

# Thoughts About Bioenergy Research Programs and Opportunities

## *View from a Vice President for Research*

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*10 April 2012*



Tuesday, April 10, 2012  
Oklahoma State University

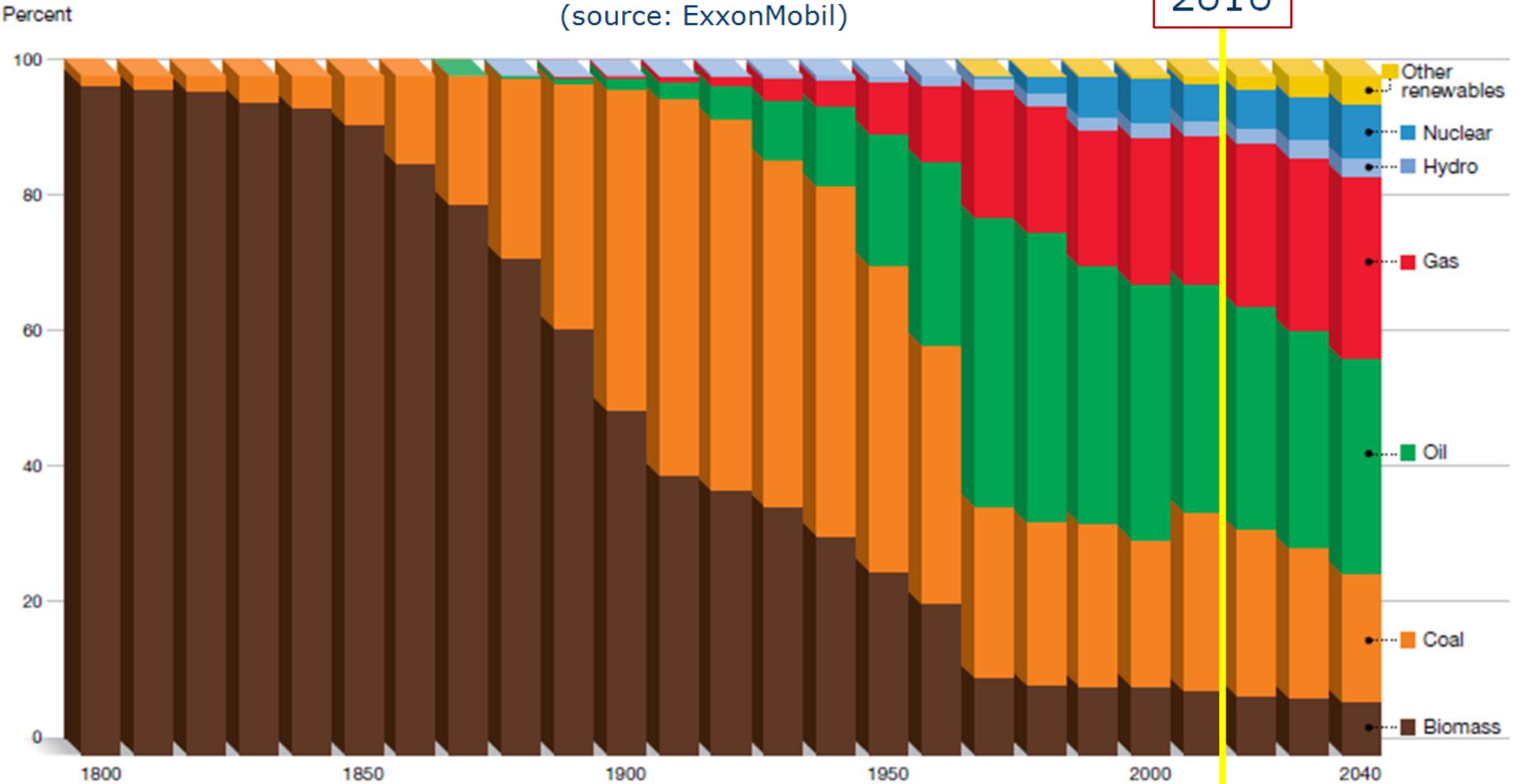
# Disclaimer

- This talk represents my personal views as a faculty researcher and VP for Research
- I am not representing the National Science Foundation or operating in my capacity as a National Science Board Member (in contrast to what is noted in the program)

# Fuel Mix of The World

(source: ExxonMobil)

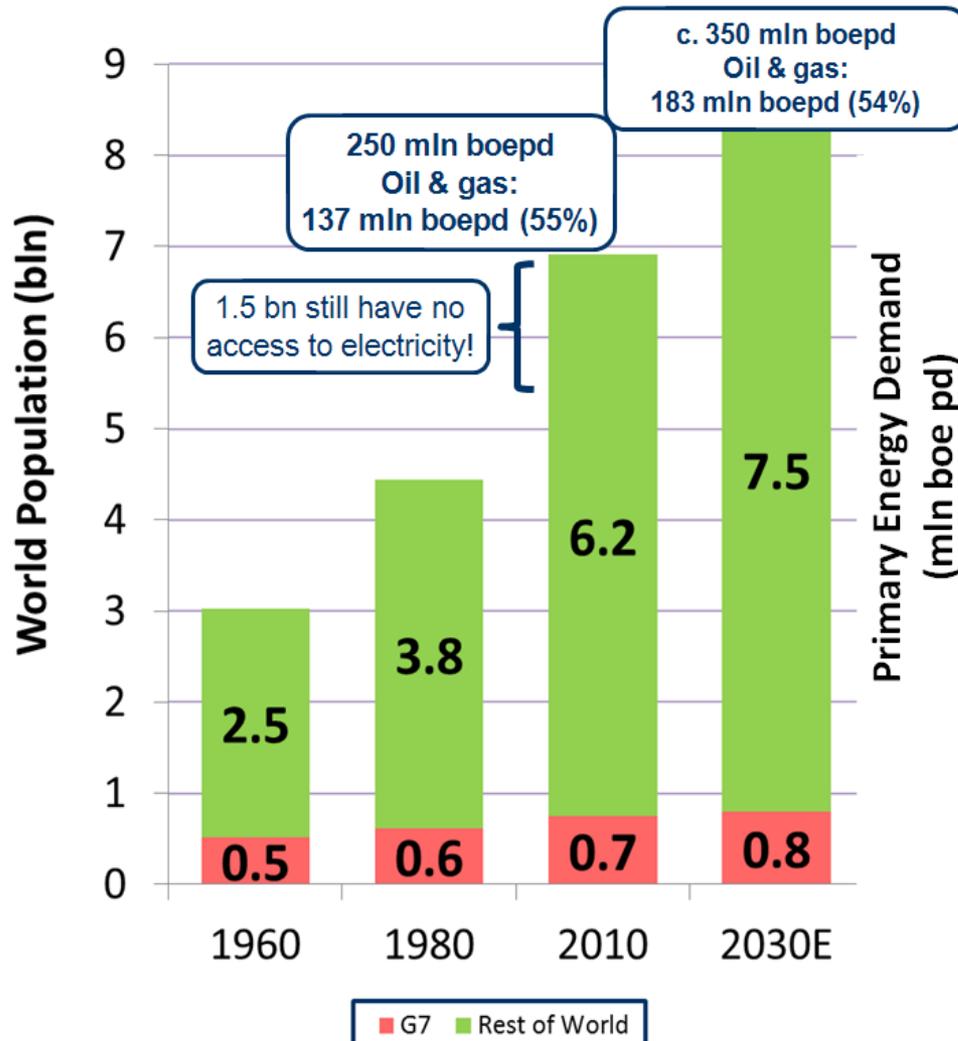
2010



Courtesy Bruce Stover and Lambert Energy of London, UK

# The Challenge: Matching Capacity to Demand

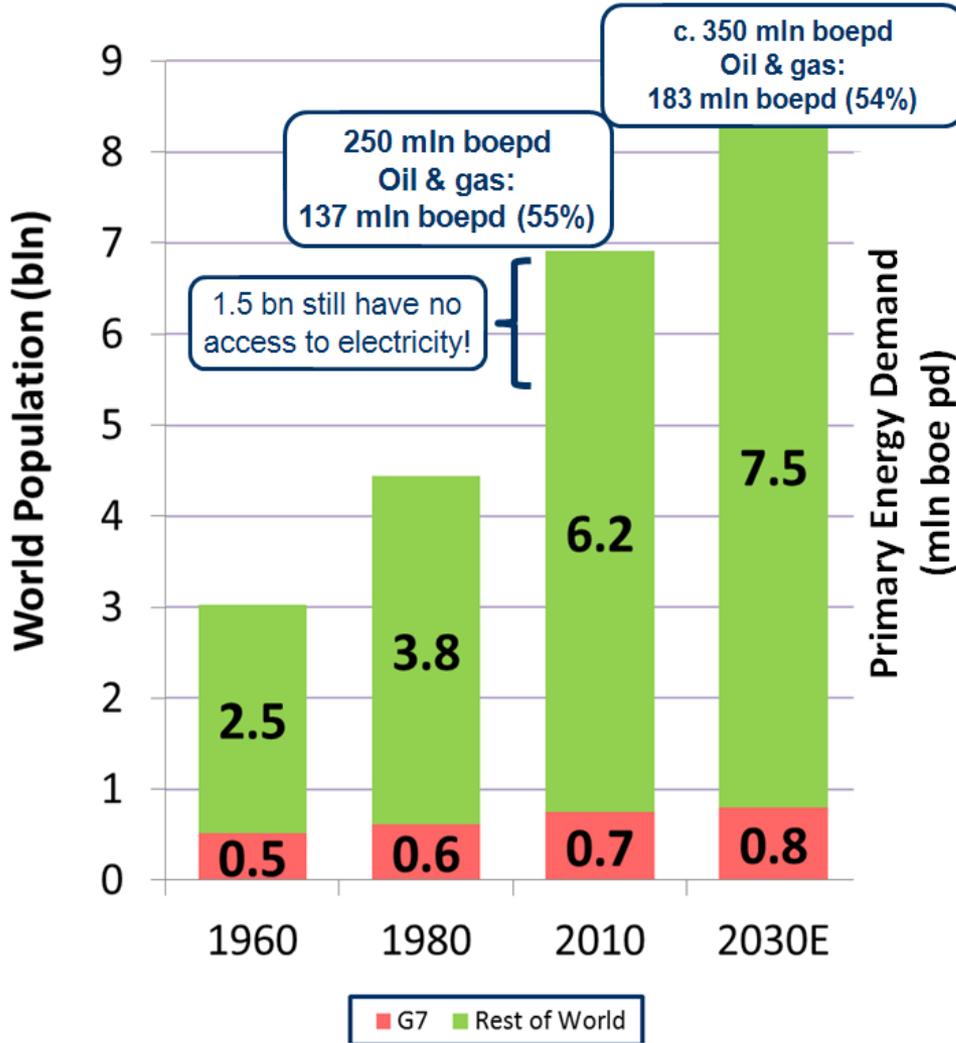
**Global Population Trends**  
(source: UN Population Division)



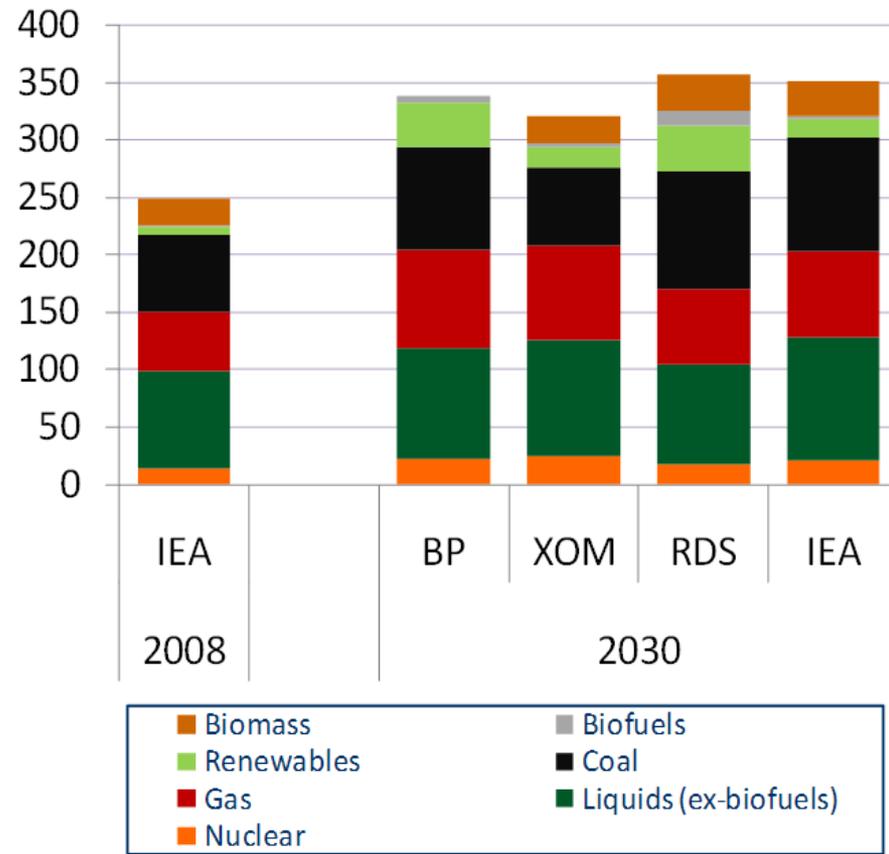
Courtesy Bruce Stover and Lambert Energy of London, UK

# The Challenge: Matching Capacity to Demand

**Global Population Trends**  
(source: UN Population Division)



**Global Primary Energy Demand Estimates by Fuel**



Courtesy Bruce Stover and Lambert Energy of London, UK

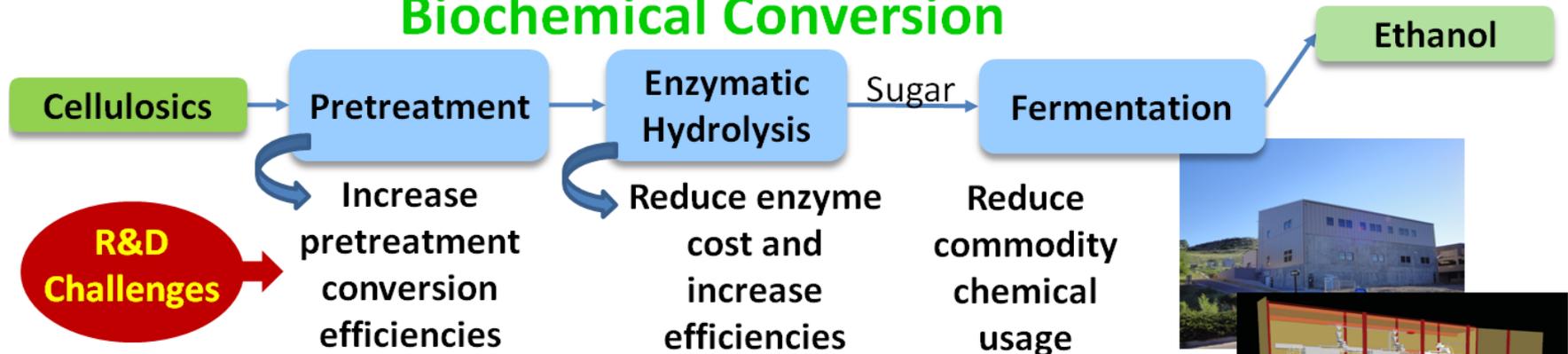
# A Look at DOE



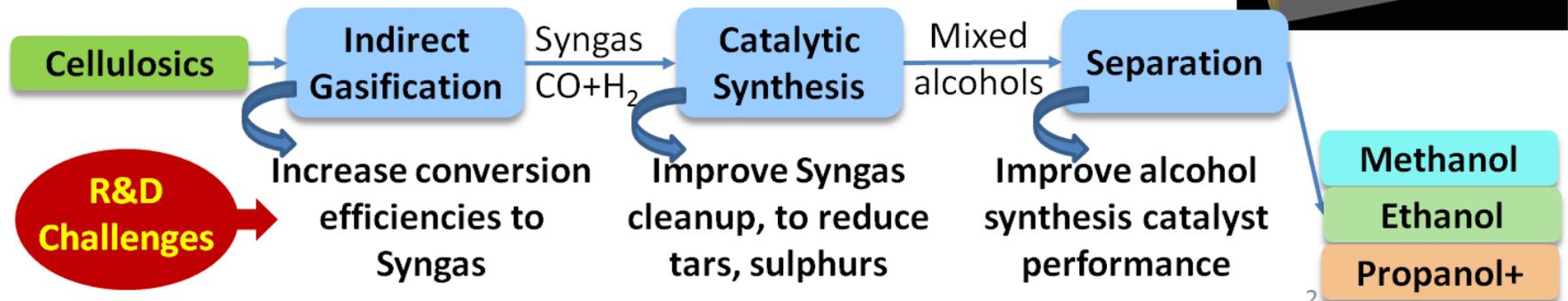
Over the past decade, the DOE biomass R&D focus has been on **cellulosic ethanol**

- developing technologies and reducing costs for both Biochemical and Thermochemical conversion of lignocellulosic materials
- to ethanol, a light duty vehicle fuel to displace gasoline

## Biochemical Conversion



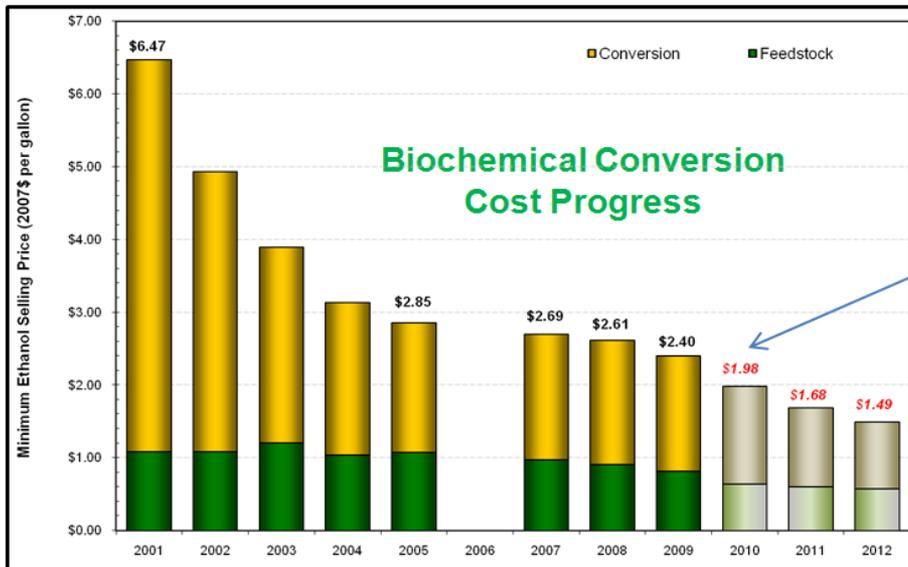
## Thermochemical Conversion



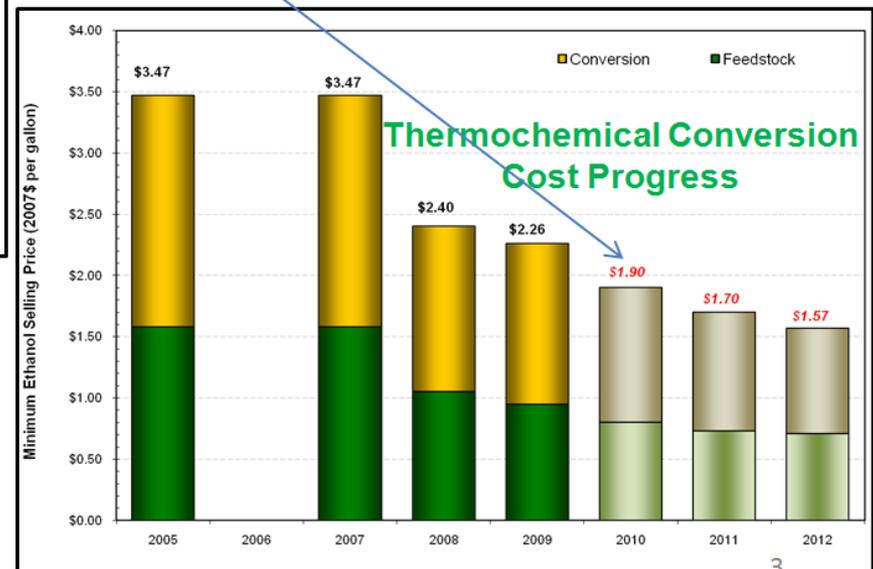
# Biomass Conversion Cost Reduction

**Goal:** Make cellulosic ethanol cost competitive with gasoline by 2012

**Progress:** Industry, Academia, and National Labs technology innovations and cost reductions have that goal in reach



- DOE Cost Target for 2012 = **\$1.76/gal**
- 2010 analysis not complete, but initial results show that we are on track to meet the 2010 interim goals



**Notes:**

- *Black \$\$ = demonstrated; Red \$\$ = future targets*
- *Cost is at the Biorefinery gate (not the consumer pump) – includes producer IRR, but not distribution costs, taxes, or distributor profit*
- *analysis not performed in 2006*

# DOE/Industry Funded Demonstration Plants

and, that progress has produced 29 “iron on the ground” industry biorefinery projects – coming on line in the 2011-2012 timeframe

Integrated Biorefinery Project Locations

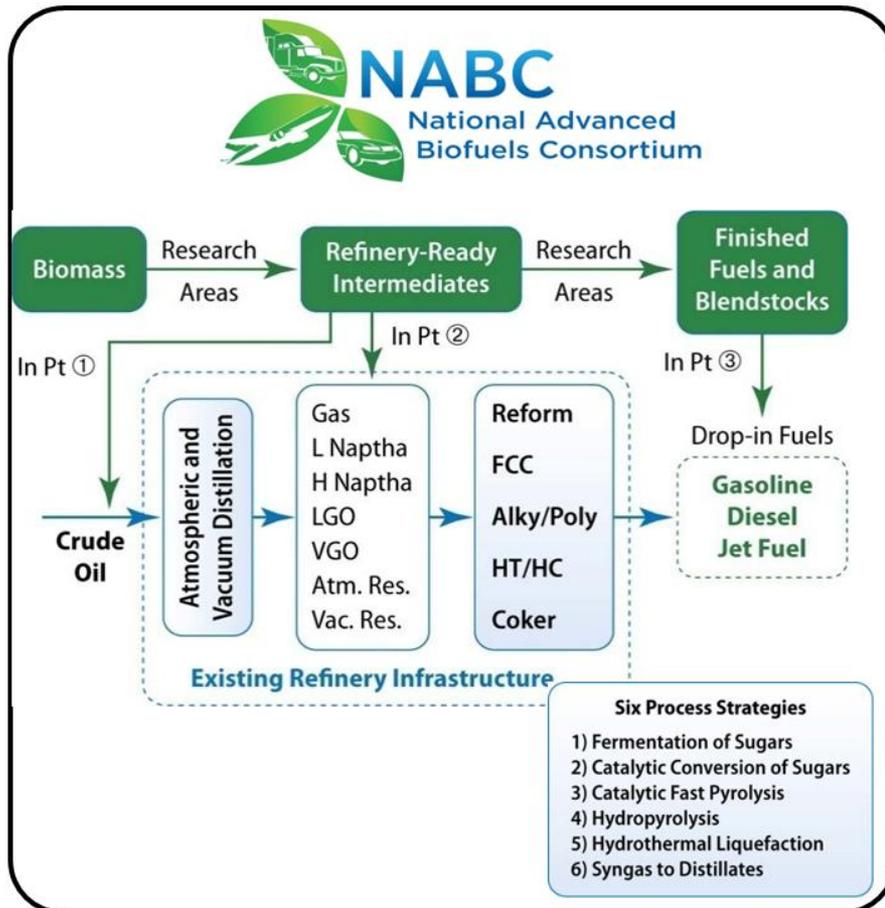


Courtesy Dr. Dan Arvizu, DOE/NREL

# Next Step: Advanced Biofuels

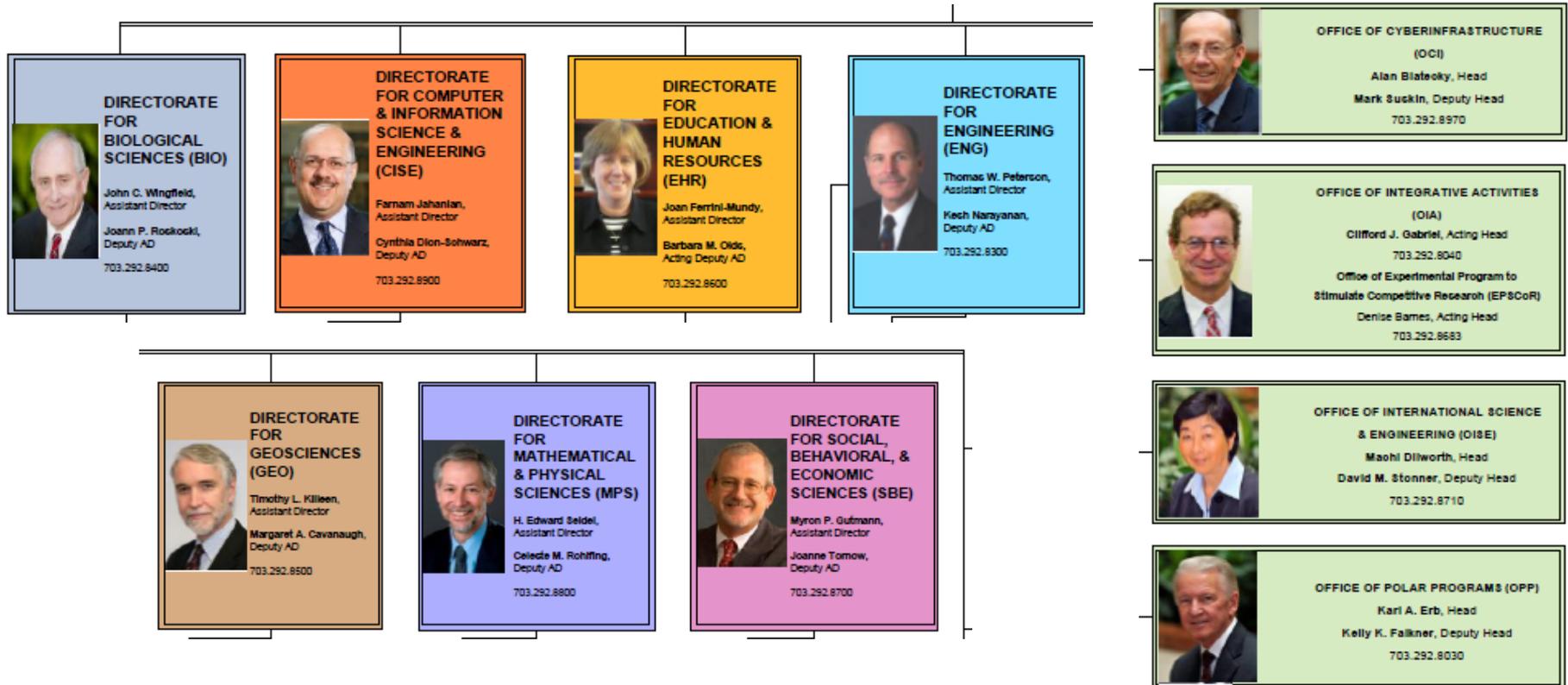
In this decade, a shift is underway to R&D on biomass conversion to new, non-ethanol fuels -- hydrocarbon fuels:

- direct replacements for or blends with gasoline, diesel, jet fuel
- aka “high energy density” or “drop in” or “infrastructure compatible” fuels

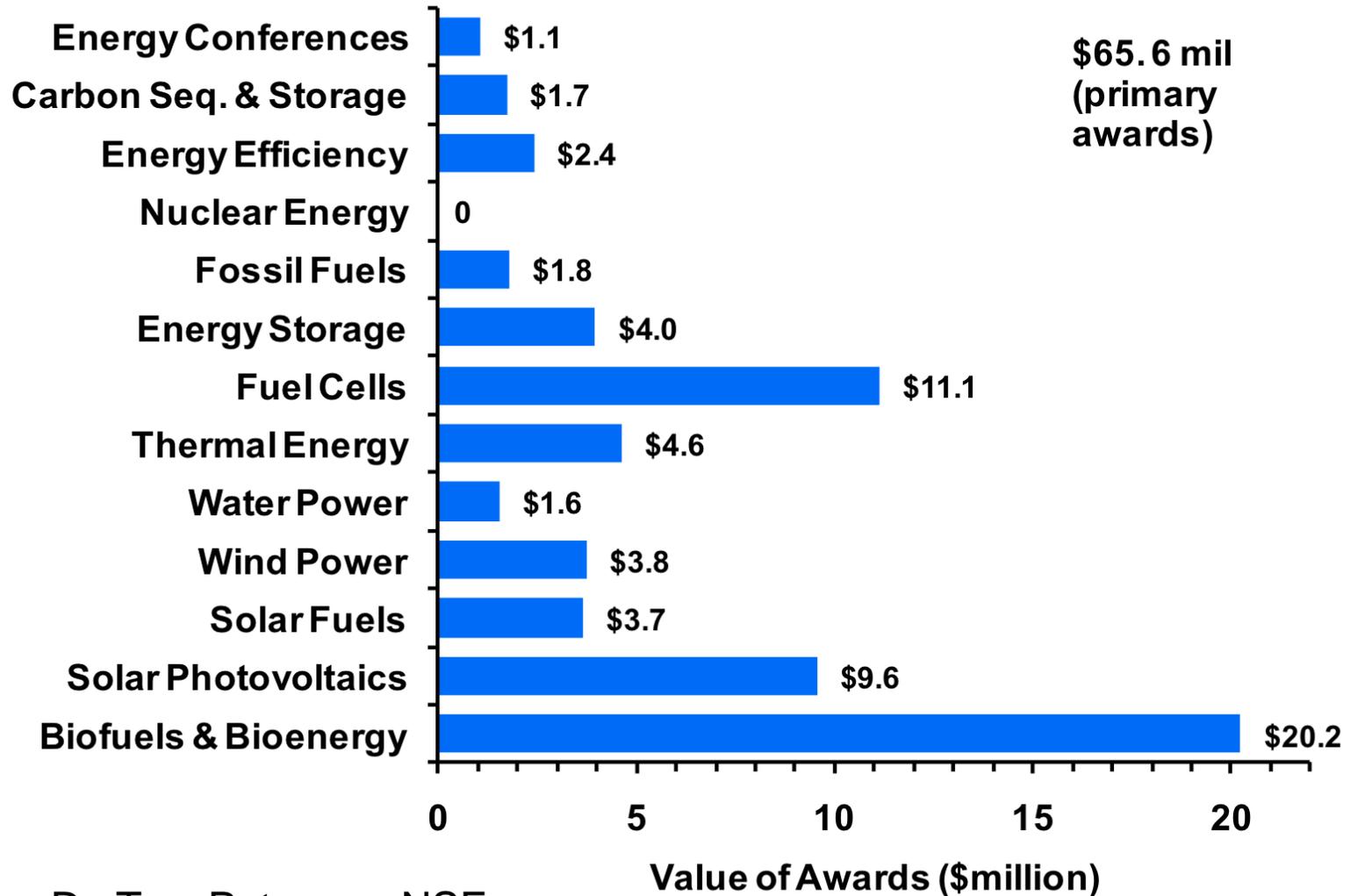


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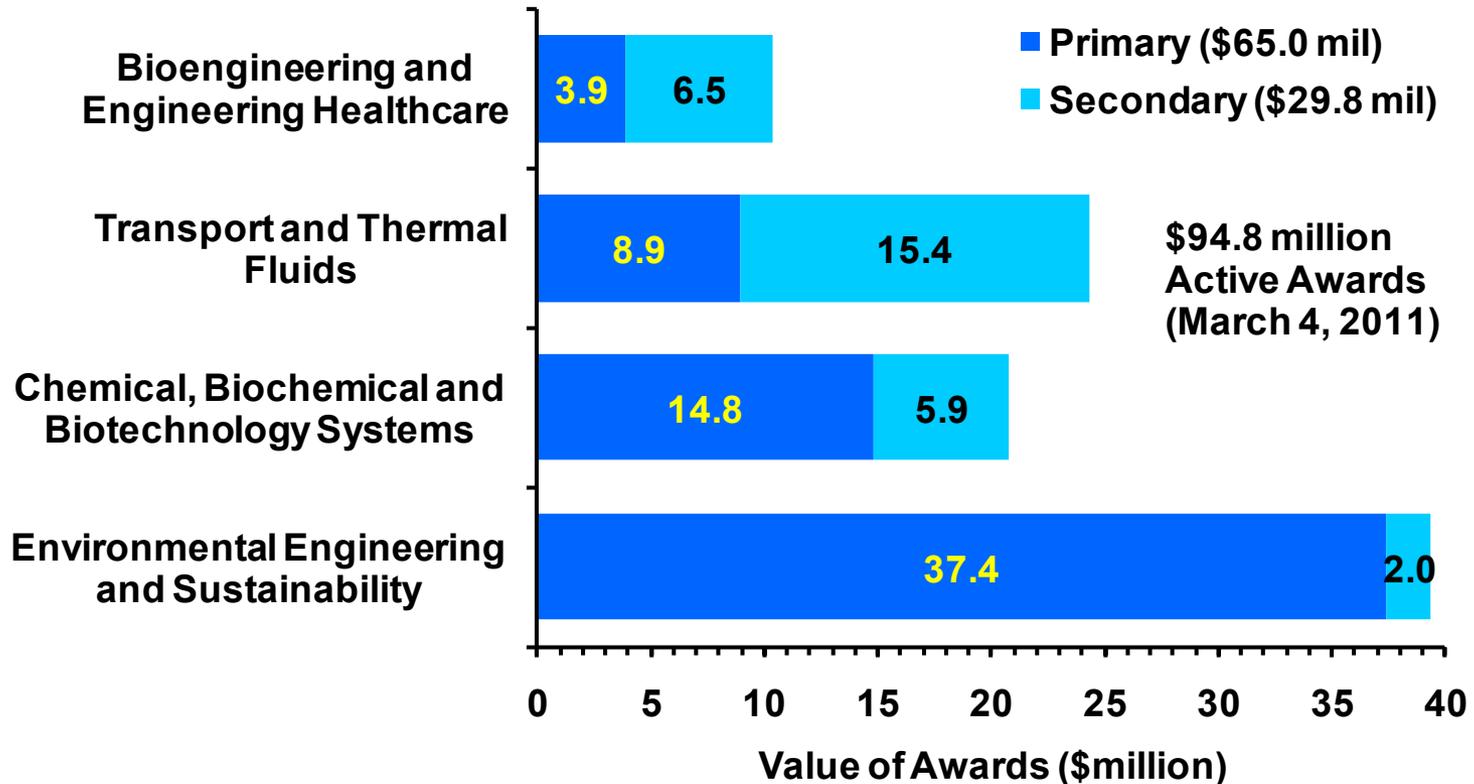
# NSF and Biofuels Research: It's Everywhere!



# Engineering Directorate Clean Energy Current Awards



# Engineering Directorate Clean Energy Current Awards by Cluster



Represents 22% of Active Awards & 14% of Portfolio Funding

# Emerging Frontiers in Research and Innovation (EFRI)

## Hydrocarbons from Biomass (HyBi) Projects

Obtaining hydrocarbons from non-food plants and microorganisms for renewable energy and chemicals.

- Getting the most from biomass
- Breaking down lignin
- Quick conversion of biomass
- Fungal fermentation of cellulose for fuels
- Optimizing fuel production, from algae to biorefinery
- Algae processing made easy
- Unlocking the power of biocatalysts
- Cooking up hydrocarbons in a unique “pot”

# EFRI for 2012

- Selected topics
  - Flexible Bioelectronics Systems (BioFlex)
  - Origami Design for Integration of Self-assembling Systems for Engineering Innovation (ODISSEI)
  - Photosynthetic Biorefineries (PSBR)
- Received 247 Letters of Intent, invited 71 Full Proposals (under review)
- Engaged partners
  - External: AFOSR
  - Internal: BIO, CISE, MPS
- URL: <http://nsf.gov/pubs/2011/nsf11571/nsf11571.htm>

# Relevant NSF Programs and Priorities

- I-CORPS (Innovation Corps)
- IGERT (Integrative Graduate Education and Research Traineeships)
- Science, Engineering and Education for Sustainability (SEES)
- INSPIRE (Integrated NSF Support for Interdisciplinary Research and Education)
- STEM Education
- Manufacturing (tied to President Obama's Advanced Manufacturing Partnership)
- Research Coordination Networks (RCN)

# Specific Announcements of Opportunity in Energy/Biofuels/Bioenergy

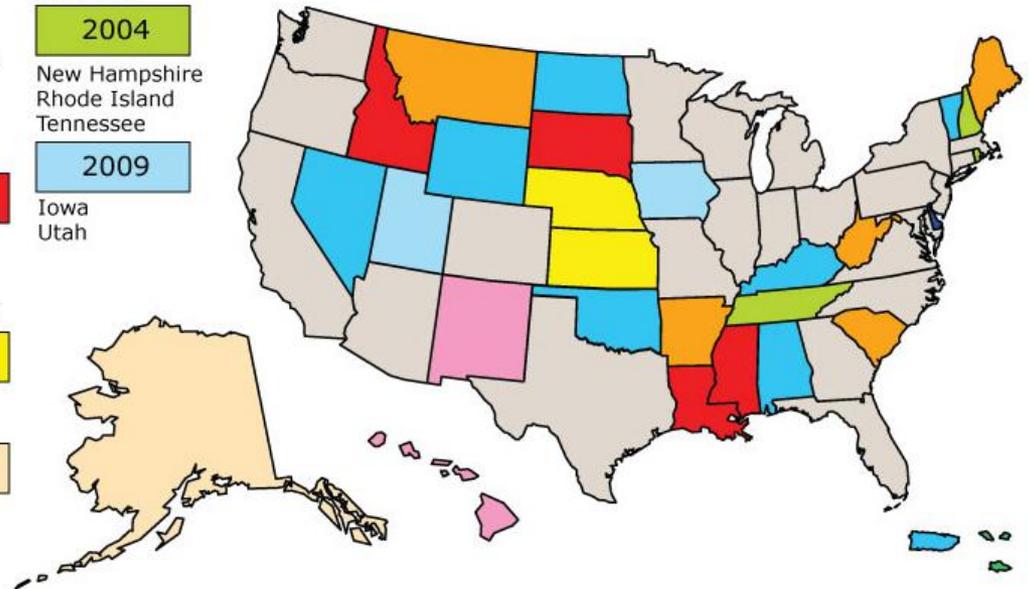
- More than 100 of them!
  - Biotechnology, Biochemical and Biomass Engineering
  - Energy for Sustainability
  - Metabolomics for a Low Carbon Society
  - Surpassing Evolution: Transformative Approaches to Enhance the Efficiency of Photosynthesis ( 10-559 )
  - Water Sustainability and Climate
  - Centers for Chemical Innovation
  - Catalysis and Biocatalysis
  - Others...

# NSF EPSCoR RII Renewable Energy Awards

- Oklahoma (cellulosic bioenergy)
- Iowa (renewable energy: wind, bio, policy)
- Kansas (climate change and energy)

<b>1980</b>	<b>2001</b>
Arkansas Maine Montana South Carolina West Virginia	Hawaii New Mexico
<b>1985</b>	<b>2002</b>
Alabama Kentucky Nevada North Dakota Oklahoma Puerto Rico Vermont Wyoming	U.S. Virgin Islands
<b>1987</b>	<b>2003</b>
Idaho Louisiana Mississippi South Dakota	Delaware
<b>1992</b>	<b>2004</b>
Kansas Nebraska	New Hampshire Rhode Island Tennessee
<b>2000</b>	<b>2009</b>
Alaska	Iowa Utah

## NSF EPSCoR Jurisdictions



# Important to Keep in Mind...

- Bioenergy is NOT only a physical science and engineering challenge
- Other disciplines must be engaged if bioenergy is to succeed as an alternative fuel
- NSF is THE organization for which non physical science and engineering disciplines can engage to truly study bioenergy-related topics in a holistic manner, including
  - Economics and finance
  - Public opinion and human behavioral elements (willingness to adopt/adapt to new technologies)
  - Education and workforce development
  - International relations and standards
  - Ethics

# Something for Oklahoma to Consider

- Planning across jurisdictional lines – a regional approach to bioenergy
- Submit unsolicited proposal that builds upon previous work
  - Expand research focus substantially
  - Bring in social sciences
  - Involve industry and innovation/entrepreneurship
  - Leverage State S&T plans
  - Bring in workforce development and broadening the participation of traditionally underrepresented groups
  - Make a major push on engaged/active learning framework for STEM education