Lessons Learned, Challenges, and Future Needs

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Outline

I. Introduction
II. Three Legged Stool
III. Pilot, Demonstration, and Pioneer Scales
IV. Portfolio Overview
V. Lessons Learned
VI. Challenges and Future Actions
BETO’s Demonstration and Deployment Program

De-risking of:
- Technology
- Construction
- Operations
- Finance
- Feedstock Supply
- Product Off take
- Markets
Success Depends On

- Policy
- Technology
- Finance
DOE Financing Assistance - Technology Pipeline

- **Basic Science**
- **Applied Science**
- **Technology Investors**
- **Asset Investors**
- **Markets**

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**Research**
- Up to 80% federal cost share

**Development**
- Up to 50% federal cost share

**Demonstration**

**Deployment**

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**GRANTS**

**COOPERATIVE AGREEMENTS**

**TECHNOLOGY INVESTMENT AGREEMENTS**

**LOAN GUARANTEES**

**TAX CREDITS**
**PILOT**
Integrate unit operations and validate techno-economic assessments

**DEMONSTRATION**
Verify performance at industrial scale and provide design specifications for a pioneer plant

**PIONEER**
Prove economic production at commercial volumes

### PILOT OBJECTIVES
- Technical Performance
  - Prove conversion efficiencies
  - Confirm mass and energy balance
- Operations
  - Determine feedstock and product specifications
  - Integrate technology from feedstock in through product out
  - Evaluate process sustainability metrics
- Scale-Up to Demonstration
  - Develop robust economic model

### DEMONSTRATION OBJECTIVES
- Market Risk
  - Manufacture product for commercial acceptence testing
- Operations
  - Generate over 1000 hours of continuous operational data
  - Balance sustainability performance across environmental, social, and economic dimensions
- Scale-Up to Pioneer
  - Validate commercial equipment specifications and performance

### PIONEER OBJECTIVES
- Financial Risk
  - Prove technology is profitable to support robust replication of commercial facilities
- Feedstock Supply and Logistics
  - Demonstrate robust feedstock supply and offtake value chain
- Operations
  - Validate performance data and equipment design specifications
  - Verify sustainability performance across environmental, social, and economic dimensions
IBR Project Funding

[Graph showing IBR Project Funding with categories for Federal, Debt, and Industry, with investment amounts denoted for Pilot, Demonstration, Pioneer/1st Commercial, and NTH Plant stages.]
Portfolio Geographic Diversity

For more information visit: http://www.eere.energy.gov/biomass/integrated_biorefineries.html
Portfolio by Funding Year

**Number of IBRs by Year/FOA**

- 2007 - Commercial: 4
- 2008 - Demo: 4
- 2009 - ARRA Demo/Pilot/R&D: 7
- 2012 - I- Pilot: 18

**Investment in IBRs by Year/FOA**

- 2007 - Commercial: $17.7
- 2008 - Demo: $331.6
- 2009 - ARRA Demo/Pilot/R&D: $483.9
- 2012 - I- Pilot: $163.8

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<th>DOE Share</th>
<th>Cost Share</th>
<th>Total</th>
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D&D Portfolio by Project Scale/TRL

Number of IBRs by Scale/TRL
- R&D: 6
- Pilot: 2
- Demo: 9
- Commercial: 16

Investment in IBRs by Scale/TRL
- R&D: $6.0
- Pilot: $295.55
- Demo: $443.56
- Commercial: $251.80
D&D Portfolio by Product

Number of IBRs by Product
- Cellulosic Ethanol: 16
- Renewable Hydrocarbons: 12
- Algae Oil: 3
- Bio-Products: 2

Investment in IBRs by Product
- Cellulosic Ethanol: $694
- Renewable Hydrocarbons: $152.01
- Algae Oil: $76.38
- Bio-Products: $74.8

Lessons to Re-Learn

- **Multiple new technology steps** - equates to higher risk
- **Feeding solid biomass to reactors** - continues to be a challenge
- Commercially available, ‘off-the-shelf’ equipment
  - Does not necessarily integrate easily into new processes
- **Integrated pilot testing** - has high value for new technologies
- Energy projects have **multi-decade time horizons** ...

Valley of Death for New Technologies: IPA Key Findings

• Commercializing some level of new technology - 40% of projects fail
• New technology projects – 80% don’t meet performance expectations

• Incorrect assessment of the level of difficulty posed by underlying process
  • Leads to overoptimistic expectations on project and process performance
    • Average cost growth = 30%
    • Average schedule growth = 65%
    • Average production shortfalls over 50% in second 6 months of operation
    • Average startup durations 50% longer than industry average

• Shortcomings often don’t surface until startup and operation
  • Only remedy is costly de-bottlenecking and corrective engineering

• Core lesson:
  • Must understand and accept higher levels of project and process risk
Figure 1 – Framework for Executing DOE Project Management for Integrated Biorefinery Projects

BP = Budget Period

DOE Order 413.3B Critical Decision Points
INEOS New Planet Biorefinery
Myrian’s Bio-Succinic Acid Plant
Abengoa Bioenergy

Graphic to be included in March update of BETO's MYPP.
POET: Project LIBERTY
Future

Assumes DOE continued investment and RIN Value of $0.50
Next Steps?

Challenges, Future Needs and Actions