USDA Bioenergy/Biofuels R&D

• USDA has a long history of research, development, and deployment in:
  – Biomass, biobased products and bioenergy
  – Renewable energy for farms and ranches
  – Energy management and efficiency

VISION -

Agriculture and forestry as major providers of the Nation’s energy/fuel and industrial products and an agricultural sector less dependent on fossil fuels.
Energy Production through Agriculture - Capture carbon dioxide and convert solar energy to fuels and products

BIOMASS

- FUELS
- VALUABLE COPRODUCTS & BIOPRODUCTS
- CHEMICAL FEEDSTOCK

Tremendous opportunities for agriculture
Biofuels Legislation –
National Directions

**Energy Title IX 2002 Farm Bill**

- Established new programs and grants
- Reauthorized and broadened the bioenergy program

**Research Title 2007 Farm Bill**

Administration Proposed Title
Establish an Agricultural Bioenergy and Biobased Products Research Initiative with $500 million over 10 years to advance fundamental scientific knowledge for the improved production of renewable fuels and biobased products.

Other energy proposals are contained within the Energy, Conservation, and Rural Development titles.
USDA Bioenergy/Biofuels R&D

• Supports the President’s 20 in 10 initiative and goal.
• Develops and deliver feedstock production systems that are sustainable and competitive.
• Enables and improve commercial deployment of biomass conversion technologies.
• Supports infrastructure development through assistance to communities and businesses.
• Improves efficiency in agricultural and forestry operations.
• Supports education and outreach.
• Develops policy in support of bio-fuels and bio-products production and use.
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
    • Communication & Outreach
    • International Cooperation
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 Marion Buford (FS)

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

- Agricultural Marketing Service
- Agricultural Research Service
- Cooperative State Research, Education and Extension Service
- Farm Service Agency
- Foreign Agricultural Service
- Forest 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

Growing Energy and Opportunity in America – Linking Land Conservation, Innovation, and Value
Biofuels Legislation – National Directions

Biomass Research and Development Act 2000

The Biomass R&D Act directed the Departments of Energy and Agriculture to:

- Integrate their biomass R&D
- Create the Biomass Research and Development Board
- Establish the Biomass Research and Development Technical Advisory Committee (BTAC)
Biofuels Legislation –
National directions

Biomass Research and
Development Act 2000

BR&Di and BTAC coordinating efforts across all
Federal agencies to develop National strategy and
implementation plans

VISION

FOR BIOENERGY AND BIOBASED
PRODUCTS IN THE UNITED STATES

Bioeconomy for a Sustainable Future

2006
Desired Outcomes and Impact

- Improve national security and the U.S. balance of trade by reducing America’s dependence on imported petroleum.

- Help America transition to renewable sources of energy and other goods.

- Realize important environmental benefits such as reducing greenhouse gas emissions, increasing carbon sequestration, reclaiming unproductive lands, and rehabilitating unhealthy lands.

- Realize significant, new, sustainable (environmentally, economically and socially) economic opportunities for rural America.

- Realize secure sources of energy for rural America.
R&D Challenges/Opportunities

- Can we produce enough feedstocks?
  - Enhance productivity
  - Not disrupt markets
  - Avoid land-use competition

- Can we produce feedstocks sustainably?
  - Maintain ecological integrity
  - Enhance environmental values

- Can we make biofuels competitive?
  - Optimize agronomic and silvicultural systems
  - Innovative conversion and delivery technology deployment

- Can we enable a “Rural Renaissance?”
  - Transition to a bioeconomy – education, training, and outreach
  - Provide economic opportunities
  - Provide assistance
Complimentary Capabilities of A Nationwide Network

- **Forest Service (FS)** focuses on the production of woody biomass and its efficient conversion to bioenergy and bioproducts.

- **Rural Development (RD)** finances technologies needed to convert biomass into biobased products and bioenergy in a manner which is cost-competitive in large national and international markets.

- **Cooperative State Research, Education and Extension Service (CSREES)**, mobilizes the research resources of both small businesses and the nation’s higher-education community, especially the land-grant universities, to address the technical barriers associated with producing biomass feedstocks and converting them to biofuels and other bioproducts.

- **Economic Research Service (ERS)** develops and monitors key indicators of the agricultural system and rural communities, providing market analysis, developing projections of commodity supply, demand and retail food prices.

- **Agricultural Research Service (ARS)** the in house research are of the USDA focuses on the development, production and logistics associated with existing and new biomass feedstocks, and on their efficient and economic conversion to energy, fuel and other bioproducts.
USDA ARS Profile

- In-house Scientific research arm of USDA
- Farm-to-table research scope
- Information and technology transfer
- National Programs
- 1,100+ projects
- 2,500+ scientists
- 9,000 employees
- 100+ lab locations
- $1.1 billion annual budget (FY07)
- International collaboration
- Partnerships with universities and industry
- Stakeholder driven priority process
ARS Bioenergy Program

• Energy crop research
  – Developing new plant varieties for biofuels feedstocks

• Ethanol
  – Processing
  – Developing new microbes and enzymes for conversion
  – Developing valuable co-products from ethanol production

• Biodiesel
  – Processing
  – Quality and performance

• Other
  – Methane from manure
  – Thermo-chemical and biological conversion of biomass to hydrogen
  – On-farm and remote renewable energy systems
ARS Bioenergy/Bioproducts Research Locations

Conversion Processes:
- Biodiesel
- Ethanol
- Thermal
- Methane
- Citrus Waste

Regional Research Center
Feedstocks
On-Farm Systems
ARS Bioenergy Research - Starch Based Feedstocks

• Developing new eco-friendly processing

• Developing more energy efficient ethanol recovery/purification processes

• Broadening feedstock options (sorghum, barley)

• Developing & improving value-added coproducts (e.g., distillers grains, corn zein, corn fiber oil, corn fiber gum)
ARS Bioenergy Research - Biodiesel

• Producing biodiesel from animal fats and restaurant waste fats/oils

• Developed more efficient trans-esterification processes

• Developing new, value-added uses for glycerol, and other co-products

• Improving biodiesel quality and performance
  - storage stability
  - cold flow
  - combustion/emission characteristics
ARS Bioenergy Research-
Cellulose Based Feedstocks

- Determining the economic production cost feasibility of perennial herbaceous energy crops
- Characterizing and analysis of the switchgrass genome
- Modifying the genetics of switchgrass to enhance energy crop properties
- Developing energy cane for increased biomass yields
ARS Bioenergy Research-
Alfalfa as a viable cellulosic feedstocks

• Ubiquitous – can be grown nearly everywhere
• Production technologies are well established
• Well established industry

• Perennial plant
• Symbiotic with nitrogen fixing bacteria
• Lower production inputs

• Increases soil fertility, soil organic matter, and water penetration
ARS Bioenergy Research-
Alfalfa as a viable cellulosic feedstocks

ARS long been involved in alfalfa research for forages

• Genetics and genomics
• Disease resistance and stress tolerance
• Environmental stewardship and quality
• Feed quality and digestibility
• Biofuels and bioproducts
ARS Bioenergy Research - Cellulose Based Feedstocks – Cell Wall Initiative

• Elucidate cell wall molecular biology
  ❖ “designer” cell walls to dramatically improve ease of hydrolysis

• Germplasm collection and screening
  ❖ 20 gene banks throughout U.S.
    • 470,000 accessions
    • 11,700 species
    • 13,154 industrial crops accessions
Crop Residues Such as Corn Stover as a Major Source of Biomass

What are the consequences of residue removal? What type of management is needed?
Crop Residue Removal -
**Impact on Long Term Soil Productivity**

**Renewable Energy Assessment Project (REAP)**

- Residue needed to maintain soil function and sustain production
- Trade-off for residue use as bioenergy versus soil carbon feedstock
- Developing an algorithm to guide sustainable harvest of residue for biomass ethanol
- Developing management strategies for sustainable harvest of residue

Crop residues should not be considered wastes, and are necessary to maintain soil carbon levels required for soil sustainability. These studies will enable farmers and producers to calculate the amount of residue that can be safely removed for ethanol processing.

**National ARS effort: IA, IN, AL, NE, CO, OR, MN, ND, WA**
**ARS Bioenergy Research - Biochemical Conversion of Cellulose to Sugars**

**New enzyme discoveries**-

- Discovered the most active $\beta$-xylosidase enzyme for releasing sugars from biomass
- Discovered and patented two novel microbial enzymes for cellulose processing.
- Isolated and expressed fungal enzymes for biomass processing.
- Expressed a highly active xylanase enzyme in the fungus *Trichoderma reesei* used for producing industrial hydrolyases

**Advances in microbiology**-

- Creation of glucose resistant ethanolic microorganisms capable of using multiple sugars
- Novel application of *Lactobacillus plantarum* as biocatalyst for ethanol production
- Developed environmentally sensitive pretreatment of lignocellulose biomass

http://www.omniscellula.net/Material/images/bordons/fig3.jpg
Agricultural Research: key to food, fiber, feed and bioenergy security and natural resources stewardship.