

# High-Yield Hybrid Cellulosic Ethanol Process Using High-Impact Feedstock

WBS 5.5.11.1



2013 DOE Bioenergy Technologies Office (BETO)  
IBR Project Peer Review

May 21, 2013

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ZeaChem Inc.

# Tomorrow's Fuels & Chemicals Today

## ZeaChem

**We Create High Margin and Sustainable Alternatives  
to Petroleum-Based Fuels and Chemicals in Use, *Today.***



**Poplar Harvesting  
Boardman, OR**



**250K GPY IBR Facility  
Boardman, OR**



**Fuels and Chemicals**

# Company History

2002	2006	2008	2012	
<b>Founded</b>	<b>Lab</b>	<b>Core Pilot</b>	<b>IBR Facility</b>	<b>1<sup>st</sup> Commercial</b>
 				
<ul style="list-style-type: none"> <li>➤ Lakewood, CO</li> <li>➤ Company headquarters</li> </ul>	<ul style="list-style-type: none"> <li>➤ Menlo Park, CA</li> <li>➤ 5 GPY</li> <li>➤ Proved out technology at bench scale</li> </ul>	<ul style="list-style-type: none"> <li>➤ Golden, CO</li> <li>➤ 50K GPY</li> <li>➤ 10,000x scale up of technology</li> </ul>	<ul style="list-style-type: none"> <li>➤ Boardman, OR</li> <li>➤ 250K GPY</li> <li>➤ Demonstration of integrated process at scale</li> </ul>	<ul style="list-style-type: none"> <li>➤ Boardman, OR</li> <li>➤ 25MM+ GPY</li> <li>➤ Key development milestones completed</li> <li>➤ Co-location further mitigates risk</li> </ul>
	<p><b>Series A \$6MM</b></p>  	<p><b>Series B \$45MM</b></p>  	<p><b>Series C \$25MM</b></p>   	<p><b>Loan Guarantee - \$232.5MM</b></p>  

**Successfully Developed Technology From Lab To Pilot/Demo Scale & Raised 3 Rounds Of Financing**



# Flexible Technology and Diversified Markets

Poplar



Agricultural Residues



Eucalyptus

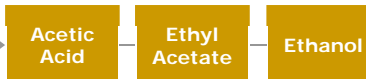


ZeaChem



Proprietary  
Technology  
and  
Processes

2 Carbon: \$485 billion Market



3 Carbon: \$595 billion Market



## C2 Platform End Markets

Ethanol



Acetic Acid/  
Ethylene Vinyl Acetate



Cellulose  
Acetate



Ethyl Acetate



Ethylene



Ethylene Glycol



Vinyl Acetate Monomer



## C3 Platform End Markets

Acrylics



Polypropylene



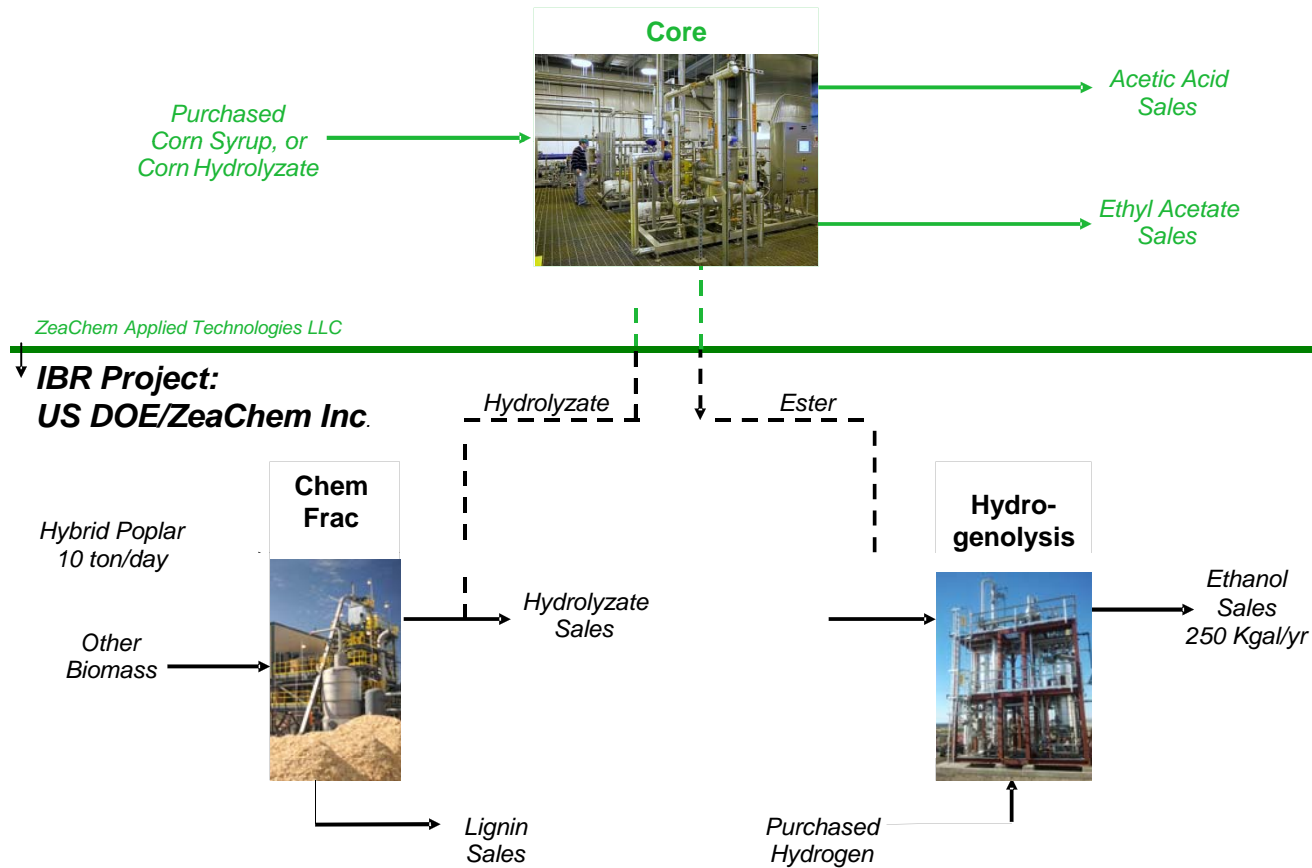
Propylene



Propionic Acid



# Project Description



**IBR Project: 10 ton/day Chem Frac unit + 250 Kgal/yr Hydrogenolysis unit**





# IBR Project: Quad Chart Overview

## Timeline

- Budget Periods
  - BP-1: 1/28/10 – 9/30/11
  - BP-2: 10/1/11 – 7/28/13
  - BP-3: 7/29/13 – 9/30/13
- Recent Major Milestones
  - Mechanical Completion: Dec 2012
  - Commissioning/Start-up: Feb 2013
- Percent complete: 92%

## Project Development

- Status: Nearing End of BP-2
  - Next milestone: IE Performance Test
- Project is on track with respect to:
  - Scope (no changes)
  - Schedule
  - Budget
- End of BP-3: 9/30/13

## Budget

- Total project funding: \$31.25 MM
  - DOE share: \$25 MM
  - ZeaChem share: \$6.25 MM
- DOE Funding to date: \$22.9 MM
- ARRA Funding: \$25 MM

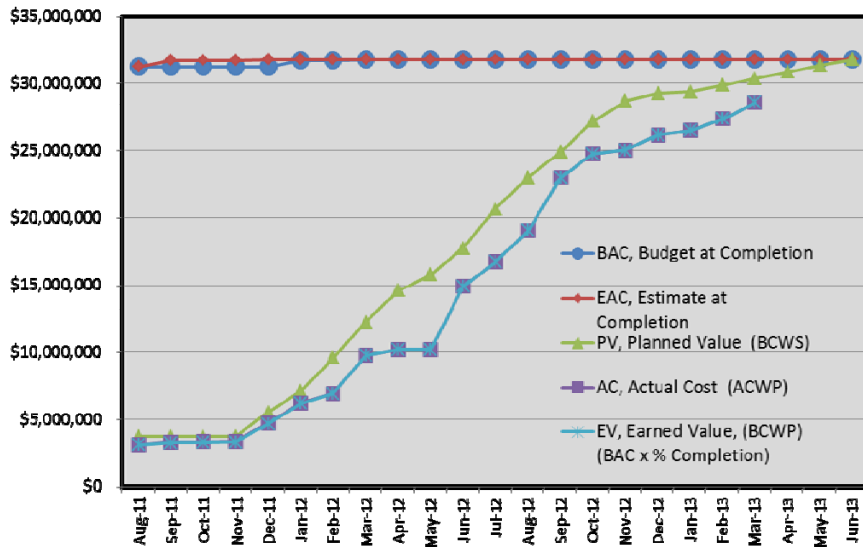
## Project Participants

- Feedstock: GreenWood Resources
- EPCM: Burns & McDonnell
- Key Vendors: Andritz, BASF
- Start-up, Commissioning & Operations: ZeaChem Inc., Pacific Ethanol Management Services

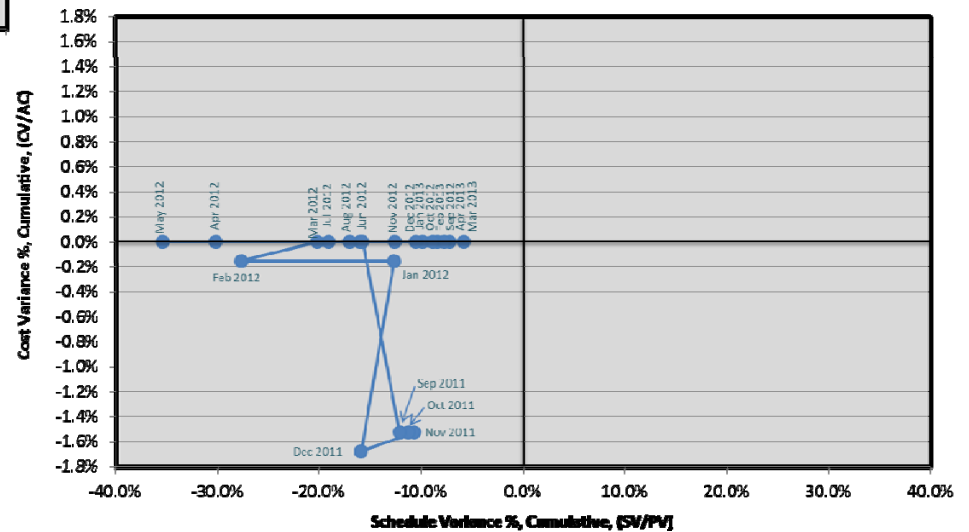


# IBR Project: Cost and Schedule Performance

**EE0002880 - ZeaChem/DOE BP2**  
**Trend Chart, EAC, PV, AC, EV, As-Billed**



**EE0002880 - ZeaChem/DOE BP2 to Date**  
**Bull's-eye Chart, As-Billed**





# 1 - Project Management

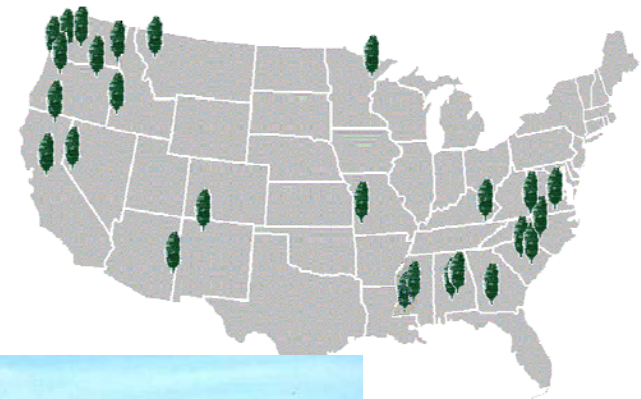
- Written Project Management Plan
  - Section A. Project Information
  - Section B. Financial Description of Project
  - Section C. Project Plan with tasks, subtasks, milestones, deliverables, Go/No Go decision points and including performance requirements and metrics
- Additional project tools
  - Work Breakdown Structure (WBS)
  - Risk Management Plan (RMP)
  - Earned Value Management System (EVMS)
- Next Go/No-Go Decision: CD-4 to enter BP-3
  - Independent Engineer's Performance Test is gating milestone
  - BP-3 is when system performance tests are conducted



# Feedstock – Hybrid Poplar

- Dedicated sustainable energy crop
  - High impact feedstock
  - “Bankable” projects
  - Geographic diversity, “Grow where we go”
- Hybrid Poplar Benefits
  - Perennial crop, low inputs, high yield
  - “Store on the stump”
  - Efficient harvesting
- GreenWood Resources
  - Agreements in place for IBR Facility and 1<sup>st</sup> Commercial Plant
  - Forest Stewardship Council Certified
  - USDA Biomass Crop Assistance Program

*GreenWood Trial Plots*



# Feedstock – Wheat Straw

Economics

Consistent Yields / Low Density  
(1-3 BDT/Acre/Year)

Medium Price Volatility / MT  
Contract

Resource Availability Exists Today

Ability to Aggregate Additional Land

Single or Multiple Pass Harvesting  
Methods

Non-GMO Annual

200,000 planted acres within 40  
mile radius of Boardman, OR

Environment

Social

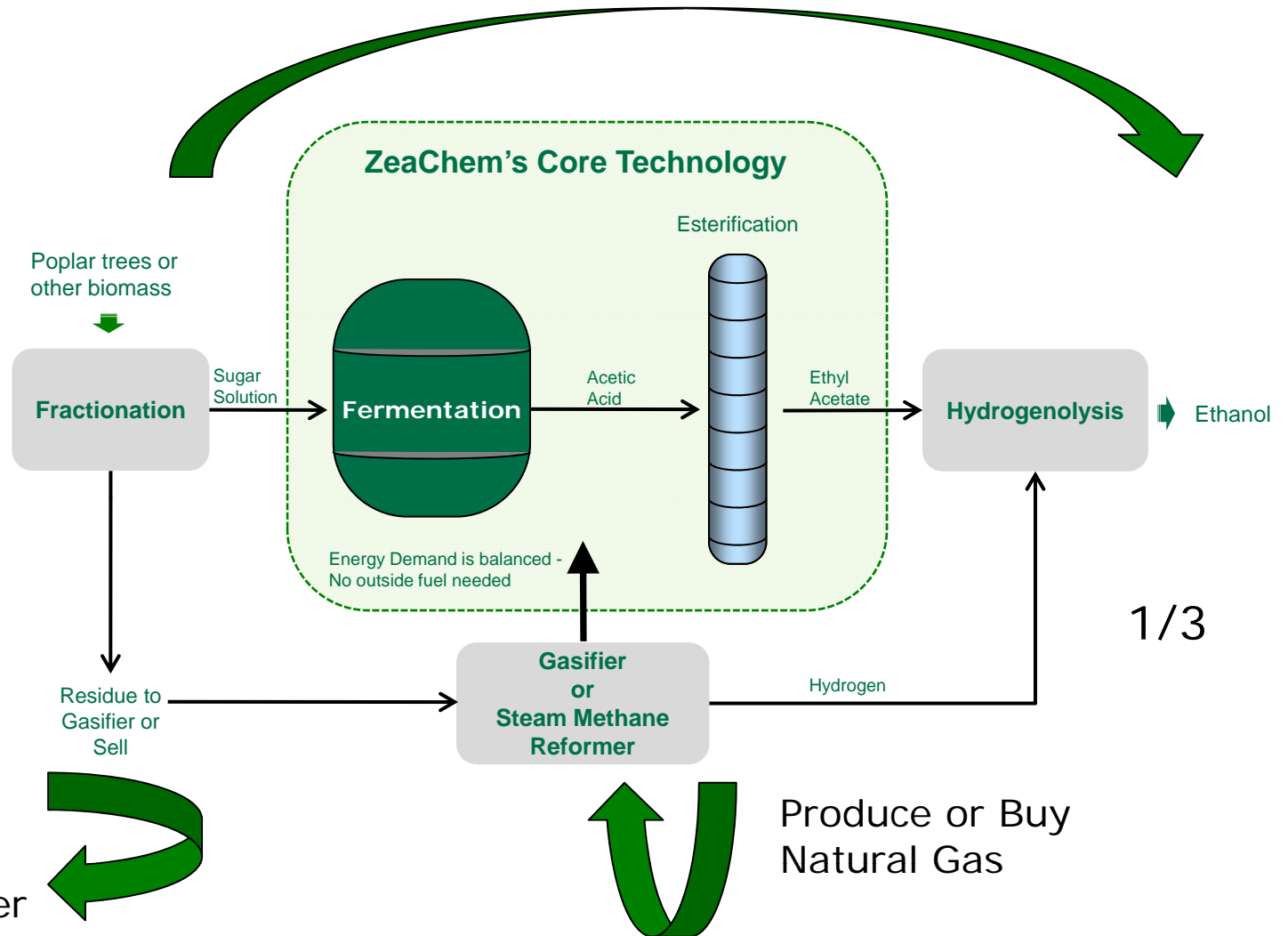




# ZeaChem C2 Platform

✓ High yield

- ✓ No GMO
- ✓ Feedstock flexibility
- ✓ Easily Replicated



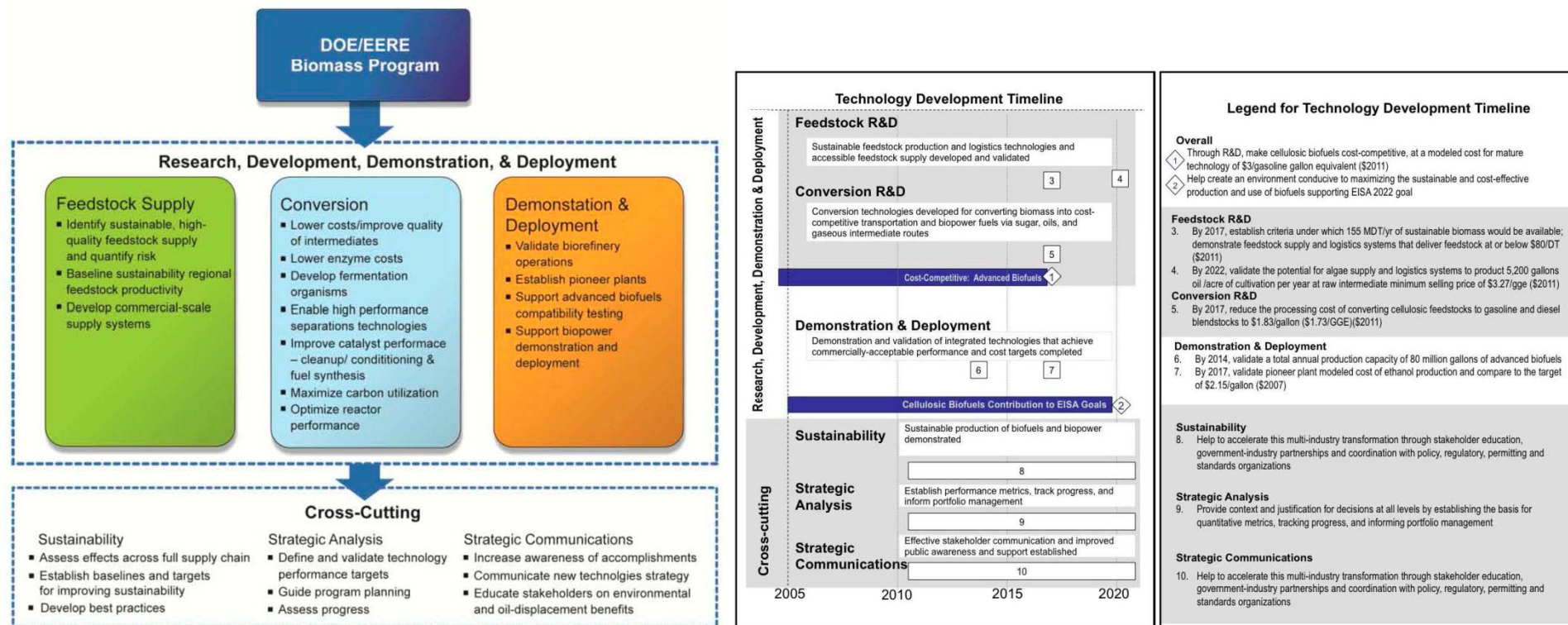
## 2 – Progress: Nearing the end of BP-2

- ✓ BP-1: Project Planning
  - ✓ NEPA Determination
  - ✓ Vendor Trials
  - ✓ Schedule A Design
  - ✓ Budget Control Cost Estimate ( $\pm 10\%$ )
- BP-2: EPC
  - ✓ Detailed Design
  - ✓ Procurement
  - ✓ Construction
  - ✓ Commissioning
  - ✓ Start-up
  - ✓ First cellulosic EtOH produced February 2013
  - Independent Engineer's Test
- BP-3: Performance Trials



# 3 – Relevance: BETO Mission and Goals

- Mission: Develop and transform our renewable biomass resources into commercially viable, high-performance biofuels, bioproducts, and biopower through targeted research development, demonstration, and deployment supported through public and private partnerships



- Goal 1: Enable sustainable, nationwide production of advanced biofuels that are compatible with today's transportation infrastructure and can displace a share of petroleum-derived fuels to reduce U.S. dependence on oil
- Goal 2: Encourage the creation of a new domestic bioenergy industry support of the Energy Independence and Security Act of 2007 goal of 36 billion gallons per year of renewable transportation fuels by 2022

From: US DOE Biomass Multi-Year Program Plan, Nov. 2012





# 3 – Relevance: BETO Integrated Biorefinery WBS

<i>Goal: Demonstrate and validate integrated technologies to achieve commercially acceptable performance and pro-forma cost targets</i>			
WBS Element	Performer	Feedstock Pathway	Barriers Addressed
<b>Integrated Biorefinery Deployment and Portfolio Management</b>			
<b>Pilot Scale</b> – Integrated unit operations to produce fuels, power, or products at the scale of at least 1 metric tonne.	ADM Logos Technologies Renewable Energy Institute International	Agricultural Residue Processing	Im-A: Inadequate Supply Chain Infrastructure; Im-B: Agricultural Sector-Wide Paradigm Shift; Im-C: Lack of Understanding of Environmental/ Energy Tradeoffs; Im-D: High Risk of Large Capital Investments; It-A: End-to-End Process Integration; It-B: Commercial-Scale Demonstration Facilities; It-C: Risk of First-of-a-Kind Technology; It-E: Engineering Modeling Tools St-C: Sustainability Data across Supply Chain
	ICM, Inc. Amyris Biotechnologies, Inc. ZeaChem, Inc.	Energy Crops Processing	
	American Process, Inc. Haldor Topsoe, Inc. UOP, LLC ClearFuels Technology, Inc.	Forest Resources Processing	
	Algenol Biofuels Solazyme, Inc.	Algae Processing	
<b>Demonstration Scale</b> – Integrated projects that convert at least 50 or 70 metric tonnes of biomass to biofuels, biopower, and/or bioproducts.	Verenium Biofuels Corp.	Agricultural Residue Processing	
	Myriant Technologies, Inc.	Energy Crops Processing	
	Red Shield Acquisition	Forest Resources Processing	
	Energem Corporation INEOS	Waste Processing	
	Sapphire Energy, Inc.	Algae Processing	
<b>Commercial Scale</b> – Integrated commercial-scale projects that convert at least 700 metric tonnes of biomass to biofuels, biopower, and/or bioproducts, without government subsidies.	Abengoa Bioenergy LLC POET	Agricultural Residue Processing	
	BlueFire Ethanol, Inc. Mascoma	Forest Resources Processing	
<b>Continued Technology Development</b>			
Identify opportunities for process optimization with the goal of reducing cost and increasing efficiency. Validate these improvements at existing pilot-, demonstration-, or commercial-scale facilities.	Gas Technology Institute	Forest Resources Processing	
	Elevance Renewable Sciences	Algae Processing	

From: US DOE Biomass Multi-Year Program Plan, Nov. 2012



## 3 – Relevance: Project Goals and Alignment

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- Goals of IBR Project:
  - Mitigate risks so that a 1<sup>st</sup> Commercial Plant can be financed, constructed, and made operational
  - Demonstrate integrated operations with high-impact feedstocks to support deployment in follow-on commercial facilities
- IBR Project critical step towards 1<sup>st</sup> Commercial Plant
  - 25-50 MMGal/yr cellulosic ethanol
  - Project development underway
  - Anticipated 2015/16 start-up
    - Timing gated by performance tests at IBR Facility
- Success of 1<sup>st</sup> Commercial Plant will lead to additional follow-on plants in further support of EISA 2007 goals



### 3 – Relevance: Sustainability of 1<sup>st</sup> Commercial

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- Economic: A profitable biorefinery supply chain providing commercial quantities of competitively priced fuel
- Environmental:
  - Feedstocks are environmentally sustainable
  - Anticipated life cycle greenhouse gas emission reduction

Fuel Technology	GHG % Reduction from Gasoline
Gasoline	0%
Corn Ethanol	21-24%
Cellulosic Ethanol w/Stover	86-89%
ZeaChem w/Hybrid Poplar	92-98%

- Social: Rural Economic Development
  - Feedstock Supply: ~300 jobs
  - Biorefinery: ~65 jobs





## 4 – Critical Success Factors

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- Prove process integration through extended operation of the facility
- Achieve technical targets and yield progression:
  - Integrated Pilot: 80 gal/BDT
  - 1<sup>st</sup> Commercial: 110 gal/BDT
  - N<sup>th</sup> Commercial: 135 gal/BDT
- Project Management: Scope, Schedule, and Budget



# 4 – Risk Management

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Process Step	Purpose
1. Risk Identification	Determining which risks might affect the project and documenting their characteristics
2. Risk Analysis	Transforming risk data into decision-making information (risk impact analysis and quantification including potential effect of environmental and other regulatory requirements on the project)
3. Risk Response	Translating risk information into decisions and mitigation action plans (risk mitigation strategies development)
4. Risk Monitoring	Monitoring residual risks, identifying new risks, executing risk-reduction plans, evaluating effectiveness throughout the project (risk monitoring)
5. Risk Documentation	Ongoing evaluation and updating of the Risk-Management Plan

- Risk Management Example
  - Identification: Shortage of trained personnel for operations
  - Analysis: Risk potentially impacts schedule and cost
  - Response: Contract with Pacific Ethanol Management Services to provide operating and maintenance staff for IBR Project
  - Monitoring: Acute needs addressed, plan for long-term mitigation by establishing community college training program
  - Documentation: Example documented as closed risk ID #30 in Risk Management Plan

## 5 - Future Work

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- Complete Budget Period 2
  - Milestone: Complete Independent Engineer's Performance Test
  - Prepare application for Budget Period 3
- Go/No-Go: Critical Decision (CD-4) for entry into Budget Period 3
- Budget Period 3
  - Performance Test Runs
  - Technical and Financial Reports
  - Project Close-out



# Summary

- Successfully built and operated
  - 10 ton/day Chem Frac unit
  - 250 Kgal/yr Hydrogenolysis unit
  - First cellulosic ethanol produced in February 2013
- IBR Project has meet expectations for:
  - Scope
  - Schedule
  - Budget
- Project is well aligned with BETO's Multi-Year Program Plan
- Future work under IBR Project:
  - BP-2: IE Performance Test
  - BP-3: Performance Tests
- ZeaChem is on-track for deployment of 1<sup>st</sup> Commercial Plant



# Acknowledgment and Disclaimer

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- *Acknowledgment:* This material is based upon work supported by the Department of Energy under Award Number DE-EE0002880
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