U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

U.S. Department of Energy Biomass Program

Domestic Drivers -- The Presidents Aggressive Approach on Biofuels and the Need Expeditiously Address Standards, Codes, and Regulation Barriers

Neil P. Rossmeissl
Technology Development Manager

ANSI Biofuels Standards Panel (ANSI-BSP) Inaugural Meeting
Wednesday, May 9, 2007
Westin Arlington Gateway, Arlington, Virginia

2005 Global Transportation Fuel Production

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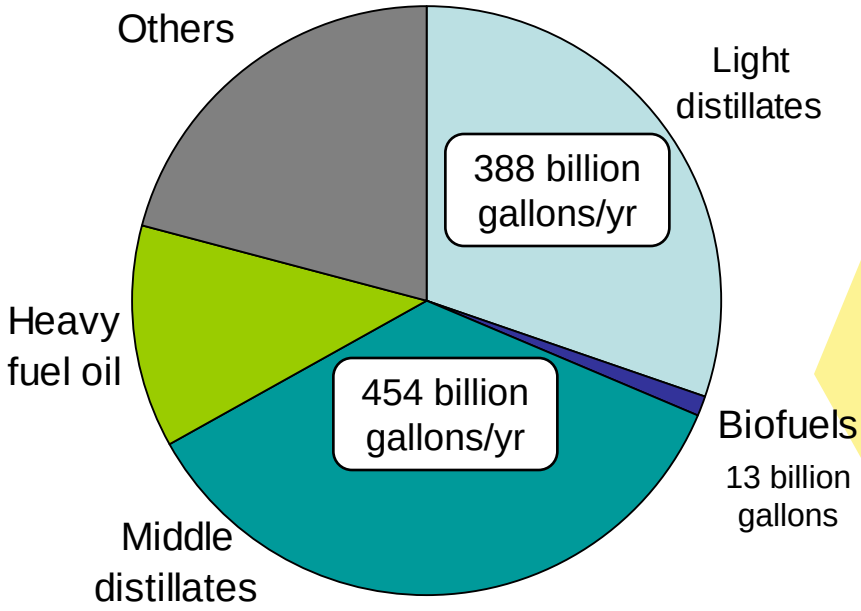
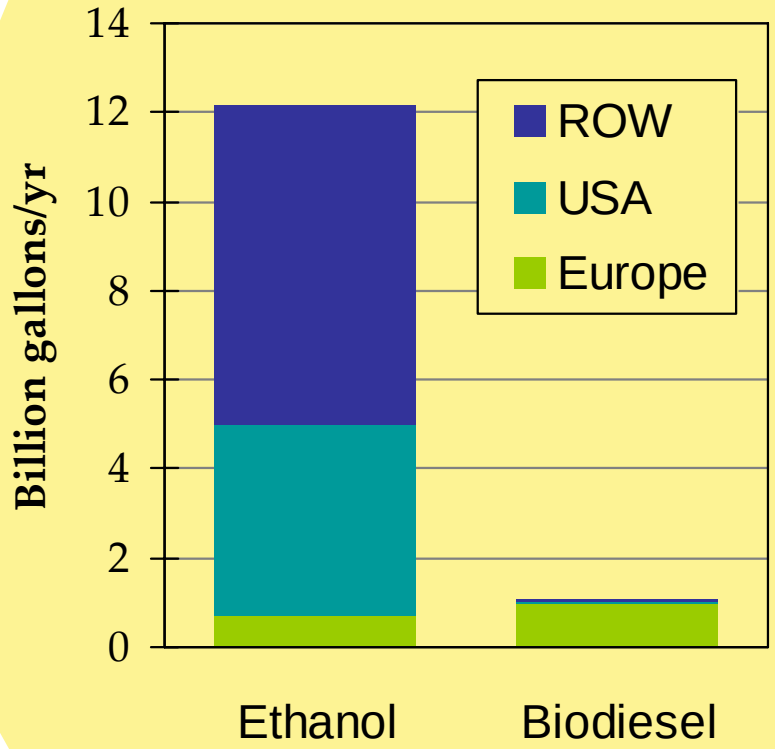
2005 Global Petroleum Product Consumption



Total = 82.4 million barrels/day

2005 Global Biofuel Production



Total = 862 thousand barrels/day

Biofuels Represented < 2% of Global Trans. Fuel Production in 2005, but is increasing.

Sources: BP Statistical Review of World Energy; National Biodiesel Board, European Biodiesel Board, Renewable Fuels Association; Navigant

Global Ethanol Status

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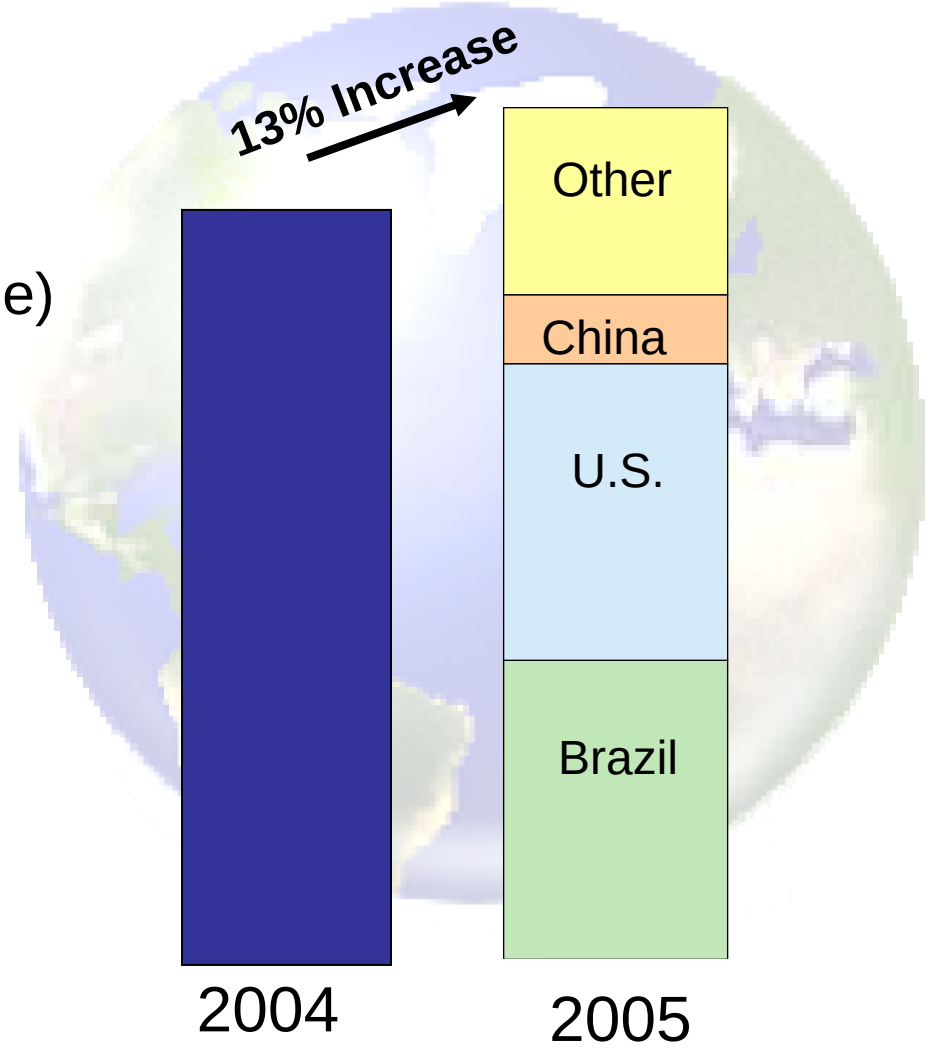
- 2005 Production: 12,150 million gallons
  - 35% -- U.S. (corn)
  - 35% -- Brazil (sugarcane)
  - 8% -- China (feedstock unknown)
  - 22% -- Other Countries (wheat, barley, beet)
- 2004 Production: 10,770 million gallons



Worldwide production of ethanol is growing steadily

Why Biofuels?

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- Improve diversity and security of fuel supply.
- Only alternative liquid transportation fuel available in significant quantities.
- Homegrown fuel with export potential
- Increased economic opportunity for agricultural sector.
- Variety of feedstocks to meet specific soils and climates (agricultural, forest, and other).
- Environmental benefits.

Mission of the DOE Biomass Program

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Support advanced technology R&D to transform our abundant, domestic biomass resources into clean, affordable biofuels and high-value products.

- ***Partnerships***
- ***Policy***
- ***Interagency Coordination***
- ***FY07 Budget: $199 million***

Collaborative R&D

Integrated Biorefineries: Systems Integration and Demonstration

Our core activities accelerate technology advances needed to support a domestic bioindustry producing cellulosic ethanol and other biofuels in integrated biorefineries.

Biomass Program Portfolio

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Removing barriers to large-scale production of cellulosic biofuels

Collaborative R&D

- **Feedstocks:** integration of feedstocks with conversion processes
- **Conversion Technologies:** biochemical and thermochemical
- **Integrated Biorefineries:** systems integration, demonstrations, infrastructure development

Integrated Biorefineries

- **Systems Integration:** feedstocks, conversion, biopower, infrastructure
- **Demonstrations:** pilot scale and commercial scale for diverse feedstocks

DOE efforts are paving the way for a strong, domestic bioenergy industry—with commercial success possible in the next six years.

U.S. Presidential Commitment to Ambitious Biofuels Goals

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- Cost-competitive cellulosic ethanol" by 2012
- **"20 in 10"**
  - Reduce U.S. gasoline* use by **20%** by 2017 through…
    - **15%** reduction from new Alternative Fuels Standard at **35 billion** gallons/year
    - **5%** reduction from enhanced efficiency standards (CAFÉ)
- **"30 in 30"**
  - Longer-term DOE biofuels goal
  - Ramp up the production of biofuels to **60 billion** gallons
  - Displace **30%** of U.S. gasoline consumption* by 2030

* light-duty vehicles only

20-in-10 Market Goal

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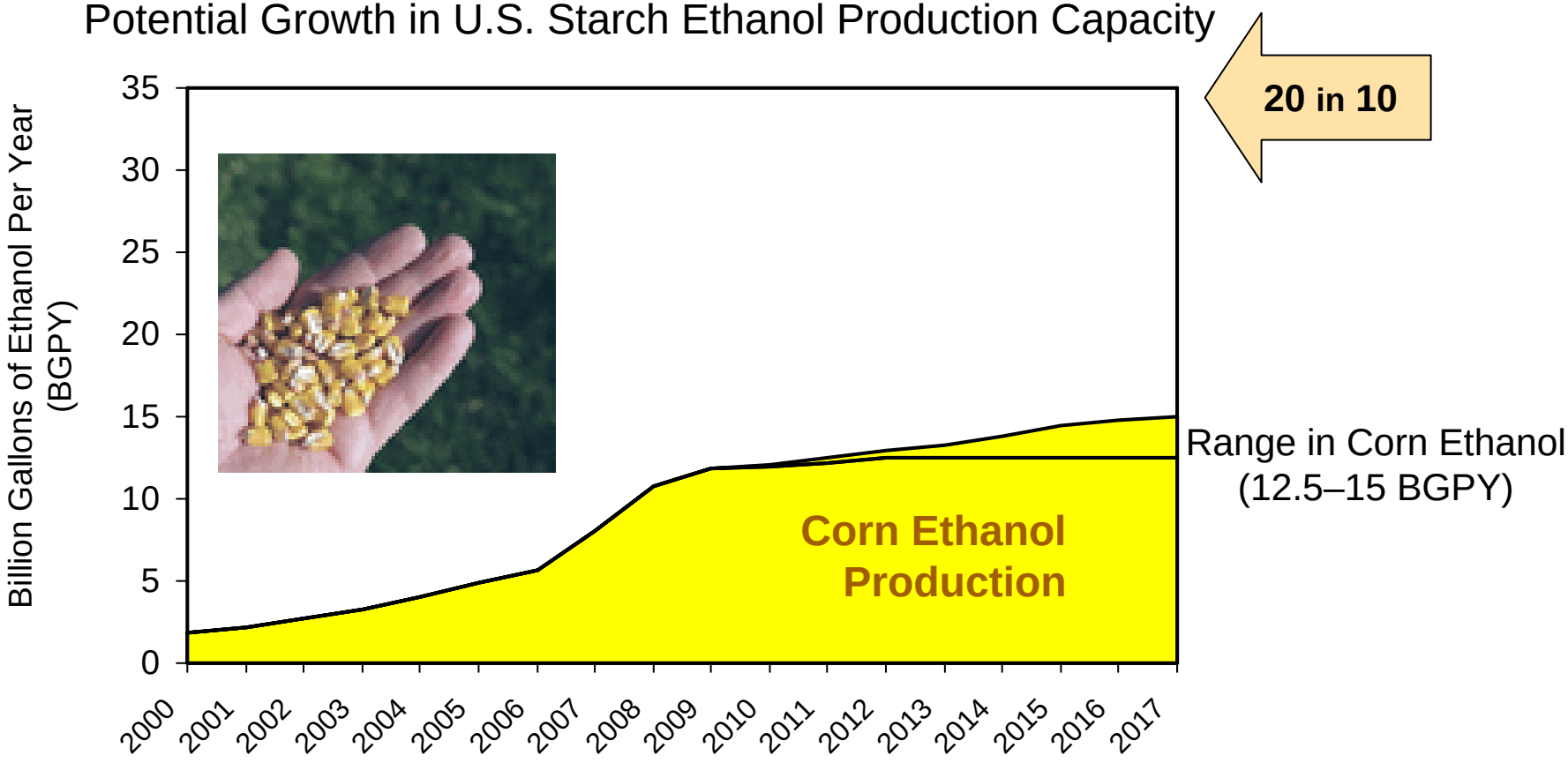
Potential Growth in U.S. Starch Ethanol Production Capacity



Corn ethanol will contribute substantially to the 20-in-10 market goal – but an incremental 20 billion gallons per year will be needed.

The corn-ethanol industry is a prime example of today's biorefining industry

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- 1.43 billion bushels of corn
  - 13% of U.S. corn crop
  - 3rd largest market for U.S corn
- Purchased Energy
  - Electricity
  - Natural Gas

- 4 billion gallons ethanol
  - ~2.7% U.S. gasoline consumption
- >11 million metric tons animal feed
- 565 million pounds corn oil
- Sweeteners, starch, CO_2, specialty chemicals

Additional Developments

- Continued process improvements
- Use of biomass for onsite power and heat production

Source: Navigant

Collaborative R&D Is Producing Results

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Achievements

- Achieved substantial decrease in cost of ethanol production – from over $5 to approximately $2.26 per gallon
- Developed organisms with superior ability to convert mixed sugars to ethanol – an important step toward cellulosic ethanol and the 2012 goal
- Developed high-value plastics, foams, and coatings from oil crops and corn sugar

Cell phone casings made from bio-based polymers developed through DOE-industry cost-shared R&D

Using biomass for both biofuels and high-value bioproducts will enable more cost-effective operation of integrated biorefineries.

The future will likely include multiple biofuels options

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- Corn ethanol and biodiesel production are established technologies
  - Incremental improvements will further reduce production costs
- Cellulosic ethanol technologies have reached the pilot stage
  - All of the technology components are ready for initial commercial deployment
  - Several commercial plants are in advanced development
- Other options, like renewable diesel are also relatively well developed
  - Alternative feedstocks are also being developed for biodiesel
- Technology to produce mixed alcohols or ethanol from syngas (via gasification) is under development, but significant hurdles remain
  - In particular, the catalysts are not well developed and thermodynamics of synthesis are challenging
  - Several U.S. companies are developing mixed alcohol and ethanol synthesis from syngas, but none are commercially ready
- Other technologies for producing fuels from syngas (e.g., FT diesel, DME) are more developed and have backing of major companies (e.g., Shell, Volvo)

Source: Navigant

Cellulosic Biorefinery Investments

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Recently announced competitive selections to provide up to $385 million over four years for cost-shared integrated biorefineries in six states

- **Abengoa Bioenergy Biomass of Kansas**

  Capacity to produce 11.4 million gallons of ethanol annually using ~700 tons per day of corn stover, wheat straw, milo stubble, switchgrass, and other feedstocks

- **ALICO, Inc.**

  Capacity to produce 13.9 million gallons of ethanol annually using ~770 tons per day of yard, wood, and vegetative wastes and eventually energy cane

- **BlueFire Ethanol, Inc.**

  Sited on an existing landfill, with capacity to produce 19 million gallons of ethanol annually using ~700 tons per day of sorted green waste and wood waste from landfills

Cellulosic Biorefinery Investments

Energy Efficiency & Renewable Energy

- **Broin Companies**

  Capacity to produce 125 million gallons of ethanol annually (~25% will be cellulosic ethanol) using ~850 tons per day of corn fiber, cobs, and stalks

- **Iogen Biorefinery Partners, LLC**

  Capacity to produce 18 million gallons of ethanol annually using ~700 tons per day of agricultural residues including wheat straw, barley straw, corn stover, switchgrass, and rice straw

- **Range Fuels (formerly Kergy Inc.)**

  Capacity to produce 40 million gallons of ethanol annually and 9 million gallons per year of methanol, using ~1,200 tons per day of wood residues and wood based energy crops

Policy Drivers & Incentives Supporting Biofuels

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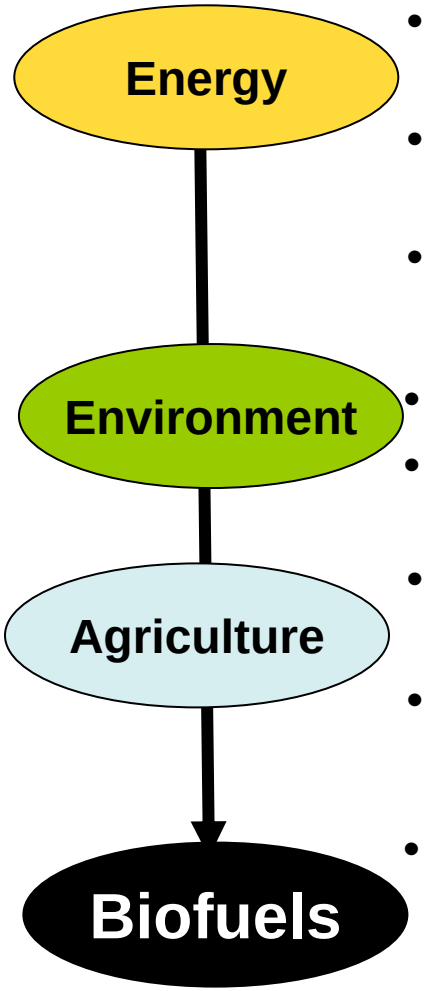

- Energy Security/ Political Tensions
- Resource Diversification
- Petroleum Prices/Volatility
- Climate Change
- Air Pollution
- Economic Development
- Farm Income
- **Ethanol is currently the most prevalent US biofuel**

Examples of Policies

United States

- Energy Policy Act of 2005 (federal policy)
- State tax credits, blend requirements…

Europe

- Tax credits: most common incentive
- EU set target for biofuels consumption (similar to RFS, but not a mandate)

Asia

- China, India, and Malaysia introducing policies to support biofuels
- Japan has tax credits in place

South America

–Brazil: Ethanol blending requirements in place and a requirement for biodiesel starting in 2008

Source: Navigant

Favorable Policies: Good Beginning, Need More

International Collaboration

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- The United States and Sweden signed a Science and Technology Agreement in allowing government agencies of both countries to collaborate on research.
- U.S. DOE is an ongoing partner in International Energy Agency activities, including several major bioenergy tasks.
- July 2005 International Biorefinery Workshop in Washington, D.C. was co-sponsored with the European Commission Directorate General for Research.
- The U.S. – Brazil 2003 Memorandum of Understanding, to strengthen bilateral cooperation on energy modernization and new technologies for both countries.

The biofuels operations value chain is "caught" between global agri-businesses and big oil

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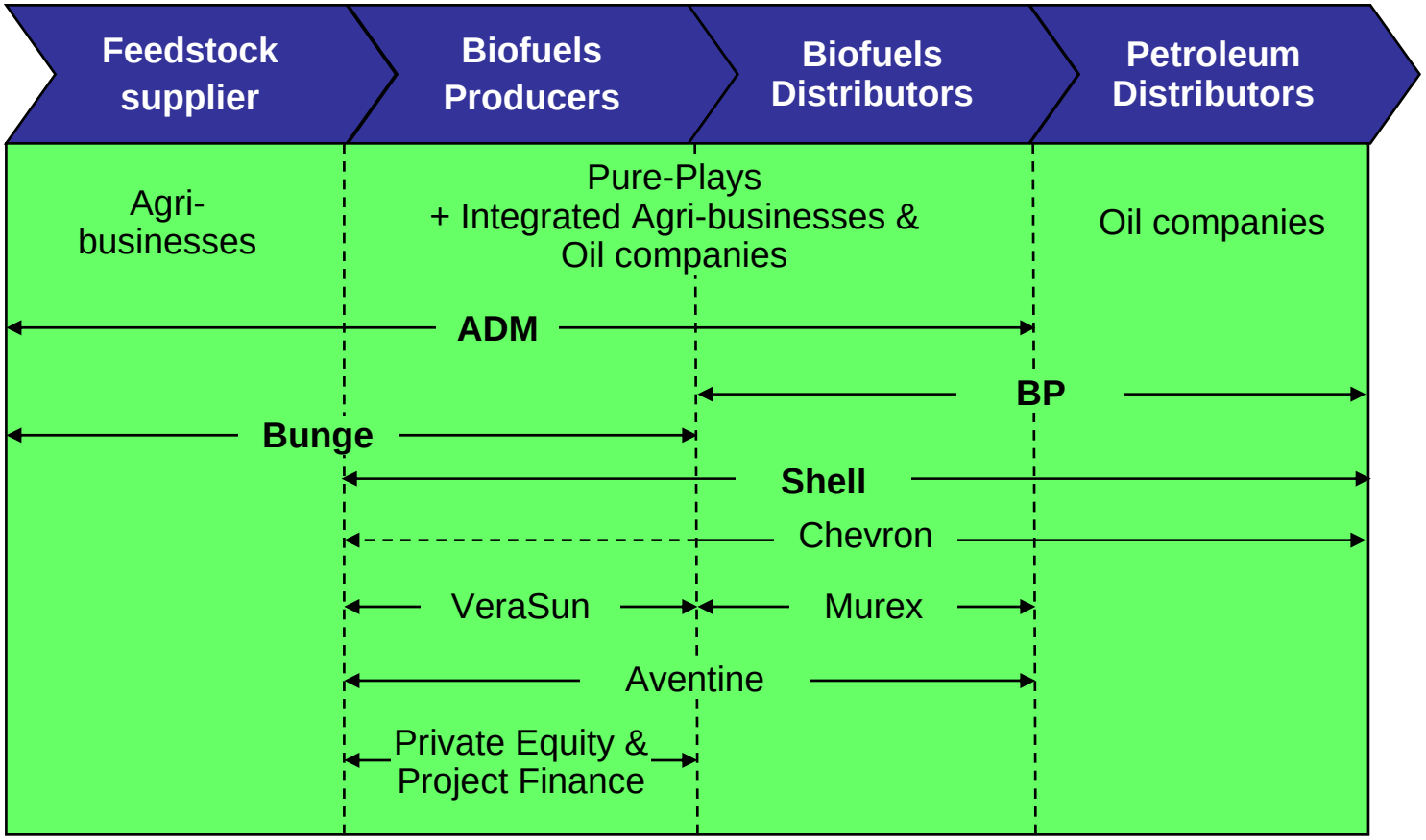

In the middle are the best opportunities for private equity investors and project financing, which have been the drivers of recent growth

Source: Navigant

Venture Capital and Private Equity Investment

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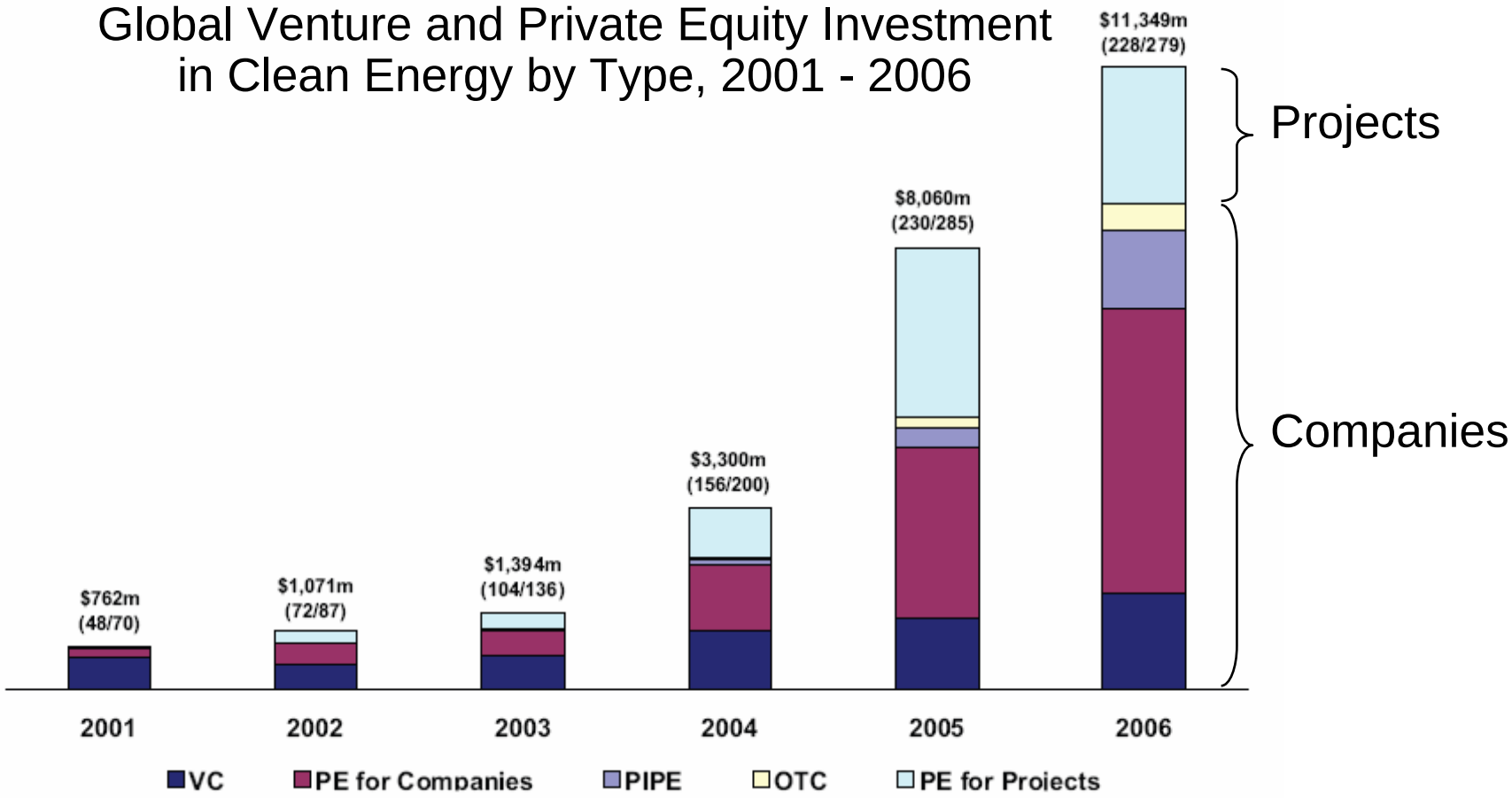
Global Venture and Private Equity Investment in Clean Energy by Type, 2001 - 2006



Global venture capital and private equity investment have skyrocketed over the last five years, with $11 billion invested in 2006.

Note: Figures in brackets represent (deals with disclosed value / total number of deals). Includes all VC/PE investments
Source: New Energy Finance, Navigant

Market Evolution of Alternative Energy Stocks

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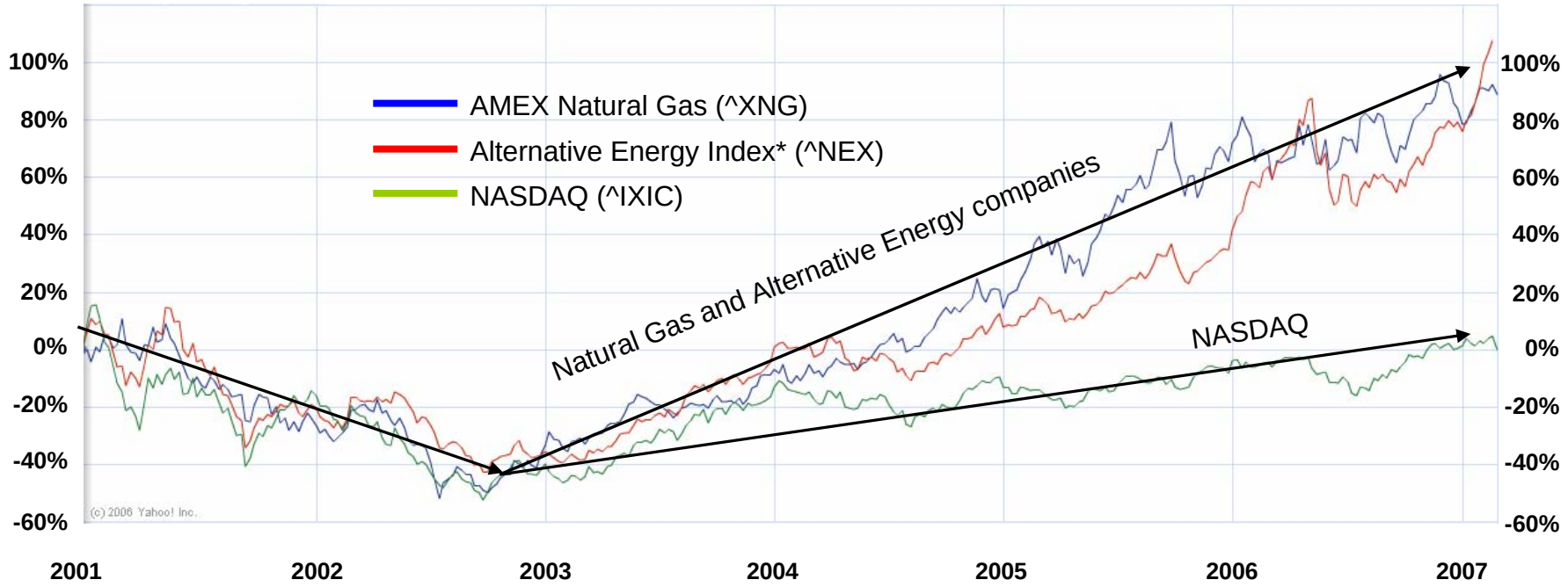
Stock Market Evolution 2001- Present

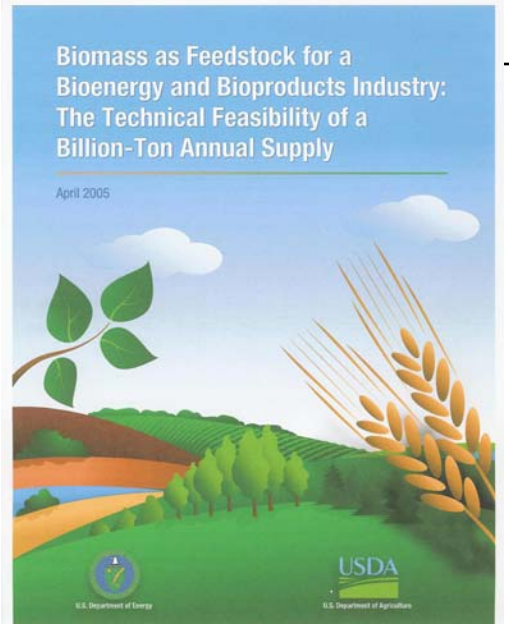


* Index is WilderHill New Energy Finance Global Innovation Index (NEX)

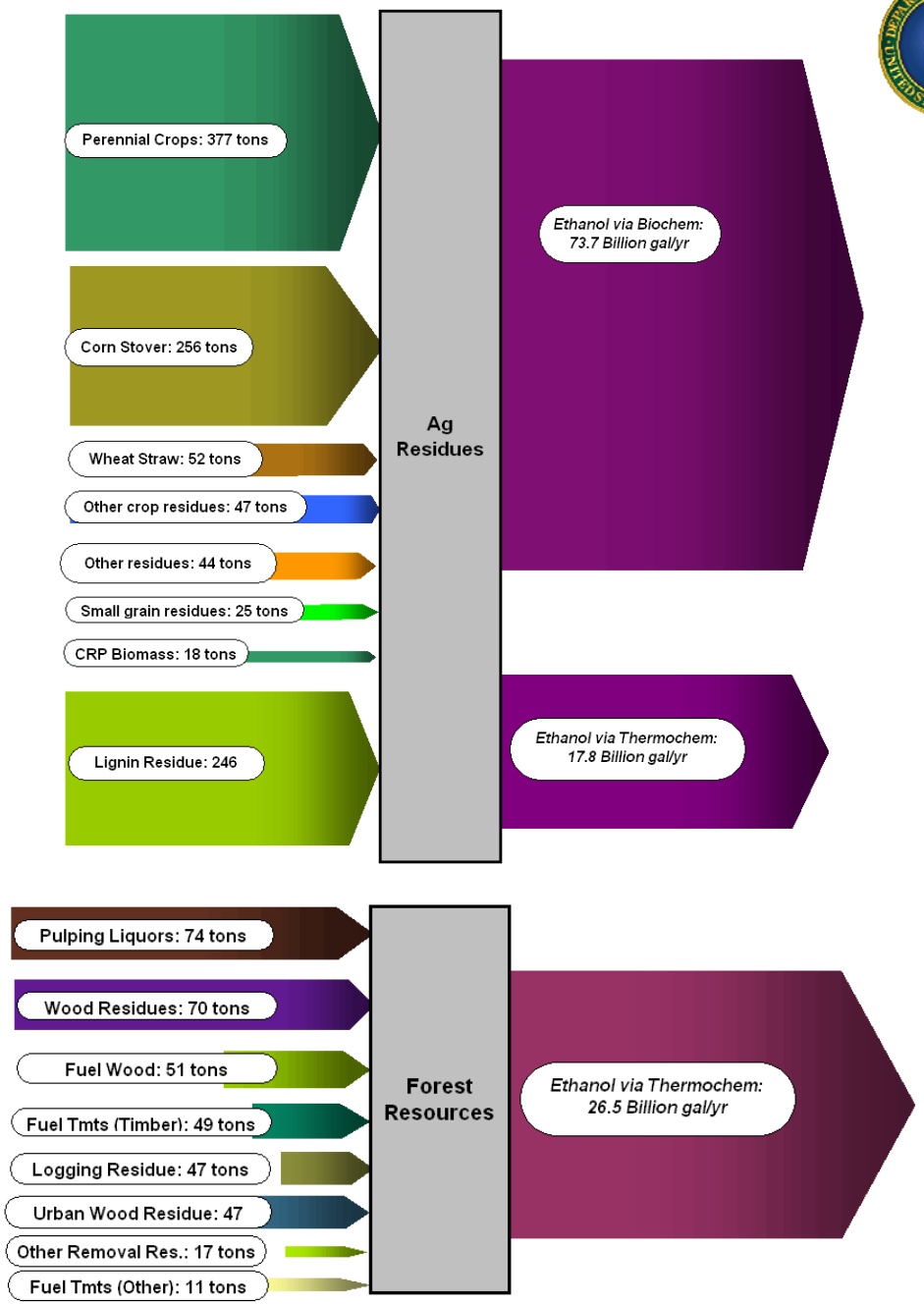
Alternative energy stocks have risen in line with the index of companies involved with natural gas and oil.

Source: Navigant

Conversion of Available Feedstocks



- "Billion Ton" study indicates that enough biomass is potentially available to displace > 30% of current U.S. petroleum consumption
- But it requires variety of biomass types
  - Agricultural lands
    - Corn stover, wheat straw, soybean residue, manure, switchgrass, poplar/willow energy crops, etc.
  - Forest lands
    - Forest thinnings, fuelwoods, logging residues, wood processing and paper mill residues, urban wood wastes, etc.



The future of biofuels will also depend on the creation of new partnerships among several industries

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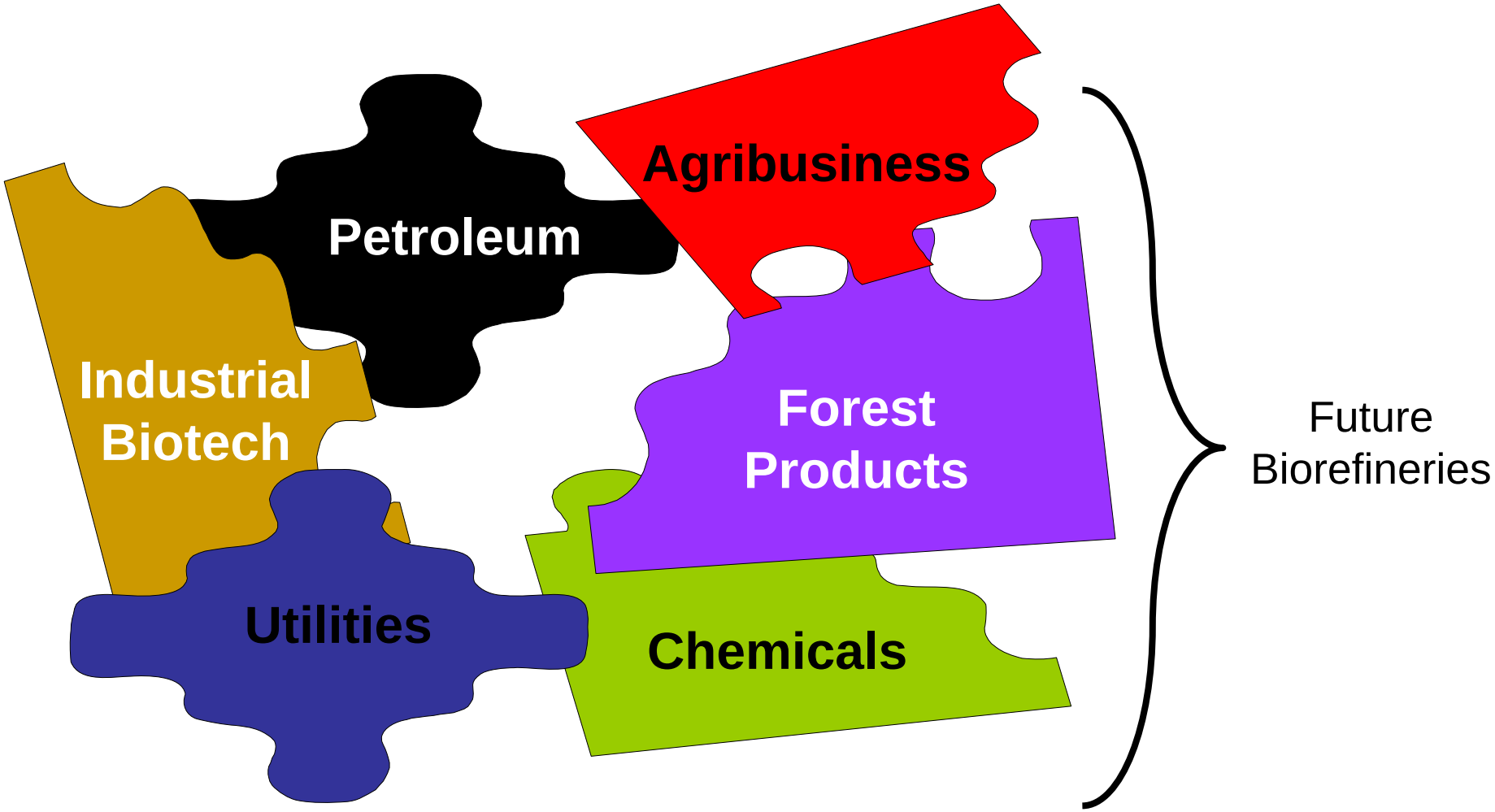

Source: Navigant

BACK UP Slides

Recent U.S. Ethanol Prices Exceed Historical Range…

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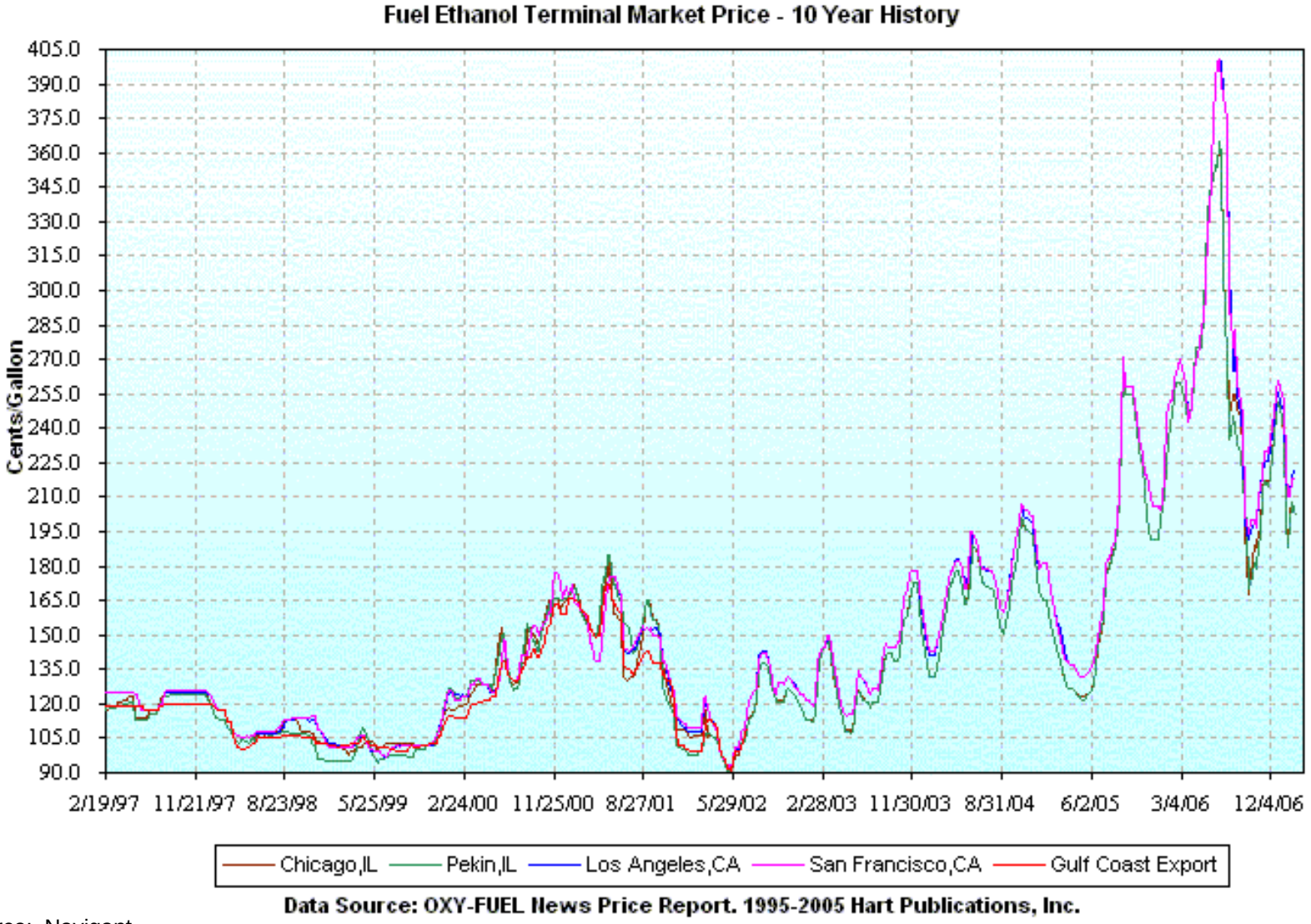

Source: Navigant

Targeted R,D &D: Overcoming Barriers

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Barriers	Solutions
• High cost of enzymatic conversion	• R&D to improve effectiveness and reduce costs of enzymatic conversion
• Inadequate technology for producing ethanol from sugars derived from cellulosic biomass	• R&D on advanced micro-organisms for fermentation of sugars
• Limitations of thermochemical conversion processes	• Re-establish thermochemical conversion as a second path to success
• Demonstration/integration of technology in biorefineries	• Fund loan guarantees, commercial biorefinery demonstrations, and 10% scale validation projects
• Inadequate distribution infrastructure for expanding markets	• Form interagency infrastructure team and Regional Feedstock Partnerships

Future efforts will address obstacles to biochemical and thermochemical routes to biofuels, support demonstrations, and resolve infrastructure issues.

"First generation" biofuels are commercially developed technologies, but have high costs and limited scalability…

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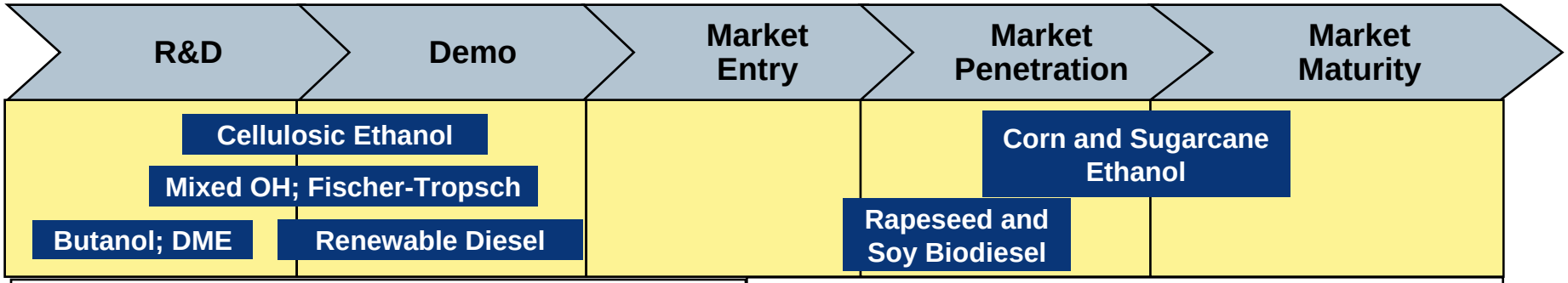

2nd Generation Biofuels

- **R&D efforts are focused on***:*
  - Increasing the range of feedstock from which to produce biofuels
  - Reducing biomass-to-liquid conversion costs
- **Two main technology platforms in development:**
  - *Biochemical pathway*: conversion of the cellulose to sugars and fermentation to alcohol fuels
  - *Thermochemical pathway*: gasification of biomass to syngas and synthesis to fuels
- **Commercial renewable diesel plants are under construction (e.g., Neste oil "NexBTL")**

1st Generation Biofuels

- ***Ethanol*** is a clean burning, high-octane alcohol fuel used as a replacement and extender for gasoline
  - Has been commercially produced since the 70s in the US and Brazil, still the market leaders
  - Corn ethanol is cost competitive (with no subsidies) with gasoline when crude oil is above $50/barrel ($30/brl from sugar cane)
- ***Biodiesel*** is a high-cetane, sulfur-free alternative to (or extender of) diesel fuel and heating oil
  - Commercialized in Europe in the 90's
  - Worst economics (and smaller market) than ethanol

Source: Navigant

Second generation" technologies aim to resolve these limitations