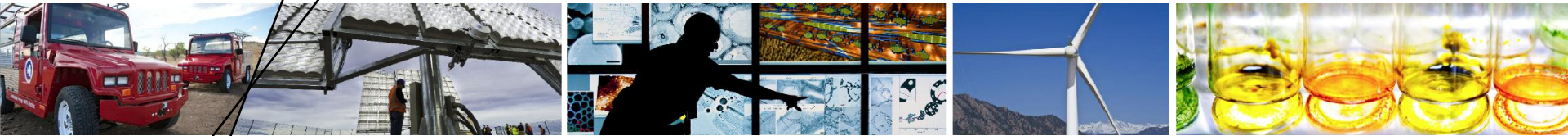


U.S. and Brazil Bilateral Collaboration on Biofuels



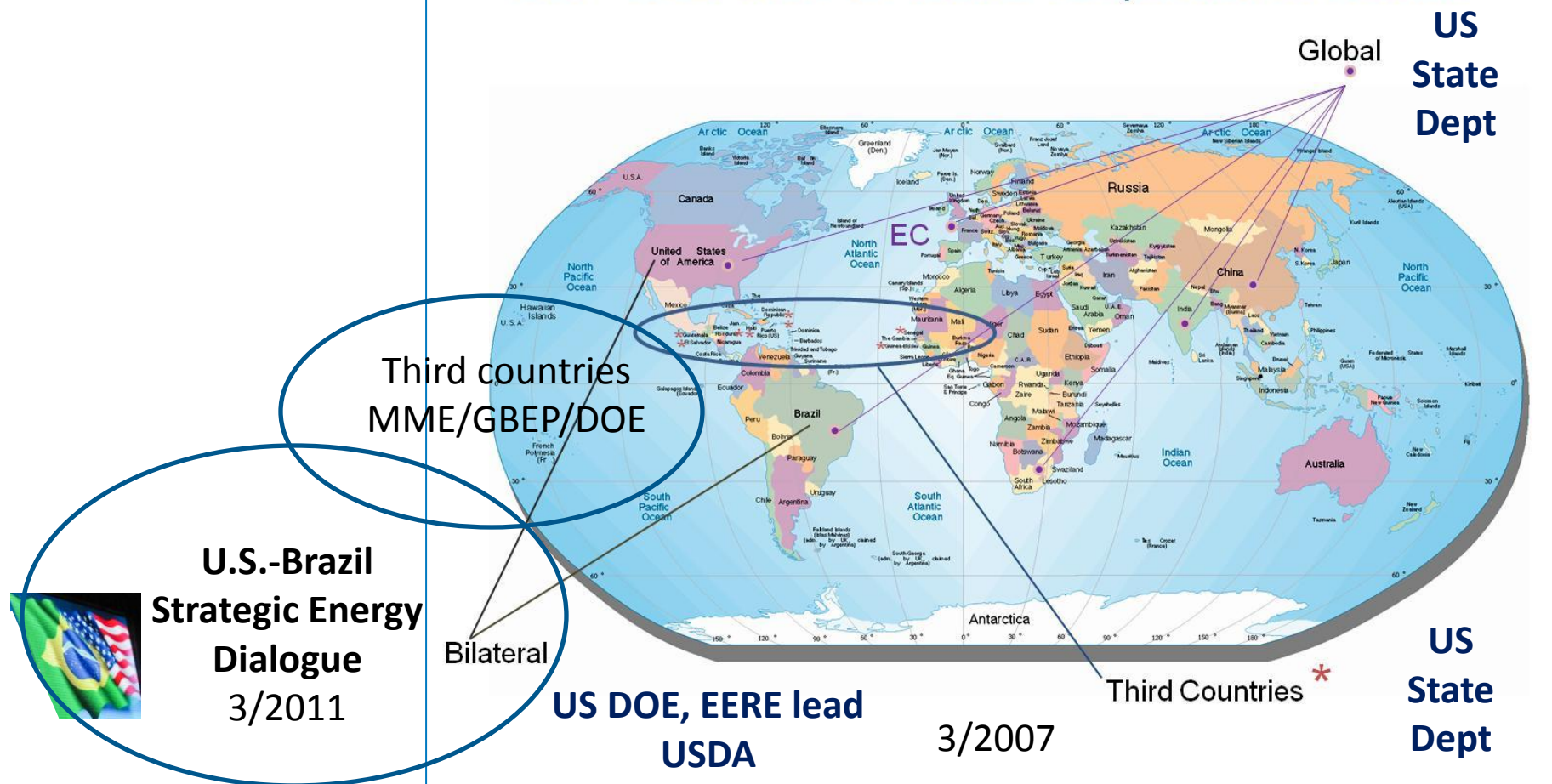
**Global Solutions for Global Challenges:
International Collaborations to
Advance Bioenergy Research**

Helena Chum, NREL Research Fellow
Helena.Chum@nrel.gov

December 5, 2012

Cooperation Frameworks

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

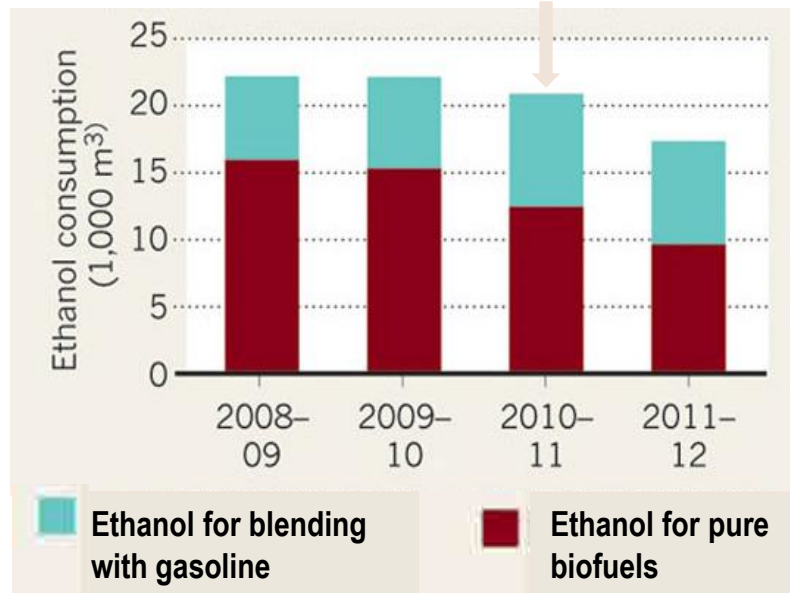


Brazilian governmental Ministries: Science, Technology and Innovation (MCTI); Mines and Energy (MME); Development, Industry and Foreign Trade (MDIC); Agriculture, Livestock and Supply (MAPA) led by the Department of Energy of the Ministry of Foreign Relations

Industry in the two countries: 2007-2011

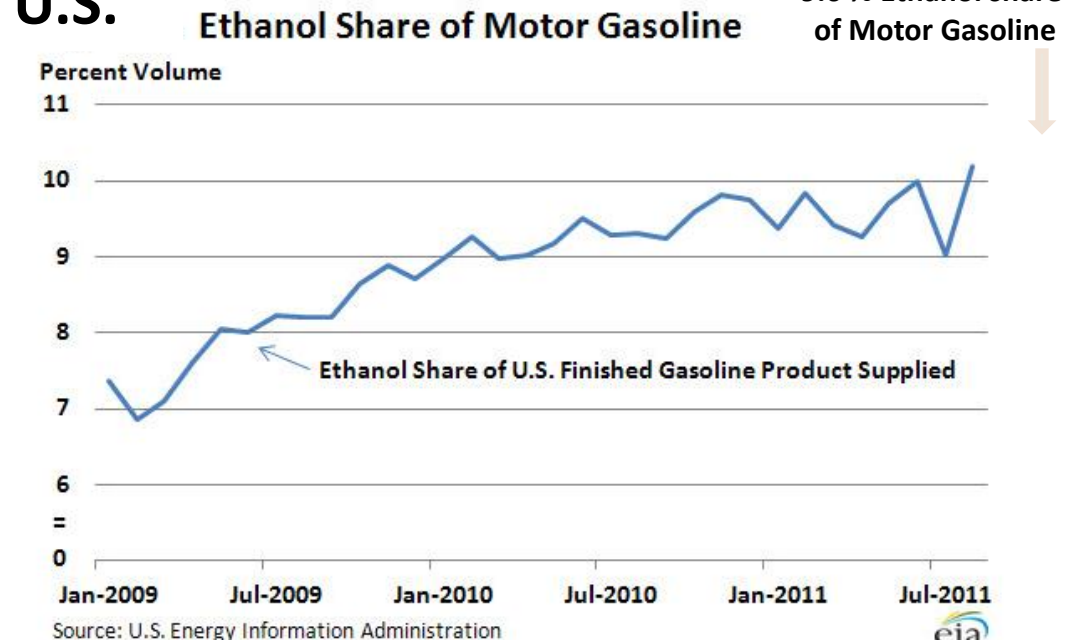
- **2007 global MOU goal:** work towards biofuels becoming global commodities to reduce imported petroleum, increase economic development and Western Hemisphere energy security. Brazilian and U.S. mills produced 5.3 and 6.5 Bi gal, respectively.
- **2011 Brazil and U.S. ethanol production globally traded -- start of commoditization:**
 - U.S. industry imported 0.2 Bi gal from Brazil - meet the EPA volumetric target
 - U.S. overcame blend wall by exporting 1.2 Bi gallons to: Brazil to offset bad weather and global sugar temporary shortage; Canada; EU meeting, 15+ nations

Brazil



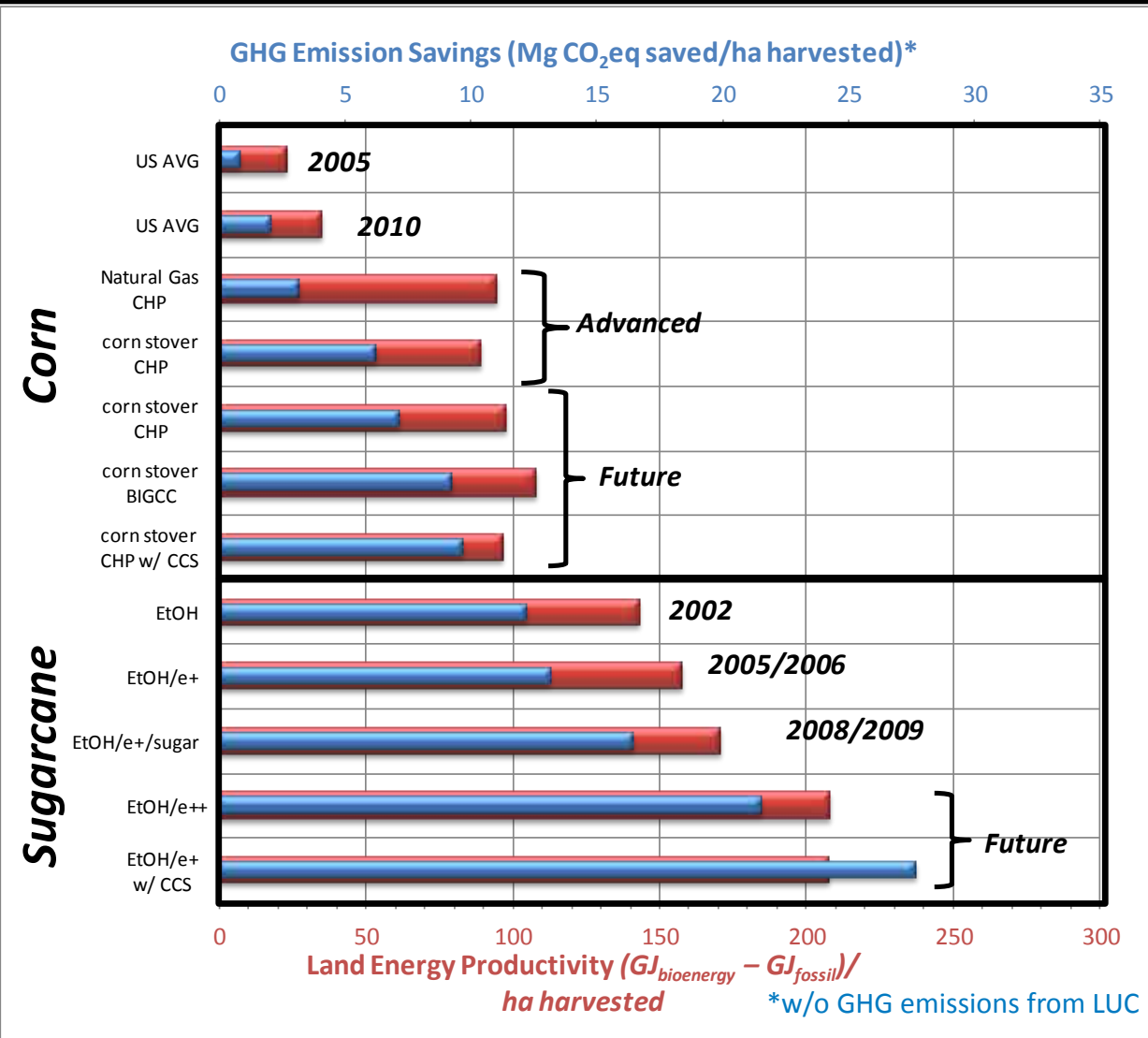
Nature, **491**, 646–647, 11/29/2012,
DOI: doi:10.1038/491646a

U.S.



EIA, Biofuels Issues and Trends, October 2012,
<http://www.eia.gov/biofuels/issuestrends/pdf/bit.pdf>

Benchmarking the two countries' industries

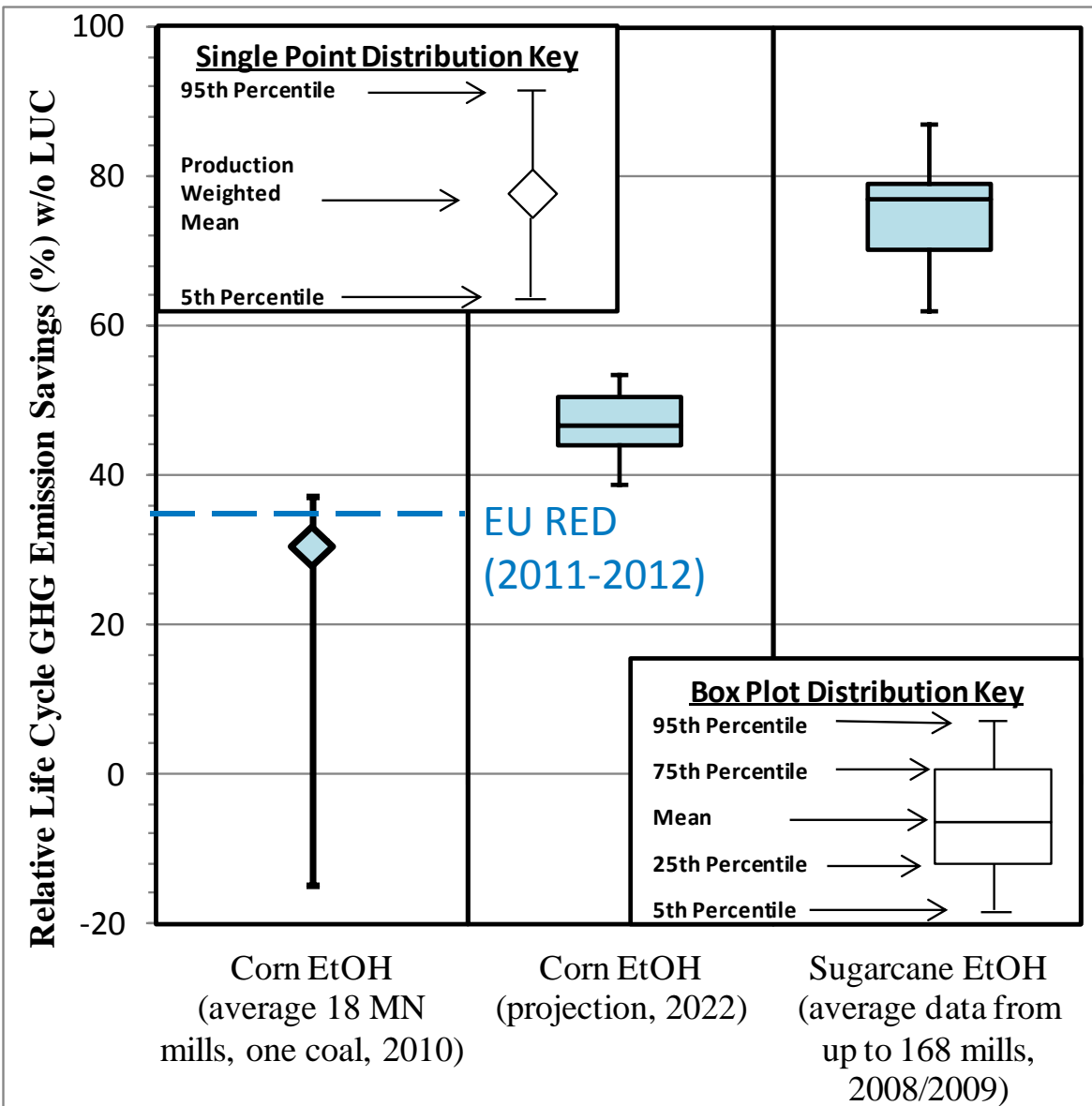


Bilateral MOU:
science-based sustainability data



A Comparison of Commercial Ethanol Production Systems from Brazilian Sugarcane and U.S. Corn – H. Chum, E. Warner NREL and J.E.A. Seabra and I.C. Macedo (UNICAMP, Brazil). Submission to BioFPR

Benchmarking the two countries' industries



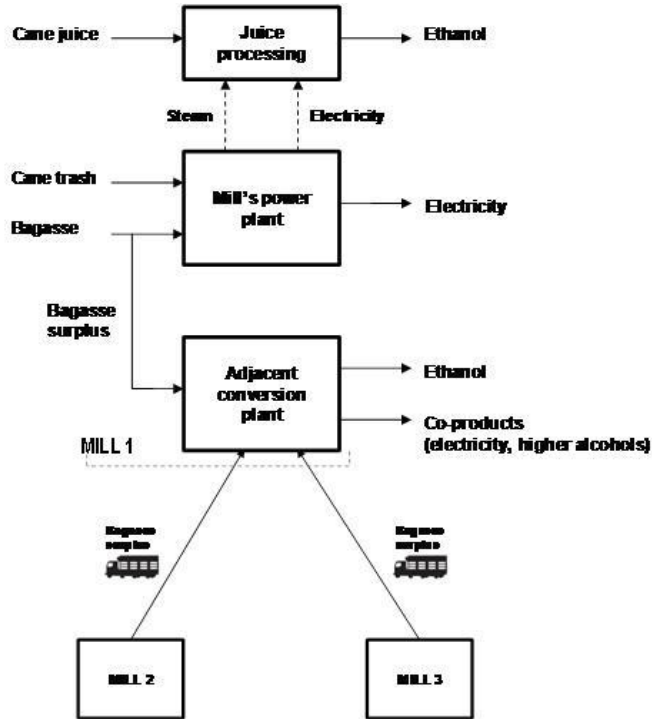
50% mechanized harvest
in Center South Brazil in
2008/2009; ~100% by 2020

EPA: Brazilian ethanol meets
Advanced Biofuels threshold with
50% reduction of GHG emissions
including Land Use Change

U.S. dry mills with energy efficient
technologies meet EU RED 35%

Scenarios for bagasse ethanol production by 2020

6-mo Postdoc Fellow Joaquim Seabra at NREL



Continued work:
NREL/CTBE/UNICAMP continue
collaboration Aspen+ Modelling
best practices and integration

BIOMASS AND BIOENERGY 34 (2010) 1065–1078



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<http://www.elsevier.com/locate/biombio>



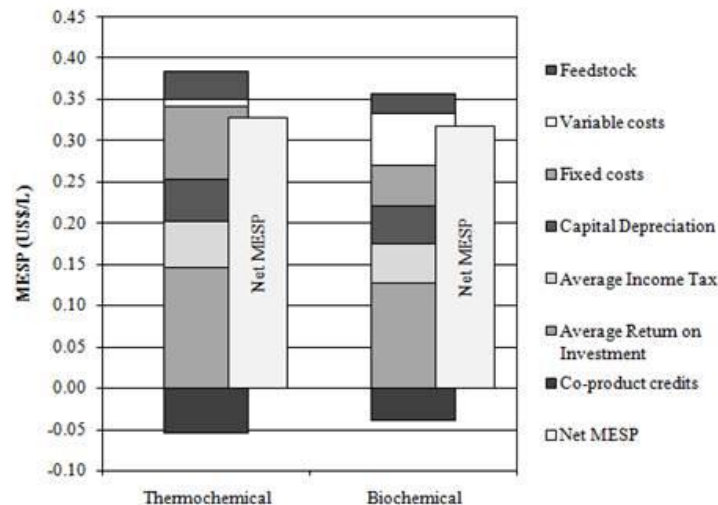
A techno-economic evaluation of the effects of centralized cellulosic ethanol and co-products refinery options with sugarcane mill clustering

Joaquim E.A. Seabra ^{a,*}, Ling Tao ^a, Helena L. Chum ^a, Isaias C. Macedo ^b

^aNational Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401, USA

^bInterdisciplinary Center of Energy Planning (NIPE), UNICAMP, ZIP: 13084-971, Campinas, SP, Brazil

Ethanol & higher alcohols (thermal) Ethanol and power (biochem)

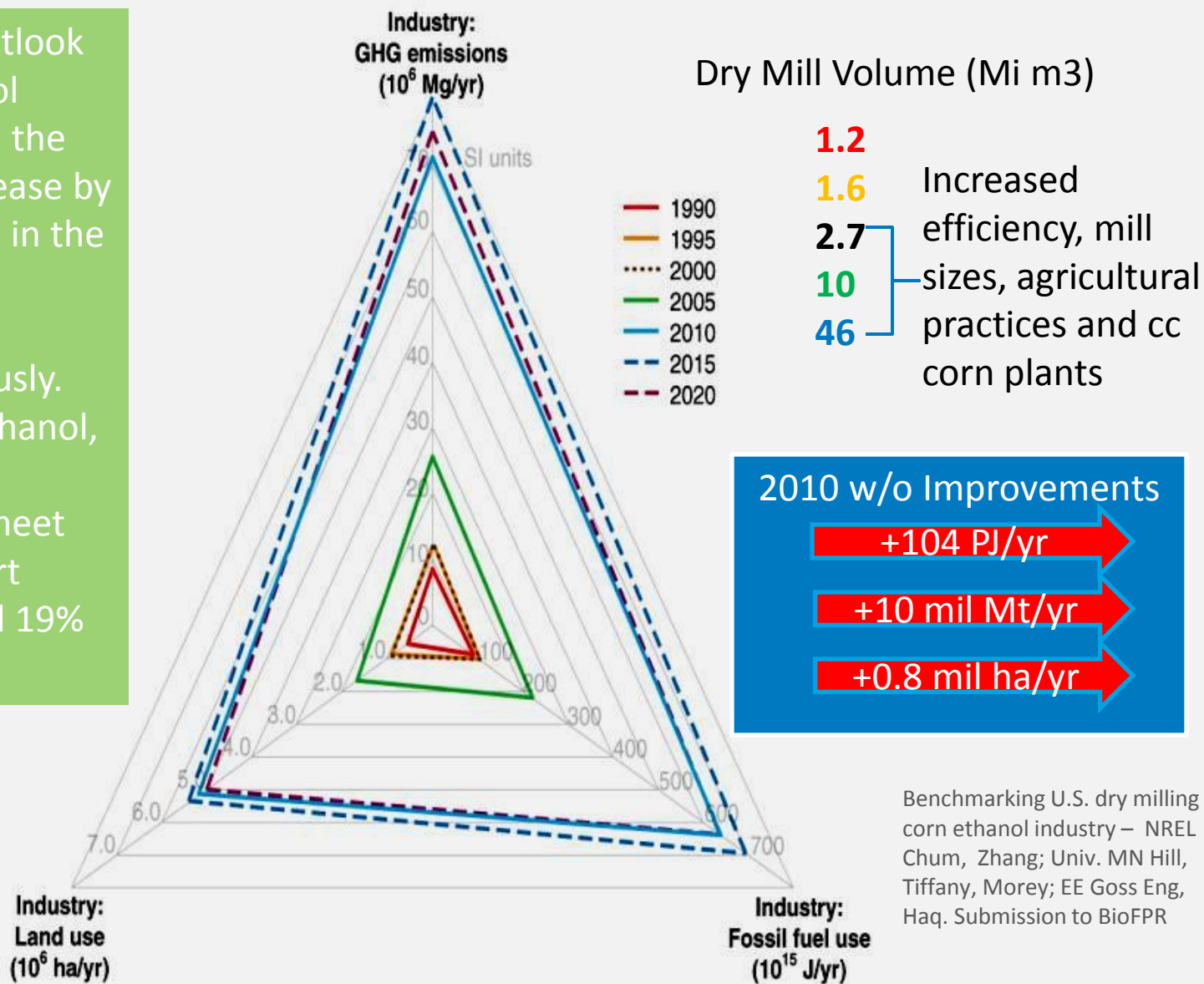


Net minimum ethanol selling price (MESP) \$1.25/gal close to sugarcane ethanol in Brazil in 2010. (nth plant cost)

Benchmarking the U.S. dry mill industry

IEA World Energy Outlook 2012 projects ethanol consumption in both the US and Brazil to increase by a factor of nearly **2.5** in the scenario of existing countries' policies implemented cautiously. By 2035, biofuels (ethanol, biodiesel and 35% advanced biofuels) meet 37% of road transport demand in Brazil and 19% in the United States.

Cellulosic ethanol penetration in Brazil expected to minimize sugar market issues. Many partnerships to demonstrate and commercialize bagasse to ethanol ongoing



Benchmarking U.S. dry milling corn ethanol industry – NREL Chum, Zhang; Univ. MN Hill, Tiffany, Morey; EE Goss Eng, Haq. Submission to BioFPR

Good analytical results = good biofuel process cost data



BRAZIL - Analytical Round Robin (2011-2012)

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

USA –Homogeneous Bagasse Sample Preparation & Round Robin Analysis Audit and Joint Paper Preparation Comparing **learners and advanced professionals**

- NREL: National Bioenergy Center (NBC), Biomass Analysis

Conclusions

- Committed researchers and government managers to building mutually supportive partnerships championed work recognized by both countries (e.g., U.S.-Brazil CEO Forum that reports to both countries' Presidents, Council on Competitiveness)
- Providing science-based information on GHG emissions and other sustainability factors to increase shared understanding and disseminate it globally (IEA Bioenergy, GBEP).
- Training Brazilian capability by ANL/GREET and NREL to participate effectively in the discussions of the EPA RFS2 and CARB relative to LCA/GHG. Brazilian ICONE, UNICA, UNICAMP, Brazilian government organizations mapping land use and land use change in the Amazonas region along with statistics of land use enabled correction of models of land use in Brazil that decreased values of indirect land use change for all biofuels. Sustainability indicators work for biofuels sustainability continues with both countries sharing data and methodologies (ORNL, ANL, NREL) and disseminating results globally.
- Bilateral collaboration expanded networks of R&D in underpinning analyses of lignocellulosic conversion to biofuels, enabling common understanding of processes, economics, environmental impacts, some sustainability parameters, and standards. Major cost share and increased knowledge overall.
- Collaborations leverage US and Brazilian investments and impact trade indirectly through standards, sustainability analysis, and building capacity in the developing advanced biofuels industry.

Joint Lignocellulosic R&D Areas Defined



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

Sharing Best Practices

1. Techno-economic analysis (TEA) models/NREL; Lifecycle (LCA) methodology GREET/ANL

2. Biomass chemical characterization/NREL

3. Biofuels Sustainability ORNL/ANL/NREL



Dedini



CTBE

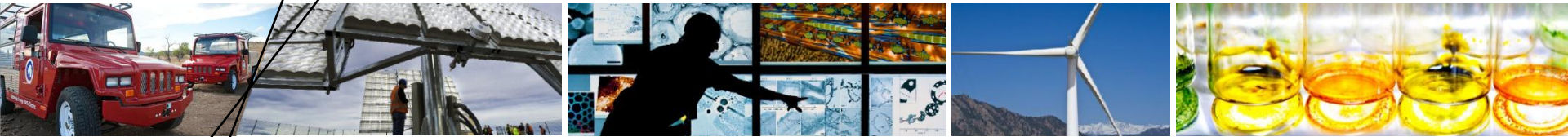


Usina da Pedra

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

1. Ricardo Dornelles, BR MME; 2. Adriano Duarte Jr., BR MCTI; 3. Amy Chiang, US DOE EERE; 4. Amy Miranda, US DOE OBP

Thanks for your support



Five years of collaborative research were only possible with continued support of DOE/EERE Office of the Biomass Program and EERE International Programs and the efforts at NREL, ANL, ORNL and collaborators, U.S. State Dept facilitating personnel exchanges, and Brazilian government institutions MCTI, MME, MDIC, MAPA, and the Department of Energy of the Ministry of Foreign Relations and their associated research and strategic institutions, industry, academia, and associations

DOE/EERE

OBP Managers: V. Sarisky-Reed, A.Goss Eng,
P. Grabowski, Z.Haq, K. Johnson, J. Ferrell
International: D. Birns, R. Sandoli

Brazilian Managers:

MME: Ricardo Dornelles
MCTI: Adriano Duarte Jr.
Marcelo Poppe, CGEE