



Demonstration & Deployment
Plenary Presentation

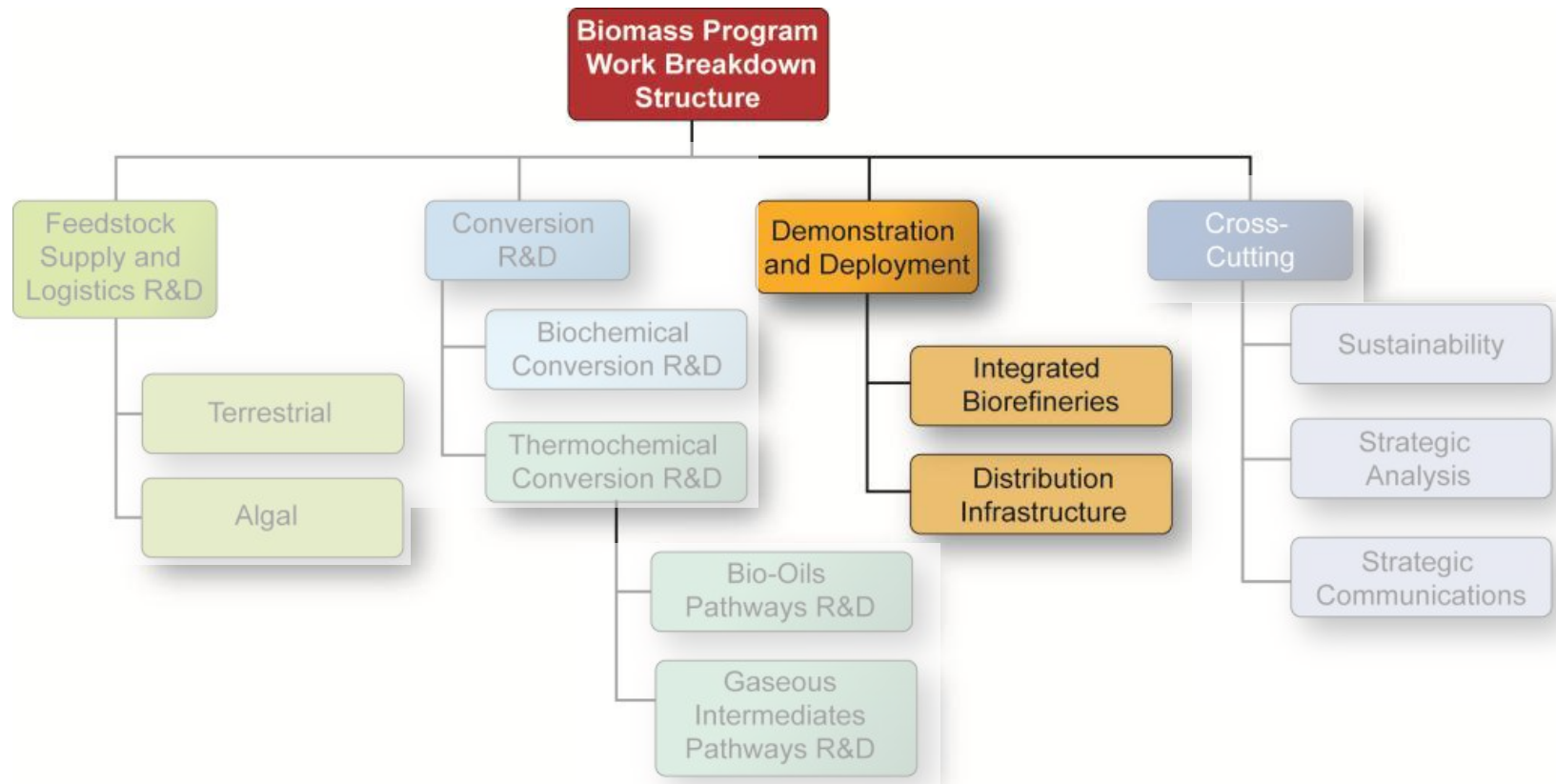
Brian Duff
May 20, 2013

Demonstration & Deployment Peer Review Plenary

- Introduction to the Demonstration & Deployment (D&D) Subprogram
- Overview of the D&D Technology Portfolio of Projects
- The Role of D&D in Biofuels Commercialization
- D&D Budget and Portfolio Analysis
- The D&D Peer Review Agenda
- Q&A

Introduction to Demonstration & Deployment

The **Demonstration and Deployment (D&D) subprogram** (formerly the **Integrated Biorefinery Platform**) is focused on demonstrating and validating biomass conversion technologies through successful construction and operation of cost-shared pilot, demonstration, and commercial scale integrated biorefineries (IBRs).



Purpose of the D&D Subprogram

The purpose of the D&D subprogram is to “de-risk” emerging biomass conversion technologies sufficiently so that broad replication and industry expansion can occur.

BETO does this by providing financial assistance for scaleup and demonstration of emerging technologies. We work in partnership with private-sector technology developers to leverage federal financial assistance funding.

The D&D subprogram plays a vital role in “de-risking” technologies in 2 primary ways:

- Technologically, to scale-up and validate conversion process performance so that “Wrap-around” performance guarantees can be provided by EPC firms.
- Financially, to verify the CAPEX and OPEX so private-sector financing can invest without fear of default.

BETO D&D Staff

- Program Manager
 - Brian Duff
- Technology Managers
 - Glenn Doyle
 - Paul Grabowski
 - Elliott Levine
 - Neil Rossmeissl
 - Travis Tempel
 - Bryna Berendzen (also on R&D staff)
 - Liz Moore (also on R&D staff)
 - Gene Petersen (also on R&D staff)
 - Leslie Pezzullo (also on R&D staff)
 - Christy Sterner (also on R&D staff)

The D&D Technology Portfolio

BETO D&D Technology Portfolio (IBR)

- To date, BETO has or is investing in 33 R&D, pilot, demonstration, and commercial-scale IBR projects selected to validate technologies

- Diverse feedstocks represented:

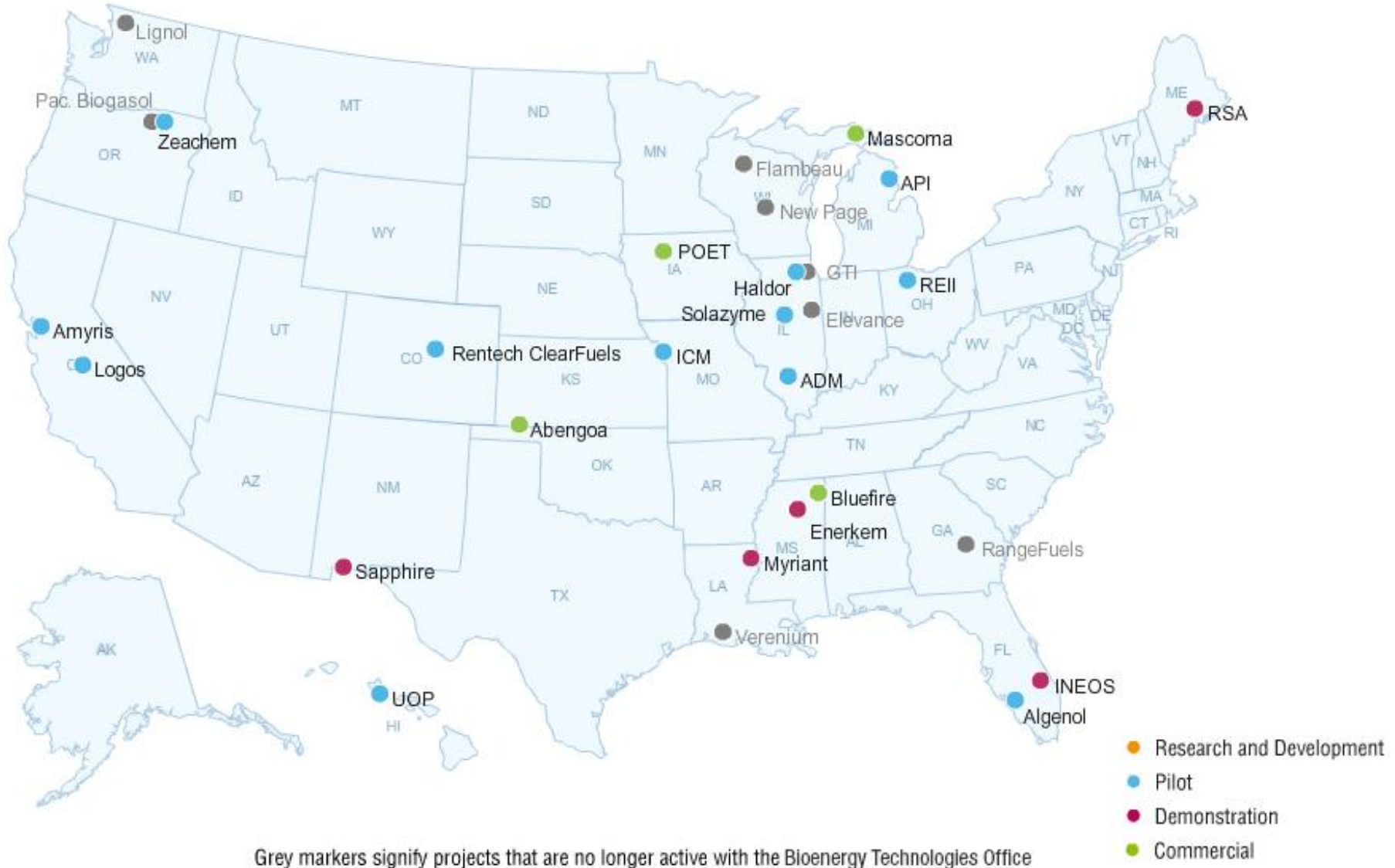
- | | | |
|-----------------------|------------------|-----------------------|
| Agricultural Residues | Algae/CO2 | Municipal Solid Waste |
| Energy Crops | Forest Resources | Non-edible oils |

- A variety of transportation fuels, biobased products, and biopower are being developed

- | | | |
|--------------------|--------------------|------------------------|
| Cellulosic Ethanol | Renewable Gasoline | Biobased Chemicals |
| Butanol | Renewable Diesel | Process heat and steam |
| Methanol | Jet Fuel | Electricity |
| | Biodiesel | |

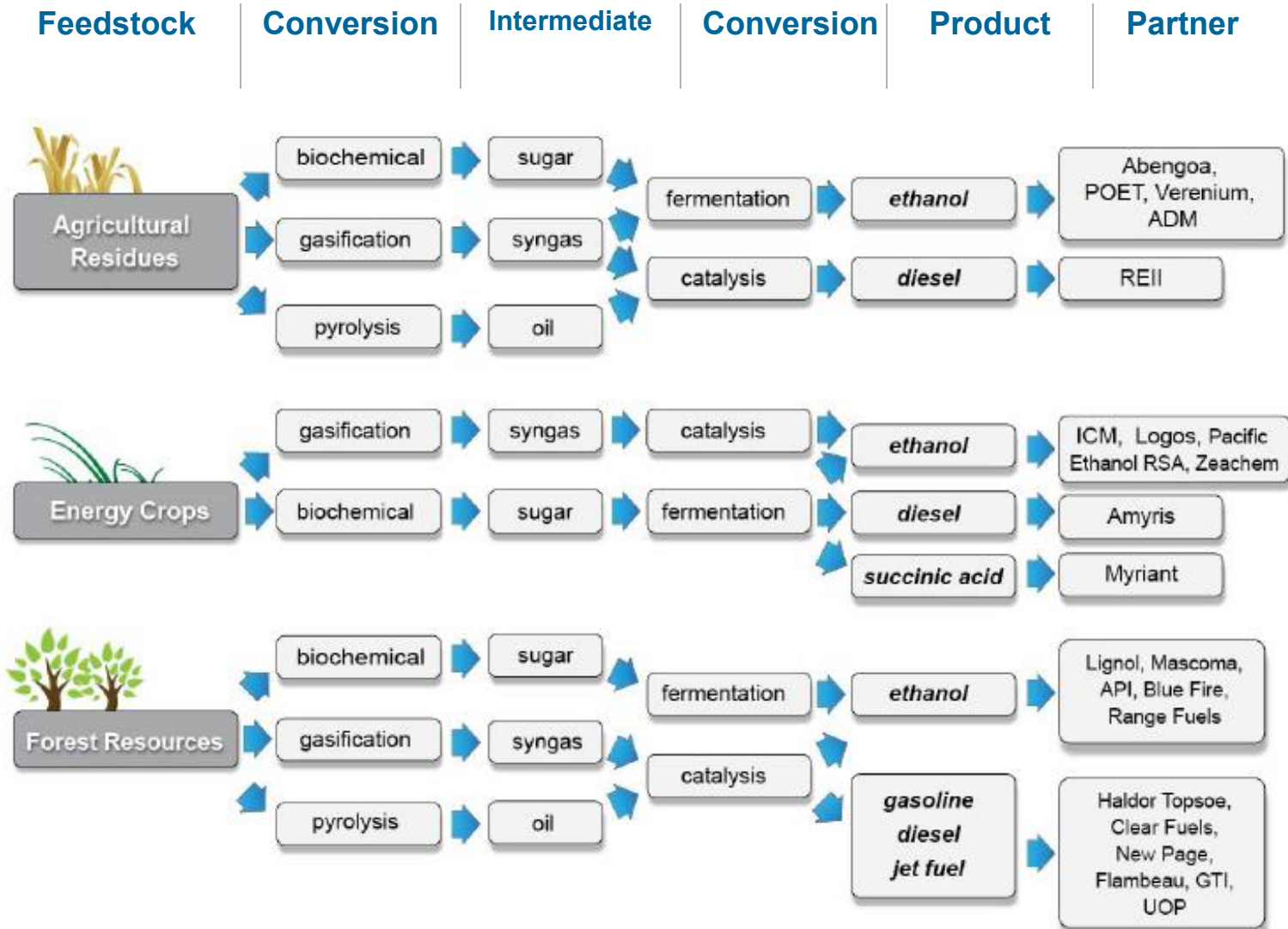


BETO IBR Project Portfolio – Geographic Diversity

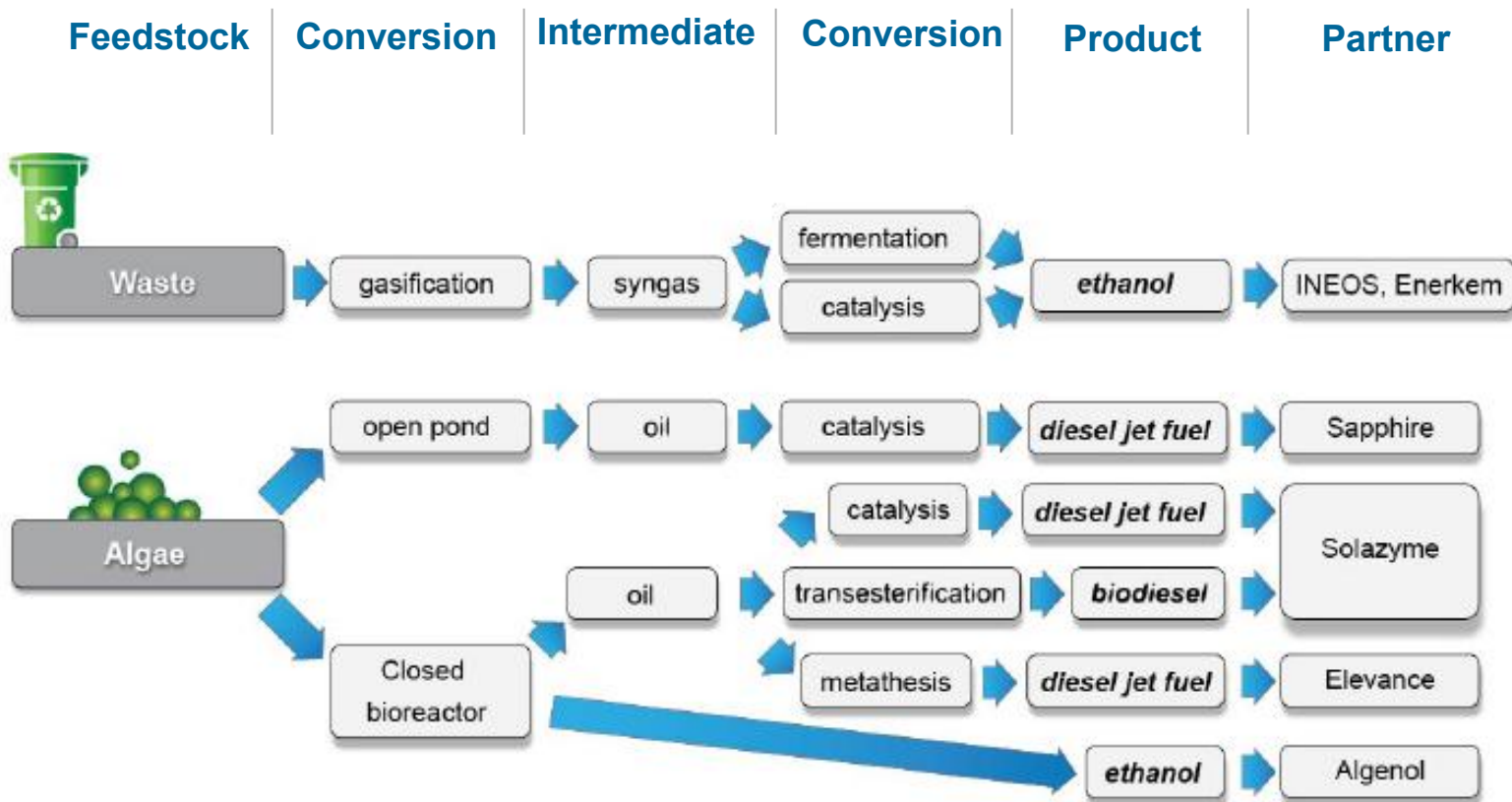


For more information visit:
http://www.eere.energy.gov/biomass/integrated_biorefineries.html

IBR Portfolio – Pathway Diversity



IBR Portfolio – Pathway Diversity



Current Status of D&D Portfolio

Total of 33 Integrated Biorefinery projects awarded to date:

- 5 Mutually Terminated
- 5 Complete (two still compiling final report)
- 19 Active
- 4 New awards under negotiation

33 Integrated Biorefinery projects awarded to date or in negotiation:

- 16 are Cellulosic Ethanol
- 12 are Renewable Hydrocarbons
- 3 are Algae Oil
- 2 are Bioproducts

Of the 19 active and 4 in negotiation:

- 4 Commercial scale
- 5 Demonstration scale
- 14 Pilot scale

Of the 19 active projects:

- 7 are in operations phase
- 2 semi-works plants are in commissioning phase
- 5 are in construction
- 2 still in FEED
- 3 trying to finalize financing

Key D&D Accomplishments since 2011

- 2 commercial scale biorefineries are under construction and are expected to begin production in 2014
- 1 pre-commercial, semi-works biorefinery has completed construction and is undergoing commissioning and will begin operations this summer; this plant will be the first “commercial” cellulosic ethanol plant in the USA
- 1 pre-commercial, semi-works bioproduct facility has completed construction and is undergoing commissioning in anticipation of start of production this summer
- 4 of 18 ARRA projects have been completed (two are preparing their final reports)
- 7 ARRA projects are currently in the operations phase
- 4 ARRA projects are still in the construction phase
- 4 new awards are under negotiation from the recent Innovative Pilot Solicitation

Key D&D Lessons Learned

- Applicants tend to exaggerate their technology readiness at all scales
- Applicants are uniformly over-optimistic in their cost and schedule assumptions
- All elements of projects take longer than estimated, so plan for it; this includes FEED, Detailed design and engineering, construction, startup and commissioning
- Startup and commissioning uniformly take at least twice as long as project if not 3 or 4 times longer
- 25% contingency should be considered a minimum
- General rule of thumb: Projects take twice as long and cost twice as much

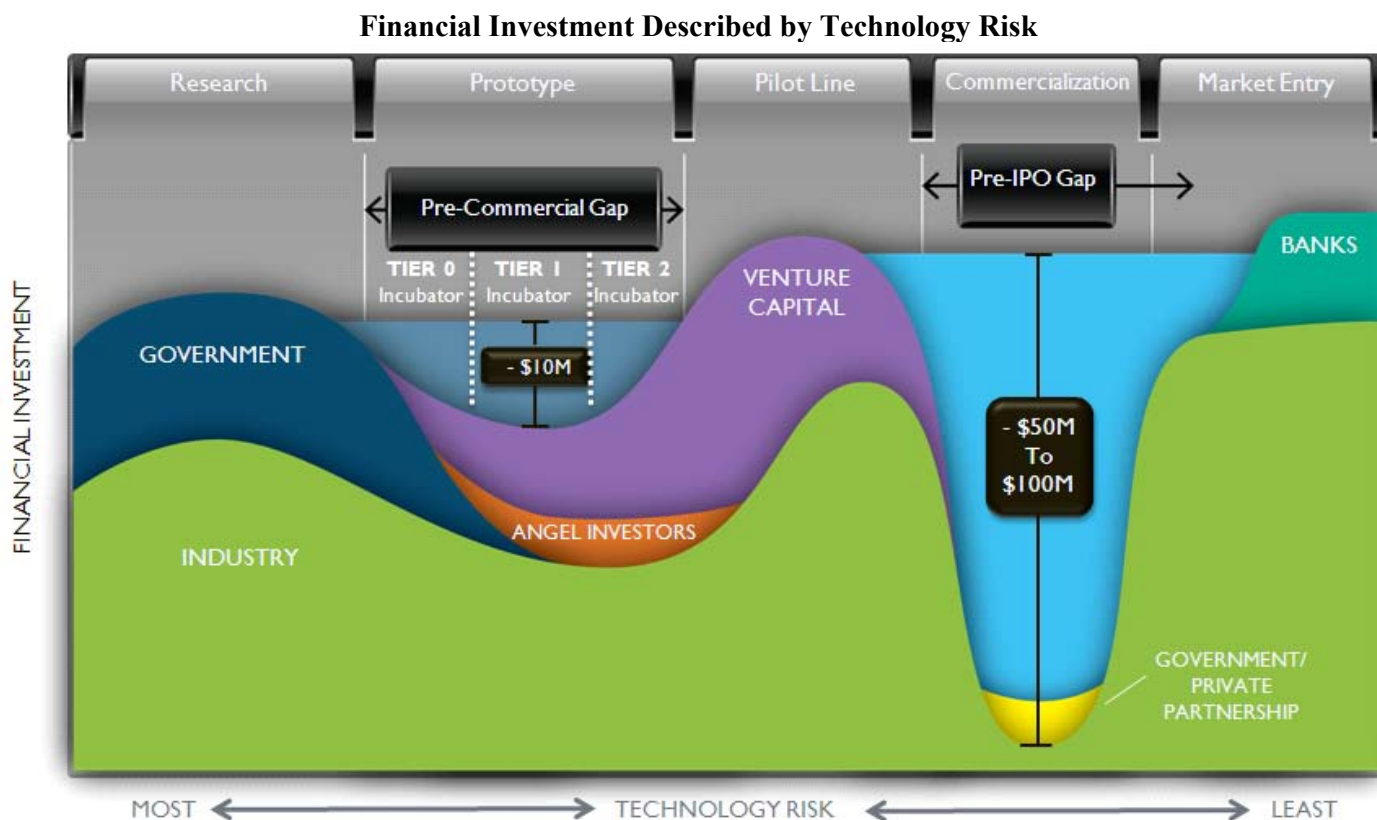
Key D&D Lessons Learned (cont'd)

- Project financing continues to plague large demonstration and commercial scale projects; documented cost share and contingency should be “in hand” at start of projects
- Don't make any announcements based on schedule estimates; wait for the proof
- Feedstock handling, pre-processing and introduction into reactors, both biochemical and thermochemical, continues to be a challenge
- “Scale-down” of commercially proven equipment for custom pilot and demo applications is not straightforward and has proven to be the source of costly redesigns and retrofits
- Syngas compression and cleanup continues to challenge technology demonstrations

The D&D Role in Commercializing Emerging Bioconversion Technologies

The Essential Role of Demonstration and Deployment in Technology Development and Commercialization

Pre-commercial funding provides early-stage assistance to help startup companies cross technological barriers to commercialization while encouraging private sector investment. See the “Pre-Commercial Gap” depicted in the figure below.



Reference: SunShot Funding Opportunity Announcement Number DE-FOA-0000838

Crossing the Valley of Death -

Solutions to the next generation clean energy project financing gap

There are two critical locations where a shortfall of capital often comes into play. The first occurs early in a technology's development, just as it is ready to exit the lab. This barrier is known as the early-stage "Technological Valley of Death".

The second barrier occurs later, when much more substantial levels of capital availability are needed to prove the viability of a new technology at commercial scale. This later-stage barrier is known as "Commercialization Valley of Death."

The problems posed by this commercialization funding challenge represent fundamental, structural market shortcomings that **most experts believe cannot be resolved by the private sector acting on its own.**

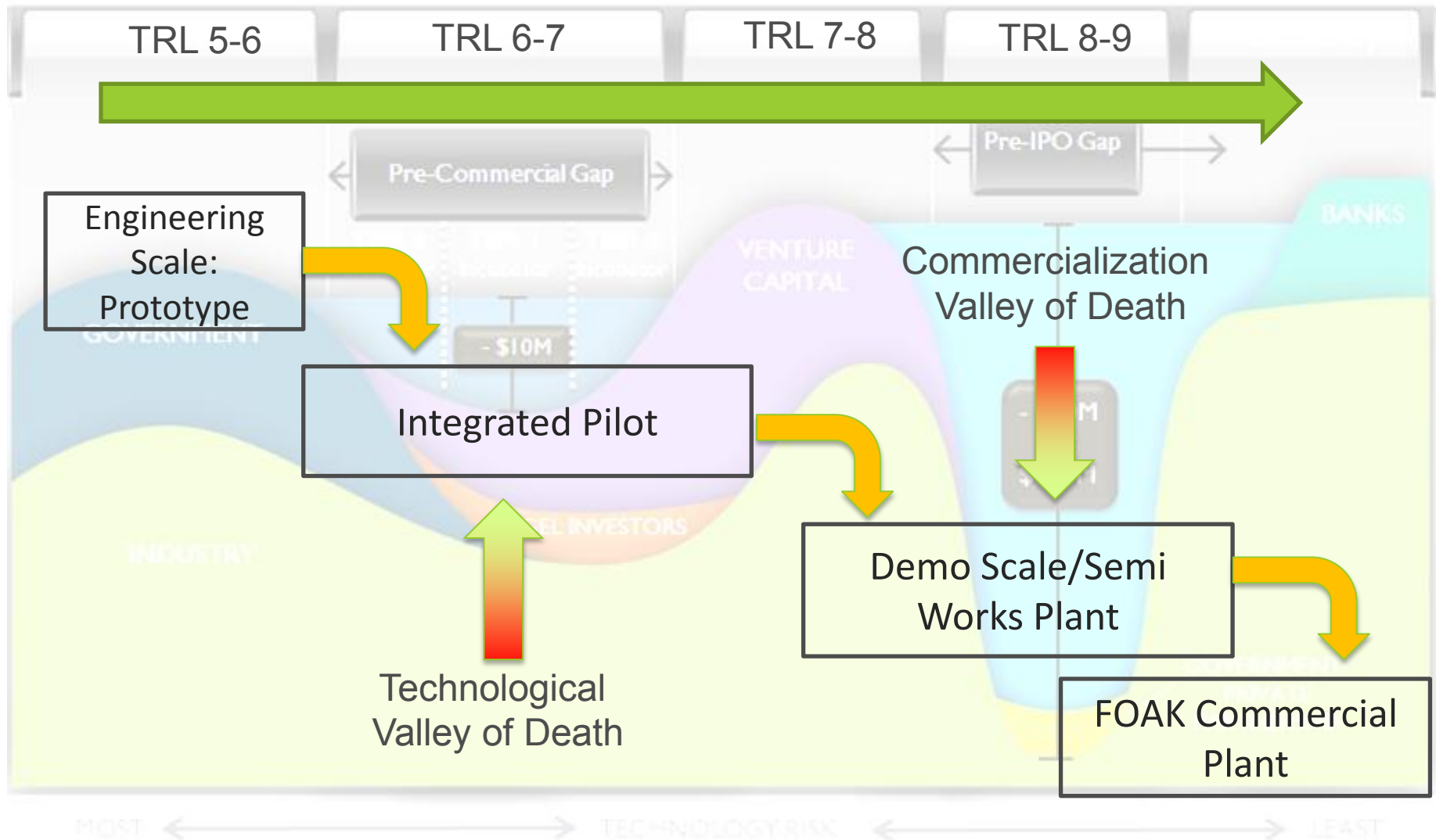
Even in good times, when lending standards are most flexible, banks and other financial institutions are simply not structurally positioned to back large-scale projects deploying new technology.

<https://www.bnef.com/WhitePapers/download/29>

Role of Demonstration & Deployment in Commercializing Emerging Bioconversion Technologies

- “De-risking” is the essence of the D&D role in commercializing new process technologies: D&D projects address technical risk, financial risk, construction and operations risk
- “De-risking” facilitates private sector financing and the provision of “wrap-around” EPC performance guarantees
- Who else is going to fund demonstration scale facilities and first-of-a-kind commercial facilities? Not Startups, not VCs, not Angels, not banks.....
- Demonstration scale facilities result in a more precise cost estimate for the commercial plant and more accurate equipment specifications for capital equipment
- Demonstration scale facilities identify process design improvements and cost improvement opportunities that reduce the cost of the first-of-a-kind commercial plant.
- Demonstration scale facilities are necessary to generate product for market qualification testing, product certification, and vendor tests
- BETO D&D is the only federal program that has been actively working to put steel in the ground to support the administrations policies and address the RFS
- To meet RFS2, we need between ~500-1000 new production plants: this will require the involvement of 50+ private sector banks which means the technology has to be completely proven and de-risked – **this is why DOE/BETO has a role in D&D.**

The Steps in Technology Development and Scaleup to First-of-a-Kind (FOAK) Commercial Process Facility



How D&D Assistance Helps De-Risk Conversion Technologies

Pilot-scale IBR projects focus on integrating all unit operations and key recycle streams from feedstock introduction to product purification at pilot scale to:

- Confirm mass & energy balance models
- Verify key process performance parameters
- Prove the process can run continuously for hundreds or thousands of hours
- Produce the data required to generate equipment specifications for commercial equipment
- Refine the techno-economic model (TEA) to confirm process is worth commercializing

Demonstration-scale IBR projects focus on integrating all unit operations, including all recycle streams and heat integration strategies at the pre-commercial or “semi-works” scale to:

- Validate the same process design that will be used at commercial scale
- Validate the equipment specifications used to procure commercially-available process equipment
- Demonstrate the mechanical operability, durability and reliability of unit operation equipment
- Generate sufficient product for market development purposes
- Further confirm and refine the TEA and cost estimate for the commercial plant.

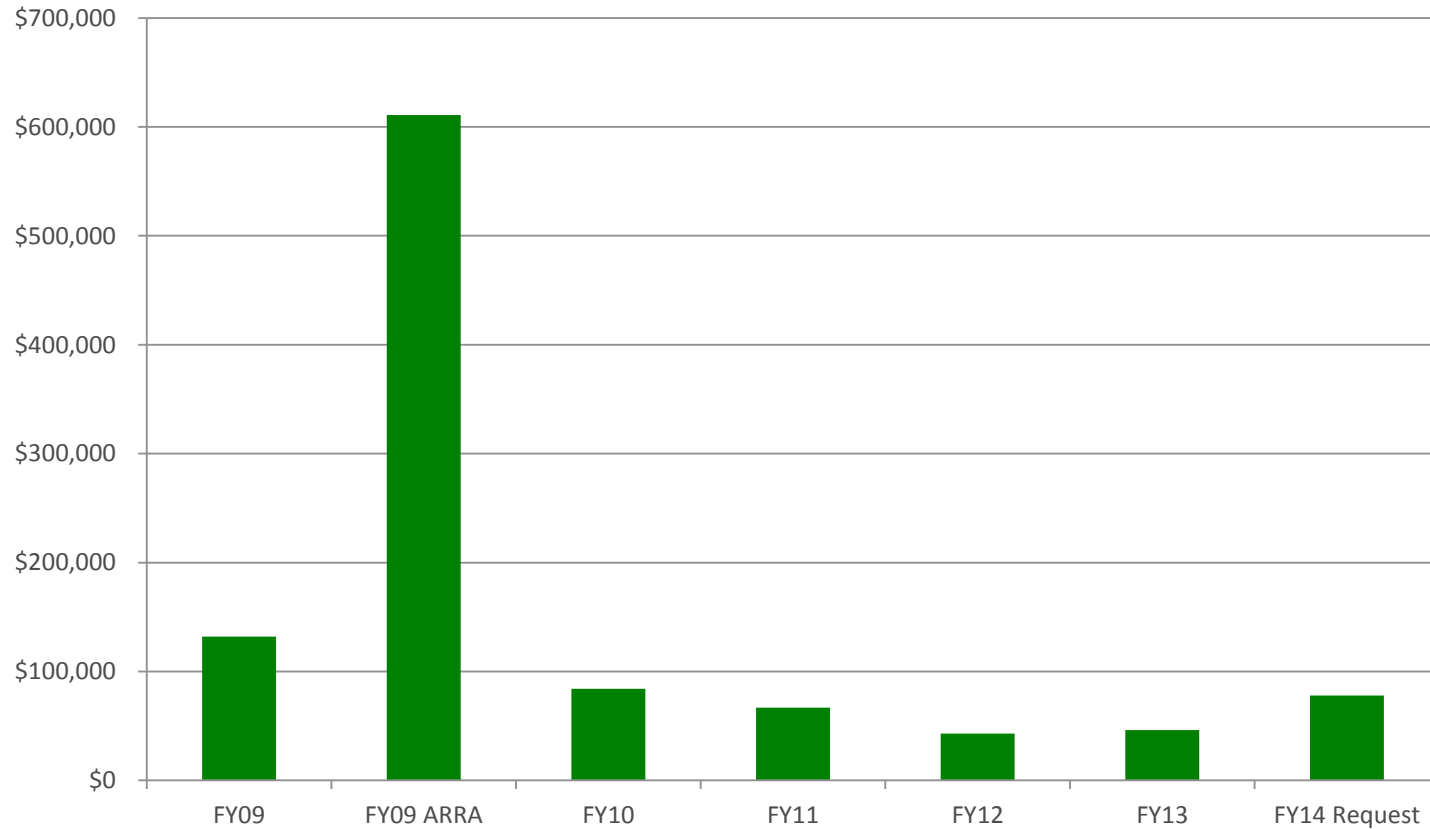
Commercial-scale IBR projects focus on demonstrating the biomass conversion process in a “pioneer” or “First-of-a-Kind” (FOAK) plant at the full commercial scale to:

- Prove the commercial production process can “cash flow”
- Prove the production process is sufficiently robust that performance guarantees can be provided for follow-on plants
- Demonstrate the technology at scale to prove to the financial community that the facility can generate adequate revenues to service the debt and meet the hurdle rate of equity investors

The D&D Budget and Portfolio Analysis

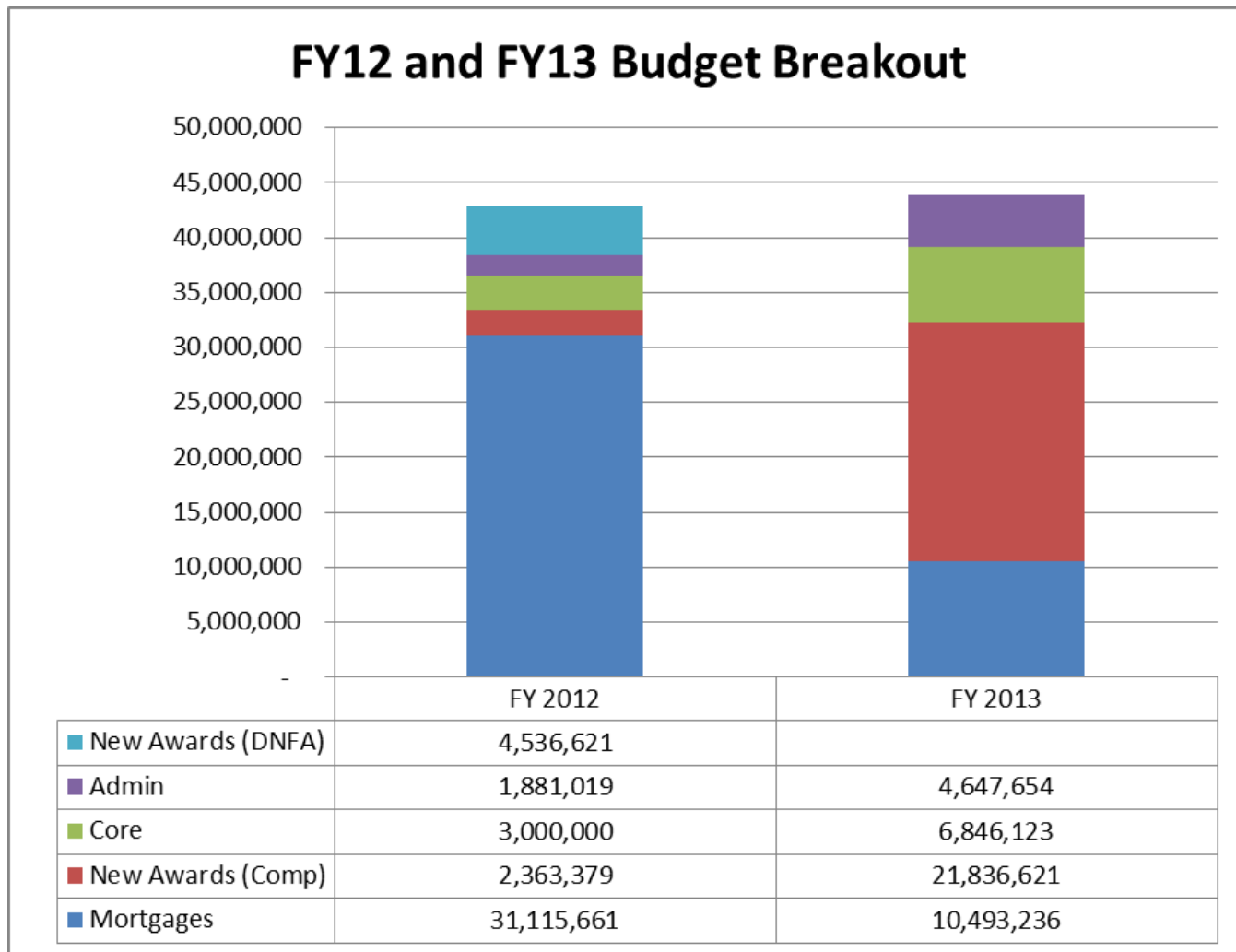
Demonstration & Deployment Budget

D&D/IBR Budget History '09-14



FY09	FY09 ARRA	FY10	FY11	FY12	FY13	FY14 Request
\$132,000	\$611,000	\$84,278	\$66,695	\$42,897	\$46,248	\$78,000

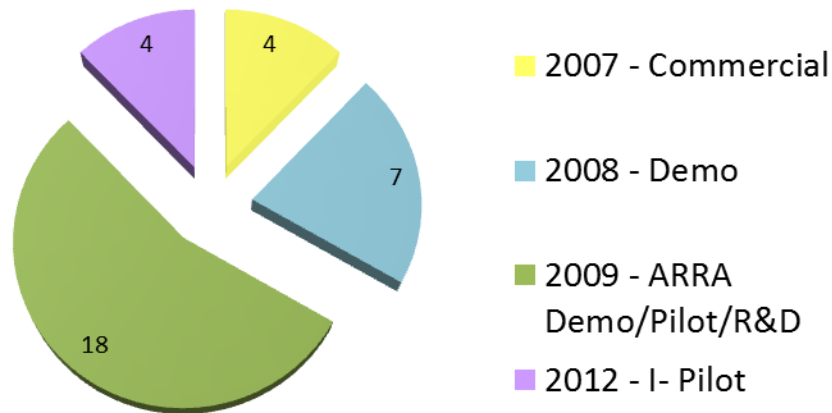
Demonstration & Deployment Budget



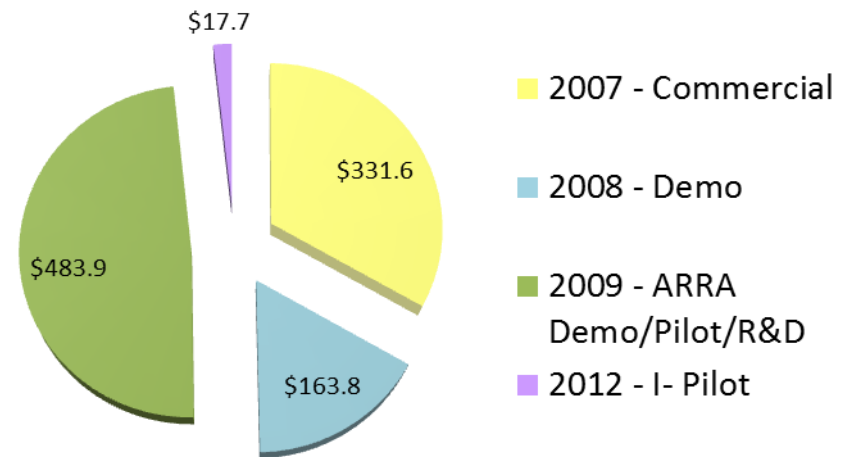
Demonstration & Deployment Budget Analysis

D&D Portfolio by Funding Year

Number of IBRs by Year/FOA



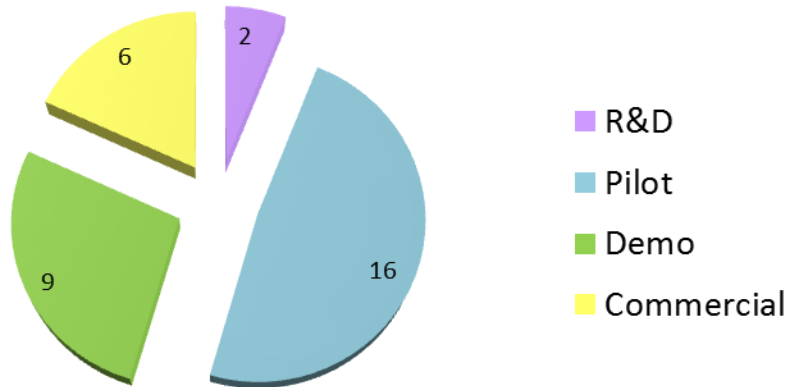
Investment in IBRs by Year/FOA



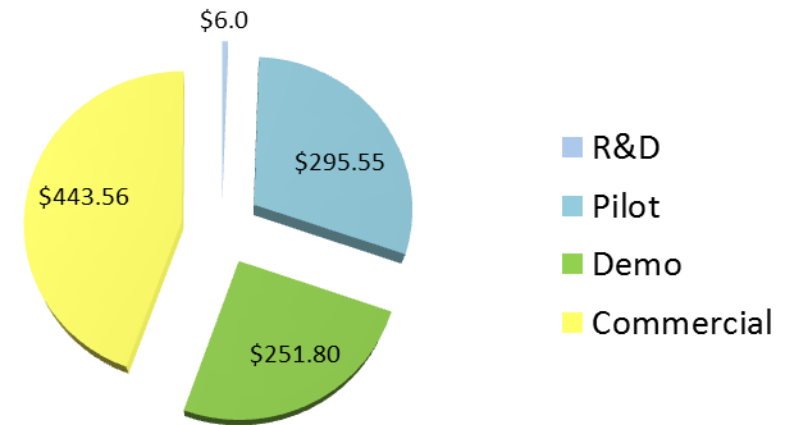
Demonstration & Deployment Budget Analysis

D&D Portfolio by Project Scale/TRL

Number of IBRs by Scale/TRL



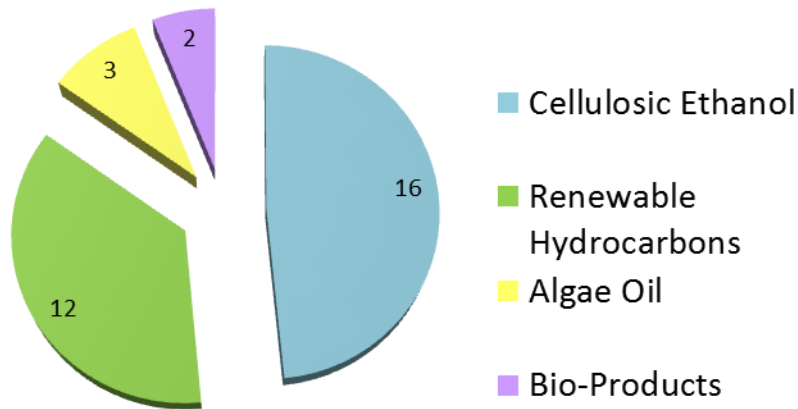
Investment in IBRs by Scale/TRL



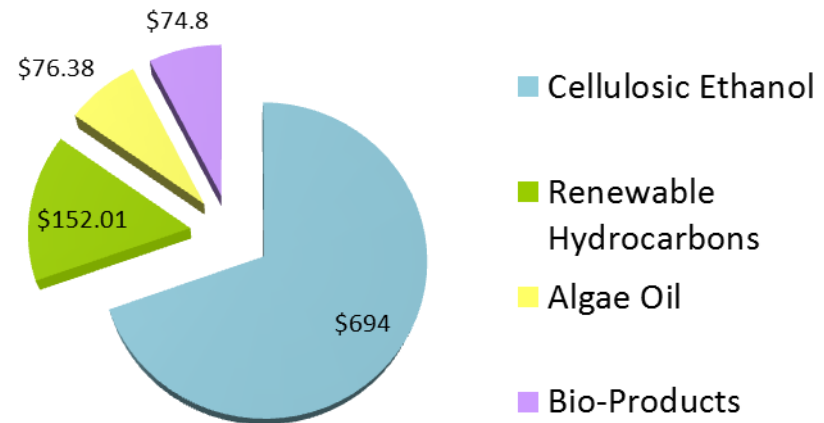
Demonstration & Deployment Budget Analysis

D&D Portfolio by Product

Number of IBRs by Product



Investment in IBRs by Product



The D&D Peer Review Agenda

D&D Reviewers

Bill Crump*	SAIC/RW Beck
Steve Moorman	Babcock & Wilcox Company
George Philippidis	University of Southern Florida
Dan Strobe	Consultant/Ret. VP Tech, KIOR
James Doss	Professional Project Services, Inc.
Ralph Anthenien	Army Research Office
John Wyatt	Carmagen Engineering, Inc.

* **Lead Reviewer**

D&D Agenda Overview

Monday: 5 of 21 Projects

Start Time	End Time	Min.		Project Title	Performing Organization	Principle Investigator
DAY 1 - Monday, May 20, 2013						
1:00 PM	1:15 PM	15		IBR Technology Area Introduction		<i>Travis Temple</i>
1:15 PM	1:45 PM	30		IE/SI Summary (30min)		<i>NREL SI</i>
1:45 PM	2:30 PM	45	5.5.12.1	Pilot Integrated Cellulosic Biorefinery Operations to Fuel Ethanol (Pilot)	ICM Inc. (Travis)	<i>Douglas Rivers</i>
<i>2:30 PM</i>	<i>2:45 PM</i>	<i>15</i>		<i>Break</i>	<i>All</i>	
2:45 PM	3:30 PM	45	5.4.9.1	Conversion of Lignocellulosic Biomass to Ethanol and Ethyl Acrylate (Pilot)	Archer Daniels Midland (Leslie)	<i>Thomas Binder</i>
3:30 PM	4:15 PM	45	5.5.3.2	Fulton Ethanol Facility: A landfill waste feedstock to cellulosic ethanol facility - Award 2 - ARRA (Comm)	Bluefire LLC (Gene)	<i>Necy Sumait</i>
4:15 PM	5:00 PM	45	5.2.3.1	BEI - Myriant Succinic Acid Biorefinery (MySAB) (Demo)	Myriant (Gene)	<i>John Ellersick</i>
5:00 PM	5:45 PM	45	5.7.5.1	Modification of Corn Starch Ethanol Refinery to Efficiently Accept Variou High-Impact Cellulosic Feedstocks. (Pilot)	Logos/Edeniq (Gene)	<i>Dan Derr</i>

D&D Agenda Overview

Tuesday: 9 of 21 Projects

DAY 2 – Tuesday, May 21th							
8:30 AM	9:15 AM	45		Opening Plenary Session - Cellulosic Ethanol Cost Target	BETO and/or Lab	<i>TBD</i>	
9:15 AM	9:25 AM	10		Topical Introduction/Day Overview	DOE Staff	<i>TBD</i>	
9:25 AM	10:10 AM	45	5.7.4.1	Green Gasoline from Wood using Carbona Gasification and Topsoe TIGAS Processes (Pilot)	Haldor Topsoe Inc. (Paul)	<i>Niels R. Udengaard</i>	
<i>10:10 AM</i>	<i>10:25 AM</i>	<i>15</i>		<i>Break</i>	<i>All</i>		
10:25 AM	11:10 AM	45	5.5.9.1	ClearFuels-Rentech Integrated Biorefinery Pilot Project for Diesel and Jet Fuel Production by Thermochemical Conversion of Woodwaste (CF-RTK IBR)	ClearFuels Rentech (Paul)	<i>Josh Pearson</i>	
11:10 AM	11:55 AM	45	5.5.7.1	MAS10BIO5 (Comm)	Mascoma (Gene)	<i>Michael Ladish</i>	
<i>11:55 AM</i>	<i>1:00 PM</i>	<i>65</i>		<i>Lunch</i>	<i>All (Reviewer lunch together, public</i>		
1:00 PM	1:45 PM	45	5.5.11.1	High-Yield Hybrid Cellulosic Ethanol Process Using High-Impact Feedstock for Commercialization by 2013 (Pilot)	ZeaChem Inc. (Paul)	<i>Tim Eggeman</i>	
1:45 PM	2:30 PM	45	5.6.2.1	Demonstration of an Integrated Biorefinery at Old Town, Maine	RSA (Glenn)	<i>Jim St. Pierre</i>	
2:30 PM	3:15 PM	45	5.2.4.1	INP BioEnergy Indian River County Facility, Phase I (Demo)	INEOS (Glenn)	<i>Dan Cummings</i>	
<i>3:15 PM</i>	<i>3:30 PM</i>	<i>15</i>		<i>Break</i>	<i>All</i>		
3:30 PM	4:15 PM	45	5.5.10.1	Heterogeneous Biorefinery Project (Demo)	Enerkem (Glenn)	<i>Tim Cesarek</i>	
4:15 PM	5:00 PM	45	5.7.3.1	Demonstration of a Pilot Integrated Biorefinery for the Economical Conversion of Biomass to Diesel Fuel	REII (Liz)	<i>Greg Tamblyn</i>	
5:00 PM	5:45 PM	45	5.4.10.1	Pilot Scale Biorefinery: Sustainable Transport Fuels from Biomass and Algal Residue via Integrated Pyrolysis and Catalytic Hydroconversion (Pilot)	UOP LLC (Liz)	<i>Stephen Lupton</i>	

D&D Agenda Overview

Wednesday: 7 of 21 Projects

DAY 3 – Wednesday, May 22th						
8:30 AM	9:15 AM	45		Opening Plenary Session - Pathways Analysis	BETO and/or Lab	<i>TBD</i>
9:15 AM	9:25 AM	10		Topical Introduction/Day Overview	DOE Staff	<i>TBD</i>
9:25 AM	10:10 AM	45	5.4.4.1	Integrated Biorefinery for Conversion of Biomass to Ethanol, Synthesis Gas, and Heat (Comm)	Abengoa (Neil)	<i>Thomas Elgin</i>
<i>10:10 AM</i>	<i>10:25 AM</i>	<i>15</i>		<i>Break</i>	<i>All</i>	
10:25 AM	11:10 AM	45	5.1.4.1	Scale-up and Mobilization of Renewable Diesel and Chemical Production from Common Intermediate using US-based Fermentable Sugar Feedstocks (Pilot)	Amyris Biotechnologies Inc. (Bryna)	<i>Joel Cherry</i>
11:10 AM	11:55 AM	45	5.4.3.3	LIBERTY - Launch of an Integrated Bio-refinery with Eco-sustainable and Renewable Technologies (Comm)	POET (Bryna)	<i>Larry Ward</i>
<i>11:55 AM</i>	<i>1:00 PM</i>	<i>65</i>		<i>Lunch</i>	<i>All (Reviewer lunch together, public)</i>	
1:00 PM	1:45 PM	45	5.11.1.2	Integrated Pilot-Scale Biorefinery for Producing Ethanol from Hybrid Algae (Pilot)	Algenol Biofuels Inc (Christy)	<i>Ed Legere</i>
1:45 PM	2:30 PM	45	5.11.1.1	Sapphire Integrated Algal Biofinery (IABR) (Demo)	Sapphire Energy Inc. (Christy)	<i>Jaimie Moreno</i>
2:30 PM	2:45 PM	15		<i>Break</i>	<i>All</i>	
2:45 PM	3:30 PM	45	5.11.3.1	Solazyme Integrated Biorefinery (SzIBR): Diesel Fuels from Heterotrophic Algae (Pilot)	Solazyme Inc. (Christy)	<i>Sarah McQuaid</i>
3:30 PM	4:15 PM	45	5.7.1.1	Alpena Prototype Biorefinery (Pilot)	American Process	Kim Nelson

Thank you! Any Questions?



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