

Overcoming Resource and Transportation Constraints for Cellulosic Ethanol

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USDA/OCE/OEPNU**

Conference at Sciences Po:

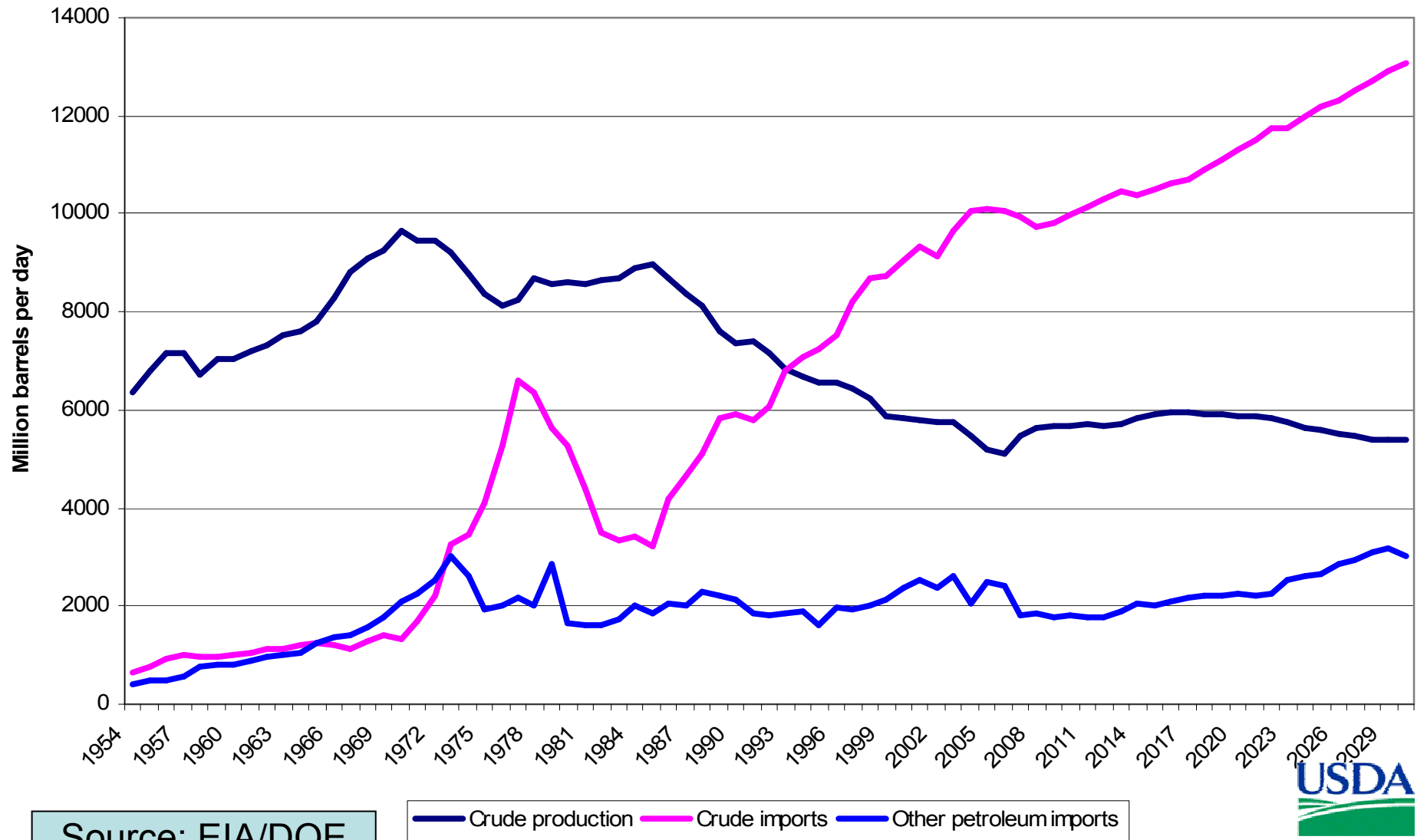
September 21, 2007, Paris France



OVERVIEW

- **Feedstock Availability**
- **Biomass to Fuel**
- **Energy Costs**
- **Local Infrastructure**
- **Environmental Impacts of Biofuel Production**
- **Challenges**
- **Conclusions**

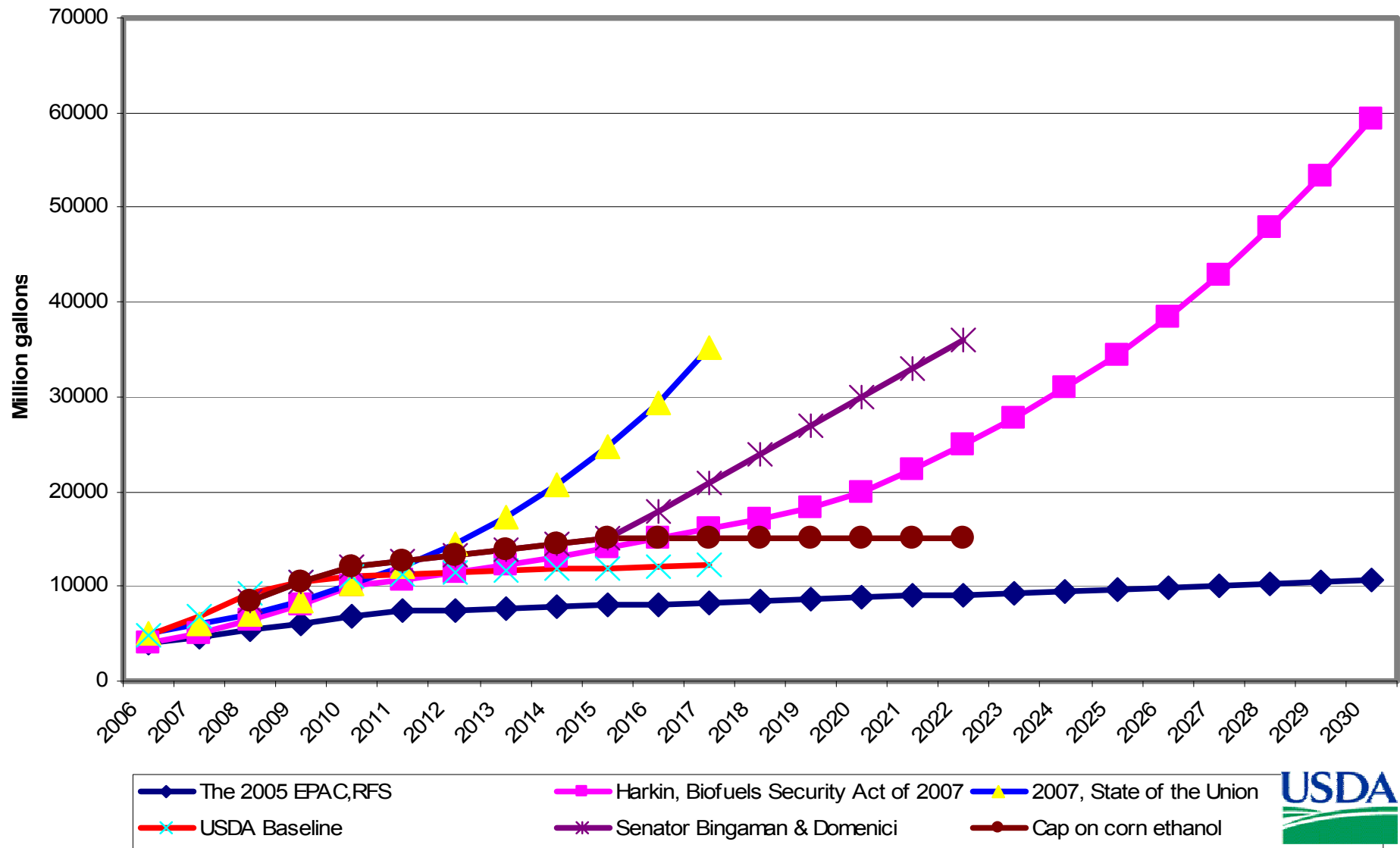
U.S. Crude Oil Production vs. Imports, 1954-2030



Source: EIA/DOE



Projected Biofuel Production



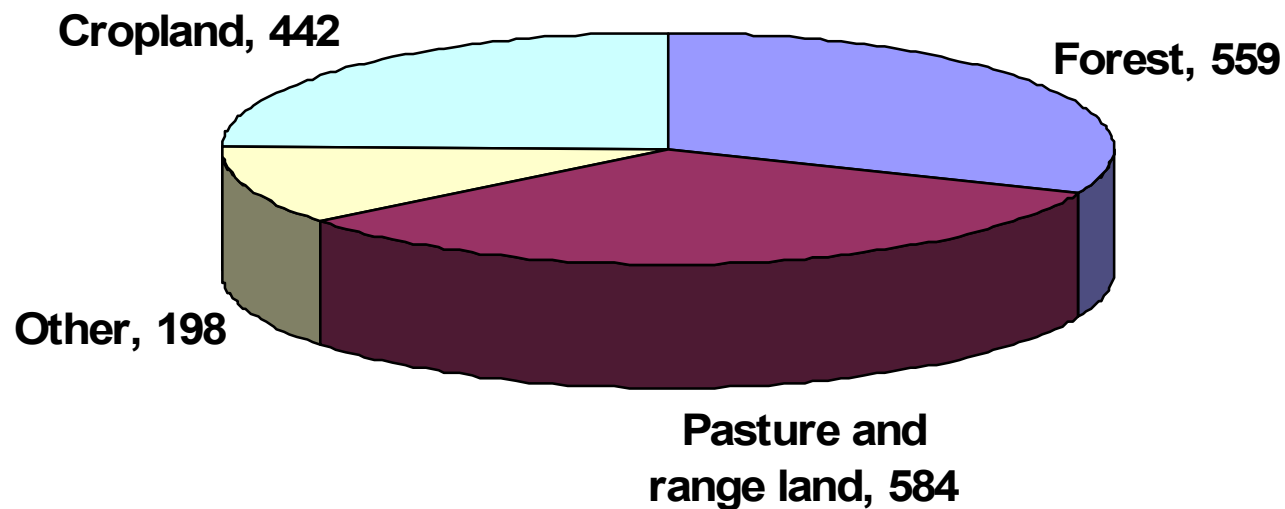
Agriculture Sector Biomass

- **Food and feed grains**
- **Oilseeds**
- **Grasses and trees**
- **Dedicated energy crops**
- **Crop residues**
- **Food and feed industries byproducts**
- **Animal manure**
- **Animal fats & greases**
- **MSW**

Forest Sector Biomass

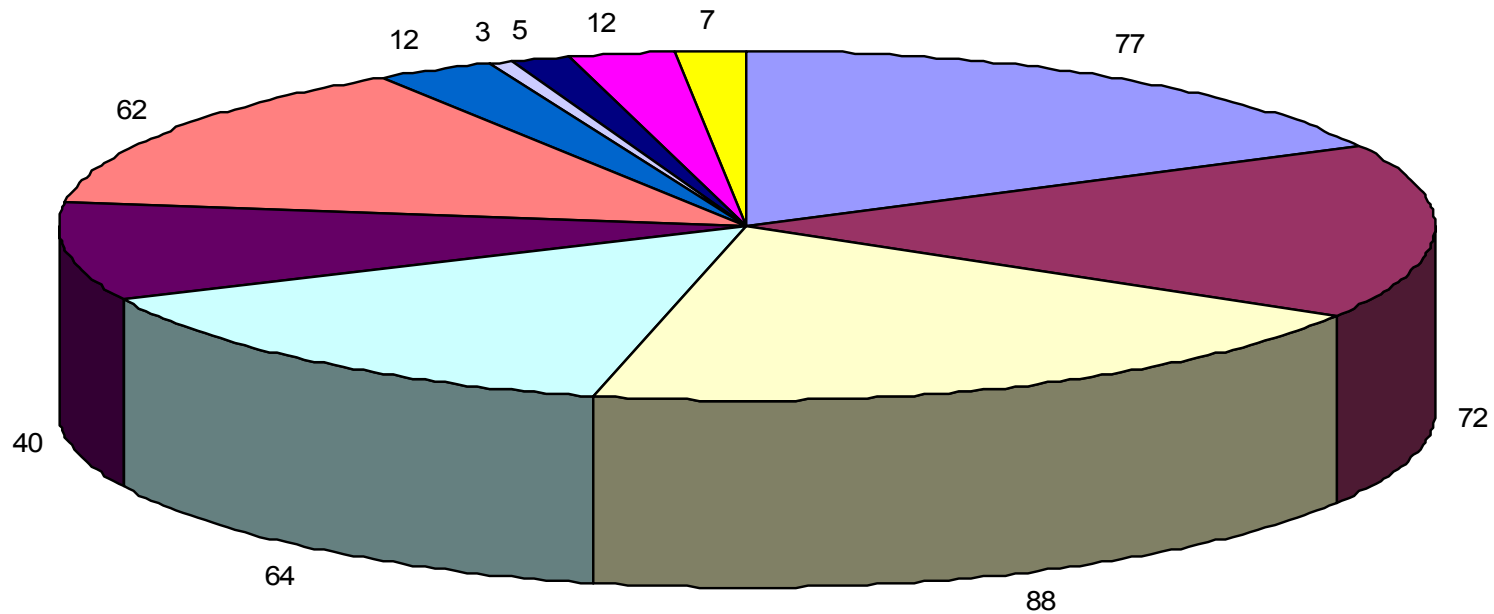
- **Logging & other residues**
- **Fuel treatments**
- **Fuel wood**
- **Forest products industry waste**
- **Urban wood residues**
- **Forest growth**

Land Resource Base, Million Acres

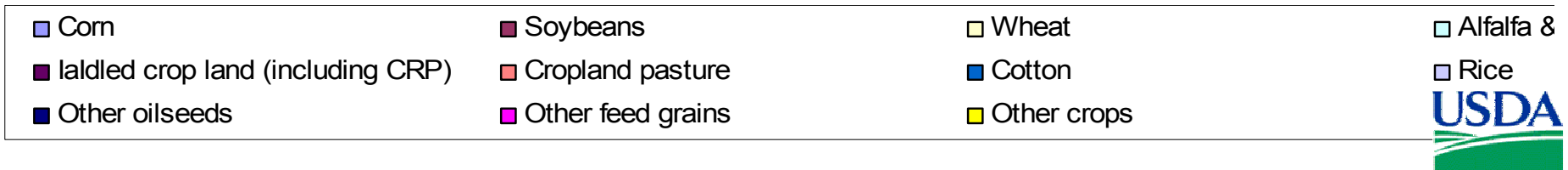


Source: USDA, Census of Agriculture

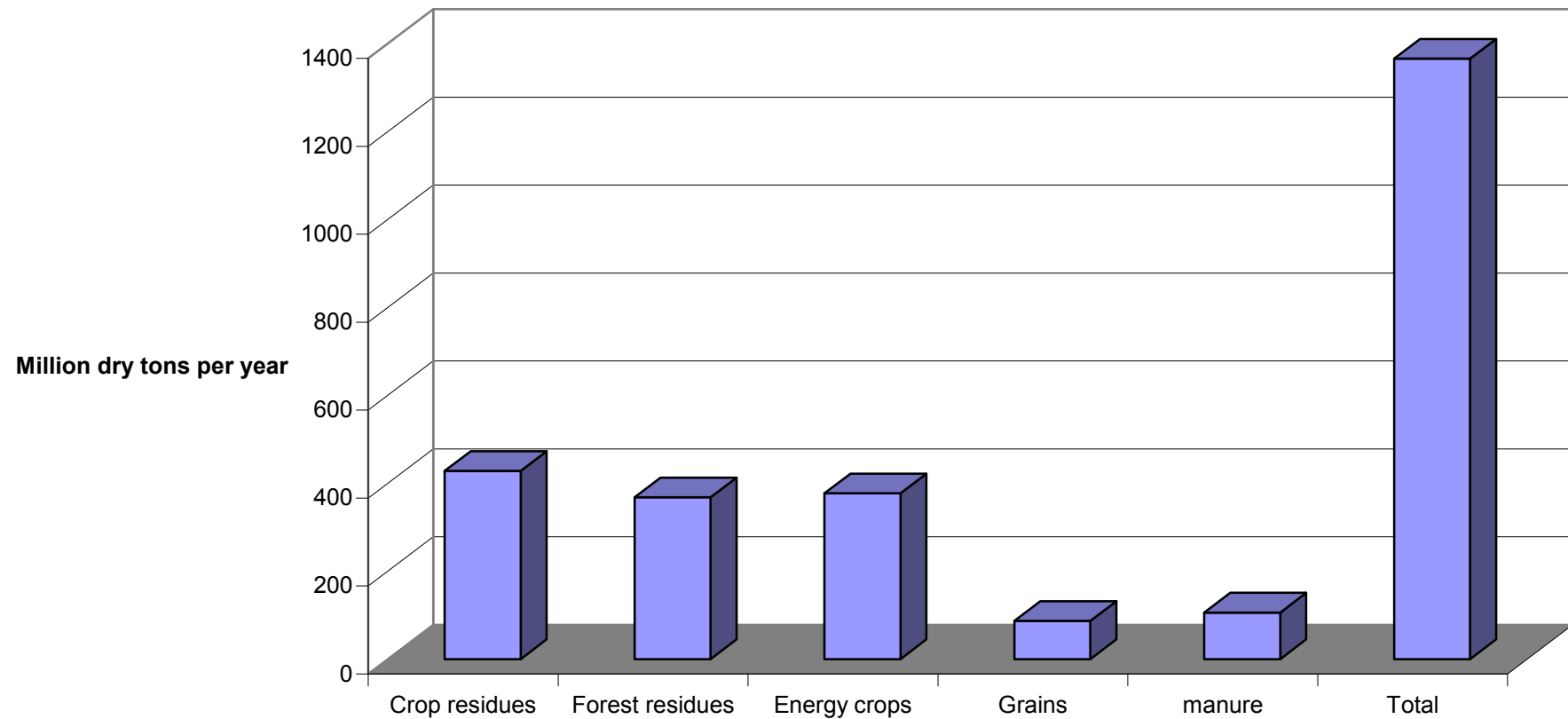
Cropland for Crops



Source: USDA, Census of Agriculture



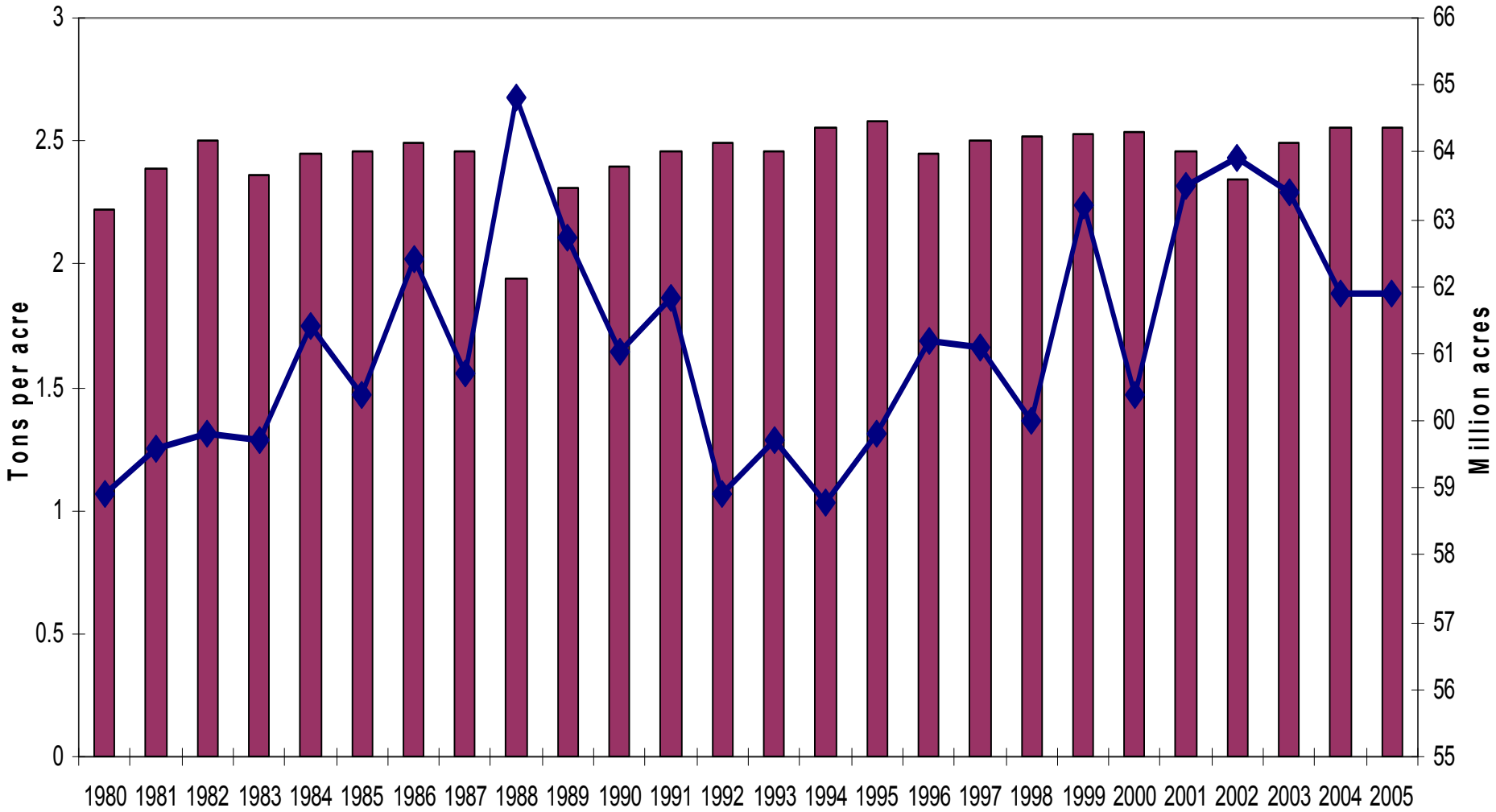
Annual Biomass Resource Potential from Forest and Agricultural Resources, 2050



Source: DOE/USDA, Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply



All Hay: Area Harvested and Yield

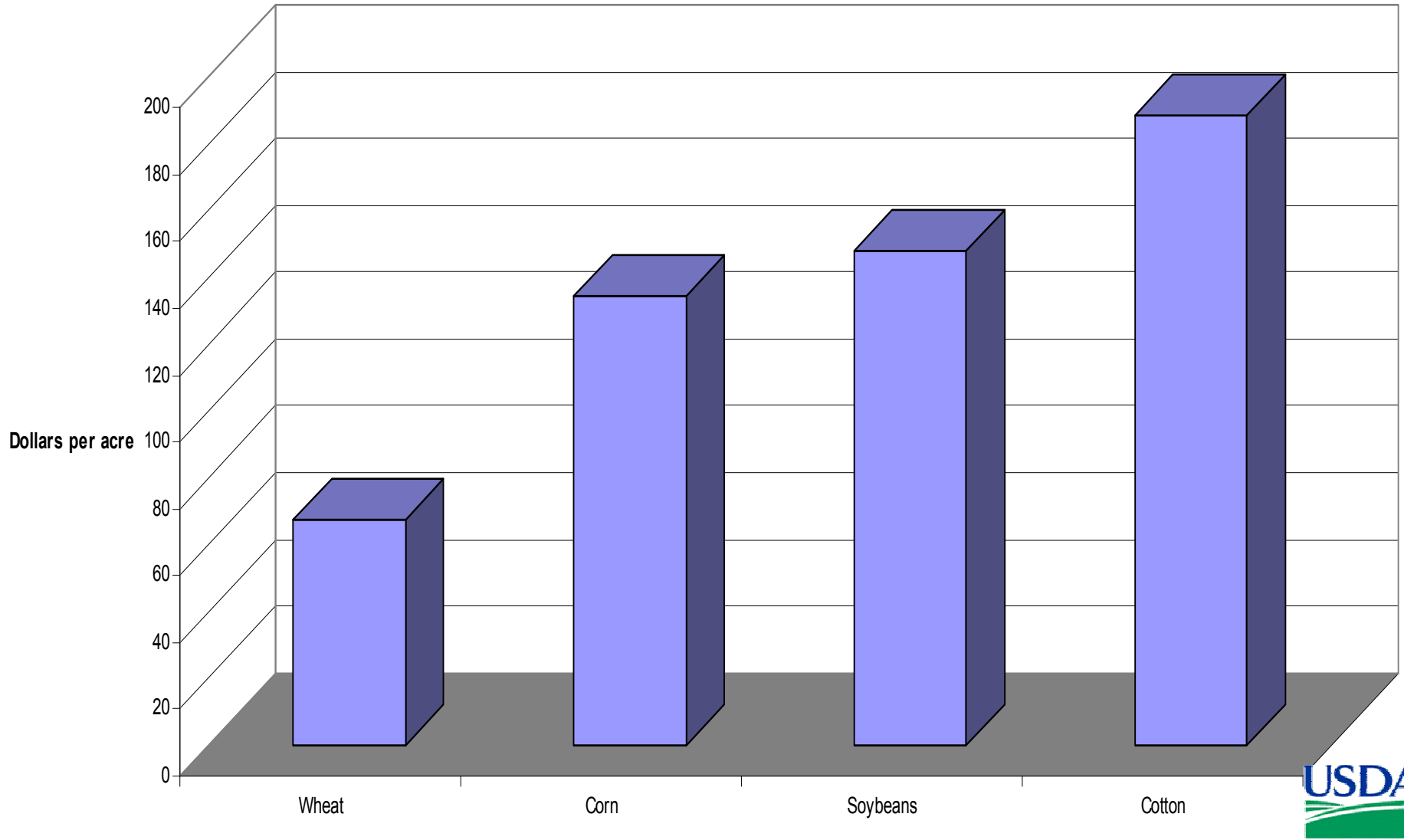


Yield per acre Area harvested

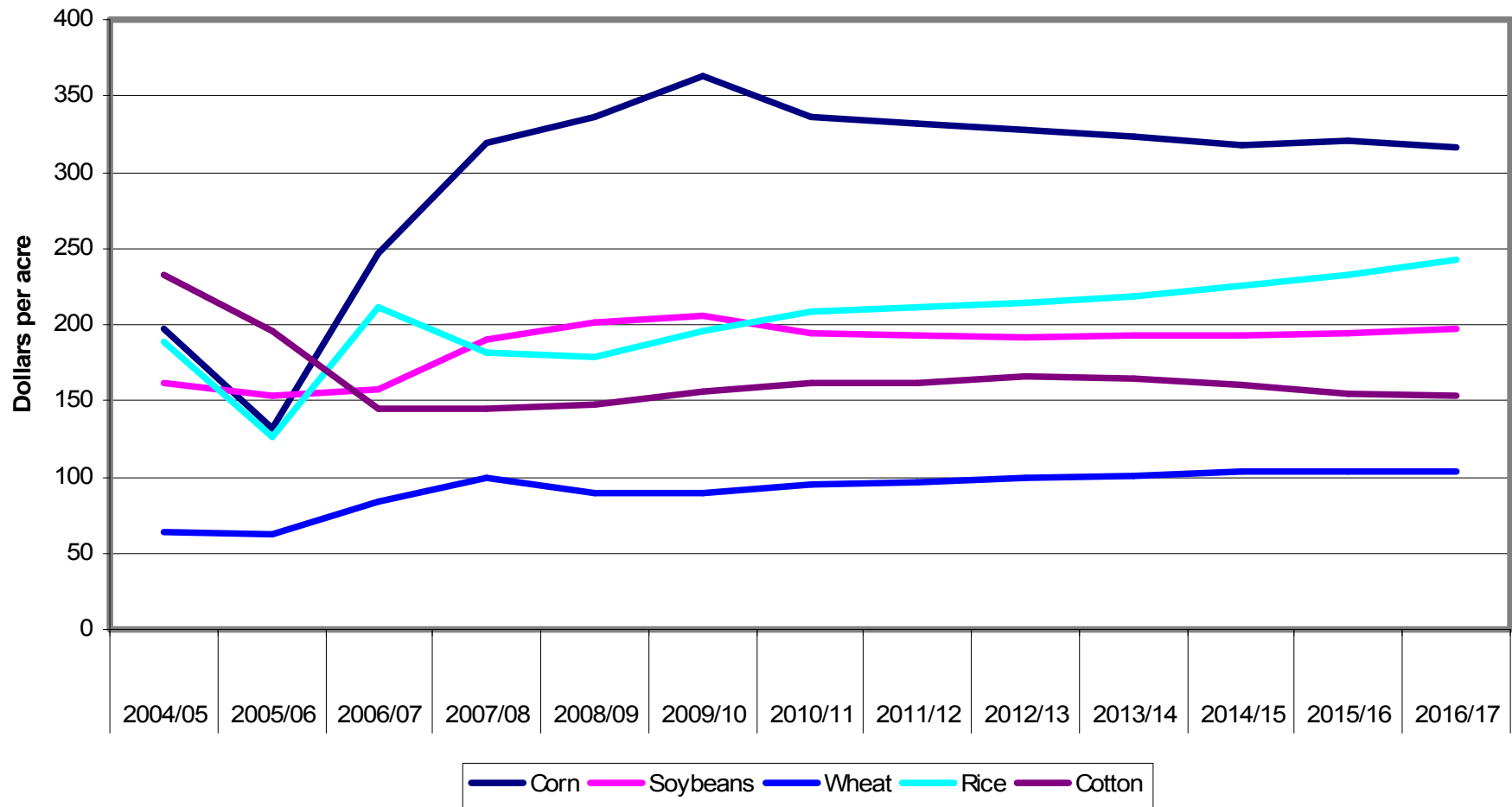


Net Returns Over Variable Costs, 2001/02-05/06 Average

(includes marketing loan benefits)



Projected Net Returns Over Variable Costs, Selected Crops



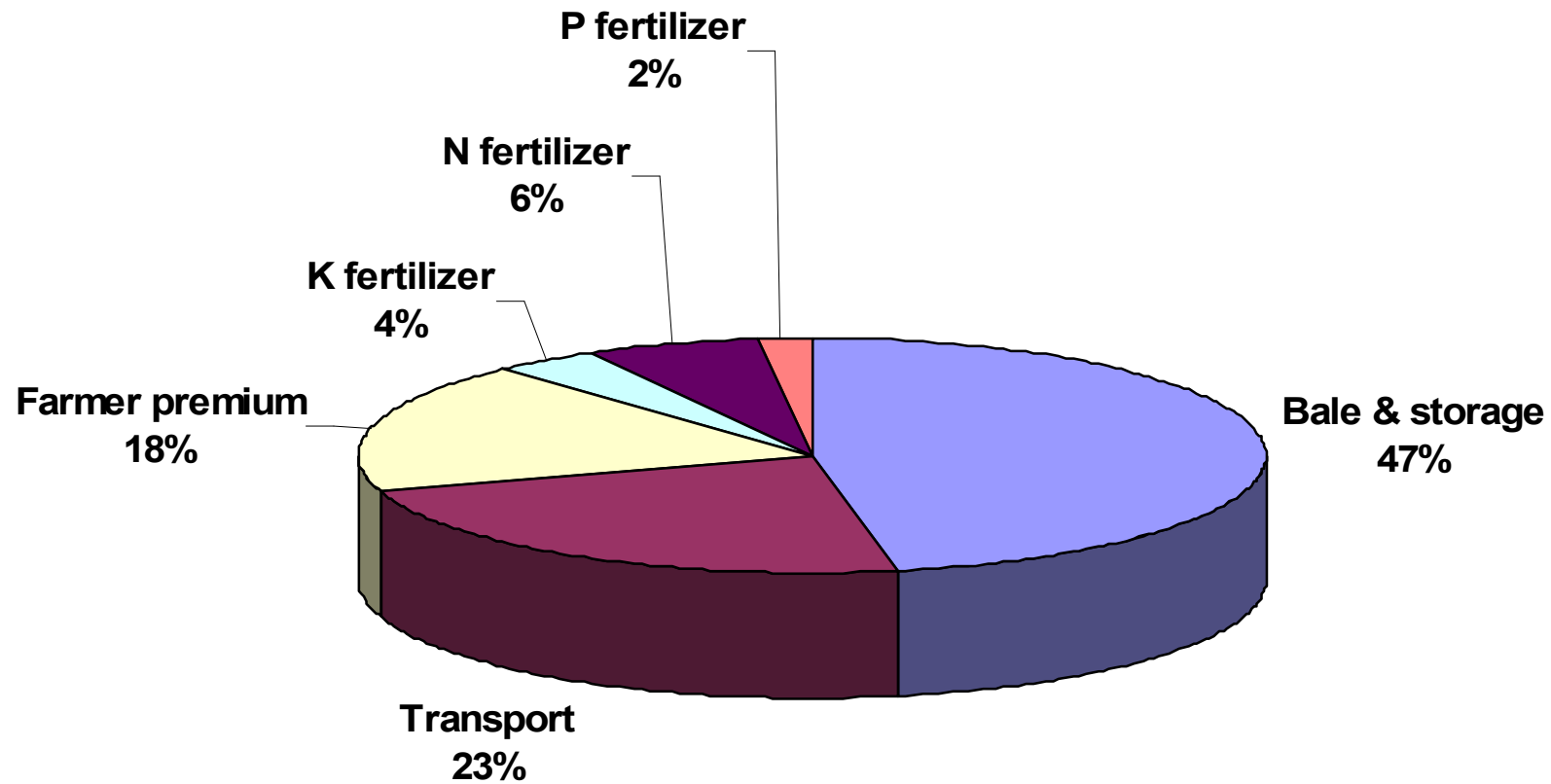
Source: USDA Agricultural Projection to 2016



Biomass Production Costs

- **Corn stover and wheat straw**
 - About \$40 per dry ton, farm gate, ORNL and NREL reports
- **Switchgrass**
 - \$50 to \$60 per dry ton, farm gate, Chariton Valley, Iowa, Nebraska, North and South Dakota

Total Delivered Stover Cost



Source: NREL Technical Report, NREL/TP-510-32438, page 10, June 2002

Biomass Total Costs per Dry M³

	Farm gate	Hauling and receiving facilities	Total costs
Round bales	51.9	27.4	79.3
Chopped	51.9	20.3	72.20
Wood-chip	0	44.35	44.35

Source: Economic Analysis of two Receiving Facility Designs for Biomass plant, John Cundiff, Hosein Shapouri, and Robert Grisso, Virginia Tech.



Value-Added Benefits

- **Cellulosic materials to ethanol:**
 - **Biomass 1 dry ton** **-\$70 to -\$80**
 - **Biomass ethanol 80 gallons** **\$134**
 - **Excess electricity 320 kwh** **\$25**
 - **CO²** **+**
 - **Value of ethanol and byproducts** **\$159**
 - **Value-added** **\$79 to \$89**

Nth plant



Renewable Fuels

- **Ethanol**
- **Bio-methanol**
- **Bio-buthenol**
- **Bio-diesel**
- **Synthesis diesel**
- **Biocrude, diesel, gasoline**
- **Hydrogen**

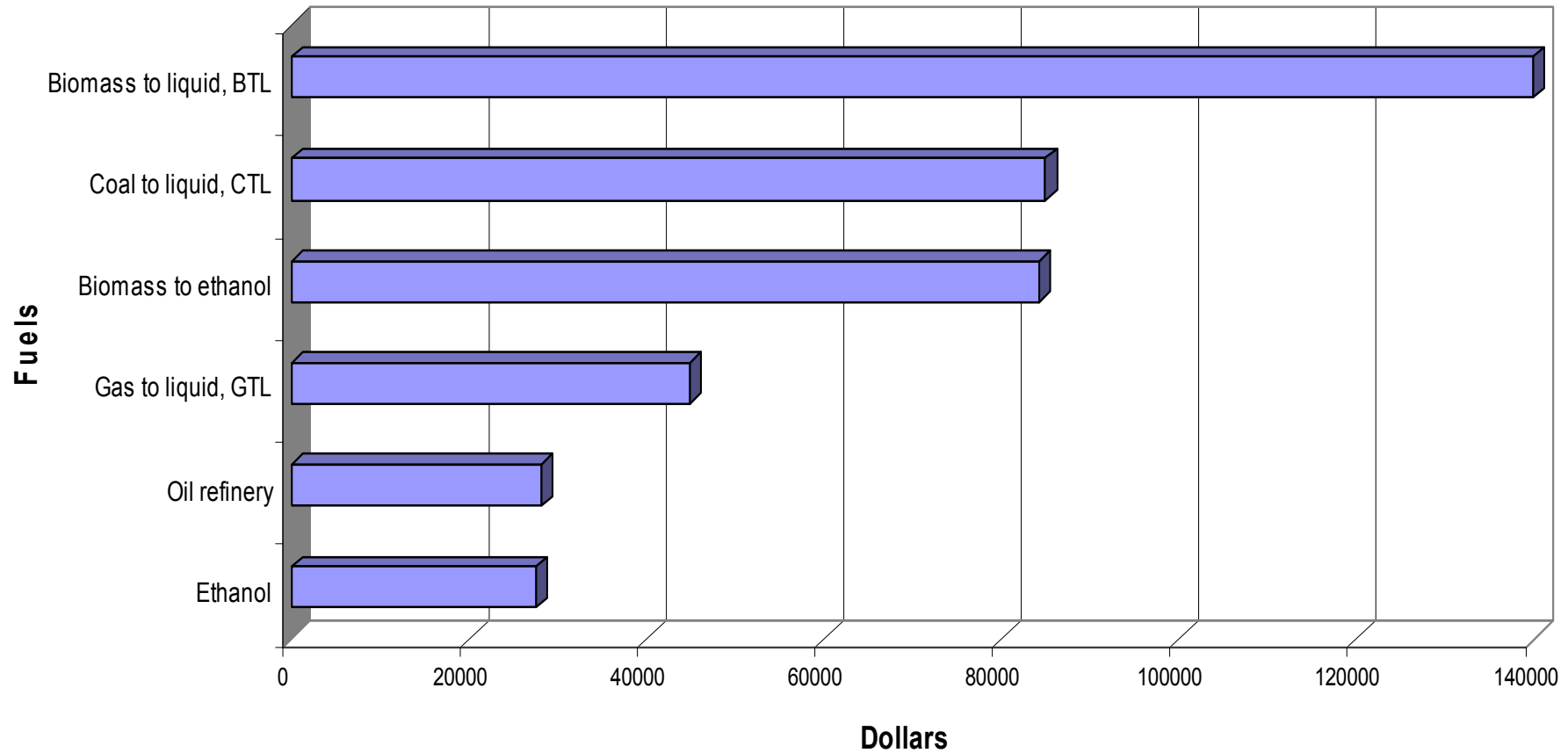
Biomass to Fuel

- **Conventional (1st generation)**
 - Ethanol--fermentation
 - Biodiesel—trans-esterification
- **2nd generation, cellulose materials**
 - Bio-chemical conversion, fermentation
 - Thermo-chemical conversion
 - Gasification- Fischer & Tropsch
 - Gasification- fermentation
 - Gasification-hydrogen
 - Fast pyrolysis- bio-crude, “py oil”
 - Hydrotreating-biodiesel

Characteristics of Ethanol from Corn Versus Cellulosic Materials

	<i>Corn</i>	<i>Cellulosic materials</i>
Capital cost to build plant, per gallon	\$1.75-\$2.00	\$4.50 -\$5.75
Conversion process	Simple	Complex
Enzyme cost, per gallon	3 cents	15 -20 cents
Byproducts	Protein & oil	Electricity
Energy used in processing	NG & Electricity	Self-sufficient
Alcohol content of beer, percent	14-20	4
Fermentation time, number of days	2 to 3	7
Labor use in processing plants	Low	High
Ethanol cost of production, per gallon	\$1.60	\$2.30
Ethanol yield per dry ton, gallons	113	79
Transportation cost of raw materials	Low	High

Capital Investment per Barrel per Day



Source: DOE, 2006 Annual Energy Outlook Conference



Infrastructure

- **Grains and oilseeds**
 - Mature
- **Biomass materials**
 - Only for hay and alfalfa hay
 - Wood chip & forest logs

Infrastructure Required for Expanding Biofuels

- **Production level**
- **Policies**
- **Land resource base:**
 - Existing cropland
 - CRP
 - Fallow land and cropland pasture
 - Pasture and rangeland
- **Water, used in production of biofuels**
 - Wells and pumps
 - Irrigation systems
- **Capital**
 - Farm equipments
 - Farm machinery, harvester, combine
 - Other farm inputs, seed, fertilizers, chemicals, fuels

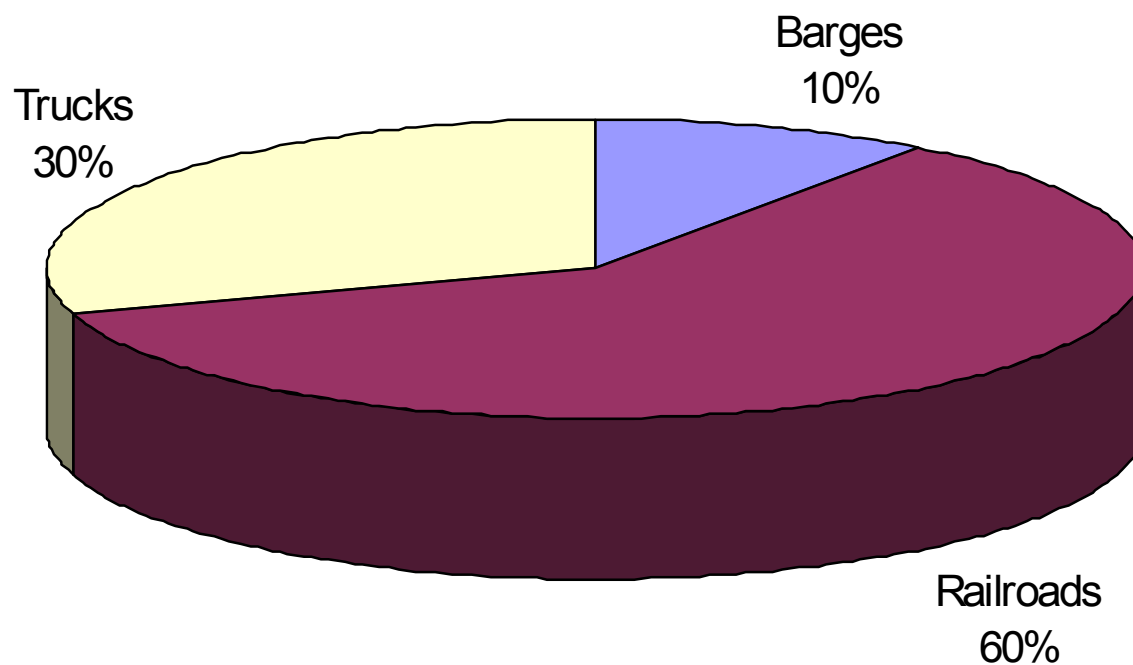
Infrastructure Required for Expanding Biofuels--Continued

- **Labor, farms and processing plants**
- **Feedstock storage and handling:**
 - **Satellite storage locations**
 - **Mode of transportation**
 - **Availability of roads , water ways, rail road tracks**
 - **Load limit and road congestions**
- **Processing plants**
 - **Capital**
 - **Process**
 - **Plant capacity**
 - **Feedstock availability and crop density**

Infrastructure Required for Expanding Biofuels--Continued

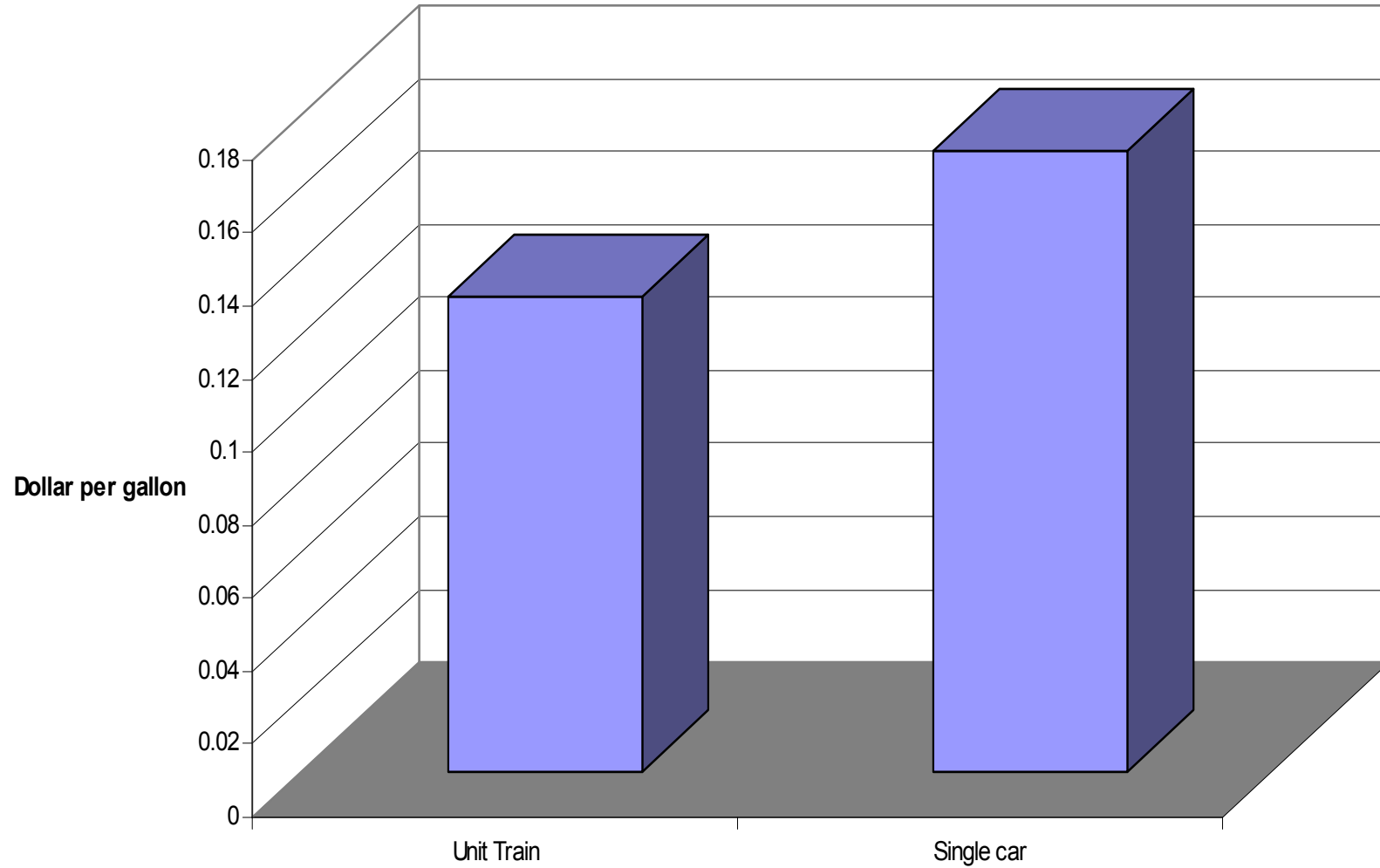
- **Biofuels:**
 - Marketing
 - Biofuel transportation and distribution, (pipelines, trucks, unit trains, barges)
 - Receiving terminals and storage
 - Biofuel use, additives and fuels
 - E-85 and bio-diesel pumps
 - Flexible fuel vehicles

Percent of U.S. Ethanol Production Moved by Mode, 2005



Source: USAD/AMS Ethanol Transportation Backgrounder

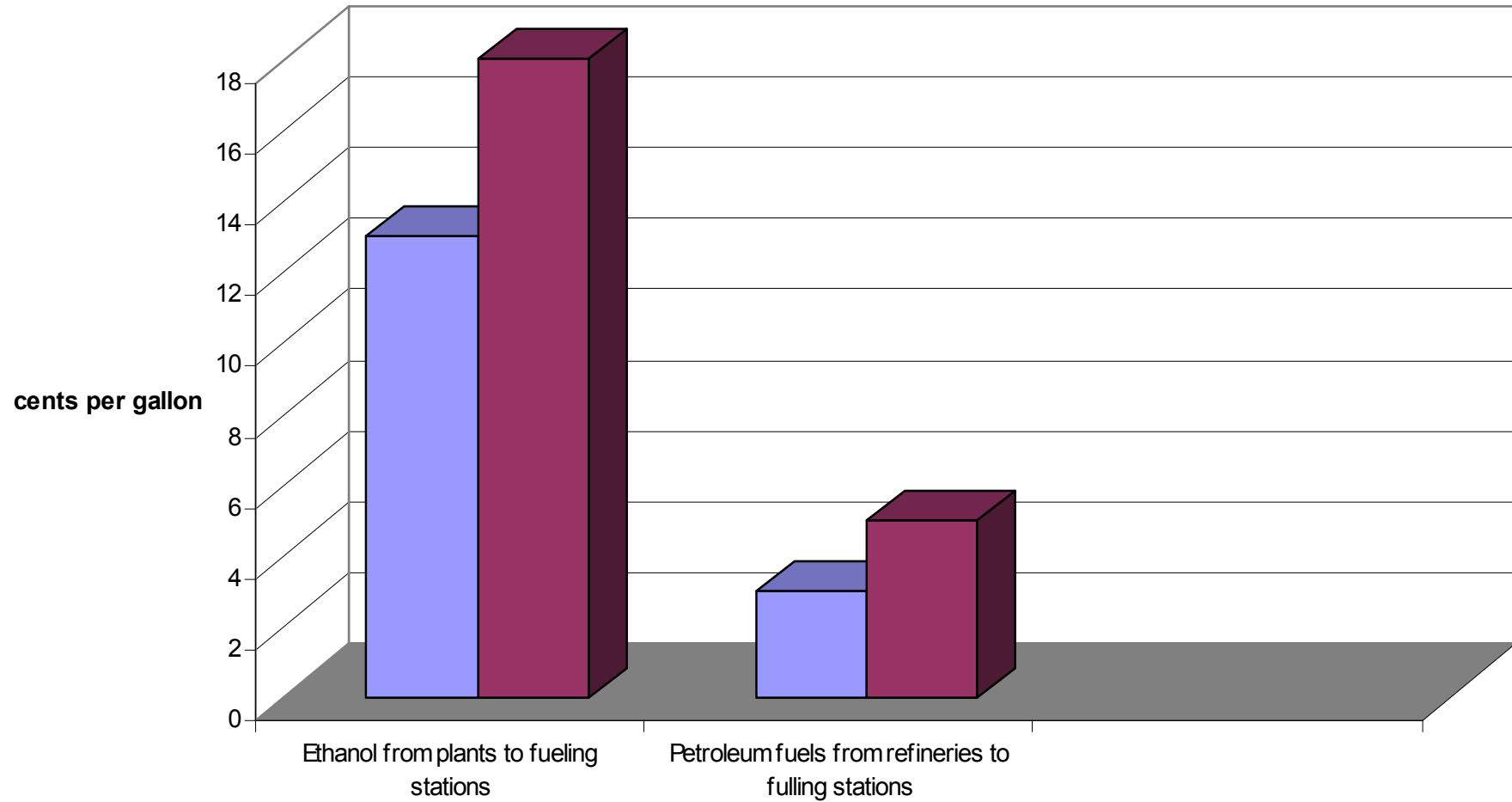
Railroad Tariff Rate per gallon



Source: USDA/AMS



Current Biofuel and Petroleum Fuels Transportation Costs



Source: GAO, Biofuels, June 2007



Environmental Impacts of Biofuel Production

- **Soil erosion**
- **Soil compaction**
- **Nutrients leaching**
- **Water use in production of raw materials and in processing plants**
- **Greenhouse gas emissions associated with feedstock production, transportation, processing, fuel evaporation, and tail pipe emissions**

Energy Costs and Its Impacts on Renewable Fuel

- **Low crude oil prices, \$40 per barrel**
 - Reduces the competitiveness of biofuels without any changes in RFS
- **High crude oil prices, +\$60 per barrel**
 - Expands market share for biofuels
 - Mandate on production of corn-ethanol increases cellulosic–ethanol market share

Opportunities

- **Decreased imported oil**
- **Reduced GHG emissions**
- **New jobs in rural areas**
- **Better use of natural resources**
- **Improved balance of trade**
- **Lower government payments**

Conclusions

- **There are abundant supplies of cellulosic materials available in the United States, which could be converted to biofuels in the near future**
- **Advanced technologies in cellulose materials production, harvesting, transportation, and conversion will reduce biofuel production costs**