2015 DOE Bioenergy Technologies Office (BETO) Project Peer Review

Demonstration of Pyrolysis Biorefinery Concept for Biopower, Biomaterials and Biochar

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Thermochemical Conversion Peer Review

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This presentation does not contain any proprietary, confidential, or otherwise restricted information

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Goals/Objective Statement

Project Goals:

- Design, Build and Operate 2.5 ton/day Integrated Pilot Plant
  - Wood and corn stover feedstocks
  - Make Products and Collect Engineering Data
  - Demonstrate continuous operation
- Pre-Commercial Testing of Products
  - Bioasphalt® binder, Chemicals, Fuel Oil, Transportation Fuels and Biochar Applications

Supports BETO Goals:

- Conversion of renewable biomass into commercially viable, high performance biofuels, byproducts and biopower

Relevance to the United States:

- Reduces dependence on petroleum feedstocks
- Reduces net greenhouse gas emissions

Project Quad Chart Overview

Timeline

- Project start date: April 1, 2014
- Project end date: 3 yrs. from start
- Percent complete: 8%

Barriers

- **Tt-A.** Feeding Of Dry Biomass
- **Tt-F.** Deconstruction Of Biomass To Form Bio-oil Intermediates
- **Tt-H.** Bio-oil Stabilization And Vapor Cleanup
- **Tt-K.** Product Finishing

Budget

	Total Costs FY 10 – FY 12	FY 13 Costs	FY 14 Costs	Total Planned Funding (FY 15-Project End Date
DOE Funded	$0	$0	$87k	$2.41M
Project Cost Share	$0	$0	$128k	$6.33M

Partners & Roles

- Avello – Lead
- ConTech – EPC
- Emerson – Engineering support
- Borregaard – Product R&D
- Cargill – Biofuel Oil demo
- Leading roofing company – Bioasphalt R&D
- Virent – Biofuels R&D
- ISU – Biomass and product R&D
- APAI, Iowa DOT, USDA – Advisors

1- Project Overview

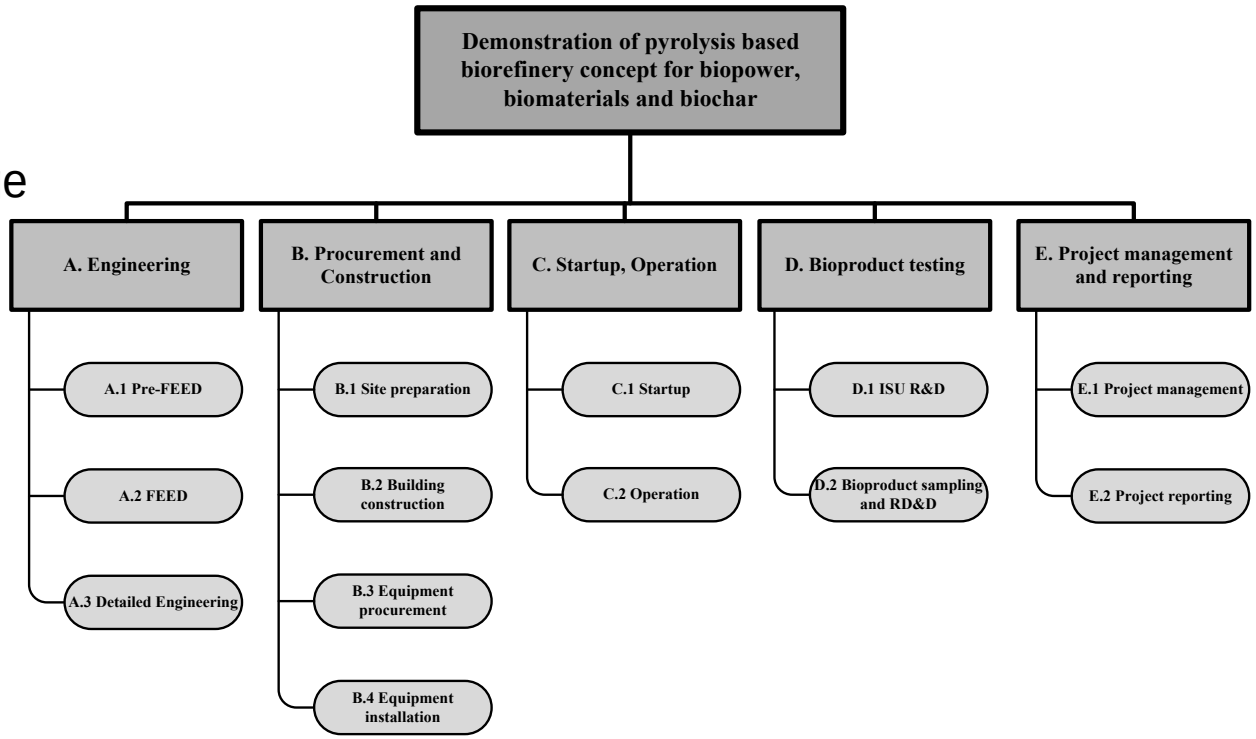
- Process integration and scale-up of the entire process train including
  - Biomass pre-processing
  - Pyrolysis conversion and fractionation of Bio-oil
  - Bio-oil fraction use and upgrading as petroleum replacement products
  - Front-end and back-end storage/logistics
  - Bioasphalt binder production
- Generate engineering data to design commercial scale plants
- Product development and demonstration

2 – Approach Technical

- Leverage ISU ¼ ton/day PDU data and operational experience for scale-up
- Leverage market leader expertise in product evaluation and development
- Utilizing project engineering stage gate approach based on key decision points within Work Breakdown Structure
- Go/No-Go decision point after FEED engineering (+/- 10% capital cost estimate) → Budget Period 2
- Technical challenges:
  - Feed system design
  - Unit operation integration
  - End-product market acceptance

2 – Approach Management

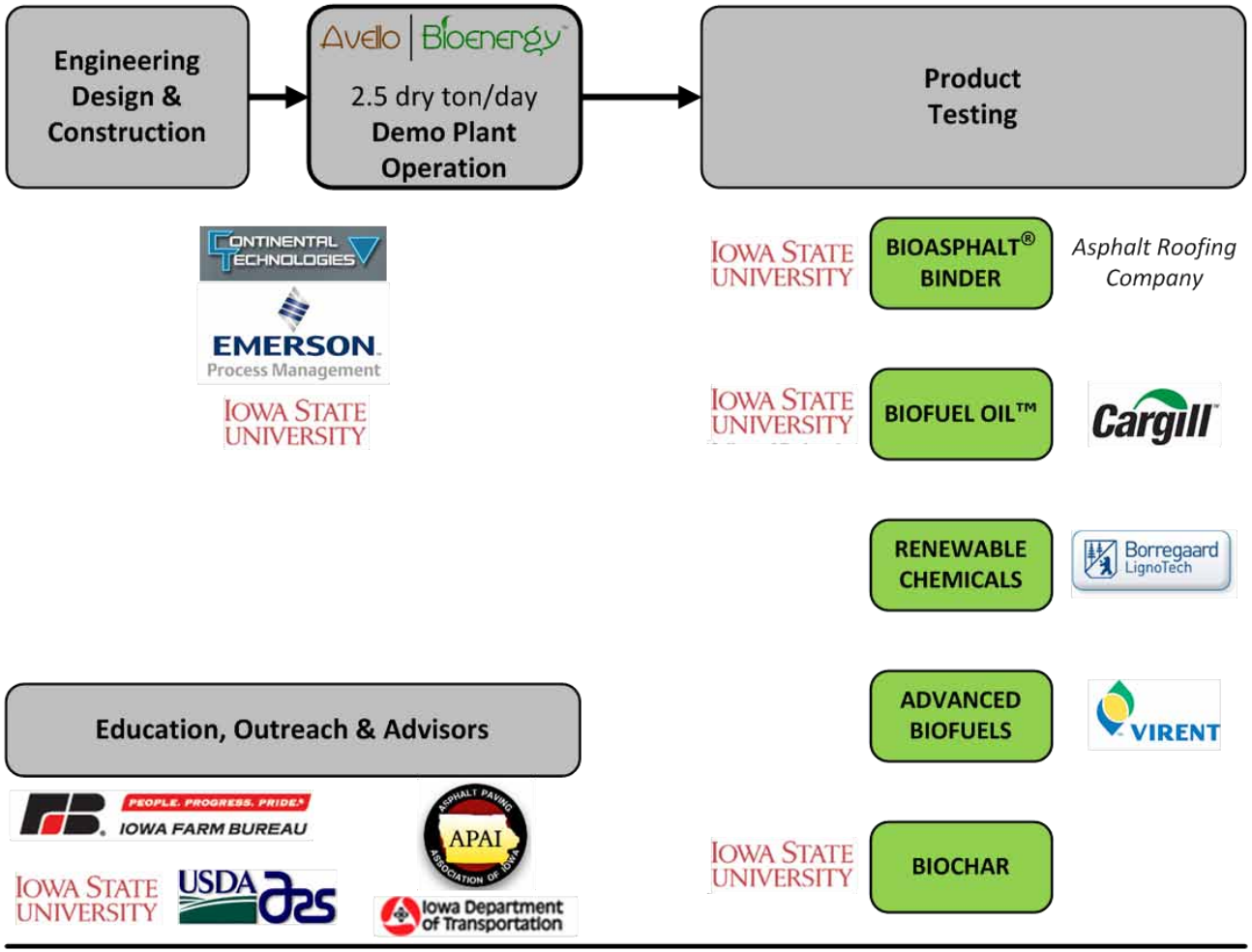
- Management team, advisors, and partnerships to manage critical success factors and solve/minimize challenges
- Project milestones, schedule, and risk mitigation plan
- Internal reviews after subtasks



- Critical success factors for project
  - Successful start-up and continuous operation
  - Demonstration of end-product performance and market acceptance
  - Verification of commercial proforma economics

3- Project Overview/Partners

Avello Bioenergy Demonstration Plant Project Partners



3- BCRF Site

* Approximate size and location shown for lease area

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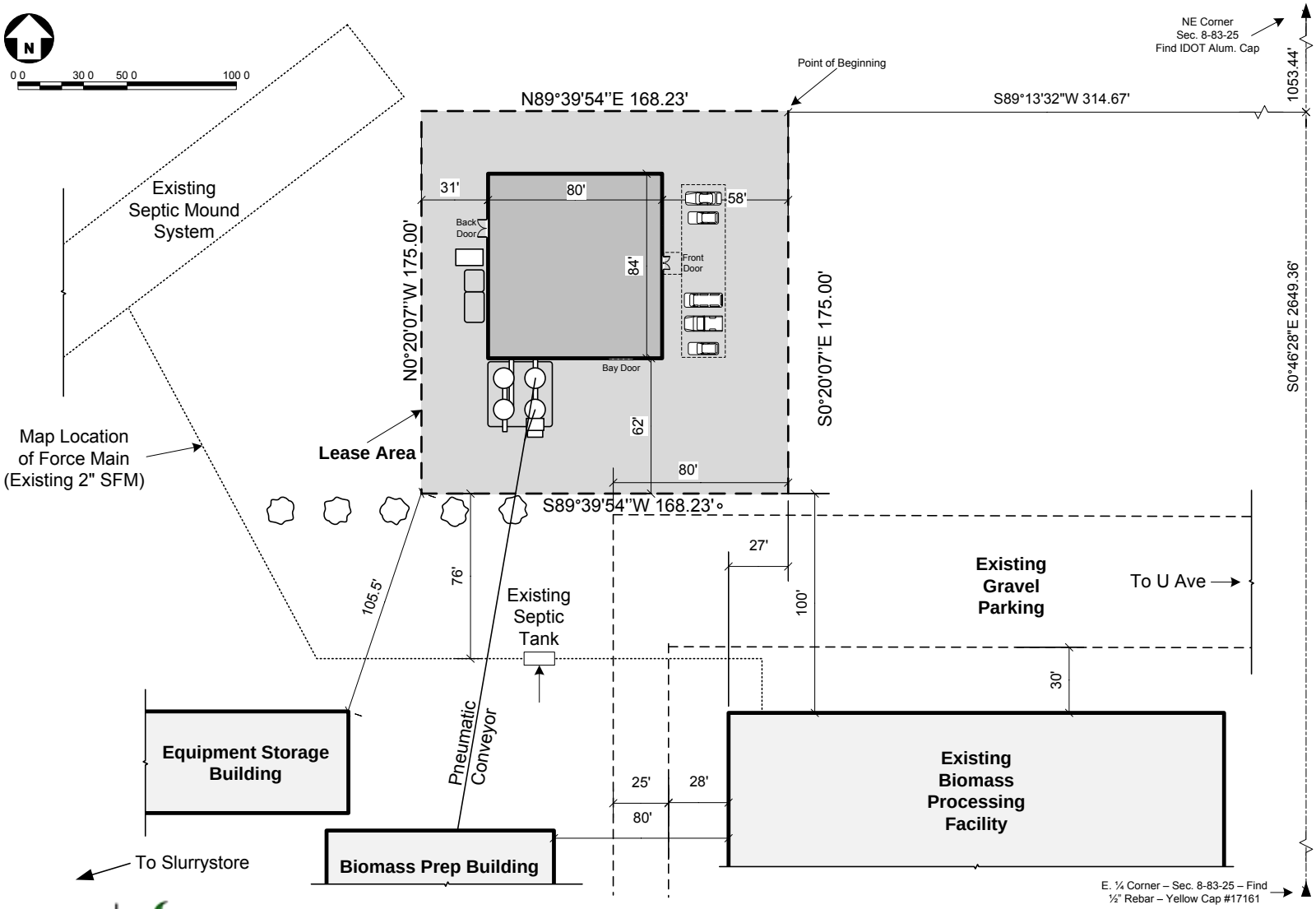
3- Plot plan



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3- Project RD&D

Feedstocks

- **ISU ABE Dept., Matt Darr**
- Single pass stover baling
- Switchgrass likely
- Harvest, Storage, Transport (HST)
- Pre-treatment
- Torrefaction?

RESEARCH COMPLETED OUTSIDE OF PROJECT (publications available)

Bioasphalt® binder

- **ISU CCEE Dept.,**
- Performance testing & verifications
- Coordinate up to 4 demo paving projects with **IA DOT** and **APAI**

- **Roofing Company**
- Roofing asphalt formulations
- Analysis, blending, modifying, performance testing

Biofuel Oil™

- **ISU ME Dept.,**
- **Power Systems**
- Non-transport biofuel blends
- Combustion testing: furnace (heat) and stationary engine (power)
- Emissions analysis

- **Cargill**
- Co-fire test burn
- Renewable power & reduced CO_2 profile for biofuels

Chemicals

- **Borregaard LignoTech** Analysis, characterization, screening, modifying
- Specialty, high-value chemical applications

- **ISU**
- Fraction 5 uses
- Chemicals from fractions

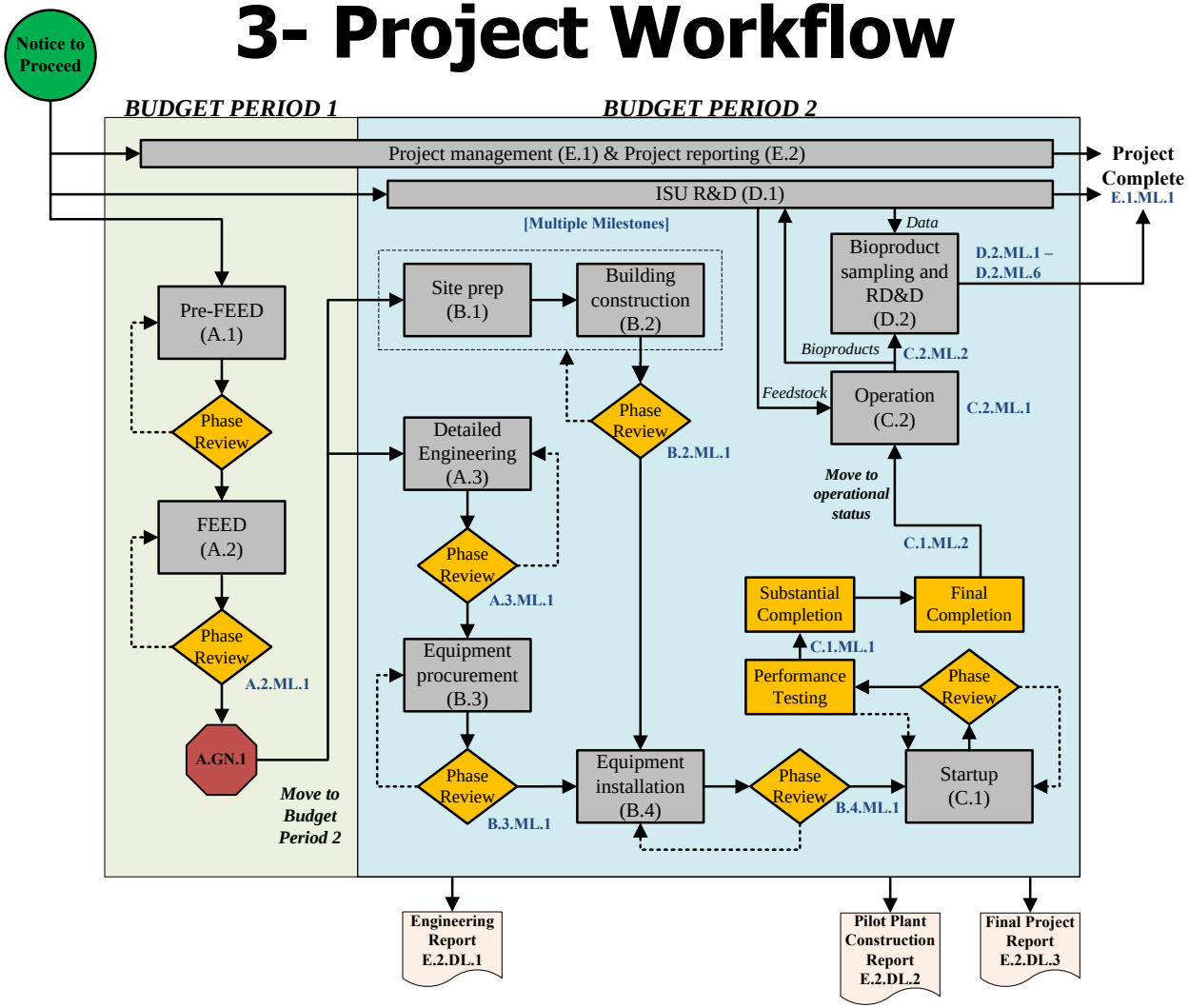
Biofuels

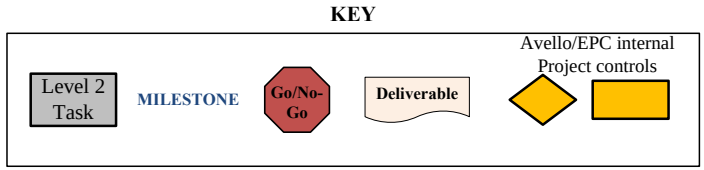
- **Virent**
- Feasibility study
- Bench and pilot scale testing
- Utilize BioForming to convert Biooil fractions to drop in fuels.
- Proof-of-concept completed

Biochar

- **ISU ABE Dept.,**
- USDA
- Multiple on farm applications

3- Project Workflow





3- Technical Accomplishments/Progress

- PreFeed- Completed (Q4 2014)
  - Process Design Basis
  - Block Flow Diagram (BFD)
  - Preliminary Heat and Material Balances
  - Process Flow Diagrams (PFDs)
  - Estimates of Emissions
  - Equipment List
  - Utility Requirements Summary
  - Overall Plot Plan
  - Basic Engineering Design Data
  - Final Process Design Basis for FEED
  - Preliminary Hazards Analysis Review (based on PFDs)
  - Battery Limit Interface Table
  - Updated Project Schedule

3- Technical Accomplishments/Progress

- FEED On-going (partial list of deliverables below):
  - Final PFDs
  - Final Material & Energy Balances
  - Detailed P&IDs (including piping material class specifications and line list)
  - Plot Plan and 3-D Equipment Layout (including hazardous area classification drawings)
  - Final Equipment, Electrical and Instrument List (include fire and gas detection)
  - Mechanical Data Sheets and Specifications for all Equipment
  - Updated Utility Requirements
  - Control Systems Definition (including interlock strategy and drawings/table)
  - Environmental Requirements (including any permit applications)
  - Project Execution Strategy (including contracting and procurement)
  - Process Hazards Analysis
  - Updated Project Schedule (including identification of long-lead items for early procurement)
  - **Updated Project Cost (+/- 10%)**
- Go/No-Go after FEED completed

4- Relevance

- Project focuses on petroleum replacement products (fuels, materials, chemicals) that reduce dependence on petroleum
  - Seek to prove commercial feasibility (economic and technical) of products
  - Seek to demonstrate compatibility within existing infrastructure (fuel, transportation, chemical)
  - Remove water and acid from bio-oil for new downstream processing schemes
- Joint development with public and private partnerships to leverage expertise, cut cost
- Evaluate various biomass feedstocks to quantify risk (feedstock supply critical risk)
- Test high performance separation technology (conversion critical risk)
- Test biopower demonstration and deployment (demonstration and deployment risk)

5- Future Work

- FEED completed (March)
- DOE Go/No-Go (April)
- Engineering and Construction (12 months)
  - Detailed Engineering
  - Site Preparation
  - Procurement and Construction
- Plant Startup and Operation (April 2016)
- Product Testing

Summary

- Expands pyrolysis platform to improve bio-oil utilization
- Integrated pilot scale plant and commercial product testing builds upon previous developmental scale work, refines economics and prepares for commercial scale up
- Public and private partnerships to leverage expertise, cut costs, increase probability of successful project
- Management team, advisors, and partnerships to manage critical success factors and solve/minimize challenges
- FEED completed; Go/No-Go review scheduled
- Project execution pending Go/No-Go decision

Additional Slides

Responses to Previous Reviewers' Comments

- Reviewer concern about multiple product streams and potential for lack of economies of scale.

- Response: Overall process proforma economics have been developed based on Class 5 capital cost estimates and market prices for the various products. The economics show strong economic returns for commercial plants as small as 250 tpd plant input. This project will help confirm the assumptions and improve the capital cost estimates when completed. We do not foresee the scale issues predicted.
- This project has purposely focused on the rest of the barrel concept and not only on transportation fuels.

Publications, Patents, Presentations, Awards, and Commercialization

- No activity in this area during the period under review.