U.S. Department of Energy (DOE)  
Bioenergy Technologies Office (BETO)  
2017 Project Peer Review  

POET-DSM Project LIBERTY  

March 6th, 2017  
Demonstration and Market Transformation  
Session Area Review  

Mike Dishman  
POET-DSM  

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Project LIBERTY
Goal Statement

- Project Objectives
  - Process 700 metric tonnes of biomass for the purpose of manufacturing cellulosic ethanol in a co-located IBR model
  - Implement a sustainable stover collection, storage and delivery system
  - Demonstrate shared DOE/POET-DSM foresight for biomass investments and technology for rapid deployment of commercial scale biorefineries
  - Maximize alternative energy production and minimize traditional energy usage *(MYPP goal)*

- As with BETO, POET-DSM goal is to develop commercially viable bioenergy
  - To enable sustainable, nationwide production of biofuels
  - Displace a share of petroleum-derived fuels to reduce U.S. dependence on foreign oil
  - Encourage the creation of a new domestic bioenergy and bioproduct industry. *(MYPP goal)*

- Project LIBERTY is one of the first commercial scale cellulosic biorefineries operating in the U.S
  - DOE grant accelerated DMT construction and operations
  - Successful DMT will help launch replication
Quad Chart Overview

Timeline

- Project start dates (construction):
  - Biomass stackyard - 2010
  - Biorefinery - 2012
- Project end date:
  - Commercial biomass handling operations began: July 2014
  - Mechanically Complete: Dec. 2014
  - Final Acceptance: Dec 2017
- Percent complete:
  - EPC & cost share funding 100%

Barriers

Barriers Addressed:
- Start up & operations are underway
- System improvements are being executed.
- Preparing for Performance Testing and Final Acceptance

Partners

- DOE & State of Iowa for grant funding
- Business is joint venture between POET (50%) and DSM (50%).
- Collaborating with Novozymes and NREL.
- Intellectual property licenses are held by POET and DSM.
- Project/construction management and commissioning contracted to POET Design and Construction.
- Start-up and Operations contracted to POET Plant Management.

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- **Environmental Engineering, Design, Feedstock Development**
- **Demo Harvest**
- **Commercial Harvest**
- **Pilot Plant Operations & Continuous R&D**
- **IPA Review**
- **Liberty Construction**
- **Ops Reporting Period**
Key Milestones

- Project schedule status
  - Major construction was complete August 2014
    - Front end processing construction was complete June 2014
      » Baseline was May 2014
    - Back end processing construction was complete August 2014
      » Baseline was May 2014
  - Front end operational start was July 07, 2014
  - Major commissioning was complete September 2014
    - 28 months of operation
  - Achieved Mechanical Completion December 2014
  - Operational capacity goal of 770 BDT/day to achieve Final Acceptance by end of 2017
## Detailed Project Budget Table

<table>
<thead>
<tr>
<th>Budget Periods and Phasing</th>
<th>DOE Funding</th>
<th>Project Team Cost Shared Funding</th>
<th>Contingency</th>
<th>Project Spending and Balance</th>
<th>Final Project Costs</th>
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What funding is needed to complete the project.
## Detailed Project Scope Change Detail

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<th>Date</th>
<th>Logic / Reasoning</th>
<th>Approval / Rejection Date</th>
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<td>Solid Fuel Boiler Added to Project Could not break down lignin thermophyically.</td>
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<td>Change order to support engineering adjustments to scope design. JV formed. Switched vendor technology for ADBG</td>
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<td>Scope / Schedule</td>
<td>2013/11</td>
<td>Scope increases to complete project on time.</td>
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1 - Project Overview

- **Location of project and company headquarters**: Project LIBERTY is located in Emmetsburg, IA, co-located with POET Biorefining - Emmetsburg. POET-DSM company headquarters is in Sioux Falls, SD.

- **High Level overview of**:  
  - Feedstock handling: Manual handling from trailer to milling equipment by rolling stock. Net wrap removal will be automated by POET designed equipment.  
  - Conversion technology: Acid pretreatment with enzymatic conversion  
  - Product purification: Standard fuel ethanol distillation and molecular sieves

- **Scale of the project under development with DOE assistance**:  
  - Feedstock(s) tons per day at this facility: Minimum of 700 metric tonnes per day  
  - product(s) gallons (or pounds) per year of this facility: 20 million gallons of cellulosic biofuel per year, ramping up to 25 million gallons per year
Company Structure and Project Management

Key Partnership Objectives

- Global footprint – ability to enhance POET’s US footprint with global assets
- Leadership in licensing model – licensing opportunity for cellulosic key value proposition
- Ability to match POETs strong history of technological advancement – mitigate technology risk
- Matching culture – critical to success
2 - Approach Management

- POET-DSM Advanced Biofuels uses its combined expertise to address open technical issues.
- The POET pilot plant in Scotland, SD has been operating since 2008. The technologies used in the LIBERTY project have been either piloted in Scotland or at vendor locations.
- Commercial, pilot plant, and lab results are reviewed on a continuous basis.
- All of the critical go/no go decisions have been cleared for the project. The technical teams continue to review results and seek continuous improvements.
- All process development activities are evaluated through an economic model. The economic model evaluates key indicators such as operational cost/gallon, total capex/gallon, etc.
2- Overall Technical Approach

Goal: Commercial-scale cellulosic plant

Objectives
- Integrated model
- Sustainable biomass supply
- Replication model
2 - Overall Technical Approach

- Manual corn stover bale handling from trailer to milling equipment by rolling stock.
- Sized biomass is processed with acid pretreatment and enzymatic conversion.
- Sugars created in acid pretreatment and enzymatic conversion are fermented with a propagated GMO yeast.
- Standard fuel ethanol distillation and molecular sieves are used to purify the fermentation beer.
- Beer solids and evaporator solids are converted to steam in a solid fuel boiler. The steam is used at LIBERTY and co-located grain ethanol plant.
- Waste water is anaerobically treated to produce methane gas which is used at Liberty and the co-located plant.
2 - Critical Management Success Factors

1. Feedstock supply & management

2. Commercial scale technology demonstration

3. Replication
2 - Management Potential Challenges

1. Feedstock supply & management

2. Commercial scale technology demonstration

3. RFS / Market access / Financing for replication
The technical objectives continue to be tested both at lab and pilot scale. The basis for the LIBERTY design specifications and current operations are created based on this data.

Commercial biomass handling operations began in July 2014.

Technical Accomplishments include:
- Completion of detailed design engineering including anaerobic digestion and biogas scrubbing technology based on pilot plant results.
- Mechanical Completion issued by Design Builder.
- Commissioning is complete and start-up efforts continue.
- Design Builder turnover of entire facility completed.
- Facility operations have commenced
- Optimization to meet design rate improving
2- Technical Accomplishments/Progress/Results Progress Benchmarks

• **Recent Key Milestones Include:**
  - Operations turned over to POET Plant Management July 2014
  - Mechanical Completion certification July 2015
  - Begin operations of anaerobic digestion/biogas scrubbing unit operation Q2 2015

• **Future Key Milestones Include:**
  - D/B Guaranteed Performance Test Q3 2017 - Behind Schedule
  - D/B Final Acceptance Certification Q4 2017 - Behind Schedule
2 - Technical Accomplishments/Progress/Results
Progress Benchmarks

- Mechanical Completion, commissioning and start-up were achieved slightly behind the planned schedule.
  - Progress was slowed by winter construction and finalization of the anaerobic digestion and biogas scrubbing detailed design.

- Operational turn-over to POET Plant Management was partially completed on schedule.
  - The majority of the facility was turned over as planned. The anaerobic digestion and biogas scrubbing systems were turned over later than the other areas of the facility.

- Currently working toward continuous cellulosic ethanol production
  - Biomass conveyance
  - Pretreatment
3- Relevance

- Project LIBERTY is one of the first commercial scale cellulosic biorefineries designed to 770BDT/day (MYPP goal)
- DOE grant accelerated commercial demonstration scale construction and operations of Project LIBERTY.
- Successful demonstration at commercial scale will encourage replication at other biorefineries. (MYPP goal)
- POET plans to have a hand in producing billions gallons of cellulosic ethanol by 2022. (MYPP goal)
- Within 3 years of continuous production, POET anticipates a 15% reduction in the cost per gallon
- Over 25 years of POET corn-to-ethanol technology improvements are strong evidence that cellulose-to-ethanol technology improvements will be significant
  - Corn based ethanol yields have improved by 20%
  - POET plants are using 33% less energy/gallon than 12 years ago
  - POET plants’ water usage/gallon is down 80%
3 - Relevance
The POET Plan

- Our vision is to enable all consumers in every state to choose domestic, renewable fuels
- Our objective is to ensure sufficient supply to meet the consumer demand
- We will start with a goal...
- **3.5 billion gallons of cellulosic ethanol by 2022**
  - 1 billion from adding cellulosic technology to POET plants
  - 1.4 billion from licensing technology to other corn-based ethanol producers
  - 1.1 billion from other forms of biomass produced by POET through joint ventures and opportunities
# Risk Registry Table

<table>
<thead>
<tr>
<th>Tracking Number</th>
<th>Project Area</th>
<th>Project Risk</th>
<th>Risk Mitigation Plan</th>
<th>Risk Probability</th>
<th>Potential Impact</th>
<th>Mitigation Location / Strategy</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>Management</td>
<td>Turnover in project management or engineering staff during the course of the project</td>
<td>Project oversight by multiple managers will create virtual redundancy.</td>
<td>Medium</td>
<td>Medium</td>
<td>POET</td>
<td>Open</td>
</tr>
<tr>
<td>4 Biomass Feedstock</td>
<td>Bale age and how it relates to dry matter loss/carbohydrate content/ferment ability/ethanol yield and fines creation during milling.</td>
<td>Continued research by PRI and PBM with LIB stack yard material.</td>
<td>Medium</td>
<td>Medium</td>
<td>Gather yield data at LIBERTY and take corrective action as data indicates.</td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>Pretreatment</td>
<td>Solids /Liquid Ratio control</td>
<td>Install new POET technology</td>
<td>High</td>
<td>High</td>
<td>Technology installed and being optimized</td>
<td>Open</td>
</tr>
<tr>
<td>12</td>
<td>Biomass Feedstock</td>
<td>Feedstock oversupply due to less than design rate steady state operations.</td>
<td>Currently working to increase feed rates to the solid fuel boiler. Increase steady feed from biomass handling to pretreatment</td>
<td>High</td>
<td>High</td>
<td>This is a concern and we are establishing contracting management strategies to have flexibility. Getting to design rate will mitigate this issue.</td>
<td>Open</td>
</tr>
<tr>
<td>13</td>
<td>Biomass Feedstock</td>
<td>Alternative option to disposing of older material.</td>
<td>Working on strategies to enable the product to be fed into the plant. It will require more resources to do so.</td>
<td>High</td>
<td>High</td>
<td>Working on possible alternative outlets for aged material. Evaluation continues on handling viability for conversion of older biomass</td>
<td>Open</td>
</tr>
<tr>
<td>14</td>
<td>Biomass Feedstock</td>
<td>Ability to contract an unknown amount of volume.</td>
<td>Based on lack of run-time experience, the quantity necessary for full production in unknown.</td>
<td>Medium</td>
<td>High</td>
<td>Continue to keep producers informed of forecasted needs while maintaining realistic expectations.</td>
<td>Open</td>
</tr>
<tr>
<td>7</td>
<td>Pretreatment</td>
<td>Continuous Operations challenge due to solids/liquid ratio</td>
<td>Evaluate alternative systems</td>
<td>Medium</td>
<td>High</td>
<td>Technology for solids management installed and showing success, optimization continues</td>
<td>Open</td>
</tr>
<tr>
<td>9</td>
<td>Solid Fuel Boiler</td>
<td>Syrup to SFB could cause slagging issue in combustor.</td>
<td>Disposal of syrup to other uses.</td>
<td>Medium</td>
<td>Medium</td>
<td>Sending syrup off to digester company.</td>
<td>Open</td>
</tr>
</tbody>
</table>
Technical Performance

Project LIBERTY- Process Operations Block Diagram

- String/Twine Removal
- Bale Shredder
- Biomass Conveyance
- Pretreatment
- Sacc-Ferm-Distillation
- Solid Liquid Separation
- Solid Fuel Boiler
- Sacc-Ferm-Distillation
- Ethanol Storage

OSM Mid 2018

- String/Twine Shredder

Issues:
- No Issues
- Minor Issues
- Major Issues
- Future Process

Future Process
4 - Future Plans

- Continue to Optimize Project LIBERTY to meet 770bdt/day *(MYPP Goal)*
- Begin replication planning for next project in POET network as we approach commercial rates at Project LIBERTY *(MYPP Goal)*
- Rollout POET-DSM licensing plan starting with US based biorefineries
Summary

• POET/DSM Project LIBERTY construction is complete.
• Operations have started; commercial reality is here now.
  - System performance is being improved daily; advancements made
  - Driving towards Guaranteed Performance Tests
• Project LIBERTY is a significant contributor to the goals of the DOE Bioenergy Technology Office.
• The approach to integrate with corn-based ethanol plants allows for rapid deployment across the Corn Belt.
• Commercial-scale feedstock supply chain and biomass storage area is in place.
• Maintaining RFS is critical to drive further investment to meet volume goals.
Additional Slides
Responses to Previous Reviewers’ Comments

2015 Peer Review Report Comments

“Well done POET-DSM!”

“This is an excellent project for the DOE portfolio. There is high potential for this project to have a significant impact on the development of advanced biofuels. The start-up challenges are not unusual and generally around materials handling, separations, and biological performance”.

“The POET project is an outstanding success and demonstrates exactly what BETO’s DMT platform should be doing to advance the state of the industry. The performance of the principal investigator and the sub-awardees on the project were exemplary and demonstrates superior project planning, project management, and project implementation. BETO should be commended for supporting the POET project. This project is an excellent example of sound project management and implementation on the part of both the performer and the BETO project officers”.

“As in 2013, the project continues to demonstrate the value of having an experienced operator/developer, with other sources of cash flow, and managing the project”.

“This is an excellent example of a well-planned and executed project. The feed supply chain work is particularly impressive. I would like to see more reporting of safety indexes during construction”.

Response- Safety is the primary focus for Project LIBERTY. The operations team and contractors on site demonstrate sound behavior-based safety culture. Unsafe condition and Near-miss reporting have improved year-over-year since commissioning.

POET-DSM appreciates the support and guidance DOE-BETO has provided our world-changing project.
Patents, Awards, Publications, and Presentations

Patents
- DOE Funded Intellectual Property
  - None
- POET-owned Liberty Related Process Technology IP
  - 7 PCT (filed nationally)
  - 9 US patent applications pending
  - 2 US issued patents
- POET-owned Biomass Collection, Storage and Logistics IP
  - 1 PCT (filed nationally)
  - 2 US patent applications pending
  - 2 US issued patents
- IP-related Agreements
  - C5 Ethanologen: use in pilot plant (secured); commercial license (secured); tolling agreement (secured)
  - Process Technology & Enzyme Use: enzyme supply (field exclusive/time advantage; secured)
  - Pretreatment Equipment Technology: commercial use
  - Many nondisclosure and material transfer agreements

Awards
- None

Publications
- None

Presentations
- None, other than those related to Department of Energy Reviews