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

Public/Government: Selected for $97MM Section 932 Cost Share Grant (DOE) in 2007; awarded $133MM EPAct 2005 loan guarantee in 2011 for development of the Abengoa Bioenergy commercial facility in Hugoton, Kansas

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.

COMPANY PROFILE
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.

Abengoa Bioenergy commercial site

Estimated completion 4Q 2013

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, feedstock partners secured.

PATH TO COMMERCIAL DEPLOYMENT

- Begin deploying technology to existing Abengoa Bioenergy facilities, as well as to new greenfield locations
- License the use of proprietary technologies
- Feedstock supply contracts executed from local biomass producers for Hugoton facility
- DOE: $133M EPAct 2005 loan guarantee awarded for Hugoton plant
- Groundbreaking on Hugoton, KS first commercial cellulosic ethanol plant (Sept.)
- Completed construction of demonstration plant in Salamanca, Spain
- Produced first U.S. gal. of cellulosic ethanol (’07)
- Developed first biomass-to-ethanol plant in Hugoton, KS
- Completed construction of demonstration plant in Salamanca, Spain
- Started signing contracts for crop residues and other feedstocks for Hugoton plant
- Completed connection to 21MW annual electricity requirements for successful plant
- Benchmarks hit for improved process efficiencies at Spanish plant
- Reduced plan to build first commercial cellulosic ethanol plant in Hugoton, KS
- Signed Cooperative Agreement with DOE to build commercial demonstration biomass derived process technology (’05)
- Completed construction of U.S. pilot plant in York, NE (’07)
- Produced first U.S. gal. of cellulosic ethanol (’07)
- DOE: $97M Sec. 932 cost share grant awarded (’07)
- Began operations 2009
- Began operations 2007
COMPANY PROFILE
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.

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

PLANT PROFILE: The plant is co-located with the Decorative Panels International (DPI) hardboard manufacturing facility. Plant construction began April 2011; commissioning occurred in June 2012. The plant is in startup mode.

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.

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

PROJECT PROFILE: Plant will begin startup in Q1/2013. Thomaston will be the site of AVAPCO’s supply chain integrated alliances with downstream sugar converters to chemicals, fuels and materials. AVAPCO is an affiliate of American Process, Incorporated. AVAPCO was created in 2011 in order to commercialize the AVAP technology developed by American Process. AVAPCO owns the Thomaston, GA AVAP Demonstration Facility.

American Process & AVAPCO Partners
Green Power+ Strategic: ArborGen, Decorative Panels International, Green Tech America, Metsa
AVAP Strategic: ArborGen, Green Tech America, Metsa, Novozymes
AVAPCO Strategic: ArborGen, Green Tech America, Metsa, Novozymes
AVAPCO Public/Government: Private investment

PATH TO COMMERCIAL DEPLOYMENT
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 biorefining technology.

Beta Renewables Partners
Private Equity: Over $200 million invested in PROESA technology development by M&G’s Chemtex division. Beta Renewables formed as $350 million joint venture by Chemtex and TPG.
Strategic: GraalBio, Colbiocel, Novozymes, Genomatica, Gevo, Codexis, 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

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

PATH TO COMMERCIAL DEPLOYMENT

- MAG Group and Chemtex formally launch PROESA technology Beta Renewables formed to license plant technology for rapid industry adoption
- USDA conditional loan guarantee awarded for Project Alpha (NC)
- Construction begins on Crescentino commercial plant
- Continuous operation of demo plant; one ton per day
- Genomatica & GraalBio license PROESA technology
- Multiple additional commercial plants
- Project Alpha Startup; 20 MGy cellulosic ethanol plant starts in NC
- Multiple additional commercial plants
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 cellulose 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 cellulose 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, OF-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 Sino Bioway - Both out of Beijing, China

SucrSource, a wholly owned subsidiary of BlueFire Renewables, signed agreements in 2012 with GS Caltex, a Korean petroleum company, to build a cellulosic 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 SucrSource providing the process design package, equipment procurement and technical and engineering support.

Commercial Facility

LOCATION: Fulton, MS

STATUS: Site Preparation Completed. 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: 750 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 feedstock and products complete. Turn-key EPC contract completed.

PATH TO COMMERCIAL DEPLOYMENT


Licensed technology with over 50,000 hours of pilot plant activity

Secured 340 MM grant under FY08 Section 932 Program of Farm Bill

Began Developing Fulton, MS Facility

Increased grant to 790MM under AREA

Began site preparation and detailed engineering for Fulton facility

Began due diligence on future sites

Launched SucrSource targeted cellulose to sugar technology

Completed site preparation and detailed engineering for Fulton facility

Launch construction of Fulton facility

Begin construction of Fulton, MS Facility

Complete financing for 79 MM MPP Fulton, MS Facility

SucrSource signed agreement with GS Caltex to build cellulose to sugar plant in Korea

Finishing construction of Fulton, MS Facility and start production

Continue developing multiple sites for deployment
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 |
| PRODUCT | Cellulosic Ethanol, Cellulosic Sugars, Bio-based Chemicals |
| CAPACITY | Feedstock dependent; ranges between 18-60 MGy |
| JOBS | To be determined |

**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 cellulosic feedstocks. |

**DEMONSTRATION FACILITY**

| LOCATION | Straubing, Germany |
| FEEDSTOCK | Agricultural Residues (Phase 1); Dedicated Energy Crops (Phase 2) |
| PRODUCTS | Cellulosic Ethanol, Cellulosic Sugars, Bio-based Chemicals |
| CAPACITY | 330,000 GPY |
| PLANT PROFILE | The plant produced the first volumes of cellulosic ethanol on July 20, 2012. The sunliquid® demonstration plant will produce cellulosic ethanol from a number of ligno-cellulosic feedstocks. The sunliquid® demo plant will also demonstrate advantages of feedstock specific enzyme utilization, on-site process integrated enzyme production, simultaneous C5 and C6 fermentation in a one-pot reaction and an energy saving ethanol separation and purification process. |

**PATH TO COMMERCIAL DEPLOYMENT**
Enerkem Partners


**Strategic:** Waste Management (upstream: feedstock), 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 commercial facility in Pontotoc, MS; $23MM CAD (Investissement Québec) for commercial facility in Varennes, Québec; $18MM CAD grant (Québec Ministry of Natural Resources and Wildlife) and $9 MM loan (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.

**Private Equity:** Enerkem Partners

**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

**Status:** Under development

**Demonstration Facility**

**Location:** Westbury, QC, Canada

**Feedstock:** Used utility/telephone poles, municipal solid waste

**Products:** Syngas, Biomethanol (2011), 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.

**Estimation Completion 2013**

**Estimated completion 2013**

**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-biofuels producer to turn MSW into methanol and ethanol. The plant will produce 2.5 BFS-eligible cellulosic biofuels and enable Edmonton to increase its residential waste diversion rate to 90 percent.

**Path to Commercial Deployment**

- **2008:** announced Edmonton commercial project with the government of Alberta
- **2009:** launched U.S. business development strategy in wake of BFS2
- **2010:** Westbury Demo: gasification plant mechanically complete
- **2011:** announcement Edmonton commercial project & $27m Gov’t funding
- **2012:** Westbury Demo: full-scale construction to start
- **2013:** Edmonton full-scale facility construction to start
- **2014:** Enerkem commercial project
- **2015:** estimated completion 2013

**Plants in Operation**

- **Westbury Demo:** completed $20MM in private financing
- **Westbury Demo:** announced $30MM loan guarantee by USDA for MS Project
- **Westbury Demo:** construction of syngas-to-methanol island

**Future Projects**

- **Fast Company:** announced $15MM of synergies from World’s 50 Most Innovative Companies (10)
- **Valero:** development of new projects in North America and overseas
COMPANY PROFILE
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 20+ employees.

PATH TO COMMERCIAL DEPLOYMENT

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
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.

**COMMERCIAL FACILITY**

**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 MMY of low-carbon, renewable transportation fuel annually, the project will combine new, innovative technology with existing commercial systems.

**PATH TO COMMERCIAL DEPLOYMENT**

- Acquired development rights for Sierra; entered into technology licensing and development agreements; executed MSW feedstock agreement for Sierra  
- Engineered, constructed and commercial operation of alcohol synthesis PDU; demonstrating at full-scale Fulcrum’s proprietary process for the conversion of synthesis gas to alcohol  
- Signed EPC contract with Fluor Corporation  
- Executed offtake agreement with Sierra BioFuels  
- Raised $93 million of equity capital for Sierra BioFuels  
- Begun site preparation work for Sierra BioFuels  
- Sierra BioFuels received conditional commitment for a $105MM USDA loan guarantee  
- Completed engineering phase of Sierra BioFuels  
- Continue EPC activities of Sierra BioFuels  
- Commercial operations to begin at Sierra BioFuels Plant  
- Development of additional commercial scale MSW-to-ethanol projects to commence throughout the U.S.
Inbicon began pioneering biomass conversion technology in the late 1990s. Using steam, enzymes, and yeast, Inbicon turns soft lignocellulose (e.g. wheat straw, corn stalks, energy grasses) into cellulosic ethanol, as well as renewable lignin and industrial sugar molasses for power and bio-chemicals. Inbicon is a subsidiary of DONG Energy, Denmark’s largest energy company with 6,000 employees and $9.8 billion in revenues (2011). DONG Energy has invested over $100 million to develop and commercialize Inbicon technology, which is licensed worldwide.

**Inbicon Kalundborg Plant**

*Cellulosic ethanol, renewable electricity*

- **PROJECT:** Cellulosic Ethanol, Renewable Electricity
- **CAPACITY:** 1.5 MGY of cellulosic ethanol, 11,400 metric tons of lignin (fuel pellets), and 13,600 metric tons of industrial sugar molasses
- **PLANT PROFILE:** Fully operational. Integrated with adjacent power station to utilize excess steam. Cellulosic ethanol sold at 36 retail petrol stations (45 gallon-size blends). Lignin co-product replaces coal in Danish power generation; sugar molasses co-product used for biogas production.

**Dakota Spirit AG Energy Concept**

*Cellulosic ethanol, renewable power, industrial molasses*

- **PROJECT:** Cellulosic Ethanol; Renewable Power; Industrial Molasses
- **CAPACITY:** 10+ MGY Cellulosic Ethanol; 83,000 Tpy Renewable Biofuel pellets, 94,000 Tpy Industrial Molasses
- **PROJECT PROFILE:** Project of Great River Energy; site adjacent to its Spiritwood Station CHP plant in North Dakota. A conventional dry mill ethanol plant is planned for Phase 1, with cellulosic ethanol production from wheat straw added in Phase 2 (using Inbicon Biomass Refinery technology). Partners include the North Dakota Utilization Commission (APUC) and the North Dakota Industrial Commission Renewable-Energy Council.

**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.

**Path to Commercial Deployment**

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<td>1st plant processes 2.4 M/ty day biomass</td>
<td>2nd pilot plant processes 24 M/ty day biomass</td>
<td>Grand Opening of the Inbicon Biomass Refinery (Kalundborg, Denmark); project showcased at COP15 Summit in Copenhagen</td>
<td>Inbicon Kalundborg facility processes 100 M/ty day</td>
<td>Commercial scale model designed; 1200 M/ty day</td>
<td>1st to market cellulosic ethanol to consumers; contract signed with Statoil and 165 gallon blends</td>
<td>1st technology license to Milaca forreference in Southeast Asia</td>
<td>Integrated model design introduced to improve carbon intensity of U.S. grain ethanol</td>
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**Commercial Project**

- **LOCATION:** Maasburg, Denmark
- **STATUS:** Engineering and Permitting
- **FEEDSTOCK:** Wheat Straw (50 Tons per hour)
- **PRODUCTS:** Cellulosic Ethanol, Biogas, Renewable Electricity, Renewable Fertilizer, Bold Biocat
- **CAPACITY:** 20 MGY (Cellulosic Ethanol); 1.7 Billion Cubic Feet (Biogas); Renewable Electricity for 25,000 households, 565,000 Tpy of renewable fertilizer; 56,000 Tpy of solid biofuel for power generation

**Project Profile:** Integrates 6 Danish technologies on a 247-acre site in northwesten Jutland, to utilize 400,000 tons of wheat straw and 770,000 tons of livestock waste annually.
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.

RESEARCH AND DEVELOPMENT FACILITY
LOCATION: Fayetteville, AR
FEEDSTOCK & PRODUCTS: Synthesis Gas, Ethanol, Other
CAPACITY: 1.5 tons per day
PLANT PROFILE: INEOS Bio utilizes its integrated pilot plant to test, prove and optimize its proprietary technology. INEOS Bio’s pilot plant and research and development facility represents a vitally important step-on the road to commercialization. The company will continue to operate its pilot plant in parallel with its commercial and licensed facilities. Experience has shown that continued development and research with an integrated pilot plant supports an overall continuous improvement process that benefits our licensees and operating facilities.

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.

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

PATH TO COMMERCIAL DEPLOYMENT

INEOS VERO BEACH COMMERCIAL FACILITY
LOCATION: Vero Beach, FL
STATUS: Commissioning Stage
FEEDSTOCK: Vegetative and Yard waste; MSW
PRODUCTS: Cellulosic ethanol and renewable power
CAPACITY: 8 MGY; 6MW (gross) electricity generation
JOBS: 400 direct and indirect jobs, 60 full time
PLANT PROFILE: The site, adjacent to the Indian River County landfill, ensures flexibility and long-term feedstock availability.

Technology tested, proven and optimized at fully integrated pilot plant scale
Awarded $50MM DOE Grant through IBA program
First DOE awarded facility to move to construction phase
Groundbreaking on first commercial scale plant in Florida, USA
Selected/awarded USDA Loan Guarantee
Completion of construction/commissioning and operations of Florida plant
Additional INEOS Bio Licensed & Operating Facilities
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ESTIMATED START UP 2012
INOS Bio
Since Iogen’s founding in the late 1970s, more than $425 million has been invested in Iogen’s cellulosic ethanol technology, including more than $75 million in the Iogen demonstration plant in Ottawa. Investors include Royal/Dutch Shell, Goldman Sachs, Petro Canada, and Volkswagen. The company, based in Ottawa, has produced more than 560,000 gallons of cellulosic ethanol to date and holds more than 250 patents. Iogen also operates a thriving business making enzymes that digest fiber.

**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**

**Location:** Piracicaba, São Paulo, Brazil

**Status:** Development and Engineering

**Feedstock:** Bagasse

**Products:** 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.

**Path to Commercial Deployment**

- 2008: Implemented Release 6 Technology at Demo Plant
- 2010: Demonstrated sustainable 24/7 operability at Demo Plant with Release 6 Technology
- 2011: Started-up and achieved all B8 Technology and production milestones at Demo Plant
- 2012: Detailed evaluation of several commercial roll-out options
- 2013: Sugarcane bagasse processing started in Demo Plant
- 2014: Initiated collaboration with Raízen on cellulosic ethanol in Piracicaba (Brazil)
- Targets not yet announced
- Targets not yet announced
- Targets not yet announced
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 has 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**

**KiOR Partners**

Private Equity/Investment: Initial public offering proceeds were approximately $148.6 million. Major stock ownership: Class A&B shares - 57.2 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.

**PATH TO COMMERCIAL DEPLOYMENT**

**Demonstration Facility**

**Location:** Pasadena, TX

**Feedstock:** Forestry Residues

**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.

**2nd Commercial Project Under Development**

**Location:** Natchez, MS

**Feedstock:** Forestry Residues

**Products:** Cellulosic Gasoline & Cellulosic Diesel

**Capacity:** 40 MY

**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.

**Commercial Facility**

**Location:** Columbus, MS

**Status:** Operational

**Feedstock:** Forestry Residues

**Products:** Cellulosic Gasoline & Diesel

**Capacity:** 13 MY

**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.

**KiOR Commercial Project in Columbus, MS**

**Estimated Startup:** Q4 2012

**Estimated Completion:** 2014

**KiOR COMMERCIAL PROJECT IN COLUMBUS, MS**
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 2006, 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

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
- First Plant operating at 15,000 gal/year capacity
- LanzaTech successfully produces 2,3-Butanediol in key building block used to make polymers, plastics and hydrocarbon fuels
- Construction begins on Baosteel demonstration facility
- First Demonstration facility becomes operational in China
- Full Commercial scale plant to be constructed with Baosteel
- Construction begins on Freedom Plant
- Production at Freedom (Iowa Commercial Biorefinery) begins
- Full scale commercial plant with Baosteel to be operational
- Construction begins on second commercial plant (Capital Steel) begins
- MSW to ethanol commercial project to be constructed in Asia
- Second Commercial Facility operating in China (Shougang)
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.

**Demonstration Facility**
- **Location:** Rome, NY
- **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 extended validation run using Mascoma’s hardwood CBP microorganisms.

**Commercial Project**
- **Location:** Kinross, MI
- **Status:** Final Engineering, Closing Financing
- **Feedstock:** Wood pulp and chips
- **Products:** Cellulosic ethanol
- **Capacity:** 20 MGY
- **Jobs:** 150 construction jobs; 60 permanent operations jobs, up to 500 indirect jobs according to State of Michigan
- **Project Profile:** First-of-its-kind 20 million gallons per year cellulosic ethanol facility utilizing proprietary CBP technology; agreement in place for hardwood pulpwood feedstock to be sourced from Michigan counties located within a 150-mile radius area of the site.

**Path to Commercial Deployment**
- 2008
  - 1st gallon of cellulosic ethanol produced at Rome, NY demonstration facility
  - Awarded $20MM grant from Department of Energy Economic Development Corporation for Kinross, MI project
  - $20MM DOE grant awarded for construction of an industrial scale fermentation system and development of integrated cellulosic ethanol plant
  - Acquired SunOpta Bioproducts, a company that provides pretreatment equipment and process solutions for biomass conversion
  - Awarded up to $50MM in funding from DOE to assist in development of a commercial-scale cellulosic ethanol facility in Kinross, MI
  - Demonstrated $2.00/gallon cash operating cost and hardwood to ethanol conversion yield of 71 gallons per bone dry ton at NY demo facility
  - Received contractor bids for Kinross, MI facility and conducted final engineering design work
- 2009
  - Ground breaking at Kinross, MI commercial facility
  - Ground breaking at 2nd commercial-scale cellulosic ethanol facility in Drayton Valley, Alberta
- 2010
  - Construction completed, first gallons produced at Kinross, MI commercial facility
- 2011
  - Target: 2012/13 timeframe
- 2012
  - Construction completed, first gallons produced at Alberta commercial facility
- 2013
  - Target: 2013/14 timeframe
- 2014
  - Construction completed, first gallons produced at Alberta commercial facility
- 2015
  - Target: 2015/16 timeframe

**Mascoma Partners**
- **Private Equity:** Raised $120MM in four rounds of financing (Khosla Ventures, Flagship Ventures, General Catalyst Partners, Kleiner Perkins Caufield & Byers, Pinnacle Ventures, VantagePoint Partners, Jeremy Grantham, Valero Energy Corporation, Marathon Petroleum Company, General Motors Ventures).
- **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.
COMPANY PROFILE
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-DSM demonstrated the feasibility of converting corn crop residue into cellulosic bio-ethanol. The project, dubbed Project LIBERTY, will produce 20 MGY of cellulosic bio-ethanol.

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 stackyard completed, first commercial biomass harvest (56,000 tons); 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
- DSM starts extensive enzyme development program for cellulosic ethanol

2009
- Significant cost reductions at pilot facility, 12,000 acres of biomass harvested
- Commercial biomass stackyard completed
- DSM identifies enzyme system effective at breaking down lignin cellulose
- Site work started on commercial-scale biorefinery

2010
- First commercial biomass harvest (56,000 tons)
- Second commercial biomass harvest (61,000 tons)
- DSM acquires C5 Yeast Company from Novo

2011
- Site work completed on commercial-scale biorefinery
- DSM acquires CS Yeast Company from Novo

2012
- Joint venture formed with Royal DSM
- Vertical construction begins on commercial-scale biorefinery
- Third commercial biomass harvest (65,000 tons)

2013
- Anticipated completion of construction at commercial-scale facility
- Validate technology at commercial scale

2014
- Validate technology at commercial scale

2015
- Estimated completion 4Q 2013

Project LIBERTY will make use of cobs, leaves, husk, and some stalk that pass through the combine during harvest. The process uses about 25% of the available material, leaving 75% on the ground for erosion control, nutrient replacement and other important farm management practices. The co-product from the cellulosic ethanol process will be energy, enough to power LIBERTY and send excess to the adjacent corn grain-based plant.

2008-2009
- Poet pilot plant becomes operational
- Second round of biomass harvested
- DSM starts extensive enzyme development program for cellulosic ethanol

2009-2010
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- Third commercial biomass harvest (65,000 tons)

2012-2013
- Anticipated completion of construction at commercial-scale facility
- Validate technology at commercial scale

2013-2014
- Validate technology at commercial scale

2014-2015
- Estimated completion 4Q 2013
- Project LIBERTY
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 GYP
PLANT PROFILE: Construction completed on schedule and significantly under budget; created 52 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, Itosu, 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.

ZeaChem’s Core Technology
BIOREFINERY
ZeaChem’s Core Technology
FRACTIONATION
HYDROGENATION
CARBON TECHNOLOGY
LIGNIN
SUGAR
ACETIC
ACID
ETHYL
ACETATE
GASIFICATION
ESTIMATED COMPLETION TQ 2018

Commercial Facility
LOCATION: Boardman, OR
STATUS: USDA Conditional Loan Guarantee Awarded
FEEDSTOCK: Poplar Trees, Wheat Straw
PRODUCTS: Cellulosic Ethanol, Bio-Chemicals
CAPACITY: 25+ MGY
JOBS: 200 direct construction jobs; 65 full-time operations jobs; 250 indirect jobs for construction and full-time operations
PLANT PROFILE: Located adjacent to ZeaChem’s demo plant; agreements in place for 100% of the required feedstock from GreenWood Resources and local agricultural residue processors.

Path to Commercial Deployment
2008
2009
2010
2011
2012
2013
2014
2015
Raised $34MM Series B
Selected as one of 19 advanced biofuels projects for DOE Integrated Biorefinery Cooperative Agreement ($25MM)
Established partnerships with Chrysler and P&G
Began operations at demonstration bio-refinery, 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 bio-refinery
Anticipated start of production at 1st commercial bio-refinery