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

BlueFire Fulton Renewable Energy Project

a forest residues to cellulosic ethanol facility

May 20, 2013
Award 2 ARRA
Presenters/Principal Investigators: Necy Sumait and John Cuzens
BlueFire Renewables, Inc.

BlueFire RENEWABLES

Project Description –

BlueFire HQ: 31 Musick Irvine, CA.

Project Location

Fulton, MS – 5,000 population

Itawamba County ~20,000 population

Feedstock handling -Truck dumps with in-bed conveyor to 3-day onsite storage pile, processing to remove dirt and process by size (3/4"-+/- ½"), dried using boiler exhaust in rotary drum driers, 3-day dry storage.

Conversion technology – Concentrated Acid (~75%) decrystallyzation and chemical hydrolysis (~30% conc) at atmospheric pressure < 100 deg C, < 45 minutes overall.

Product purification – Filtration to separate lignin solids from liquor, SMB to separate sugars from acid, lime neutralization, continuous fermentation at high microbe loading, centrifuge yeast for recycle, distillation/dehydration of beer, R.O. recovery of residual organics for yeast growth train, multi-effect evaporation for reconcentration and recycle of acid.

Feedstock: 700 bdmtpd Mixed Forest Residues (82 gal/mbdt) supplemented with 140 bdmtpd bark & sawmill residues

Products – 57,250 gpd fuel ethanol, 445 bdmtpd Lignin, 12.7 bdmtpd Yeast, 20 mbdtpd Gypsum

BlueFire RENEWABLES

Quad Chart Overview–

Timeline

Project start date: BP1:9-30-2007 BP2: 2-28-09

Project End Date: Q4 2015

Percent complete: 100% complete on activities prior to EPC

Budge

	tBP1	BP2	Total
DOE Share	$ 6,425,564	$ 81,134,686	$ 87,560,250
BF Cost Share	$ 14,028,504	$ 232,185,496	$ 246,214,000

* Costs exclusive of soft cost accounts

DOE Funding

	DOE 932 Funding	DOE ARRA Funding	Total DOE Funding
2008	$3,849,429	0	$3,849,429
2009	$1,524,721	0	$1,524,721
2010	$685,786	$2,211,361	$2,897,147
2011	0	$724,961	$724,961
2012	0	$1,134,900	$1,134,900
2013	0	$348,704	$348,704
2013*		$16,125,261	$16,125,261
2014*		$60,955,127	$60,955,127
2015*	0	0	0

* Planned Funding 2013-2015

Project Development

- Site controlled
- site prep including construction laydown completed
- permits issued and maintained
- contracts for feedstock, off-take and EPC complete
- Cost on track, Schedule forward affected by close of financing
- Site change in 5/2009. No other changes since.
- On-line Q4 2015

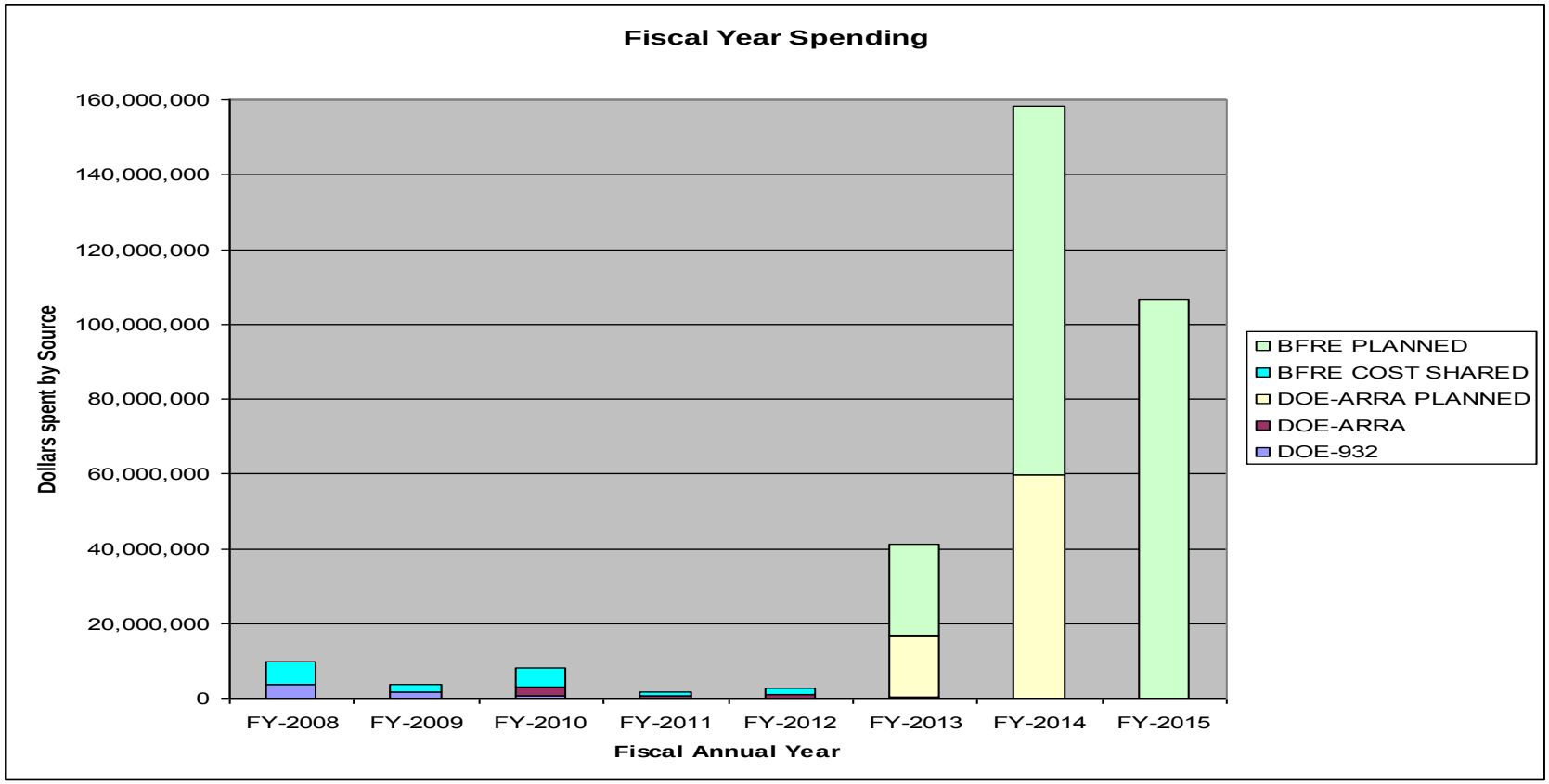
Project Participants

Interactions/ collaborations:

- County of Itawamba – Site/funding support
- City of Fulton – Utilities/funding support
- State of Mississippi – Project incentives
- Mastec (Wanzek/Zachary) – EPC/Start-up/Commissioning
- Tenaska Biofuels – Ethanol Sales
- Cooper Marine Timberlands - Feedstock
- Arkenol, Inc. – Process IP
- Operations – in discussion with companies such as North American Energy Services (NAES)

BlueFire RENEWABLES

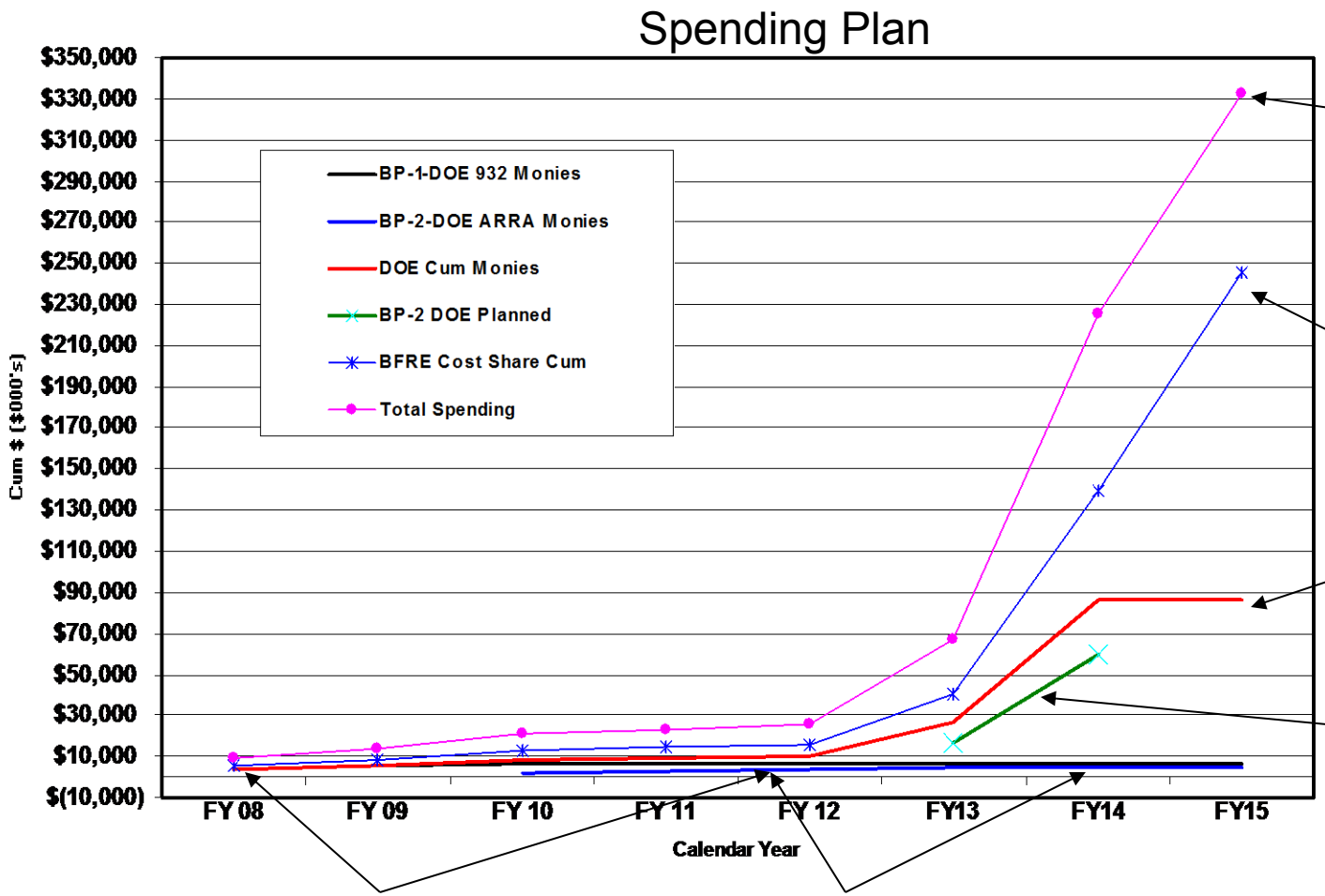
Cost & Schedule Performance



Spend Plan

	Award 1	Award 2 (ARRA)	Total
DOE Share	$ 6,425,564	$ 81,134,686	$ 87,560,250
BF Cost Share	$ 14,028,504	$ 232,185,496	$ 246,214,000
DOE Funds Received	$ 6,059,936	$ 4,419,926	$ **10,479,861**
DOE Funds Unspent	$ 365,628	$ 76,714,760	$ 77,080,389

Cost & Schedule Performance



Total Project Cost less Soft Cost Account Reserves

Total BFRE Cost Share

Total DOE Grant Monies

Planned DOE ARRA Monies Disbursement

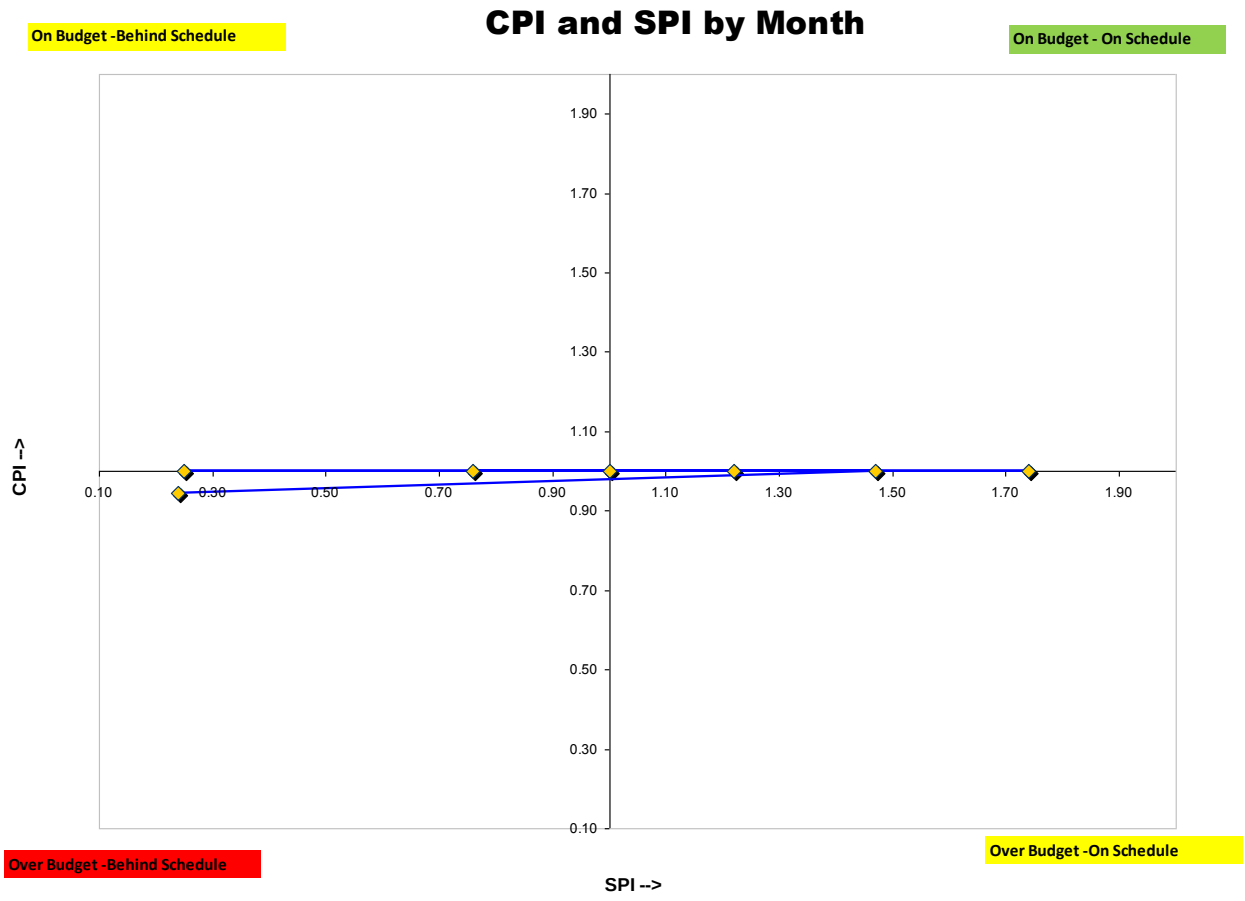
DOE 932 Monies

DOE ARRA Monies

Cost & Schedule Performance

Latest Specific Milestone Performance

	CPI	SPI
Award 2 DOE Core	1.00	1.00
SITE ISSUES - 5.5.3.1.C	1.00	0.76
PERMITTING - 5.5.3.1.D	1.00	1.74
COMMERCIAL CONTRACTS	1.00	0.25
FEL 2 - 5.5.3.1.F	1.00	1.22
FEL 3 - 5.5.3.1.G	1.00	1.47
EPC - 5.5.3.1.H	0.94	0.24

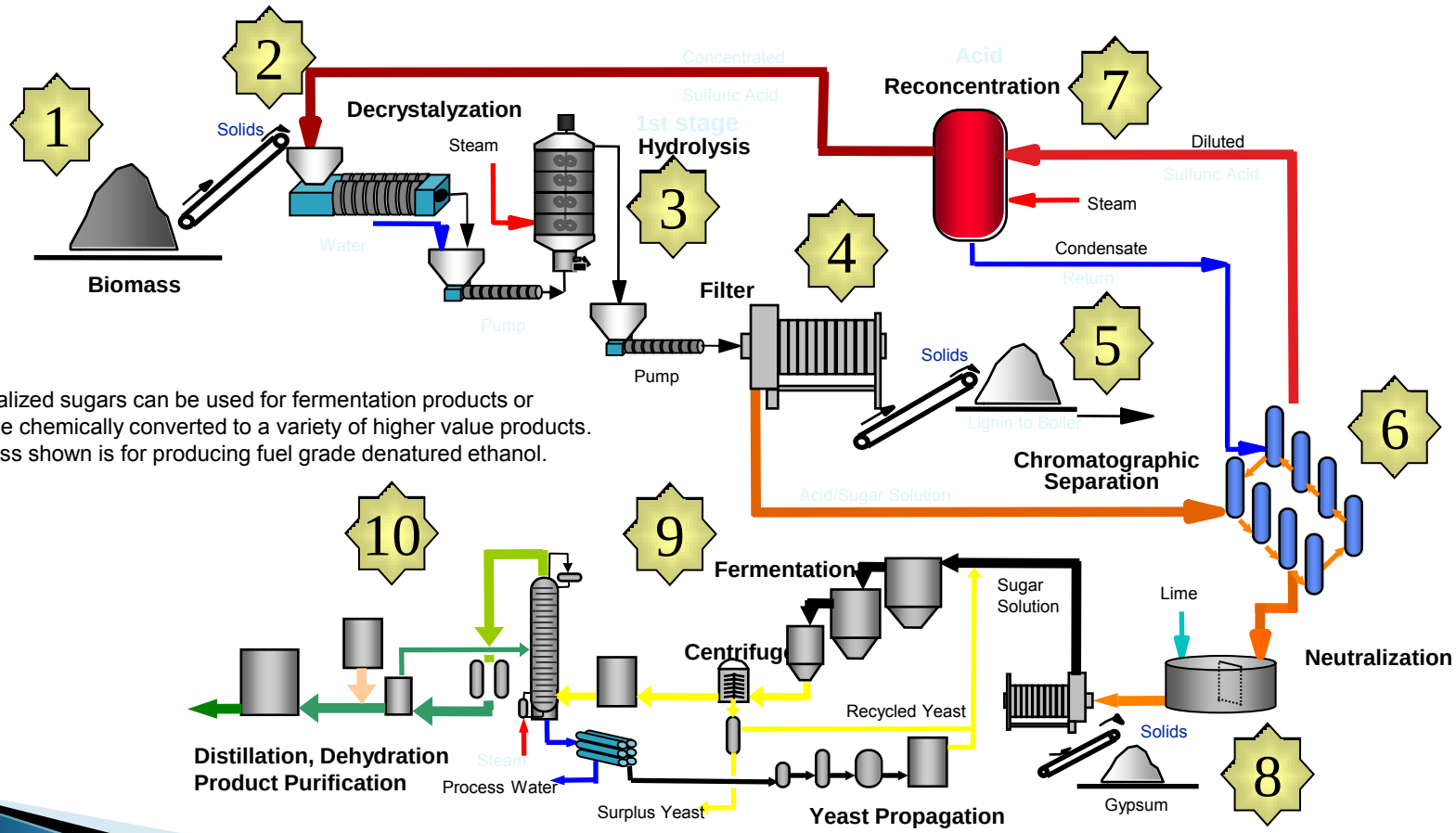


Earned Value
(Bull's Eye Diagram)

A 10-Step Process Overview

Conversion of Biomass Cellulose/Hemicellulose to Mixed Sugars And Chemical Products Using Patented Arkenol Process Technology of Concentrated Acid Hydrolysis

Simplified Flow Diagram



Neutralized sugars can be used for fermentation products or
Can be chemically converted to a variety of higher value products.
Process shown is for producing fuel grade denatured ethanol.

Project Overview –

- Performance Against Baseline
  - No cost variance
  - Schedule variance due to delays in financing
    - Over 2 year USDA Loan guarantee process
    - Global bank found not be compliant with a certain financial ratio
  - Milestone or critical decision point – delayed due to financing hurdles
- Project baseline changes- No rescoping
- Barriers Addressed/Hurdles Overcame
  - Completion of design & development of firm costs allowed for commercial contracts to be executed for a first of a kind technology
    - Process education of 3 x EPC contractors led to progressive development of FEL-3 design package.
    - Utility balances of initial design had large H.P. steam (~60% 250 psig) load and required large electric demand. Redesign of Acid Reconcentration system dropped HP load to <20% and overall drop through back pressure STG provided net zero import of electricity on average annual basis.
    - Feedstock drying load of forest residue feedstock was solved using boiler exhaust energy (lower inlet temp than volatilization point and outlet acceptable for SOx scrubber).
  - Net zero energy import from lignin use (natural gas only for start-up)
  - Execution of 3 key contracts (feedstock, ethanol, EPC) with credit-worthy companies on terms consistent with project financing requirements
- Hurdles to be Overcome
  - Plant financing and construction
  - Demonstrate expected yield and cost of production per gallon of ~$1.00
  - Realize cellulosic ethanol market value

Project Management Approach –

- **Objectives**
  - Construct a commercial scale facility demonstrating the feedstock flexibility of process, effective use of lignin, product yields and expected cost structures

- **Management Approach**
  - Develop project parameters to risk level acceptable for project finance structure
  - Utilize project management team with broad and relevant experience/ Enter into partnerships and collaborations to the extent it reduces risks and advances objectives
  - Implement BF Fulton Project Management Plan (PMP) which includes scope, expectations, project organization, design strategy, procurement plan, construction plan, project controls plan, resource needs and risk management plan

- **Milestones and Monitoring**
  - Gantt charts, RASCI charts, Project Management Plan (PMP), Project Execution Plan (PEP)

Project Management Approach –

- **Risk Mitigation Strategy**
  - Technology
    - Demonstrated by IP owner, validated by third parties including commercial equipment vendors for Fulton Project
    - Comprehensive material and energy balances based on demonstrated performance of process
  - Siting and Development
    - Appropriate zoning and consistent adjacent land uses, good access, within waste-shed for biomass supplies, accessible for deliveries and shipments of products
  - Engineering, Procurement & Construction
    - Lump-sum, turn-key contract with qualified entity
  - Feedstock Supply
    - Long-term, incentive based to encourage least cost procurement, credit-worthy supplier, guaranteed volumes
  - Offtake Supply
    - Take and pay contract with credit-worthy party, indexed but provides upside of cellulosic ethanol
  - Asset Management – O&M company experienced in industry space, transparency in financial reporting and controls

Project Management Approach –

BlueFire will utilize a two fold EVMS system, one (lite) in phase 1 prior to financing and EPC NTP and one for phase 2 during the EPC and startup.

- The first EVMS will utilize the DOE reporting spreadsheet as the reporting and tracking tool, with milestone actual start dates, actual costs and spent to budget (progress) against the DOE approved baseline. Tracking of CPI, SPI, TCPI and EAC are somewhat lacking for permitting and pre-financing activities less than $20 million that are difficult to schedule.

- The second EVMS will be based on a fixed schedule, budget and scope as defined in the EPC package. Vendor (Wanzek/Zachry) will utilize a packaged EVMS tracking package conforming to DOE-413.3-10 and ANSI/EIA-748 including conformance certification.

- EVMS concepts adjusted for startup and operations where budgets are not as defined by schedules and earned progress.

Project Management Approach –

Critical Path Milestones Ahead:

- Financing – Targeted for September 30, 2013 to issue EPC NTP and initiate long lead procurement.
- EPC NTP targeted for October 29, 2013 will complete FEL-4 site engineering for mobilization on site, final procurement engineering packages of long lead equipment.
- Long lead procurement of boiler (October 15, 2013), decrystallyzer (October 20, 2013, filter presses (October 27, 2013), acid concentrator (October 24, 2013), fermentation (October 18, 2013) and SMB (October 7, 2013) packages followed by remaining equipment and systems. FEL-3 bid packages are still 90% relevant and communications with major equipment vendors has confirmed swift purchase finalization including performance guaranty negotiations.
- Site Mobilization (February 1, 2014) with rough grading and site prep completed, mobilization and the start of underground and foundation excavation can be initiated quickly and prior to the rainy season for the site.
- Continue to look for optimization of schedule based on financing.

Project Management Approach –

The phase 2 EVMS will:

- Expand the milestone scope to critical or items >$10,000.
- Percent physical completion will be proposed by the EPC and approved by BFRE for critical or milestones >$50,000, all others will be 20% on start and remaining 80% upon completion.
- Scheduled dates and planned expenditures will be through a critical path, resource loaded schedule updated monthly through 20% completion and biweekly thereafter with weekly site meetings of construction managers. Site critical impacts may be added to the schedule for tracking, but may not be tracked in the EVMS system.
- Deficit reports will be issued and tracked weekly.
- Summary reports and EVMS tracking graphicals will be issued to DOE monthly.

Technical Accomplishments/Progress/Results

- Process Pilot Plant validation through Commercial Scale-up Program (CSP) program where advances were made in filtration, SMB separation and fermentation.
- Engineering completion of FEL-2 & FEL-3 used in development of the firm price EPC contract.
- Environmental review under NEPA, and permits from ACE Wetlands, MDEQ water quality certification, air, storm water and wastewater completed for project.
- Will serve letters for all utilities completed
- Site geotechnical studies, drainage plans and rough grading plans completed and site rough grading and drainage near complete
- Engineering package validated through DOE due diligence engineering firm R.W. Beck.

Competitive Site Location Secured

Competitive Site Location consistent with risk mitigation approach

✓Industrial setting

✓Tri-modal access (rail, interstate and barge) for receipt of materials and shipment of products

✓Within close proximity of biomass supplies including idle chip mill

✓Infrastructure available or requiring minimum upgrade

Local Funding and Support Provided

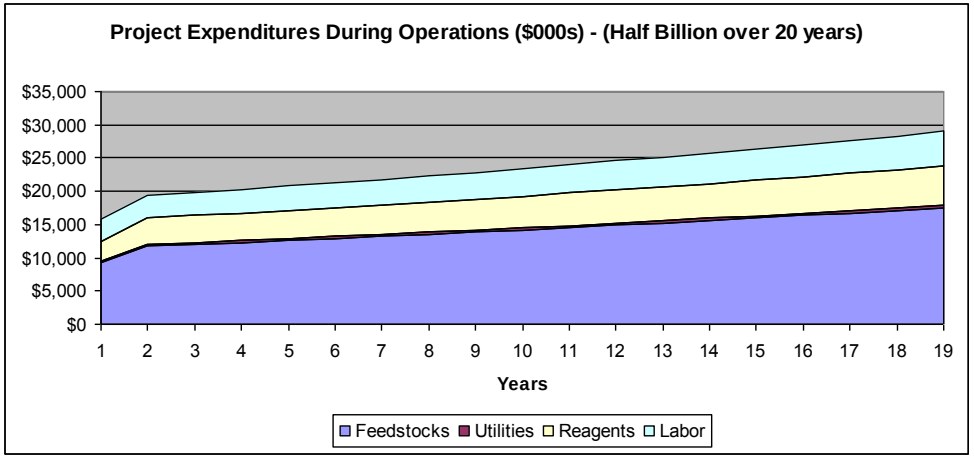
Itawamba County & City of Fulton

- Land Purchase – $1.6 million
- Wetlands Mitigation $150,000
- Site clearing, rough grading & drainage improvement – $2.95 million
- In-kind development support – $500k

City of Fulton Providing Site Services

- Water
- Wastewater disposal
- Natural gas

State of Mississippi – over $47 million in incentives over 10 year period



All Permits For Construction Issued

- NEPA Compliance – Finding of No Significant Impact from U.S. Department of Energy
- Wetlands permit from Army Corps of Engineers, wetlands mitigation complete
- Air permit from Mississippi Department of Environmental Quality (MDEQ)
- Water Quality Certification from MDEQ
- Baseline Stormwater Permit from MDEQ
- Wastewater disposal permit from MDEQ
- Construction Stormwater Permit from MDEQ

US Army Corps of Engineers

MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

U.S. DEPARTMENT OF ENERGY

Feedstock Supply for 15 Years Secured

the COOPER GROUP of companies

- Process can use broad spectrum of feedstock
  - Furniture & other manufacturing cellulosic waste
  - Greenwaste from municipal collection
  - Greenwaste from utility rights of way
  - Slash and logging residues
  - Pre-commercial thinnings

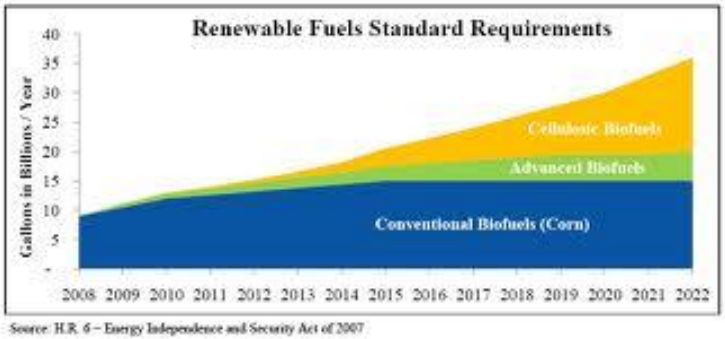
- 15 year contract with Cooper Marine Timberlands
  - with several chip mills in operation in Mississippi and Alabama
  - a member company of Cooper/T. Smith one of America's oldest and largest stevedoring and maritime related firms with operations on all three U.S. coasts and foreign operations in Central and South America

- Contract provides for incentives to supplier for least cost procurement strategy by taking advantage of lower cost materials

Ethanol Sold Under 15 year Contract

- 19 million gallons of cellulosic ethanol annually
- 15 year contract signed with Tenaska Biofuels
  - an affiliated company of Tenaska, one of the largest independent power producers in the United States with gross operating revenues were $7.9 billion and its assets were $2.8 billion dollars
- Site allows flexibility in shipments & storage – access to rail, interstate and barge available

>>60% reduction in GHG from the Fulton Project



Provides an immediate pathway for meeting cellulosic requirements under RFS

Technology Ready for Commercialization

- Several plants utilizing the acid hydrolysis process were built from the 1930's to the late 1980's with advancing process improvements – demonstrated @ ~50-65% conversion of C+H to sugars. BlueFire improvements @~80% conversion efficiency
- Patents provide improvements for current market economics
- Arkenol (BlueFire) process improvement to allow for more effective separation of acid from sugars through SMB improves yield and commercialization potential
- SMB development has been proven at commercial scale for hundreds of facilities including mining that uses acid/mineral separation techniques utilized even more effectively for acid/sugar separation
- Five Pilot Plant programs with over 6,000 cumulative hours of operation have been completed to validate the commercialization of the process in the configuration employed for the Fulton Project
- Partnered with back-end technology producing other biochemicals from cellulosic sugars

Accomplishments Against Technical Targets

Key Operating Parameters	JGC Izumi Biorefinery	ATC BlueFire Pilot Plant	The Facility
Production (Denatured)	28,196 GPY	10L	18.9 MGPY
C6 Decrystallizer & Hydrolysis Yield	75%	80%	80%
Lignin Press C6 Sugar Losses	4	2%	4%
SMB C6 Sugar Losses	2%	4%	0.2%
Clarifier C6 Sugar Losses	1%	0.10%	0.8%
C6 Fermentation Conversion (% of Theoretical)[(1)]	85%	92%	91%
C6 Fermentation Yield (Pound Ethanol/Pound Glucose)	0.432	0.4692	0.469
Fermentation C5 Consumption	16.63%	20%	12%
Fermentation Time	6-24 hours	28 hours	12.5 hours
Overall Yield [(2)]	65 gallon/ton feedstock	82 gallon/ton feedstock	72.5 gallon/ dry ton feedstock

DOE Sponsored Third Party Engineer's Report Table (RW Beck)

Progress Against Design

- Front End Loading (FEL) 2 & 3 packages were completed. Results included:

  ✓Over 125 process drawings
  ✓Four phases of Geotechnical Investigations
  ✓ 50 site plans and sketches
  ✓75 specifications and procurement bids for over 400 of 500+ pieces of equipment
  ✓ A resource loaded level 3 project schedule
  ✓ A Project Execution Plan
  ✓A firm Project Cost Estimate

- Engineering, Design, and Construction for site clearing, grading, and storm drains were completed in January, 2011

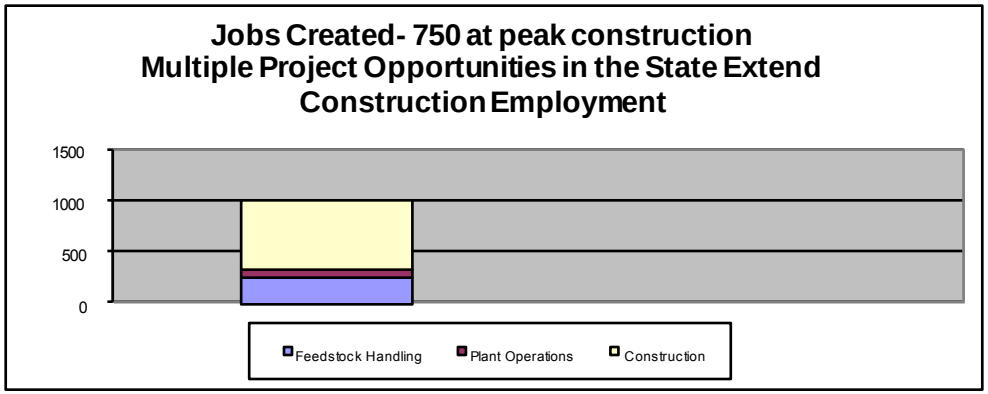
- The Fulton Project's state of readiness has been summarized by IPA in a report to DOE:

  ✓ *The BlueFire Fulton Renewables Project is entering execution with better than industry average drivers. The finalized scope, cost estimate, and strong execution plans should minimize the risk of cost growth, changes, and schedule slip, and position the project team to attain the competitive cost target.*

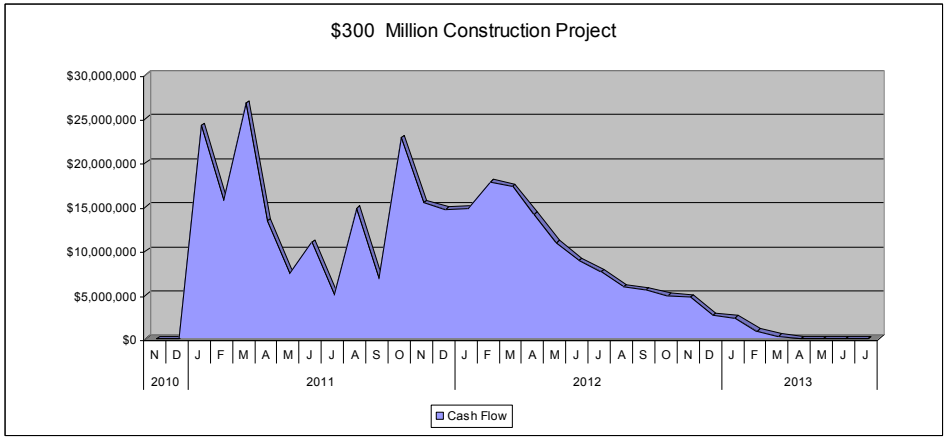
- IPA has benchmarked the Project's FEL Index and Rating as "Best Practical" stating *"The level of project definition achieved by the team is better than the industry average and falls in the industry top quintile."*

Lump Sum, Turn-key Contract to Build Complete

- Engineering, Procurement & Construction (EPC) contract signed with Mastec, Inc.
  - with construction by Mastec company, Wanzek Heavy Industrial Constructors



- Provides for liquidated damages, guaranteed by the parent company, Mastec, for up to 100% of the total contract price. The contract also includes schedule and delay penalties for Mastec.



Site Work Completed

52 local construction workers at work on-site during this phase.

Work completed:

✓Geotech studies & surveys
✓Drainage & Rough grading plans
✓Geotech fabric laid
✓Drainage pipe installed
✓Cut & fill to rough elevations

Relevance– Supports DOE Biomass Program Goals

- Supports volumetric goals of the Renewable Fuels Standard
  - Fulton design replicable, sites in SE and elsewhere already identified
    - Process allows for geographic flexibility given ability to use wide range of feedstocks
    - Facilities can be located in urban, forest or agricultural regions
- Project contributes to sustainability and lower life cycle emissions
  - Greater than 80% GHG reduction at Fulton, even higher for projects utilizing predominantly urban cellulosic wastes
  - Use of residues helps increase forest health (use of slash, etc.)
  - Works well in conjunction with biomass users requiring higher quality wood materials (paper mills, pellet plants, biomass power plants, furniture & other manifacturing

Relevance to goals of Bioenergy Technologies Office and broader bioenergy industry

- Helps reduce dependence on foreign oil
- Establishes a domestic bio industry
  - Supports biorefinery concept for production of several different biofuels and biochemical products
  - Economic development

Success Factors and Challenges

- Critical success factors that will define technical and commercial viability of the project
  - Attract capital based on risk mitigation strategies employed (contracts, pilot and CSP, pro-forma reserves)
  - Optimize use of low cost feedstock
  - Ethanol market recognition of cellulosic supply value
- For Widespread deployment (successor plants)
  - Commercial process demonstration that reduces financial market process risk concerns for access to private capital
  - Cost reduction (capital and operating)
  - Optimization of feedstock logistics to take advantage of seasonal biomass, infested forest wood, agricultural residues, energy crops
  - Deployment of process for higher value biochemical products
- Challenges Met
  - Reduced utility costs:
    - Balance production of lignin to match thermal & energy needs (natural gas only for start-up)
    - Designed acid reconcentrator to allow back-pressure turbine to supply 100% of average electrical needs
  - Completed key contacts for feedstock, ethanol and EPC
- Challenges to overcome
  - Financing
  - Deployment and management of lump-sum EPC contract
  - Management of operations to achieve expected costs

Future Work thru Sept 2015

- Upcoming Key Milestones
  - Begin Plant Construction by First Quarter 2014
  - Complete All Project Financing
    - Convert terms discussed into definitive documents for equity debt financing
    - Continue to explore potential project structures and configuration to increase likelihood of success
- Start-up, Commissioning and Performance Tests

2011 Reviewers Comments

- 2011 Reviewers found the approach sound. The most significant concern is the financing for project
- Multiple pathways being pursued
  - Consider reducing balance of funds required through reduction of capital from reduced scope (down-size project to minimum requirement for DOE IBR – 700MT/day).
  - Pursue financing structures that insulate debt provider from ethanol downside to raise credit quality by achieving greater revenue certainty from coupled financing with bio-product facility utilizing lignin to gain access to broader range of debt mechanisms.
  - Convert discussions of terms of engagement and funding into term sheets and definitive agreements. Discussions maturing on foreign debt and equity financing terms.
  - Participation by partners using A/H front end technology to produce biochemical products.

Summary

- **Relevance**
  - **Project enables compliance with DOE Biomass Program goals and broader bioenergy industry**
- **Approach**
  - **Consistent with the goal to build a commercial plant**
  - **Status to date of project consistent with approach**
- **Technical Accomplishments**
  - **Focused on de-risking process and costs for financing**
- **Success factors and challenges**
  - **All issues that can be resolved prior to actual construction and operations addressed**
- **Benefits and Expected outcomes**
  - **Consistent with goals of Bioenergy Technologies Office and broader bioenergy industry**
- **Future Work**
  - **Implementation of management approach upon completion of all financing**
  - **All pathways to financing progressing**

Patents, Awards, Publications, & Presentations Resulting From Work on this project

- None developed from current work
- All patents developed prior to award

Patents, Awards, Publications, and Presentations

i) Patent No. 5,562,777 for Arkenol's basic technology, "A Method of Producing Sugars Using Strong Acid Hydrolysis of Cellulosic and Hemicellulosic Materials" on October 8,1996;

ii) Patent No. 5,580,389 for "Method of Separating Acids and Sugars Resulting from Strong Acid Hydrolysis as Amended" on December 3, 1996;

iii) Patent No. 5,597,714 for "Strong Acid Hydrolysis of Cellulosic and Hemicellulosic Materials" on January 28, 1997;

iv) Patent No. 5,620,877 for "A Method of Fermenting Sugars Resulting From Strong Acid Hydrolysis As Amended" on April 15, 1997;

v) Patent No. 5,726,046 for "Method of Producing Sugars Using Strong Acid Hydrolysis" on March 10, 1998;

vi) Patent No. 5,782,982 for "Method of Removing Silica from Solids Resulting from the Strong Acid Hydrolysis of Cellulosic and Hemicellulosic Materials" on July 21, 1998;

vii) Patent No. 5,820,687 for "Method of Separating Acids and Sugars Using Ion Resin Separation" on October 13, 1998;

viii) Patent No. 5,892,107 for "Method for the Production of Levulinic Acid and Its Derivatives" on April 6, 1999.

(ix) Patent No. 6,054,611 for “Method for the Production of Levulinic Acid and Its Derivatives” on April 25, 2000;

(x) PCT International Publication Number WO 03/010339 A1 for “The Separation of Xylose and Glucose from Process Acid Hydrolysate” on February 6, 2003;

(xi) Patent No. 2,158,430 for “Method of Producing Sugars Using Strong Acid Hydrolysis of Cellulosic and Hemicellulosic Materials” on December 16, 2003