U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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

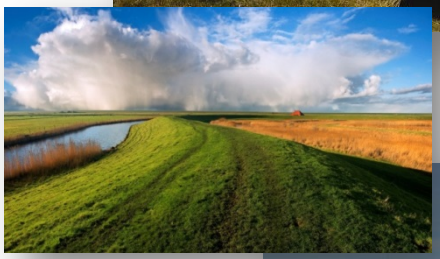
GBEP Bioenergy Week
Maputo, Mozambique
May 5-9, 2013

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



POET-DSM Project LIBERTY, Emmetsburg, Iowa

National Drivers for Bioenergy

Increasing the use of bioenergy in the United States supports several national priorities

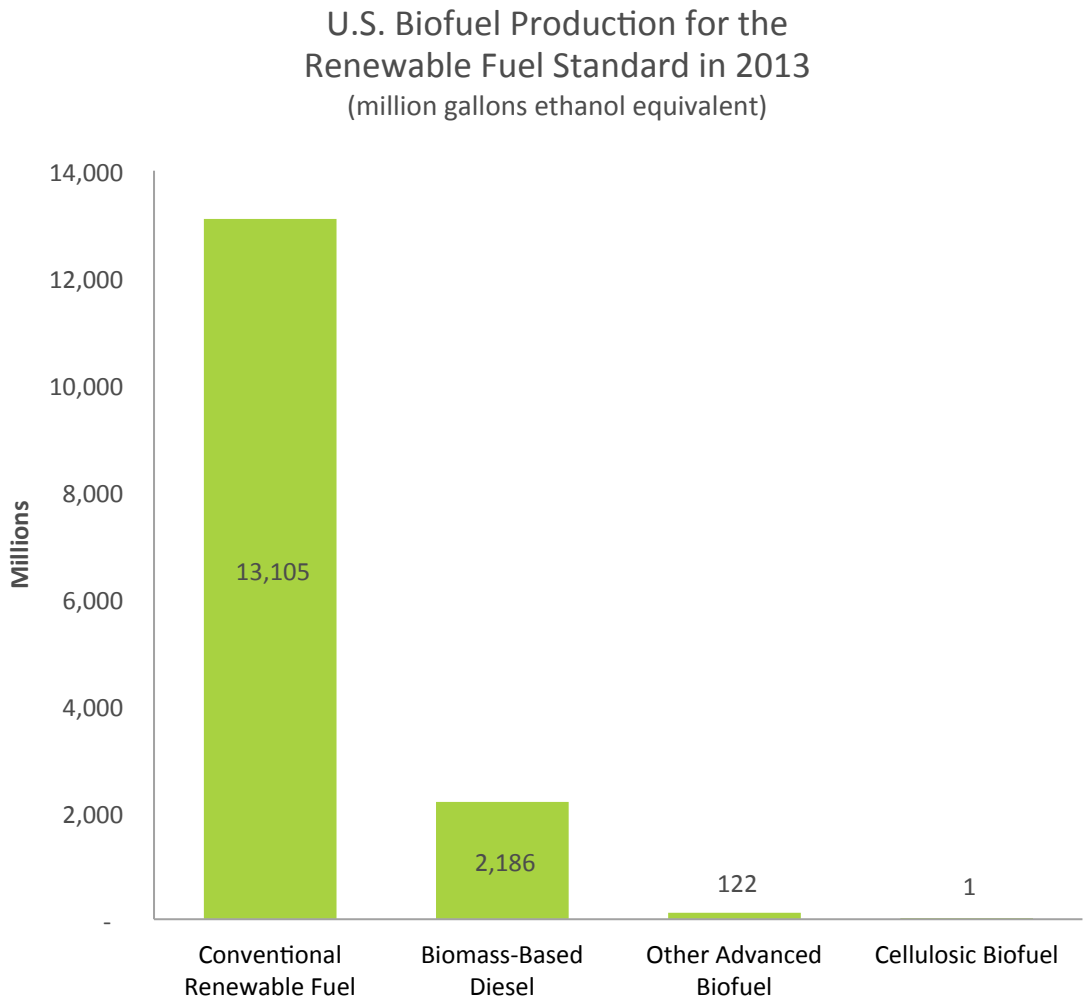
Dramatically reduce dependence on foreign oil

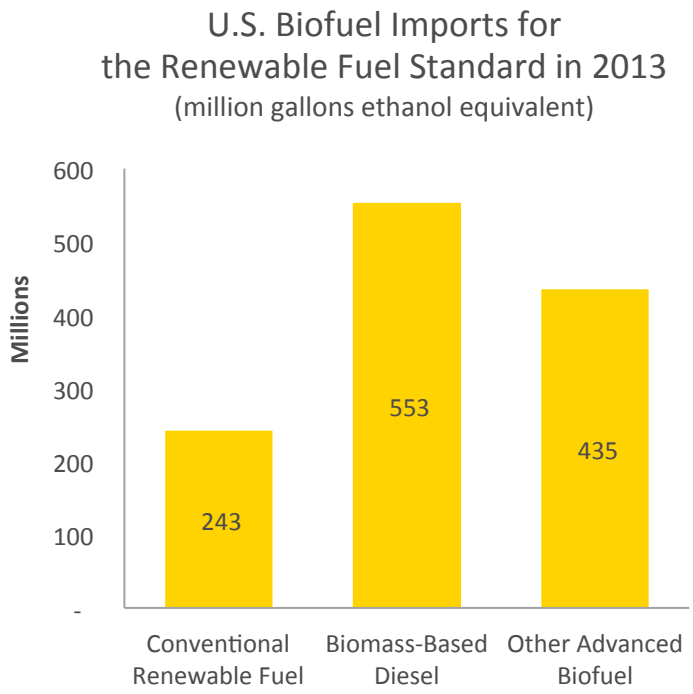
Promote the use of diverse, domestic, and sustainable energy resources

Establish an advanced bioindustry and create jobs

Reduce carbon emissions from energy production and consumption

2013 U.S. Biofuel Production and Imports

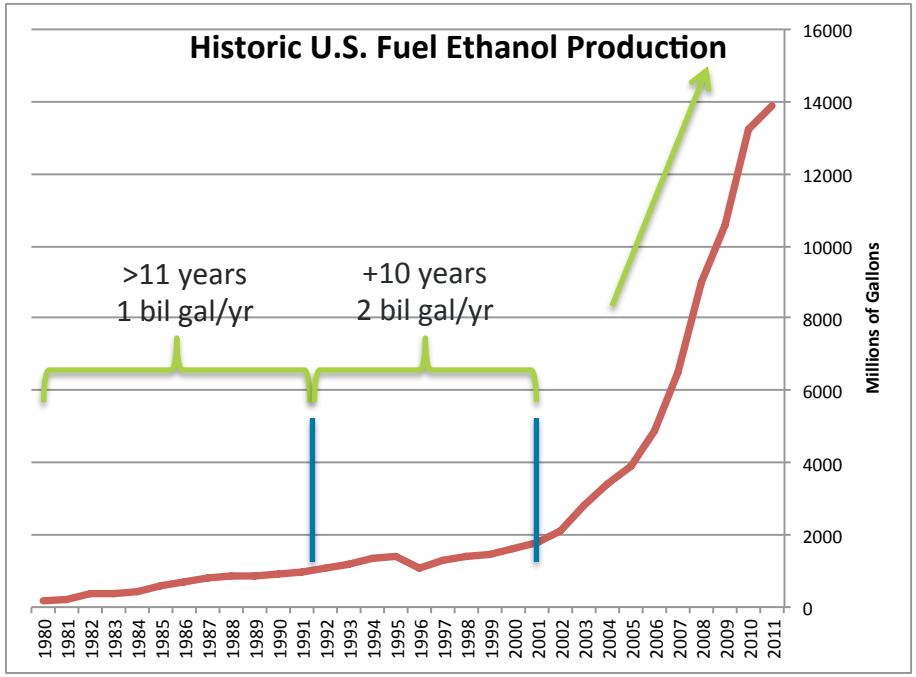




Multi-Decade Endeavor

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

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

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

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)

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

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

http://www.biomassboard.gov

Commitment to Sustainability

Objective: to understand and promote the positive economic, social, and environmental effects and reduce the potential negative impacts of bioenergy production activities.

Advanced Bioenergy Supply Chain

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.

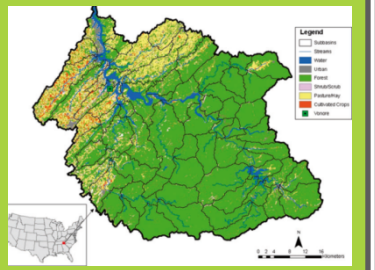
Demonstration at Increasing Scale

Validate integrated technologies at cost-shared pilot, demonstration, and pioneer scale facilities.

Cross Cutting

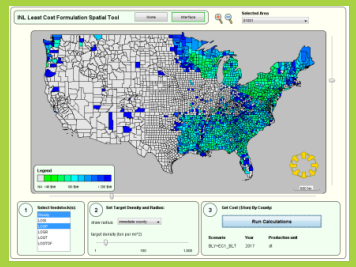
Sustainability

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



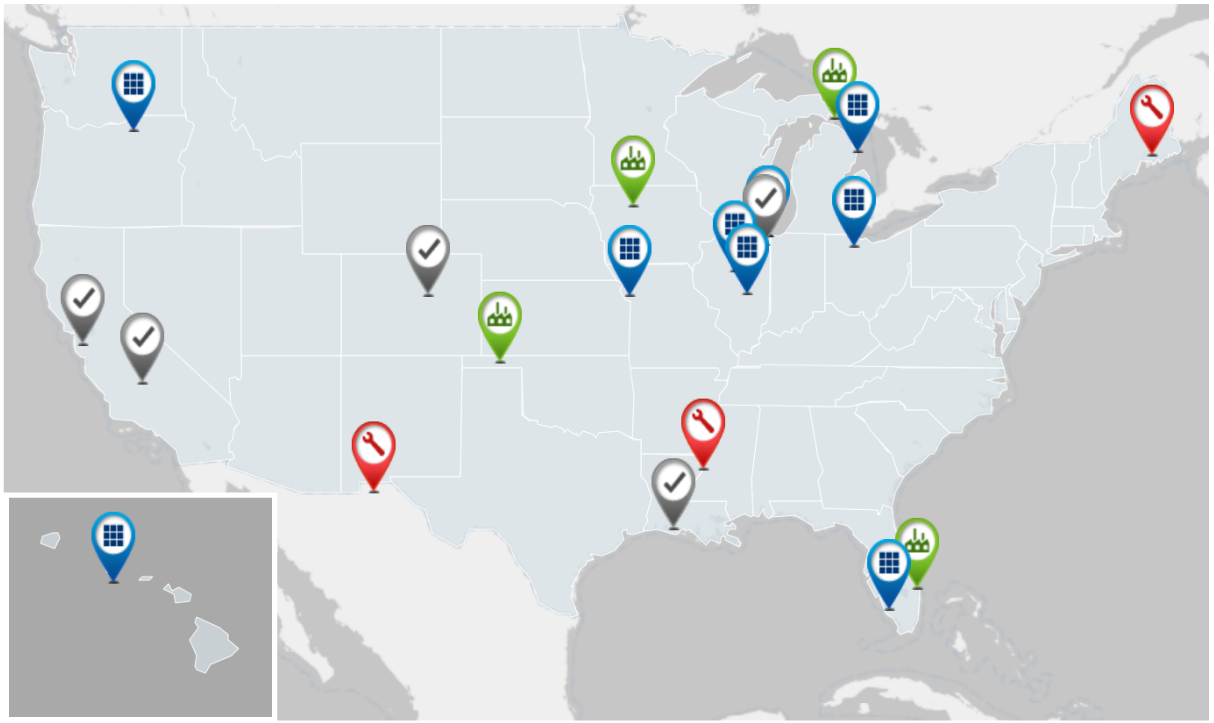
Strategic Analysis

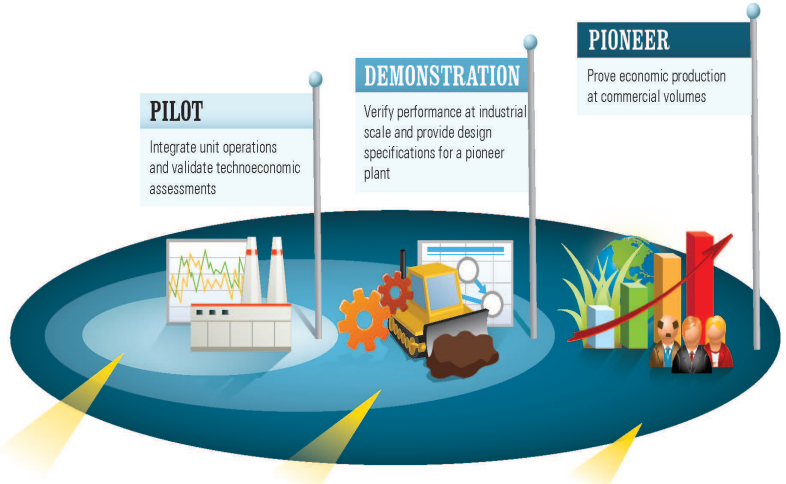
Conduct market, policy, environmental, and other analyses to inform planning and decisions.



DOE-Supported Integrated Biorefinery Projects

- 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





Pioneer

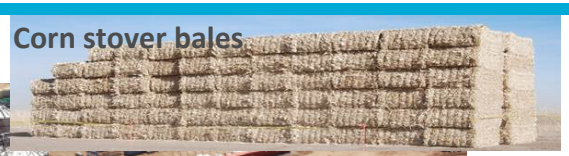
Demonstration

Pilot

For more information visit:
http://www.eere.energy.gov/biomass/integrated_biorefineries.html

Note: 4 I-Pilot Projects do not appear on this map

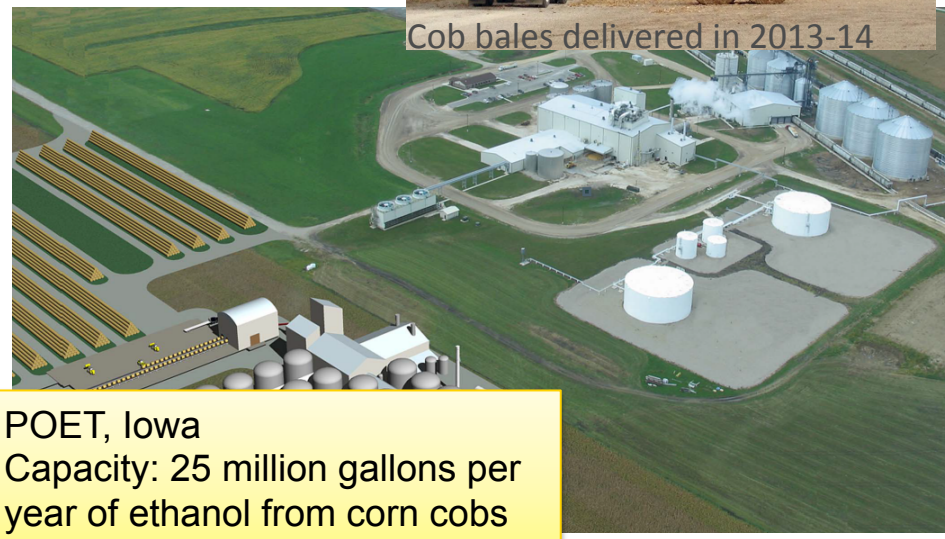
DOE-Supported Integrated Biorefinery Projects



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

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

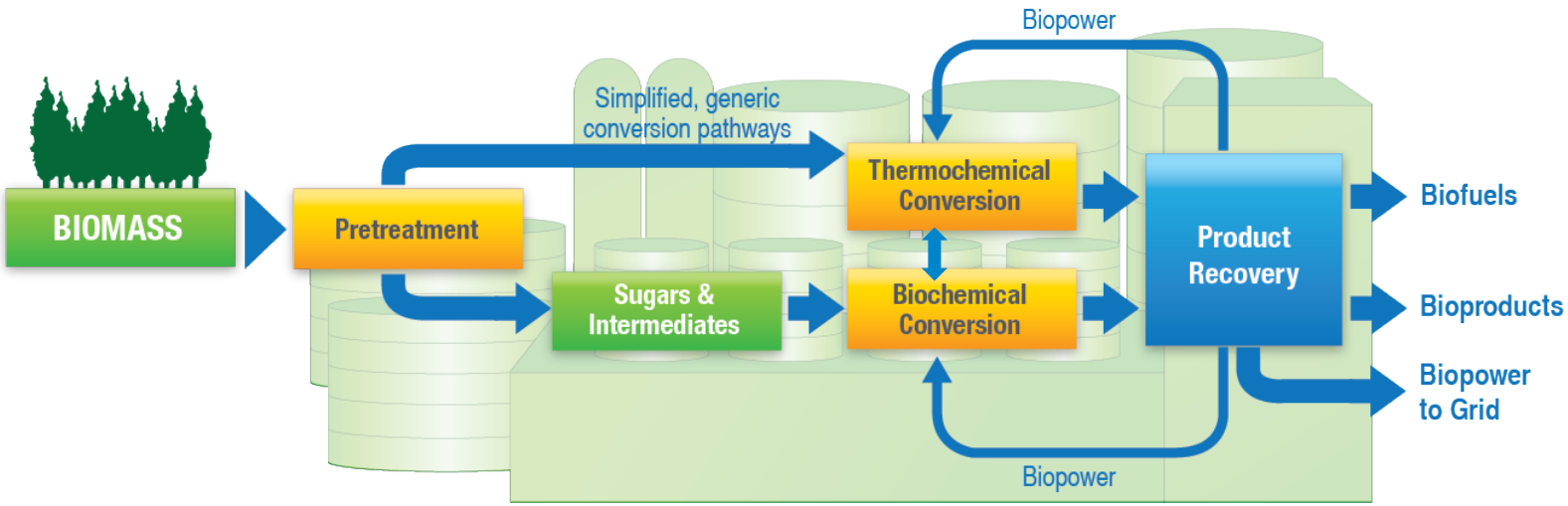
INEOS, Florida
Capacity: 8 million gallons per year of ethanol from residues and municipal solid waste



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	Pretreatment Key Challenges	Conversion Key Challenges	Product Key Challenges
• Reliable supply • Consistent quality • Affordable delivery	• Biomass feeding • Biomass sizing and moisture • Solids handling • Construction materials	• Products Yields • Construction materials • Catalysts • Fermentation organisms	• Separations • Catalytic upgrading • Recycle loops

Scaling up Innovative Technologies: Lessons Learned

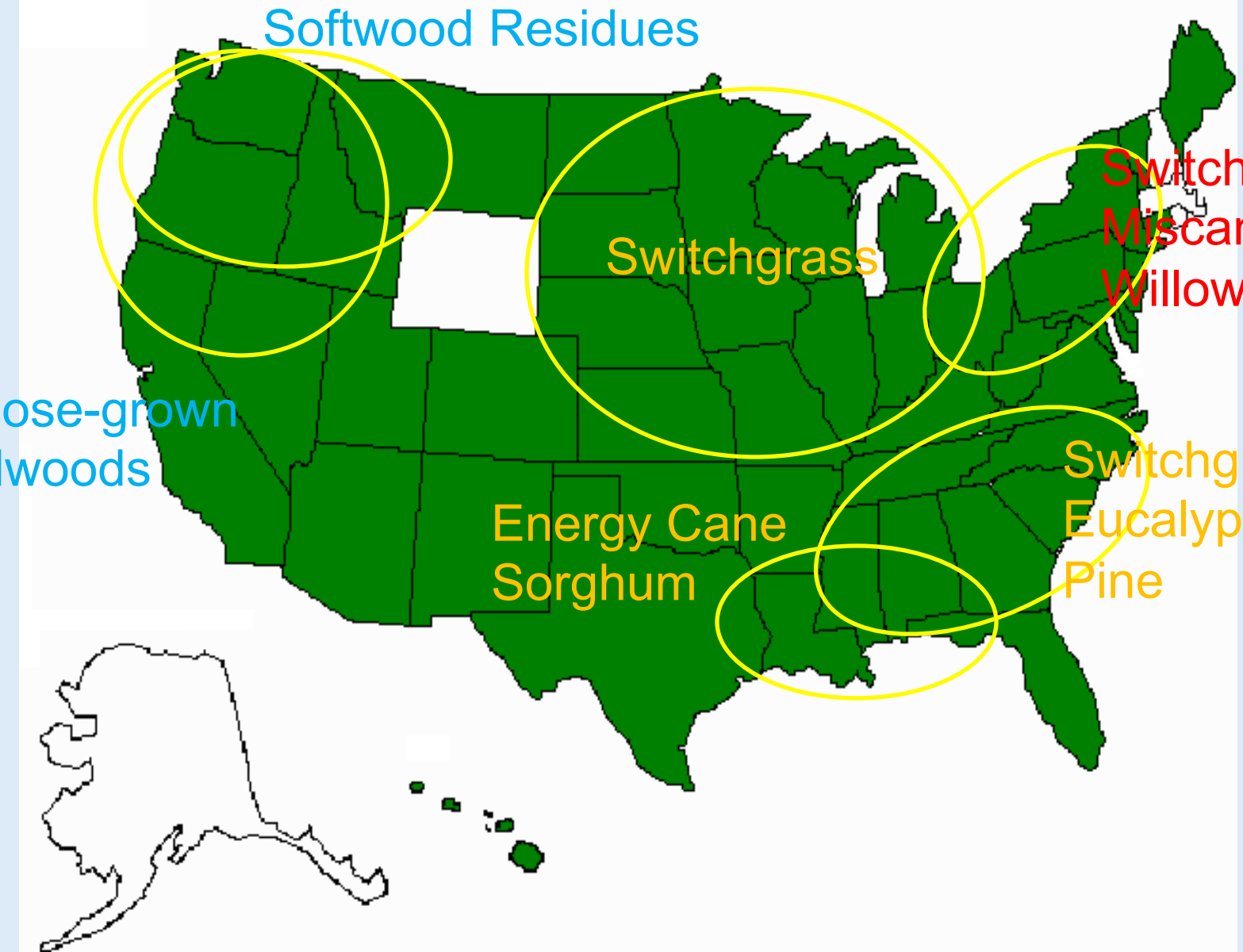
- **Multiple new technology steps -** equates to higher risk [1]
- **Feeding solid biomass to reactors -** continues to be a challenge [1]
- Commercially available, **'off-the-shelf'** equipment does not necessarily integrate easily into new processes [1]
- **Integrated pilot testing -** has high value for new technologies [1]
- Energy projects have **multi-decade time horizons …**[2]

1 - Quantitative Assessment of R&D Requirements for Solids Processing Technology. E .W. Merrow (1986) R-3216-DOE/PSSP
2 – Koonin S, Gopstein A, *Accelerating the Pace of Energy Change*, Issues in Science and Technology, Dec 2010

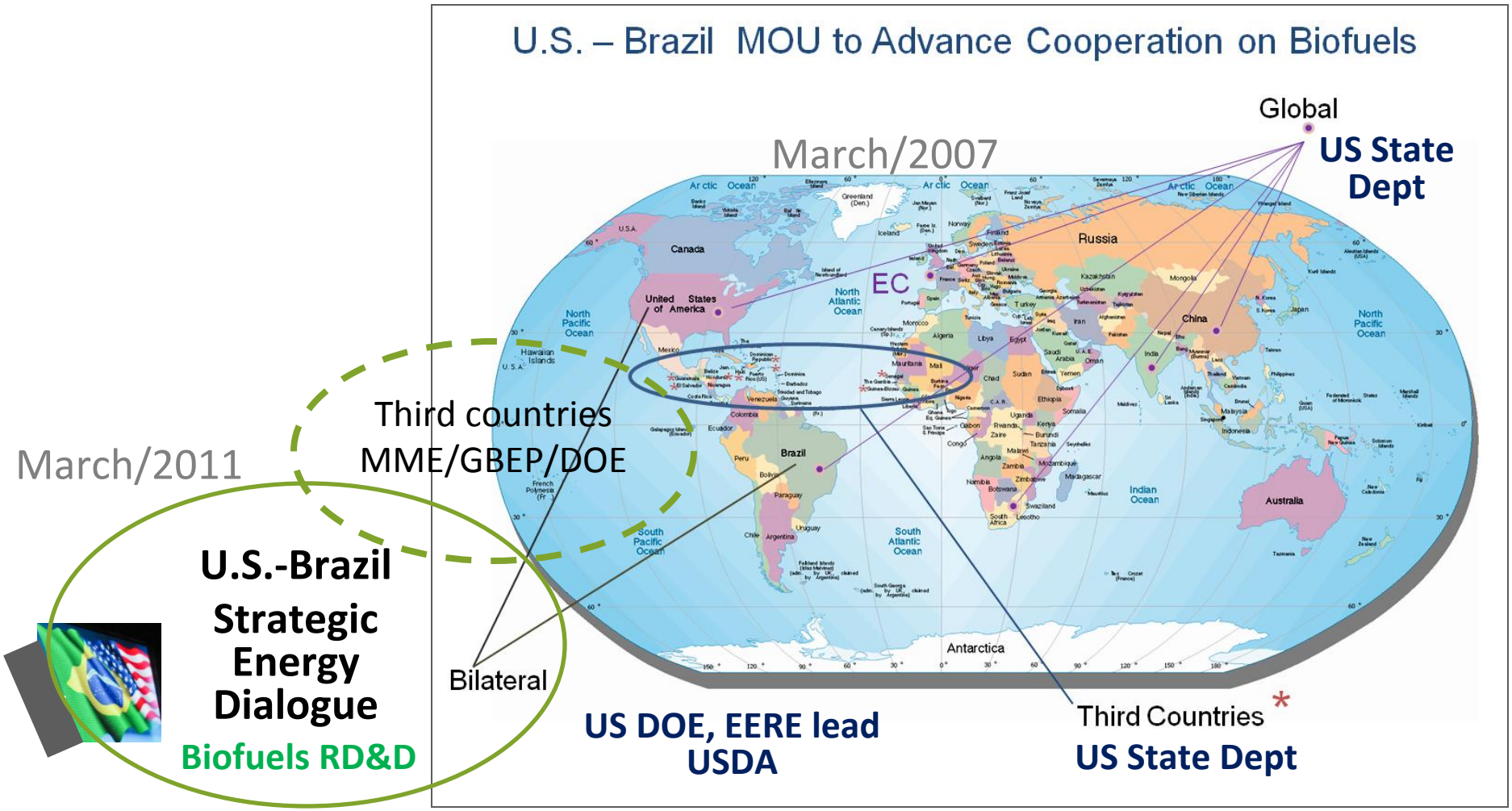
Regional Approaches to Bioenergy Systems

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)


Softwood Residues
Switchgrass
Switchgrass
Miscanthus
Willow
Purpose-grown
Hardwoods
Energy Cane
Sorghum
Switchgrass
Eucalyptus
Pine

U.S.-Brazil Cooperation Frameworks



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

Sharing Best Practices

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

Dedini CTBE Usina da Pedra

U.S. Delegation (DOE, USDA) in Brazil, May 30-June 6, 2008

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)

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

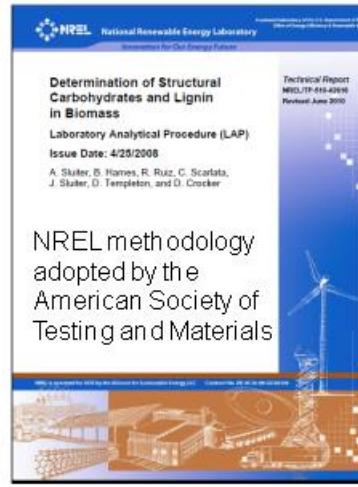
- Ethanol and biodiesel (2007 MOU)
- Aviation biofuels added (2011 SED)

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

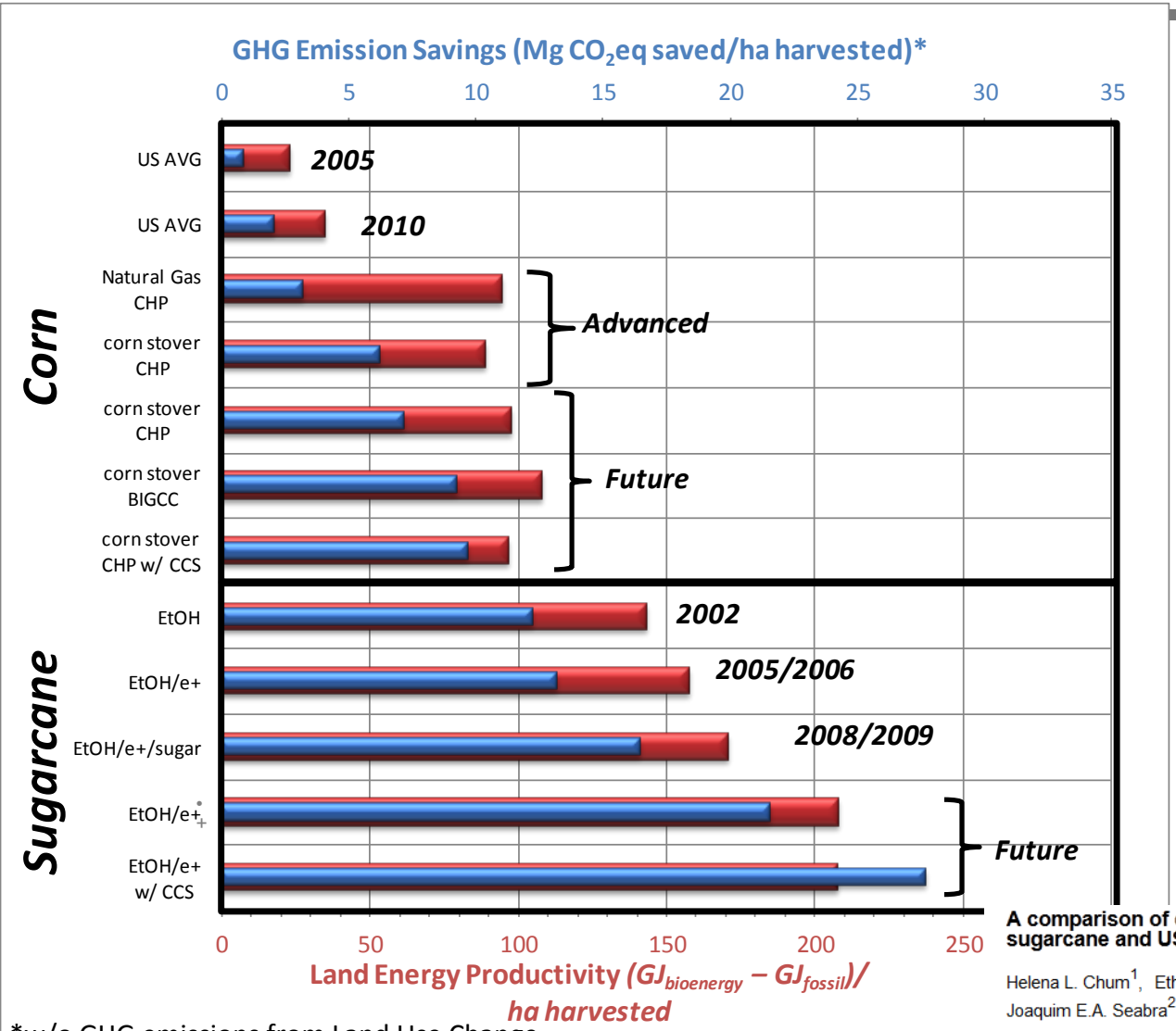


Future analytical challenge: understanding cane straw composition and best use of this biomass for fuels, chemicals, or power.

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

http://ts.nist.gov/measurementservices/referencematerials/index.cfm

Bilateral MOU: science-based sustainability data



*w/o GHG emissions from Land Use Change

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

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

Helena L. Chum[1], Ethan Warner[1,*], Joaquim E.A. Seabra[2] and Isaias C. Macedo[2]

Article first published online: 10 OCT 2013

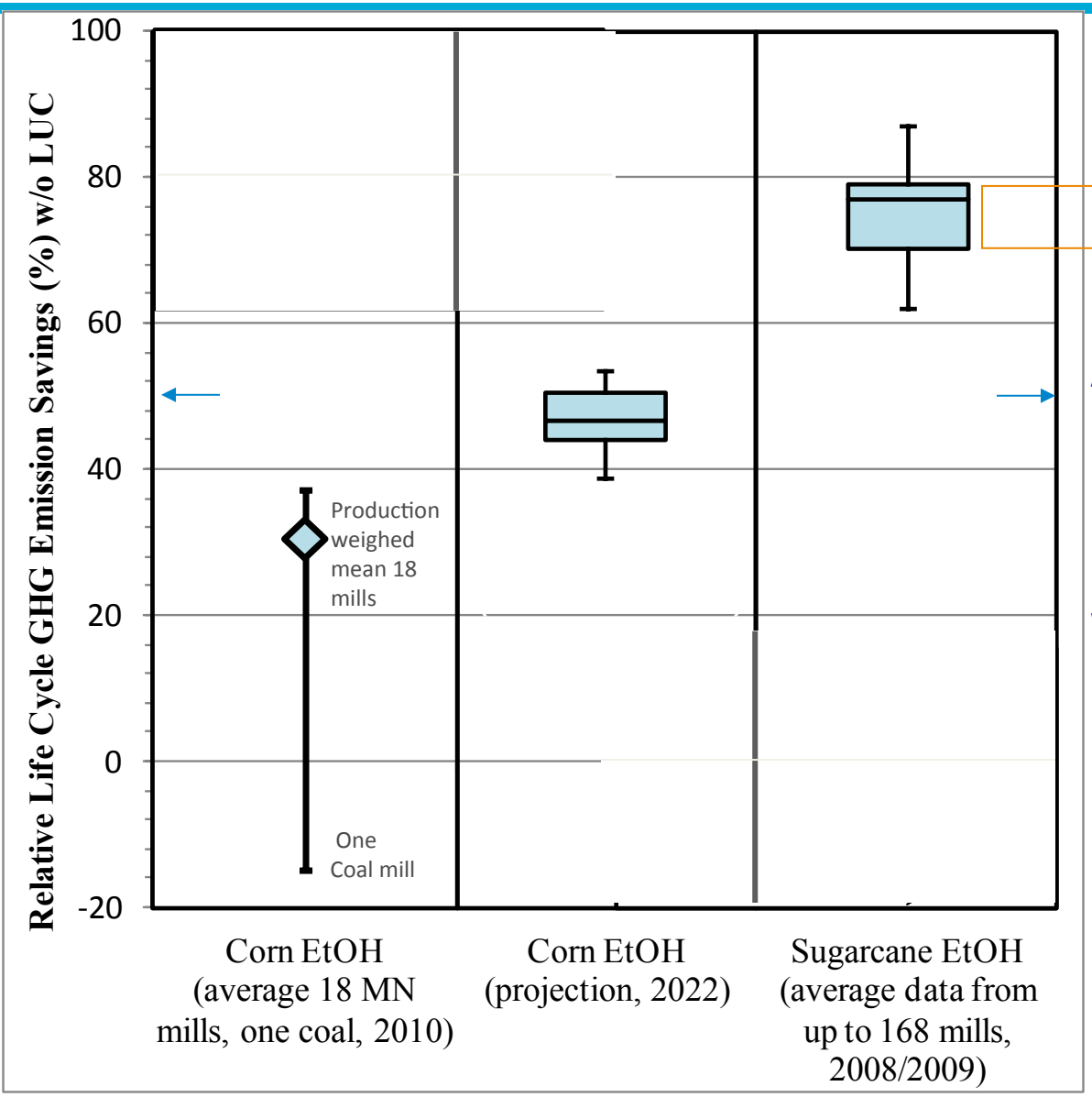
DOI: 10.1002/bbb.1448

Issue

Biofuels, Bioproducts and Biorefining

Volume 8, Issue 2, pages 205–223, March/April 2014

Bilateral MOU: Benchmarking the two countries' industries



Narrow industry performance range 25% to 75%

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

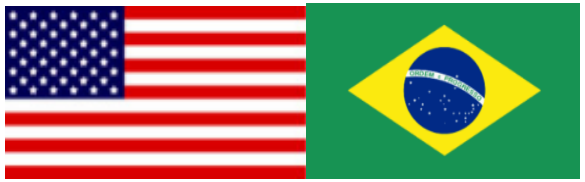
- Fuel ethanol industry in the US uses dry milling process primarily with natural gas and its environmental performance is improving with time.

Biofuels, Bioproducts and Biorefining

Volume 8, Issue 2, pages 205–223, March/April 2014

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.

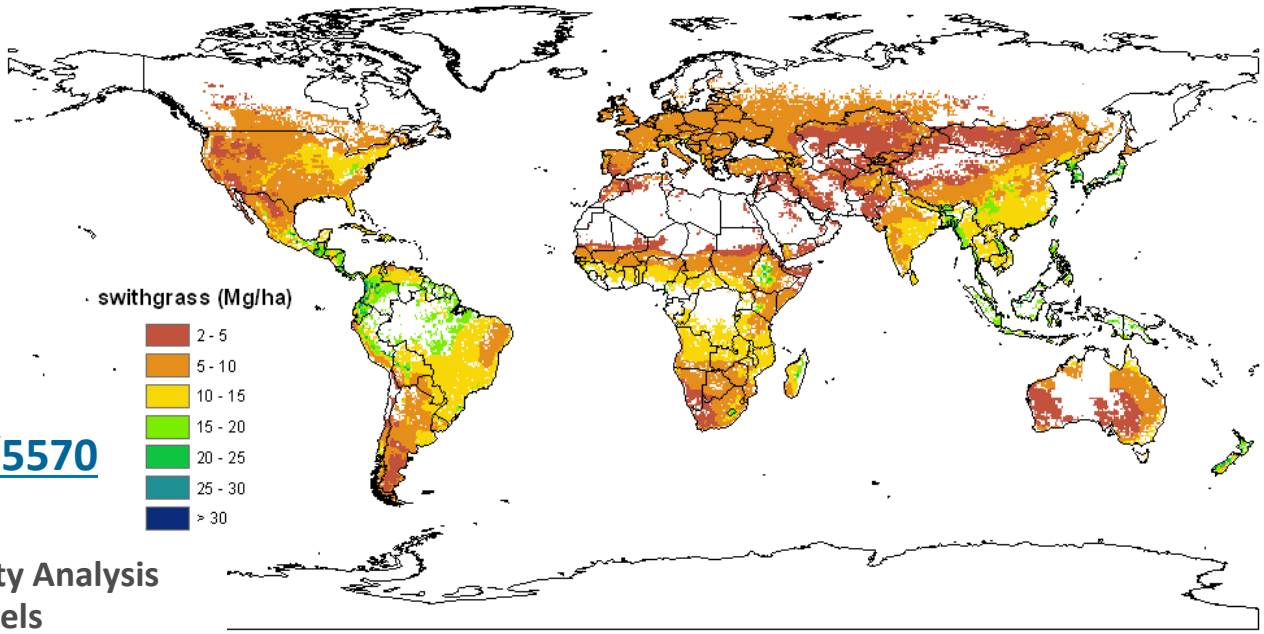


International Engagement

- 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



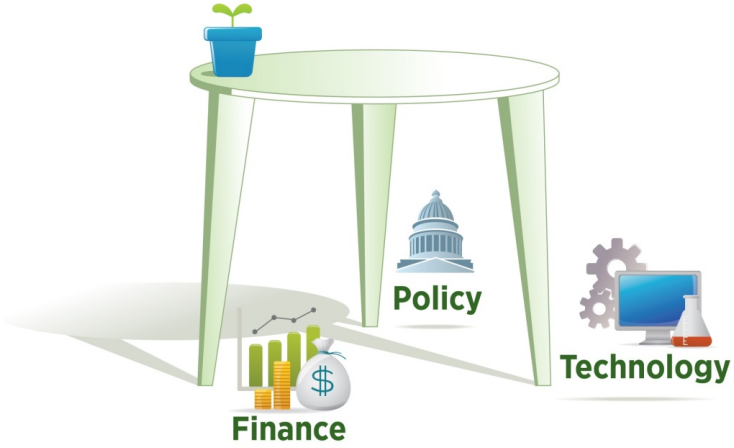
http://www.fapesp.br/en/5570

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

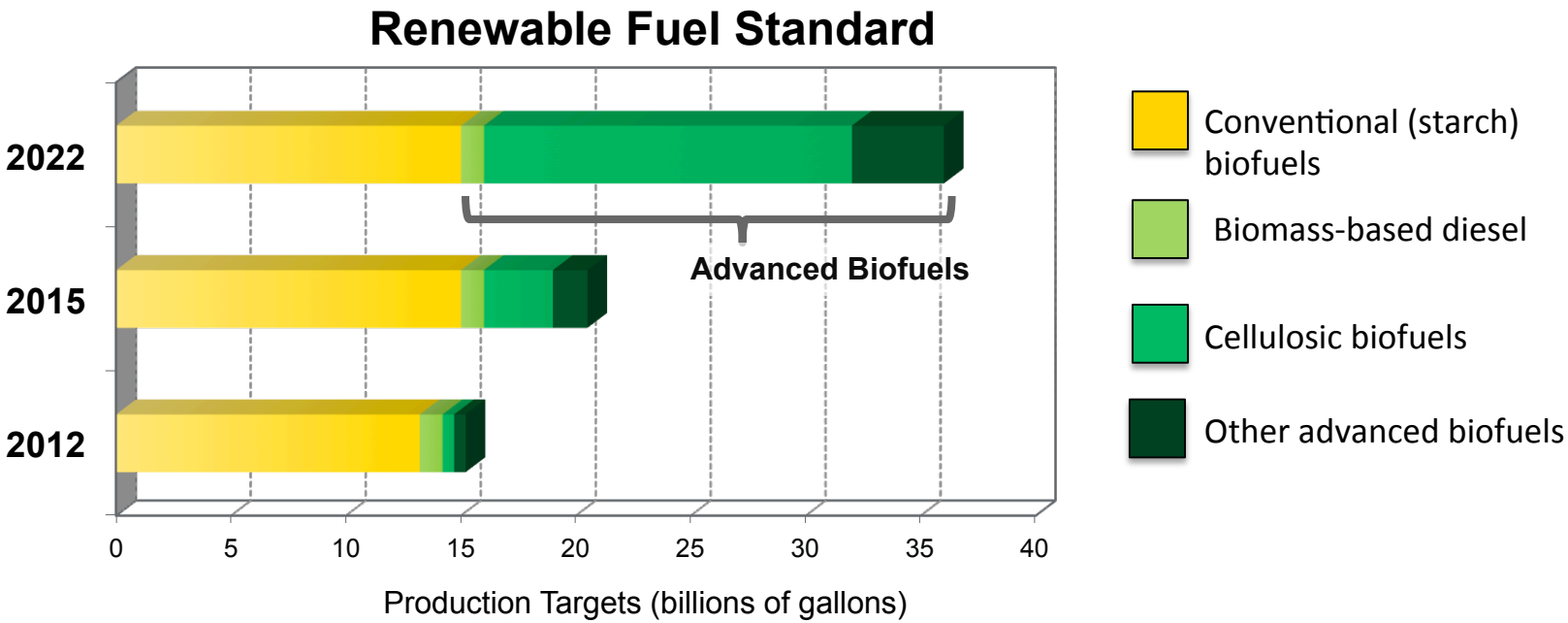
Back Up Slides

Useful Links

1. Bioenergy KDF: https://www.bioenergykdf.net/
2. Biomass R&D Board: http://www.biomassboard.gov/
3. DOE Bioenergy News and Announcements: http://www1.eere.energy.gov/bioenergy/news.html
4. Biomass 2014: http://www1.eere.energy.gov/bioenergy/biomass_2014.html

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.



- 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.

The 2011 U.S.-Brazil Strategic Energy Dialogue (SED)

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)

International Energy Agency (IEA)

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.

International Energy Agency

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)

IEA Bioenergy