2015 Survey of Non-Starch Ethanol and Renewable Hydrocarbon Biofuels Producers

Amy Schwab, Ethan Warner, and John Lewis
National Renewable Energy Laboratory

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Technical Report
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January 2016

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List of Acronyms

BC	biochemical
BC/TC	hybrid biochemical/thermochemical
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EtOH	ethanol
HC	hydrocarbons
IEA	International Energy Agency
MMGY	million gallons per year
MSW	municipal solid waste
NREL	National Renewable Energy Laboratory
RIN	renewable identification number
TC	thermochemical
TPD	tons per day
USDA	U. S. Department of Agriculture

Abstract

In order to understand the anticipated status of the industry for non-starch ethanol and renewable hydrocarbon biofuels as of the end of calendar year 2015, the National Renewable Energy Laboratory (NREL) updated its annual survey of U.S. non-starch ethanol and renewable hydrocarbon biofuels producers. This report presents the results of this survey update, describes the survey methodology, and documents important changes since the original 2013 survey published at the end of 2014 (Schwab et al. 2015).

We selected 114 companies because of their reported commercial-scale biofuels production capacity (or intentions of developing commercial-scale production capacity) during calendar year 2015. We asked representatives from these companies a standard set of questions during the second half of 2015. The questionnaire topics included facility stage of development, facility scale, feedstock, and biofuel products. Industry experts from NREL and the U.S. Department of Energy validated the responses and compared them with publicly available data. We supplemented missing survey data elements (when possible) with publicly available data obtained directly from company websites, press releases, and public filings. Sixty-one facilities with sufficient data were included in this report. Twenty-nine non-starch ethanol facilities (27 cellulosic ethanol facilities plus 2 algal-derived ethanol facilities) and 32 renewable hydrocarbon facilities were obtained or researched and validated to justify inclusion of these facilities in this survey report. Eleven (5 at the commercial scale) of the 29 non-starch ethanol facilities were operational in 2015, and 12 (2 at the commercial scale) of the 32 renewable hydrocarbon facilities were operational in 2015.

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1 Why Is This Survey Needed?

The published literature includes a number of biofuels industry data compilations, covering a range of products, technologies, countries, and timeframes (Hart Energy 2011; Bacovsky et al. 2013; Soleki, Scodel, and Epstein 2014; Lane 2014; British Petroleum 2014; PricewaterhouseCoopers LLP 2014; IEA Task 39 2013; USDA 2015; IEA Task 42 2014). In the past, extensive review and reconciliation across these differing sources was required to help track industry progress by, for example, creating inputs to models tracking industry development (Peterson et al. 2013). This survey report was established to provide a publicly available, open-source documentation of the status of the non-starch ethanol and renewable hydrocarbon biofuels industry in the United States, as it existed at the end of 2015.

2 Methodology

Updates to the survey methodology used in the original 2013 biorefinery survey (Schwab et al. 2015) include the use of an online survey instrument and an updated and expanded set of survey questions. The original list of survey recipients from 2013 formed the basis of the 2015 survey population so we could track updated status for these original facilities. This list was expanded to include companies that were founded since the original survey as well as companies that existed in 2013 but were not contacted (e.g., USDA 2015). The list was further refined to eliminate companies that were only providers of feedstock or the conversion technology, with no active plans to commercially produce biofuels. The online survey questionnaire (Appendix A) was distributed via email (Appendix B) during July of 2015 to 114 companies with subsequent emails to encourage responses.

We collected information on 45 facilities operated by 34 companies. Nine of the companies operated multiple facilities. Survey responses were obtained directly from 11 companies, and supplemented by research for the 23 remaining companies. Survey responses were screened to ensure that respondents fell within the defined scope of this study as a non-starch ethanol or renewable hydrocarbon biofuels producer planning, developing, owning, or operating a pilot-, demonstration-, or commercial-scale facility in the United States. Projects that had been cancelled or idled without plans for future operations or for which assets had been sold were eliminated.

This screening eliminated 9 projects, resulting in 25 survey responses with sufficient relevance and completeness to justify inclusion in this report. An additional 30 companies were added based on recommendations from subject matter experts from the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) and based on sufficient availability of facility data in the public domain. In all, data were compiled for 61 facilities operated by 49 companies (10 of the companies operated multiple facilities.) Data updates were compiled through early December 2015.

Appendix C provides the list of facilities included in this report and indicates the data source for each facility.

3 Survey Questionnaire

The survey questions (Appendix A) targeted development of a basic understanding of companies and their planned or completed facilities. Requested project details included company information, partnership information, stage of development, facility scale, feedstock, and technology pathway. To facilitate consistency in survey responses, some survey questions required response selection from a pre-defined list. Survey questions requiring response selection from a pre-defined list are summarized in Appendices D–G, along with definitions of the response options.

4 Stages of Biorefinery Development

This report follows a staged development process and groups facilities into pilot-, demonstration- and commercial-scale facilities as defined previously (DOE 2015). We review the definition to be as specific as possible in its application to this report. We will continue to work with BETO to ensure that we are not excluding or including plants that should or shouldn't be included. Typically, a company will select an economically promising feedstock and technology pathway combination and move incrementally up the development scale chain in the following order:

1. Pilot-scale: verifying the integrated technical performance of the selected suite of technologies

2. Demonstration-scale: providing data and equipment specifications for the next development step

3. Commercial-scale: proving economical production at commercial volumes on a continuous basis.

Ultimately, each company will make its own individual choices regarding optimal feedstock throughput rates and scaling strategies for a particular facility, and some of these particular choices might not be fully represented by this report. However, this staged development process allows the project specifics to be vetted at increasing levels of process integration and size, while mitigating project risk and improving a company's confidence in its technology design prior to construction of a large commercial-scale facility. As an expected part of the development process, smaller-scale facilities can eventually become idle (or be repurposed) as the project matures, a facility has served its purpose, and larger-scale facilities are built.

We obtained and validated data from 29 non-starch ethanol facilities (27 cellulosic ethanol facilities plus 2 algal-derived ethanol facilities) and 32 renewable hydrocarbon facilities for use in this survey report. Eleven (3 at the commercial scale) of the 29 non-starch ethanol facilities were operational in 2015, and 12 (2 at the commercial scale) of the 32 renewable hydrocarbon facilities were operational in 2015.

5 Status of Non-Starch Ethanol Biorefineries in the United States

Several U.S. facilities began producing cellulosic ethanol during the 2014/2015 timeframe that resulted in the assignment of a renewable identification number (RIN) (EPA 2014; EPA 2015).

In 2014, about 0.7 million gallons of cellulosic ethanol were produced; as of November, about 2.0 million gallons of cellulosic ethanol were produced in 2015. Table 1 summarizes the U.S. commercial cellulosic ethanol capacity identified during this survey. Eight of the commercial facilities identified in this survey were scheduled to become operational sometime after the end of 2015.

Table 1. Status of Commercial-Scale Cellulosic Ethanol Capacity in the United States at the End of 2015

Company	Project Location	Technology Pathway	Feedstock Category	Capacity [MMGY]	Operational Year [Anticipated]
Abengoa	Hugoton, KS	Biochemical	Crop Residues	23	2015 (idled in 2015)
Ace Ethanol (Sweetwater Energy, Inc.)	Stanley, WI	Biochemical	Corn Kernel Cellulose	3.5	[2017]
Beta Renewables Inc.	Clinton, NC	Biochemical	Dedicated Energy Crops	20	[2017]
Canergy	Brawley, CA	Biochemical	Dedicated Energy Crops	25	[2017]
DuPont	Nevada, IA	Biochemical	Crop Residues	30	2015
Enerkem	Pontotoc, MS	Thermochemical Gasification	Municipal solid waste (MSW)	10	[2020]
Front Range Energy (Sweetwater Energy Inc.)	Windsor, CO	Biochemical	Cellulosic Sugars	3.6	[2017]
INEOS New Planet Bioenergy LLC[a]	Vero Beach, FL	Hybrid Biochemical/Thermochemical	MSW	8	[2016]
Pacific Ethanol (Sweetwater Energy Inc.)	Madera, CA	Biochemical	Corn Kernel Cellulose	3.6	[2017]
POET	Emmetsburg, IA	Biochemical	Crop Residues	25	2015
Quad County Corn	Galva, IA	Biochemical	Corn Kernel Cellulose	3.8	2014
ZeaChem	Boardman, OR	Biochemical	Woody Biomass	22	[2017]

[a] INEOS became operational in 2012 but was idled in 2015 while working on mechanical improvements and was expected to resume operations in 2016.

Figure 1 presents a summary of all the non-starch ethanol facilities included in this report. Two[1] of the 29 non-starch ethanol facilities included in this report was under construction at the end of 2015, with the remainder of the facilities spread across the other stages of development. Ten facilities (four pilot-scale, five demonstration-scale, and one commercial-scale facilities) were reported as idle at the end of 2015. There were various reasons for these facilities being idled. For example, Fiberight's demonstration-scale facility was idled due to the planned commercial facility being refocused on producing other products (e.g., biogas) (Sapp 2015). American Process Inc. shifted demonstration-scale operations to a facility in a different location (Lane 2015b). BP's facility was recently sold as BP divested from biofuels (Lane 2015c).

[1] "Under construction" includes INEOS New Planet Bionenergy that is in the start-up phase, but was idle in 2015.

Scale of the Facility	Company Name Facility Location	Planning	Under Construction	Operating	Idle
Commercial	Abengoa_KS				+
	Ace Ethanol (Sweetwater Energy, Inc.)_WI	✱			
	Beta Renewables Inc._NC		×		
	Canergy_CA	×			
	DuPont_IA			+	
	Enerkem_MS	▽			
	Front Range Energy (Sweetwater Energy Inc.)_CO	○			
	INEOS New Planet Bioenergy LLC_FL		▽		
	Pacific Ethanol (Sweetwater Energy Inc.)_CA	✱			
	POET_IA			+	
	Quad County Corn_IA			✱	
	ZeaChem_OR	△			
Demonstration	American Process Inc._GA			△	
	American Process Inc._MI				△
	BP_LA				×
	DuPont_TN			+	
	Fiberight_VA				▽
	GeoSynFuels_WY				+
	ICM, Inc._MO			✱	
	Joule_NM			□	
	Summit Natural Energy_OR				▽
	ZeaChem_OR			△	
Pilot	Abengoa_NE				+
	Aemetis_MT				×
	Algenol Biofuels Inc._FL			□	
	Archer Daniels Midland_IL				+
	LanzaTech_GA			△	
	Logos Technologies (Edeniq, Inc.)_CA				✱
	POET_SD			+	

Technology Pathway
- Algae (EtOH)
- Biochemical (EtOH)
- Thermochemical Gasification (EtOH)
- Hybrid BC/TC

Feedstock Category
- □ Algae
- + Crop Residues
- △ Woody Biomass
- × Dedicated Energy Crops
- ▽ MSW
- ○ Cellulosic Sugars
- ✱ Corn Kernel Cellulose

Figure 1. Characteristics of the non-starch ethanol facilities included in this survey report

Most of the cellulosic ethanol facilities—23 of 30—used or are planning to use a biochemical technology pathway, with 2 using a thermochemical gasification route, two using a hybrid biochemical/thermochemical technology, and 2 using an algal technology pathway for the direct production of ethanol.

The 23 facilities using a biochemical technology pathway used a range of feedstock materials. Of the 23 biochemical pathway facilities, 7 used crop residues, 4 used woody biomass, 5 used corn kernel cellulose, 4 used dedicated energy crops, 2 used MSW, and 1 facility did not report a specific feedstock beyond cellulosic sugars. The two thermochemical gasification facilities used either woody biomass or MSW as feedstock. Two facilities used a hybrid biochemical/thermochemical pathway: one utilized crop residues and the other MSW as feedstock.

6 Status of Renewable Hydrocarbon Biorefineries in the United States

The total installed U.S. commercial capacity for renewable hydrocarbons at year-end 2015 was approximately 255 million gallons per year. Only 167 million gallons per year of capacity were

operational at the end of 2015. There were two previously producing plants that no longer produce renewable hydrocarbon biofuels at commercial scale. One plant, KiOR, was producing in 2013, but was idled in 2014. Another plant, Renewable Energy Group, Inc. (formerly idled Dynamic Fuels) was in the process of start-up[2] in early 2015 before idling due to a fire. In 2014, only around 5,000 gallons of hydrocarbons from cellulose were produced (EPA 2014); as of September, 0.2 million gallons of hydrocarbons from cellulose were produced in 2015 (EPA 2015). The status of U.S. renewable hydrocarbon capacity as of the end of 2015 is summarized in Table 2.

Table 2. Status of U.S. Commercial-Scale Renewable Hydrocarbon Capacity at the End of 2015

Company	Project Location	Technology Pathway	Feedstock Category	Capacity [MMGY]	Operational Year [Anticipated]
AltAir Fuels	Los Angeles, CA	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	30	2015
Cool Planet Energy Systems[a]	Alexandria, LA	Thermochemical Pyrolysis	Woody Biomass	10	[2017]
Diamond Green Diesel	Norco, LA	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	137	2013
Emerald Biofuels	Plaquemine, LA	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	82	[2017]
Fulcrum BioEnergy	Reno, NV	Thermochemical Gasification	MSW	10	[2017]
KiOR	Columbus, MS	Thermochemical Pyrolysis	Woody Biomass	13	2013 (idled in 2014)
Red Rock Biofuels	Lakeview, OR	Thermochemical Gasification	Woody Biomass	15.5	[2017]
Renewable Energy Group, Inc.	Geismar, LA	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	75	[2016]
SG Preston	South Point, OH	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	120	[2020]
SG Preston	Logansport, IN	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	120	[2020]
Sundrop Fuels	Boyce, LA	Thermochem Gasification	Woody Biomass	200	[2020]

[a] This facility has reportedly been put on hold (Lane 2015d).

Figure 2 summarizes the characteristics of the 32 renewable hydrocarbon facilities included in this survey report and shows the various combinations of technology pathways and feedstocks being pursued at these renewable hydrocarbon facilities. The six feedstock types used across the six technology pathways indicate the diversity of the developing hydrocarbons production capability in the United States.

[2] Classified as "under construction".

Scale of the Facility	Company Name Facility Location	Planning	Under Construction	Operating	Idle
Commercial	AltAir Fuels_CA			✱	
	Cool Planet Energy Systems_LA	△			
	Diamond Green Diesel_LA			✱	
	Emerald Biofuels_LA	✱			
	Fulcrum BioEnergy_NV	▽			
	KiOR_MS				△
	Red Rock Biofuels_OR	△			
	Renewable Energy Group, Inc._LA		✱		
	SG Preston_IN	✱			
	SG Preston_OH	✱			
	Sundrop Fuels_LA	△			
Demonstration	Blue Sun_MO			✱	
	Cool Planet Energy Systems_CA			△	
	Haldor Topsoe, Inc._IA				△
	KiOR_TX				△
	REII_OH				△
	Renewable Energy Group, Inc._FL			○	
	Sundrop Fuels_ND				△
Pilot	Algae Systems_AL				□
	Amyris_CA			○	
	BioProcess Algae_IA			□	
	Envergent Technologies_HI				△
	Frontline BioEnergy, LLC_TX	▽			
	KiOR_TX				△
	Mainstream Engineering Corporation_FL			▽	
	Mercurius Biofuels_ME	+			
	Mississippi State University_MS			△	
	Research Triangle Institute International_NC			△	
	Sundrop Fuels_CO				△
	Thermochem Recovery International_NC			△	
	Versa Renewables LLC_GA			△	
	Virginia Tech_VA				▽

Technology Pathway
- Algae (HC)
- Hydrotreating/Isomerization
- Thermochemical Gasification (HC)
- Thermochemical Pyrolysis
- Biochemical (HC)
- Biochemical Catalytic

Feedstock Category
- □ Algae
- + Crop Residues
- △ Woody Biomass
- ▽ MSW
- ○ Cellulosic Sugars
- ✱ Vegetable Oils, Fats, and Greases

Figure 2. Characteristics of renewable hydrocarbon biofuel facilities included in this survey report

Seven pilot-scale facilities were identified as operational and two as in the planning stage of development. Four of the seven operational pilot-scale facilities used a thermochemical pyrolysis technology. At the demonstration-scale, three facilities were operational (each with a different technology pathway and feedstock combination), but none was currently under construction. At the commercial scale, two facilities were operational, both using the hydrotreating/isomerization technology on vegetable oils, fats, and greases. The survey documented five pilot, four demonstration, and one commercial facilities that were idle at the end of 2015. The one under construction plant is an idled commercial plant that is projected to resume operations in 2016 (The Associated Press 2015). Four of these 10 idle facilities used the thermochemical gasification technology pathway, and 5 of the 10 idle facilities used the thermochemical pyrolysis technology. Development of these technology pathways still continues at other facilities. Most of the thermochemical gasification and pyrolysis facilities used woody biomass

as feedstock, with four facilities planning to use MSW. The two operational hydrotreating/isomerization commercial facilities used vegetable oils, fats, and greases as feedstock.

7 Future Directions

The purpose of this survey report is to document the status of the non-starch ethanol and renewable hydrocarbon biofuels industry in the United States and provide perspective on the development of this industry over time. Future improvements will focus on ensuring all existing and new facilities and companies are identified, expanding outreach to obtain information directly from company sources, and expanding the type of data gathered on each facility. We welcome feedback and suggestions and especially appreciate information from companies currently represented as well as companies that were not included in this report.

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Appendix A: Survey Questionnaire

Welcome to the 2015 Biorefinery Survey

The National Renewable Energy Laboratory, for the United States Department of Energy, is gathering information on the status of the advanced biofuels industry as it existed at the beginning of calendar year 2015. This survey is being sent to existing or planned biorefinery projects involved with the production of biofuels and chemicals from cellulosic or algal biomass. The information gathered during this survey will be compiled and published in an annual update to the inaugural 2013 Biorefinery Survey Report. At the end of the survey, you will have the option to request a copy of the updated survey report when it is published.

This survey asks general information about each biorefinery project, its status, and direct jobs being created. It also asks about feedstock choices and capacity, conversion technologies, and products produced. Additionally, it includes questions regarding piloting or demonstration experience for the utilized technologies. Finally, it includes questions regarding commercial-scale activities.

Your participation will help inform policy-makers and other stakeholders on industry choices and direction. Your feedback is essential to establishing a complete and accurate inventory of the industry. If you are aware of other current or planned projects that should be included in this survey, please send this https://www.surveymonkey.com/s/2015BiorefinerySurvey link to the appropriate contacts.

We appreciate your taking the time to provide thorough information, and thank you for participating in our survey.

Respondent Contact Information

Contact information will only be used to follow up on your responses. This information will not be published with the report and will not be used for any other purpose.

* 1. Who is completing this survey?

Name

Company

Job Title

Email Address

Phone Number

* 2. Was this company operating, constructing or actively planning construction of a cellulosic or algal biomass biorefinery at any scale (e.g., pilot, demonstration, pioneer, commercial) as of January 1, 2015?

Company Information

* 3. What is the name of the company developing/operating the biorefinery?

* 4. Where is your company currently headquartered?

City

State

Country

5. What is the web address (URL) for your company's website?

Biorefinery Information

* 6. What is the scale of the biorefinery?

If "Other" scale, please describe the scale of this biorefinery.

* 7. What was the operational status of the biorefinery on January 1, 2015?

8. When did/will the biorefinery become operational?

	MM	DD	YYYY
Date	/	/	

9. Where is the biorefinery located?

City

State

Country

10. How many temporary jobs (full-time equivalents including construction jobs and contractors not expected to continue into operations, but excluding consultants) does the project currently support (or has supported)?

11. How many permanent jobs will the project directly support when fully operational? (full-time equivalents)

12. Did ownership of this biorefinery change during calendar year 2014?

If yes, please describe the conditions that led to the change in ownership.

Conversion Technology

* 13. What type of conversion technology does your biorefinery use?

- ○ Hydrolysis with fermentation (biochemical)
- ○ Hydrolysis with catalytic upgrading
- ○ Direct liquefaction (e.g., pyrolysis, hydrothermal liquefaction)
- ○ Indirect liquefaction (e.g., gasification)
- ○ Algae technology
- ○ Hydroprocessed esters and fatty acids (HEFA)
- ○ Other (please specify)

Biorefinery Feedstocks

* 14. What types of feedstock does the biorefinery use?

	Feedstock Category
Primary Feedstock	
Alternate Feedstock 1	

Alternate Feedstock 2	
Alternate Feedstock 3	

Other (please specify)

15. What is the feedstock capacity of the biorefinery?

Capacity

Units (e.g., bone dry tons / day)

Biorefinery Primary Product

Based on volume, what is the primary product being produced?

* 16. What is the primary product category produced by the biorefinery?

- ○ Biofuels
- ○ Bioproducts

17. What type(s) of product does your biorefinery produce?

- ○ Ethanol
- ○ Gasoline, diesel, or jet fuel
- ○ Bio-butanol

Other product (please specify)

18. Did production of the primary product result in the assignment of any Renewable Identification Numbers (RINs) in 2014?

19. What is the facility's production capacity for the primary product?

Capacity

Capacity units (million gallons per year [MMGY] or specify other units)

20. Was the primary product sold commercially during 2014? If so, how much was sold?

Was primary product sold (Y/N)?

Quantity sold

Quantity units ([MMG] or specify other units)

Biorefinery Secondary Product

Based on volume, what is the secondary product being produced

21. Is there a secondary product being produced?

○ Yes

○ No

22. What is the secondary product produced by the biorefinery?

23. Did production of the secondary product result in the assignment of any Renewable Identification Numbers (RINs) in 2014?

24. What is the facility's production capacity for the secondary product?

Capacity

Capacity Units (million gallons per year [MMGY] or specify other units)

25. Was the secondary product sold commercially during 2014? If so, how much was sold?

Was secondary product sold (Y/N)?

Quantity sold

Quantity units ([MMGY] or specify other units)

Other Biorefinery Products (if any)

If any, what other products are produced by the biorefinery?

26. Are there other products to be produced other than the primary or secondary products?

27. What other product(s) are being produced?

28. What is the facility's production capacity for other product(s)?

Capacity

Capacity units (million gallons per year [MMGY] or specify other units)

29. Were other products sold commercially during 2014? If so, how much was sold?

Was other product sold (Y/N)?

Quantity sold

Quantity units ([MMGY] or specify other units)

If Facility Larger than Pilot

30. Was this technology piloted? (A pilot-scale facility is defined as one that verifies technical performance for a given suite of technologies from feedstock in through product out.)

- ○ Yes
- ○ No

31. Owner or name of pilot project

32. Location of pilot project

City

State

Country

33. What was the feedstock capacity of the pilot facility?

Capacity

Units (e.g., [bone dry tons/day] or specify other units)

34. What types of feedstock did the pilot facility use?

	Feedstock Category
Primary Feedstock	
Alternate Feedstock 1	

Alternate Feedstock 2	
Alternate Feedstock 3	

Other (please specify)

For Pioneer- or Commercial-Scale Biorefineries

35. Have you operated a demonstration-scale facility? (Demonstration facilities are typically between one-fiftieth and one-tenth of the scale for a first-of-a-kind commercial facility.)

- ○ Yes
- ○ No

36. Owner or project name

37. Location of demonstration-scale facility

City	
State	
Country	

38. What was the feedstock capacity of the demonstration-scale facility?

Capacity	
Units (e.g., dry tons / day or specify other units)	

39. What types of feedstock did the demonstration-scale facility use?

	Feedstock Category
Primary Feedstock	
Alternate Feedstock 1	
Alternate Feedstock 2	
Alternate Feedstock 3	

Other (please specify)

For Commercial-Scale Biorefineries

40. Have you operated a first-of-a-kind pioneer facility? (A pioneer facility is defined as a first-of-a-kind biorefinery for the company proving production at commercial volumes on a continuous basis.)

○ Yes

○ No

41. Location of pioneer facility

City

State

Country

42. What was the feedstock capacity of the pioneer facility?

Capacity

Units (e.g., dry tons / day or specify other units)

43. What types of feedstock did the pioneer facility use?

	Feedstock Category
Primary Feedstock	
Alternate Feedstock 1	
Alternate Feedstock 2	
Alternate Feedstock 3	

Other (please specify)

Additional Commercial-Scale Biorefineries

* 44. Is your company actively planning additional commercial-scale biorefineries?

45. If multiple commercial-scale biorefineries are planned, where are the selected or anticipated locations?

Commercial Facility 1 Location

Commercial Facility 2 Location

Commercial Facility 3 Location

Commercial Facility 4 Location

Commercial Facility 5 Location

46. If additional commercial scale biorefineries are planned, what are the characteristics of these biorefineries?

	Anticipated Operational Start Year	Feedstock	Production Capacity
Commercial Facility 1			
Commercial Facility 2			
Commercial Facility 3			
Commercial Facility 4			
Commercial Facility 5			

Other Commercial Facility Comments (please specify)

Request Notification When Survey Results Are Available

Thank you again for taking the time to contribute to this survey. If you have questions, suggestions, or other comments about this survey please contact John Lewis at NREL at 303-275-3021 or john.lewis@nrel.gov.

47. Please indicate here if you would like to receive email notification when an updated version of the Biorefinery Survey Report is available online.

- ○ Yes, please notify me.
- ○ No, thanks.

Appendix B: Email Text Accompanying Survey Questionnaire

We're conducting a survey and your input would be greatly appreciated. Click the button below to start the survey.

We are conducting an inventory of cellulosic and algal biorefineries and biorefinery projects that were underway in 2015. While our primary focus is on U.S.-based projects, we are also tracking projects in other countries. The results of this survey will be compiled into a report to be used by policymakers and industry stakeholders.

Please click the button below to complete the short survey about your company's biorefinery project(s). If you feel there are others who are better qualified to respond to this survey, please forward this email to them or email their contact information to john.lewis@nrel.gov.

At the end of the survey, you will have the opportunity to request a copy of final survey results. If you have any questions about the survey, please contact John Lewis at the National Renewable Energy Laboratory at 303-275-3021.

Thank you in advance for your participation!

Begin Survey

Appendix C: Facilities, Data Sources Included in Report, and Changes Since the 2013 Survey

Company	Facility Location (State)	Ethanol	Hydrocarbon	Developments since the 2013 Survey
Abengoa	KS	x†		now idle
Abengoa	NE	x		N/A - new data
Ace Ethanol (Sweetwater Energy, Inc.)	WI	x*		N/A - new data
Aemetis	MT	x*		N/A - new data
Algae Systems	AL		x*	N/A - new data
Algenol Biofuels Inc.	FL	x		no change
AltAir Fuels	CA		x*	N/A - new data
American Process Inc.	MI	x†		now idle
American Process Inc.	GA	X		N/A - new data
Beta Renewables Inc.	NC	x†		no change
Amyris	CA		x	N/A - new data
Archer Daniels Midland	IL	x†		now idle
BioProcess Algae	IA		x*	now operational
Blue Sun	MO		x*	N/A - new data
BP	LA	x*		now idle
Canergy	CA	x*		no change
Cool Planet Energy Systems	LA		x†	no change
Cool Planet Energy Systems	CA		x†	no change
Diamond Green Diesel	LA		x†	now operational
DuPont	IA	x†		now operational
DuPont	TN	x		no change
Emerald Biofuels	LA		x*	N/A - new data
Enerkem	MS	x†		N/A - new data
Envergent Technologies	HI		x†	reclassified as pilot-scale for this report
Fiberight	VA	x		reclassified as demonstration-scale for this report
Frontline BioEnergy, LLC	TX		x†	no change
Front Range Energy (Sweetwater Energy Inc.)	CO	x*		N/A - new data
Fulcrum BioEnergy	NV		x*	N/A - new data
GeoSynFuels	WY	x*		N/A - new data
Haldor Topsoe, Inc.	IA		x	reclassified as demonstration-scale for this report
ICM, Inc.	MO	x		reclassified as demonstration-scale for this report
INEOS New Planet Bioenergy LLC	FL	x		will resume operating in 2016
Joule	NM	x*		N/A - new data
KiOR	MS		x*	now idle
KiOR (demo)	TX		x*	N/A - new data
KiOR (pilot)	TX		x*	N/A - new data
LanzaTech	GA	x		now operational
Logos Technologies (Edeniq, Inc.)	CA	x		no change
Mainstream Engineering Corporation	FL		x*	N/A - new data
Mercurius Biofuels	ME		x	no change
Mississippi State University	MS		x*	N/A - new data
Pacific Ethanol (Sweetwater Energy Inc.)	CA	x*		N/A - new data
POET	IA	x		now operational
POET	SD	x		no change
Quad County Corn	IA	x*		N/A - new data
Red Rock Biofuels	OR		x*	N/A - new data
REII	OH		x	now idle
Renewable Energy Group, Inc.	LA		x†	formerly Dynamic Fuels, LLC, will resume operating in 2016
Renewable Energy Group, Inc.	FL		x*	N/A - new data
RTI International	NC		x*	N/A - new data
SG Preston	OH		x*	N/A - new data
SG Preston	IN		x*	N/A – new data
Summit Natural Energy	OR	x*		N/A - new data

Company	Facility Location (State)	Ethanol	Hydrocarbon	Developments since the 2013 Survey
Sundrop Fuels	LA		x†	no change
Sundrop Fuels	CO		x	no change
Sundrop Fuels	ND		x	no change
Thermochem Recovery Institute	NC		x*	N/A - new data
Versa Renewables LLC	GA		x*	N/A - new data
Virginia Tech	VA		x*	N/A - new data
ZeaChem	OR	x*		N/A - new data
ZeaChem	OR	x*		now operational
Included in the previous 2013 survey but now excluded in the 2015 survey:				
Arkenol	NV	x†		reclassified as bench scale
BlueFire Renewables	MS	x		now cancelled
Coskata	PA	x*		now defunct
Fiberight	IA	x		now focused on biogas
Lignol Innovations	CO	x		now cancelled
Mascoma	MI	x		now cancelled
Origin Oil	CA		x	now cancelled
Red Shield Acquisition, LLC	ME	x		now defunct
Renmatix	NY			formerly Mascoma, now focused on bioproducts
Rentech	CO		x	now defunct
Sapphire Energy	NM			now focused on bioproducts

Definitions: Cancelled: The project was previously in planning or construction stages but since the 2013 survey has been cancelled. Defunct: The facility existed at one point but has since been divested.
Notes: N/A = not applicable. * Indicates company did not respond to the survey but sufficient facility data was collected from public sources (company websites, press releases, and/or public filings) to include in this report.
† Indicates survey data for this facility was supplemented with data from a public website.

Appendix D: Survey Response Options and Definitions for Stage of Facility Development

Category	Response Selections— Definitions
Stage of Development	**Planning:** Ground has not been broken for construction. However, one or more of the following activities has occurred: a facility location has been selected, project financing negotiations have started, and/or permits have been obtained for a specific site. **Under Construction:** Ground breaking at the selected site has occurred, and the facility is under construction. This includes facilities undergoing startup and commissioning. **Operating:** The facility is currently producing fuel and/or conducting development work on a regular basis. **Idle:** The facility is no longer producing fuels but was producing at one point. Possible reasons for an idle facility include unfavorable market conditions, completion of a development period, or project bankruptcy.

Appendix E: Survey Response Options and Definitions for Scale of Facility

Category	Response Selections— Definitions
Scale of Facility	**Pilot:** Small-scale facility with unit operations integrated; primarily used for research and development work. **Demonstration:** Small-scale, fully integrated facility used for determining design specifications for a larger facility. **Commercial:** First-of-a-kind or subsequent full-scale facility for commercial production of fuel products.

Appendix F: Survey Response Options and Definitions for Type of Technology Pathway

Category	Response Selections— Definitions
Type of Technology Pathway	**Algae Tech:** Broad category of technology pathways that involve using algae to a produce a fuel product. **Biochemical:** Chemical or enzymatic conversion of biomass to cellulose, which is then fermented or reacted to a fuel product. **Biochemical Catalytic:** Conversion of a solubilized carbohydrate stream to a fuel product utilizing a catalytic conversion route. **Hybrid BC/TC:** Using a combination of the biochemical and thermochemical technology pathways to produce a fuel product. **Hydrotreating/Isomerization:** Conversion of organic material using hydrogen at elevated temperature and pressure levels often in the presence of a catalyst. **Thermochemical Gasification:** The thermal conversion of organic material to a syngas that is catalytically converted into a fuel product. **Thermochemical Pyrolysis:** The thermal conversion of organic material to an intermediate oil that is further refined into a fuel product.

Appendix G: Survey Response Options and Definitions for Feedstock Category

Category	Response Selections— Definitions
Feedstock Category	**Algae:** A large, aquatic group of simple plant-like photosynthetic organisms—from microscopic cyanobacteria to giant seaweed. **Cellulosic Sugars:** Sugars derived from non-food biomass such as wood, biomass residues, and grasses. **Corn Kernel Cellulose:** Fibrous cellulose remaining after corn grain ethanol production in a dry mill **Crop Residues:** Crop residues are divided into two sub-categories: harvesting crop residues and processing crop residues. Harvesting crop residues are materials such as leaves, stalks, and straw left on the field after crop harvesting. Processing crop residues remain after the crop has been processed into a primary product and include materials such as husks and bagasse. **Dedicated Energy Crops:** Dedicated energy crops are specifically grown for bioenergy production and include herbaceous and woody resources. **Municipal Solid Waste (MSW):** The term refers to solid wastes from residential and business sources that are then converted to produce biofuels and/or electricity. Yard trimmings are a subcategory of MSW and include grass clippings, leaves, and tree/brush trimmings. **Vegetable Oils, Fats, and Greases:** Lipid-based feedstock that has historically been used to produce biodiesel, but is emerging as a feedstock for renewable hydrocarbon fuels production. **Woody Biomass:** A broad category capturing forest logging residues, mill residues, and other woody waste sources.