Biomass Feedstocks for a Rapidly Growing Biofuels Industry

Presented to
Biofuels, Food & Feed Tradeoffs
St. Louis, Missouri

Presented by
Dr. James R. Fischer
Senior Scientific Advisor
USDA’s Research, Education & Economics Mission Area

April 12, 2007

Today’s Discussion

• During conference planning, this presentation was to be about the “USDA/DOE Biomass Action Plan”.

• In lieu of a published plan, I will help lay the groundwork for a discussion of impacts and tradeoffs by:
  – Reviewing some possible Future Directions in Energy
  – Looking at several Plans and Goals
  – Discussing possible sources of the feedstocks needed for this biofuels expansion, and
  – Presenting some of the actions underway in USDA.

Future Directions

Short Term Now
• Hybrid or Clean Diesel Vehicles
• Clean Coal Efficiency
• Energy Efficiency Standards
• Renewable Fuel Standards
• Nuclear Plant Relicensing
• Enhanced Oil Recovery
• Biological Sequestration
• Methane to Markets*
• Federal Facility Management Plan
• Fuel Economy Standards
• Wind, Solar Tax Incentives
• Climate Leaders
• Climate VISION
• SmartWay Transportation

Mid Term
• Hybrid/Clean Diesel Vehicles
• Clean Coal Gasification
• Renewable/Efficiency Partnership
• Cellulosic Biomass
• Advanced Nuclear
• Geological Sequestration*

Long Term
• Hydrogen*
• FutureGen*
• Zero Energy Homes & Buildings
• Bio-Energy Systems
• GenIV Nuclear/Fusion*

Source: June 30, 2005 White House Press Release on G-8 Summit

History of Federal Energy and Environmental Policy

1978 – Public Utility Regulatory Policies Act (PURPA)
1978 – Energy Tax Act (ethanol blends $.40/gallon tax exemption)
1992 – Energy Policy Act (tax credit for renewable energy production)
1998 – Energy Conservation Reauthorization Act (included biodiesel credit)
1998 – Alternative Motor Fuels Act (Encouraged cars fueled by alternative fuels)
2000 – Biomass R&D Act (DOE/USDA joint R&D on biobased industrial products)
2002 – Farm Bill (First energy title in Farm Bill history)
2004 – Job Bill – (included biodiesel fuel tax credit)
2006 – State of the Union – “addicted to oil”
2006 – Advanced Energy Initiative
2007 – State of the Union – Twenty in Ten
2007 – Biweekly Energy Briefings to USDA Secretary
2007 – Farm Bill – Increase Budgets for bioenergy R&D

Federal Environmental Policies
• 1990 Clean Air Act (CAA) – (first major environmental policy to have an impact on renewable energy).
• 2006 – (EPA requires the use of ultra low sulfur diesel fuel (15 parts per million sulfur)
• 2010 – Non-road diesel fuel regulations will take place

Future Directions —
We are living in a new world of potential

• Growing need for clean and affordable supply of energy
• Opportunity for agriculture to supply some of that energy
• USDA agencies support renewable energy production
• USDA collaborates with other Federal agencies
• Government policies and initiatives support these efforts
  – Increase R&D Funding
  – Commercialization partnerships
• Potential beneficiaries of agriculture energy development?
• Proposed USDA FY 2008 budget for energy
  – $397 million energy outlays
  – 68 percent increase compared to FY 2007
• The 2007 Farm Bill proposes expanding renewable energy for U.S. agriculture and rural areas

Desired Agricultural Energy Outcomes?

• Improve national security and the U.S. trade balance
• Help America transition to renewable sources of energy and other goods
• Realize important environmental benefits
• Realize significant, new, sustainable economic opportunities for rural America
• Realize secure sources of energy for rural America
**Much Interest**

**Many Goals**

**Advanced Energy Initiative**

*“Change how we power our automobiles”*
- Advanced battery technologies — plug-in hybrids
- Cellulosic ethanol costs
- Hydrogen fuel cells by 2020

*“Change how we power our homes and offices”*
- Clean Coal
- Nuclear Energy
- Renewable Energy

**Biofuels Initiative**

The Biofuels Initiative objective is to foster the production of biofuels to replace more than 75 percent of our oil imports from the Middle East by 2025 (+$53M)

Achieving this ambitious goal will require looking at corn and other biomass resources to produce ethanol, including:
- Agricultural crops & residues
- Woody plants & grasses

Biomass Program has conducted a major solicitation in FY 2007 to validate near-term ethanol biorefineries in collaboration with industry (1st validation will occur in FY 2009)

Benefits (2030): Develop technologies to enable US to displace 2.6 MMbbl/d oil equivalent, keeping $44 billion in the US economy to create jobs at home

**NATIONAL BIOMASS ACTION PLAN**

- Commissioned by the Biomass R&D Board
- Purposes:
  - Define agency roles and activities
  - Identify gaps and synergies
  - Assess budgets
- Process:
  - Conducted Workshop Nov. 26-27, 2006
  - Breakout Sessions:
    - Feedstocks
    - Biotechnologies
    - Biotechnological Conversions Technologies
    - Technology Integration
    - Biofuels Infrastructure
    - Communication, Education and Outreach
  - Interagency Teams formed for each breakout session topic
  - Developing draft R&D Plan
  - Reviewed by Agencies
  - Then Presented to Board
- Product – to be released soon

Adapted from BR Di – Biomass Research & Development Initiative

**Renewable Energy Goals**

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<thead>
<tr>
<th>Goal Areas</th>
<th>Approach</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>President's Biofuels Initiative 30 x ’30</td>
<td>Cellulosic ethanol – 30% gasoline replaced by 2030 – 60 billion gallons</td>
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<td>Commissioner’s (R&amp;D) Committee</td>
<td>Commissioner’s (R&amp;D) Committee implementation planning workshop</td>
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<td>DOE &amp; Agency strategies to provide letter for 30x30 planning</td>
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<td>Proposed Implementation Plan in EPA agency roles</td>
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R & D Challenges for Fermentation

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<tr>
<th>Feedstock</th>
<th>2005</th>
<th>2012 Goal</th>
</tr>
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<tbody>
<tr>
<td>Xylose to Ethanol</td>
<td>27%</td>
<td>97%</td>
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<tr>
<td>Biomass to Ethanol</td>
<td>0%</td>
<td>89%</td>
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</table>

R & D Challenges for Thermochemical Conversion

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<thead>
<tr>
<th>Parameter</th>
<th>2005</th>
<th>2012 Goal</th>
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<tbody>
<tr>
<td>Minimum Oxygen Dilution Factor</td>
<td>$1.00</td>
<td>$1.00</td>
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<tr>
<td>Minimum Alcohol Dilution Factor</td>
<td>$1.00</td>
<td>$1.00</td>
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<tr>
<td>Oxygen Cost (kg/kg ethanol)</td>
<td>$2.00</td>
<td>$2.00</td>
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</table>

DOE’s Actions

Funding Three Molecular Bioenergy Centers $250 Million each.

Cellulosic Cost-share (FY07-10), $385M Funding - Total $1.2 B

<table>
<thead>
<tr>
<th>Company</th>
<th>Funding Mil. $</th>
<th>Ethanol Mil. gal.</th>
<th>Feedstock</th>
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<tbody>
<tr>
<td>Abengoa</td>
<td>$76</td>
<td>11.4</td>
<td>Stover, wheat, switchgrass</td>
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<tr>
<td>ALICO</td>
<td>$53</td>
<td>13.9</td>
<td>Yard, wood, vegetative wastes</td>
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<tr>
<td>BlueFire</td>
<td>$40</td>
<td>19</td>
<td>Green, wood wastes</td>
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<tr>
<td>Brom</td>
<td>$80</td>
<td>31</td>
<td>Corn fiber, cobs</td>
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<tr>
<td>Iogen</td>
<td>$80</td>
<td>18</td>
<td>Agricultural residues</td>
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<tr>
<td>Range Fuels</td>
<td>$76</td>
<td>40</td>
<td>Wood residues, wood energy crops</td>
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</table>

DOE Regional Feedstocks

- Biomass Resource Assessment
  - Regional Supply Curves and GIS
- Biomass Resource Development
  - Field trials of dedicated feedstocks
  - Impact of residue removal on yields
- Crop Development
  - Genetic evaluation of energy crops
- Education and Outreach
  - BioWeb

“20 in 10”

- During his 2007 State of the Union Address, President Bush announced the goal of reducing U.S. gasoline usage by 20% in the next ten years — “Twenty in Ten.” Goals include:
  - Increasing the supply of renewable and alternative fuels by setting a mandatory fuels standard to require 35 billion gallons of renewable and alternative fuels in 2017 — nearly five times the 2012 target now in law.
  - Reforming and modernizing Corporate Average Fuel Economy (CAFE) standards for cars and extending the current Light Truck rule.

Energy: The New Normal?

- Convened Experts for 4 day dialogue
- Generated 16 Unanimous recommendations on R&D Policy and Incentives – including
  - Stimulating and Deploying energy technologies
  - Promoting energy efficiency
  - Reducing US oil imports
  - Reducing carbon dioxide emissions
- Called for 100 Billion Gallons of Ethanol by 2025
Agriculture and Forestry for Energy, Chemicals and Materials: The Road Forward

NABC Road Forward

- Liquid Transportation Fuels
  - 50 Billion Gallons by 2025
  - 100+ Billion Gallons by 2035
- Organic Chemicals
  - Glucose - $0.04 per pound
  - Competitive price ethylene
  - Genetic modification
- Organic Materials
  - New Fiber Crops
  - Genetic modification

25x’25 Projected Energy Contributions by Feedstock/Source

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<td>Transportation Fuels</td>
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<tr>
<td>Grain Ethanol Biomass</td>
<td>0.25</td>
<td>0.35</td>
<td>1.00</td>
<td>1.75</td>
<td>1.90</td>
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<tr>
<td>Cellulosic Ethanol Biomass</td>
<td>0</td>
<td>0</td>
<td>1.75</td>
<td>3.28</td>
<td>6.12</td>
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<tr>
<td>Crop Oil</td>
<td>0.92</td>
<td>0.62</td>
<td>0.84</td>
<td>0.95</td>
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<tr>
<td>Animal Fat</td>
<td>0.85</td>
<td>0.62</td>
<td>0.84</td>
<td>0.95</td>
<td>0.95</td>
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<tr>
<td>Electricity</td>
<td></td>
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<tr>
<td>Solid Biomass</td>
<td>0.12</td>
<td>0.29</td>
<td>2.39</td>
<td>6.38</td>
<td>6.40</td>
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<tr>
<td>Livestock Solid Biomass</td>
<td>0.50</td>
<td>0.54</td>
<td>0.57</td>
<td>0.57</td>
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</table>

Possible Feedstock Sources?

- “Billion Ton” study indicates that enough biomass is potentially available to displace > 30% of current U.S. petroleum consumption, with no impacts to food, feed, or export demand
- Requires a variety of biomass types
Annual Biomass Resource Potential from Forest & Agricultural Resources

- **Primary**
  - Logging residues from conventional harvest operations and residues from forest management and land clearing operations
  - Removal of excess biomass (fuel treatments) from timberlands and other forestlands
  - Fuelwood extracted from forestlands
- **Secondary**
  - Primary wood processing mill residues
  - Secondary wood processing mill residues
  - Pulping liquors (black liquor)
- **Tertiary**
  - Urban wood residues — construction and demolition debris, tree trimmings, packaging wastes and consumer durables

Annual Biomass Resource Potential from Forest Resources

- **Primary**
  - Crop residues from major crops — corn stover, small grain straw, and others
  - Grains (corn and soybeans) used for ethanol, biodiesel, and bioproducts
  - Perennial grasses
  - Perennial woody crops
- **Secondary**
  - Animal manures
  - Food/feed processing residues
- **Tertiary**
  - MSW and post-consumer residues and landfill gases

Actions Underway in USDA

- Biomass Research and Development Board – Joint USDA/DOE
- Energy Council – USDA
- Bioenergy – Bioproducts Coordinating Council (BBCC) – USDA
- Agricultural Bioenergy Bioproducts Research Education and Economics (ABBREE) Task Force – USDA REE
The Biomass Research and Development Technical Advisory
Committee

- The Advisory Committee is responsible for providing guidance to the Biomass Research and Development Board on the technical focus of the Biomass Research and Development Initiative.
- Official functions of the Advisory Committee include:
  - Advise the Secretary of Energy, the Secretary of Agriculture, and the points of contact concerning:
  - the technical focus and direction of requests for proposals issued under the Initiative; and
  - procedures for reviewing and evaluating the proposals.
  - Facilitate consultations and partnerships among Federal and State agencies, agricultural producers, industry, consumers, the research community, and other interested groups to carry out program activities relating to the Initiative
  - Evaluate and perform strategic planning on program activities relating to the Initiative
- The Advisory Committee holds quarterly, public meetings. Meetings are announced in the Federal Register.

Biomass Research and Development Board

- A panel consisting of Senior Level representatives responsible for ensuring coordination among the following agencies:
  - Co-Chaired by US Departments of Agriculture and Energy
  - Responsible for coordinating Federal activities for the purpose of promoting the use of biobased fuels and biobased products.

  - U.S. Department of Agriculture (co-chair): Thomas Dorr, Under Secretary for Rural Development
  - Department of Energy (co-chair): Alexander Karsner, Assistant Secretary of Energy Efficiency and Renewable Energy
  - National Science Foundation: Dr. Bruce Hamilton, Director, Bioengineering and Environmental Systems Division
  - Environmental Protection Agency: In transition
  - Department of Interior: Johnnie Burton, Acting Assistant Secretary, Land and Minerals Management
  - Office of Science and Technology Policy: Dr. Sharon Hays, Chief of Staff
  - Office of the Federal Environmental Executive: Dana Arnold, Chief of Staff
  - Department of Transportation (new): Dr. Ashok G. Kaveshwar, Administrator, Research and Innovative Technology Administration

  - Co-Vice Chairs: Keith Collins, OCE; Mark Rey, NRE
  - Chair: Tom Dorr, RD

  - Purposes:
    - Integration
    - Coordination

  - Methods:
    - Coordinate Secretary’s bi-weekly energy briefings
    - Established four standing oversight committees
      - Research and Development
      - Commercialization
      - Outreach/Marketing
      - International Relations
    - Provides leadership for Biomass Research and Development Initiative

USDA’s Energy Council

- Purposes:
  - Oversight of implementation of President’s National Energy Plan including EPAct of 2005.
  - Coordination of USDA Energy Related Programs.
  - Review and evaluation of key policy and program decisions on energy matters.
  - Development of initiatives to transform and generate alternative energy sources.
  - Assist and oversee continued implementation of Title IX of 2002 Farm Bill.

- Chair: Tom Dorr, RD
- Co-Vice Chairs: Keith Collins, OCE; Mark Rey, NRE
- Ex-Officio Members: DOE, EPA, DOC, DOI, DOT

- Methods:
  - Coordinate Secretary’s bi-weekly energy briefings
  - Established four standing oversight committees
    - Research and Development
    - Commercialization
    - Outreach/Marketing
    - International Relations
  - Provides leadership for Biomass Research and Development Initiative

Biobased Products and Bioenergy Coordination Council (BBCC)

- Program Scope
  - Helping farmers and forest landowners to provide Food, Feed, and Fuels
  - Reusing technology and market barriers for biobased and bioenergy
  - Leading biobased products development and Federal procurement.
  - Providing information and education to support the biobased and bioenergy.
- Coordination
  - Representation and participation from all agencies and programs
  - Develop 5-year plan and annual priorities
  - Work with Energy Council Committees
  - Utilize the different agency education and training programs
  - Provide information and education to support the biobased and bioenergy.
- Integration
  - Link basic/applied/research and commercialization
  - Fully develop and use demonstration and pilot opportunities
  - Submit formal and informal education/learning opportunities across mission programs
  - Provide energy and biobased education and training

Biobased Products and Bioenergy Coordination Council (BBCC)

- Chair – Gale Buchanan, Under Secretary REE
- Vice Chair – Rodger Conway, Director, OEPNU
- Working Chair: Bob Fireovid (ARS), Working Vice Chair: Bill Goldner (CSREES), Secretary Monan Buford (FS)

- Agricultural Marketing Service
- Agricultural Research Service
- Cooperative State Research, Education and Extension Service
- Farm Service Agency
- Foreign Agricultural Service
- Global Change Program Office

- Natural Resources Conservation Service
- Office of Budget and Program Analysis
- Office of Energy Policy and New Uses
- Office of the Assistant Secretary for Administration Office of the Under Secretary for Research, Education and Economics
- Rural Business-Cooperative Service
- Rural Utilities Service

http://www.ars.usda.gov/bbcc/

BBCC Vision and Goals

Growing Energy and Opportunity in America – Linking Land Conservation, Innovation, and Value

- Vision
  - Reduce dependence on foreign oil imports
  - Improved National security
  - New economic and environmental opportunities for America’s farmers, ranchers, and forest landowners
- Goals
  - Conserve and reduce energy in farm and forest operations
  - Acquire renewable energy & biobased products from America’s lands without supply and market disruption
  - Produce energy and biobased feedstocks sustainably
The National Agricultural Research, Extension, Education, and Economics Advisory Board (NAREEEAB)

- Provides advice to the Secretary of Agriculture and land-grant colleges and universities through REE Undersecretary on top priorities and policies for food and agricultural research, education, extension and economics. The Board –
  - Reflects the broad interests of food, fiber, and agricultural stakeholders nationwide,
  - Holds regional and national stakeholder listening sessions, and
  - Develops consolidated advice based on stakeholder input that is vital to the current and future success of food, forestry, and agricultural programs.
- Consults with appropriate agricultural committees of the U.S. Congress

Includes 31 Members, each of which represents a specific category of U.S. agricultural stakeholders, as mandated by Congress.

March and October 2006 meetings - focus groups on REE's responsibilities with respect to energy and bioproducts agriculture.

http://www.ree.usda.gov/

Recommendations of the NAREEE Board

- Take the lead on strategies for development of a bioenergy and bioproducts based economy.
- Announce a holistic and coherent vision of its role and strategy in bioenergy and to convey the message to the public.
- Undertake a focused effort to request the increased funding required to develop a nationally visible program.
- Take a portfolio approach while identifying which new intermediates for current and new applications may hold the most promise for potential commercialization.
- Develop a systems approach including economics, engineering and social management to evaluate research directions and alternatives.
- Seek additional funding for new and enhanced research and education bioenergy and bioproducts initiatives.

Agricultural Bioenergy Bioproducts Research Education and Economics (ABBREE) Task Force

- Formed in October 2006 by Dr. Buchanan
- Advises the REE Under Secretary on matters relating to agricultural bioenergy and related bioproducts via bi-weekly meetings
- Comprised of individuals with bioenergy and bioproducts expertise from all REE Agencies
  - Joseph Dunn (REE)
  - Ghassem Asrar (ARS)
  - Carmela Bailey (CSREES)
  - Chavonda Jacobs-Young (CSREES)
  - Neil Conklin (ERS)
  - Mark Miller (NASS).
- Initiating various educational forums including a monthly seminar series focusing on USDA research in bioenergy and related bioproducts and “Bioenergy Day”
- Planning for a REE bioenergy and related bioproducts workshop for fall 2007

USDA – REE – ABBREE

Energy Science and Education Workshop

- Committee: Bill Goldner (CSREES), Frank Flora (ARS), Neil Conklin (ERS), Mark Miller (NASS).
- Purpose:
  - Set Vision and Goals
  - Identify Program Areas of Focus
  - Identify Critical Cross Cutting Issues
  - Establish Agencies’ Responsibilities
  - Suggest Process to Achieve Goals
- Outcomes:
  - Vision and Goals Established
  - Program Areas of Focus Established
  - REE Responsibilities and Comparative Advantages Identified
  - Agencies’ Responsibility Accepted
  - Cross Cutting Issues Integrated into Program Areas
  - Initial Program Priorities Identified
  - Process for Moving Forward Presented

USDA – RESEARCH EDUCATION AND ECONOMICS MISSION AREA

ENERGY SCIENCE AND EDUCATION

VISION:
Building A Prosperous Future Where Agriculture Produces and Uses Energy Efficiently and Effectively

GOALS:

- Develop comprehensive, integrated intramural and extramural research program that effectively explores the role of agriculture as both a user and producer of energy.
- Establish energy science, education and extension activities related to agriculture with university and industry partners as well as other federal and state agencies.
- Initiate comprehensive technology transfer programs for agriculture energy research to agriculture producers, suppliers and users.
**USDA/REE ENERGY SCIENCE**

**PROGRAM FOCUS**

- **Renewable Energy**
  - Bio-Based Sources
  - Other Sources – Wind, Solar, Geothermal
- **Energy Efficiency and Sustainability**
  - Production Systems
  - Management Systems

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**USDA/REE ENERGY SCIENCE**

**RENEWABLE ENERGY PROGRAM**

<table>
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<tr>
<th>Focus Area</th>
<th>Inputs</th>
<th>Sources</th>
<th>Feedstocks</th>
<th>Conversion Processes</th>
<th>Products</th>
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<tr>
<td>Bio-based Resources</td>
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<td>Feedstocks</td>
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**USDA/REE ENERGY SCIENCE**

**ENERGY EFFICIENCY AND SUSTAINABILITY PROGRAM**

- **Production Systems**
  - Inputs
    - Fuels
    - Nutrients
    - Water
  - Practices
    - Precision farming
    - Plant breeding/genetic selection
    - Pest Management
- **Management Systems**
  - Material Handling
  - Building Design
  - Processing

---

**Working Together to Develop**

- Renewable Energy, Energy Efficiency & Sustainability

**National Renewable Energy Goals**

**Goal Areas**

- National Biomass Initiative
  - Biofuels – 60 billion gallons by 2030
  - Biopower – 15 quadrillion Btu by 2030
  - Bioproducts – 55 billion pounds by 2030

- President’s Biofuels Initiative
  - 30 x ‘30
  - Cellulosic ethanol – 30% gasoline displaced by 2020
  - Biogas – 10 billion Btu by 2020

<table>
<thead>
<tr>
<th>Goal Area</th>
<th>Approach</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| Biofuels – 60 billion      | Vision  | Goal: Adapted from BR&D – Biomass Research & Development Initiative
| gallons by 2030            | workshop| Biofuels | Vision to energy goals | National Biomass Initiative
| Biopower – 15 quadrillion | Consult | Goal: Biofuels | Biofuels goals | President’s Biofuels Initiative
| Btu by 2030               |          |          | Biofuels goals | President’s Biofuels Initiative
| Bioproducts – 55 billion   | Vision  | Goal: 30 x ‘30 | Ethanol goals | President’s Biofuels Initiative
| pounds by 2030            | workshop| Vision to energy goals | Bioproducts goals | President’s Biofuels Initiative

*Adapted from BR&D – Biomass Research & Development Initiative*
**ABBREE Process**

**to Establish Future Directions for USDA’s Energy Science and Education Programs.**

- Set Vision and Goals
- Establish Program Focus
- Build on Comparative Advantages
- Seek Input
- Conduct Workshop to Finalize Program Direction

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**Activities and Events (October 2006 – 2007)**

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<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>Sept. 2007</td>
<td>REE Energy Science &amp; Education Workshop: Vision, Goals, Programs</td>
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<tr>
<td>April – Sept</td>
<td>Seeking Additional Input and Developing Plans for Workshop</td>
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<tr>
<td>March/April</td>
<td>Seeking Input from Regional Associations</td>
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<tr>
<td>March</td>
<td>Budget Hearings Senate Ag Committee</td>
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<tr>
<td>FEB.</td>
<td>The BBCC Presents Vision and Goals for USDA Bioenergy Programs</td>
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<tr>
<td>FEB.</td>
<td>Input Sought on REE Energy Plan - ARS &amp; CSREES Admin. Councils</td>
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<td>FEB.</td>
<td>NAREEE Advisory Board - Energy Recommendations</td>
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<td>JAN.</td>
<td>USDA Budget Submitted with Request for Increase Funding for Energy</td>
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<td>JAN.</td>
<td>Energy Science &amp; Education Workshop Planning Committee Charged</td>
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<td>JAN. 2007</td>
<td>REE Agency Heads Engaged on REE Energy Science &amp; Education Plan</td>
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<tr>
<td>DEC.</td>
<td>Proposed Vision and Goals for REE Energy Program Developed</td>
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<td>NOV.</td>
<td>Established ABBREE Advisory Committee</td>
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<td>OCT. 2006</td>
<td>NAREEE Advisory Board - Focus - USDA Bioenergy Recommendations</td>
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