



Presentation to the Biomass
Research and Development
Technical Advisory Committee

Brian Duff
June 5, 2013

The Role of the Demonstration and Deployment Subprogram in Biomass Conversion Technology Deployment

U.S. Department of Energy

Energy Efficiency and Renewable Energy

Bioenergy Technologies Office (BETO)

Presentation to the BRD TAC: Agenda

- Introduction to the Demonstration & Deployment (D&D) Subprogram
- Overview of the D&D Technology Portfolio of Projects
- Project Management in D&D
- The Role of D&D in Biofuels Commercialization
- D&D Budget and Portfolio Analysis
- Description and Current Status of the Active Integrated Biorefinery Projects (IBRs)
- Q&A

Program Mission

“The mission of the Bioenergy Technologies Office (BETO: formerly the Biomass Program) is to partner with U.S. industry to foster research and development on advanced technologies that will transform our abundant biomass resources into clean, affordable, and domestically-produced biofuels, biopower and high-value products. The result will be improved economic development, expanded energy supply options, and increased energy security”

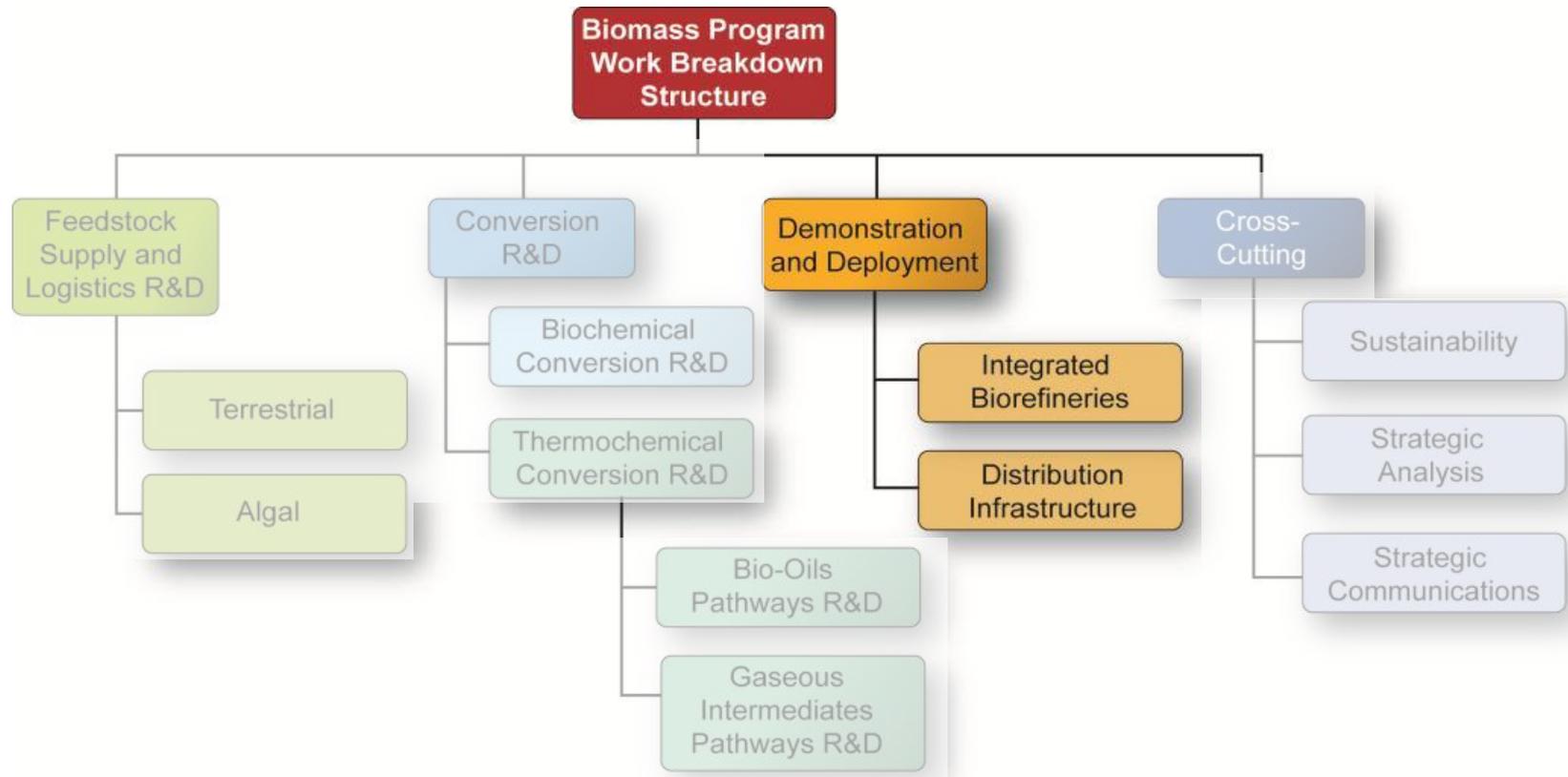
Program Objectives

Primary Objectives Addressed

- Foster development of U.S. bioindustry
- Decrease U.S. dependence on imported oil
- Strengthen rural economies
- Reduce air and water pollution
- Reduce greenhouse gas emissions (most important - CO₂)

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.

Overview of the D&D Technology Portfolio

BETO D&D Technology Portfolio (IBRs)

- 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:

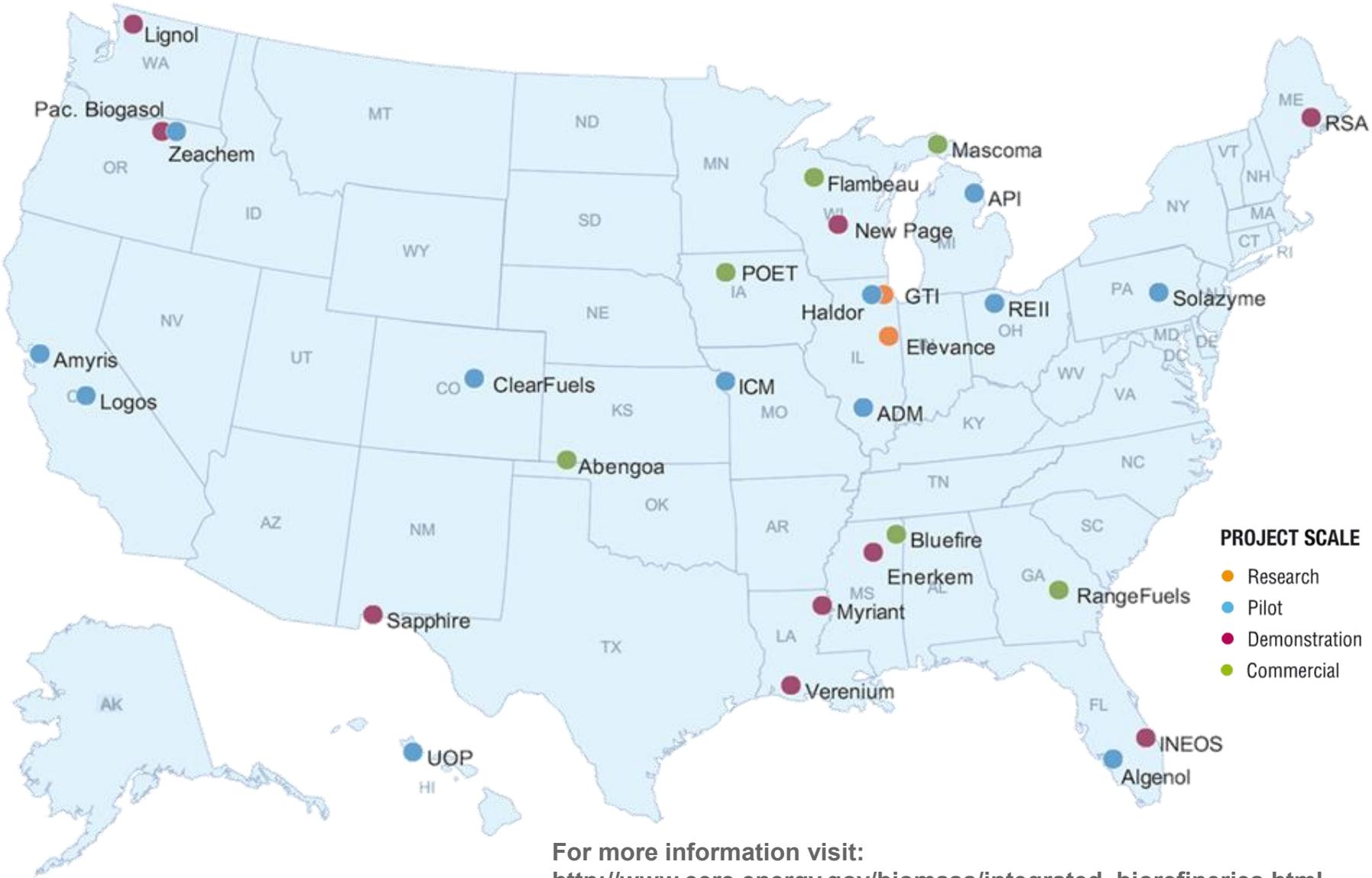
Agricultural Residues	Algae/CO2 Forest Resources	Municipal Solid Waste
Energy Crops		Non-edible oils

- 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

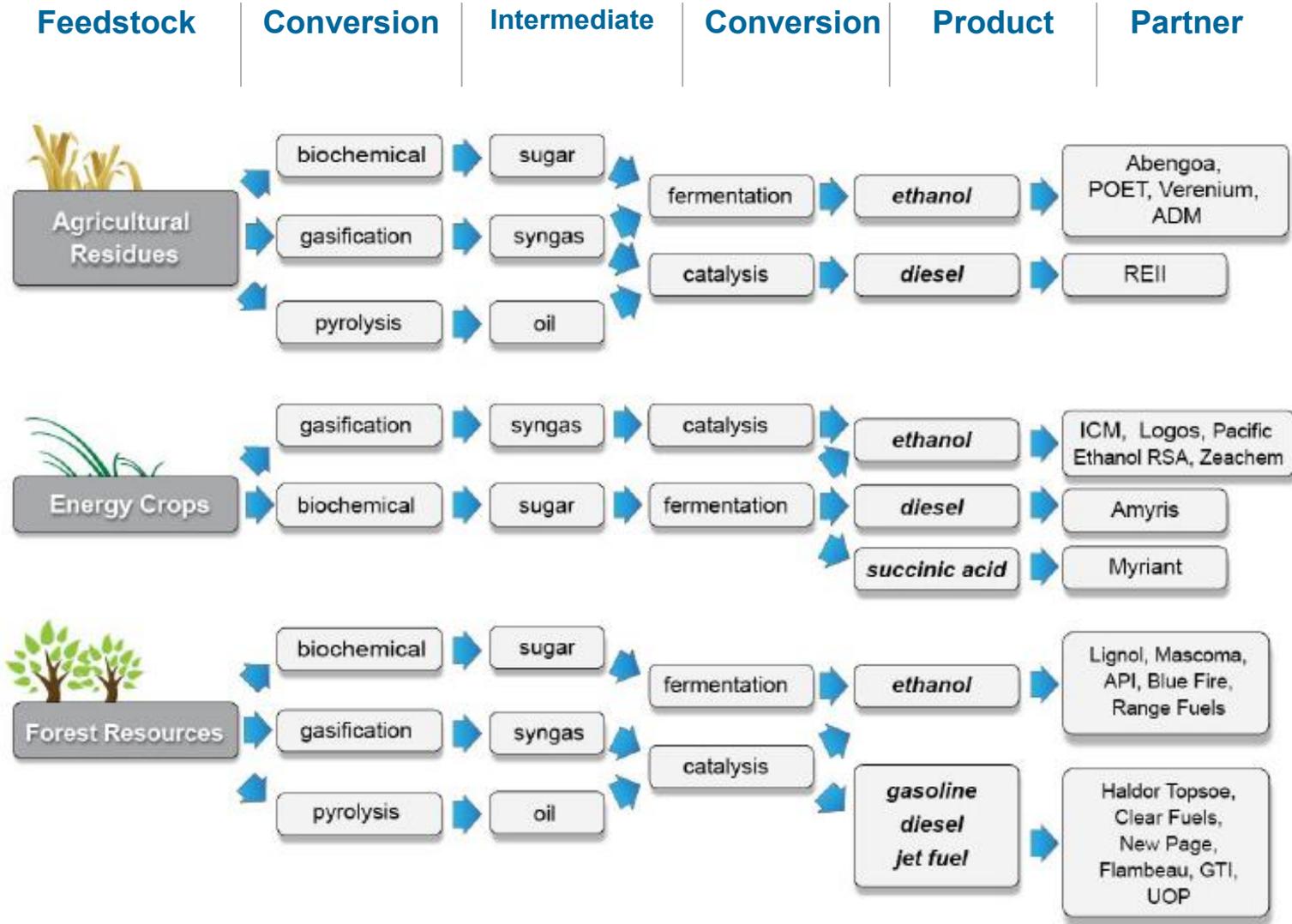


BETO IBR Project Portfolio – Geographic Diversity

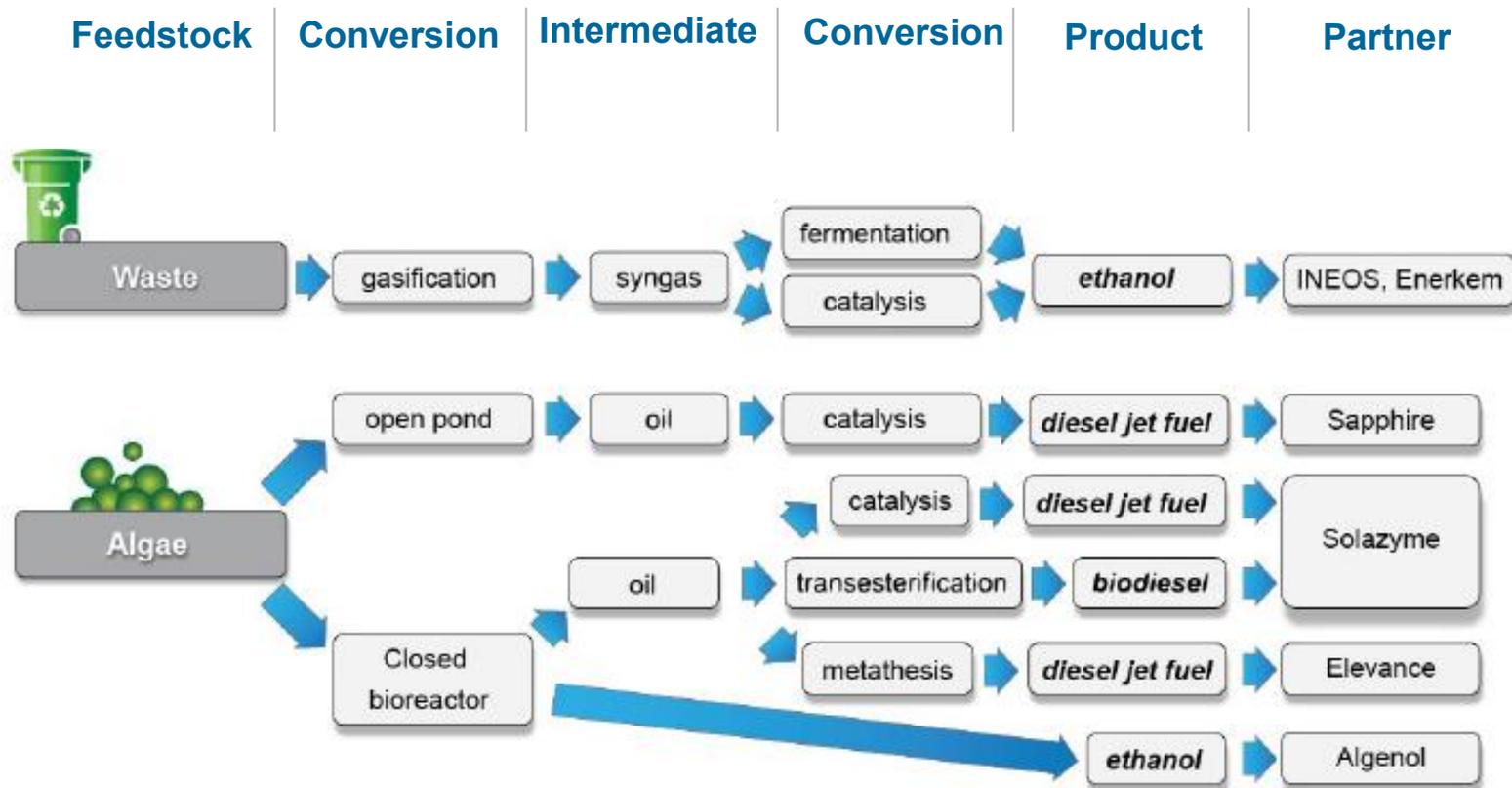


For more information visit:
http://www.eere.energy.gov/biomass/integrated_biorefineries.html

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

Current Status of D&D Portfolio

Of the 4 Commercial Scale Projects awarded in 2007:

- 2 plants under construction
- 1 project still trying to solidify financing
- 1 project mutually terminated

Of the 7 Demonstration Scale Projects awarded in 2008:

- 1 project complete
- 1 project still in FEED stage
- 1 project still trying to solidify financing
- 4 projects mutually terminated

Current Status of D&D Portfolio

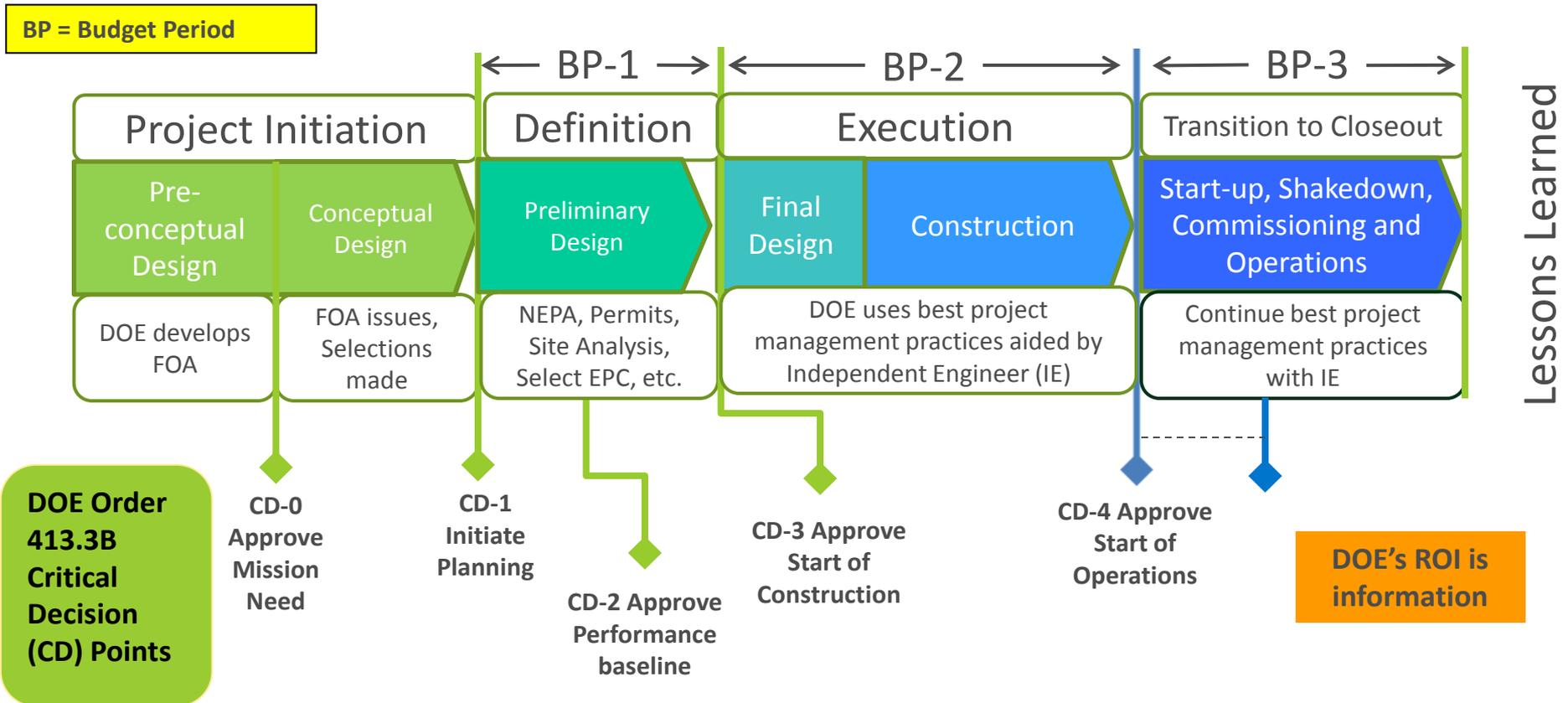
Of the 18 Projects awarded under ARRA in 2009:

- 1 demonstration-scale project is in the operations phase
- 2 demonstration scale projects have completed construction and are undergoing commissioning in anticipation of start of operations this summer
- 1 large demonstration-scale project is finalizing its FEED package and seeking additional financing
- 6 pilot projects are currently in the operations phase
- 4 pilot-projects are still in the construction phase
- 4 R&D projects have been completed (two are preparing their final reports)
- None have been terminated

Project Management in D&D

Project Management

Framework for Executing DOE Project Management for Integrated Biorefinery Projects



Elements of “Active Project Management”

- “Substantial involvement” by federal agency
- Project Management Plans
- Mandatory use of EVMS
- Mandatory Risk Mitigation Program with Risk Register
- Rigorous Critical Decision Criteria
- Weekly or Biweekly calls with DOE Project Officer and IE
- Monthly, Quarterly Reports
- Quarterly Project Management Reviews
- Annual Comprehensive Project Review
- Annual Process Operations and Technical Target reports
- Biannual Public Peer Review (Soon to be annual)

Annual Comprehensive Project Review (CPR)

- Annual review of IBR project – consisting of proprietary, confidential or otherwise restricted information
- Review Process:
 - Principal Investigator, Project Manager and other partners present to IE, DOE Review panel, and IPA analyst (when applicable)
 - Review template includes three key review area
 - Company Structure and Project Team
 - Technical Performance
 - Financial Health and Market Approval/Commercialization Plans
 - The review concludes with an open discussion between review panel and project team
 - A report is generated consolidating reviewers comments and delivered to project team

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

Active Project Management:

What Constitutes a Successful D&D Project?

- What does Success mean for a D&D Project?
 - Is it spending the award?
 - Is it completing the original scope as proposed?
 - Is it finishing on time?
 - Is it completing the original scope, within budget and on time?
- What if a project fails to achieve it's proposed scope, but in doing so finds a better or cheaper way to produce the biofuel?
- What if a project achieves it's original scope within the obligated budget but takes 2 years longer to do it?
- What if a project successfully validates it's design basis within its period of performance but it overruns its budget?

Active Project Management: What's the Criteria to be called a "Success"?

Nothing but Absolute Success?		
The 3 Elements of Project Management		
Cost	Scope	Schedule
yes	yes	yes
yes	yes	no
yes	no	yes
no	yes	yes
no	yes	no
yes	no	no
no	no	yes
no	no	no

Anything but Abject Failure?		
The 3 Elements of Project Management		
Cost	Scope	Schedule
yes	yes	yes
yes	yes	no
yes	no	yes
no	yes	yes
no	yes	no
yes	no	no
no	no	yes
no	no	no

Two Out of Three?		
The 3 Elements of Project Management		
Cost	Scope	Schedule
yes	yes	yes
yes	yes	no
yes	no	yes
no	yes	yes
no	yes	no
yes	no	no
no	no	yes
no	no	no

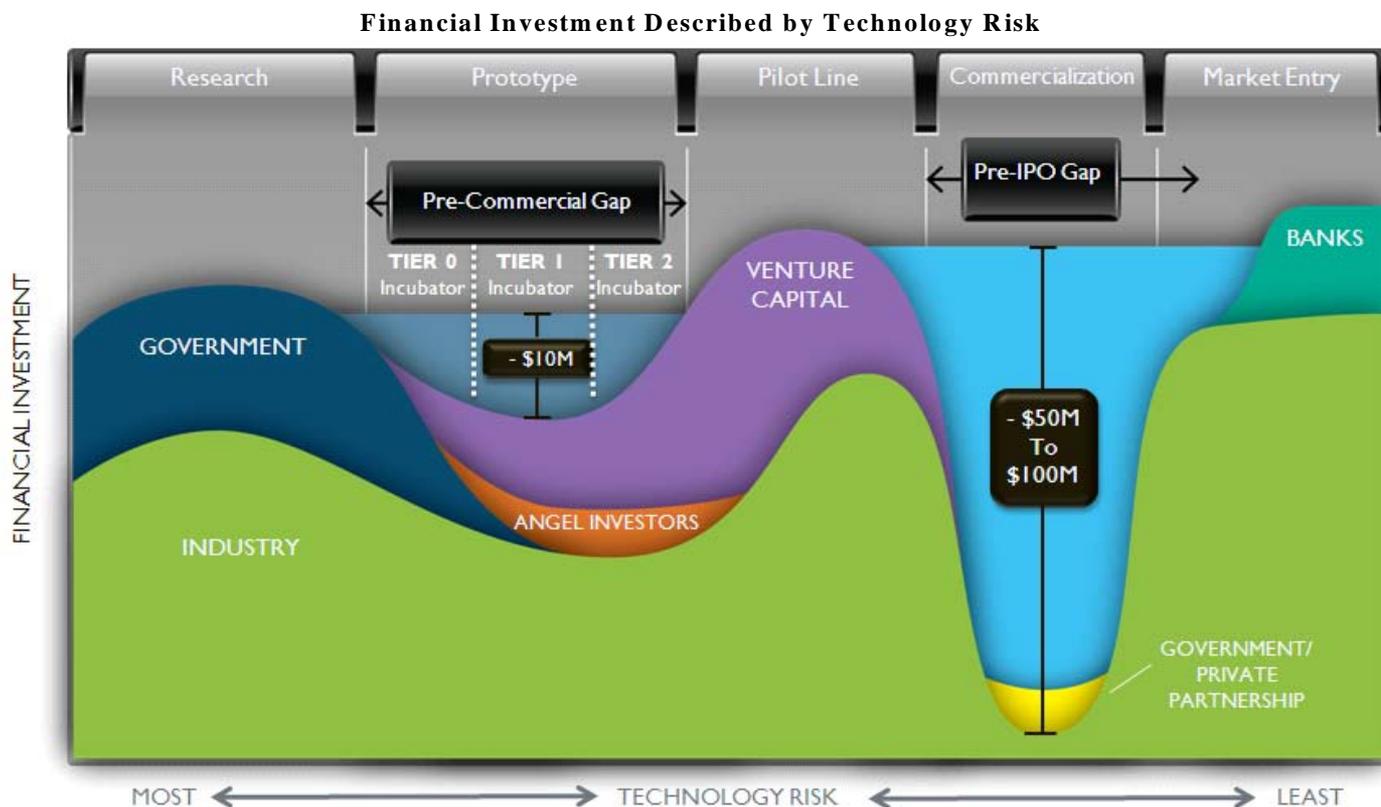
A Range from Total Success to Total Failure?		
The 3 Elements of Project Management		
Cost	Scope	Schedule
yes	yes	yes
yes	yes	no
yes	no	yes
no	yes	yes
no	yes	no
yes	no	no
no	no	yes
no	no	no

A rhetorical question, but something to think about when talking about federal financial assistance for emerging technologies.

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.**

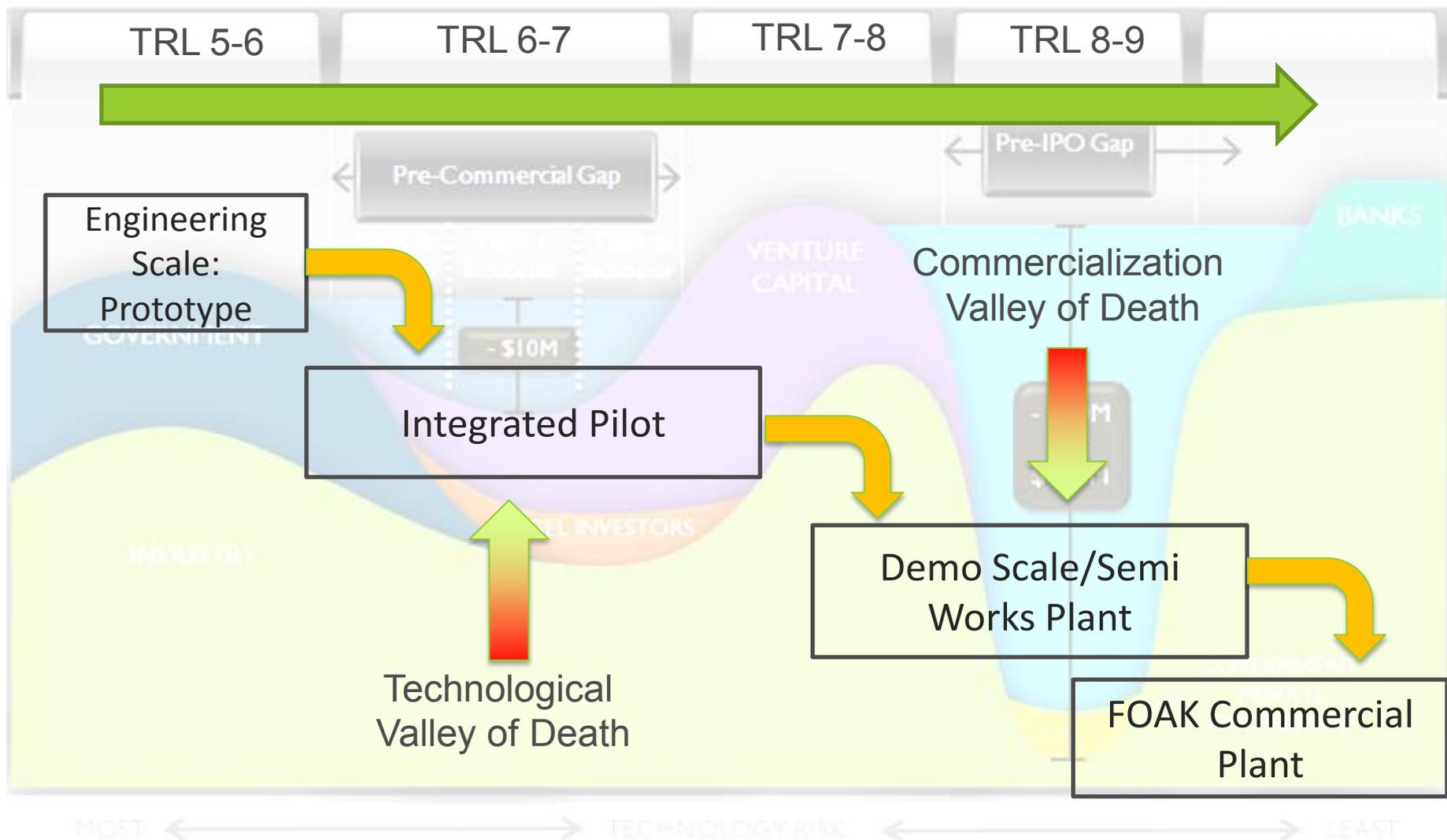
Even in good times, when lending standards are most flexible, banks and other financial institutions are simply not structurally positioned to back large-scale projects deploying new technology.

<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

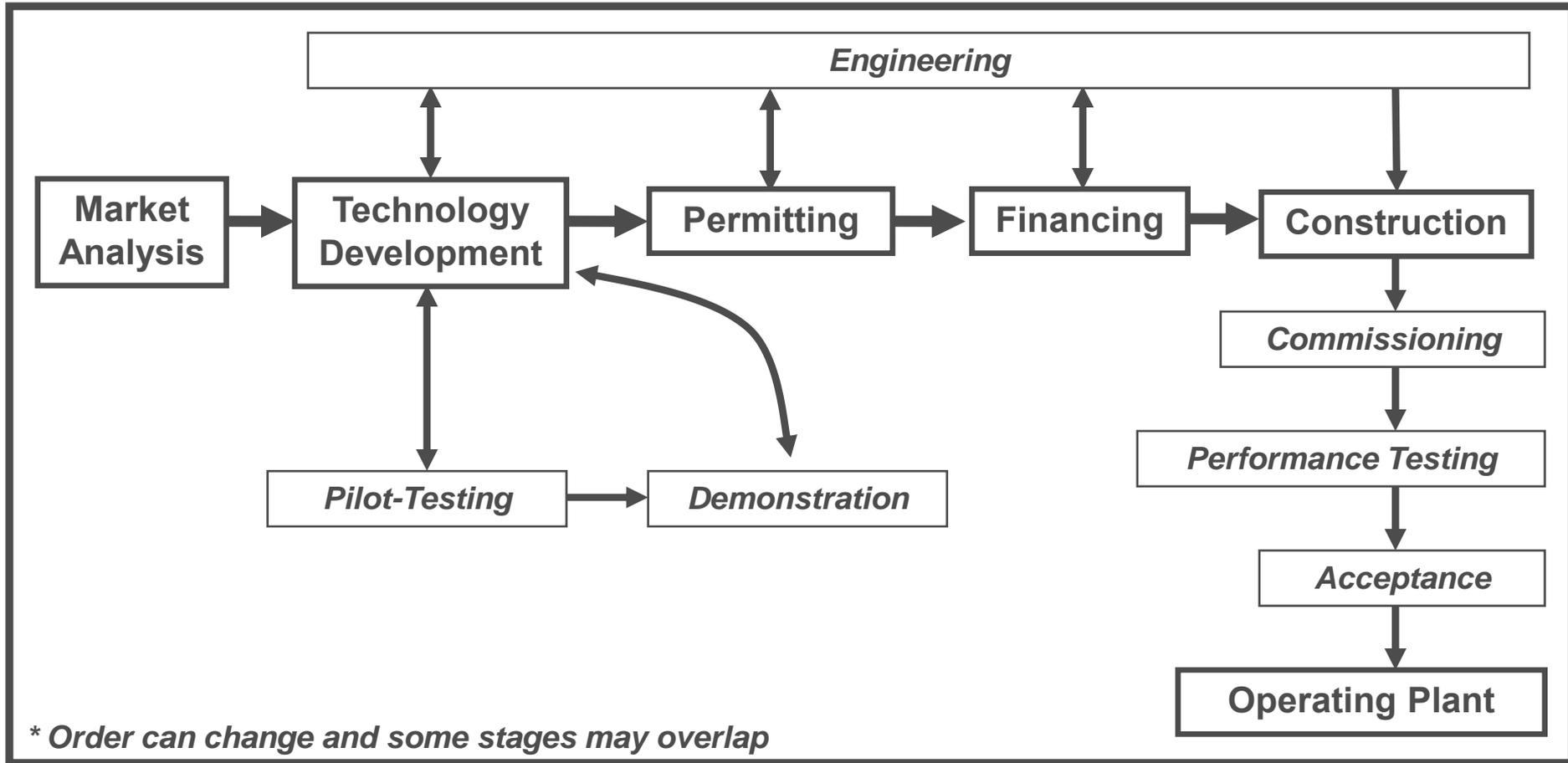
Demonstration-scale IBR projects focus on integrating all unit operations, including all recycle streams and heat integration strategies at the pre-commercial or “semi-works” scale to:

- 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.

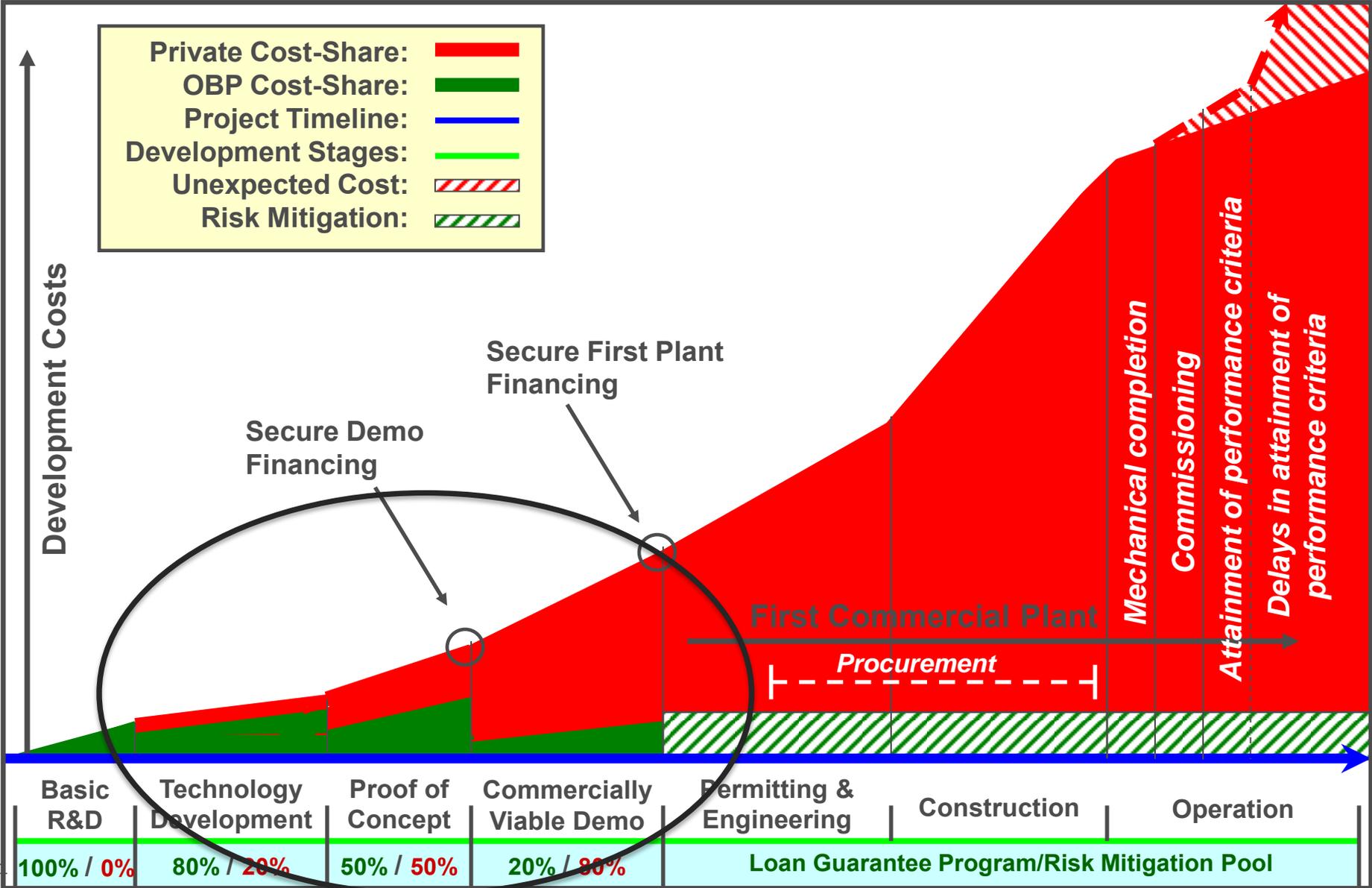
Commercial-scale IBR projects focus on demonstrating the biomass conversion process in a “pioneer” or “First-of-a-Kind” (FOAK) plant at the full commercial scale to:

- 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

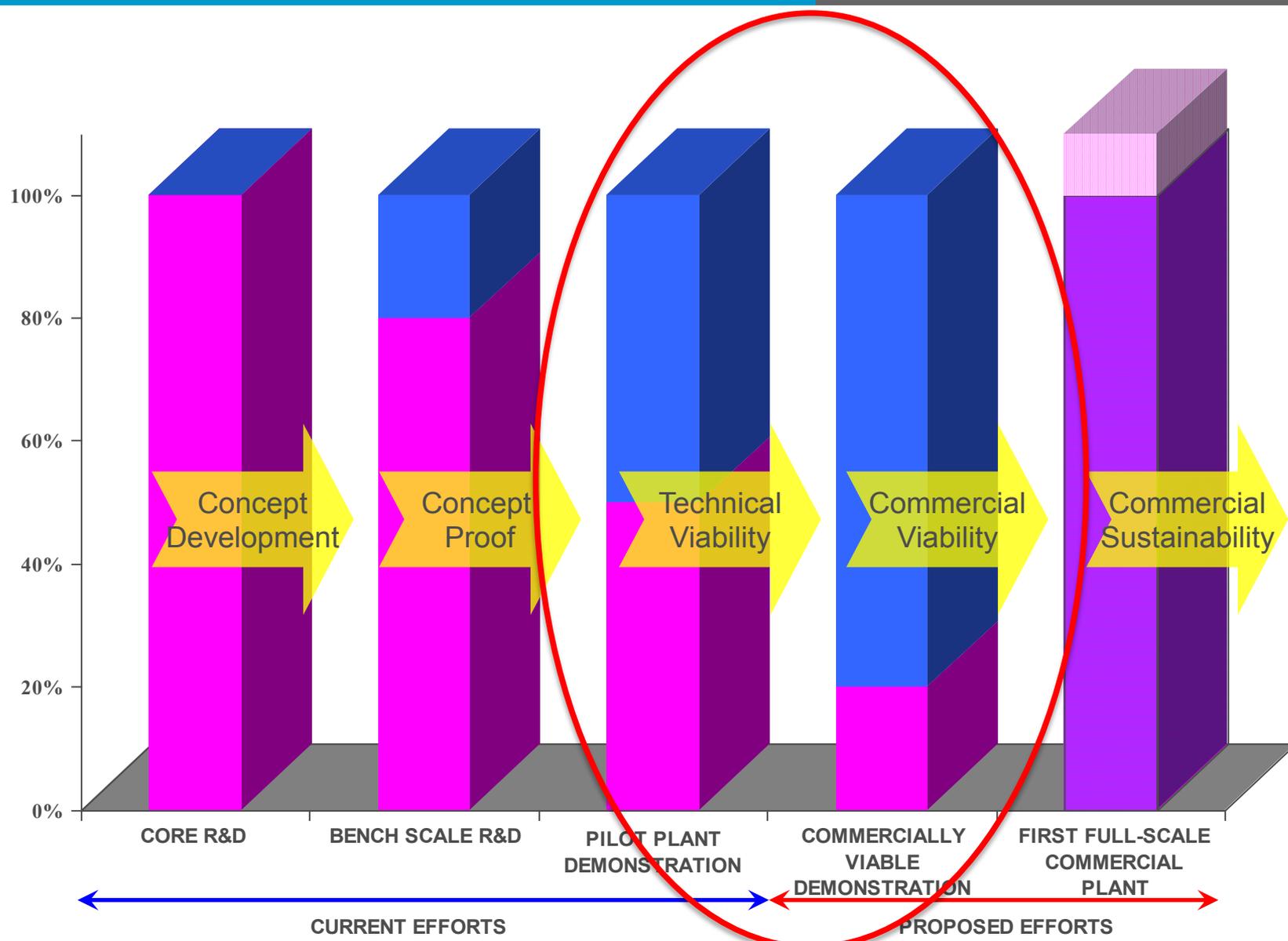
Deployment - Stages



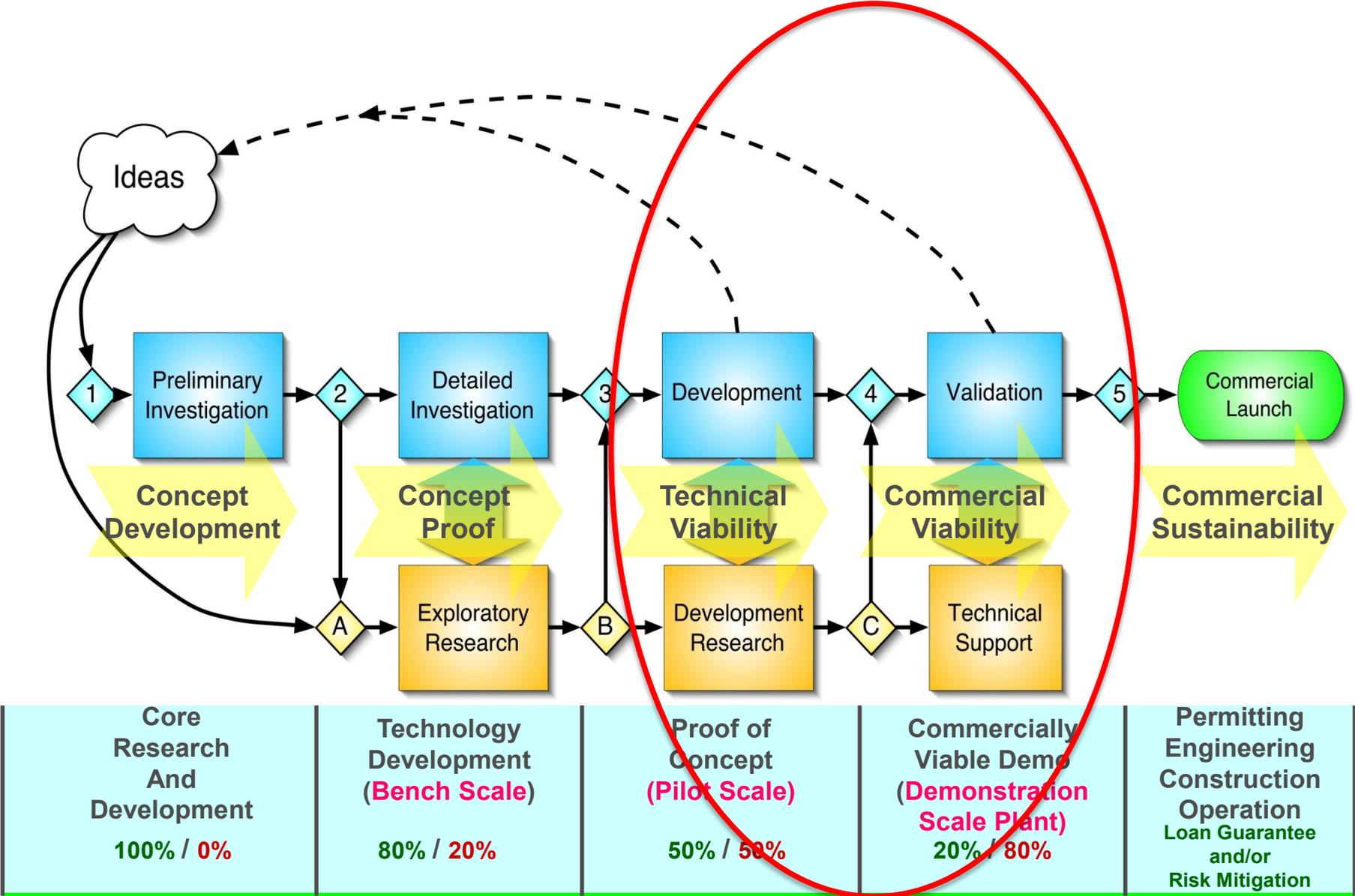
Deployment – Barriers



Deployment – Cost-Share



Deployment – Stage Gate



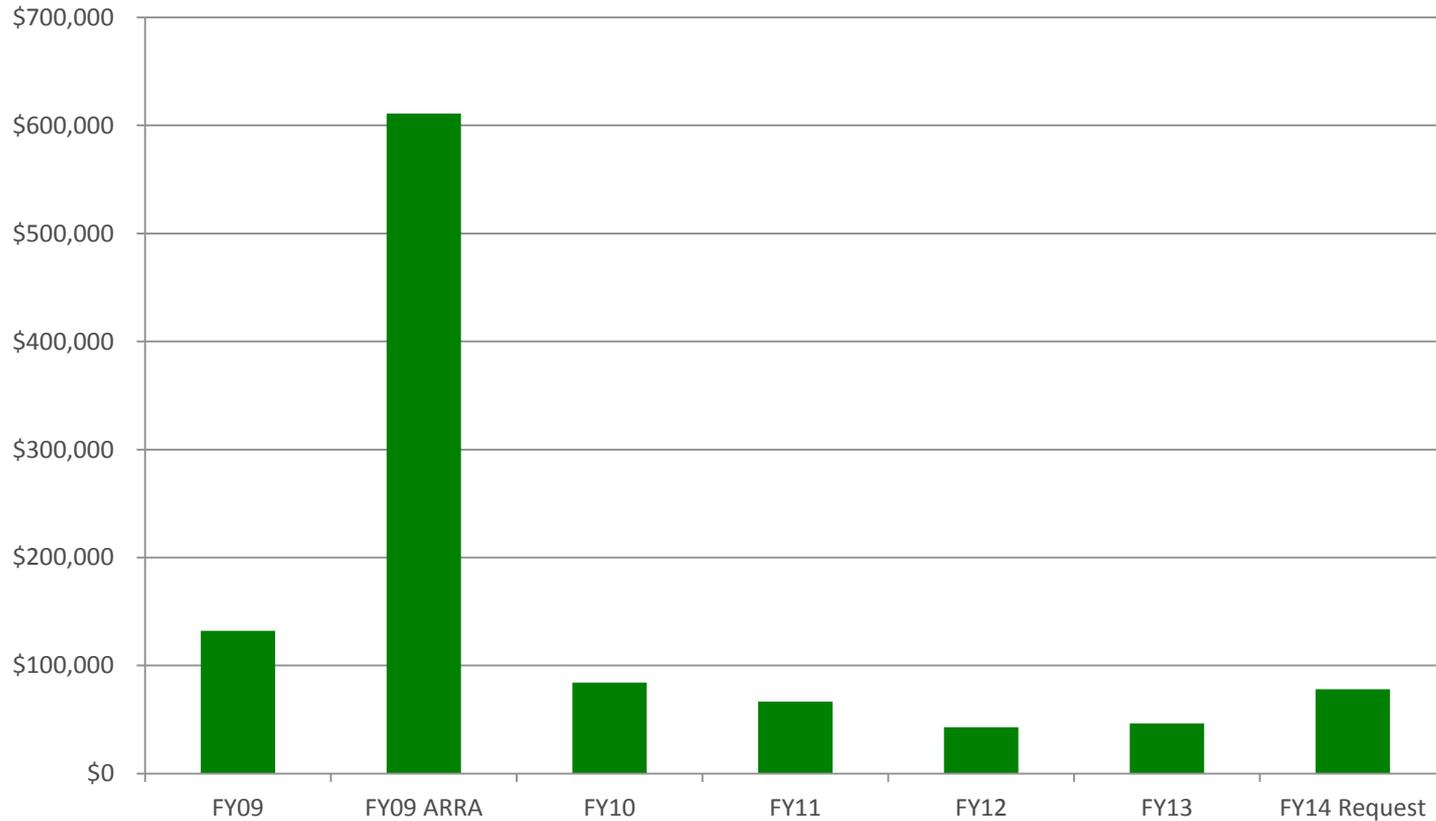
The Future of D&D in EERE

- D&D is Different than R&D
 - Scaleup
 - Construction
 - Part of Chemical Process Industry
 - Risk is even higher than VC sector
 - Not manufacturing widgets but validating process technologies
- We got going in reverse order
- Failures are to be expected
- D&D role is vital or industry will be slow or fail to emerge
- Now being more strategic
- Anticipate 2-3 year “cycles” of D&D to support “Pipeline” of R&D TRLs:
 - 6 Pilots
 - 2 Demos
 - 1 FOAK commercial

The D&D Budget and Portfolio Analysis

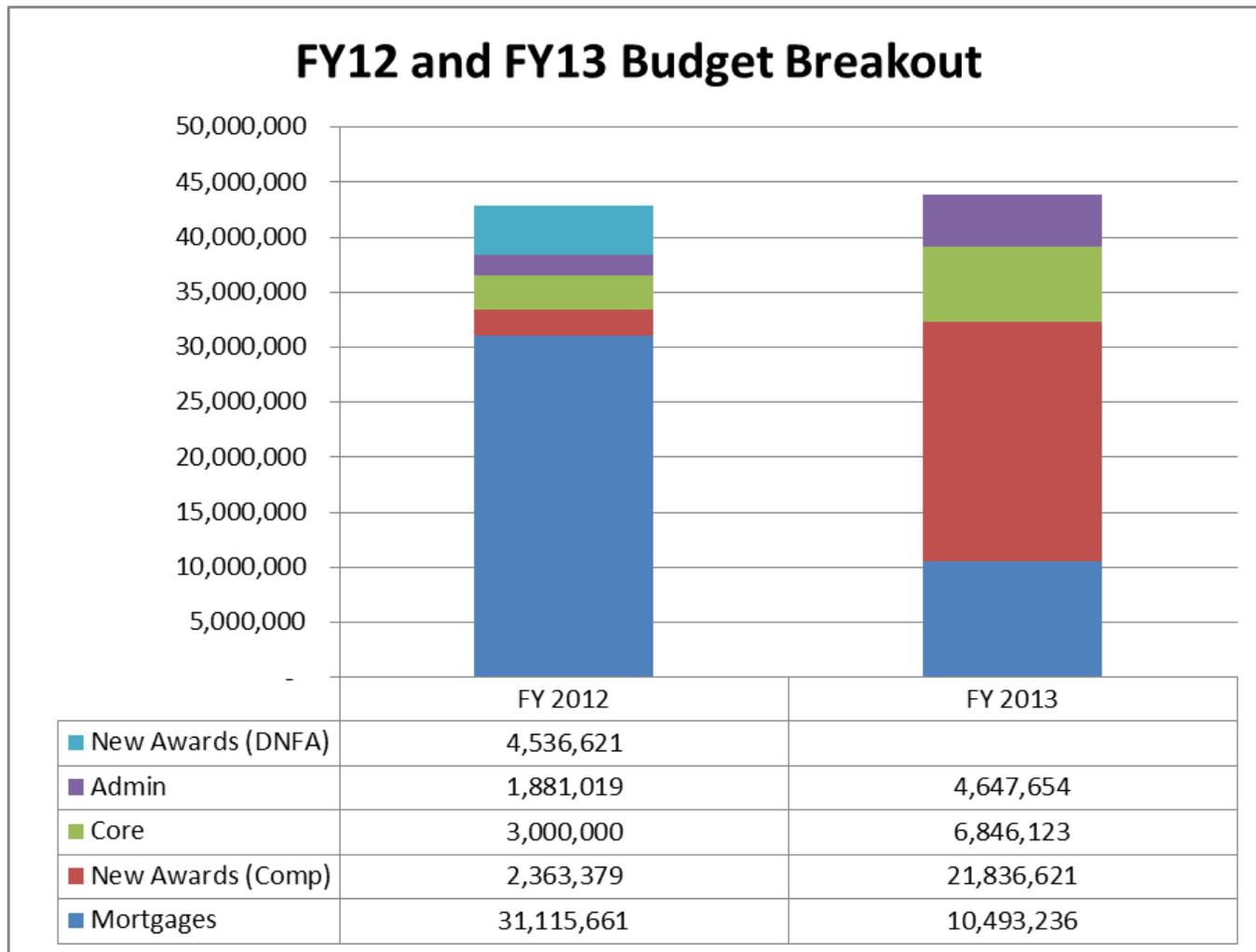
Demonstration & Deployment Budget

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

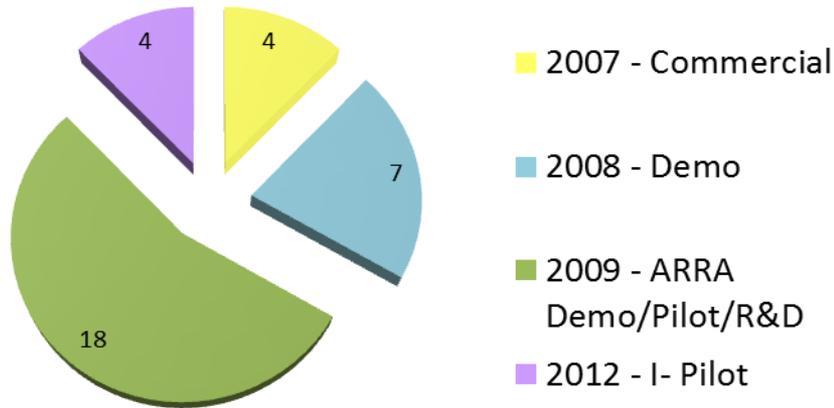
Demonstration & Deployment Budget



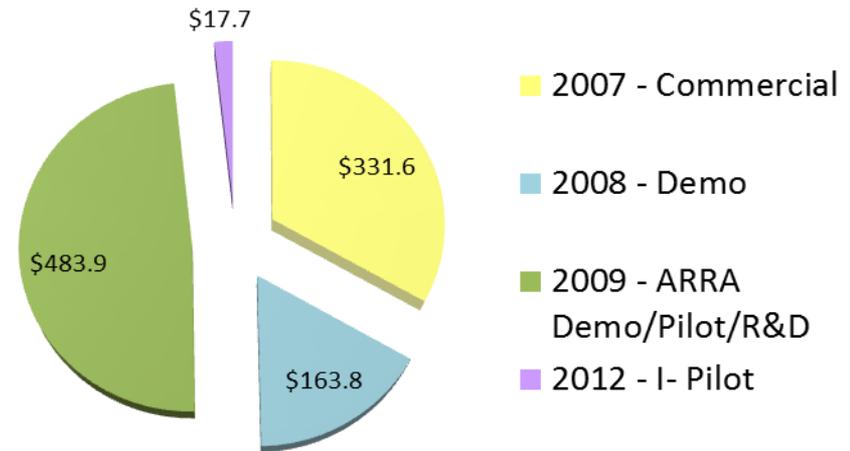
Demonstration & Deployment Budget Analysis

D&D Portfolio by Funding Year

Number of IBRs by Year/FOA



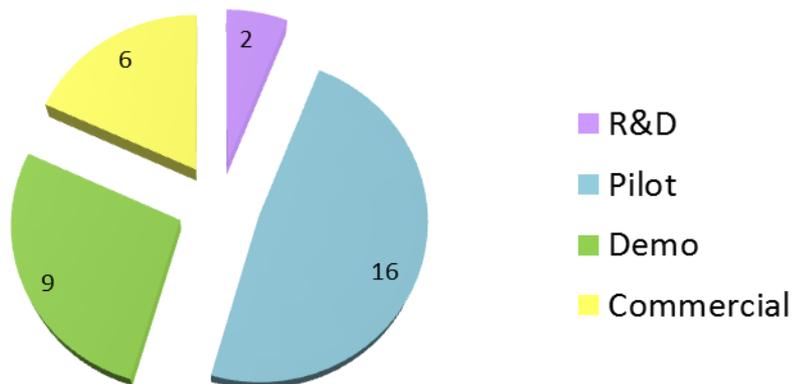
Investment in IBRs by Year/FOA



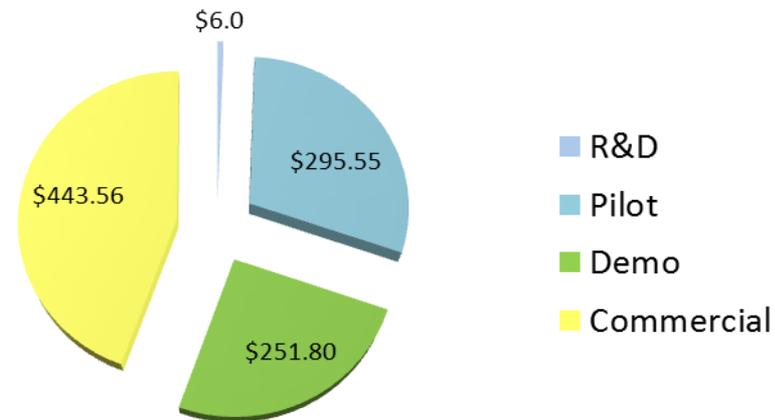
Demonstration & Deployment Budget Analysis

D&D Portfolio by Project Scale/TRL

Number of IBRs by Scale/TRL



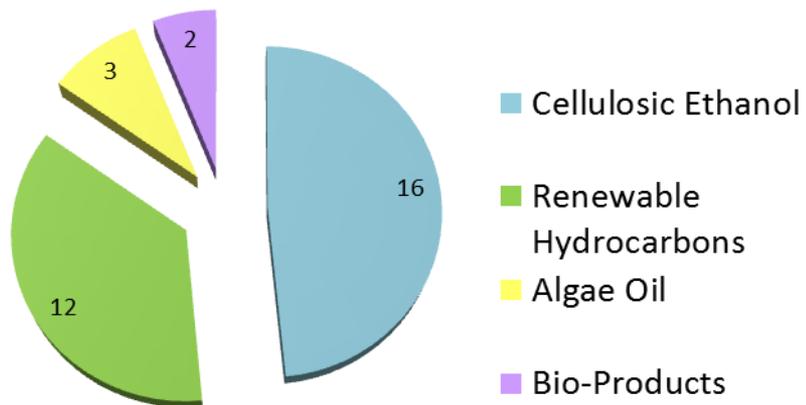
Investment in IBRs by Scale/TRL



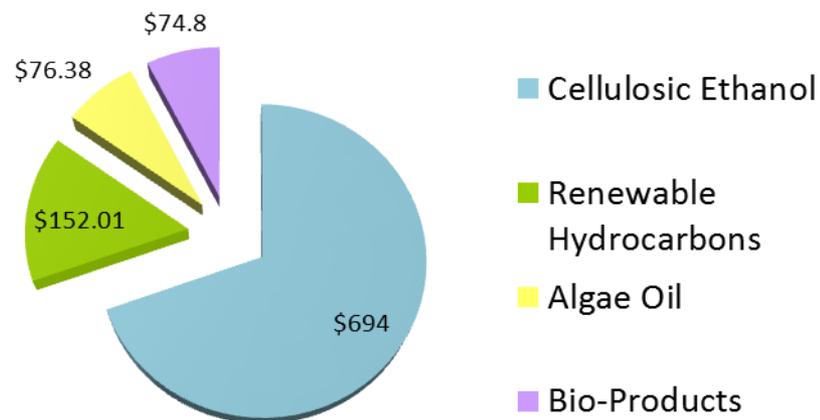
Demonstration & Deployment Budget Analysis

D&D Portfolio by Product

Number of IBRs by Product



Investment in IBRs by Product



Description and Status of Active IBRs

D&D Summary of IBR Projects

Project (State)	Fuel Type	Scale	2010	2011	2012	2013	2014	2015	2016	2017
1 Bluefire (MS)	Cellulosic Ethanol	commercial						18.9	18.9	18.9
2 Abengoa (KS)	Cellulosic Ethanol	commercial					25	25	25	25
3 Poet (IA)	Cellulosic Ethanol	commercial					25	25	25	25
4 Mascoma (MI)	Cellulosic Ethanol	commercial					20	20	20	20
5 Flambeau (WI)	FT diesel and waxes	commercial						7.7	7.7	7.7
6 RangeFuels (GA)	Mixed alcohol	commercial		2.5	2.5	2.5	2.5	2.5	2.5	2.5
7 RSA (ME)	Cellulosic Sugars	demonstration								
8 NewPage (WI)	FT diesel and waxes	demonstration				4.6	4.6	4.6	4.6	4.6
9 Pacific Biogasol (CA)	Cellulosic Ethanol	demonstration				2.7	2.7	2.7	2.7	2.7
10 Lignol (OR)	Cellulosic Ethanol	demonstration				1.8	1.8	1.8	1.8	1.8
11 Verenium (LA)	Cellulosic Ethanol	demonstration	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
12 INEOS (FL)	Cellulosic Ethanol	demonstration			8	8	8	8	8	8
13 Enerkem (MS)	Cellulosic Ethanol	demonstration						10	10	10
14 Sapphire (NM)	Jet fuel and diesel	demonstration			1	1	1	1	1	1
15 Solazymes (PA)	Biodiesel and renewable diesel	pilot				0.3	0.3	0.3	0.3	0.3
16 Alpena (MI)	Cellulosic Ethanol	pilot		0.76	0.76	0.76	0.76	0.76	0.76	0.76
17 ICM (MO)	Cellulosic Ethanol	pilot		0.26	0.26	0.26	0.26	0.26	0.26	0.26
18 Logos/EdenIQ (CA)	Cellulosic Ethanol	pilot			0.05	0.05	0.05	0.05	0.05	0.05
19 ADM (IL)	Cellulosic Ethanol	pilot			0.026	0.026	0.026	0.026	0.026	0.026
20 Zeachem (OR)	Cellulosic Ethanol	pilot			0.25	0.25	0.25	0.25	0.25	0.25
21 Algenol (FL)	Cellulosic Ethanol	pilot			0.1	0.1	0.1	0.1	0.1	0.1
22 REII (OH)	Diesel	pilot			0.625	0.625	0.625	0.625	0.625	0.625
23 Amyris (CA)	Diesel	pilot		0.001	0.001	0.001	0.001	0.001	0.001	0.001
24 UOP (HI)	Diesel, gas, jet fuel	pilot			0.06	0.06	0.06	0.06	0.06	0.06
25 Clearfuels (CO)	FT diesel and jet fuel	pilot		0.151	0.151	0.151	0.151	0.151	0.151	0.151
26 Haldor Topsoe (IL)	Green gasoline	pilot				0.345	0.345	0.345	0.345	0.345
	Cumulative Capacity in Million Gals / Year		1.4	5.072	12.68	15.828	85.828	114.728	114.728	114.728
27 Elevance	Metathesis Chemistry for Oil to fuels/products	R&D	Bench scale R&D work only							
28 Gas Tech. Institut	Pyrolysis Oils for fuels	R&D	Bench scale R&D work only							
29 Myriant	Succinic Acid	Pilot	Bioproduct not fuel							

Summary of EPO Act 2005 Section 932:

“Commercial-Scale” Biorefineries Selected in 2007

Performer	Location	DOE Award	Feedstock Type	Conversion Technology	Fuel / Capacity*
Bluefire	Fulton, MS	\$87.6M	Wood Wood Waste Sorted MSW	Biochemical- Concentrated Acid Hydrolysis	19M gals ethanol/yr
Poet	Emmetsburg, IA	\$100M	Corn Cob	Biochemical	25M gals ethanol/yr
Range Fuels	Soperton, GA	\$76.2M/ \$46M Spent	Wood Waste	Gasification + Mixed Alcohol synthesis	20M gals per yr mixed alcohols/ 2.0 mmgy installed
Abengoa	Hugoton, KS	\$100M	Agricultural Residues	Biochemical	15M gals ethanol/yr & 75 MW power

*Fuel capacities are based on performers estimates.

Summary of Demonstration-Scale Biorefineries Selected in FY2008

Performers	Location	DOE Award*	Feedstock Type	Conversion Technology	Fuel / Amount
Alltech Envirofine	Washington County, KY	\$30M	Corn Cobs	Biochemical-Solid State Fermentation	1M gals ethanol/yr
Lignol Innovations	TBD	\$30M	Woody Biomass	Biochemical-Organisolv	2.5M gals ethanol/yr
Mascoma	Upper Peninsula, MI	\$32M	Woody Biomass	Biochemical	5M gals ethanol/yr
NewPage	Wisconsin Rapids, WI	Up to \$50M	Woody Biomass	Thermochemical-Fischer-Tropsch	5.5M gals FT Liquids/yr
Pacific Ethanol	Boardman, OR	\$30M	Wheat Straw, Stover, Poplar Residuals	Biochemical-Biogasol	2.7M gals ethanol/yr
RSA	Old Town, ME	\$33.9M	Hemicellulose from Wood	Biochemical-Pentose Extraction	2.2M gals of Ethanol or Butanol
Verenium Biofuels Corp.	Jennings, LA	\$14.9M	Energy Cane and Sugar Cane Bagasse	Biochemical Process	1.5M gals ethanol/yr
Flambeau River Biofuels LLC	Park Falls, WI	up to \$80M	Forest Residues and Wood Waste	Thermochem to Fischer-Tropsch	9M gals FT Liquids/yr and 50M lbs of FT wax

Summary of ARRA Biorefineries Selected in FY2009

Performer	Feedstock	Technology	1° Product	Scale (gal/yr)	Class
Algenol	Algae	Closed Ponds	Ethanol	100,000	Pilot
Solazyme	Sugar/Hydrolysates	Heterotrophic Algae	Oil	300,000	Pilot
American Process Inc.	Hardwood Hydrolysate	Biochemical	Ethanol	894,000	Pilot
Renewable Energy Inst. Inc.	Rice Hulls & Forest Residues	TC Gasification	RE Diesel	625,000	Pilot
Haldor Topsoe	Wood Waste	TC Gasification	RE Gasoline	345,000	Pilot
ADM	Corn Stover	Biochemical	Ethanol	25,800	Pilot
ICM	Corn Fiber, Switchgrass, Energy Sorghum	Biochemical	Ethanol	345,000	Pilot
Clear Fuels/Rentech	Wood Waste, Bagasse	TC Gasification	RE Diesel, RE Jet	151,000	Pilot
Zechem	Hybrid Poplar, Stover, Cobs	BC/TC Hybrid	Ethanol	250,000	Pilot
Amyris	Sweet Sorghum	Biochemical	RE Diesel	1,370	Pilot
Logos	Corn Stover, Switchgrass, Wood Waste	Biochemical	Ethanol	50,000	Pilot
UOP	Forest Residues, Corn Stover, Bagasse, Switchgrass, Algae	TC-Pyrolysis	RE Gasoline, RE Diesel	60,000	Pilot
Sapphire	Algae	Open ponds	Oil	1,000,000	Demo
Enerkem	MSW, Forest Residues	TC Gasification	Ethanol	10,000,000	Demo
Ineos	MSW	Hybrid/TC Ferm	Ethanol	8,000,000	Demo
Myriant	Sorghum	Biochemical	Succinic Acid	30,000,000 lbs/yr	Demo
Elevance	Algae oil, Plant oil, Animal oil	Chemical-Metathesis	RE Diesel, RE Jet	NA	R&D only
Gas Technology Institute	Wood Waste, Corn Stover, Algae	TC-Pyrolysis	RE Gasoline, RE Diesel	NA	R&D only

*Award amounts still under negotiation.

ABENGOA



ABENGOA



LOGOS/EDENIQ



LOGOS/EDENIQ



Thank you! Any Questions?



Brian Duff

Program Manager, Demonstration & Deployment

DOE Office of the Biomass Program

303-619-1747

brian.duff@ee.doe.gov

<http://www1.eere.energy.gov/biomass/>

