Cellulosic biofuel is a liquid fuel or feedstock produced from lignocellulose, a structural material that comprises much of the mass of plants, including grasses, wood and municipal/agricultural waste.

Most companies use some combination of heat (including gasification), enzymes and chemicals to break down complex cellulosic materials into simple sugars (for fermentation into ethanol) and other marketable products such as bio-crude and renewable power.

According to the Sandia National Lab, the U.S. could produce 75 billion gallons per year of cellulosic biofuels without displacing food and feed crops (the U.S. consumed ~134 billion gallons of gasoline in 2011). The U.S. advanced biofuels industry is ramping up to compete in the $2.5 trillion global clean energy marketplace. Compliance with the federal Renewable Fuel Standard (RFS) is forecasted to create up to 800,000 jobs by 2022.

The RFS was amended to include cellulosic biofuels just 5 years ago. Despite the global recession, the cellulosic biofuels industry now has facilities and projects under development in more than 20 U.S. states representing billions of dollars in private investment. Enzyme costs are down 80% in the last decade, and cellulosic biofuels are being produced for $2.00 per gallon or less today. The cellulosic biofuels industry has reached the commercial deployment phase. However, high capital risk from OPEC-induced price distortions, constrained blending markets and policy uncertainty continues to slow the rate of deployment. The federal policies that put the United States at the global forefront of the development of the cellulosic biofuels industry are at risk. How U.S. policymakers address these challenges will determine whether the country leads or falls behind in the global race to produce next generation bio-based fuels and products.

Disclaimer: This report provides a commercial deployment update for a number of first movers in the cellulosic biofuels sector. The report does not profile all cellulosic biofuel projects under development in the U.S. and abroad, and does not cover other advanced biofuel sectors.
Abengoa Bioenergy Partners

Private Equity: Abengoa Bioenergy equity

Strategic: None; contracted with professional biomass harvesting and removal firms


The Abengoa Bioenergy Hugoton Biorefinery will utilize the company’s proprietary technology to produce 25 million gallons of cellulosic ethanol per year. The plant will utilize approximately 1,100 dry tons of agricultural waste per day for the ethanol production process. The residue of that process (approximately 300 tons per day of lignin) will be combusted to produce 20 megawatts of electricity. This will allow the facility to be fueled entirely by biomass.

Abengoa Bioenergy is a worldwide leader in the development of biofuels for transportation, as well as in chemical bioproducts which use biomass as raw material. Abengoa Bioenergy owns and operates 14 bioethanol facilities throughout the United States, Europe and Brazil with a total production capacity of 842 million gallons per year.

PILOT FACILITY
LOCATION: York, NE
FEEDSTOCK: Wheat Straw, Corn Stover
PRODUCTS: Cellulosic Ethanol
CAPACITY: 20,000 GPY
PLANT PROFILE: Completed and first cellulosic ethanol produced in September 2007

DEMONSTRATION FACILITY
LOCATION: Salamanca, Spain
FEEDSTOCK: Wheat and barley straw
PRODUCTS: Cellulosic Ethanol
CAPACITY: 1.3 MGy
PLANT PROFILE: Construction completed and first cellulosic ethanol produced in 2009.

COMMERCIAL FACILITY
LOCATION: Hugoton, KS
STATUS: Under construction
FEEDSTOCK: Agriculture residues, dedicated energy crops, prairie grasses
PRODUCTS: Cellulosic ethanol, 20 MW renewable electric power
CAPACITY: 25 MGy
JOBS: 300 construction; 65 operations; 120 external biomass procurement
PROJECT PROFILE: Construction started September 2011; will utilize proprietary enzymatic hydrolysis technology; 1,100 dry tons per day feedstock; construction complete December 2013, awarded $133MM EPAct 2005 loan guarantee.

COMPLETED 2013

ABENGOA BIOENERGY

PATH TO COMMERCIAL DEPLOYMENT


2003-07

2008

2009

2010

2011

2012

2013

2014

Signed Cooperative Agreement with DOE to license pilot plant for commercialization of a biomass derived process technology (’03)
Completed construction of U.S. pilot plant in York, NE (’07)
Produced first U.S. gal. of cellulosic ethanol (’07)
DOE: $31MM Sec. 932 cost share grant awarded (’07)

2008

2009

2010

2011

2012

2013

2014

Completed construction of demonstration plant in Salamanca, Spain
Completed construction of commercial cellulose ethanol plant in Hugoton, KS

2008

2009

2010

2011

2012

2013

2014

Begun deploying technology to existing Abengoa Bioenergy facilities, as well as to new greenfield locations

Begun deploying technology to existing Abengoa Bioenergy facilities, as well as to new greenfield locations

License for use of proprietary technologies

Begun deploying technology to existing Abengoa Bioenergy facilities, as well as to new greenfield locations

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License for use of proprietary technologies

Begun deploying technology to existing Abengoa Bioenergy facilities, as well as to new greenfield locations

License for use of proprietary technologies
Based in Atlanta, American Process Inc. was founded in 1994 as a consulting practice serving the forest products industry. Since 2005, the company has been developing technologies for the conversion of biomass into cellulosic sugars to be used in the production of biofuels and bio-based chemicals. American Process now owns two patented cellulosic technologies, Green Power+ and AVAP.

**Green Power+ Technology**

Green Power+ is a cellulosic technology that co-locates with biomass power plants. The hemicelluloses are selectively extracted and hydrolyzed into monomer sugars. The resulting sugars are fermented into cellulosic ethanol. The process configuration enables Green Power+ to convert the hemicelluloses to higher value added products: cellulosic ethanol and renewable chemicals.

**AVAP Technology**

AVAP is a greenfield technology that fractionates any biomass via the proprietary, patented use of SO2 and ethanol into cellulose, lignin and hemicelluloses. The cellulose and hemicelluloses are then converted into sugars. Resultant sugars are high purity and low cost, making them an ideal feedstock for downstream conversion into bio-based chemicals and biofuels. The lignin is burned as fuel in the boiler.

**Green Power+ Demonstration Facility**

- **Location:** Alpena, MI
- **Feedstock:** Mixed hardwood
- **Products:** Cellulosic ethanol, Potassium acetate
- **Capacity:** 700,000 GPy per product
- **Jobs:** ~25 operational, including biomass logistics

**AVAP Demonstration Facility**

- **Location:** Thomaston, GA
- **Feedstock:** Variety of biomass – up to 10 tons/day
- **Products:** Cellulosic sugars, Ethanol, Cellulose
- **Capacity:** Up to 300,000 GPy Cellulosic Ethanol
- **Jobs:** ~30 operational, including biomass logistics

**Path to Commercial Deployment**

2008: Begin construction: Thomaston, GA AVAP demo plant
2011: Begin construction: Thomaston, GA AVAP demo plant
2012: Awarded $5MM (DOE) for Alpena, MI Green Power+ demo plant
2013: Awarded $5MM (Michigan) for Alpena, MI Green Power+ demo plant
2014: Commissioning and startup of Alpena, MI Green Power+ demo plant
2015: Operate and optimize Alpena, MI demo plant
2016: Start up: 1st Coren, Green Power+ Plant

**American Process & AVAPCO Partners**

- **Green Power+ Strategic:** ArborGen, Decorative Panels International, Green Tech America, Metso
- **Green Power+ Public/Government:** U.S. Department of Energy ($18MM grant to Alpena Biorefinery); Michigan Economic Development Corporation ($4MM grant for Alpena Biorefinery);
- **AVAPCO Strategic:** ArborGen, Green Tech America, Metso, Novozymes
- **AVAPCO Public/Government:** Private investment

**Estimated Startup 1Q 2013**

American Process & AVAPCO Partners

Green Power+ Strategic: ArborGen, Decorative Panels International, Green Tech America, Metso
Green Power+ Public/Government: U.S. Department of Energy ($18MM grant to Alpena Biorefinery); Michigan Economic Development Corporation ($4MM grant for Alpena Biorefinery);
AVAPCO Strategic: ArborGen, Green Tech America, Metso, Novozymes
AVAPCO Public/Government: Private investment
**COMPANY PROFILE**

Beta Renewables is a $350 million joint venture formed from the Chemtex division of Gruppo Mossi & Ghisolfi and TPG. The M&G Group (~$3b USD annual revenue) brings over 60 years of success in process development and plant commercialization worldwide. The joint venture has invested over $200 million in the development of its advanced PROESA™ cellulosic biofining technology.

**Beta Renewables Partners**

**Private Equity:** Over $200 million invested in PROESA technology development by M&G’s Chemtex division. Beta Renewables formed as a $350 million joint venture by Chemtex and TPG.

**Strategic:** GraalBio, Colbiocel, Novozymes, Genomatica, Gevo, Codecix, Amyris, Biofuels Center of North Carolina

**Public/Government:** USDA, $99M loan guarantee for Project Alpha in North Carolina, plus $4M BCAP award

**U.S. COMMERCIAL FACILITY UNDER DEVELOPMENT: PROJECT ALPHA**

**LOCATION:** Sampson County, NC

**STATUS:** $99M conditional loan guarantee awarded August 2012

**FEEDSTOCK:** Dedicated energy feedstock crops; $3.9M BCAP award

**PRODUCTS:** Cellulosic Ethanol, Bio-based Chemicals

**CAPACITY:** 20 MGy

**JOBS:** 300+ direct and indirect jobs

**PROJECT PROFILE:** Project Alpha to use Chemtex PROESA technology; $3.9M Biomass Crop Assistance Program (BCAP) grant to facilitate the establishment of over 4,000 acres of energy crop development across eleven counties in North Carolina, with expected additional revenues to exceed $4.5M annually for local biomass producers

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**DEMONSTRATION FACILITY**

**LOCATION:** Rivalta, Italy

**FEEDSTOCK:** Variety of cellulosic, non-food biomass

**PRODUCTS:** Cellulosic Ethanol, Bio-based Chemicals

**CAPACITY:** One ton per day

**PLANT PROFILE:** Continuous operation since 2009.

**COMMERCIAL FACILITY**

**LOCATION:** Crescentino, Italy

**STATUS:** Started operations 4Q 2012

**FEEDSTOCK:** A mix of Wheat Straw, Rice Straw, Bagasse, Arundo Donax, Corn Stover and Poplar

**PRODUCTS:** Cellulosic Ethanol

**CAPACITY:** 20 MGy

**JOBS:** 200+ direct and indirect jobs

**PROJECT PROFILE:** On schedule to be world’s first commercial-scale plant; multiple additional plants have licensed PROESA technology; technology to be utilized at Project Alpha in North Carolina.

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**PATH TO COMMERCIAL DEPLOYMENT**


- 2009: Construction begins on Crescentino commercial plant
- 2010: M&G Group and Chemtex formally launch PROESA technology
- 2011: Beta Renewables forms to license PROESA technology for rapid industry adoption
- 2012: USDA conditional loan guarantee awarded for Project Alpha (NC)
- 2013: Construction starts operations: world’s first commercial-scale cellulosic ethanol plant
- 2014: Genomatica & GraalBio license PROESA Technology
- 2015: Project Alpha Startup; 20 MGy cellulosic ethanol plant starts in NC

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**BETA RENEWABLES COMMERCIAL FACILITY**

**LOCATION:** Crescentino, Italy

**STATUS:** Started operations 4Q 2012

**FEEDSTOCK:** A mix of Wheat Straw, Rice Straw, Bagasse, Arundo Donax, Corn Stover and Poplar

**PRODUCTS:** Cellulosic Ethanol

**CAPACITY:** 20 MGy

**JOBS:** 200+ direct and indirect jobs

**PROJECT PROFILE:** On schedule to be world’s first commercial-scale plant; multiple additional plants have licensed PROESA technology; technology to be utilized at Project Alpha in North Carolina.
COMPANY PROFILE
BlueFire was established to deploy the Arkenol Process Technology for the conversion of cellulosic waste materials into renewable fuels and other products. BlueFire is the exclusive North America licensee of the technology, which converts widely available, inexpensive, organic materials such as agricultural residues, wood residues, municipal solid wastes and purpose grown energy crops into renewable end products. BlueFire also operates SucreSource, which converts cellulosic into intermediate sugars for the production of bio-chemicals and other products.

DEMONSTRATION FACILITY
LOCATION: Anaheim, CA
FEEDSTOCK: Various wood and paper wastes, MSW, bagasse
PRODUCTS: Cellulosic Sugars
CAPACITY: 200 lbs per day
PLANT PROFILE: Pilot testing complete; now utilized for production of cellulosic sugars for sale to companies developing processes to convert sugar to bio-products.

Bluefire Partners
Private Equity: Quercus Trust, Arkenol Inc., ARK Energy Inc.
Strategic: Feedstock Contract with Cooper Marine Timberlands, Off-Take Agreement with Tenaska Biofuels. EPC contract with MasTec North America, Applied Power Concepts
Project Development: Launched SucreSource, a wholly-owned subsidiary constructing a cellulosic sugar facility in South Korea with GS Caltex for development of sugar to chemicals process. Designing cellulose to fuels plant with China Huadian Engineering Co and SynBioWay - Both out of Beijing, China

SucreSource, a wholly owned subsidiary of BlueFire Renewables, signed agreements in 2012 with GS Caltex, a Korean petroleum company, to build a cellulose to sugar plant in Korea. The facility will process 2 tons of construction and demolition debris per day into cellulosic sugar, which will be converted into a high value chemical by GS Caltex. The facility will be owned and operated by GS Caltex with SucreSource providing the process design package, equipment procurement and technical and engineering support.

PATH TO COMMERCIAL DEPLOYMENT

2008
Licensed technology with over 30,000 hours of pilot plant activity
Secured $40MM grant under USDA Program of Farm Bill

2009
Begun developing Fulton, MS facility
Increased grant to $87.5MM from Dept of Energy

2010
Begun due diligence on future sites
Launched SucreSource to market cellulose to sugar technology

2011
Completed site preparation and detailed engineering for Fulton facility
Begun site utility testing

2012
Complete financing for 19 MMGPY Fulton, MS Facility
SucreSource signed agreement with GS Caltex to build cellulose to sugar plant in Korea

2013
Begin Fulton Facility Construction Early 2013

2014
Begin Operations 2016

2015
Estimated Completion 2014

COMMERCIAL FACILITY
LOCATION: Fulton, MS
STATUS: Site Preparation Complete. Pending financing for facility construction, recipient of $87.5MM Dept of Energy grant
FEEDSTOCK: Forestry residues and other cellulosic wastes
PRODUCTS: Cellulosic Ethanol, Gypsum, Lignin and Protein Cream
CAPACITY: 19 MGy
JOBS: 740 peak construction jobs. Over 100 for plant operation and handling of biomass and products
PROJECT PROFILE: All permits for construction obtained, long-term contracts for all of feedstock and products complete. Turn-key EPC contract completed.
COMPANY PROFILE
Clariant, headquartered in Muttenz near Basel, Switzerland, is an internationally active specialty chemical company with $8 billion in annual turnover and over 22,000 employees worldwide. Clariant has over 100 group companies and production sites in 44 countries including the United States. The Clariant Biotech and Renewables Center is based in Munich and Straubing, Germany, and is focused exclusively on the development and commercial deployment of renewable technology solutions.

RESEARCH FACILITY
LOCATION: Munich, Germany
FEEDSTOCK: Various ligno-cellulosic feedstocks
PRODUCTS: Cellulosic Ethanol, Cellulosic Sugars, Bio-based Chemicals
CAPACITY: 2 tons per year
PLANT PROFILE: Plant utilized to test and improve the sunliquid® technology across several different ligno-cellulosic feedstocks.

CLARIANT Partners
Private Equity: No funding was requested from Private Equity for the demonstration plant. Funding sources for the first commercial plant will be evaluated.
Strategic: No funding was requested from Strategic Partners for the demonstration plant. Funding sources for the first commercial plant will be evaluated.
Public/Government: The Bavarian State Government and the German Federal Ministry of Education and Research have each funded 5 million euros into the demonstration plant for research relating to the project. Funding sources for the first commercial plant will be evaluated.

CLARIANT COMMERCIAL STRATEGY
STATUS: Clariant is in the process of evaluating site locations for the first commercial sunliquid® production plant in the U.S., EU, Brazil and Canada
FEEDSTOCK: Agricultural residues
PRODUCTS: Cellulosic Ethanol, Cellulosic Sugars, Bio-based Chemicals
CAPACITY: Feedstock dependent; range between 18-60 MGy
JOBS: To be determined

PATH TO COMMERCIAL DEPLOYMENT
BEGAN OPERATIONS 2009
BEGAN OPERATIONS 2012
Demonstration Facility
LOCATION: Munich, Germany
FEEDSTOCK: Various ligno-cellulosic feedstocks
PRODUCTS: Cellulosic Ethanol, Cellulosic Sugars, Bio-based Chemicals
CAPACITY: 2 tons per year
PLANT PROFILE: Plant utilized to test and improve the sunliquid® technology across several different ligno-cellulosic feedstocks.

Clariant Partners
Private Equity: No funding was requested from Private Equity for the demonstration plant. Funding sources for the first commercial plant will be evaluated.
Strategic: No funding was requested from Strategic Partners for the demonstration plant. Funding sources for the first commercial plant will be evaluated.
Public/Government: The Bavarian State Government and the German Federal Ministry of Education and Research have each funded 5 million euros into the demonstration plant for research relating to the project. Funding sources for the first commercial plant will be evaluated.

CLARIANT Commercial Strategy
STATUS: Clariant is in the process of evaluating site locations for the first commercial sunliquid® production plant in the U.S., EU, Brazil and Canada
FEEDSTOCK: Agricultural residues
PRODUCTS: Cellulosic Ethanol, Cellulosic Sugars, Bio-based Chemicals
CAPACITY: Feedstock dependent; range between 18-60 MGy
JOBS: To be determined
COMPANY PROFILE
Headquartered in Montreal, Canada, Enerkem employs 140 employees in the U.S. and Canada. Enerkem builds modular, copy-exact and scalable 10 million gallon per year biorefineries that utilize its proprietary thermochemical conversion technology to produce advanced ethanol and bio-chemicals from municipal solid waste (MSW). Founded in 2000, Enerkem started piloting its technology in 2003.

U.S. COMMERCIAL STRATEGY
SUMMARY: Enerkem has identified dozens of potential sites in the United States to deploy its modular, copy-exact 10 MGy biorefineries.
FIRST PROJECT: Pontotoc, MS
 FEEDSTOCK: MSW, wood residues
PRODUCTS: Syngas, Biomethanol, Acetates, Cellulosic Ethanol (2012)
CAPACITY: 1.3 MGy

PROJECT PROFILE: Enerkem’s Westbury facility is the first plant in the world to utilize used electricity poles (a negative-cost and heterogeneous material) to produce ethanol and methanol. The plant, co-located with a saw mill that recycles wood from utility poles, utilizes the portion of the pole that cannot be reclaimed. The plant began producing conditioned syngas in 2009, methanol in 2011, and cellulosic ethanol in 2012.

Enerkem Partners
Strategic: Waste Management (upstream: feedstock), Valero (downstream: blending), GreenField Ethanol (distributor: largest traditional ethanol producer in Canada)
Government/Public: up to $50 MM cost-share (DOE) and $80MM loan guarantee (USDA) to support construction full-scale facility in Canada. Enerkem builds modular, copy-exact and scalable 10 million gallon per year biorefineries that utilize its proprietary thermochemical conversion technology to produce advanced ethanol and bio-chemicals from municipal solid waste (MSW). Founded in 2000, Enerkem started piloting its technology in 2003.

Demonstration Facility
LOCATION: Edmonton, AB, Canada
FEEDSTOCK: Used utility/telephone poles, municipal solid waste
CAPACITY: 1.3 MGy

PROJECT PROFILE: Enerkem’s Edmonton facility is the first plant in the world to utilize used electricity poles (a negative-cost and heterogeneous material) to produce ethanol and methanol. The plant, co-located with a saw mill that recycles wood from utility poles, utilizes the portion of the pole that cannot be reclaimed. The plant began producing conditioned syngas in 2009, methanol in 2011, and cellulosic ethanol in 2012.

PATH TO COMMERCIAL DEPLOYMENT

2008
- Announced Edmonton commercial project with the City of Edmonton
- Westbury Demo: gasification plant mechanically complete

2009
- Launch U.S. business development strategy in wake of BFE
- Announced plan to enter the US with Pontotoc, MS project

2010
- Awarded funding agreement from DOE for MS project (up to $50 million)
- Westbury Demo: gasification plant commissioned, plant startup

2011
- Strategic Partner: Second Waste Management
- Groundbreaking ceremony for Edmonton green energy project

2012
- Strategic Partner: Secord Waste Management
- Completions: $20MM in private financing
- Awarded $30MM loan guarantee by USDA for MS Project

2013
- Westbury opens methanol production
- Enerkem announces new projects
- Full-scale commercial project to begin operations

2014
- Construction of methanol-to-ethanol plant to begin in Edmonton
- Massachusetts full-scale facility construction to start

2015
- Start development of new projects in North America and overseas

COMMERCIAL FACILITY
LOCATION: Edmonton, AB, Canada
STATUS: Phase 1 Completion in 3Q 2013
FEEDSTOCK: MSW from the City of Edmonton
PRODUCTS: Syngas, Biomethanol, Acetates, Cellulosic Ethanol
CAPACITY: 10 MGy

PLANT PROFILE: Enerkem has a 25-year agreement with the City of Edmonton to build and operate a plant that will produce next-generation biofuels from non-recyclable, non-compostable municipal solid waste (MSW). It is the world’s first major collaboration between a metropolitan centre and a waste-to-liquids producer to turn MSW into methanol and ethanol. The plant will produce 2.5 RFS-eligible cellulosic biofuels and enable Edmonton to increase its residential waste diversion rate to 90 percent.
Fiberight is a privately held company founded in 2007 with current operations in Virginia, Maryland and Iowa. Fiberight applies its proprietary technology to refine municipal solid waste (MSW) and waste fiber pulp into cellulosic sugars that can be further processed into cellulosic biofuels. Fiberight demonstrated the ability to produce commercial scale batches of cellulosic ethanol at its Iowa plant in 2010. Fiberight is targeting rapid expansion of its prototype commercial plants in population dense municipalities with high-stranded trash costs or landfill limitations.

REFERENCE COMMERCIAL FACILITY
LOCATION: Lawrenceville, VA
FEEDSTOCK: Municipal solid waste, commercial waste, energy crops
PRODUCTS: Cellulosic Ethanol/biofuels, Cellulosic Sugars, Bio-chemicals
CAPACITY: 1 MGY
PLANT PROFILE: Utilized to test core business and technology platforms since 2007; upgraded in 2011 to be fully integrated MSW-to-biofuels reference commercial plant; operations commenced in 2012 with 25+ employees.

Fiberight Partners
Private Equity: Confidential Private Equity Fund, SEC Reg. D offering completed in 2012 - $15M
Strategic: Novozymes
Government/Public: Iowa Power Fund - $2.9M, USDA Loan Guarantee - $25M

COMMERCIAL FACILITY
LOCATION: Blairstown, IA
STATUS: Existing Facility To Be Modified in 2013
FEEDSTOCK: Municipal Solid Waste, Non-Food Wastes
PRODUCTS: Cellulosic Ethanol, Bio-chemicals
CAPACITY: 6 MGY
JOBS: 55 Full-time Operational Positions
PROJECT PROFILE: Facility is a retro-fitted former corn ethanol plant within 30 miles of well over 1,000 tons per day of MSW.

PATH TO COMMERCIAL DEPLOYMENT

Lab scale research continues
Pilot scale testing in Lawrenceville
Purchase of Blairstown commercial ethanol facility
Engineering and design completed for full-scale demo testing in Blairstown
Equity funding for reference commercial plant secured
Design & engineering for Lawrenceville reference commercial plant
USDA loan guarantee secured
Lawrenceville reference commercial plant processing begins
Novozymes partnership formalized
Fiberight to help put MSW-to-cellulosic ethanol EPA pathway approved
Blairstown commercial facility constructed, operations commence
2-4 Commercial plants constructed in Mid-Atlantic, Iowa Expansion
Additional 3-5 plants in Mid-Atlantic Region

Estimated Completion 2013
Fulcrum BioEnergy

**Company Profile**
Founded in 2007, Fulcrum BioEnergy is headquartered in Pleasanton, California. The company operates a process demonstration unit in Durham, North Carolina that converts synthesis gas to ethanol. Fulcrum is ready to begin construction on a commercial-scale advanced biofuels facility, the Sierra BioFuels Plant, that will convert municipal solid waste (MSW) into ethanol. Sierra is located near Reno, Nevada.

**Process Demonstration Facility**
- **Location:** Durham, NC
- **Feedstock:** Synthesis Gas
- **Products:** Ethanol
- **Capacity:** Fulcrum’s alcohol synthesis PDU operates with a full-scale tubular reactor packed with catalyst under the same operating parameters that will be used at its commercial-scale plants.

**Plant Profile:** The PDU converts synthesis gas to ethanol – the second step in Fulcrum’s waste-to-ethanol process. The PDU has operated in excess of 20,000 hours over a period of three and a half years.

**Fulcrum Partners**
**Private Equity:** Raised $93 million of capital in 2011 from investors such as US Renewables Group, Rustic Canyon and Waste Management.

**Strategic:** Fulcrum has partnered with Waste Connections and Waste Management, two of the nation’s largest waste companies, for long-term feedstock supply and joint development activities. These agreements give Fulcrum the ability to produce more than 700 million gallons of ethanol per year throughout the United States.

**Government/Public:** Fulcrum received a $105 million conditional commitment for a USDA loan guarantee in August 2012. The final terms are currently being negotiated with the USDA.

**Sierra BioFuels Commercial Project**
- **Location:** McCarran, Storey County, NV
- **Status:** Initial site preparation work completed. Construction will begin once the USDA loan guarantee is closed.
- **Feedstock:** Municipal solid waste contracted with Waste Connections and Waste Management.
- **Products:** Advanced Ethanol
- **Capacity:** 10 MGy
- **Jobs:** 430 engineering and construction jobs; 53 permanent jobs

**Project Profile:** Located at the Tahoe-Reno Industrial Center approximately 20 miles east of Reno, Nevada, Sierra will be one of the first projects of its kind to be built in the United States. Designed to produce approximately 10 MYD of low-carbon, renewable transportation fuel annually, the project will combine new, innovative technology with existing commercial systems.

**Path to Commercial Deployment**


- **2008:** Acquired development rights for Sierra.
- **2009:** Entered into technology licensing and development agreements; executed MSW feedstock agreement for Sierra BioFuels.
- **2010:** Engineered, constructed and commenced operation of alcohol synthesis PDU, demonstrating at full-scale Fulcrum’s proprietary process for the conversion of synthesis gas to alcohol.
- **2011:** Signed EPC contract with Fluor Corporation.
- **2012:** Executed off-take agreement with Sierra BioFuels.
- **2013:** Raised $93 million of equity capital for Sierra BioFuels.
- **2014:** Began site preparation work for Sierra BioFuels.
- **2015:** Continued EPC activities for Sierra BioFuels.
- **Commercial operations to begin at Sierra BioFuels Plant.**
- **Development of additional commercial-scale MSW-to-ethanol projects to commence throughout the US.**
Inbicon Partners

Marketing: Leifmark, LLC is the independent Inbicon partner authorized to license Inbicon Biomass Refinery technology in North America. Leifmark has developed a pipeline of U.S. projects, including the Fair Oaks (IN) and Spiritwood (ND) projects.

U.S. Engineering: To assure quality control for U.S. projects, Inbicon has certified three American firms to perform engineering for U.S. projects: Harris Group (Seattle, WA); Pöyry (Appleton, WI); and, APS (Richmond, VA).

Enzyme: Novozymes; DuPont Genencor

Project Finance: Inbicon is working with the Danish Export Fund (EKF) to bring loan guarantees to its North American projects.
**COMPANY PROFILE**

INEOS Bio is a BioEnergy company producing advanced biofuels and renewable power from a wide range of low-cost carbon materials. The company’s highly innovative technology provides an alternative to waste disposal for communities around the globe. INEOS Bio is one of the global businesses in INEOS.

**INEOS Partners**

**Marketing**: JV Project between INEOS Bio and New Planet BioEnergy

**Strategic** (Project) AMEC, Air Products, VogelBusch, Emerson, CDM-Smith

**Public/Government**: $50MM (DOE) grant, $75MM (USDA) loan guarantee, $2.5MM (State of Florida) grant

The INEOS Bio technology is a combined thermo-chemical and bio-chemical process that efficiently converts a wide range of organic materials, including municipal solid waste, yard, forestry and agricultural waste into ethanol and renewable energy. This flexibility allows facilities to be built anywhere in the world, providing jobs and locally sourced renewable energy for urban and rural communities.
Iogen Partners

**Private Equity:** $425 million aggregate investment through partners including Royal Dutch/Shell Group, Goldman Sachs & Co., Volkswagen and Petro-Canada.

**Strategic:** Iogen is currently working closely with Raízen, Brazil’s largest sugar and ethanol producer and a 50:50 JV between Royal/Dutch Shell and Cosan.

**Government/Public:** $20MM from Government of Canada, of which $10MM (Technology Partnership Canada) was for Ottawa demonstration facility.

**Commercial Strategy:** Development and Engineering

**Feedstock:** Bagasse

**Product:** Cellulosic Ethanol

**Capacity:** To be determined

**Project Profile:** Raízen Group, the world’s largest producer of sugarcane ethanol, has made an initial investment in Iogen Energy to develop a commercial cellulosic ethanol project in Brazil. The investment will cover development and engineering costs associated with the front-end design of a bagasse-to-ethanol facility to be co-located with Raízen’s Costa Pinto facility in Piracicaba, São Paulo.

**Implemented Release 6 Technology at Demo Plant**

**$10MM Capital upgrades for Release 7 Technology**

**Demonstrated sustainable 24/7 operability at Demo Plant with Release 7 Technology**

**$10MM Capital upgrades for Release 8 Technology**

**Start-up and achieved all R8 Technology and production milestones at Demo Plant**

**Detailed evaluation of several commercial roll-out options**

**Sugarcane bagasse processing started in Demo Plant**

**Initiated collaboration with Raízen on cellulose in Piracicaba (Brazil)**

**Targets not yet announced**

**Targets not yet announced**

**Targets not yet announced**

**Path to Commercial Deployment**

<table>
<thead>
<tr>
<th>Year</th>
<th>[L]</th>
<th>(Gallons)</th>
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<tbody>
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<td>34,223</td>
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<tr>
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<td>371,626</td>
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<tr>
<td>2012</td>
<td>219,090</td>
<td>57,877</td>
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*To July 31, 2012*
KiOR is a next-generation renewable fuels company that has developed a unique two-step proprietary technology platform to convert abundant and sustainable biomass resources into cellulosic gasoline, diesel, jet fuel and fuel oil. KiOR’s cellulosic biofuels may be transported using existing distribution networks and are suitable for use in vehicles on the road today. KiOR strives to help ease dependence on foreign oil, reduce lifecycle greenhouse gas emissions and create high-quality jobs and economic benefit across rural communities.

**KIOR PARTNERS**

Private Equity/Investment: Initial public offering proceeds were approximately $148.6 million. Major stock ownership: Class A & B shares - $7.2 million/Khosla Ventures; 17.5 million/Artis Capital Management; 8.5 million/Alberta Investment Management Corporation. Class C shares 3.0 million – Khosla Ventures.

Public/Government: Mississippi Development Authority loan for $75 million, and significant support from other state departments as well as local economic development teams.

KiOR has developed a proprietary technology platform to convert sustainable, low-cost biomass into a hydrocarbon-based renewable crude oil. The platform combines proprietary catalyst systems with a process based on existing Fluid Catalytic Cracking (FCC) technology, a standard process used for over 60 years in oil refining. KiOR processes its renewable crude oil in a conventional hydrotreater into gasoline and diesel blendstocks that can be combined with existing fossil-based fuels used in vehicles on the road today.

**COMPANY PROFILE**

LOCATION: Pasadena, TX

FEEDSTOCK: Forestry Residuals

PRODUCTS: Cellulosic Gasoline, Cellulosic Diesel for R&D and business development purposes

CAPACITY: 15 barrels per day

PLANT PROFILE: Produces up to 15 barrels of renewable crude oil per day, facility co-located with R&D operations with approximately 100 employees, 30 of whom are Ph.D.'s.

**DEMONSTRATION FACILITY**

**PATH TO COMMERCIAL DEPLOYMENT**

**COMMERCIAL FACILITY**

LOCATION: Columbus, MS

STATUS: Operational

FEEDSTOCK: Forestry Residuals

PRODUCTS: Cellulosic Gasoline & Diesel

CAPACITY: 13 MGY

JOBS: ~60 direct; several hundred indirect

PROJECT PROFILE: Facility completed ahead of schedule with a project cost of $213 million; production fully committed prior to end of construction; will produce enough fuel for 25,000 vehicles when fully sized out.

**2ND COMMERCIAL PROJECT UNDER DEVELOPMENT**

LOCATION: Natchez, MS

FEEDSTOCK: Forestry Residuals

PRODUCTS: Cellulosic Gasoline & Cellulosic Diesel

CAPACITY: 40 MGY

JOBS: 60-70 direct, several hundred indirect

PROJECT PROFILE: $350 million investment; flagship commercial project serving as logistical hub for production and delivery; construction beginning early 2013 with ~500 construction employees.

KiOR has a mission to reduce greenhouse gas emissions and help ease dependence on foreign oil. KiOR is focused on delivering a commercially viable process for converting low-cost, sustainable biomass resources into cellulosic gasoline, diesel, jet fuel, and fuel oils that can be combined with existing fossil-based fuels used in vehicles on the road today.
COMPANY PROFILE
Founded in 2005, LanzaTech offers a fully integrated sustainable fuels and chemicals platform that uses available waste resources to produce fuels such as ethanol and chemicals such as 2,3-Butanediol (2,3BDO) at high selectivity and yield. Since 2008, the company has been operating a 15,000 gallon per year waste-gas to ethanol facility in New Zealand and this year scaled its platform to a 100,000 gallons per year demo facility in Shanghai, China. LanzaTech is headquartered in Chicago, IL and has additional offices in New Zealand, China and India.

LANZATECH PARTNERS
Private Equity: LanzaTech has raised more than $100 million in private equity and debt financing. Investors include Khosla Ventures, Qiming Venture Partners, K1W1, Malaysian Life Sciences Capital Fund, Western Technology Investment, PETRONAS Technology Ventures Sdn Bhd, Dialog Group, and Strategic: PETRONAS, INVISTA, Baosteel, Capital Steel, Virgin Atlantic.

LANZATECH’s gas fermentation technology converts carbon containing gases produced by industries such as steel manufacturing and oil refining, as well as gases generated from forestry and agricultural residues, municipal waste, and coal, into valuable fuel and chemical products.

PATH TO COMMERCIAL DEPLOYMENT

Pilot Plant becomes operational in NZ
Pilot Plant operating at 15,000 gal/year capacity
LanzaTech successfully produces 2,3-Butanediol in key biocatalytic step used to make polymers, plastics and hydrocarbon fuels
Construction begins on Baosteel demonstration facility
First Demo facility becomes operational in China
Second demonstration facility becomes operational
Full commercial scale plant to be constructed in cooperation with Baosteel
Construction begins on Freedom Pines Plant
Production at Freedom Pines Commercial Biorefinery begins
Full-scale commercial plant with Baosteel to be operational
MSW to ethanol commercial project to be constructed in Asia
Second Commercial Facility operating in China (Shougang)
COMPANY PROFILE
Mascoma Corporation, founded in 2005, is a renewable fuels company that has developed an innovative, highly adaptable technology for the low-cost conversion of abundant biomass into cellulosic ethanol and renewable chemicals. Using its proprietary consolidated bioprocessing (CBP) technology platform, Mascoma has also developed bioengineered yeasts and other microorganisms to reduce costs and improve yields in the production of renewable fuels and chemicals. The company operates a demonstration facility in Rome, New York to evaluate new technologies and conduct large-scale process demonstration runs. Mascoma also operates a research and development laboratory in Lebanon, New Hampshire and maintains offices in Waltham, Massachusetts and Toronto, Canada.

mascoma Partners
Commercial: Lallemand Inc., a global developer, producer and marketer of yeast, bacteria and related products, to commercialize the TransFerm yeast product, which is the first commercial application of Mascoma’s proprietary consolidated bioprocessing (CBP) technology platform.
Public/Government: Cooperative agreement with DOE for up to $80MM to assist in the design, construction and operation of commercial-scale hardwood cellulosic ethanol facility in Kinross, Michigan; $20MM in R&D assistance (DOE) for Kinross, MI project; $20MM grant agreement with the Michigan Economic Development Corporation for Kinross, MI facility; $20MM grant agreement with the NY State Energy Research and Development Authority to assist building and operation of demonstration plant in Rome, New York.

Demonstration Facility
LOCATION: Rome, New York
FEEDSTOCK: Multiple feedstock (biomass)
PRODUCTS: Cellulosic ethanol, biochemicals
CAPACITY: 200,000 GPY
PLANT PROFILE: Ground breaking, December 2007; first fermentation, June 2008. Currently employs 15 operations staff. Completed 1,000 hour run using Mascoma’s hardwood CBP microorganisms.

Path to Commercial Deployment

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2008</td>
<td>1st gallon of cellulosic ethanol produced at Rome, NY demonstration facility.</td>
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<tr>
<td>2009</td>
<td>Initiated complete cellulosic ethanol process validation runs at Rome, NY demo facility.</td>
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<tr>
<td>2010</td>
<td>Awarded SanOpti Biosystems, a company that provides commissioning equipment and process solutions for biomass conversion.</td>
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<tr>
<td>2011</td>
<td>Demonstrated $2.00/gallon cash operating cost and hardwood to ethanol conversion yield of 71 gallons per bone dry ton at NY demo facility.</td>
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<tr>
<td>2012</td>
<td>Ground breaking at Kinross, MI commercial facility.</td>
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<tr>
<td>2013</td>
<td>Ground breaking at 2nd commercial-scale cellulosic ethanol facility in Drayton Valley, Alberta.</td>
</tr>
<tr>
<td>2014</td>
<td>Construction completed, first gallons produced at Kinross, MI commercial facility.</td>
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POET-DSM Advanced Biofuels, LLC is a 50/50 joint venture between Royal DSM and POET, LLC. Based in Sioux Falls, SD, the joint venture utilizes a proprietary technology to convert corn crop residue into cellulosic bio-ethanol. POET-DSM’s first commercial-scale plant, dubbed Project LIBERTY, will produce 20 MGY of cellulosic bio-ethanol. Based on this plant the JV plans to license globally an integrated technology package for the conversion of corn crop residue to cellulosic bio-ethanol.

POET-DSM PARTNERS

Strategic: JV between DSM (enzymes and yeast) POET (process, feedstock procurement). Each party to contribute ~ 50% of the value to the JV. DSM will contribute $150MM in equity and debt financing. POET will contribute the existing Project LIBERTY, including secured grants from the U.S. Department of Energy and the State of Iowa.

Public/Government: $100MM in grants from U.S Department of Energy; $14.8MM grant from State of Iowa for biorefinery construction, engineering and feedstock acceleration activities; $5.25MM in credits from State of Iowa for tax and training.

POET-DNM Demonstration Facility

LOCATION: Scotland, SD
FEEDSTOCK: Corn Crop Residue
PRODUCTS: Ethanol, Biogas
CAPACITY: 20,000 Gpy
PLANT PROFILE: POET’s pilot/demo cellulosic ethanol plant has been crucial to improving the process for commercial-scale production. Preliminary harvests by Iowa farmers are helping solidify the feedstock pipeline for Project LIBERTY.

PROJECT LIBERTY

LOCATION: Emmetsburg, IA
STATUS: Under Construction
FEEDSTOCK: Corn Crop Residue
PRODUCTS: Ethanol, Biogas
CAPACITY: 20 MGY, later growing to 25 MGY
JOBS: 37 biorefinery jobs, 309 direct construction jobs
PROJECT PROFILE: Located adjacent to current POET grain ethanol plant; 22-acre biomass storage site is complete, biorefinery construction underway with anticipated completion in 4Q 2013; continuing to ramp-up farmer contracts for biomass harvesting toward goal of 285,000 tons per year.

PATH TO COMMERCIAL DEPLOYMENT

2008
- Poet pilot plant becomes operational, second round of biomass harvested testing
- DSM starts extensive enzyme development program to cellulose ethanol

2009
- Significant cost reductions at pilot facility, 12,000 acres of biomass harvested

2010
- Commercial biomass stackyard completed, first commercial biomass harvested (56,000 tons)
- DSM identifies enzyme system effective at breaking down lignin-cellulose to component sugars at increased thermal stability

2011
- Site work started on commercial-scale biorefinery

2012
- Second commercial biomass harvest (65,000 tons)
- DSM acquires CF Yeast Company from Novo

2013
- Joint venture formed with Royal DSM
- Vertical construction begins on commercial-scale biorefinery
- Third commercial biomass harvest (80,000 tons)

2014
- Anticipated completion of construction at commercial-scale facility

2015
- Validate technology at commercial scale
- Validate technology at commercial scale
COMPANY PROFILE
Incorporated in 2002, ZeaChem Inc. is headquartered in Lakewood, Colorado. The company operates a research and development laboratory facility in Menlo Park, California, and a 250,000 gallon per year demonstration biorefinery in Boardman, Oregon. ZeaChem has developed a cellulose-based biorefinery platform capable of producing advanced biofuels and bio-chemicals.

DEMONSTRATION FACILITY
LOCATION: Boardman, OR
FEEDSTOCK: Poplar Trees, Wheat Straw
PRODUCTS: Cellulosic Ethanol, Bio-Chemicals
CAPACITY: 250,000 Gpy
PLANT PROFILE: Construction completed on schedule and significantly under budget; created 50 construction jobs and employs 35 full-time operations staff in the region.

Phase 1: high-value bio-chemicals for paints and lacquers
Phase 2: cellulosic ethanol and bio-chemicals by YE12
Phase 3: cellulosic jet and diesel (’13).

ZeaChem Partners
Private Equity: Raised $65MM in three rounds of financing (Birchmere Ventures, Firelake Capital, Globespan Capital Partners, Mohr Davidow Ventures, PrairieGold Venture Partners, Spring Ventures, Itcho, and Valero Energy Corporation)
Strategic: Chrysler Group LLC (fuels); P&G (bio-chemicals)
Government/Public: $25MM (DOE) cooperative agreement to support construction of demonstration facility; $40MM (USDA) cooperative agreement with Univ. of Washington and others to expand the demo plant for bio-based jet and diesel production; $17MM Biomass Crop Assistance Program (BCAP) grant from the USDA to GreenWood Resources, ZeaChem’s primary feedstock supplier to establish and maintain 7,000 acres of intercropped poplar trees for the demo and 1st commercial facilities; $232.5MM (USDA) conditional loan guarantee to support the financing of the 1st commercial plant.

ZeaChem utilizes a hybrid process of biochemical and thermochemical processing that preserves the best of both approaches from yield and economic perspectives.

PATH TO COMMERCIAL DEPLOYMENT
Raised $34MM Series B
Selected as one of 19 advanced biofuels projects for DOE Integrated Biorefinery Cooperative Agreement ($25MM)
ZeaChem’s Core Technology
Established partnerships with Chrysler and P&G
Begins operations at demonstration biorefinery, cellulosic ethanol production by YE12
Selected for USDA conditional loan guarantee for 1st commercial plant
Estimated start of production of cellulosic jet and diesel fuel at demo scale
Anticipated start of construction on 1st commercial biorefinery
Anticipated start of production at 1st commercial biorefinery

ZeaChem Commercial Facility Site
ZeaChem Demonstration Facility