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2013 Survey of Non-Starch Ethanol and Renewable Hydrocarbon Biofuels Producers

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NREL is a national laboratory of the U.S. Department of Energy
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Technical Report
NREL/TP- 6A10-63389
January 2015

Contract No. DE-AC36-08GO28308

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Prepared under Task No. BZ14.3008

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Acronyms

BC	biochemical
BC/TC	hybrid biochemical/thermochemical
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection 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

Abstract

In order to understand the status of the industry for non-starch ethanol and renewable hydrocarbon biofuels as of the end of calendar year 2013, the National Renewable Energy Laboratory (NREL) conducted the first of what is anticipated to be an annual survey of U.S. non-starch ethanol and renewable hydrocarbon biofuels producers. This report presents the results of this initial survey and describes the survey methodology. Subsequent surveys will report on the progress over time of the development of these facilities and companies.

Seventy-four companies were selected because of their reported commercial-scale biofuels production capacity (or intentions of developing commercial-scale production capacity) as of December 31, 2013. Representatives from these companies were asked a standard set of questions during the second half of 2014. The questionnaire topics included facility stage of development, facility scale, feedstock, and biofuel products. The responses were validated by industry experts from NREL and the U.S. Department of Energy (DOE) and compared with publicly available data. Missing survey data elements were supplemented (when possible) with publicly available data obtained directly from company websites, press releases, and public filings. Sufficient data from 25 non-starch ethanol facilities (24 cellulosic ethanol facilities plus one algal-derived ethanol facility) and 17 renewable hydrocarbon facilities (for production of cellulosic renewable gasoline and/or cellulosic diesel) were obtained and validated to justify inclusion of these facilities in this survey report. Data for these 42 facilities were included in this report.

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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 2013; *Biofuels Digest* 2014; British Petroleum 2014; PricewaterhouseCoopers LLP 2014). This survey report is distinguished from these other data compilations in that it provides a publically 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 2013.

2 Methodology

An initial list of 86 company names was compiled from the Biofuels Digest SuperData Access Service (*Biofuels Digest* 2014), which lists companies active in the biofuels sector. This initial list of potential survey recipients was downselected to 74 companies by excluding companies that were only feedstock or technology providers, with no active plans to commercially produce biofuels. The survey questionnaire (Appendix A) was distributed during the spring of 2014 to the 74 identified companies via email (Appendix B), with subsequent follow-up phone calls to each survey recipient to encourage timely and accurate responses. Participation in this survey was completely voluntary, and represents a bottom-up data-collection to estimate the status of non-starch ethanol and renewable hydrocarbon producers in the United States at the end of 2013.

At the conclusion of this survey effort, 37 survey responses were received; representing 37 facilities operated by 31 companies (five of the companies operated multiple facilities). This represents a survey response rate of 42% from the companies contacted. Future surveys will focus on increasing the survey response rate to capture a more complete inventory of U.S. facilities. Survey responses were vetted to ensure that the facility fell within the defined scope of this study as a non-starch ethanol or renewable hydrocarbon biofuels producer with commercial intentions in the United States. Based on this vetting process, four of the survey responses were determined not relevant to the stated scope of the survey (specifically, the respondent had no plans to commercially produce or the production facility was not located in the United States). This resulted in 33 survey responses with sufficient relevance and completeness to justify inclusion in this report. Data for an additional nine non-responding facilities were added to the final data compilation, based on knowledge of their existence by experts at the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) and relevance to this report, as well as sufficient availability of facility data in the public domain. In all, data for 42 facilities were included in the final data compilation used to produce this report.

Some survey data elements were provided by companies under the provision that these data elements would not be presented publicly. Thus, these sensitive survey data elements were omitted from the results presented in this report. Appendix C provides the final list of facilities included in this report and indicates the data source for each facility.

3 Survey Questionnaire

The survey questions (Appendix A) target 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 2014). Typically, a company will select an economically promising feedstock and technology pathway combination and move incrementally up the development scale chain, from the pilot scale verifying the integrated technical performance of the selected suite of technologies, to the demonstration scale providing data and equipment specifications for the next development step and eventually to the 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 may 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 thus improving a company's confidence in their technology design for a commercially viable solution by the time the large, commercial-scale facility is constructed. As a natural part of the development process, the smaller scale facilities may eventually become idle (or be repurposed) as the project matures, a facility has served its purpose, and larger scale facilities are built.

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

No U.S. facilities produced cellulosic ethanol during 2013 that resulted in the assignment of a renewable identification number (RIN) (EPA 2013). Table 1 summarizes the U.S. commercial cellulosic ethanol capacity identified during this survey. Four of the commercial facilities identified in this survey were scheduled to become operational sometime after the end of 2013. As shown in Table 1, the INEOS facility entered service in 2012; however, it did not produce any cellulosic ethanol that resulted in RINs during 2013. For the purposes of this report, this INEOS facility was classified as still under construction during 2013 as the facility underwent modifications and upgrades (INEOS 2013).

Table 1. Status of Commercial-Scale Cellulosic Ethanol Capacity in the United States at the End of 2013

Company	Project Location	Technology Pathway	Feedstock Category	Capacity [MMGY]	Operational Year (Anticipated)
Abengoa	Hugoton, KS	Biochemical	Crop Residues	24	(2014)
Beta Renewables, Inc.	Clinton, NC	Biochemical	Dedicated Energy Crops	20	(2016)
DuPont	Nevada, IA	Biochemical	Crop Residues	30	(2014)
INEOS New Planet Bioenergy LLC	Vero Beach, FL	Thermochemical Gasification	Vegetative and Yard Wastes	8	2012
POET Design & Construction	Emmetsburg, IA	Biochemical	Crop Residues	22.5	(2014)

Figure 1 presents a summary of all the non-starch ethanol facilities included in this report. Nine of the 25 non-starch ethanol facilities included in this report were under construction at the end of 2013, with the remainder of the facilities spread across the other stages of development. It was observed that five of the facilities (three pilot-scale facilities and two demonstration-scale facilities) were reported as idle at the end of 2013. Insufficient information was gathered during this survey to determine why these particular facilities were idle at the end of 2013. Documenting the reasons behind companies idling particular facilities will be probed more thoroughly during the next survey.

Scale of Facility	Company Name_Facility Location	Planning	Under Construction	Operating	Idle
Commercial	Abengoa_KS		+		
	Beta Renewables_NC		×		
	BlueFire Renewables, Inc._MS	△			
	Canergy, LLC_CA	×			
	DuPont_IA		+		
	Fiberight_IA	◇			
	INEOS New Planet BioEnergy LLC_FL		◇		
	Mascoma_MI	△			
	POET Design & Construction_IA		+		
Demonstration	American Process Inc_MI		△		
	BP_LA			×	
	Coskata_PA				△
	DuPont_TN			+	
	Lignol Innovations_Undisclosed	△			
	Mascoma_NY				△
	RSA d/b/a Old Town Fuel & Fiber_ME	△			
	ZeaChem_OR			△	
Pilot	Algenol Biofuels Inc._FL		□		
	Archer Daniels Midland_IL		+		
	Arkenol_CA				△
	Fiberight_VA				◇
	ICM, Inc._MO			*	
	LanzaTech_GA		△		
	Logos Technologies_CA				+
	POET Design & Construction_SD			○	

Technology Pathway
- Algae Tech
- Biochemical
- Hybrid BC/TC
- Thermochemical Gasification

Feedstock Category
- ○ Not Reported
- □ Algae
- \+ Crop Residues
- × Dedicated Energy Crops
- * Herbaceous Mix
- ◇ Vegetative and Yard Waste
- △ Woody Biomass

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

Most of the cellulosic ethanol facilities—20 of 25—use or will use a biochemical technology pathway, with three using a thermochemical gasification route, one using a hybrid biochemical/thermochemical technology, and one using an algal technology pathway for the direct production of ethanol.

The 20 facilities using a biochemical technology pathway used a range of feedstock materials. Of the 20 biochemical pathway facilities, eight facilities were using woody biomass, five were using crop residues, three were using dedicated energy crops, two were using vegetative and yard waste, one was using an herbaceous mix, and one facility did not report a specific feedstock. The three thermochemical gasification facilities used either woody biomass (two facilities) or vegetative and yard waste (one facility) as feedstock. The one facility using a hybrid biochemical/thermochemical pathway utilized crop residues as feedstock.

6 Status of Renewable Hydrocarbon Biorefineries in the United States

As of the end of 2013, there was only one plant (the KiOR facility in Mississippi) producing renewable hydrocarbon biofuels at commercial scale; however, this plant was subsequently idled in 2014. The total installed U.S. commercial capacity for renewable hydrocarbons at year-end 2013 was approximately 224 million gallons per year; however, only 13 million gallons per year of capacity was operational at the end of 2013 and only 514,627 gallons were produced in 2013 (EPA 2013). The status of U.S. renewable hydrocarbon capacity as of the end of 2013 is summarized in Table 2.

Table 2. Status of U.S. Commercial-Scale Renewable Hydrocarbon Capacity at the End of 2013

Company	Project Location	Technology Pathway	Feedstock Category	Capacity [MMGY]	Operational Year (Anticipated)
Diamond Green Diesel	Norco, LA	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	136	(2014)
Dynamic Fuels, LLC	Geismar, LA	Hydrotreating/ Isomerization	Vegetable Oils, Fats, and Greases	75	2010 [Idle in 2013]
KiOR	Columbus, MS	Thermochemical Pyrolysis	Woody Biomass	13	2013 [Idled in 2014]

Figure 2 summarizes the characteristics of the 17 renewable hydrocarbon facilities included in this survey report. Figure 2 shows the various combinations of technology pathways and feedstock being pursued at these renewable hydrocarbon facilities. The six feedstock types used across the four technology pathways indicate the diversity of the developing hydrocarbons production capability in the United States.

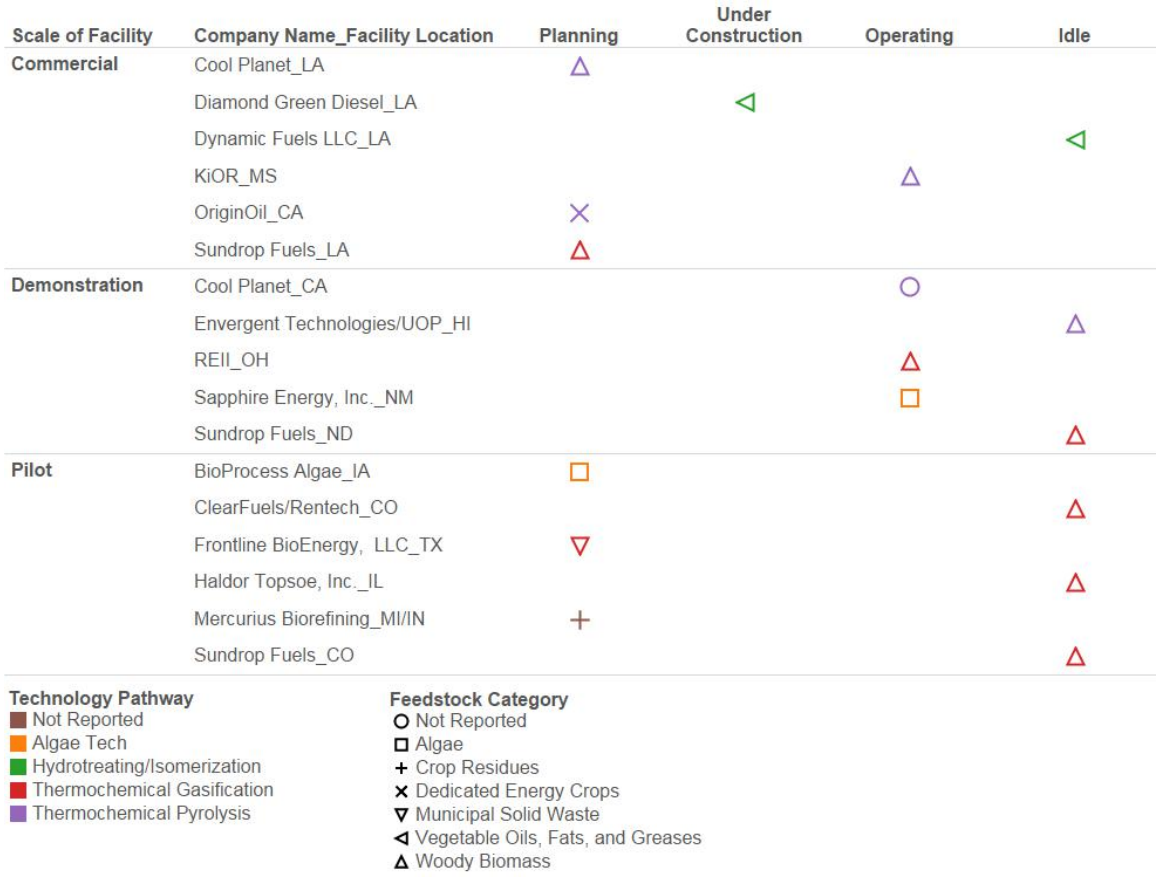

Figure 2. Characteristics of renewable hydrocarbon biofuel facilities included in this survey report

No pilot-scale facilities were identified as operating or under construction—though three pilot facilities were in the planning stage of development. At the demonstration scale, three facilities were operating (each with a different technology pathway and feedstock combination), but none were currently under construction. The survey documented three pilot, two demonstration, and one commercial facility that were idle at the end of 2013. Four of these six idle facilities used the thermochemical gasification technology pathway, but development of this technology pathway still continues at other facilities. All of the thermochemical gasification facilities used woody biomass as feedstock, with the exception of the Frontline BioEnergy facility, which plans to use municipal solid waste (MSW). The two hydrotreating/isomerization commercial facilities were using 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, as it existed at the end of 2013. This initial report is intended to provide an industry baseline upon which future bottom-up data-collection efforts can build upon to examine industry trends over time.

In this initial effort, we have identified a number of areas for improving the questionnaire by better clarifying the questions and defining terms, expanding the outreach to additional recipients, and improving validation techniques for vetting responses. In future surveys, we intend to update and refine the questionnaire, reach out to more biofuels companies, and welcome feedback from those companies currently represented as well as companies that were not included in this initial survey report.

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Appendix A: Survey Questionnaire

Date:	Time:
Company Information:	
Company name?	
Company location?	
Project owner?	
Partnership Information	
What is your interest in partnering with other companies in the biofuels industry? (50 words or less)	
Please describe your facility capabilities offered for partnership: (50 words or less)	
Partnership Business Contact	
Contact Name	
Contact Phone #	
Contact Email	
Project Information (as of 12/31/2013)	
Was the company a part of a biofuels refinery project that was ongoing on 12/31/13? Yes/No?	
Project name?	
Project location?	
Completion of Commissioning and Shakedown Date (planned or actual)?	
Stage of Development?	(Select One)
Refinery Products:	
Primary Product	
By-Products	
Refinery Capacity	
Scale of Facility?	(Select One)
If larger than pilot:	
Have you piloted the technology?	
Location	
Capacity [tons feed/day]	
Timeframe	
Owner or Project Name?	
If pioneer or commercial:	
Have you operated a demonstration or pilot scale facility?	
Location	
Capacity [tons feed/day]	
Timeframe	
Owner or Project Name?	
Type of Technology Pathway?	
Description:	
Binning	(Select one)
Feedstock Category?	
Description:	
Type:	(Select One)

Appendix B: Email Text Accompanying Survey Questionnaire

Dear [Recipient],

We are compiling public information on cellulosic biorefineries for the ***Department of Energy's Bioenergy Technologies Office's Market Assessment report.*** This report will provide a status of the biofuels market as of December 31, 2013. Your DOE Project Officers are aware of this effort and seeking your participation. We appreciate your help in creating a complete and accurate assessment of the state of the development of the biofuels industry.

We are also building a ***Biomass Industry Partnership website*** for companies to openly offer and seek matching partners. This will help companies match up with other interested companies and will improve DOE funding opportunities.

Attached is a short survey questionnaire regarding your biorefinery project and your interest in partnerships. Would you please complete this information and return to me by May 2, 2014 at [email link].

Please let me know if you prefer me to contact someone else at your organization for this information.

We hope that establishing a current, complete and accurate status of the biofuels industry will assist in positive decision making by all stakeholders, from policy-makers to investors. Thank you in advance for your help!

Appendix C: Facilities and Data Sources Included in Report

Company	Facility Location (State)	Ethanol Facility	Renewable Hydrocarbon Facility
Abengoa	KS	x*	
Algenol Biofuels Inc.	FL	x	
American Process Inc.	MI	x	
Archer Daniels Midland	IL	x	
Arkenol	CA	x†	
Beta Renewables	NC	x	
BioProcess Algae	IA		x
BlueFire Renewables, Inc.	MS	x	
BP	LA	x*	
Canergy, LLC	CA	x	
ClearFuels/Rentech	CO		x
Cool Planet	CA		x
	LA		x
Coskata	PA	x*	
Diamond Green Diesel	LA		x*
DuPont	IA	x	
	TN	x	
Dynamic Fuels LLC	LA		x
Envergent Technologies/UOP	HI		x
Fiberight	IA	x*	
	VA	x*	
Frontline BioEnergy, LLC	TX		x
Haldor Topsoe, Inc.	IL		x
ICM, Inc.	MO	x	
INEOS New Planet BioEnergy LLC	FL	x	
KiOR	MS		x*
LanzaTech	GA	x*	
Lignol Innovations	(Undisclosed)	x	
Logos Technologies	CA	x	
Mascoma	MI	x	
	NY	x	
Mercurius Biorefining	MI/IN		x
OriginOil	CA		x
POET Design & Construction	IA	x	
	SD	x	
RSA d/b/a Old Town Fuel & Fiber	ME	x	
REII	OH		x
Sapphire Energy, Inc.	NM		x
Sundrop Fuels	CO		x
	LA		x
	ND		x
ZeaChem	OR	x*	

* 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. **Operational:** 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. **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. **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. **Herbaceous Mix:** A mixture of herbaceous residues. **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. **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. **Vegetative and Yard Waste:** Yard trimmings are a subcategory of MSW and include grass clippings, leaves, and tree/brush trimmings. **Woody Biomass:** A broad category capturing forest logging residues, mill residues, and other woody waste sources.