DOE Efforts to Accelerate Deployment and Commercialization of Advanced Biofuels

National Conference of State Legislators
Energy Policy Summit
San Antonio, TX August 8, 2011

Brian Duff, Chief Engineer
DOE EERE Biomass Program
AGENDA

• Overview of DOE Biomass Program Mission and Goals
• Importance of Biofuels
• Description of Demonstration and Deployment Activities
• Federal Legislation, Funding and Incentive Programs
Advancing Presidential Objectives

Science & Discovery - Maintaining our leadership position

Economic Prosperity – Job Creation

Climate Change – GHG Reduction

Clean, Secure Energy – Energy Security
Key Tenets of the Office of Energy Efficiency and Renewable Energy Strategic Plan:

- Dramatically reduce dependence on foreign oil
- Promote the use of diverse, domestic and sustainable energy resource
- Establish a domestic bioindustry
- Reduce carbon emissions from energy production and consumption
Mission of the Biomass Program

“Develop and transform our renewable biomass resources into cost-competitive, high-performance biofuels, bioproducts, and biopower through targeted research, development, demonstration, and deployment supported through public and private partnerships.”
At low % blends, refiners can adjust operations to produce suitable blendstocks
- Ethanol, e.g., Vapor Pressure
- Biodiesel, e.g., Cold-Flow

At higher % biofuel, displaced hydrocarbons may be shifted to less-valuable markets
- Gasoline, e.g., to Cracker Feed
- Diesel, e.g., to Fuel Oil

As crude is displaced as a source of one product, there may be shortfalls in other markets
- Gasoline, e.g., Diesel & Jet
- Motor Fuels & Jet, e.g., chemicals
- Aromatics, e.g., hydrogen

EISA Mandated Biofuel Production Targets

Renewable Fuel Standard (RFS2)

15 BGY Cap on Conventional (starch) Biofuels

>20% of all liquid transportation fuels demand

Advanced Biofuels (include cellulosic biofuels other than starch-based ethanol)

Production Targets (Billions of Gallons)

- Conventional (Starch) Biofuels
- Cellulosic Biofuels
- Biomass-based diesel
- Other Advanced Biofuels
Climate Change: GHG Reduction/ Low Carbon Fuels

EPA RFS2 CO2 e Intensity
Biofuel lifecycle greenhouse gas emission reductions relative to petroleum fuels

- Gas
- Diesel
- Corn Ethanol
- Sugarcane Ethanol
- Switchgrass Diesel
- Stover Diesel
- Switchgrass TC Ethanol
- Stover TC Ethanol
- Switchgrass BC Ethanol
- Stover BC Ethanol

Petroleum
Commercial Biomass
RD&D Biomass

* TC = Thermochemical conversion | BC = Biochemical conversion
Source: EPA RFS2 Final Rule, March 26, 2010
The Importance and Relevance of Biofuels

Why are Biofuels so Important?

- Economy
- Environment

Security

www.navy.mil/
The Importance and Relevance of Biofuels

SECURITY!

Energy Security:
- We import ~64% of our liquid fuels, often from countries who are antagonistic towards the US
- We are a captive market dependent on countries we cannot rely on

National Security:
- We expend a significant amount of our military budget in funding and personnel in activities directly related to maintaining our access to oil
- Our National Security is related to our Economy

Economic Security:
- Our dependence on oil and impact of oil prices acts like a throttle on our economic engine
- The impact of rising oil prices reverberates through the economy, raising the prices of goods and services and driving inflation
The Importance and Relevance of Biofuels II

**ECONOMICS!**

**Trade Deficit**
- We spend $400 billion/year on imported oil, of which about $300B finds its way into foreign treasuries as profit: >$1 billion/day!!!!

![Graph showing U.S. International Trade in Goods and Services](image1)

**GDP: Rural Economic Development and JOBS**
- Creating 50-75 new direct jobs per biorefinery
- Reinvigorating rural economies
- Creating major new energy crop markets

![Graph showing United States GDP Growth Rate](image2)

Source: TradingEconomics.com, Bureau of Economic Analysis
The Importance and Relevance of Biofuels III

The Environment!

- Petroleum dependency contributes to anthropogenic GHG emissions
- Rising levels of CO$_2$ are decreasing the pH of our oceans, potentially upsetting delicate and vital ecosystems such as coral reefs
- Biofuels can reduce GHG and CO$_2$ emissions up to 130%
- Biofuels can reduce risks & damages from oil production/transport

Sustainability

- Many of our industrial practices are not sustainable
- Biofuels are renewable
- Production technologies and metrics are being developed for sustainable biofuels production
The Importance and Relevance of Biofuels IV

**QUALITY OF LIFE!**

• Biofuels contribute to our economic prosperity

• As China and India continue to grow their economies, the US will need to move away from using 25% of every daily barrel of oil to ~10% or less, more reflective of our relative populations

• To maintain our quality of life, we need to develop new energy sources and renewable bio-based analogs for petrochemical fuels and products
Other Intangible Considerations

- Liquid fuels are a premium product application: we pay for energy density and convenience. In the near term, biofuels are the only alternative that fits our lifestyle.
- Biomass is not unlimited: “Best Use of Biomass” dictates the highest value product application.
- Electricity generation has many other options: Hydro, Nuclear, Wind, Solar, Geothermal, Wave, Ocean Thermal.
- There is no other currently available option for liquid transportation fuels besides biomass.
- Electrifying the vehicle fleet does not address GHG issues unless generation uses renewable, sustainable sources.
- Ethanol is a “transition” fuel. The technologies being developed for ethanol are being leveraged to other renewable liquid fuels: gasoline, diesel and jet fuel.
- We need every arrow in our quiver, every tool in our box, and biofuels is one
Biofuels Development Efforts at the Biomass Program of DOE
Strategic Focus: Sustainable Biofuels, Biopower, Bioproducts

The Biomass Program is working to advance biomass technologies in support of DOE’s mission to strengthen America’s energy security, environmental quality, and economic vitality through:

- **Feedstocks**
  - Developing lower cost feedstock logistics systems

- **Conversion technologies**
  - Improving conversion efficiencies and costs

- **Integrated biorefineries**
  - Systematically validating and deploying technology at first-of-a-kind facilities

- **Infrastructure**
  - Evaluating vehicle emissions, performance, and deployment options

- **Biopower**
  - Providing a clean, domestic, dispatchable renewable source of power

- **Advanced biofuels**
  - Expanding portfolio beyond cellulosic ethanol to hydrocarbon fuels
Strategic Focus: Sustainability Across the Supply Chain

Biomass-to-Bioenergy Supply Chain

**Feedstocks**
- Evaluate nutrient and carbon cycling
- Assess impact on land and resource use

**Conversion**
- Minimize water consumption and air pollution
- Maximize efficiency

**Distribution**
- Reduce carbon footprint of new facilities
- Utilize co-products and fully integrate systems

**End Use**
- Ensure minimal greenhouse gas emissions
- Avoid negative impacts on human health

**Cross cutting**
- Life cycle analysis of water consumption and GHG emissions
- Land-use change
- Water quality analysis
Research on multiple conversion pathways aims to improve the efficiency and economics of biofuels production.
Description of Demonstration and Deployment Activities
### Biomass R&D and Demonstration Projects - $800 Million

<table>
<thead>
<tr>
<th>Funding</th>
<th>Initiative</th>
<th>Details</th>
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</thead>
</table>
| $509M   | **Pilot and Demonstration-Scale Biorefineries**                            | Validate technologies for integrated production of advanced biofuels, products, and power to enable financing and replication. DOE recently selected:  
- 14 pilot-scale projects for up to $25M each  
- 4 demonstration-scale projects for up to $50M |
| $81M    | **Commercial-Scale Biorefineries**                                         | Increase in funding for prior awards; one project  
Expedite construction; accelerate commissioning and start-up |
| $107M   | **Fundamental Research**                                                   | $24M: Integrated Process Development Unit - LBNL  
$5M: Sustainability research with the Office of Science  
$34M: Advanced Biofuels Technology Consortium  
$44M: Algal Biofuels Consortium to accelerate demonstration |
| $20M    | **Mid-Level Blends Testing and Infrastructure Research**                  |                                                                        |
| $13.5M  | **Expand NREL Integrated Biorefinery Research Facility**                  |                                                                        |
| $69.5M  | **SBIR and Program Direction**                                             |                                                                        |
Integrated Biorefinery Portfolio

- 29 R&D, pilot, demonstration, and commercial-scale projects selected to validate IBR technologies
- Diverse feedstocks represented

<table>
<thead>
<tr>
<th>Agricultural Residues</th>
<th>Algae/CO₂</th>
<th>Municipal Solid Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Crops</td>
<td>Forest Resources</td>
<td>Non-edible oils</td>
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</tbody>
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- A variety of transportation fuels, biobased products, and biopower will be developed

<table>
<thead>
<tr>
<th>Cellulosic Ethanol</th>
<th>Renewable Gasoline</th>
<th>Biobased Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butanol Methanol</td>
<td>Renewable Diesel</td>
<td>Process heat and steam</td>
</tr>
<tr>
<td></td>
<td>Jet Fuel</td>
<td>Electricity</td>
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</tbody>
</table>
Integrated Biorefinery Portfolio – Pathway Diversity

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Conversion</th>
<th>Intermediate</th>
<th>Conversion</th>
<th>Product</th>
<th>Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Residues</td>
<td>biochemical</td>
<td>sugar</td>
<td>fermentation</td>
<td>ethanol</td>
<td>Abengoa, POET, Verenium, ADM</td>
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<tr>
<td></td>
<td>gasification</td>
<td>syngas</td>
<td>catalysis</td>
<td>diesel</td>
<td>REII</td>
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<td></td>
<td>pyrolysis</td>
<td>oil</td>
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<tr>
<td>Energy Crops</td>
<td>gasification</td>
<td>syngas</td>
<td>catalysis</td>
<td>ethanol</td>
<td>ICM, Logos, Pacific Ethanol RSA, Zeachem</td>
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<td>sugar</td>
<td>fermentation</td>
<td>diesel</td>
<td>Amyris</td>
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<td>succinic acid</td>
<td>Myriant</td>
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<tr>
<td>Forest Resources</td>
<td>gasification</td>
<td>syngas</td>
<td>catalysis</td>
<td>ethanol</td>
<td>Lignol, Mascoma, API, Blue Fire, Range Fuels</td>
</tr>
<tr>
<td></td>
<td>pyrolysis</td>
<td>oil</td>
<td></td>
<td>gasoline</td>
<td>Haldor Topsoe, Clear Fuels, New Page, Flambeau, GTL, UOP</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>diesel</td>
<td></td>
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<tr>
<td>Waste</td>
<td>gasification</td>
<td>syngas</td>
<td>fermentation</td>
<td>ethanol</td>
<td>INEOS, Enerkem</td>
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<td>Algae</td>
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<td>oil</td>
<td>catalysis</td>
<td>diesel jet fuel</td>
<td>Sapphire</td>
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<tr>
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<td>oil</td>
<td>catalysis</td>
<td>catalysis</td>
<td>diesel jet fuel</td>
<td>Solazyme</td>
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<tr>
<td>Closed bioreactor</td>
<td>transesterification</td>
<td>biodiesel</td>
<td>metathesis</td>
<td>diesel jet fuel</td>
<td>Elevance</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>ethanol</td>
<td>Algenol</td>
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Energy Efficiency & Renewable Energy
Federal Legislation, Funding and Incentive Programs
### Legislation, Funding and Incentive Programs

In recent years in particular, several legislative, regulatory, and policy efforts have strengthened the focus on increasing and accelerating biomass-related RDD&D.

<table>
<thead>
<tr>
<th>Date</th>
<th>Legislation/Act</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>August 2005</td>
<td>Energy Policy Act of 2005 (EPAct)</td>
<td>Renewed and strengthened federal policies fostering ethanol production, including incentives for the production and purchase of biobased products; these diverse incentives range from authorization for demonstrations to tax credits and loan guarantees.</td>
</tr>
<tr>
<td>December 2007</td>
<td>Energy Independence and Security Act (EISA) of 2007</td>
<td>Supported the continued development and use of biofuels, including a significantly expanded Renewable Fuels Standard, requiring 36 bgy renewable fuels by 2022 with annual requirements for advanced biofuels, cellulosic biofuels and biobased diesel.</td>
</tr>
</tbody>
</table>
| May 2008    | The Food, Conservation, and Energy Act of 2008 (Farm Bill) | • Provided grants, loans, and loan guarantees for developing and building demonstration and commercial-scale biorefineries.  
• Established a $1.01 per gallon producer tax credit for cellulosic biofuels.  
• Established the Biomass Crop Assistance Program (BCAP) to support the production of biomass crops.  
• Provided support for continuation of the Biomass R&D Initiative, the Biomass R&D Board, and the Technical Advisory Committee. |
| February 2009 | American Reinvestment and Recovery Act (ARRA)      | • Provided funds for grants to accelerate commercialization of advanced biofuels R&D and pilot-, demonstration-, and commercial-scale integrated biorefinery projects.  
• Provided funds to other DOE programs for basic R&D, innovative research, tax credits, and other projects. |
| May 2009    | Presidential Memorandum on Biofuels                | Memorandum that, among other requirements, established a Biofuels Interagency Working Group to consider policy actions to accelerate and increase biofuels production, deployment, and use. The Group is co-chaired by the Secretaries of DOE and U.S. Department of Agriculture (USDA) and the Administrator of the U.S. Environmental Protection Agency (EPA). |
Legislation, Funding and Incentive Programs

• DOE Loan Guarantee Program

Section 1703 of Title XVII of the Energy Policy Act of 2005 authorizes the U.S. Department of Energy to support innovative clean energy technologies that are typically unable to obtain conventional private financing due to high technology risks.

• Current Applications under review:
  • Abengoa (ethanol)
  • POET (ethanol)
Legislation, Funding and Incentive Programs

• USDA Loan Guarantee Program: SECTION 9003 Biorefinery assistance program

Loan guarantees are made to fund the development, construction, and retrofitting of commercial-scale biorefineries using eligible technology. The maximum loan guarantee is $250 million. Mandatory funding is available through FY 2012.

• Current Applications approved or under review:

  RangeFuels (ethanol) – approved
  Sapphire (algal jet fuel/diesel) – approved
  BlueFire (ethanol)
  Enerkem (ethanol)
  Coskata (ethanol)
Legislation, Funding and Incentive Programs

• Cellulosic Reverse Auction
  • Accelerate deployment and commercialization of biofuels in delivering the first billion gallons in annual cellulosic biofuels production by 2015
  • Not acquisition (DOE does not take possession of the fuel) - basically a fuel subsidy
  • Annual cap: $100 million; Lifetime cap: $1 billion
  • Project cap: 25% of funds, minimum 4 recipients
  • Applicant – Fuels producer (intends to) own and operate an eligible cellulosic biofuels production facility in “Commercially Significant Quantities” and places bid for amount of subsidy
  • Only for biofuels (not products or power): Lignocellulosic Ethanol, “Green” Diesel, and Other fuel substitutes – alcohols, oxygenates
  • Must have lifecycle greenhouse gas emissions that are at least 60 percent less than the baseline lifecycle greenhouse gas emissions (EISA 2007 Sec. 202)
Additional Federal Incentives

- **Blender’s Credit for Ethanol (VEETC)**. The Volumetric Ethanol Excise Tax Credit is a 45 cents per gallon “blender credit” currently set to expire at the end of 2011.

- **Tariff on Imported Ethanol**. The 54 cent per gallon tariff on imported ethanol is set to expire 2011.

- **Small Producer Tax Credit**. The 10 cent per gallon producer tax credit for small ethanol producers producing no more 60 million gallon of ethanol a year is also set to expire at the end of 2011. The tax credit is applicable to just the first 15 million gallons of production for eligible producers.

- **Excise tax credits for alternative fuel and alternative fuel mixtures**. The measure extends through 2011 the $0.50 per gallon alternative fuel credit and the alternative fuel mixture tax credits, excluding black liquor (liquid fuel derived from a pulp or paper manufacturing process) from credit eligibility.

- **Alternative fuel vehicle refueling property**. The measure extends the 30 percent investment tax credit for alternative vehicle refueling property for one year, through 2011.
Information Resources: Links

- DOE on Twitter - http://twitter.com/energy
- Secretary Chu on Facebook - http://www.facebook.com/stevenchu
- EERE Info Center - http://www1.eere.energy.gov/informationcenter
- Alternative Fuels Data Center http://www.eere.energy.gov/afdc/fuels
- Bioenergy Feedstock Information Network - http://bioenergy.ornl.gov/
- Grant Solicitations - http://www.grants.gov
"Developing the next generation of biofuels is key to our effort to end our dependence on foreign oil and address the climate crisis -- while creating millions of new jobs that can't be outsourced. With American investment and ingenuity -- and resources grown right here at home -- we can lead the way toward a new green energy economy."

- Secretary of Energy Steven Chu
Backup Slides: Barriers to Commercialization
Challenges for the Demonstration and Deployment of IBRs

"Got a few problems going from lab scale up to full-scale commercial."
Challenges for the Demonstration and Deployment of IBRs

Barriers exist throughout the value chain:

Feedstock:
Who’s going to invest in planting a new crop when there’s no plant to take it to?

Financing/Capital:
Who’s going to finance a plant when there’s no feedstock to supply it?
Who’s going to finance a plant when the Conversion Technology can’t get a performance guarantee?

Product Off-take:
Who’s going to finance a plant when the longest off-take contract you can get is 2-3 years?
Challenges for the Demonstration and Deployment of IBRs

Conversion Technology Development

Market Surety

Project Financing
Challenges for the Demonstration and Deployment of IBRs

Conversion Technology Development

Technology developers must contend with the “Valley of Death” between bench scale reduction to practice and true commercial production.

Conversion Technologies must be scaled up to generate the engineering data required for plant construction.

Conversion Technologies must be validated at scale to obtain engineering data and support project financing.
Market Surety

The price of oil fluctuates dramatically and therefore there is no surety in the off-take product price for the renewable analogs.

Federal incentive policies and market mandates are subject to change and expiration, and there is no surety that they will cover the tenor of the loan.

Market Surety can be increased through consistent public policy.
Project Financing

The lack of a performance guarantee can be addressed through the federal loan guarantee programs.

Feedstock supply chain issues can be addressed through programs like the USDA’s Biomass Crop Assistance Program (BCAP).

Project financing can be improved through financial assistance programs and capital construction tax incentive programs.

Product off-take supply issues can be addressed with programs like the Cellulosic Biofuels Reverse Auction.
What’s the Biomass Program Doing to Address these Barriers?

Investing across the value chain

- Feedstock & Feedstock Logistics
- Conversion: expanding beyond ethanol; leveraging investments
- Demonstration and Deployment Projects
- Infrastructure Development for Mid-Level Blends
- Fuel Certification
What’s the Biomass Program Doing to Address these Barriers?

Working with Stakeholders to Access Capital and Secure Project Financing

Financial/Market:

Financial assistance programs
LGP – DOE and USDA
Interagency collaborations: USDA – BCAP; EPA – markets; DOD – potential off-take partner
Market development: RFS2, reverse auction, off-take contract opportunities with industry