

DOE Bioenergy Technologies Office(BETO) IBR 2015 Project Peer Review

Integrated Biorefinery for conversion of Biomass to Ethanol, Synthesis Gas, and Heat

March 25, 2015
Integrated Biorefinery Peer Review

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Abengoa Bioenergy

Abengoa Bioenergy Biomass of Kansas

Corporate Headquarters – St. Louis MO

Subsidiary of Abengoa SA, Spain



Ethanol facilities in Nebraska, Kansas, New Mexico, Illinois, Indiana, Spain, France, Netherlands and Brazil

Goal Statement

- Design, build and operate a commercial scale bioethanol facility that uses sustainable biomass feedstock, drastically reduces green house gas emissions while achieving output production, yield and cost targets.

Quad Chart Overview

Timeline

October, 2007
3rd Quarter 2014

Budget

- \$444.6 MM Total
 - DOE share: \$97.5MM
 - Abengoa share: \$347.1 MM

Project Development

EPC Cost +18% / Schedule +6 Months
Multiple Criteria Changes in the Start
Startup - 1st Quarter 2014

Project Participants

Various Abengoa Companies
US Department of Energy
Various Equipment Vendors

1 - Project Overview

Development Background

		Date	Remarks
1. Hybrid plant – Grain ethanol	84 MGPY	2008	Original Project Concept
Biomass ethanol	11.4 MGPY		
2. Biomass with Cogen - Ethanol	11.4 MGPY	2009	Movement away for grain based ethanol plus GHG reduction
Electrical Cogeneration	20 to 60 MW		
Lignin	21.2K DT/yr		
Syngas	157 MM BTU/hr		
3. Biomass with Cogen - Ethanol	16 MGPY	Aug-2009	Economy of scale for Ethanol and Cogeneration plant
Electrical Cogeneration	125 MW		
4. Biomass with Cogen - Ethanol	25 MGPY	Aug-2010	Economy of scale for Ethanol Failure of REC legislation reduced cogen to only GHG reduction
Electrical Cogeneration	21 MW		

Hugoton project highlights

- Capacity: 25 MGPY ethanol from biomass
- Electricity capacity: 21-MW electrical power. Excess power to the grid
 - Location: Hugoton, Kansas
- Site: 391-acre parcel plus 427 adjacent farmland
 - Feedstock: Corn stover, wheat straw, seasonal grasses
 - Biomass: ~320,000 dry tons per year
- Initial Cogen Start-up: December 2013
- Objective is to build a commercial-scale enzymatic hydrolysis facility for conversion of biomass to ethanol at a competitive price
- DOE awarded \$97 MM cost share and a short term federal loan guarantee to facilitate design development and construction



Timeline since finalized criteria

	Date
1. Basic Design	1/2/11 to 6/15/11
2. EPC estimating	6/15/11 to 8/15/11
3. Signed EPC Contract	9/30/11
4. Begin limited construction	12/1/11
5. Initial detailed engineering design approvals	9/28/12
6. Completed PHA/HAZOP, constructability reviews and 3D model reviews.	1 st Quarter 2013

Milestones

	Date
1. Boiler Hydro Tested	5/4/13
2. Energized Main Substation	6/15/13
3. Cogen Mechanical Completion	8/30/13
4. Cogen placed in service and synced to the grid	12/29/13
5. Ethanol Mechanical Completion	3 rd Quarter 2014
6. Commenced Ethanol Commissioning	Late 3 rd Quarter 2014
7. Full Production	Summer 2015

Project Participants

- Abengoa Bioenergy Biomass of Kansas
- Abengoa Bioenergy New Technologies
- US Department of Energy – Biomass Program
- US Department of Energy – Loan Guarantee Program
- Abeinsa EPC
- Multiple Equipment Vendors

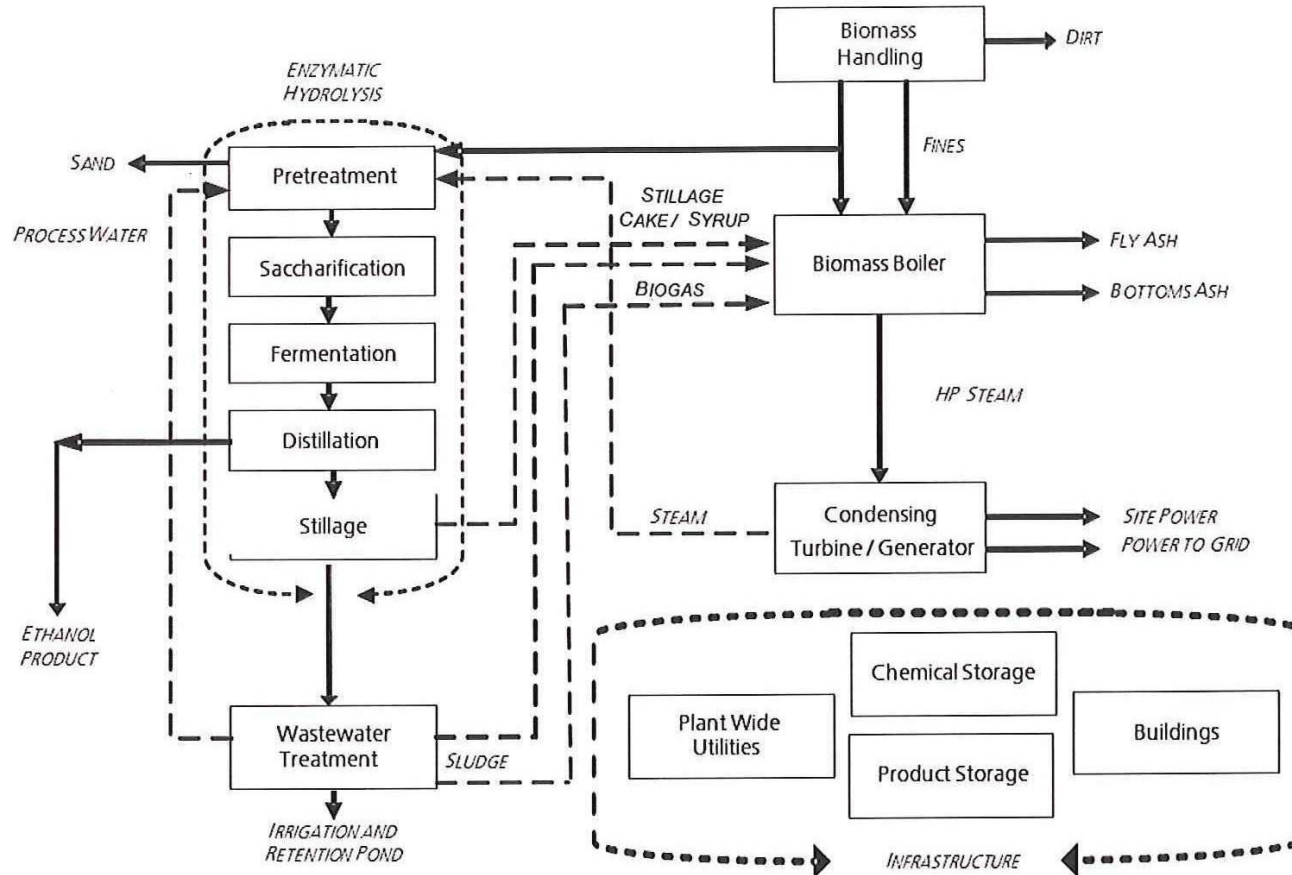
Construction Status as of May 2014



Safety

Abengoa Hugoton Project Safety Record			
Injury/Illness Summary	Jan-15	year to date	project to date
1. Man-hours worked*	23,053	23,053	3,735,117
Abeinsa EPC personnel*	7,811	7,811	371,712
Subcontracts*	14,158	14,158	3,317,515
Security guard: (Securitas)*	1,084	1,084	45,890
2. First aid cases	0	0	209
3. Lost work day cases	0	0	3
4. Lost work days	0	0	39
5. Restricted work day cases	0	0	3
6. Recordable only cases	0	0	27
7. Total recordable cases (3+5+6)	0	0	33
8. Total recordable incident rate (TRIR)	0.00	0.00	1.77
Frequency Rate (IF)	0.00	0.00	0.80

Process Flow Diagram



Abengoa Bioenergy Biomass of Kansas

2 – Approach (Management)

- Project Management - Abengoa Bioenergy Biomass of Kansas (ABBK)
- Research and Development - Abengoa Bioenergy New Technologies (ABNT)
- Final Detailed Design and Procurement - Abeinsa EPC
- Construction Management - Abeinsa EPC, as a General Contractor
- Start-up and Commissioning - Abeinsa EPC, ABBK, ABNT and Plant Personnel
- Operations – Abengoa Bioenergy - ABBK and Plant Personnel

2 – Approach (Technical)

- Internal process and equipment design by process engineering ABNT
- Research and development by Abengoa Bioenergy New Technologies
- Internal subject matter expert teams for each process area
- Used engineering firms to support development of equipment specifications and preliminary bidding.
- Risk mitigation testing and verification by internal R&D facilities and 3rd party experts and vendors
- Employed formal project design procedures for document and change control

3 – Technical Accomplishments/Progress/Results

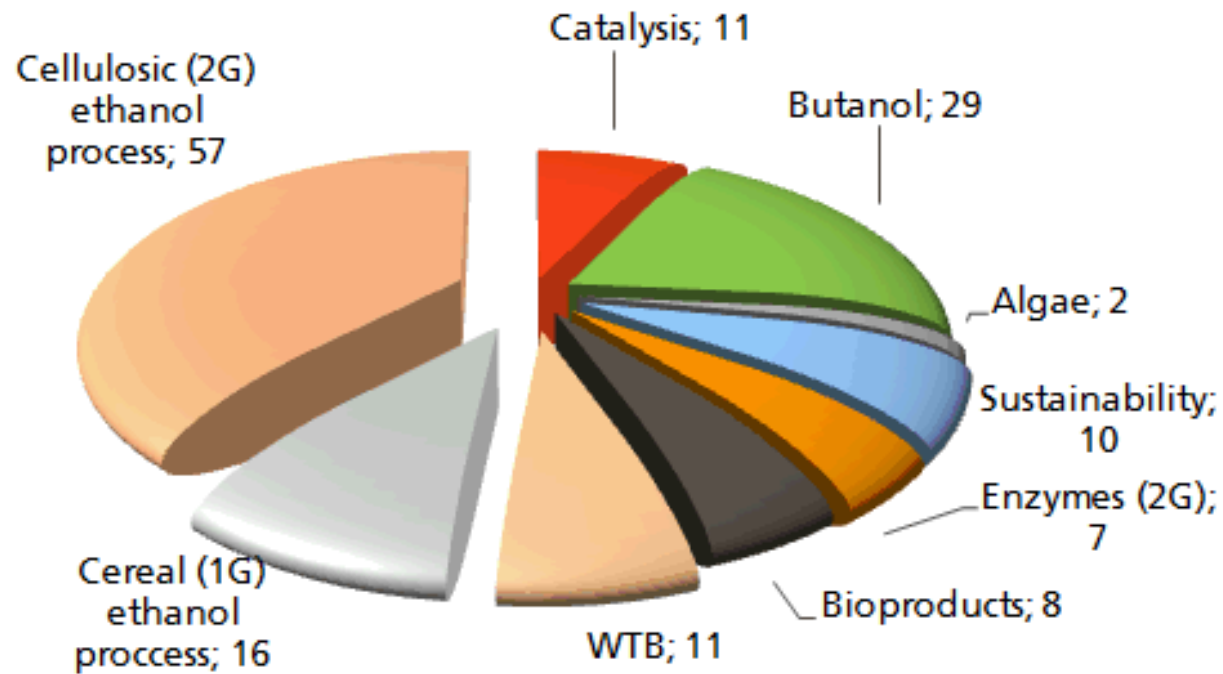
- Achieved gallons of ethanol per ton of biomass productivity target in pilot plants
- Developed a modified biomass handling system that utilizes both square and round bales for multiple feed stocks.
- Worked with vendors to develop new live bed trucks
- Developed a process design that allows for multiple types of yeast and enzymes resulting in a more reliable supply chain and less cost.

3 – Technical Accomplishments/Progress/Results - Continued

- Developed and tested a waste water treatment process that met project treatability requirements for a variety of biomass feed stocks.
- Designed a new pretreatment system material handling system resulting in higher yields.
- Designed and verified a processing system that provides heat recovery of stillage and syrup

Intellectual Property

Cumulative number of patent application filed (total 151)



4 – Relevance (BETO Multi-Year Program Plan)

The Hugoton project will commercially demonstrate the Biomass Program objectives through a first of a kind commercial scale biomass to ethanol facility that will;

- Demonstrate the enzymatic hydrolysis sugar platform for ethanol and bio-based chemicals
- Develop and demonstrate cellulosic feedstock supply system
- Demonstrate the commercial performance of new recombinant yeast and enzymes systems
- Meet all air emissions and water discharge permit requirements
- Reduce green house gas
- Can be replicated and added to existing ethanol facilities

Critical Success Factors/Technical Targets

Consistent production at demonstrated yield rates

- Impacted by redundancy in design
- Minimization of yield loss due to contaminations
- Strong development of yeast and enzymes
- Consistent number of “on-stream” days per year
 - Again strongly impacted by redundancy in design
 - Material handling issues – clogs, material inconsistencies, fouling, etc.

4 – Critical Success Factors (Cont)

Biomass Supply (collection, harvest, storage and transportation)

- Securing contracts for supply (Joint venture)
- Multiple harvest demonstrations
- Quality of harvest collected
 - Fines
 - Ash
 - Foreign matter

Benefits and Expected Outcomes

Initial: A commercial scale biomass to ethanol facility that produces ethanol at a competitive cost and drastically reduced green house gas emissions without the consumption of animal feed products and hydrocarbon based fuels.

Secondary: Advancement of second generation yeast and enzymes capable of converting other biomass based feed stocks into sugars.

5 – Future Work

Key activities for next 3 months;

- Complete commissioning activities at full rate
- Successfully execute final performance test
- Achieve performance guarantees

Summary

- Project achievements are directly usable on existing corn ethanol facilities and future hybrid plants.
- Currently working on waste to biofuel design
- All process technology challenges and objectives have been achieved.
- All environmental regulations and permitting have been met.
- Final design and construction is complete.

Additional Slides

Responses to Previous Reviewers' Comments

- Comment; No flow sheet or technical discussion of the project.
Response; Process flow diagram provided and verbal description to be given during presentation.
- Comment; No mention of construction safety.
Response; Construction safety metric provided in the presentation.
- Comment; Concern that “surprises” in startup and operation could arise since the project was not piloted on integrated demo scale.
Response; Cost and time did not permit a large scale integrated demo scale.

Patents, awards, publications, and presentations

- Patents: 64 Cellulosic 2G, 50 other products, 11 Catalysis, 16 Cereal 1G
- Awards: Biofuels Digest's 2015 Advanced Bioeconomy Award - Project of the Year: Cellulosic Biofuels at scale
- Publications: 89 unique articles
- Presentations: Various

Commercialization efforts

- A second 2G project is in progress in Brazil that will utilize bagasse as the biomass feedstock for ethanol.
- Currently working on waste to biofuel design
- Formed and staffed a business development group that is actively marketing 2G hybrid and greenfield systems.

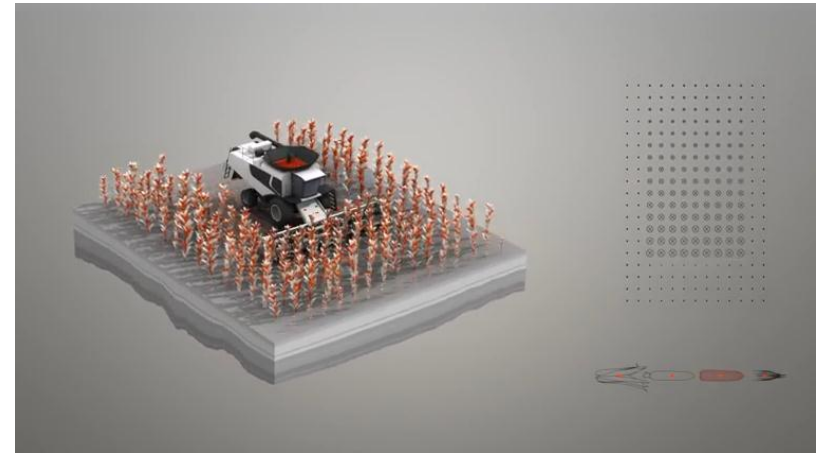


- **Associated Press** – *Biofuels Plant is Harbinger of Renewable Fuel Future*
- **Bloomberg** – *Abengoa Making Ethanol From Crop Waste at Plant in Kansas*
- **Ethanol Producer Magazine** – *Abengoa Facility is a Hugoton Diamond*
- **Huffington Post** – *New Biofuels Facility Converts Plant Waste to Ethanol, is 90% Cleaner than Gasoline*
- **New York Times** – *Biofuel Companies Look Beyond the Gas Tank*
- **NBC** – *New Biorefinery Brings Jobs to Kansas*





Biotechnology Renewed > **ABENGOA**



The Future of What's Left Behind

Biofuels Digest's 2015
Advanced Bioeconomy
Award Nominee

Project of the Year:
Cellulosic Biofuels at scale



2015

Advanced Bioeconomy Awards