

Integrated Biorefinery Progress

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Successive Generations of Biofuels



Current Demonstration and Piloting Focus



Corn Ethanol

- Commercially available (no DOE research ongoing)
- Reduced GHG emissions
- Capped by RFS



Cellulosic Ethanol

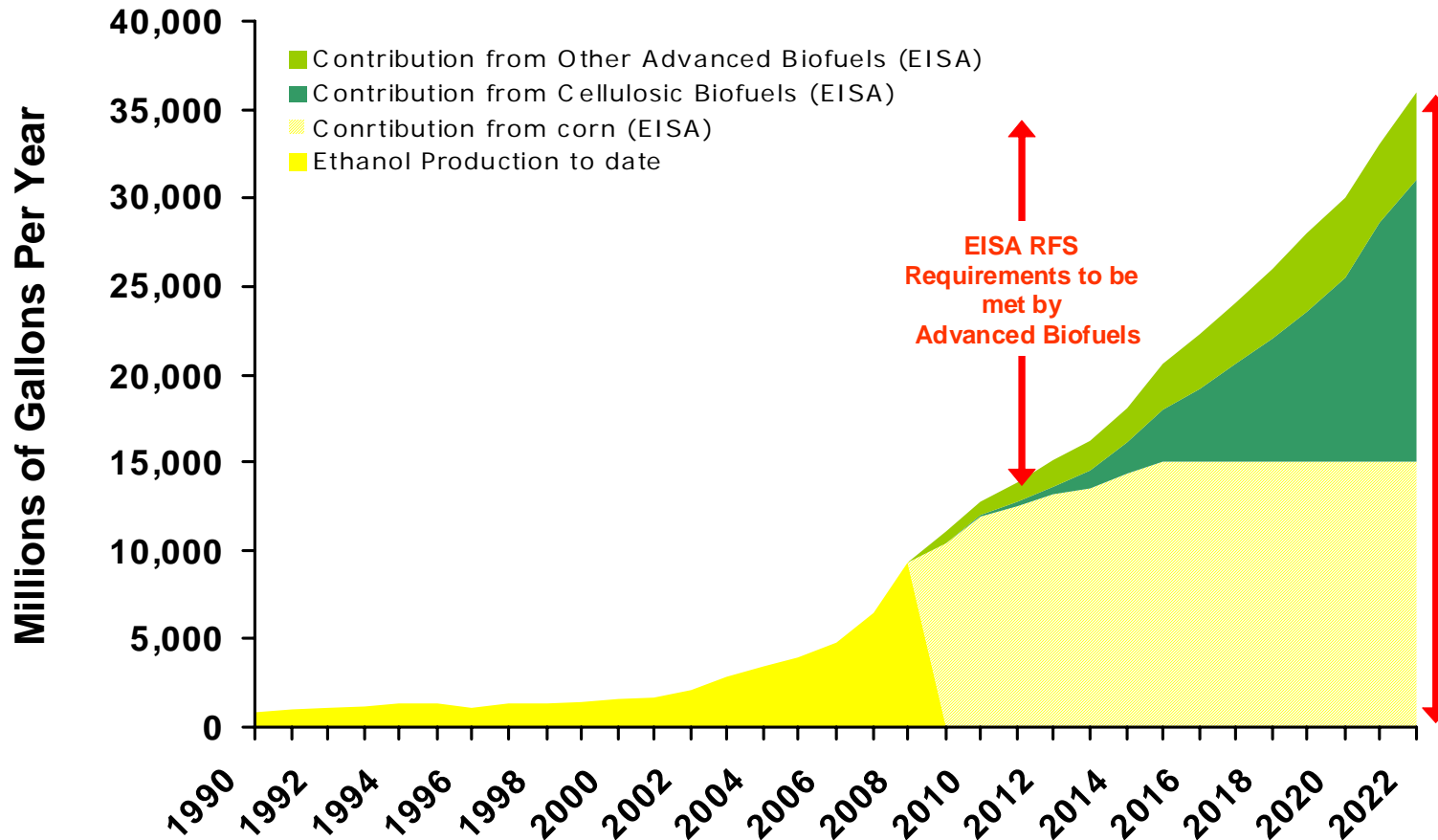
- Focus of current DOE research
- Potential to lower GHG emissions 86%
- Uses biomass from waste and non-agricultural land



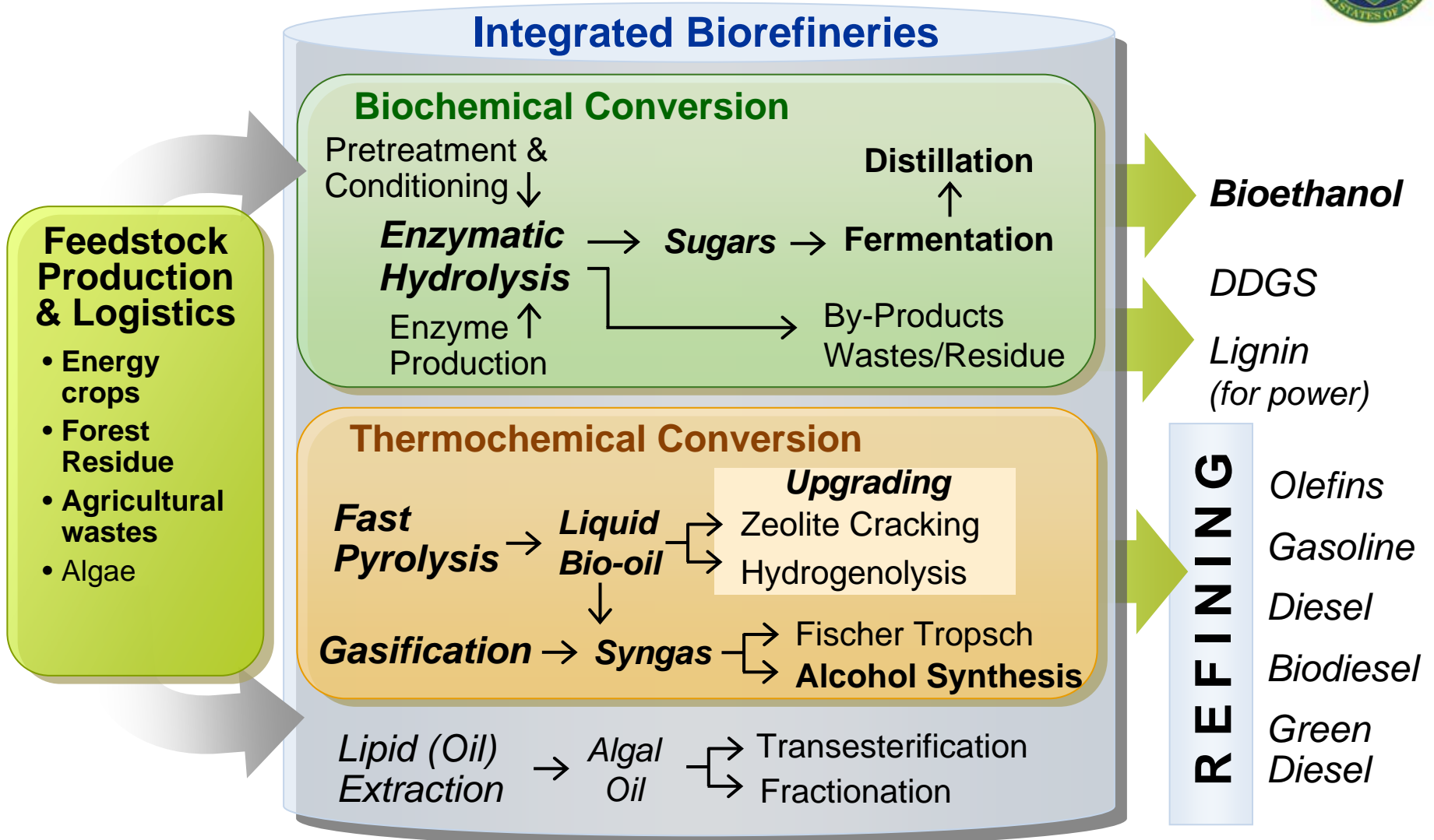
Advanced Biofuels

- DOE scoping studies in progress for algae; green oil
- Could minimize environmental footprint
- Energy content and fuel economy similar to petroleum-based fuels

EISA Renewable Fuels Standard



Exploring Routes to Convert Cellulosic Biomass



Research on biochemical and thermochemical conversion pathways is improving the efficiency and economics of biofuels production.

Major Biofuels Policy Milestones



2005:
EPACT

- Section 932: Cellulosic biorefinery R&D and Demonstrations
- Title 17: Loan Guarantees for GHG reduction energy technology

2007:
"20 in 10"

- Executive call to reduce U.S. gasoline use 20% by 2017 through:
 - 5% reduction in annual gasoline use from enhanced efficiency standards (CAFE)
 - 15% reduction from Alternative Fuels Standard (consistent with the current RFS)

2007:
EISA

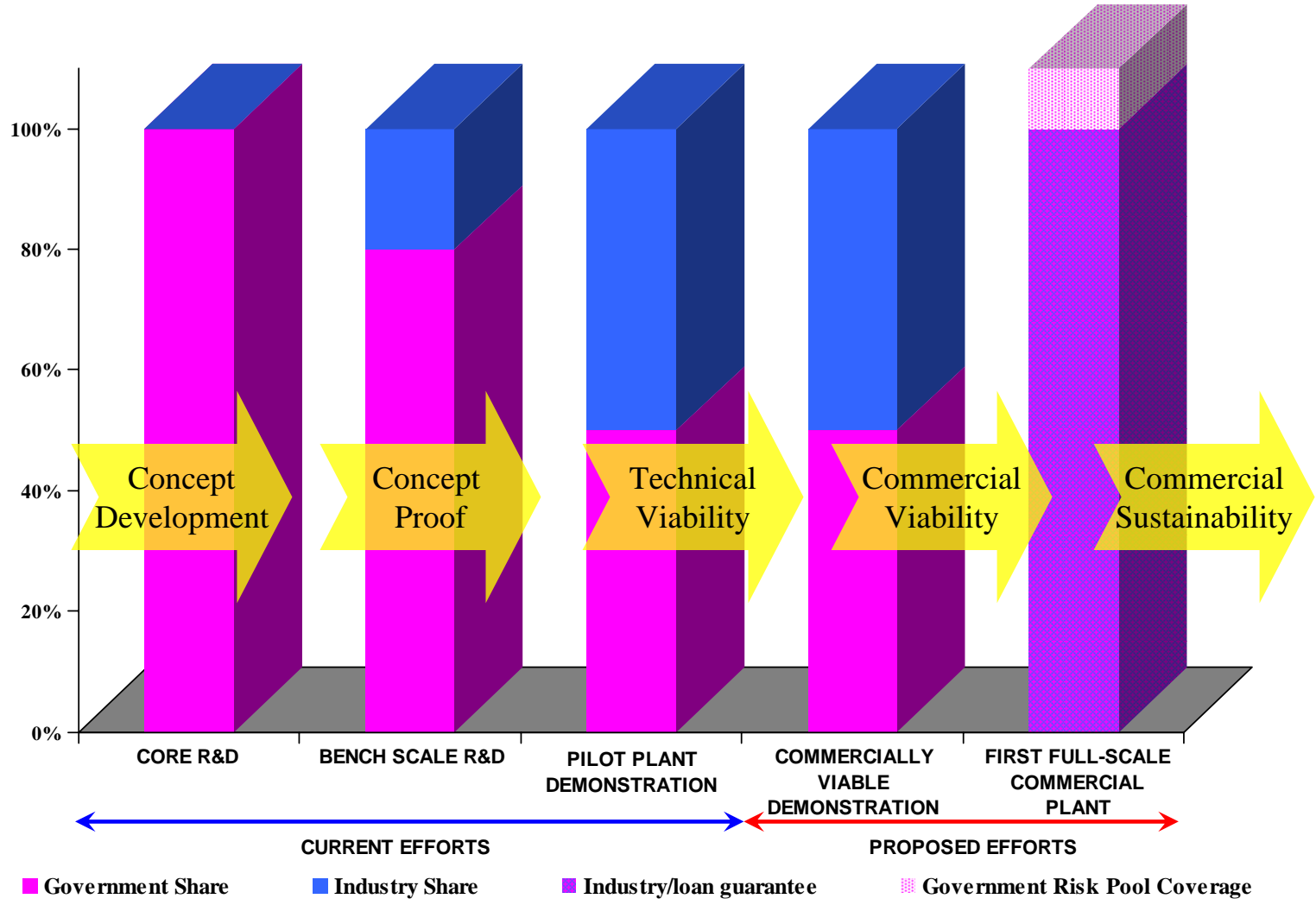
- Updated Renewable Fuels Standard. By 2022:
 - 36 billion gallons renewable fuel
 - 21 billion gallons advanced biofuels
- Required studies on ethanol blends and renewable fuels infrastructure

2008:
Farm Bill

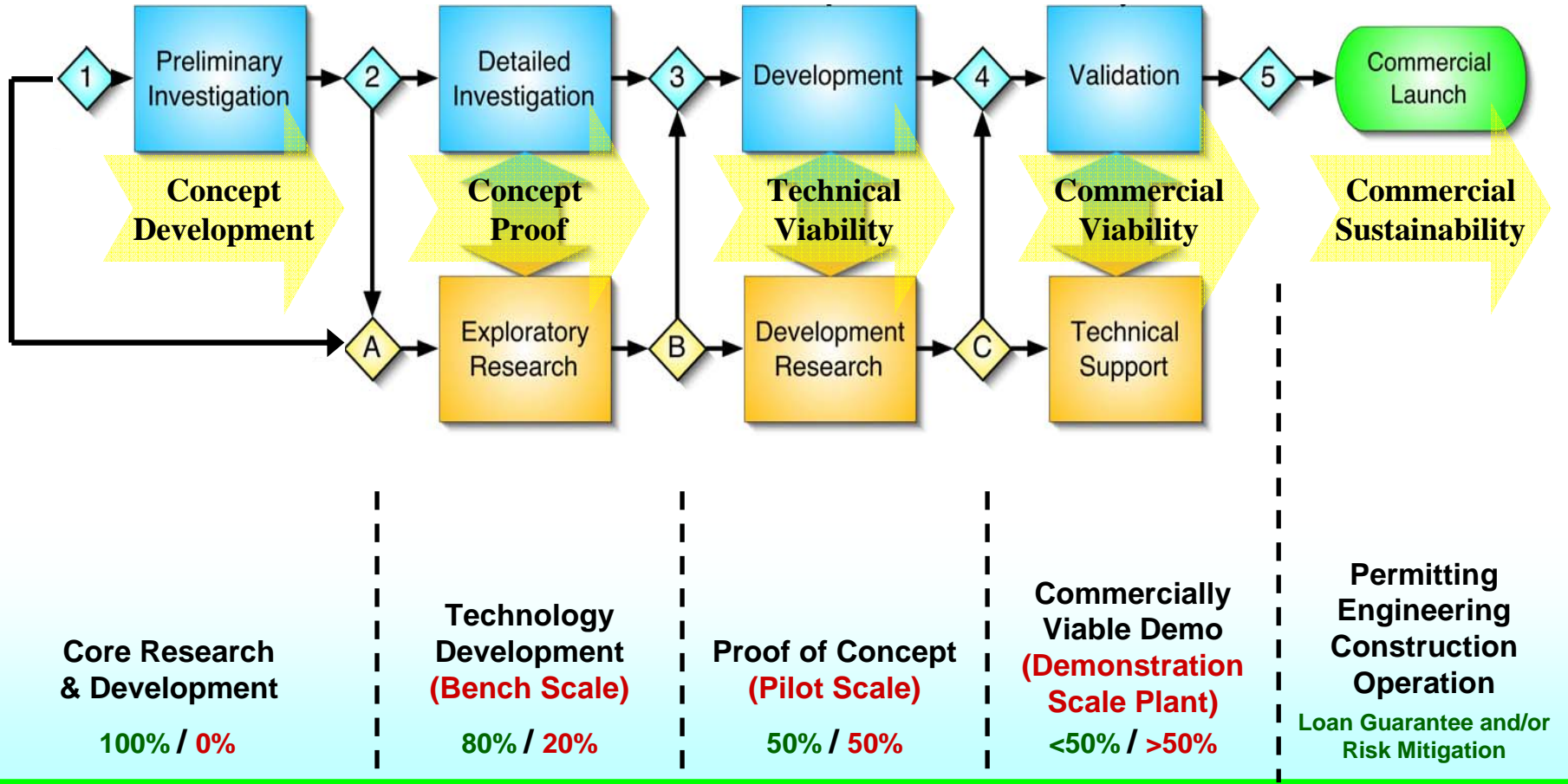
- Section 15321: \$1.01/gallon cellulosic ethanol tax credit
- Biodiesel tax credit
- USDA loan guarantees for commercial scale biorefineries
- Renews funding for the Biomass Research and Development Initiative

Current Deployment Funding Plan

Government Grants / Industry Cost-Share/ Loan Guarantees



Current Deployment Progression Plan



Biomass Program Deployment Highlights



The response to the executive and legislative mandates includes:

• Awarded \$385 million via competitive solicitations for six full scale Integrated Biorefineries. **(4 currently in development)**

• Awarded \$240 million via competitive solicitations for a total of nine small-scale biorefineries using range of feedstocks to test conversion technologies for the production of cellulosic biofuels **(8 currently in development)**

• Offering \$200 million via competitive solicitations for pilot and demonstration-scale biorefineries to produce biofuels

- including algal feedstocks and the production of advanced biofuels such as bio-butanol and green gasoline. **(FOA is on the Street)**

• **Stimulus Potential -unknown**

2005:
EPACT

2007:
"20 in 10"

2007:
EISA

2008:
Farm Bill

Solicitations: Leveraging Partnerships to Achieve Goals



Commercial-Scale Biorefineries (up to \$272 million)

- Four cost-shared, integrated biorefinery demonstration projects to produce 130 million gallons of cellulosic ethanol in 5 years using variety of conversion technologies and cellulosic feedstocks

10%-Scale Biorefinery Validation (up to \$210 million)

- Cost-shared, integrated biorefinery demonstrations using cellulosic feedstocks to produce renewable fuels; one-tenth of commercial scale
- Eight selectees announced for a total investment of \$210 million

Ethanologen Solicitation (up to \$23 million)

- Five selected research teams working on microorganisms

Enzyme Solicitation (up to \$33.8 million)

- Four selected research teams working on inexpensive enzyme systems for commercial biomass hydrolysis

Thermochemical Solicitation (up to \$16.7 million)

- Integration of gasification and catalyst development
- Pyrolysis oil stabilization

Joint DOE-USDA Solicitation (\$5.2 million of \$18 million funded by DOE)

- Biomass R&D Initiative: 20 awards announced March 2008

POTENTIAL FUTURE SOLICITATIONS

- **Integrated Pilot Scale Biorefinery**
- **Integrated Demonstration Scale Biorefinery**
- Annual USDA/DOE Joint Solicitation
- Feedstock Logistics Solicitation



EPACT Section 932 “Commercial-Scale” Biorefineries



DOE investments in cellulosic biofuels will accelerate commercialization and help create a biofuels market based on non-food feedstocks.

Performers	Feedstock Type	Conversion Technology	Location	Status
Bluefire	Sorted MSW	Biochemical- Concentrated Acid Hydrolysis	Mecca, CA	Lease and NEPA issues being resolved. Anticipate an Award 2 for construction in FY09.
Poet	Corn Cob Corn Fiber	Biochemical	Emmetsburg, IA	Award 2 TIA issued, engineering and construction in progress.
Range Fuels	Woody Waste	Gasification + Mixed Alcohol synthesis	Soperton, GA	Award 2 TIA issued, engineering and construction in progress.
Abengoa	Agricultural Residue	Biochemical	Hugoton, KS	NEPA EIS process initiated. Award 2 anticipated in FY09.

Demonstration-Scale Biorefineries Selected in FY08 Award One's Under Negotiation




Performers	Feedstock Type	Conversion Technology	Location
Alltech-Envirofine	Corn Cobs, Corn Fiber	Biochemical-Solid State Fermentation	Washington County, KY
Lignol Innovations	Woody Biomass	Biochemical-Organisolve	Grand Junction, CO
Mascoma	Woody Biomass	Biochemical	Upper Peninsula, MI
NewPage	Woody Biomass - Mill Residue	Thermochemical-Fischer-Tropsch	Wisconsin Rapids, WI
Pacific Ethanol	Wheat Straw, Stover, Poplar Residuals	Biochemical-Biogasol	Boardman, OR
RSE	Woody Biomass - mill residues	Biochemical-Pentose Extraction	Old Town, ME
Verenium Biofuels Corp.	Energy Cane and Bagasse	Biochemical Process	Jennings, LA
Flambeau River Biofuels LLC	Forest residues and wood waste	Thermochem to Fischer-Tropsch	Park Falls, WI




Major DOE Biorefinery Project Locations

Geographic, Feedstock, and Technology Diversity



 Eight Small-Scale Biorefinery Projects

 Four Commercial-Scale Biorefinery Projects

Demonstration of Integrated Biorefinery Operations Solicitation



- The intent of the FOA will be to *select integrated biorefinery projects that have the necessary technical and economic performance data that validates readiness for the next level of scale up.*
- In general, integrated biorefineries employ various combinations of “acceptable feedstocks” (includes algae) and conversion technologies to produce a variety of products, with *the main focus on producing a liquid transportation biofuel as the main product.*
- Co- or by-products can include chemicals (or other materials) and heat and power
- *Supports meeting the advanced biofuels mandates of the Energy Independence and Security Act of 2007 (EISA) Renewable Fuel Standards (RFS).*
- DOE *encourages applications that propose novel or breakthrough technologies* and those that include appropriate collaboration between and among industry, academia, and DOE National Laboratories, FFRDCs (Federally Funded Research and Development Centers) or other government-funded facilities.

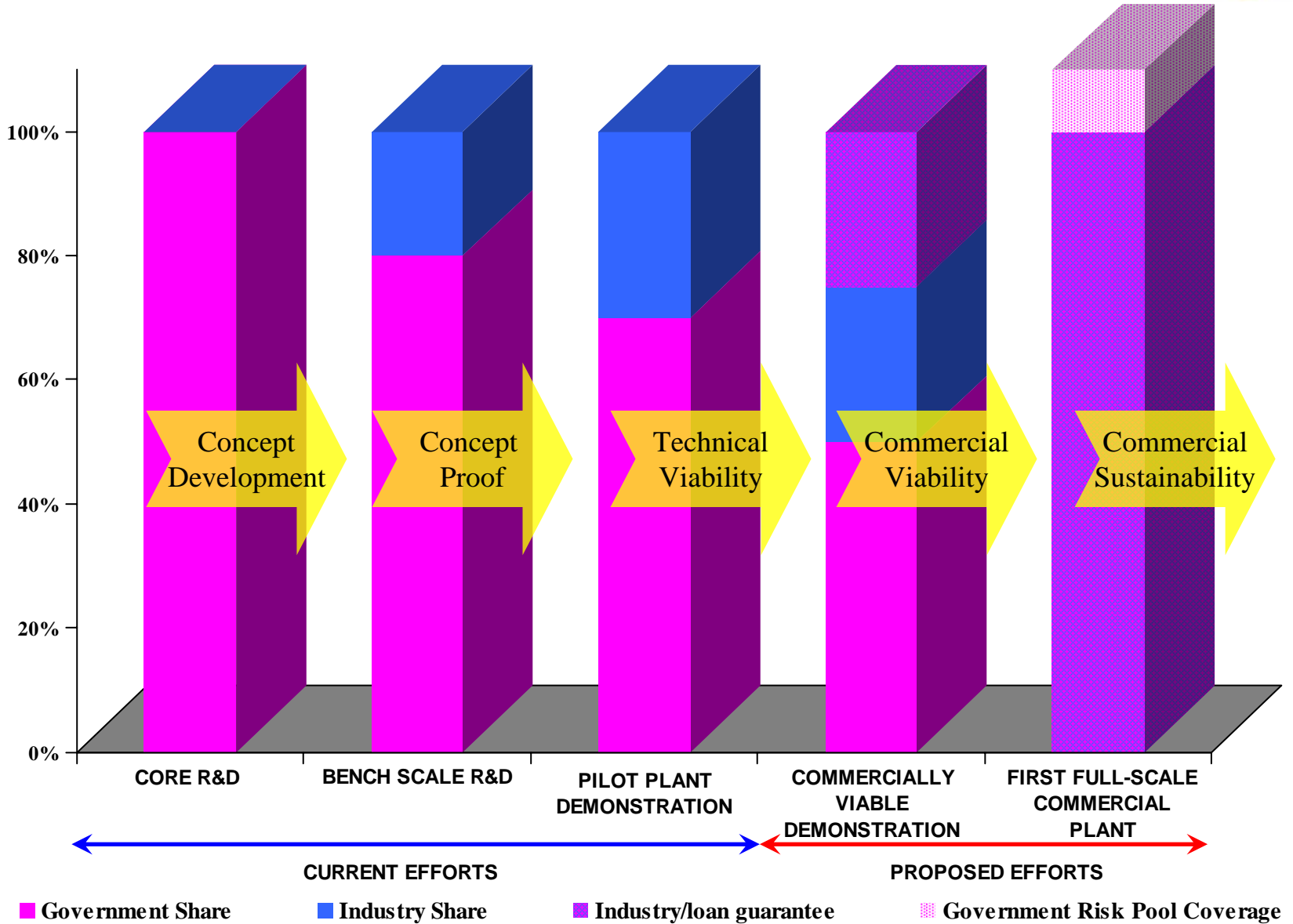
Demonstration of Integrated Biorefinery Operations Solicitation - continued



- The FOA has two topic areas:
 - *Topic 1:* Design, construct and operate an integrated *pilot-scale biorefinery project with a throughput of no less than one (1) dry tonne of feedstock per day.*
 - *Topic 2:* Design, construct and operate a *demonstration-scale biorefinery of no less than fifty (50) dry tonnes of feedstock per day.*
- Validate key process metrics and provide continuous operational data at the scale needed to *lower the technical risks associated with the development of a viable future commercial plant.*
- The applicant may propose constructing a new facility or making modifications to an existing facility (including adding equipment or modules).
- The proposed biorefineries must be located within the United States and use “acceptable feedstock” from a domestic source. The list of “acceptable feedstocks” was guided by EPACT Section 932, EISA Section 201, and the 2008 Farm Bill.

Proposed Deployment Funding Balance

Government Grants / Industry Cost-Share/ Loan Guarantees



Information Resources



- Office of Biomass Program,
- Web Site: <http://www1.eere.energy.gov/biomass/>
- EERE Info Center - www1.eere.energy.gov/informationcenter
- Alternative Fuels Data Center -
<http://www.eere.energy.gov/afdc/fuels/ethanol.html>
- Bioenergy Feedstock Information Network - <http://bioenergy.ornl.gov/>
- Biomass R&D Initiative – www.biomass.govtools.us
- Grant Solicitations - www.grants.gov
- Office of Science - <http://www.er.doe.gov/>
- Loan Guarantee Program Office - <http://www.lgprogram.energy.gov>
- Loan Guarantee Final Rule - <http://www.lgprogram.energy.gov/lgfinalrule.pdf>