Overview of U.S. Bioenergy and Recent Initiatives in the Americas

GBEP Bioenergy Week
Maputo, Mozambique
May 5-9, 2013

Kristen Johnson
Sustainability Technology Manager
Bioenergy Technologies Office
U.S. Department of Energy (DOE)
Overview

• National Drivers for Bioenergy
• Statistics on U.S. Biofuels Production
• U.S. Initiatives and Lessons Learned
  – Interagency cooperation
  – Commitment to sustainability
  – Scaling up innovative technologies
  – Regional approaches to bioenergy systems
  – Bilateral cooperation: U.S.-Brazil MOU
• Importance of International Engagement
• Conclusions
Increasing the use of bioenergy in the United States supports several national priorities:

- Dramatically reduce dependence on foreign oil
- Promote the use of diverse, domestic, and sustainable energy resources
- Establish an advanced bioindustry and create jobs
- Reduce carbon emissions from energy production and consumption
2013 U.S. Biofuel Production and Imports

U.S. Biofuel Production for the Renewable Fuel Standard in 2013
(million gallons ethanol equivalent)

- Conventional Renewable Fuel: 13,105
- Biomass-Based Diesel: 2,186
- Other Advanced Biofuel: 122
- Cellulosic Biofuel: 1

U.S. Biofuel Imports for the Renewable Fuel Standard in 2013
(million gallons ethanol equivalent)

- Conventional Renewable Fuel: 243
- Biomass-Based Diesel: 553
- Other Advanced Biofuel: 435
Multi-Decade Endeavor

Corn Ethanol
We did not get there overnight

- >11 years to reach 1 billion gallons/year
- +10 years to exceed 2 billion gallons/year
- Latest decade
  - From 2 billion gallons/year to nearly 14 billion gallons/year

Source: Renewable Fuels Association: http://ethanolrfa.org/pages/statistics

Alignment of federal policies, state policies, tax and other incentives facilitated introduction and significant industry investment:
http://www.afdc.energy.gov/fuels/laws/3252/US
Interagency Coordination on Bioenergy R&D

Biomass Research and Development Board

- Established by the Biomass Research and Development Act of 2000
- Composed of senior decision-makers from federal agencies and the White House
- Coordinates federal government bioenergy R&D efforts.

Biomass Research and Development Technical Advisory Committee (TAC)

- Provides recommendations on the implementation of the awards and the overall scope and focus of federal bioenergy R&D.

Approximately 30 representatives from industry, academia, research institutions, state and local agencies, and nongovernmental organizations.

http://www.biomassboard.gov
Objective: to understand and promote the positive economic, social, and environmental effects and reduce the potential negative impacts of bioenergy production activities.
**Objective:** Through targeted Research, Development, and Demonstration (RD&D), enable sustainable, nationwide production of advanced biofuels that will displace a share of petroleum-derived fuels, mitigate climate change, create American jobs, and increase U.S. energy security.

### Research, Development, and Demonstration at Increasing Scale

**Feedstock Supply**
Develop sustainable and affordable feedstock supply and efficient logistics systems.

**Conversion R&D**
Develop commercially viable technologies for converting feedstocks into liquid transportation fuels and products.

**Demonstration at Increasing Scale**
Validate integrated technologies at cost-shared pilot, demonstration, and pioneer scale facilities.

### Cross Cutting

**Sustainability**
Promote the positive economic, social, and environmental effects of bioenergy.

**Strategic Analysis**
Conduct market, policy, environmental, and other analyses to inform planning and decisions.
The Integrated Biorefineries Program manages a diverse portfolio of demonstration projects focused on the scale-up of biofuel production technologies from pilot- to demonstration- to pioneer-scale.

Projects utilize a broad spectrum of feedstocks and conversion techniques:

- Agricultural residues
- Algae
- Woody biomass
- Energy crops
- Municipal solid waste
- Vegetative and yard waste

For more information visit: [http://www.eere.energy.gov/biomass/integrated_biorefineries.html](http://www.eere.energy.gov/biomass/integrated_biorefineries.html)

Note: 4 I-Pilot Projects do not appear on this map.
**DOE-Supported Integrated Biorefinery Projects**

- **INEOS** initiated commercial operations in 2013.
- **POET** and **Abengoa** are currently under construction and due for completion in 2014.

**INEOS, Florida**
- Capacity: 8 million gallons per year of ethanol from residues and municipal solid waste

**Abengoa, Kansas**
- Capacity: 25 million gallons per year of ethanol from corn stover

**POET, Iowa**
- Capacity: 25 million gallons per year of ethanol from corn cobs
Challenges to Scaling up Innovative Technologies

• Technical, construction, operational, financial, and market risks
• Requires systematic development steps: R&D, lab-scale testing, and piloting before demonstration and pioneer scale

Biomass Key Challenges
- Reliable supply
- Consistent quality
- Affordable delivery

Pretreatment Key Challenges
- Biomass feeding
- Biomass sizing and moisture
- Solids handling
- Construction materials

Conversion Key Challenges
- Products yields
- Construction materials
- Catalysts
- Fermentation organisms

Product Key Challenges
- Separations
- Catalytic upgrading
- Recycle loops
Multiples new technology steps - equates to higher risk
Feeding solid biomass to reactors - continues to be a challenge
Commercially available, ‘off-the-shelf’ equipment does not necessarily integrate easily into new processes
Integrated pilot testing - has high value for new technologies
Energy projects have multi-decade time horizons...

Regional Approaches to Bioenergy Systems

Coordinated Agricultural Projects (CAP)

- 2010, 2012-13: 7 awards totaling ~$156 M over 5 years
- Regional partnerships
  - Academic, government, non-government, industry
- Develop entire supply chains
- Build on existing infrastructure and previous investments
- Integrate research, education, and extension/tech transfer
- Conduct robust sustainability analysis: impacts on economics, rural communities, and the environment
- Targeted feedstocks (perennial grasses, energy cane, sorghum, woody biomass, oil crops)
U.S.-Brazil Cooperation Frameworks

U.S. – Brazil MOU to Advance Cooperation on Biofuels

March/2007

March/2011

U.S.-Brazil Strategic Energy Dialogue

Biofuels RD&D

US DOE, EERE lead USDA

US State Dept

Brazilian Government Ministries:  Science, Technology and Innovation (MCTI); Mines and Energy (MME); Development, Industry and Foreign Trade (MDIC); Agriculture, Livestock and Supply (MAPA) -- led by the Ministry of External Relations
MOU-SED Activities

Participants reached a better understanding of each country’s capabilities and limitations in the production of biofuels

Collaborative RD&D Work: Petrobras – NREL, Includes IP
Facilitate technical, economic and sustainability assessment of biomass fast pyrolysis, followed by upgrading to gasoline, diesel, fuel oils, liquid petroleum gas (LPG)

Sharing Best Practices

Bilateral Activities

1. Biomass chemical characterization (NREL)
2. Technoeconomic analysis models (NREL), Lifecycle analysis methodology/GREET (ANL)
3. Biofuels sustainability (ORNL/ANL/NREL)

Global Activities

Harmonized Biofuels Standards (U.S.-Brazil-EC) NIST-INMETRO- ASTM
• Ethanol and biodiesel (2007 MOU)
• Aviation biofuels added (2011 SED)
Biomass Chemical Characterization (2010-2014)

USA (NREL) – Held methods training (2010), prepared homogeneous bagasse sample, conducted round robin analysis audit, and developed joint publication (http://www.nrel.gov/biomass/analytical_procedures.html)

Brazil – Participated in training, development of methods, supplied bagasse for reference material, and performed round robin analysis

Brazilian Biomass Characterization Network and NREL prepared a Brazilian Reference Material through this effort

Future analytical challenge: understanding cane straw composition and best use of this biomass for fuels, chemicals, or power.

Brazilian Participants
1. CENPES: R&D Center of Petrobras, Rio de Janeiro (RJ)
2. CTBE: Brazilian Bioethanol Science and Technology Lab., Campinas/ Ministry of Science, Technology and Innovation (MCTI)
3. CTC: Sugarcane Technology Center, Piracicaba (private sector)
4. EMBRAPA AGROENERGIA: Brazilian Company on Agronomy Research, Brasilia/MAPA
5. INT: National Institute of Technology (MCTI), RJ
6. IPEN: Institute of Nuclear and Energy Research, São Paulo
7. IQ/UNESP: Chemistry Inst., State University of São Paulo, Araraquara
8. EEL/USP: Engineering School, Lorena, University of São Paulo (USP)
9. IQSC/USP: Chemistry Inst., São Carlos, USP
10. INMETRO = National Institute of Metrology, Quality, and Technology, RJ/ Ministry of Development, Industry and Foreign Trade
Bilateral MOU: science-based sustainability data

**GHG Emission Savings (Mg CO₂eq saved/ha harvested)**

- **US AVG**
- **Natural Gas CHP**
- **corn stover CHP**
- **corn stover BIGCC**
- **corn stover CHP w/ CCS**
- **EtOH**
- **EtOH/e+**
- **EtOH/e+/sugar**
- **EtOH/e+ w/ CCS**

---

**Land Energy Productivity (GJ.bioenergy – GJ.fossil)/ha harvested**

- **Corn**
- **Sugarcane**

---

*AVG=average; CHP=combined heat and power; BIG=biomass integrated gasification; CCS=carbon capture and storage; EtOH=ethanol; e+ = electricity coproduction

*without GHG emissions from Land Use Change

A comparison of commercial ethanol production systems from Brazilian sugarcane and US corn

Helena L. Chum¹, Ethan Warner¹*, Joaquim E. A. Seabra² and Isaias C. Macedo²

Article first published online: 10 OCT 2013
DOI: 10.1039/bbb.1448

© 2013 Society of Chemical Industry and John Wiley & Sons, Ltd

Biofuels, Bioproducts and Biorefining
Volume 8, Issue 2, pages 205–223, March/April 2014
Bilateral MOU: Benchmarking the two countries’ industries

- Brazilian ethanol meets U.S. Advanced Biofuels threshold with 50% reduction of GHG emissions including Land Use Change

- Fuel ethanol industry in the US uses dry milling process primarily with natural gas and its environmental performance is improving with time.

Narrow industry performance range 25% to 75%
MOU Accomplishments and Take-Aways

• Sharing best practices
  – Visiting researchers and joint publications are very successful
  – Sharing models and tools for techno-economic, life-cycle, and sustainability analysis enable results that are broadly comparable
  – Identifying gaps in knowledge and jointly filling them with bilateral work
  – Benchmarking has enabled data-driven comparisons
  – Development of fuel standards for biofuels was greatly accelerated (still ongoing, principally for aviation biofuels)

• Direct RD&D where organizations in both countries hold intellectual property took longer to set up, but shows great promise of technology transfer between Brazil and U.S.
International Engagement

- Global Bioenergy Partnership
- International Energy Agency
- Intergovernmental Panel on Climate Change
- International Organization for Standardization
- SCOPE Bioenergy and Sustainability: Bridging the Gaps
- Roundtable on Sustainable Biomaterials
Oak Ridge National Lab: Cooperation in Selected Partner Countries

- Latin America Caribbean and Africa Project (LACAf), Global Sustainable Bioenergy project:
  - Guatemala, Colombia, Mozambique and Republic of South Africa
  - Issues of land-use change and resource assessment for sustainable production
- Global bioenergy crop modeling:
  - Collaborative research with partners from The Sao Paulo Research Foundation (FAPESP), University of Campinas and its Institute for Energy Policy Research (NIPE), & the Institute of Agronomy
  - Geospatial data analysis and modeling for global productivity
    - Pastures
    - Dedicated energy crops

http://www.fapesp.br/en/5570

1st-cut Global Biomass Productivity Analysis Based on Regression Models
Developing a Robust Bioenergy Economy

Depends on...

- Sound and stable policies
- Adequate capital investments
- Proven, effective technologies

Key Factors in U.S. Biofuel Development

- Considerable RD&D investment and supportive policies
- Public-private collaborations and risk-sharing
- Inter-agency coordination and collaborations
- International partnerships that enhance best practices, benchmarking, and trade
- Foundation of well-established industries (agriculture and forestry) where biofuel production represents one additional co-product
  - Ability to adjust output to respond to market signals
  - Resilience to unforeseen shocks (e.g., weather events)
  - Existing infrastructure (shipping, logistics, etc.)
  - Workforce with technology experience and know-how
Thank You
Kristen Johnson
kristen.johnson@ee.doe.gov
www.biomass.energy.gov
Back Up Slides
Useful Links

1. Bioenergy KDF: https://www.bioenergykdf.net/
Key Policy Driver – Renewable Fuel Standard (RFS)

- The Renewable Fuel Standard (RFS) sets aggressive goals for the use of renewable fuels:
  - 36 billion gallons of renewable fuels by 2022; 21 billion gallons of advanced biofuels that reduce GHG emissions by 50% relative to petroleum fuels.
  - No more than 15 billion gallons of conventional corn-based ethanol.
- Producers and importers of petroleum fuel are required to meet minimum annual blending requirements or purchase credits for renewable fuels from other entities.

![RFS Graph]

- The RFS and other policies have helped bring about an annual U.S. production of about 14 billion gallons of biofuel.
U.S. Climate Action Plan

In June 2013, President Obama released the Climate Action Plan:

1. Cut carbon pollution in America
   - Deploy Clean Energy Technologies
   - Build a 21st Century Transportation Sector
   - Develop and Deploy Alternative Transportation Technologies
     - Cut Energy Waste and Improve Efficiency
     - Reduce Other Greenhouse Gas Emissions

2. Prepare the United States for the Impacts of Climate Change

3. Lead International Efforts to Combat Climate Change and Prepare for its impacts.
Biofuels Area

- Incorporated 2007 Memorandum of Understanding to Advance Biofuels Collaboration:
  - Promote Energy Security
  - Reduce GHG Emissions
  - Expand Economic Development

- Implementation:
  - in the two countries (Bilateral R&D led by DOE/EERE);
  - expanded deployment in third countries; and
  - joint work with other countries to make biofuels global commodities (accelerate & harmonize biofuels standards)
An International Collaboration in Bioenergy

IEA Bioenergy’s vision is to achieve a substantial bioenergy contribution to future global energy demands by accelerating the production and use of environmentally sound, socially accepted and cost-competitive bioenergy on a sustainable basis.

The U.S. coordinates with other countries through a number of IEA Tasks, including:

**Task 33: Thermal Gasification of Biomass**
Members: Austria, Denmark, Finland, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, Switzerland, Turkey, USA

**Task 34: Pyrolysis of Biomass**
Members: Canada, Finland, Germany, UK, and USA

**Task 38: Climate Change Effects of Biomass and Bioenergy Systems**
Members: Australia, Austria, Belgium, Brazil, Finland, Germany, the Netherlands, Sweden, USA

**Task 39: Commercializing Conventional and Advanced Liquid Biofuels from Biomass**
Members: Australia, Austria, Brazil, Canada, Denmark, Finland, Sweden, Germany, Japan, South Korea, the Netherlands, New Zealand, Norway, South Africa, Sweden, USA

**Task 40: Sustainable International Bioenergy Trade – Securing Supply and Demand**
Members: Austria, Belgium, Brazil, Canada, Denmark, Finland, Germany, Italy, Japan, The Netherlands, Norway, Sweden, UK, USA

**Task 43: Biomass Feedstocks for Energy Markets**
Members: Australia, Canada, Denmark, Finland, Germany, Ireland, Italy, New Zealand, Norway, Sweden, UK, USA

_for more information, please contact:_

Secretariat: Pearse Buckley (pbuckley@odbtbioenergy.com)
Executive Committee Chair: Paul Grabowski (Paul.Grabowski@ee.doe.gov)