2013 DOE Bioenergy Technologies Office (BETO) Project Peer Review

Pilot-Scale Demonstration of a Fully Integrated Process for Converting Woody Biomass into Clean Biomass Diesel Fuel

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Gasification Peer Review

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Organization: Southern Research Institute

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Project's Goal/Objective Statement

Project Goal

- Integrate and demonstrate a hot gasification clean up process at the pilot scale for the production of FT diesel fuel from woody biomass

Project Objectives

- A 300 hr steady state pilot scale operation of the syngas clean up system for Techno-economic analysis and commercial evaluation
- Validate syngas clean up technology for at least 500 hours of steady state operation, with at least 100 hours continuous operations

Project goals/objectives support:

- BETO's and technology area's objective of enhancing gas clean up and production of transportation fuels from high impact biomass
- Industry's objective to lower cost of wood-to-fuels commercial processes to meet RFS2 milestones

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Quad Chart Overview

Timeline

- Start: September 1, 2008
- End: December 31, 2014
- 25 % complete, project has undergone significant restructuring

Budget

Total project funding : $3,141,751

- DOE share: $1,997,793
- Contractor share: $1,143,958

FY09 Funding: $ 158,757 ($153,339 DOE)
FY10 Funding: $ 71,121 ($69,264 DOE)
FY11 Funding: $ 54,777 ($49,010 DOE)
FY12 Funding: $1,619,793 ($488,847 DOE)
FY13 Funding Est.: $682,424 DOE
FY14 Funding Est.: $441,393 DOE
FY15 Funding Est.: $113,486 DOE
ARRA Funding: None

Barriers

- Barriers addressed
  - Cost effective tar reforming and syngas cleanup
  - Pilot-scale demonstration of integrated gasification and gas cleanup
  - Pilot-scale demonstration of integrated biorefinery

Partner

Mott Corporation

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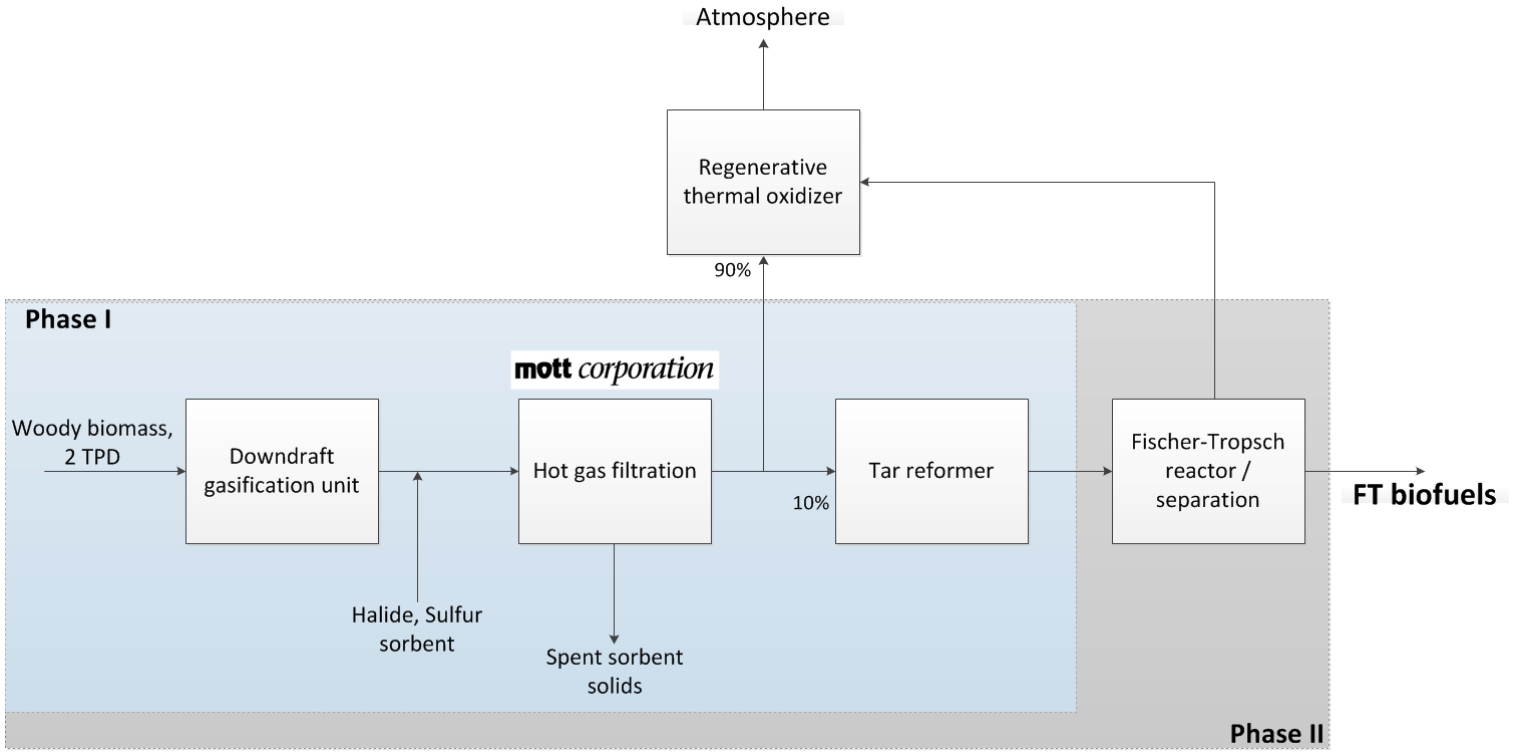
Project Overview



Unit Operation Being Improved

- Gas clean up
  - High temperature filtration
  - Sorbent removal of contaminants

Barrier Addressed

- Integration challenges
- Filtration technologies and FT biomass catalyst longevity

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1 – Approach

Activity / Milestones	Approach and Outputs
Integrate and validate a syngas cleanup system with a biomass gasifier **Milestone:** System shake down; 300 hours of operation	• Engineering design and specification of system; PI&Ds, electrical drawings, plant outlay, HAZOP study, construction / instrumentation plans • Procurement of equipment instrumentation • System installation and instrumentation set up • System shake down • Operate integrated system, measure process performance; QA data
Integrate and test a gasifier/syngas cleanup system with a Fischer-Tropsch unit **Milestone:** 500 hours of operation	• Connect gasifier/syngas clean up system ▪ engineering design and construction • HAZOP study to include FT unit • Experimental plan design and execution
Develop techno-economic modeling of process **Milestone:** Functional model determines process feasibility	• Build upon gasifier's Techno-economic modeling with hot gas clean up (hot filtration and tar reformer) data; add FT data when collected
Project management and reporting	• Project management, required quarterly and annual progress and financial reports, meetings, final report

2 - Technical Accomplishments/ Progress/Results

- Demonstrated steady state biomass gasification on woody biomass using the gasifier (pictured below)

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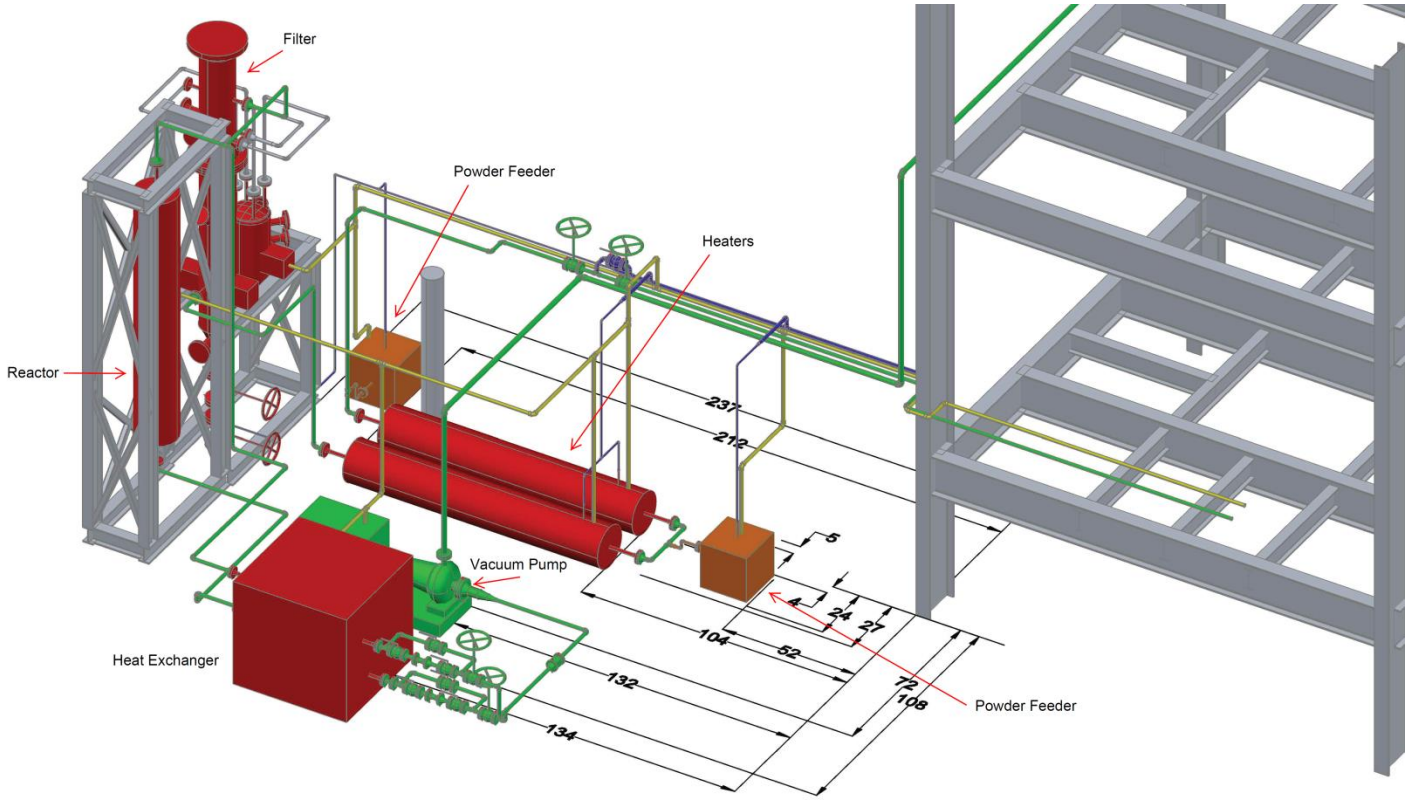
2 - Technical Accomplishments/ Progress/Results (cont'd)

Integrated high temperature clean up:

- Engineering drawings (PI&Ds, 3D AutoCAD for facility layout), electrical drawings
- Equipment and instrument specifications for skid unit, pictured below



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2 - Technical Accomplishments/ Progress/Results (cont'd)

- All major equipment, instruments, high T flanges / gaskets, etc. have been have been ordered
- Subcontracts and scope of works in place for construction work, fabrication, controls, electrical work

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2 - Technical Accomplishments/ Progress/Results (cont'd)

- Disposable sorbent candidates selected and sources identified
- Commercial feeders were found in range of the desired flows

Impurities	Removal Reason	Sorbent Types and Expected Reductions		
		Dolomite	Kaolin Clay	Barium Carbonate
AsH_3	C, F	>99%	---	---
Cl, F, HCl (Halides)	F	>50%	---	>90%
H_2S & COS	C, F, P	>60%	---	---
Toxic Metals	C, F	---	>99%	---
Potassium	C, F, P	---	>99%	---

Reasons for reducing impurities
C = Catalyst (tar cracking) Protection
F = Filter Protection
P = Polishing Filter Protection

Tar reforming catalyst vendors have been identified – confidentiality agreements put in place & samples obtained

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3 - Relevance

Project addresses several conversion goals, cross-cutting goals, and demonstration & deployment goals in Biomass Multi-Year Program Plan Conversion Goals:

- Development and deployment of integrated biorefineries:
  - Demonstration of technology at the pilot scale using scalable gasifier, high impact woody biomass, and industrially relevant FT reactor
- Conversion enabling technologies
  - Cost and energy efficient gas clean up
  - Testing the catalyst efficacy after clean up
- Integration and scale-up
  - Integration of gasification with gas clean up
  - Integration of gasification/clean up with Fischer-Tropsch

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3 – Relevance (cont'd)

- Relevance to bio-energy industry
  - Cost effective tar reforming and syngas cleanup
  - Pilot scale and TEA scale data will generate basis for small commercial scale system
  - Interest of hot gas clean up by multiple gasification development companies
  - Adaptable to multiple gasification platforms test for other gasification platforms at the pilot scale
  - Enable industry to meet RFS2 goals and comply with EISA 2007
  - Potential for use with advanced TRI/EFT or Chevron selective FT catalyst form separate DOE-funded project to further advance the current state-of-the-art

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4 - Critical Success Factors

- **Factors that will define technical and commercial viability**
  - Successful integration/operation of commercially demonstrated gasifier & FT line with new catalytic syngas cleaning system (500hrs); leading to intellectual property opportunities
  - Consistent reductions occur during operation in all FT and cracking catalyst poisons
  - Successful road test in diesel passenger vehicle
  - Economic viability estimated from final techno-economic analysis

  Challenges to be overcome
  - Catalytic syngas cleaning reactor size reduction
  - Maximize catalyst effectiveness on a wide range of tars & hydrocarbons
  - Maximize catalyst life using effective sorbents for tar reforming catalyst and FT contaminants

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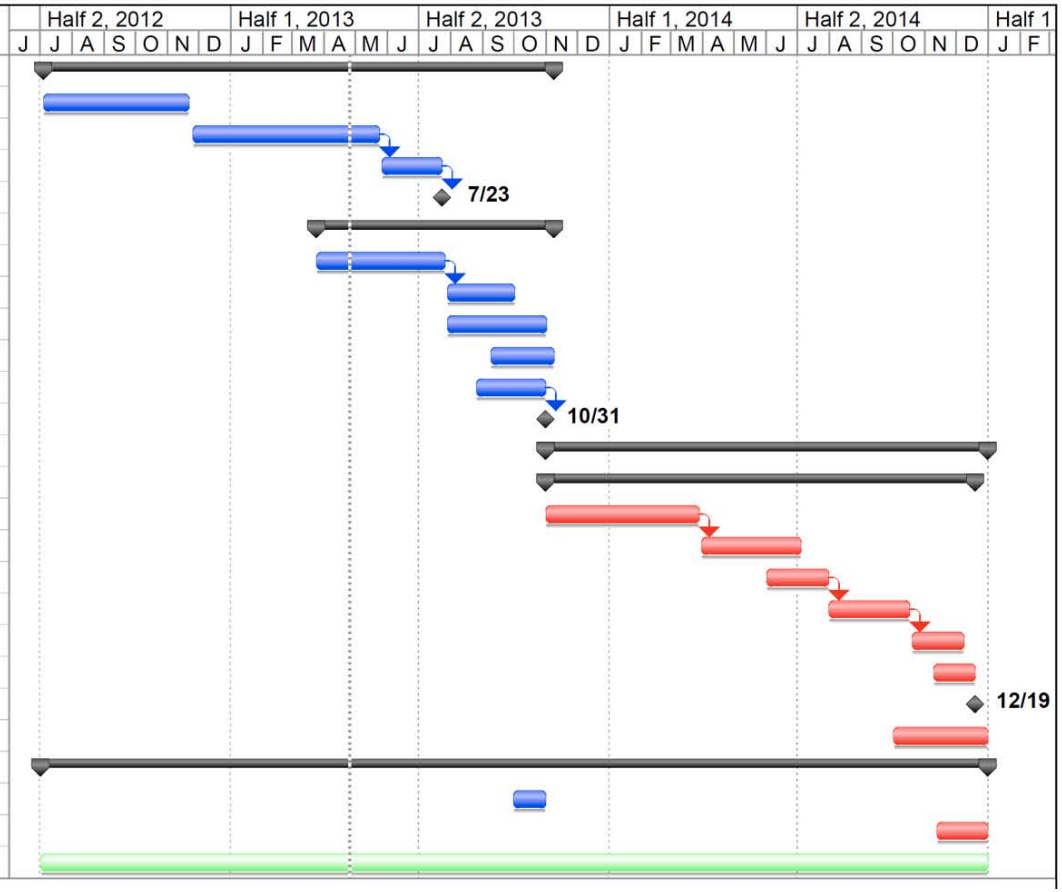
5. Future Work

ID	Task Name
1	**Phase 1: Syngas Cleaning**
2	**Task A: Integration Plan for Syngas Cleaning**
3	**Task B: Fabrication, Erection and Integration**
4	**Task C: Commissioning and Shakedown**
5	Syngas Cleaning System Shakedown
6	**Task D: Operation, Validation, and Optimization**
7	*Subtask D.1.: Develop Operating Plan*
8	*Subtask D.2.: Operate, Test, and Validate*
9	*Subtask D.3.: Data Validation and Analysis*
10	*Subtask D.4.: Optimization and Value Engineering*
11	**Task E: Phase 1 Economic Analysis**
12	Go/No-Go Decision Point
13	**Phase 2: Gas-to-Liquids**
14	**Task I: Operation, Validation, and Optimization**
15	*Subtask I.1.: Develop Operating Plan*
16	*Subtask I.2.: Operate, Test, and Validate*
17	*Subtask I.3.: Analysis of Product Fuel*
18	*Subtask I.4.: Data Validation and Analysis*
19	*Subtask I.5.: Optimization and Value Engineering Analysis*
20	*Subtask I.6.: In-Use Testing of the Product Fuel*
21	*Final Validation of Integrated System*
22	**Task J: Final Economic Analysis**
23	**Task K: Reporting for Phase 1 and Phase 2**
24	*Subtask K.1.: Phase 1 Final Report*
25	*Subtask K.2.: Phase 2 Report and Final Report*
26	*Subtask K.3.: Other Required Reports*



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Summary

- Engineering, procurement, and preliminary experimental planning completed for pilot-scale woody biomass hot gas filtration and catalytic tar removal
- Construction and electrical engineering contracts are being finalized for DOE approval
- Construction for gas clean up integration with gasifier construction imminent, followed by shake down and commissioning
- Must overcome challenge of filter deactivation by removing halides and
- System has significant potential for advancing BETO's goal for system integration and clean up for gasification
- Techno-economic modeling in parallel to pilot operation data
- Goal of project to have 300 hours of operation with gas clean up system and 500 hours with the clean up/FT systems integrated
- Demonstrated success will lead to IP development, cross-platform testing and commercialization

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Additional Slides

Responses to 2011 Reviewers' Comments

Comment: Tar reforming catalyst selection needed more discussion

Response: Catalyst selection and testing conditions used could potentially infringe on intellectual property

Comment: Goals are not quantitative in nature

Response: The go/no-go decisions and goals have a set amount of hours that are explicitly detailed. The upper and lower control limits to be considered at steady state will depend on operational data

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