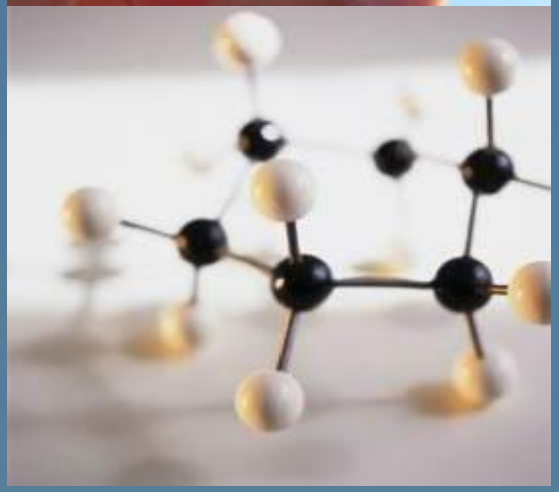

Conference on Biomass and Energy for the Great Lakes Economy

Shabnam Fardanesh
U.S. Department of Energy

Overview

- DOE's Position on Biofuels
- Biofuels: Opportunities and Barriers
- DOE's Plans for Facilitating Development and Deployment of Biofuels

Petroleum Consumption and Availability Trends

- EIA projects that global fuel consumption will increase an average of 1.4% a year from 2004-2030.
- Worldwide, a total of 82.5 million barrels of oil were consumed in 2004; That number is projected to rise to 97.3 in 2015 - An increase of nearly 18%.
- Demand by emerging nations will increase significantly:
  - Demand in India is projected to increase 2.2% per year between 2004-2030; China's demand will increase 3.5% per year.
  - According to a study by Argonne National Lab, by 2030, China's vehicle count alone will be a half a billion.

Sources: History: Energy Information Administration (EIA), International Energy Annual 2004 (May-July 2006), web site www.eia. doe.gov/iea. Projections: EIA, Annual Energy Outlook 2007, DOE/EIA-0383(2007) (Washington, DC, February 2007), AEO2007 National Energy Modeling System, run AEO2007.D112106A, web site www.eia.doe.gov/oiaf/aeo; and System for the Analysis of Global Energy Markets (2007).

National Biofuels Targets

New Renewable Fuel Standard

- EISA 2007 - Expand use of renewable fuels to 36 billion gallons annually by 2022
- Cellulosic biofuels component
  - 0.5 billion gallons by **2012**
  - 3 billion gallons by **2015**
  - 16 billion gallons by **2022**
- Includes Significant Safeguards
  - Ethanol production from corn is capped at 15 bgy
  - EPA authorized to waive targets annually
  - Requires GHG reductions, which include land use impact
  - Requires studies on environmental impacts

Best short-term option to alleviate gasoline prices and heating oil costs

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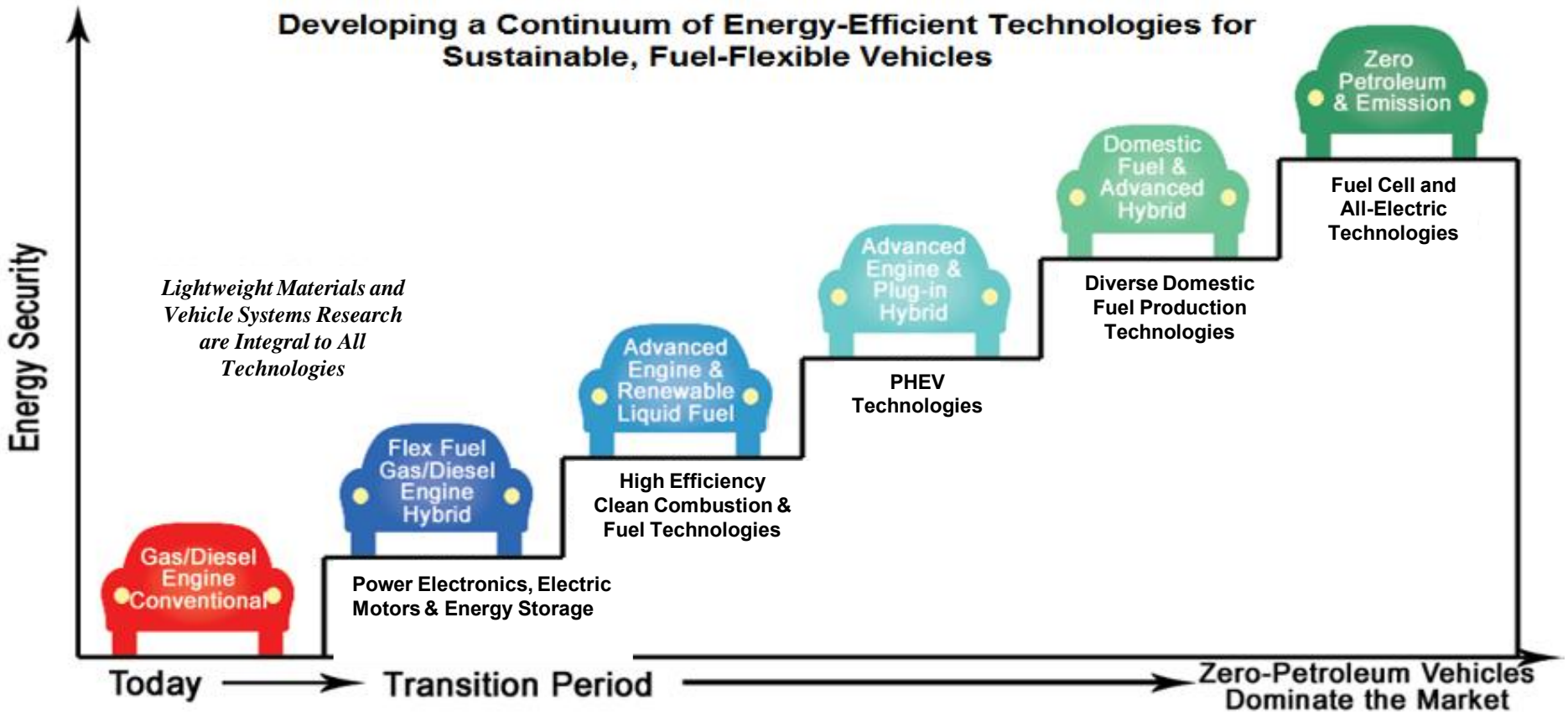
Strategic Approach to Transportation Energy Security



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Why Biomass?

- Can be converted to other usable forms of energy
  - Fuel
  - Products
  - Power
- Offers attractive petroleum alternative
  - Renewable
  - Globally dispersed
  - Environmentally friendly technologies
- Biomass is the only renewable resource that can be converted to liquid fuels (unlike wind, solar, geothermal)

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Lifecycle Greenhouse Gas Emissions Associated with Different Fuels

Gasoline

Petroleum

19% Reduction

28% Reduction

52% Reduction

Corn Ethanol

Current Average | *Natural Gas* | *Biomass*

78% Reduction

Sugarcane Ethanol

Biomass

86% Reduction

Cellulosic Ethanol

Biomass

Sources: Wang et al, *Environ. Research Letters*, May 2007; Wang et al, *Life-Cycle Energy Use and GHG Implications of Brazilian Sugarcane Ethanol Simulated with GREET Model*, Dec. 2007.

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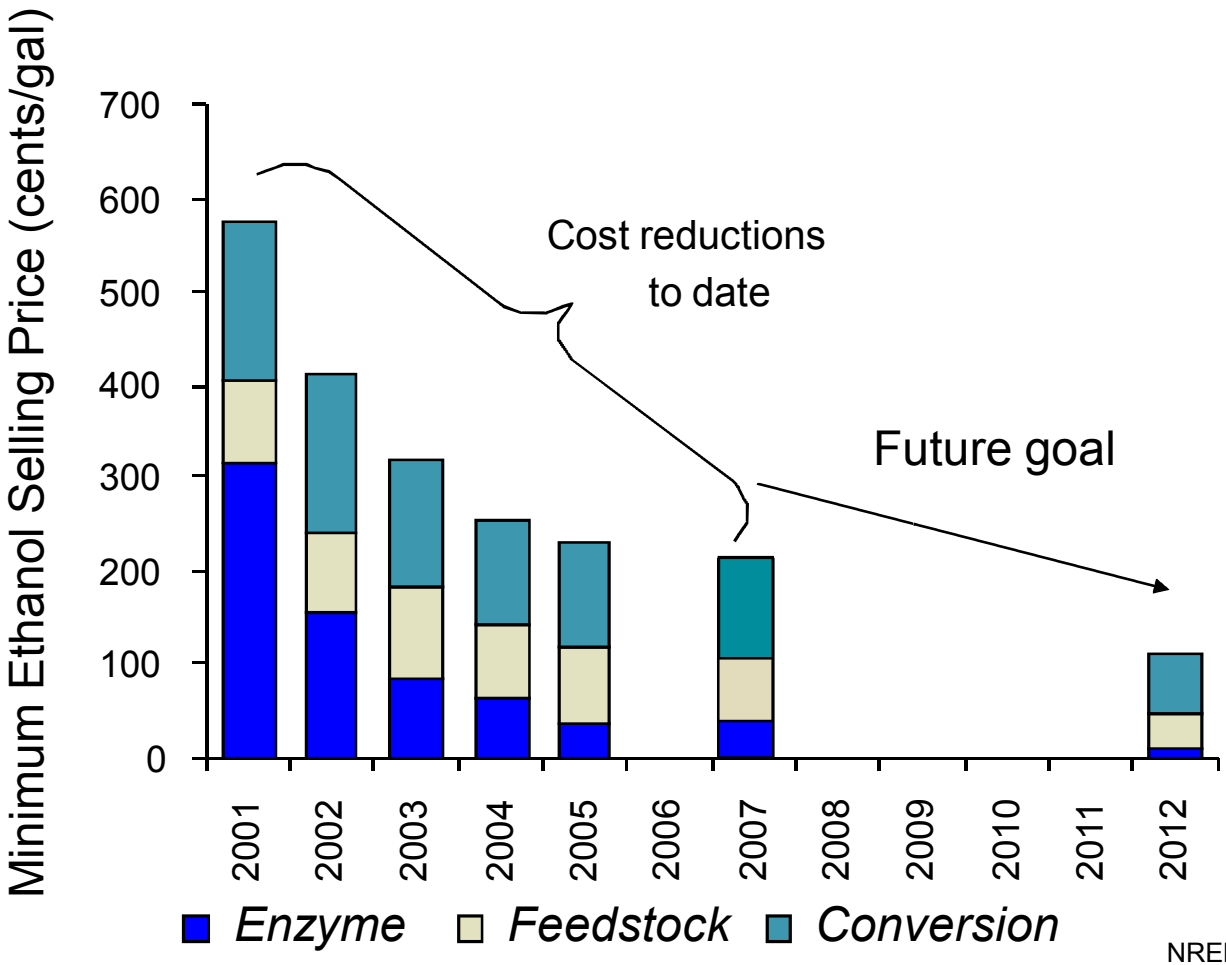
Reducing Cost of Cellulosic Ethanol

Modeled Ethanol Cost for "nth Plant"

Historical and Projected Cellulosic Ethanol Costs



NREL Modeled Cost

In order for biofuels to succeed in the US and world-wide, they must be both cost-competitive and sustainable.

Cost Goal:
$1.33 by 2012

Cost-competitive in the blend market by 2012

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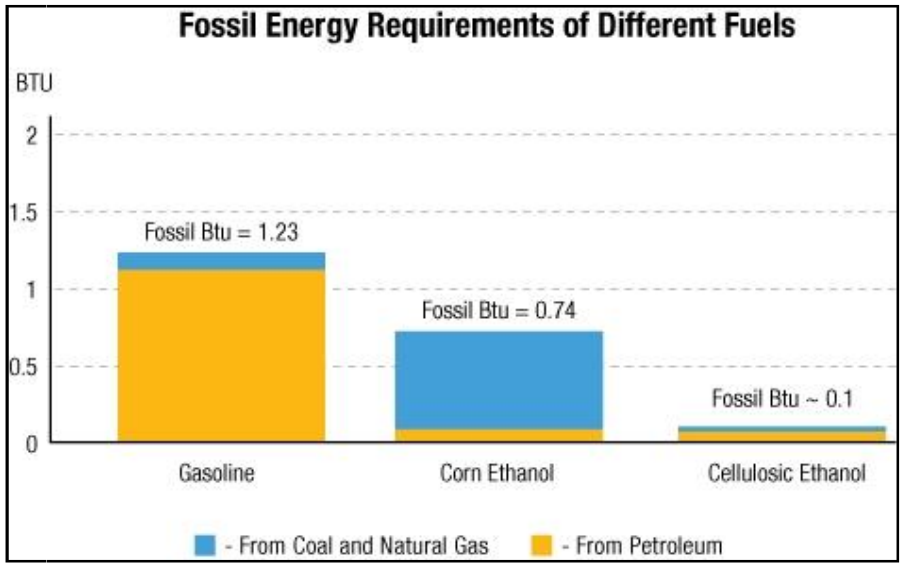
Opportunity: Non-food feedstocks

Today

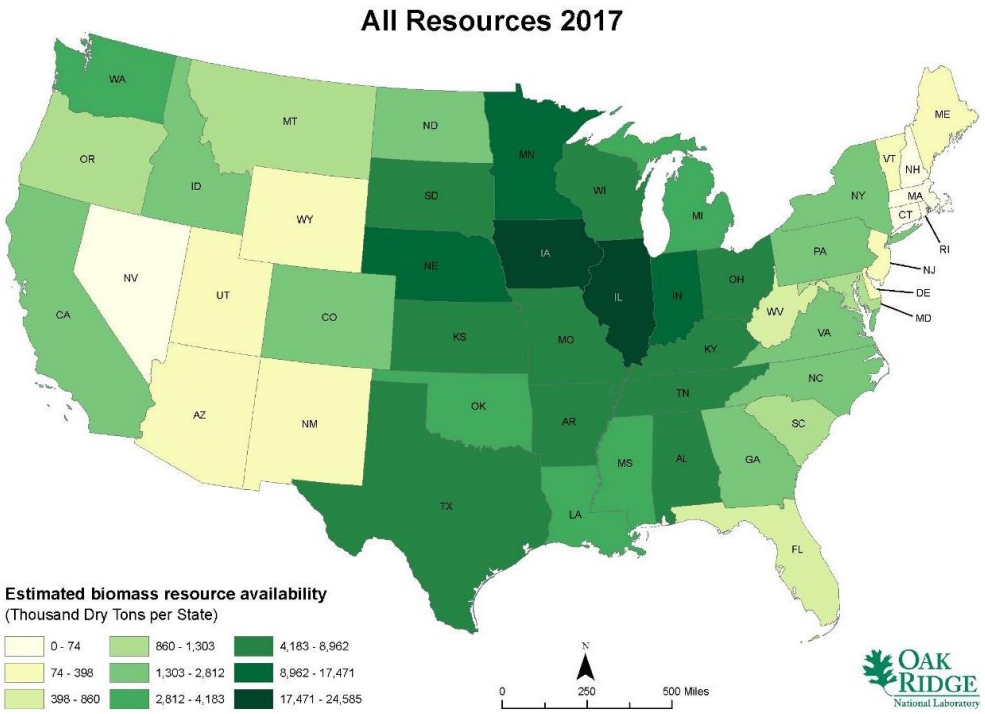
- Grains (corn, sorghum, wheat)
- Oilseeds and plants (soybeans)

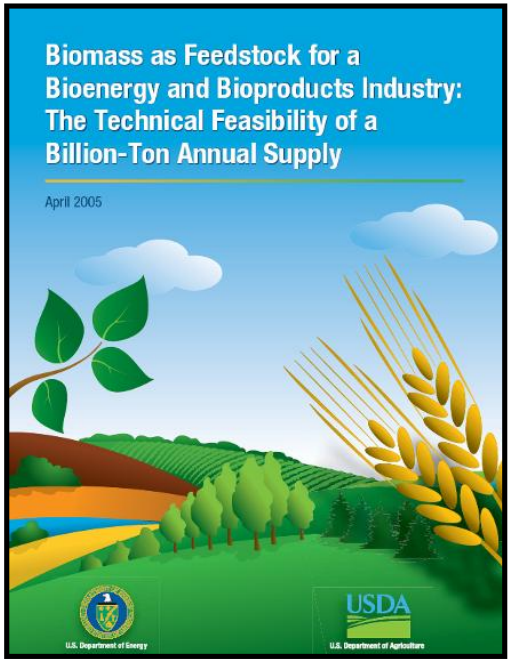


Tomorrow

- Agricultural residues (stalks, stems, other crop wastes)
- Energy crops (switchgrass, miscanthus, poplar, willow)
- Forest resources (wood waste, forest thinnings, small-diameter trees)
- Oilseeds and oil crops (Algae, Jatropha)
- Green wastes (urban wood wastes, sorted municipal solid waste)

Biomass Resources Adequate to Meet RFS (by 2030)





By 2017, forest and cropland resources can yield 23-30 billion gallons of cellulosic biofuels

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Current Barriers to Development and Deployment

- **Market Barriers**, e.g., lack of cellulosic feedstock market, high capital costs
- **Technical Barriers**, e.g., lack of feedstock collection equipment, high requirements of enzymes and organisms
- **Myth about biofuels**

  (public perception)

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Biomass Program Mission

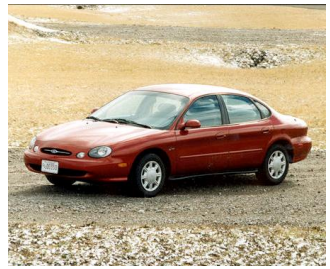
Develop and transform our renewable and abundant biomass resources into cost-competitive, high-performance biofuels, bioproducts, and biopower.

Focus on targeted research, development, and demonstration

- Support through public and private partnerships
- Deploy in integrated biorefineries

Strategic Focus: Biofuels

Feedstock Production → Feedstock Logistics → Biofuels Production → Biofuels Distribution → Biofuels End Use



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Biofuels Beyond Ethanol

Today

Ethanol – as a blending agent from either grain or cellulosic material from Ag and/or Forestry industry

Biodiesel – Transesterified vegetable oils blended with diesel

Green Diesel – fats, algal oils, waste oils, or virgin oils converted to low-sulfur diesel in petroleum refinery

Higher alcohols – examples include: butanol, mixed alcohols, higher carbon alcohols (C5- and greater)

Fischer-Tropsch Liquids – and other products from syn gas including methanol, dimethyl ether, etc

Pyrolysis Liquids – alternative feedstock to petroleum refinery or gasification facility

Methanol derived fuels – Methanol to gasoline technology, dimethyl ether and other products

Other fuels – Liquid transportation fuels from sugars/oils refinery not discussed or yet envisioned

Future

Biomass

Our Commitment to Sustainability

DOE is committed to developing the resources, technologies, and systems needed for biofuels to grow in a way that enhances the health of our environment and protects our planet. To that end, we are working to…

- Develop diverse, non-food feedstocks (e.g., switchgrass, sorghum) that require little water or fertilizer
- Foster sustainable forestry practices (e.g., advanced harvesting techniques) to enhance forest health
- Selectively harvest biomass components while leaving adequate soil nutrients
- Assess life-cycle impacts of major scale-up in biofuels production, from feedstocks to vehicles, addressing:
  - land use and soil health
  - water use
  - air quality issues
  - impacts on greenhouse gas (GHG) emission

Efforts are anchored into senior-level Biomass R&D Board Sustainability Working Group

Biomass

Leveraging Partnerships to Achieve Goals

- **Commercial-Scale Biorefineries (up to $385 million)**
  - Six cost-shared, integrated biorefinery demonstration projects to produce 130 million gallons of cellulosic ethanol in 5 years using variety of conversion technologies and cellulosic feedstocks
- **10%-Scale Biorefinery Validation (up to $200 million)**
  - Cost-shared, integrated biorefinery demonstrations using cellulosic feedstocks to produce renewable fuels; one-tenth of commercial scale
  - Seven selectees announced for a total investment of $200 million
- **Ethanologen Solicitation (up to $23 million)**
  - Five selected research teams working on microorganisms
- **Enzyme Solicitation (up to $33.8 million)**
  - Four selected research teams working on inexpensive enzym commercial biomass hydrolysis
- **Thermochemical Solicitation (up to $16.7 million)**
  - Integration of gasification and catalyst development
  - Pyrolysis oil stabilization
- **Joint DOE-USDA Solicitation ($18 million)**
  - Biomass R&D Initiative: 20 awards announced March 2008

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Major DOE Biofuels Project Locations

Geographic, Feedstock, and Technology Diversity

- Seven Small-Scale Biorefinery Projects
- Six Commercial-Scale Biorefinery Projects
- Four Improved Enzyme Projects
- Five Projects for Advanced Organisms
- Five Thermochemical Biofuels Projects
- Three Bioenergy Centers
- DOE Joint Solicitation Biomass Projects

Regional Partnerships

South Dakota State University, Brookings, SD
Cornell University, Ithaca, NY
University of Tennessee, Knoxville, TN
Oklahoma State University, Stillwater, OK
Oregon State University, Corvallis, OR

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Food vs. Fuel

- Biofuels are **not** the primary, or a major, driver affecting worldwide food prices.
- Many studies have found that food prices have increased due to many factors, including:
  - **high oil prices** (used both in transportation and production of food);
  - **droughts** in some key exporting countries (Australia);
  - **increasing demand** from developing economies; and
  - **speculative fund activities** in futures markets among other factors.
- About 25% of the U.S. corn crop went to biofuels production; but, this fact can be misleading in isolation.
  - **US corn exports have been stable** throughout this decade, and have increased recently.
  - Almost one-third of each ton of corn used for ethanol production is recovered as a protein-rich livestock feed. Thus, **only one-sixth of the corn crop** by mass is used for fuel production.

Information Resources

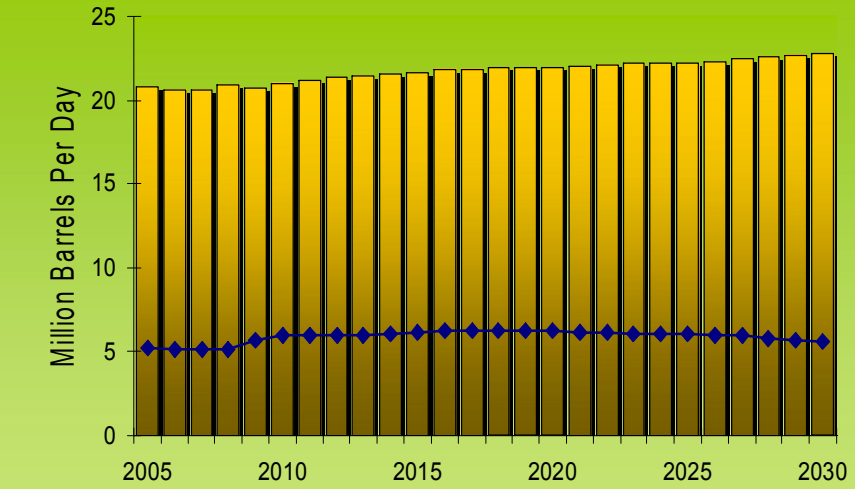
- Office of Biomass Program, Jacques Beaudry-Losique

  Tel: 202-586-5188.

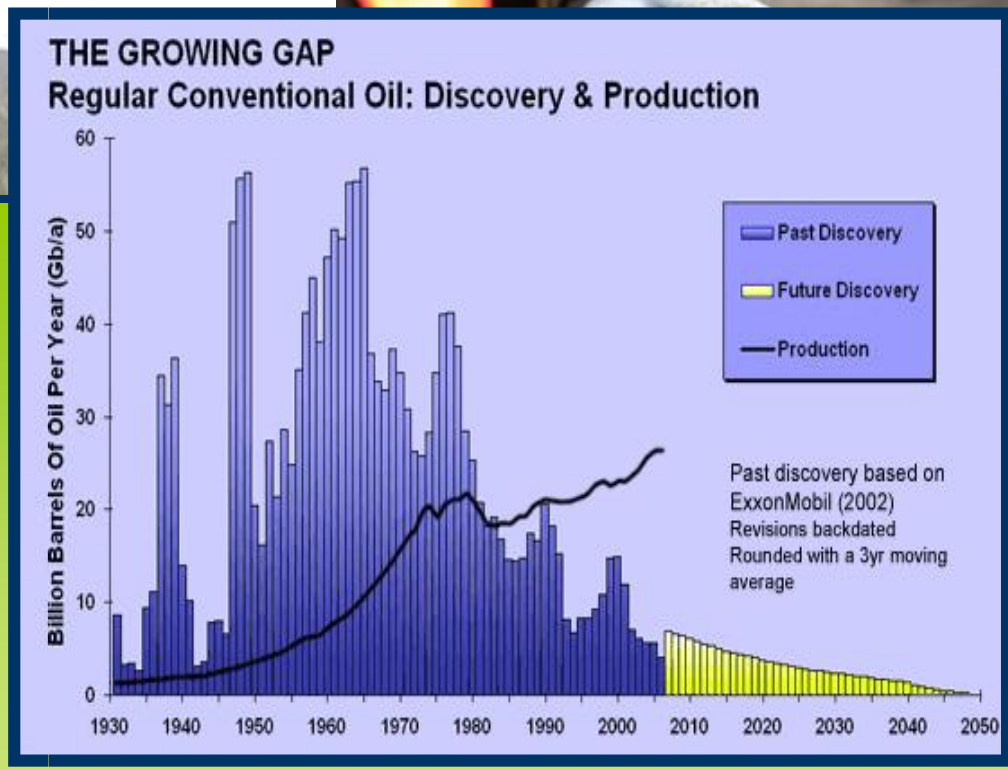
  Web Site: http://www1.eere.energy.gov/biomass/
- EERE Info Center - www1.eere.energy.gov/informationcenter
- Alternative Fuels Data Center - http://www.eere.energy.gov/afdc/fuels/ethanol.html
- Bioenergy Feedstock Information Network - http://bioenergy.ornl.gov/
- Biomass R&D Initiative – www.biomass.govtools.us
- Grant Solicitations - www.grants.gov
- Office of Science - http://www.er.doe.gov/

Backup Slides

The Future of Oil



Source: Energy Information Administration

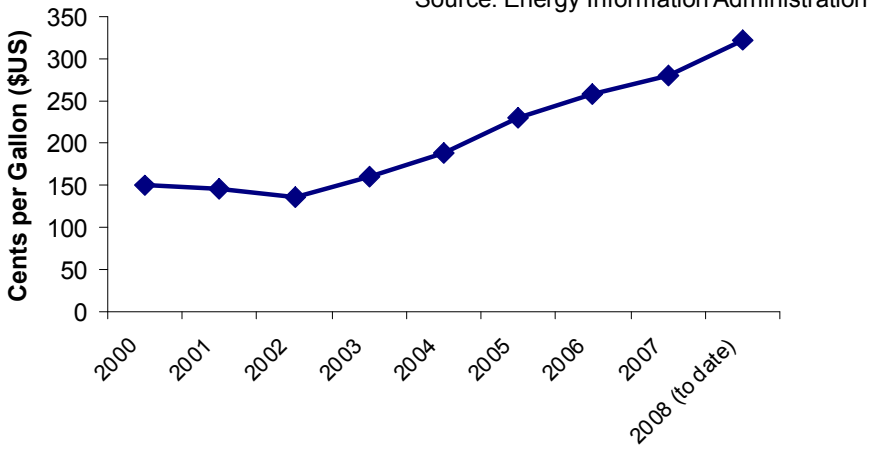


"Oil prices would be at least 15% higher than they are, if not for today's output of ethanol."

- Francisco Blanch, head of global commodity research at Merrill Lynch, as quoted in "Is Ethanol Getting a Bum Rap?" BusinessWeek, May 1, 2008

(Nominal Cents per Gallon Including Taxes)

Source: Energy Information Administration



DOE Current Work on Sustainability

- **Biodiversity**
  Working with Conservation International to conduct pilot studies to identify best land to locate biofuel crops worldwide while preserving biodiversity
- **Climate Change**
  NREL is conducting a life cycle assessment of replacing 30 percent of gasoline use in the U.S. with biofuels by 2030
- **Indirect Land Use**
  Argonne National Laboratory and Purdue University are refining models that can analytically address international land use change issues due to increasing growth of biofuels
- **Feedstock Production**
  Conducting in-field studies to determine best location for energy crops in collaboration with USDA, the Sun Grant Initiative universities, and other regional partners
- **Water**
  Argonne and NREL are conducting LCA of water demand for biofuels production over the lifecycle in comparison to corn ethanol, sugar cane ethanol, and competing petroleum fuels
- **National Bioenergy GIS**
  ORNL, ANL, INL, UC-Davis and others are developing a national scale GIS-based framework to assist in the analyzing the economic and environmental impacts of feedstock, biorefinery, and infrastructure development options.

Reducing Gas Prices & Oil Imports

- Gas prices would be significantly higher without ethanol in the market.
- Ethanol is helping reduce our nation's dependence on foreign oil and improve our trade balance.
  - In 2007, the U.S. imported 65% of its crude oil supplies at a cost of more than $333 billion, accounting for more than 45% of the record trade deficit.
  - In 2007, U.S. production of 6.5 billion gallons of ethanol helped to reduce foreign petroleum imports by 4.3 billion gallons and reduce the U.S. trade deficit by $9 billion.

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Myths and Facts about Biofuels

Myth: Ethanol cannot be produced from corn in large enough quantities to make a real difference without disrupting food and feed supplies.

Fact: Corn is only one source of biofuel. As we address the technical hurdles associated with the efficient and cost-effective production of biofuels, a significant amount of ethanol will be made from more abundant cellulosic biomass sources.

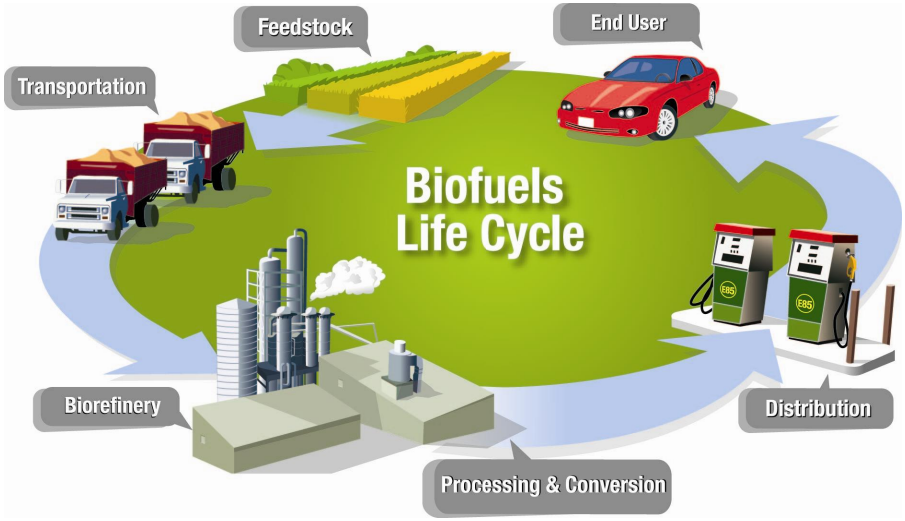
Myth: More energy goes into producing ethanol than it delivers as a fuel.

Fact: Each gallon of corn ethanol today delivers about one-third more energy than the amount of fossil energy used to produce it.

Myths and Facts about Biofuels

Myth: In terms of emissions, ethanol pollutes the same as gasoline or more.

Fact: On a life-cycle basis, ethanol results in fewer greenhouse gas (GHG) emissions than gasoline and is fully biodegradable, unlike some fuel additives.



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