion, the first new biorefineries can be assessed for both their emissions performances as well as local economic contributions. By 2020 this will help streamline permitting processes in some areas, especially if air quality concerns are alleviated.

Although there are not any announced plans for cellulosic butanol production in the coming years, this could be an attractive alternative for some companies exploring the alcohol-as-fuel market, as butanol may be blended with gasoline up to 16% without modification to vehicles.



Edeniq's Cellunator mill produces sugar from plant materials. Photo credit Edeniq.

<sup>3</sup> Bloomberg New Energy Finance, "Big Oil and Biofuels: Best Frenemies Forever?" July 11, 2013 Research Note.



CAPACITY COMPARISON TO RFS MANDATE					
ETHANOL EQUIVALENCY, MILLIONS OF GALLONS/YEAR					
	2012	2013	2014	2015	2016
<i>E2 Numbers:</i>					
Cellulosic biofuel	25	33	148	488	653
Biomass based diesel (non-virgin oil)	675	1,475	1,657	1,787	2,031
Other Advanced	3	4	34	186	681
<i>Additional volumes from other sources (outside E2 scope):</i>					
Cellulosic biofuel	0	23	23	93	93
Biomass based diesel (virgin oil)	916	1,413	1,580	1,906	2,169
Other (biogas, waste sugar, more)	51	52	53	54	56
Imports	722	736	751	766	781
<b>Total Advanced Capacity</b>	<b>2,391</b>	<b>3,736</b>	<b>4,245</b>	<b>5,278</b>	<b>6,463</b>
<i>RFS Advanced Mandate</i>	<i>2,000</i>	<i>2,750</i>	<i>3,750</i>	<i>5,500</i>	<i>7,250</i>
<b>Cumulative Excess RINs</b>	<b>391</b>	<b>1,378</b>	<b>1,873</b>	<b>1,651</b>	<b>864</b>

**Table 4:** E2 capacity numbers in relation to RFS mandate, in ethanol equivalencies. Non-E2 sources include 2012 RFS emissions trading system data plus growth projections from individual companies, and National Biodiesel Board.

## Meeting U.S. Fuel Standards

Advanced biofuel production is key to compliance with two important policies: the federal Renewable Fuel Standard (RFS) and California's Low Carbon Fuel Standard (LCFS). RFS is a volumetric mandate that requires specific levels of a variety of renewable fuels each year and includes an advanced biofuels mandate. The LCFS is a performance standard that requires a gradual reduction in the carbon intensity of California's fuel mix between 2011 and 2020. We use our domestic capacity projections to assess the industry's potential to meet these standards and discuss the policies themselves in section V. For both standards, it is possible there will be additional capacity beyond projects tracked by E2.



*ZeaChem's demonstration-scale facility in Boardman, OR, processing woodchips for conversion to ethanol. Photo credit ZeaChem Inc.*

## RFS

Adding E2's capacity numbers to other projections, we estimate that RFS is technically achievable through our 2016 projections. This is detailed in Table 4. Of course, since E2 tracks capacity only, actual production volumes and generation of Renewable Identification Number (RIN) credits may fall short of the mandates. In order to operate at full capacity, operating expenses, which depend primarily on feedstock prices, must remain low.

A refiner that has credits above the mandated level may carry them over into the next year. This eases compliance in future years.

Meeting 2020 mandates could prove difficult on the specific timeline currently in the RFS rule, but EPA retains the authority to modify the program and adjust to market realities.

## LCFS

The LCFS is technology-neutral, and may be met through a variety of alternative fuels, including natural gas, electricity, and biofuels. After considering contributions by electric vehicles and natural gas, ICF International recently identified a need for 1.6 billion gallons of biofuel in 2016,<sup>4</sup> which may be met with a combination of the advanced biofuel tracked here, corn ethanol, soybean biodiesel, and imports of renewable diesel. Of the 1.6 - 2.1 billion gallons of nationwide capacity that E2 counts for 2016, ICF estimates that delivering 340 million gallons of advanced biofuel to California is sufficient to generate these excess credits and for the LCFS to succeed. ICF estimates that 1 billion gallons of advanced biofuels will be required to comply with the 2020 requirement.

California will not use all 1.6 - 2.1 billion gallons of advanced biofuel that could be produced nationwide in 2016 for a variety of reasons, including infrastructure, demand in other markets, or costs of delivery. Our estimates indicate that the consumption of a combination of conventional biofuel (including soybean biodiesel and corn ethanol - bolstered by producers seeking to lower their carbon intensity through technology improvements) and imports of low carbon biofuel could generate excess credits in the LCFS market through 2016.

<sup>4</sup> ICF International. "California's Low Carbon Fuel Standard: Compliance Outlook for 2010." 2013. Scenarios 1 and 2. <<http://www.caletc.com/wp-content/downloads/LCFSReportJune.pdf>>

## Operating costs

In addition to intensive capital costs for facility construction, a critical step on the path to commercialization for advanced biofuels is achieving low and competitive operating costs.

Operating costs include feedstock costs and are related to productivity per unit of feedstock. The importance of feedstock costs was shown by the effects of the summer 2012 drought. Because the drought made corn prices too high for operating margins, some corn ethanol facilities were idled in spring 2013.<sup>5</sup> Novozymes, an enzyme developer, reports that the costs of cellulosic ethanol production per gallon have decreased approximately 50% since 2007, from \$4-\$8 to \$2-\$3.50, in part because of advances in enzyme and catalyst technology.<sup>6</sup> Bloomberg New Energy Finance reports an eight percent increase in yields for cellulosic ethanol from 2008-2012, and expects this trend to continue.<sup>7</sup>

These figures vary from company to company, and across fuel type. Joule Technologies reported operating



*Solazyme's integrated biorefinery in Peoria, IL has produced renewable oils since June 2012. Photo credit Solazyme, Inc.*

costs of \$1/gallon to produce cellulosic ethanol or renewable diesel.<sup>8</sup> A 2012 University of Illinois study estimated operating costs as ranging from \$0.52 - \$4.02/gallon, depending on plant size, conversion process, and feedstock type.<sup>9</sup> Algae producers face relatively low capital costs but continue to research methods to lower operating costs.

While many companies still face higher operating costs, the overall trend is moving downward. Bloomberg estimates the minimum price at which cellulosic ethanol could be sold profitably as \$3.65/gallon and declining to \$2.54/gallon by 2016.<sup>10</sup> Some companies are within reach of these figures.

## Jobs

Currently, advanced biofuel companies are self-reporting approximately 4,500 direct, full-time jobs in the United States. Companies expect this number will grow to about 8,000 employees with 2016 production and expansion plans. This number does not incorporate jobs within the supply chain. Jobs derived from the feedstock production portion of the supply chain are generally considered the largest employment driver in biofuel production. Feedstock production alone could employ 12,300 people by 2016, totaling **20,300 direct jobs by 2016**. Construction of new facilities could create an additional 33,000 temporary jobs.<sup>11</sup> Our job figures also do not consider the significant research personnel at academic institutions across the country and additional value chain-related companies.

5 The Gazette, "Corn Shortage Continues to Idle Ethanol Plants", February 11, 2013. <http://thegazette.com/2013/02/11/corn-shortage-continues-to-idle-ethanol-plants/>

6 Nielsen, Peder Holk. "The Path to Commercialization of Cellulosic Ethanol – A Brighter Future." PowerPoint Presentation. Conference Call. February 22, 2012. [http://www.novozymes.com/en/investor/events-presentations/Documents/Cellic3\\_conf\\_call\\_220212.pdf](http://www.novozymes.com/en/investor/events-presentations/Documents/Cellic3_conf_call_220212.pdf).

7 Bloomberg New Energy Finance. "Cellulosic Ethanol Costs: Surveying an Industry." March 18, 2013. <http://about.bnef.com/press-releases/cellulosic-ethanol-heads-for-cost-competitiveness-by-2016/>

8 Advanced Biofuel Leadership Conference 2013 presentation by Joule CEO Bill Sims.

9 Yudken, Joel S. "The Economic Benefits of Military Biofuels." Prepared for E2 November 2012. Analysis of Chen, Xiaoguang, Madhu Khanna, and Sonia Yeh "Stimulating Learning-by-Doing in Advanced Biofuels: Effectiveness of Alternative Policies." 2012. <http://www.e2.org/ext/doc/HRS-E2MilitaryBiofuelsReporNov2012.pdf>

10 Bloomberg New Energy Finance. "Cellulosic Ethanol Costs: Surveying an Industry." March 18, 2013. <http://about.bnef.com/press-releases/cellulosic-ethanol-heads-for-cost-competitiveness-by-2016/>

11 Yudken, Joel S. "The Economic Benefits of Military Biofuels." Prepared for E2 November 2012. <http://www.e2.org/ext/doc/HRS-E2MilitaryBiofuelsReporNov2012.pdf>

## International markets

Global advanced biofuel development and production continues at a strong pace. Several European companies are producing cellulosic ethanol and renewable jet fuel at commercial scale. In Brazil, conventional sugarcane ethanol production continues to expand, both for domestic consumption and global export.<sup>12</sup> Producers are also working towards reducing the fuel's carbon intensity. In 2012, Brazil exported 540 million gallons of sugarcane ethanol to the United States, which continues the increasing trend since 2009.<sup>13</sup>



*Neste Oil's NEXBTL plant in Rotterdam. Photo Credit Neste Oil.*

International development of advanced biofuels can have positive impacts for the United States in a number of ways. If we imagine a global advanced biofuel industry, then international companies with interest in the U.S. may be likely import partners for advanced fuels. One example is Neste Oil, which recently entered into an off-take agreement for drop-in renewable diesel with Celana, an algae producer in California. Other companies like Ensyn have an established international presence, and are looking for entry into the U.S. market through partnerships and new facilities, such as the Envergent project in Hawaii.

There is also likely to be capital flow and knowledge transfer from domestic companies operating internationally or international companies establishing operations in the U.S. A number of domestic companies have established joint ventures with international companies to develop technology and establish facilities. Solena Fuels is a U.S.-based company that is constructing a biorefinery for advanced jet fuel in the United Kingdom, in partnership with British Airways. Both Solazyme and Amyris,

based in California, have established Brazilian operations and partnerships which have allowed them to access favorable debt financing from Brazilian Development Bank. Also headquartered in Brazil, GranBio's partnerships with American Process and Beta Renewables will increase knowledge flow among at least three countries.

Companies producing and selling advanced biofuels abroad demonstrate the viability of technologies in markets with further developed infrastructure or regulation. Inbicon sells cellulosic ethanol in Danish markets, and is developing projects around the globe.

E2 compiled a list of 24 companies working internationally on advanced biofuel projects of particular interest to the U.S. This does not reflect the full scale or capacity of the global market, but should be understood as a survey of international activity that could be imported to the United States or technologies that may be licensed domestically. See Appendix D for a list of these companies.



*Fuel storage facility in Stockholm, Sweden.*

12 Bloomberg New Energy Finance. "US Biofuels in 2013: Stories to Watch." Bioenergy White Paper, February 2013.

13 United States International Trade Commission data, compiled and analyzed by DATAGRO. Presented to the California Energy Commission July 31, 2013. <[http://www.energy.ca.gov/2013\\_energy/policy/documents/2013-07-31\\_workshop/presentations/04\\_Nastari\\_Datagro.pdf](http://www.energy.ca.gov/2013_energy/policy/documents/2013-07-31_workshop/presentations/04_Nastari_Datagro.pdf)>

## IV. Financing

Financing is key to any business strategy, and advanced biofuel developers face steep capital requirements and require continued R&D investments. New facilities can range anywhere from \$100 million-\$300 million,<sup>14</sup> with relatively high risk profiles since most technologies have not been used at a commercial level. Each company is addressing its capital needs in a unique manner, but most have some combination of private equity and debt, government funding, partnerships, and capital from publicly traded markets.

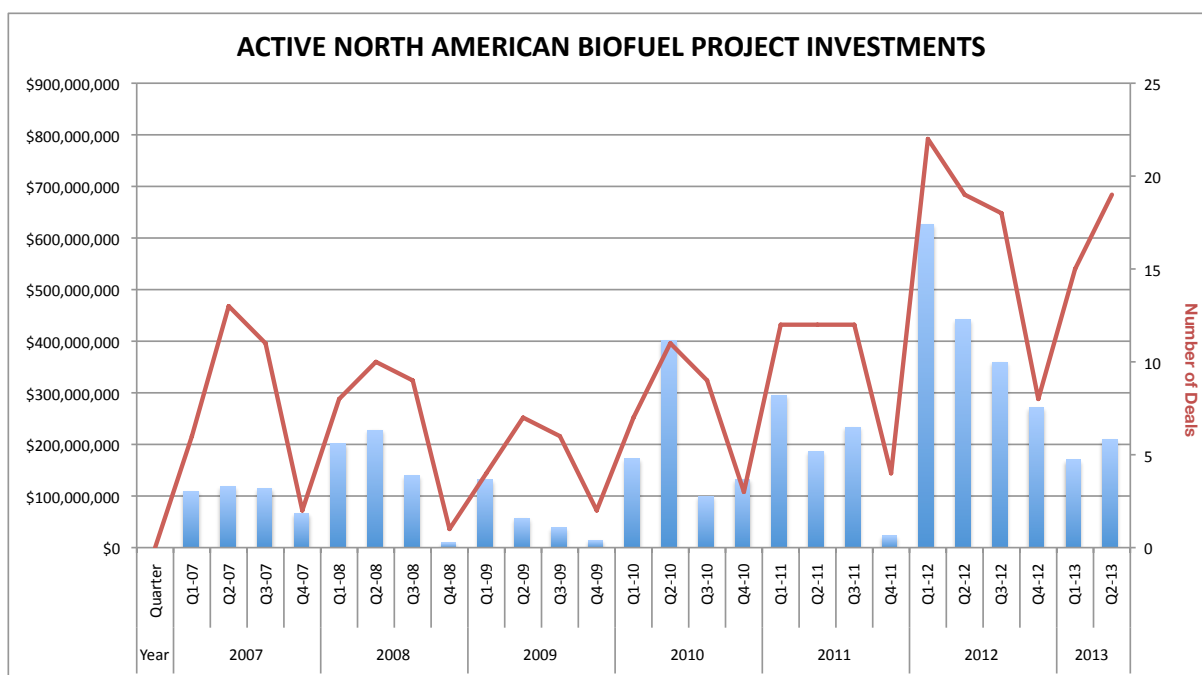
### Private equity investment

Cleantech Group has tracked \$4.85 billion of private investments into active biofuel-related projects in North America since 2007, as shown in Figure 1. Of this \$4.85 billion, \$3 billion was invested into biofuel producers, as shown in Figure 2, with the remaining \$1.45 billion invested into companies along the value chain. Investments into companies along the biofuel value chain are important to help drive down costs and provide the necessary scale of inputs.

We reported \$3.4 billion in total private investments last year. It is noteworthy that E2 tracks only active low-carbon projects, so some previously reported investments may have been divested and now fall outside this scope. New investments since the publication of our last report (between August 2012 and August 2013) total \$1.45 billion.

### Initial public offerings

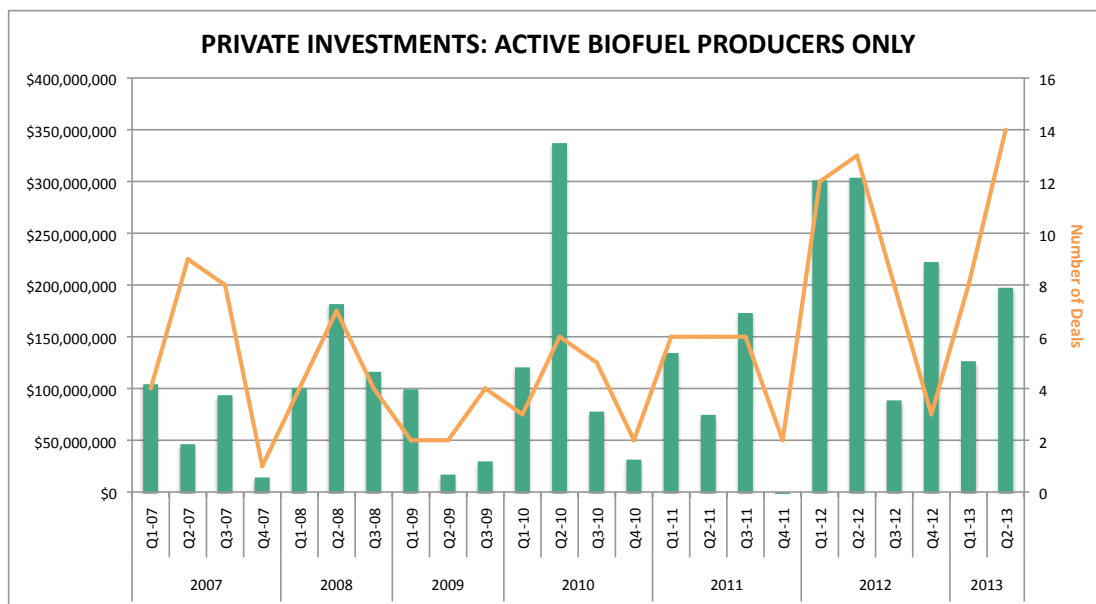
Capital intense markets like fuel production have driven many companies to look to public markets as large sources of potential funding. There have been seven initial public offerings (IPOs) in the last several years, with Ceres and Renewable Energy Group (REG) going public since last year's report. BioAmber, a related bio-chemical company, has also submitted an S-1 this year. As expected, all public companies except for REG are currently operating at a loss. For this reason, there is limited demand for new biofuel entrants into the public markets and some companies delayed their IPOs in 2011 and 2012.



**Figure 1:** Investments into both advanced biofuel producers and value chain counterparts since 2007. Data provided by [Cleantech Group](#).

14 E2 2012 Advanced Biofuel Market Report. Appendix B. <<http://www.e2.org/ext/doc/E2AdvancedBiofuelMarketReport2012.pdf>>





**Figure 2:** Investments into advanced biofuel producers in North America since 2007.  
Data provided by [Cleantech Group](#).

## Public funding

In support of federal mandates to blend biofuels, several federal agencies have programs to support the development of advanced biofuel capacity. As summarized in Appendix H, E2 has counted over \$600 million in active federal grants to advanced biofuel projects since 2008. The U.S. Department of Energy (DOE) primarily provides these grants, but there is also funding from the U.S. Department of Agriculture (USDA), the Department of Defense (DoD), and the Federal Aviation Administration. In addition to grants, the USDA and others have issued \$940 million in loan guarantees. Some states, like Mississippi, Colorado, and Florida, provide grants for in-state production activities. These states offer a variety of incentive packages to biofuel companies for locating inside their boundaries.

### Department of Defense

DoD technology development has a precedent of supporting innovations that eventually help civilians, including the internet, the Global Positioning System, semiconductors, and more. As part of its national security strategy, DoD is actively pursuing energy efficiency and clean energy initiatives. The Navy leads the clean fuel

initiatives, with a goal to replace half its consumption of petroleum fuels with alternatives by 2020. This is backed by a joint agreement from the Navy, DOE, and USDA to provide \$510 million over a three-year period for the development of advanced biofuels.

In November 2012, the U.S. Senate supported the DoD initiatives by voting 62-37 against a proposal in the National Defense Authorization Act that would have prevented the military from buying advanced biofuel to meet its energy needs. With the successive authorization of the defense budget, the DoD was able to announce \$16 million in contracts to three advanced biofuel projects in May 2013.<sup>15</sup>

### United States Department of Agriculture

The USDA provides significant assistance for biofuel production across the value chain, from research and development to feedstock cultivation and biofuel production.<sup>16</sup> The 2013 Farm Bill and specific funding amounts may be authorized by October 1st. The Farm Bill could provide five-year authorization of the following programs, in addition to several smaller and more focused areas:

<sup>15</sup> Bloomberg. "Pentagon Awards Biofuel Contracts in Obama Renewable Energy Push." May 24, 2013. <<http://www.bloomberg.com/news/2013-05-24/pentagon-awards-biofuel-contracts-in-obama-renewable-energy-push.html>>

<sup>16</sup> Yacobucci, Brent D. "Biofuels Incentives: A Summary of Federal Programs." January 11, 2012. Congressional Research Service. <<http://www.fas.org/spp/crs/misc/R40110.pdf>>

- [Biorefinery Assistance Program](#) - Rural Development program provides loan guarantees for development, construction, and retrofitting of commercial-scale biorefineries.
- [Biomass Crop Assistance Program](#) - provides financial assistance to owners and operators of agricultural and forest land to produce biomass feedstocks.
- [Rural Energy for America Program \(REAP\)](#) - provides loans and grants to agricultural producers and rural small businesses to purchase, install, and construct renewable energy systems.
- [Repowering Assistance Program](#) - payments to biorefineries to replace fossil fuels to operate biorefineries with renewable biomass.
- [Feedstock Flexibility Program for Producers](#) - allows the use of Commodity Credit Corporation funds to purchase and re-sell surplus sugar as biomass feedstock.
- [Bioenergy Program for Advanced Biofuels](#) - payments to producers to support and expand production of advanced biofuels.
- [Biomass Research and Development](#) - (joint with DOE) grants for feedstock development, bio-based product development, and development analysis.
- [Plant Feedstock Genomics for Bioenergy](#) - (joint with DOE) funding for projects that accelerate plant breeding programs and improve biomass feedstocks.

E2 and Cleantech Group have tracked over \$783 million in loan guarantees and grants provided by the USDA alone since 2008.

#### Department of Energy

In addition to the programs run jointly by USDA and DOE, the DOE supports [Integrated Biorefinery Projects \(IBR\)](#) and [bioenergy research centers](#). Many other specific funding opportunities are available under the Energy Efficiency and Renewable Energy office on biomass research and development. E2 and Cleantech Group have tracked \$671 million in active DOE loan guarantees and grants, primarily under the IBR program.

#### State funding/tax incentives

As detailed in the 2012 market report, there are a variety of different tax incentives and programs to encourage biofuel facilities, jobs, and related economic activity inside particular states. Variation in state-level incentives can prove to be a decisive factor when companies choose where to locate. For example, this summer Cool Planet publicly announced it will move its headquarters to Colorado from California owing to tax incentive that will save them \$3M, provided they create 393 new jobs in the coming years.



*Cool Planet's pilot plant in Camarillo, CA. The first biorefineries will be built in Louisiana using woody biomass. Photo courtesy of Cool Planet Energy.*

#### **Strategic partnerships**

Many companies have developed strategic partnerships to better access new capital, receive specialized technology or licenses, gain entry to infrastructure, or agree to purchase products.

One strategy for securing new venture capital is to develop partnerships with large interested parties, such as oil companies or fuel purchasers. Sapphire Energy has secured Tesoro, a fuel refiner, as a customer for its algae-based crude oil.<sup>17</sup> In an effort to explore alternative energy solutions, large oil and gas companies have invested in some advanced biofuel companies. One example is Diamond Green, which is a joint project of Darling International and Valero.

Another strategy is partnering with companies that may wish to provide exclusive use of waste feedstock. Dynamic Fuels, funded as a joint venture of Tyson Foods and Syntroleum, uses waste fats from Tyson and delivers fuel to Syntroleum. Other companies, like AltAir, are leveraging purchase agreements from companies like United to receive better debt financing. AltAir will convert an idled petroleum refinery in Los Angeles to produce renewable jet fuel and diesel.

<sup>17</sup> Survey data provided to E2 by Sapphire Energy, June 2013.

Some companies may partner with automotive manufacturers for research, testing, and investments. Companies like Oberon and Joule have partnered with Volvo Group and Audi. Such partnerships also pave the way to fuel certification and vehicle compatibility.

Dozens of additional partnerships are listed in Appendix A. Details of each partnership are typically listed on bio-fuel companies' websites.



*Sapphire Energy's Half Acre Algae Pond at its research facility in Las Cruces, NM. Photo courtesy of Sapphire Energy.*

## V. Industry Growth Factors and Barriers

Several factors drive demand for advanced biofuels. These can be divided into two large categories: policy-driven and customer demand.

### Policy-driven Demand

#### RFS

##### Policy overview

Congress established the Renewable Fuel Standard as part of the Energy Policy Act in 2005. Expanded in 2007, the Renewable Fuel Standard (RFS) is a federal renewable fuel volume mandate. There are four nested categories with specific volume and carbon intensity requirements: total renewable fuels, advanced biofuels, cellulosic, and biomass-based biodiesel. The advanced and biodiesel categories require a 50% greenhouse gas reduction, relative to a 2005 petroleum baseline, while cellulosic biofuels must achieve a 60% reduction in carbon intensity. Remaining renewable fuels (primarily corn ethanol) must have at least a 20% greenhouse gas reduction, although much of the current volume was grandfathered

from this requirement. Volumes above the mandate in any of the other three categories count towards the total renewable fuel mandate, which means excess capacities of low-carbon fuels reduce the demand for the higher-carbon fuels. The total renewable fuel mandate is 36 billion gallons of ethanol equivalent by 2022, but EPA has the authority to adjust this mandate as needed. Such adjustments may alleviate reliance on conventional biofuels, but still provide the market signal needed for advanced biofuels to scale.

RFS is the most important biofuel policy in the nation, and is a significant driver of biofuel development. However, the policy has been fraught with contention over the past year. Markets for RINs, the tracking numbers for biofuels that allows fuel producers to comply with RFS, have been highly volatile, particularly for corn ethanol RINs.<sup>18</sup> One explanation of this market volatility involves the 10% ethanol “blend wall” that limits the percentage of ethanol that can be blended into the fuel mix, unless there is greater acceptance of and access to higher ethanol blends.<sup>19</sup> In anticipation of upcoming RFS volumetric mandates exceeding the blend wall, the EPA has indicated they may adjust some 2014 mandates.<sup>20</sup> As the EPA, markets, and analysts sort out the causes of the RIN volatility, program adjustments can help ease RIN price fluctuations.

The flexibility of the RFS helps the program react to market realities. For example, in the 2013 final rule, EPA provided refiners with an additional four months to comply with the 2013 mandate. The RFS mandate in 2022 can also be adjusted, and will range between 20 billion gallons of conventional and advanced biofuel, plus cellulosic production, with a maximum of 36 billion gallons. Although advanced biofuels are scaling more slowly than the standard originally conceived, the program greatly helps drive the steady progress of the industry.

##### Technology Development

The EPA can also adjust RFS to integrate industry developments into the program. The EPA continuously evaluates new technologies and feedstock types for qualification under RFS. In 2013, the EPA approved a number of

18 Irwin, S. and Good, D. University of Illinois, Farm Doc Daily. July 19 2013. <<http://farmdocdaily.illinois.edu/2013/07/rins-gone-wild.html>>

19 Department of Agricultural and Consumer Economics, University of Illinois Urbana-Campaign. Farmdoc Daily. “Is Speculation Driving Up the Price of RINs?” April 24, 2013. <<http://farmdocdaily.illinois.edu/2013/04/speculation-driving-up-price-rins.html>>

20 U.S. EPA 2013 RFS Final Rule. Available at: <<http://www.gpo.gov/fdsys/pkg/FR-2013-08-15/pdf/2013-19557.pdf>>

new pathways, including the use of camelina oil as a feedstock for biodiesel and renewable diesel.

## LCFS

California's Low Carbon Fuel Standard, the first of its kind, is a state centralized performance standard mandating a 10% reduction in the carbon intensity of California's fuel mix by 2020. Established in 2007 as an Executive Order in support of California's climate change reduction goals, the standard phases in gradual reductions in fuel carbon intensity from 2011-2020. The transportation sector contributes over 40% of the state's greenhouse gas emissions, making cleaner fuel and vehicles a critical component of overall emissions reductions goals.

A number of mechanisms will work together to achieve the LCFS, including advanced vehicle technology, energy efficiency gains, and low-carbon fuels. Advanced biofuels, depending on the feedstock and technology used, are often more than 75% less carbon intensive than gasoline. The LCFS rewards incremental improvements to carbon intensity, as opposed to the RFS, which provides no additional benefit for exceeding the minimum required reduction. As California moves towards its future LCFS goals, more gallons of advanced biofuels will be needed to reduce the overall carbon intensity of the state's fuel mix, in addition to lowered carbon scores of traditional biofuels.

In response to litigation from interest groups, court decisions issued in the first half of 2013 have generally upheld the LCFS. However, these challenges have resulted in some delays in implementation of parts of the LCFS, including a recent delay of the increased 2014 target. The LCFS will remain at the one percent reduction level (the 2013 target) through 2014. Despite the marketplace uncertainty caused by such changes, the LCFS has delivered a fuel mix with lower carbon intensity. In 2012, Cali-



*A field of young pongamia trees in southern Florida, which will produce an oil feedstock. Photo courtesy of TerViva*

fornia displaced 1.06 billion gallons of traditional fuels with lower-carbon fuels, thus lowering the carbon intensity of the overall fuel mix.<sup>21</sup> The policy is providing reduced greenhouse gas emissions from the transportation sector, and overall is working as intended.



*NexSteppe's Palo Alto High Biomass Sorghum. Photo courtesy of Anna Rath at NexSteppe.*

## Customer-driven Demand

### Military

As mentioned previously, the Department of Defense has made renewable fuels a component of its national security strategy, as fuel made from domestic biomass sources provides greater fuel security than dependence on crude oil. Not only has DoD invested heavily in advanced biofuel projects, but the military is the nation's single largest consumer of fuels. The military is positioned as one of the largest purchasers of the finished products. Using a grant from the Federal Aviation Administration, Virent recently delivered 100 gallons of renewable jet fuel to the Air Force for testing. A national security interest combined with significant fuel usage makes the military's biofuel demand an important market signal for biofuel project developers.

### Aviation

Worldwide, environmental concerns and the rising cost of fossil fuels have spurred numerous airline companies to invest in or sign off-take agreements with renewable jet fuel projects. One example is Virgin Airlines' partnership with Lanzatech to produce renewable jet fuel in India and China. Other airlines, including United Airlines, Lufthansa, British Airways, Qantas, and others have partnerships with various advanced biofuel companies. Governmental and industry investment in renewable jet fuels is quickening the pace of commercialization.

21 Yeh, Sonia, Julie Witcover, Jeff Kessler. UC Davis Institute of Transportation Studies. "Status Review of California Low Carbon Fuel Standard." Revised Spring 2013. <[http://www.its.ucdavis.edu/?page\\_id=10063&pub\\_id=1861](http://www.its.ucdavis.edu/?page_id=10063&pub_id=1861)>



## Competition

As crude oil has increased in total cost as well as price volatility, the market for alternative fuels has become more viable. Business plans from advanced biofuel producers generally assume the ability to compete directly with crude oil based on price, quality, and availability.

## Barriers to Advanced Biofuel Development

### Feedstock availability and cost

Finding or cultivating sufficient available feedstock drives decisions on facility locations. At \$50-80/ton of biomass, feedstocks comprise a significant portion of advanced biofuel operating costs. One of the greatest challenges to the industry is securing feedstock, as well as keeping feedstock costs low. Feedstock is often not aggregated or is expensive to transport. To overcome some of these challenges, companies may attempt to co-locate facilities near sources of biomass, such as the KiOR model to locate near shuttered paper mills or INEOS' co-locating with a municipal solid waste facility. The feedstock companies listed in Appendix E are all working to provide higher yields at lower costs.

### Risk capital

As with many markets, regulatory uncertainty can create obstacles to accessing capital. Large-scale biorefineries are expensive to construct and require significant investments and lead time. Delays in pathway approval deter venture capital in new projects. Volatility in RIN pricing and compliance fees for RFS create instability in the market and increase the risk profiles of potential biofuel projects. Uncertainty about the program as a whole, partly because of political opposition, impacts investment into biorefineries and makes off-take agreements more difficult to acquire.



*Photo credit: Sapphire Energy*

Without regulatory certainty, new and expensive technologies may appear too high-risk and investors could choose to invest elsewhere. Without increased capital investment, projects will not achieve the level of commercial production required.

## VI. Conclusions

Our analysis reveals slow and steady growth for the advanced biofuel industry. Although some projects have been divested since last year's report, numerous other companies have emerged and several facilities have begun producing. As predicted in previous market reports, growth in cellulosic ethanol continues at a slower pace, while drop-in capacity is increasing. There is significant potential in the conversion of existing corn ethanol facilities to produce cellulosic ethanol, as well as increased deployment of modular technologies to reduce carbon intensities at active ethanol plants.

Capital availability remains the greatest challenge to the commercialization of advanced biofuel projects. Several technologies have been proven at a demonstration level; the next step is scaling up. New facilities require significant financial investment, which to date has not been available at necessary levels. Public funding continues to play a crucial role in industry development.

Feedstock availability and pricing are critical to the location and operating margins of a biorefinery. Significant research and development effort is focused on finding means of providing low cost feedstocks. Locating near waste feedstock streams provides long-term supply opportunities at lower costs.

Regulatory uncertainty makes investors hesitant to inject significant capital into the industry, further impeding commercialization prospects. Stability in regulation will provide stability in the industry and is necessary for continued growth.

Despite the uncertainty and challenges, advanced biofuels are meeting challenges through unique financing and commercialization plans. Advanced biofuels continue to scale, and provide significant economic and environmental opportunities to replace our fossil fuels with renewable alternatives.



In addition to the dozens of advanced biofuel companies who provided data on their businesses and perspectives, the report authors would like to acknowledge the following friends and colleagues for their time & contributions:

- Judith Albert, *E2 Staff*
- Tony Bernhardt, *E2 Member*
- Dallas Burkholder, *US Environmental Protection Agency*
- Erik Chen, *E2 Staff*
- Sheeraz Haji, *Cleantech Group*
- Jim Lane, *Biofuels Digest*
- Christine Luong, *E2 Staff*
- Jeremy Martin, *Union of Concerned Scientists*
- Michael McAdams, *Advanced Biofuels Association*
- Simon Mui, *NRDC*
- Shelby Neal, *National Biodiesel Board*
- Kinhead Reiling, *E2 Member*
- Philip Sheehy, *ICF International*
- Brian Siu, *NRDC*
- Ryan Townsend, *Presidio Graduate School*
- Sonia Yeh, *UC Davis Institute of Transportation Studies*
- Leo Zhang, *Cleantech Group*
- Paul Zorner, *Pegasus Capital Advisors and E2 Member*

## Appendix A: Facilities Coming Online by 2016 (Low-End)

Company	Facility Type	Facility Location	Fuel Type	RFS Category	Expected Online	2013 Capacity MGPY	2014 Capacity MGPY	2015 Capacity MGPY	2016 Capacity MGPY	Feedstock	Partnerships	Notes
Abengoa	commercial	Hugoton, KS	Cellulosic Ethanol	Cellulosic	2014	0	25	25	25	cellulose	Dyadic license for enzyme technology	Will harvest and collect biomass; pays farmers \$15/dry ton if Abengoa harvests
Ace Ethanol (Sweetwater)	commercial	Stanley, WI	Cellulosic Ethanol	Cellulosic	2015	0	0	3.6	3.6	cellulose	Sweetwater Energy	7% of feedstock to come from Sweetwater's cellulosic sugars
Algenol	pilot	Fort Myers, FL	Cellulosic Ethanol	Other	2012	0.1	0.1	0.1	0.1	algae	Valero, the Linde Group, Biofields, Honeywell, NREL	
AltAir Fuels	commercial	Los Angeles, CA	Renewable Jet fuel, diesel	Cellulosic diesel	2014	0	5	15	30	camelina	United	
American Process	demo	Thomaston, GA	Cellulosic Ethanol	Cellulosic	2013	0.3	0.3	0.3	0.3	cellulose		
American Process	commercial	Alpena, MI	Cellulosic Ethanol then butanol	Cellulosic	2012	0.89	0.89	0.89	0.89	woody biomass	Cobalt, GranBio	from EPA. Actual 2012 production predicted at .5 MGPY by EPA.
Beta Renewables	commercial	Sampson County, NC	Cellulosic Ethanol	Cellulosic	2014		20	20	20	miscanthus and switchgrass	Chemtex, Biofuels Center NC, Novozymes	JV of Chemtex and Gruppo Mossi & Ghisolfi; prototype in Italy.
Cool Planet	commercial	Alexandria, LA	Renewable Gasoline	Cellulosic	2015	0	0	2	2	Cellulose (wood biomass)	BP and ConocoPhillips	Announced first three modular facility plans for Louisiana.
Diamond Green	commercial	Norco, Louisiana	Renewable Diesel	Biomass based diesel	2013	140	140	140	140	animal fat, used cooking oil	Uses UOP oil. JV of Valero and Darling.	
DuPont Cellulosic Ethanol	pilot	Vonore, TN	Cellulosic Ethanol	Cellulosic	2010	0.25	0.25	0.25	0.25	lignocellulosics, corn stover, switchgrass		
DuPont Cellulosic Ethanol	commercial	Nevada, Iowa	Cellulosic Ethanol	Cellulosic	2014	0	27.5	27.5	27.5	lignocellulosics, corn stover, switchgrass		
Dynamic Fuels	commercial	Geismar, LA	Renewable Diesel	Biomass based diesel	2010	75	75	75	75	animal fat, used cooking oil	JV Syntroleum Corp and Tyson	Facility idle since Oct 2012.
Edeniq & Logos Tech	demo	Visalia, CA	Cellulosic Ethanol	Cellulosic	2012	0.05	0.05	0.05	0.05	corn stover, bagasse		Logos Tech, Novozymes, Ceres, NexSteppe, USDA and UC Davis
Emerald Biofuels	commercial	Plaquemine, LA	Renewable Diesel	Biomass based diesel	2014	0	85	85	85	waste fats and oils	Dow, Honeywell	
Enerkem	demo	Westbury, Quebec	Cellulosic Ethanol and methanol	Cellulosic	operating	1.3	1.3	1.3	1.3	MSW		
Enerkem	commercial	Edmonton, Alberta	Cellulosic Ethanol and methanol	Cellulosic	2014	0	10	10	10	MSW		

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Company	Facility Type	Facility Location	Fuel Type	RFS Category	Expected Online	2013 Capacity MGPY	2014 Capacity MGPY	2015 Capacity MGPY	2016 Capacity MGPY	Feedstock	Partnerships	Notes
Enerkem	commercial	Pontotoc, MS	Cellulosic Ethanol and methanol	Cellulosic	2014	0	0	10	10	MSW		
Envergent (Honeywell/UOP & Ensyn)	demo	Kapolei, HI	Crude oil into renewable diesel and aviation fuel	Cellulosic	2014	0	0.1	0.1	0.1	Ag waste, pulp, paper, wood, energy crops and algae		
Fiberight	commercial	Blairtown, IA	Cellulosic Ethanol	Cellulosic	2015	0	0	6	6	MSW		
Front Range Energy (Sweetwater)	commercial	Windsor, CO	Cellulosic Ethanol	Cellulosic	2014	0	3.6	3.6	3.6	woody biomass	Sweetwater Energy	7% of feedstock to come from Sweetwater's cellulosic sugars
Fulcrum Bioenergy	commercial	Reno, NV	Jet fuel, diesel, ethanol	Other	2015	0	0	10	10	MSW		Secured facility financing Nov 2012
Haldor Topsoe	demo	Des Plaines, IL	Renewable gasoline	Cellulosic diesel	operating	0.34	0.34	0	0	wood waste		
ICM	demo	St. Joseph, MO	Cellulosic ethanol	Cellulosic	operating	0.245	0.245	0.245	0.245	corn fiber, switchgrass, energy sorghum	Abengoa	
INEOS Bio	commercial	Vero Beach, FL	Cellulosic Ethanol	Cellulosic	2013	8	8	8	8	MSW, ag residue		Began production in July 2013.
Iogen	demo	Ottawa, Ontario	Cellulosic Ethanol	Cellulosic	operating (since 2004)	0.48	0.48	0.48	0.48	Stover		
Joule	demo	Hobbs, NM	Ethanol	Cellulosic	2012					CO2 and sunlight	Audi	25,000 gallons of ethanol and 15,000 gallons of diesel per acre at commercial scale
KiOR	commercial	Columbus, MS	Renewable Diesel and Gasoline	Cellulosic	operating	13	13	13	13	pre-commercial thinnings	Weyerhaeuser	
KiOR	commercial	Natchez, MS	Renewable Diesel and Gasoline	Cellulosic	2015	0	0	40	40	pre-commercial thinnings		
LanzaTech	commercial	Soperton GA	Cellulosic Ethanol	Cellulosic	2015	0	0	20	20	Miscanthus, Georgia pine	Virgin Airlines, Siemens	125 tons per day infrastructure in place
LS9	demo	Okeechobee, FL	Renewable Diesel	Other	operating, 2012	0.075	0.075	0.075	0.075	Sugar		
Mascoma	pilot	Rome, NY	Cellulosic Ethanol	Cellulosic	operating	0.2	0.2	0.2	0.2	wood and switchgrass		
Mascoma-Valero	commercial	Kinross, Michigan	Cellulosic Ethanol	Cellulosic	2016	0	0	0	20	Hardwood pulpwood	Lallemand, Pacific Ethanol	Option to expand to 80 MGPY. \$1.77 cost per gallon, cited in S-1



## Appendix A: Facilities Coming Online by 2016 (Low-End)

Company	Facility Type	Facility Location	Fuel Type	RFS Category	Expected Online	2013 Capacity MGPY	2014 Capacity MGPY	2015 Capacity MGPY	2016 Capacity MGPY	Feedstock	Partnerships	Notes
Oberon	commercial	Imperial Valley, CA	Other - DME	Other	2013	1.64	1.64	20	20	Methanol (only temp for Phase 1 of Imperial Valley plant), natural gas	Volvo	Diesel replacement for heavy duty vehicles. Volvo Group launching DME fleet.
POET	demo	Scotland, SD	Cellulosic Ethanol	Cellulosic	2009	0.02	0.02	0.02	0.02	Corn stover		
POET- DSM	commercial	Emmetsburg, IA	Cellulosic Ethanol	Cellulosic	2014	0	20	25	25	Corn stover		
Sapphire Energy	commercial	Columbus, NM	crude oil	Other	2014	0.02	1.5	1.5	1.5	algae	Linde, Tesoro as customer	100 barrels of crude oil which may be refined into any fuel
Solazyme	commercial	Clinton IA	multiple fuels - renewable	Other	2013	0	0	0.13	0.13	Plant sugars		20,000 metric tons. Oils used for multiple markets
Solazyme	commercial	Peoria IL	Renewable oils	Other	2013	0.53	0.53	0.53	0.53	Plant sugars		1,820 metric tons
Virent	demo	Madison, WI	renewable gasoline	Cellulosic diesel	operating	0.01	0.01	0.01	0.01	beet sugar		Shell and HCL Cleantech, Scuderia Ferrari
Virent	commercial	TBD	multiple fuels - renewable	Cellulosic diesel	2016	0	0	0	20			
Woodland Biofuels	demo	Sarnia, Ontario	Cellulosic Ethanol	Cellulosic	2013	0.02	0.02	0.02	0.02	wood waste		
ZeaChem	demo	Boardman, OR	Cellulosic Ethanol	Cellulosic	operating	0.25	0.25	0.25	0.25	planted trees and wheatstraw		
ZeaChem	commercial	Boardman, OR	Cellulosic Ethanol	Cellulosic	2016	0	0	0	25	planted trees and wheatstraw		
<b>43 Facilities</b>					<b>TOTAL</b>	<b>242.725</b>	<b>440.405</b>	<b>565.15</b>	<b>645.15</b>			

Summary of Appendix A Data (volume)							
	2011	2012	2013	2014	2015	2016	Count
<b>Ethanol</b>	1.00	3.79	12.11	118.21	162.81	207.81	26
<b>Drop-in</b>	75.24	88.45	228.98	320.56	382.35	417.35	16
<b>Other</b>	1.00	1.64	1.64	1.64	20	20.00	1
<b>Biodiesel (Appendix C)</b>	350.00	369.92	717.95	747.00	829.50	954.00	116
<b>TOTAL</b>	<b>427.20</b>	<b>463.80</b>	<b>960.68</b>	<b>1,187.41</b>	<b>1,394.65</b>	<b>1,599.15</b>	<b>159</b>

## Appendix B: Active Advanced Biofuel Companies (High-End)

Company	Plant Location	Finished Product	RFS Category	Anticipated 2013 Capacity MGPY	Anticipated 2016 Capacity MGPY	Technology	Feedstock	Notes
<a href="#">Abengoa</a>	Hugoton, KS	Ethanol	Cellulosic	0	25	EH	cellulose	Partnerships with Virent and Dyadic.
<a href="#">Ace Ethanol (Sweetwater)</a>	Stanley, WI	Ethanol	Cellulosic	0	3.6	EH	cellulose	7% of feedstock to come from Sweetwater's cellulosic sugars
<a href="#">Algenol</a>	Fort Myers, FL	Ethanol	Other	0.1	250.1	fermentation	algae and CO2	30 acres to grow algae on commercially at its HQs. Target completion date in 2014. 9000 gal/acre yield.
<a href="#">Alpha Jet</a>		Renewable Diesel, Jet fuel and Gasoline	Biomass based diesel	0	0	Hydrogen-efficient catalytic hydrotreating	plant oils, waste oils and fats, and algae oil	
<a href="#">AltAir Fuels</a>	Los Angeles, CA	Renewable diesel and jet fuel	Cellulosic diesel	0	30		camelina	United off-take for 15 MG of jet fuel at a 30 MG facility. Retrofit of Paramount facility in Los Angeles
<a href="#">American Process Inc.</a>	Alpena, MI; Thomaston, GA	Ethanol	Cellulosic	1.19	1.19	EH	cellulose/wood	Northern hardwood and aspen, 30 bone dry tons per day; Recent 25% investment by GranBio
<a href="#">Amyris Inc.</a>		Renewable and Jet Fuel	Other	0.01	0.01	fermentation	sugar	Flew biofuel flight at Paris Air Show in June 2013. Diesel meets ASTM D975 specs, up to 35% blend approved EPA
<a href="#">Aquatech Bioenergy</a>	SD	Ethanol	Cellulosic					Algae to ethanol + co-products
<a href="#">Archer Daniels Midland</a>		Ethanol	Cellulosic	0	0.02	EH	cellulose/stover	
<a href="#">Beta Renewables</a>	Sampson County, NC	Ethanol	Cellulosic		20		cellulose	Partnered with Chemtex, GranBio, Canergy. USDA loan guarantee
<a href="#">Blue Fuel Energy Corporation</a>		Multiple Fuels - Renewable	Other		61.32		CO2	
<a href="#">BlueFire Renewables</a>	Fulton, MS; Lancaster, CA	Ethanol	Cellulosic				MSW	Plant in Korea and pending U.S. projects
<a href="#">Cobalt Technology</a>		Butanol and Jet Fuel	Cellulosic diesel				cellulose	Biochemical plant in Brazil with Rhodia. DOE award for JP-5 development; partnered with Show Me Energy
<a href="#">Cool Planet Biofuels</a>	Colorado	Renewable Gasoline	Cellulosic	0.2	10	Biomass Fractionation	cellulose	Moving to Colorado for \$3M Job Growth Incentive Tax Credit in return for creating 393 jobs in the next 3 years.
<a href="#">CORE Biofuel</a>	Canada	Renewable Gasoline	Cellulosic	0.1	0	gasification	woody biomass	
<a href="#">D2 Renewable</a>	Convent, LA	Renewable Diesel	Biomass based diesel			hydroprocessing	brown grease	Have a number of partners, including Haldor Topsoe and financial partners. Plan to construct five 30M gallon plants (total capacity 150M)

## Appendix B: Active Advanced Biofuel Companies (High-End)

Company	Plant Location	Finished Product	RFS Category	Anticipated 2013 Capacity MGPY	Anticipated 2016 Capacity MGPY	Technology	Feedstock	Notes
<a href="#">Diamond Green Diesel</a>	Norco, Louisiana	Renewable Diesel	Biomass based diesel	140	140	hydroprocessing	animal waste	Began production June 2013; partnership with Darling International
<a href="#">DuPont Cellulosic Ethanol</a>	Vonore, TN; Nevada, IA	Ethanol	Cellulosic	0.25	54.65	EH	cellulose	
<a href="#">Dynamic Fuels</a>	Geismar, LA	Renewable Diesel	Biomass based diesel	75	75	hydroprocessing	animal waste & used cooking oil	Tyson & Syntroleum JV. RSB certification.
<a href="#">EcoTech Fuels</a>	Hot Springs, SD; Douglas County, GA	Renewable Diesel	Cellulosic diesel	0	80	AD, gasification, FT, hydrocracking	MSW, agricultural waste, biowaste, woody biomass	"Torqazine-D"
<a href="#">Edeniq</a>	Brazil and USA	Ethanol	Cellulosic	0.05	7.05	enzymatic	corn stover, bagasse	Multiple licenses at California corn ethanol facilities
<a href="#">Elevance Renewable Sciences</a>	Natchez, MS	Multiple Fuels - Renewable	Other			metathesis	algae	working with BioProcess Algae on DOE grant. First plant in Indonesia
<a href="#">Emerald Biofuels</a>	Plaquemine, LA	Renewable Diesel	Biomass based diesel	0	85	catalytic hydroprocessing	waste fats and oils	Honeywell/UOP tech on Dow Chem site. Permitted.
<a href="#">Enerkem</a>	Pontotoc, MS; Edmonton, Alberta; Varennes, Quebec; Pontotoc, MS; Westbury, Quebec (demo)	Methanol and Ethanol	Cellulosic	1.3	31.3	Thermochemical	MSW	Closed on Edmonton facility financing in January.
<a href="#">Envergent</a> (Honeywell/UOP & Ensyn)	Kapolei, Hawaii	Multiple Fuels - Renewable	Cellulosic	0	0.1	rapid thermal processing	Ag waste, pulp, paper, wood, energy crops and algae	
<a href="#">EPEC</a>		Ethanol	Cellulosic			fermentation	Sweet Sorghum	Plan to build modular plants near biomass sources
<a href="#">Fiberight</a>	Blairstown, IA	Ethanol	Cellulosic	0	6	EH	MSW	Converting existing ethanol facility
<a href="#">Frontrange Energy (Sweetwater)</a>		Ethanol	Cellulosic	0	3.6	EH	woody biomass	7% of feedstock to come from Sweetwater's cellulosic sugars
<a href="#">Fulcrum BioEnergy, Inc.</a>	Reno, NV	Renewable jet fuel, diesel and ethanol	Cellulosic diesel	0	10	Steam reforming & F-T	MSW	Partnership with Waste Management.
<a href="#">General Atomics</a>		Jet fuel	Other				algae	DARPA funded demo site in Kauai, Hawaii
<a href="#">GeoSyn Fuels</a>	Golden, CO	Ethanol	Biomass based diesel					
<a href="#">Green Biologics</a>	Columbus, OH	Biobutanol	Other	0.01	0.01	fermentation	multi-feedstock	Partnership with Easy Energy to convert to n-butanol at Emmetsburg IA demo facility
<a href="#">Green Plains Renewable Energy</a>	Shenandoah, IA	Jet fuel	Other				algae	partnership with BioProcess Algae to test algae in Shenandoah, Iowa facility.
<a href="#">Haldor Topsoe, Inc.</a>	Des Plaines, IL	Renewable Gasoline	Cellulosic	0.34	0	EH	woody biomass	Located within GTI's testing facility.

## Appendix B: Active Advanced Biofuel Companies (High-End)

Company	Plant Location	Finished Product	RFS Category	Anticipated 2013 Capacity MGPY	Anticipated 2016 Capacity MGPY	Technology	Feedstock	Notes
<a href="#">Hawaii Bioenergy</a>		Renewable Diesel	Cellulosic diesel	0	0			
<a href="#">ICM</a>	St. Joseph, MO	Ethanol	Cellulosic	0.245	0.245		corn fiber, switchgrass, energy sorghum	
<a href="#">Imperium Renewables</a>	Hoquiam, WA	Jet fuel	Biomass based diesel		30	transesterification	waste oils	Adding new storage tanks, rail infrastructure and office space at 100 MG biodiesel facility in Grays Harbor. Potential future expansion into renewable jet fuel.
<a href="#">INBICON</a>		Ethanol	Cellulosic			non-chem pretreatment, EH, sugar fermentation	cellulose - ag residues	
<a href="#">INEOS Bio</a>	Vero Beach, FL	Ethanol	Cellulosic	8	8	thermochemical gasification/biochemical fermentation	MSW	Production began July 2013.
<a href="#">logen</a>	Ottawa, Ontario	Ethanol	Cellulosic	0.48	0.48		Stover	
<a href="#">Joule</a>	Hobbs, NM	Renewable diesel and ethanol	Cellulosic	0.11	25.11	Helioculture Platform	CO2	Expect to produce 25,000 gallons of ethanol and 15,000 gallons of diesel per acre at commercial scale. Commercial plants begin construction in 2014.
<a href="#">KIOR</a>	Columbus, MS; Natchez, MS (planned)	Multiple Fuels - Renewable	Cellulosic	13	53	Biomass Fluid Catalytic Cracking	woody biomass	Began shipping renewable diesel 3/20/13
<a href="#">Lanza Tech (Freedom Pines)</a>	Soperton, GA	Ethanol	Cellulosic	0	20	gasification	Flue gas	Partnership with Virgin Airlines.
<a href="#">Logos Technologies</a>	Visalia, CA	Ethanol	Cellulosic				cellulose, MSW	Logos Technologies works in partnership with Edeniq on the Visalia facility.
<a href="#">LS9</a>	Okeechobee, FL	Renewable Diesel	Other	0.075	0.075	fermentation	first and second generation sugars	
<a href="#">Mascoma</a>	Rome, NY, Kinross, MI	Ethanol	Cellulosic	0.2	20.2	CBP	hardwood	
<a href="#">Menon International</a>		Renewable jet, gasoline, diesel, biodiesel	Cellulosic			fermentation	various, including MSW, algae	
<a href="#">Mercurius Biofuels</a>		Renewable diesel and jet fuel	Cellulosic diesel			Renewable Acid-hydrolysis Condensation Hydrotreating		
<a href="#">Novogy</a>		Ethanol	Cellulosic				paper waste	
<a href="#">Oberon</a>	Imperial Valley, CA	DME	Other	1.64	140	GTL	Methanol (only temp for Phase 1 of Imperial Valley plant), renewable natural gas	Diesel replacement for heavy duty vehicles. Volvo Group launching DME fleet.
<a href="#">OPX Biotechnologies</a>		Renewable diesel and jet fuel	Cellulosic diesel				fatty acid	Project developing under DOE Grant biofuel pathway, otherwise biochemical



## Appendix B: Active Advanced Biofuel Companies (High-End)

Company	Plant Location	Finished Product	RFS Category	Anticipated 2013 Capacity MGPY	Anticipated 2016 Capacity MGPY	Technology	Feedstock	Notes
<a href="#">Phycal</a>	Central Oahu, Hawaii (under construction)	Multiple Fuels - Renewable	Other	0.01	0.15		cassava and algae	Ethanol from cassava and other fuels from algae. Tesoro and GE as partners
<a href="#">POET</a>	Scotland, SD & Emmetsburg, Iowa	Ethanol	Cellulosic	0.04	25.04	EH	Corn stover, switchgrass, MSW, wheat straw	Project LIBERTY on schedule for early 2014 completion. Capacity of 20 mil ramping up to 25.
<a href="#">Red Rock Biofuels</a>	TBD	Renewable diesel and jet fuel	Cellulosic diesel			gasification	woody biomass	Matching government funds with \$5M private capital. Currently in Phase 1 of DoD grant to select facility location. Fluor engineering.
<a href="#">REII (Renewable Energy Institute International)</a>	Gridley, CA	Renewable Diesel	Cellulosic diesel	0.35	0.35	gasification	woody biomass	
<a href="#">Sapphire Energy</a>	Columbus, NM; Las Cruces, NM	Renewable crude oil	Other	0.02	1.5	hydroprocessing	algae	Tesoro as off-take customer.
<a href="#">Sierra Energy</a>	Sacramento, CA; Fort Hunter Liggett, CA	Renewable Diesel	Cellulosic		0.37	gasification	MSW	Fort Hunter Liggett project
<a href="#">Siluria</a>		Multiple Fuels - Renewable	Other		0.01	oxidative coupling of methane	natural gas	
<a href="#">Solazyme</a>	Peoria, IL; Clinton IA; South San Francisco, CA	Renewable oils	Other	0.53	0.66	hydroprocessing	Sugar (plant and cellulose)	Clinton: 20,000 MT, Peoria: 1,820 MT. Oils used for multiple markets
<a href="#">Solena Fuels Corporation</a>		Renewable diesel and jet fuel	Cellulosic diesel			Fischer Tropsch	MSW	Off-take agreement with British Airways for 16 MG of jet fuel starting in 2015. Production in England; not counted here. Fluor is engineering partner
<a href="#">US Envirofuels</a>	Highlands, FL	Ethanol	Cellulosic	0	30		sugarcane and sweet sorghum	
<a href="#">Virent</a>	North America	Renewable gasoline, diesel, and jet fuel	Cellulosic diesel	0.01	20.01	catalytic	plant sugars	Partnership with Shell, Scuderia Ferrari as customer
<a href="#">Woodland Biofuels</a>	Sarnia, Ontario	Ethanol	Cellulosic	0.02	0.02	enzymatic hydrolysis	woody biomass, agricultural waste, MSW	
<a href="#">ZeaChem</a>	Boardman, OR	Ethanol	Cellulosic	0.25	25.25	fermentation and gasification	biomass: poplar trees and wheatstraw	
<b>64 Companies</b>			<b>TOTAL</b>	<b>243.52</b>	<b>1,294.40</b>			

## Appendix B: Active Advanced Biofuel Companies (High-End)

Summary of Appendix B Data (volume)						
	2012	2013	2014	2015	2016	Count
<b>Ethanol</b>	3.86	12.18	118.28	224.90	531.80	28
<b>Drop-in</b>	88.91	229.69	321.41	528.69	622.59	33
<b>Other</b>	1.65	1.65	20.01	60.01	140.01	3
<b>Biodiesel (Appendix C)</b>	369.92	753.85	784.35	870.98	1001.70	134
<b>TOTAL (volume)</b>	<b>464.34</b>	<b>997.36</b>	<b>1,244.05</b>	<b>1,684.58</b>	<b>2,296.10</b>	<b>198</b>

## Appendix C: Biodiesel Producers

Company Name	Website	City	State	Capacity	Notes
ACCU CHEM Conversion		El Centro	CA	3	
ADM	www.adm.com	Velva	ND	85	
Advanced Biodiesel	www.advancedbiodiesel.com	Noblesville	IN	2	
Ag Environmental Products	www.agp.com	Multiple		119	3 facilities
Agribiofuels	www.agribiofuels.com	Dayton	TX	12	
AgriFuels	www.agrifuels.com	Bremen	OH	0.1	
Allied Renewable Energy	www.alliedenergycorp.com	Birmingham	AL	15	
Alternative Fuel Solutions		Huntington	IN	0.8	
Alterra Bioenergy Resources Corporation		Gordon	GA	12.1	
American Biodiesel Energy	eriebiodiesel.com	Erie	PA	4	
American Energy Producers	www.aepi.ws	Tina	MO	6	
Beacon Energy	www.beacontx.com	Cleburne	TX	12	
Bently Biofuels Company	www.bentlybiofuels.com	Minden	NV	0	Owned by Pacific Biodiesel
BIODICO	www.biodieselindustries.com	Port Hueneme	CA	10.0	
Biodiesel of Las Vegas	www.biodieseloflasvegas.com	Las Vegas	NV	4	
Biodiesel of PA	www.pabiodieselsupply.com	White Deer	PA	1.5	
BioDiesel One	www.biodieseloneltd.com	Southington	CT	3	
Blue Ridge Biofuels	www.blueridgebiofuels.com	Asheville	NC	1	
Blue Sun Biodiesel	www.gobluesun.com	St. Joseph	MO	30	
Bluegrass BioDiesel	www.bluegrass-biodiesel.com	Falmouth	KY	3.5	
Bridgeport Biodiesel	www.bridgeportbiodiesel.com	Bridgeport	CT	1	
Buster Biofuel	http://busterbiofuels.com	San Diego	CA		CEC award for \$2.6M
Cape Cod BioFuels	www.capecodbiofuels.com	Sandwich	MA	0.5	
Center Alternative Energy Company	www.centeroil.com	Cleveland	OH	5	
Clinton County Bio Energy	www.ccbiebiodiesel.com	Clinton	IA	10	
Community Fuels	www.communityfuels.com	Stockton	CA	10	BQ9000 certified
Crimson Renewable Energy	www.crimsonrenewable.com	Bakersfield	CA	22	
Delek Renewables	www.delekus.com	Cleburne	TX	12	
Dependable Fuels		Tomball	TX	1.2	
Down To Earth Energy	www.downtoearthenergy.net	Monroe	GA	2	
Eagle Bio Diesel		Bridgeport	AL	30	
Earl Fisher Bio-Fuels	www.earlfisherbiofuels.com	Chester	MT	0.3	
Eberle Biodiesel	www.eberlebio-diesel.com	Liverpool	TX	0.5	
Emergent Green Energy	www.egebio.com	Minneola	KS	2	
Endicott	www.endicottbiofuels.com	Houston	TX		Constructing 30MG facility Port Arthur TX
Energy Tec		Maquoketa	IA	0.03	
Eslinger		Dos Palos	CA		CEC award \$6M for 5 MG plant in Fresno
Ever Cat Fuels	www.evercatfuels.com	Isanti	MN	3	
GEN-X Energy Group	www.genxenergies.com	Moses Lake	WA	15	
General Biodiesel	www.generalbiodiesel.com	Seattle	WA	5	
Genuine Bio-Fuel	www.genuinebiofuel.com	Indiantown	FL	6	
GeoGreen Biofuels	www.geogreen.com	Vernon	CA	3	
Grecycle Arizona	www.grecycle.com	Tucson	AZ	2	
Green Earth Fuels	www.greenearthfuelsllc.com	Galena Park	TX	90	

## Appendix C: Biodiesel Producers

Company Name	Website	City	State	Capacity	Notes
Green Energy Products		Sedgwick	KS	2	
Green Gallon Solutions of North America	www.greengallonsolutions.com	Multiple		6.8	4 facilities
Green Valley Biofuels	www.greenvalleybf.com	Warrenville	SC	35	
Green Waste Solutions of Alaska	www.biodiesel.com	Anchorage	AK	0.3	Owned by Pacific Biodiesel
Greenleaf Biofuels	www.greenleafbiofuels.com	New Haven	CT	10	
Greenwave Biodiesel	http://greenwaveoil.com	Ft. Lauderdale	FL	4	
Griffin Industries	www.griffinind.com	Butler	KY	1.8	
HERO BX	www.lakeeriebiofuels.com	Erie	PA	45	
High Plains Bioenergy	www.highplainsbioenergy.com	Guymon	OK	30	
Imperial Western Products	www.biotanefuels.com	Coachella	CA	10.5	
Imperium Renewables	www.imperiumrenewables.com	Hoquiam	WA	100	
Integrity Biofuels	www.integritybiofuels.com	Morristown	IN	5	
Iowa Renewable Energy	www.irebiodiesel.com	Washington	IA	36	
Jatrodiesel	www.jatrodiesel.com	Miamisburg	OH	5	
Kelley Green	http://www.kelley-green.com	Goshen	KY	0.1	
Keystone Biofuels	www.keystonebiofuels.com	Camp Hill	PA	60	Owned by Pacific Biodiesel
Maine Bio-Fuel	www.mainestandardbiofuels.com	Portland	ME	0.5	
Michigan Biodiesel	http://www.biodieselmichigan.com	Bangor	MI	17	
Milligan Biofuels	http://milliganbiofuels.com	Calgary	AB	5.3	
Natural Biodiesel Plant		Hayti	MO	5	
Nature's Bioreserves		Sioux City	SD		DOD grant 2013
New Fuel Company	www.newfuelco.com	Sanger	TX	0.25	
New Leaf Biofuel	www.newleafbiofuel.com	San Diego	CA	6	
Newport Biodiesel	www.newportbiodiesel.com	Newport	RI	0.5	
North Star Biofuels	www.northstarbiofuels.com	Watsonville	CA	0.75	
Outpost Biodiesel	www.outpostbiodiesel.com	Grafton	NH	0.03	
Pacific Biodiesel	www.biodiesel.com	Multiple		15	8 facilities not otherwise captured
Patriot Biodiesel	www.patriotbiodiesel.com	Greensboro	NC	6.9	
Piedmont Biofuels Industrial	www.biofuels.coop	Pittsboro	NC	3.3	RSB Certified
Pinnacle Biofuels	www.pinnaclebiofuels.com	Crossett	AR	10	
Pleasant Valley Biofuels	www.pleasantvalleybiofuels.com	American Falls	ID	1.5	
Producers Choice Soy Energy	www.pcsoyenergy.com	Moberly	MO	5	
Promethean Biofuels Cooperative Corporation	www.prometheanbiofuels.com	Temecula	CA	1.5	
RECO Biodiesel	www.recobiodiesel.com	Richmond	VA	2	
Renewable Energy Group	www.regfuel.com	Multiple		225	5 facilities
Rio Valley Biofuels	www.riovalleybiofuels.com	Anthony	NM	1	
Sabine Biofuels II	www.sabinebiofuels.com	Port Arthur	TX	30	
Sanimax Energy	www.sanimax.com	Deforest	WI	20	
Scott Petroleum Corporation	www.scottpetroleuminc.com	Greenville	MS	20	
SeSequential	www.sqbiofuels.com	Salem	OR	5.0	Owned by Pacific Biodiesel
Shenandoah Agricultural Products		Clearbrook	VA	0.3	
Shintan		Paterson	NJ	2.4	
Smart Fuels Florida	www.smartfuelsllc.com	Fruitland Park	FL	3	

## Appendix C: Biodiesel Producers

Company Name	Website	City	State	Capacity	Notes
South East Oklahoma Biodiesel		Valliant	OK	5	
Southeast BioDiesel	<a href="http://www.sebd.biz">www.sebd.biz</a>	North Charleston	SC	5	
Southeastern Biodiesel Solutions	<a href="http://www.southeastbiofuels.com">www.southeastbiofuels.com</a>	Creola	AL	1	
Southern Energy Company		Shelbyville	TN	0.4	
Southern Enviro Solutions	<a href="http://www.sesbiofuels.com">www.sesbiofuels.com</a>	Garden City	GA	0.2	
Soy Energy	<a href="http://www.soyenergyllc.com">www.soyenergyllc.com</a>	Multiple		32.5	2 facilities
Stepan Company	<a href="http://www.stepan.com">www.stepan.com</a>	Millsdale	IL	22	
Sullens Biodiesel		Morrison	TN	2	
Sun Power Biodiesel	<a href="http://www.growsunpower.com">www.growsunpower.com</a>	Cumberland	WI	3	
Texas Green Manufacturing	<a href="http://www.texasgreen.biz">www.texasgreen.biz</a>	Littlefield	TX	1.3	
The La Grange Plant	<a href="http://thelagrangeplantinc.com">http://thelagrangeplantinc.com</a>	La Grange	TX	3.5	
The Sun Products Corporation	<a href="http://www.sunproductscorp.com">www.sunproductscorp.com</a>	Pasadena	TX	15	
Thumb BioEnergy	<a href="http://www.thumbbioenergy.com">www.thumbbioenergy.com</a>	Sandusky	MI	0.4	
TMT Biofuels	<a href="http://www.tmtbiofuels.com">www.tmtbiofuels.com</a>	Port Leyden	NY	0.3	
TPA Inc.	<a href="http://thepoweralternative.com">http://thepoweralternative.com</a>	Detroit	MI	17.5	
Triangle Biofuels Industries	<a href="http://www.trianglebiofuels.com">www.trianglebiofuels.com</a>	Wilson	NC	3	
United Oil Company	<a href="http://www.unitedb100.com">www.unitedb100.com</a>	Pittsburgh	PA	15	
Vanguard Synfuels	<a href="http://vanguardsynfuels.com">vanguardsynfuels.com</a>	Pollock	LA	12	
Veros Energy	<a href="http://www.verosystems.com">www.verosystems.com</a>	Moundville	AL	37	
Viesel Fuel	<a href="http://www.vieselfuel.com">www.vieselfuel.com</a>	Stuart	FL	18	
Virginia Biodiesel Refinery	<a href="http://www.virginiabiodiesel.com">www.virginiabiodiesel.com</a>	West Point	VA	7	
Walsh Bio Fuels	<a href="http://walshbiofuel.com">walshbiofuel.com</a>	Mauston	WI	5	
Washakie Renewable Energy	<a href="http://www.wrebiofuels.com">www.wrebiofuels.com</a>	Plymouth	UT	10	
Western Dubuque Biodiesel	<a href="http://www.wdbiodiesel.net">www.wdbiodiesel.net</a>	Farley	IA	36	
Western Iowa Energy	<a href="http://www.wiefuel.com">www.wiefuel.com</a>	Wall Lake	IA	30	
White Mountain Biodiesel	<a href="http://www.whitemountainbiodiesel.com">www.whitemountainbiodiesel.com</a>	North Haverhill	NH	5.5	
Whole Energy Fuels	<a href="http://whole-energy.com">http://whole-energy.com</a>	Anacortes	WA	2	
Yokayo Biofuels	<a href="http://www.ybiofuels.org">www.ybiofuels.org</a>	Ukiah	CA	0.5	
<b>116 Companies</b>				<b>1.57 Billion Capacity</b>	

E2 has reported the production of biodiesel from non-virgin oils, and not the full capacity of multi-feedstock biodiesel facilities at 1.57 billion gallons.

Virgin vegetable oils, such as soybeans and canola oil, are used in many facilities, including multi-feedstock facilities that use waste grease, oils or fats. Today about ½ of biodiesel production comes from these waste oils. There are 18 facilities in the United States that are solely processing soybean oil; those facilities were not included in this list, in line with E2's definition of advanced. These facilities may process multiple feedstocks in the future and be integrate waste oil processing, and were therefore included in the total number of high-end facilities on E2's company count.



## Appendix D: International Projects

Company	Website	Headquarters	Plant Location(s)	Fuel Type	Feedstock	Notes
Abengoa	<a href="http://www.abengoabioenergy.com">www.abengoabioenergy.com</a>	Spain	Salamanca	Ethanol	Municipal Solid Waste	In addition to its U.S. cellulosic project in Kansas, Abengoa has completed a demonstration unit in Salamanca, Spain.
Algae.Tec	<a href="http://algaetec.com.au/">http://algaetec.com.au/</a>	Australia, US	Australia, Sri Lanka, Germany, US	biodiesel, jet fuel	algae	Produce algal oil and partners with refineries to produce a variety of renewable fuel products. Australian/US based company with projects in Australia, the US, Sri Lanka, and Germany. Sri Lanka facility will eventually produce 31 million litres of oil for biofuel production.
Amyris	<a href="http://www.amyris.com">www.amyris.com</a>	US, Brazil	Sao Paulo and Usina, Brazil	Diesel; Jet Fuel	Sugar Cane	Operates pilot and demonstration facilities and is building a commercial scale production facility in San Martino, Brazil. Furthermore, Amyris is partnering with Total to develop an alternative aviation jet fuel to be sold in US, European and Brazilian markets.
Beta Renewables	<a href="http://www.betarenewables.com">www.betarenewables.com</a>	Italy	Crescentino, Italy	Ethanol	Wheat Straw	Beta Renewables is a \$350 million joint venture between Chemtex and TPG. The company began shipping fuel from its Crescentino facility in June 2013 and is building a facility in North Carolina, also several technology licenses.
Borregaard	<a href="http://www.borregaard.com">www.borregaard.com</a>	Norway	Sarpsborg, Norway	Ethanol	Woody Biomass	Borregaard produces advanced biochemicals, biomaterials and bioethanol that can replace oil-based products. Its ethanol plant in Norway has a capacity of 17-19 million liters. The company works throughout Europe, Asia, and Africa, and has several biochemical projects based in the United States.
BP Biofuels - Butamax	<a href="http://www.butamax.com">www.butamax.com</a>	Wilmington, DE	Hull, UK	biobutanol	sugarcane, lignocellulosic	Butamax™ Advanced Biofuels will work closely with Kingston Research Limited to demonstrate production of biobutanol at a technology demonstration plant in the UK.
Bunge	<a href="http://www.bunge.com">www.bunge.com</a>	Bermuda (HQ in US)	Sao Paulo and Minas Gerais, Brazil (8 plants)	Ethanol (*markets biodiesel)	Sugar Cane (ethanol);	Bunge operates eight sugarcane mills in Brazil with a combined capacity of 1.1 million cubic meters per year. Bunge also participates in the biodiesel industry, normally as a minority investor in facilities in Argentina, the US and Europe.
COFCO/Sinopec		China	Zhaodong, China	ethanol	agricultural residue	50,000 MT/year capacity. Expected online this year; no recent news. Novozymes as partner
Clariant	<a href="http://www.clariant.com/micro/biotech/">http://www.clariant.com/micro/biotech/</a>	Germany	Munich, Germany; Straubing, Germany	ethanol	agricultural residue	Clariant runs both a pilot and demonstration facility in Germany, and has an annual capacity of 1,000 tons of ethanol/year.
Shell (Raízen project)	<a href="http://www.shell.com/global/environment-society/environment/climate-change/biofuels-alternative-energies-transport/biofuels/raizen.html">http://www.shell.com/global/environment-society/environment/climate-change/biofuels-alternative-energies-transport/biofuels/raizen.html</a>	The Netherlands	Sao Paulo State, Brazil	ethanol	sugarcane	Raízen is a joint venture between Shell and Cosan, a Brazilian energy company. With 24 mills, it will produce 2 billion liters a year of sugarcane ethanol, with plans to expand into biofuels from agricultural residue.
Edeniq		US	Sao Paulo State, Brazil	ethanol	sugarcane	Edeniq has partnered with Brazilian company Usina Vale to build a cellulosic ethanol demonstration plant at Usina Vale's sugarmill.
Eni	<a href="http://www.eni.com">http://www.eni.com</a>	Italy	Venice, Italy	green diesel/biodiesel	waste oils, possibly MSW and algae	Eni is in the process of converting a traditional refinery to a biorefinery in Venice, in partnership with UOP. The plant will begin producing green diesel in 2014 and be fully operational by 2015.

## Appendix D: International Projects

Company	Website	Headquarters	Plant Location(s)	Fuel Type	Feedstock	Notes
Ensyn	<a href="http://www.ensyn.com">www.ensyn.com</a>	Wilmington, DE	Brazil	RTP Liquids	Biomass	Signed agreement in October, 2012 with Fibria to produce cellulosic biofuel in Brazil.
GranBio (formerly GraalBio)	<a href="http://www.granbio.com.br/en/">http://www.granbio.com.br/en/</a>	Brazil	Alagoas, Brazil	Ethanol	sugars	Using Beta Renewables Proesa technology at its Alagoas facility, which the company expects to be fully operational in 2014. GranBio has also partnered with American Process, Inc. to use its technology in new facilities in Brazil and the United States.
Green Biologics		United Kingdom		Biobutanol	lignocellulosic biomass	In addition to its pilot facility in Columbus, OH, Green Biologics has established offices in India, China, and Brazil, and is exploring commercial opportunities in these countries.
Inbicon/DONG	<a href="http://www.inbicon.com">www.inbicon.com</a>	Denmark	Kalundborg, Denmark	Ethanol	Wheat Straw	Currently operates a large scale pilot plant in Denmark. It has formed several strategic partnerships to develop new projects in Denmark, China, and North America.
LanzaTech	<a href="http://www.lanzatech.co.nz">www.lanzatech.co.nz</a>	US	China (Beijing and Shanghai)	Ethanol	Flue gas	In addition to its U.S. project in Soperton, GA, LanzaTech has two commercial facilities in China using flue gas.
Naturally Scientific	<a href="http://www.naturally-scientific.com">http://www.naturally-scientific.com</a>	United Kingdom	Nottingham, UK	renewable oils	Sugars	Looking at eastern United States locations for first commercial project. 15-year agreement with Sweetwater to provide sugars.
Neste Oil	<a href="http://www.nesteoil.com">http://www.nesteoil.com</a>	Finland	Singapore; Netherlands; Finland	renewable diesel; jet fuel	vegetable oils, waste residues	Renewable diesel refineries in Singapore, the Netherlands, and Finland. Importing to U.S. Entered into an offtake agreement in California with Cellana.
Petrobras	<a href="http://www.petrobras.com.br/en">www.petrobras.com.br/en</a>	Brazil	Candeias (state of Bahia), Quixadá (state of Ceará), and Montes Claros (state of Minas Gerais)	Ethanol; Biodiesel	Multi Feedstock (biomass); Sugar cane (ethanol)	Petrobras has three biodiesel plants in Brazil with total production capacity of 170,000 cubic meters per year. Also active in the ethanol market and aims to export 4.2 million cubic meters of ethanol in 2013.
Praj Industries	<a href="http://www.praj.net">www.praj.net</a>	India	India, Malawi, Thailand, Louisiana, US, El Salvador, Sri Lanka	Biodiesel, Ethanol	Sugarcane (juice/molasses), beet, grains (wheat, corn, sorghum, broken rice, and triticale), tubers like cassava	Praj is developed a demonstration plant for advanced ethanol in India with a planned annual capacity of 10 million liters annually.
Solazyme Bunge	<a href="http://solazyme.com">http://solazyme.com</a>	Brazil	Moema, Brazil	Biodiesel, renewable diesel, jet	Sugarcane, algae	100,000 MT/year by end of 2013, 300,000 MT by end of 2016. Co-located with Bunge sugarcane mill, and \$120M loan from BNDES.
Solena	<a href="http://www.solenafuels.com">http://www.solenafuels.com</a>	Washington, DC	UK, Germany, Australia	jet fuel, biodiesel	MSW, agricultural residue, woody biomass	Solena has partnerships with British Airways, Lufthansa, and Qantas, including offtake agreements. Building a 16 MG facility in England
Statoil	<a href="http://www.statoil.com/en/">www.statoil.com/en/</a>	Norway	Mestilla, Lithuania	Biodiesel	Rapeseed, cereals, sugar cane, algae (R&D)	Mestilla plant: annual capacity of 100,000 tonnes. Ethanol at 1300 stations in six countries – Norway, Sweden, Denmark, Lithuania, Latvia and Poland.

## Appendix E: Feedstock Providers

Company	Website	City	State	Note
Agrisoma	<a href="http://agrisoma.com">http://agrisoma.com</a>	Ottawa	Ontario	carinata
Algae.Tec	<a href="http://www.algaetec.com">www.algaetec.com</a>	Atlanta	Georgia	algae producer
AlgaeVenture Systems	<a href="http://algaevs.com">http://algaevs.com</a>	Marysville	Ohio	Algae producer
Aquatic Energy	<a href="http://www.aquaticenergy.com">www.aquaticenergy.com</a>	Lake Charles	Louisiana	Algae producer
ArborGen	<a href="http://www.arborgen.com">www.arborgen.com</a>	Ridgeville	South Carolina	Tree seedling provider
Arcadia Biosciences	<a href="http://www.arcadiabio.com">http://www.arcadiabio.com</a>	Davis	CA	Eucalyptus and poplar trees using nitrogen use efficiency and water use efficiency technologies.
Arvens Technology, a Pennycress Energy Co.	<a href="http://arvenstech.com">http://arvenstech.com</a>	Peoria	Illinois	pennycress seeds as a feedstock
Aurora Algae	<a href="http://www.auroraalgae.com">www.auroraalgae.com</a>	Hayward	California	Algae producer
BARD	<a href="http://www.bardholding.com">www.bardholding.com</a>	Morrisville	Pennsylvania	Algae producer
BioProcess Algae	<a href="http://www.bioprocessalgae.com">http://www.bioprocessalgae.com</a>	Portsmouth	Rhode Island	Algae bioreactors and production. Colocated five acre facility at Green Plains ethanol plant in Iowa.
Bunge	<a href="http://bunge.com">http://bunge.com</a>	Saint Louis	Missouri	Sugar production. Also makes ethanol in Brazil.
Cellana	<a href="http://www.cellana.com">www.cellana.com</a>	San Diego	California	Algae producer. Signed offtake agreement to provide algal oil to Neste in June 2013.
Ceres	<a href="http://www.ceres.net">www.ceres.net</a>	Thousand Oaks	California	Several energy crops
Chromatin	<a href="http://www.chromatininc.com">http://www.chromatininc.com</a>	Chicago	Illinois	Sorghum development and production
Comet Biorefining	<a href="http://www.cometbiorefining.com">www.cometbiorefining.com</a>	London	Ontario	
Enova Energy Group	<a href="http://www.enovaenergygroup.com">www.enovaenergygroup.com</a>	Atlanta	Georgia	Wood pellets to Europe from GA mill. Projected online 2014.
Enviva	<a href="http://www.envivabiomass.com">www.envivabiomass.com</a>	Bethesda	Maryland	wood pellets, facilities in several states, exports to Europe.
Florida Crystals Corp	<a href="http://www.floridacrystals.com">www.floridacrystals.com</a>	West Palm Beach	Florida	
Global Clean Energy Holdings	<a href="http://www.gceholdings.com">http://www.gceholdings.com</a>	Long Beach	CA	Camelina and jatropha producer. RSB Certified. Acquired Sustainable Oils in 2013.
Kent Bioenergy	<a href="http://www.kentbioenergy.com">http://www.kentbioenergy.com</a>	San Diego	California	Algae producer
Matrix Genetics	<a href="http://www.matrixgenetics.com">www.matrixgenetics.com</a>	Seattle	WA	algae producer
Mendota Advanced Bioenergy Beet Cooperative		Fresno	California	Sugar beets
Naturally Scientific	<a href="http://www.naturally-scientific.com">http://www.naturally-scientific.com</a>	Nottingham	United Kingdom	Sugar and PVO production
NexSteppe	<a href="http://www.nexsteppe.com">www.nexsteppe.com</a>	South San Francisco	California	Sorghum and switchgrass production
PacificAg (formerly Pacific Powerstock)	<a href="http://www.pacificpowerstock.com">www.pacificpowerstock.com</a>	Boardman	Oregon	biomass- energy harvest pellets
Parabel	<a href="http://www.parabel.com">www.parabel.com</a>	Melbourne	Florida	Biocrude
Proterro	<a href="http://www.proterro.com">www.proterro.com</a>	Ewing	New Jersey	Sucrose production and photobioreactor system
Purevision Technology	<a href="http://www.purevisiontechnology.com">http://www.purevisiontechnology.com</a>	Fort Lupton	CO	sugar and lignin from non-food biomass
Renewed World Energies	<a href="http://www.rwenergies.com">www.rwenergies.com</a>	Georgetown	South Carolina	Algae producer
Renmatix	<a href="http://renmatix.com">http://renmatix.com</a>	Kennesaw	Georgia	Sugar production from biomass
SG Biofuels	<a href="http://www.sgbiofuels.com">www.sgbiofuels.com</a>	Encinitas	California	jatropha
Solix	<a href="http://www.solixbiofuels.com">www.solixbiofuels.com</a>	Fort Collins	Colorado	Algae production and extraction
SunEco Energy	<a href="http://sunecoenergy.com">http://sunecoenergy.com</a>	Chino	California	Biocrude and SVO
Sweetwater Energy	<a href="http://www.sweetwater.us">www.sweetwater.us</a>	Rochester	New York	Sugar from non-food sources
TerViva	<a href="http://www.terviva.com">http://www.terviva.com</a>	Oakland	California	renewable tree oil
Virdia	<a href="http://virdia.com">http://virdia.com</a>	Redwood City	California	Working with Virent on aviation fuels project & plans for MS commercial facility.
Xylo watt	<a href="http://www.xylo watt.com">http://www.xylo watt.com</a>		Belgium	Syngas
Yulex Corporation	<a href="http://www.yulex.com">http://www.yulex.com</a>	Phoenix	AZ	Syngas from guayule

## Appendix F: Enzyme and Chemical Providers

Company	Website	City	State	Type	Note	Partnerships
AgriVida	<a href="http://www.agrivida.com">www.agrivida.com</a>	Cambridge	Massachusetts	Enzymes	INzyme™ technology	POET
Albemarle	<a href="http://www.albemarle.com">http://www.albemarle.com</a>	Baton Rouge	Louisiana	Catalysts	acquired Catilin in 2011	Neste, Velocys
Codexis	<a href="http://www.codexis.com">www.codexis.com</a>	Redwood City	California	Enzymes/Chemicals	Cellulase enzymes	Chemtex, Purolite
CRI Catalyst Co	<a href="http://www.cricatalyst.com/catalysts/renewables.html">http://www.cricatalyst.com/catalysts/renewables.html</a>	Houston	TX	catalysts	IH2 technology	Shell
DuPont & Genencor	<a href="http://biosciences.dupont.com">http://biosciences.dupont.com</a>	Wilmington	Delaware	Enzymes/Chemicals	Seeds, Fermasure, Enzymes	Butamax
Dyadic	<a href="http://www.dyadic.com">www.dyadic.com</a>	Jupiter	Florida	Enzymes	Genomic research and enzymes	Abengoa, BASF, Codexis
Kiverdi	<a href="http://www.kiverdi.com">http://www.kiverdi.com</a>	Berkeley	CA	Chemicals and catalysts	Fuel additives	
Metabolix	<a href="http://www.metabolix.com">www.metabolix.com</a>	Cambridge	Massachusetts	Chemicals	Performance additives	
Microvi	<a href="http://www.microvi.com">www.microvi.com</a>	Hayward	CA	Enzymes and catalysts		Aquatech International
NextCAT	<a href="http://www.nextcatinc.com">www.nextcatinc.com</a>	Detroit	Michigan	Catalysts	for biodiesel production	
Novozymes	<a href="http://www.novozymes.com">www.novozymes.com</a>	Davis	California	Enzymes		Fiberight, POET, Lignol, Ceres, ICM
Verenium	<a href="http://www.verenium.com">www.verenium.com</a>	San Diego	California	Enzymes		
VeruTEK	<a href="http://www.verutek.com">http://www.verutek.com</a>	Bloomfield	CT	Chemicals	Enhanced oil recovery chemicals	

## Appendix G: Related Technologies

Company	Website	Type	City	State	Partnerships	Note
Agradis	<a href="http://www.agradis.com">http://www.agradis.com</a>	Plant genomics	La Jolla	California	Synthetic Genomics	Sorghum and castor genetics. Monsanto purchased selected assets Feb 2013.
Agrisoma Biosciences	<a href="http://agrisoma.com">http://agrisoma.com</a>	plant genomics	Ottawa	Ontario		Brassica carinata research. Agricultural yield improvement technology
Algenetix	<a href="http://www.algenetix.com">www.algenetix.com</a>	Plant genomics	San Diego	CA		Bioengineering feedstocks
Arisdyne Systems	<a href="http://www.arisdyn.com">http://www.arisdyn.com</a>	Equipment and Technology	Cleveland	Ohio		Hydrodynamic cavitation
Avello	<a href="http://www.avellobioenergy.com">http://www.avellobioenergy.com</a>	Feedstock conversion	Boone	Iowa	Virent, Borregaard, Cargill	Pyrolysis separation technology
Benefuel	<a href="http://www.benefuel.net">http://www.benefuel.net</a>	Technology	Irving	Texas	Koch Industries, Sud Chemie	Catalytic process
Biocee	<a href="http://biocee.com">http://biocee.com</a>	Equipment and Technology	Minneapolis	Minnesota	Verenium	Biocatalytic reactor
Biodico	<a href="http://www.biodieselindustries.com">http://www.biodieselindustries.com</a>	Equipment	Santa Barbara	California	Navy	Construction/operation biorefineries. US Naval Base, Ventura County.
Blendstar	<a href="http://www.blendstarllc.com">http://www.blendstarllc.com</a>	Distribution	Omaha	Nebraska		Renewable fuel terminals
Carbo Analytiscs	<a href="http://www.carboanalytics.com">http://www.carboanalytics.com</a>	Sugar analytics	Fort Collins	Colorado		SBIR grant from DOE with CEM
Chemtex	<a href="http://www.chemtex.com">http://www.chemtex.com</a>	Technology	Wilmington	North Carolina	COFCO, Beta Renewables, Codexis	Biomass processing technology. Conversion of corn ethanol facilities to cellulose.
Dogpatch Biofuels	<a href="http://www.dogpatchbiofuels.com">http://www.dogpatchbiofuels.com</a>	Distribution & Marketing	San Francisco	California		San Francisco fueling center
E-Fuel Corporation	<a href="http://www.microfueler.com">http://www.microfueler.com</a>	Equipment	Los Gatos	California		Micro-ethanol production equipment
Eco-Energy	<a href="http://www.eco-energyinc.com">http://www.eco-energyinc.com</a>	Distribution & Marketing	Franklin	Tennessee		Ethanol distribution; located throughout corn belt
Fluor	<a href="http://www.fluor.com">http://www.fluor.com</a>	Engineering & construction	Irving	Texas		Performs engineering services for multiple biofuel customers, such as Joule and LS9.
Foster Wheeler	<a href="http://www.fwc.com">http://www.fwc.com</a>	Engineering & construction	Houston	Texas		
ICM	<a href="http://www.icminc.com">http://www.icminc.com</a>	Technology, equipment and construction	Colwich	Kansas	Abengoa Bioenergy	Equipment and tech used in the majority of ethanol facilities
Imperative Energy Ltd	<a href="http://www.imperativeenergy.ie">http://www.imperativeenergy.ie</a>	Equipment				Biomass boiler system and fuel handling equipment
Intrexon	<a href="http://www.dna.com/Markets/Energy">http://www.dna.com/Markets/Energy</a>	Microbe engineering	Boston	Massachusetts		S-1 filed. Engineering metabolic pathways
Inventure	<a href="http://www.inventurechem.com">http://www.inventurechem.com</a>	Technology	Tuscaloosa	Alabama	General Atomics, UOP Honeywell, SG Biofuels	Direct Extraction Technology; Univ Alabama
KBR	<a href="http://www.kbr.com">http://www.kbr.com</a>	Engineering & construction	Houston	Texas		Offers technology development, plant scale-up, Engineering, procurement, construction, operation, and maintenance services for Renewable and Biomass based facilities.
Lallemand	<a href="http://www.ethanoltech.com">http://www.ethanoltech.com</a>	Yeasts	Milwaukee	Wisconsin	Mascoma	Yeast and bacteria supplier
Linde Group	<a href="http://www.the-linde-group.com">http://www.the-linde-group.com</a>	Technology	Munich	Germany	Sapphire	Gas and engineering group. Providing gases and hydrotreating capacity.
Mendel Biotechnology, Inc.	<a href="http://www.mendelbio.com">http://www.mendelbio.com</a>	Plant genomics	Hayward	California	DuPont, Bayer CropScience	Plant gene regulatory networks
Methes Energies	<a href="http://www.methes.com/product_BP.html">http://www.methes.com/product_BP.html</a>	Equipment	Las Vegas	Nevada		Biodiesel processing units
MicroBio Engineering	<a href="http://www.microbioengineering.com">http://www.microbioengineering.com</a>	Engineering & tech development	San Luis Obispo	California		Engineering services and technology development in microalgae production
Nexterra	<a href="http://www.nexterra.ca">http://www.nexterra.ca</a>	Gasification Technology	Vancouver	British Columbia	GE, UBC, ORNL	Biomass gasification. Oak Ridge National Lab plant facility.
OpenAlgae	<a href="http://www.openalgae.com">www.openalgae.com</a>	Technology	Austin	Texas		Mobile algae extraction unit

## Appendix G: Related Technologies

Company	Website	Type	City	State	Partnerships	Note
Orbitek	<a href="http://www.orbitekinc.com">http://www.orbitekinc.com</a>	Engineering & Equipment	Tulsa	Oklahoma		Consulting services for biodiesel facilities
Propel Fuels	<a href="http://propelfuels.com">http://propelfuels.com</a>	Distribution	Redwood City	California		Leases, owns and operates biofuel stations on West Coast
ProTec Fuel Management	<a href="http://www.protecfuel.com">http://www.protecfuel.com</a>	Distribution	Boca Raton	Florida		Ethanol marketing and distribution
SkyNRG	<a href="http://skynrg.com">http://skynrg.com</a>	Demand aggregation	Amsterdam	Netherlands		RSB certified
Sylvatex	<a href="http://sylvatex.com">http://sylvatex.com</a>	Additive	San Francisco	CA		Additive to ethanol or diesel
SynGest	<a href="http://www.syngest.com">http://www.syngest.com</a>	Additive	San Francisco	California		Urea production as a fuel additive
Synthetic Genomics	<a href="http://www.syntheticgenomics.com">http://www.syntheticgenomics.com</a>	Plant genomics	San Diego	California	ExxonMobil	Exxon's main biofuel investment. Monsanto made equity investment
Tenaska Energy	<a href="http://www.tenaska.com">http://www.tenaska.com</a>	Equipment & Marketing	Omaha	Nebraska		Natural gas-fueled generation plants and biofuel marketing + distribution
TetraTech	<a href="http://www.tetrattech.com">http://www.tetrattech.com</a>	Engineering & tech development	Pasadena	CA		
ThermoChem Recovery International (TRI)	<a href="http://www.tri-inc.net">http://www.tri-inc.net</a>	Gasification Technology	Baltimore	Maryland		
Velocys	<a href="http://www.velocys.com">http://www.velocys.com</a>	Technology	Plain City	Ohio	Solena Fuels	Fischer-Tropsch and gas-to-liquid technology licenses
Verdezyne	<a href="http://www.verdezyne.com">http://www.verdezyne.com</a>	Technology licensor	Carlsbad	California	Lallemand	Enzymatic hydrolysis technology, yeast and microorganism development. Also producing chemicals.
Zarco 66	<a href="http://www.zarco66.com">http://www.zarco66.com</a>	Distribution & Marketing	Lawrence	KS		Seven biofuel gas stations across Kansas
Zeakal	<a href="http://www.zeakal.com">http://www.zeakal.com</a>	plant genomics	San Diego	California		Bioengineering feedstocks



## Appendix H: Public Investments

Company	Date	Amount	Investment Type	Investors
Abengoa Bioenergy	8/19/2011	\$133,900,000	Loan Guarantee	DOE
Algenol Biofuels	11/18/2010	\$10,000,000	Grant	Lee County Southwest Florida
Algenol Biofuels	12/4/2009	\$25,000,000	Grant	DOE
American Process	08/2011	\$4,000,000	Grant	Michigan Center of Energy Excellence
American Process	01/2010	\$18,000,000	Grant	DOE
Archer Daniels Midland	06/2010	\$24,800,000	Grant	DOE
Avello	11/2010	\$2,500,000	Grant	DOE
Bentley Biofuels	5/15/2013	\$17,362	Grant	USDA
BioCee	10/26/2009	\$2,200,000	Grant	DOE
Biodico	4/11/2012	\$2,000,000	Grant	California Energy Commission
BioProcess Algae	4/24/2013	\$6,400,000	Grant	DOE
BlueFire Renewables	01/2010	\$88,000,000	Grant	DOE
Buster Biofuels	3/20/2013	\$2,641,723	Grant	California Energy Commission
Carbo Analytics		\$150,000	Grant	
Cellana	5/6/2011	\$5,521,173	Grant	USDA
Chemtex	8/23/2012	\$99,000,000	Loan Guarantee	USDA
Cobalt & API	8/3/2011	\$18,000,000	Grant	DOE
Cobalt & API	4/22/2013	\$2,500,000	Grant	DOE
Edeniq	6/14/2012	\$3,900,000	Grant	California Energy Commission
Edeniq & Logos Technologies	12/4/2009	\$20,400,000	Grant	DOE
Emerald Biofuels	5/28/2013	\$5,650,000	Grant	DoD
Enerkem	12/2009	\$50,000,000	Grant	USDA
Enerkem	12/2010	\$80,000,000	Loan Guarantee	DOE
Fiberight	01/2010	\$2,500,000	Grant	Iowa Power Fund
Fiberight	1/16/2012	\$25,000,000	Loan Guarantee	USDA
Fulcrum	8/13/2012	\$105,000,000	Loan Guarantee	USDA
Fulcrum Bioenergy	5/28/2013	\$4,700,000	Grant	DoD
General Atomics	6/13/2011	\$2,000,000	Grant	DOE
Haldor Topsoe		\$25,000,000	Grant	DOE
INEOs	1/18/2012	\$50,000,000	Grant	DOE
INEOs New Planet BioEnergy	8/19/2011	\$75,000,000	Loan Guarantee	USDA
KiOR	8/30/2010	\$75,000,000	Structured Debt	State of Mississippi
LanzaTech	6/22/2011	\$500,000	Grant	DARPA
LanzaTech	12/2/2011	\$3,000,000	Grant	Federal Aviation Administration
LanzaTech	8/31/2011	\$4,000,000	Grant	DOE
LanzaTech	11/19/2010	\$500,000	Project Finance	DOE
LS9	5/14/2012	\$4,500,000	Growth Equity	Florida Opportunity Fund
LS9	7/18/2011	\$9,000,000	Grant	DOE
Mendota Advanced Bioenergy	11/2010	\$1,500,000	Grant	California Energy Commission
Mercurius Biofuels	4/22/2013	\$4,600,000	Grant	DOE
Natures Bioreserves	5/28/2013	\$5,650,000	Grant	DoD
NextCAT	8/29/2011	\$500,000	Grant	National Science Foundation
Oberon	6/7/2013	\$500,000	Grant	San Joaquin Valley Air Pollution Control District
OPX Biotechnologies	8/30/2010	\$6,000,000	Grant	DOE
Pennycress Energy Company	9/30/2010		Grant	USDA
Pennycress Energy Company	10/24/2011		Grant	USDA
Phycal	7/23/2010	\$24,243,509	Grant	DOE

## Appendix H: Public Investments

Company	Date	Amount	Investment Type	Investors
Propel Fuels	6/1/2012	\$10,100,000	Grant	California Energy Commission
Red Rock Biofuels	6/21/2013	\$4,100,000	Grant	DoD
REII				DOE
Sapphire Energy	12/31/2009	\$50,000,000	Grant	DOE
Sapphire Energy	11/9/2011	\$135,000,000	Loan Guarantee	USDA
Sapphire Energy	12/7/2009	\$54,500,000	Loan Guarantee	USDA
Sapphire Energy	8/1/2013	\$5,000,000	Grant	DOE
Sierra Energy	6/14/2012	\$5,000,000	Grant	California Energy Commission
Solazyme	12/2009	\$22,000,000.00	Grant	DOE
Solazyme	10/2011	\$1,500,000	Grant	California Energy Commission
Solazyme	8/4/2009	\$800,000	Grant	California Energy Commission
UOP	12/2/2011	\$1,100,000	Grant	Federal Aviation Administration
UOP	3/3/2010	\$1,500,000	Grant	DOE
Virent	12/2007	\$2,000,000	Grant	USDA
Virent	7/1/2013	\$4,000,000	Grant	DOE
Virent Energy Systems	12/2/2011	\$1,500,000	Grant	Federal Aviation Administration
Virent Energy Systems	6/13/2011	\$13,400,000	Grant	DOE
Virent Energy Systems	8/31/2011	\$4,000,000	Grant	DOE
Yokayo Biofuels	2012	\$1,970,000	Grant	California Energy Commission
ZeaChem	2/24/2012	\$12,000,000	Grant	National Institute of Food and Agriculture
ZeaChem	5/14/2010	\$25,000,000	Grant	DOE
ZeaChem	1/26/2012	\$232,500,000	Loan Guarantee	USDA
ZeaChem	10/18/2012	\$4,600,000	Grant	California Energy Commission
		<b>\$604,943,797</b>	<b>Grants</b>	
		<b>\$939,900,000</b>	<b>Loan Guarantees</b>	

DOE total	\$671,943,509
USDA total	\$783,538,535
Other total	\$169,361,723