Agricultural Research Service (USDA)

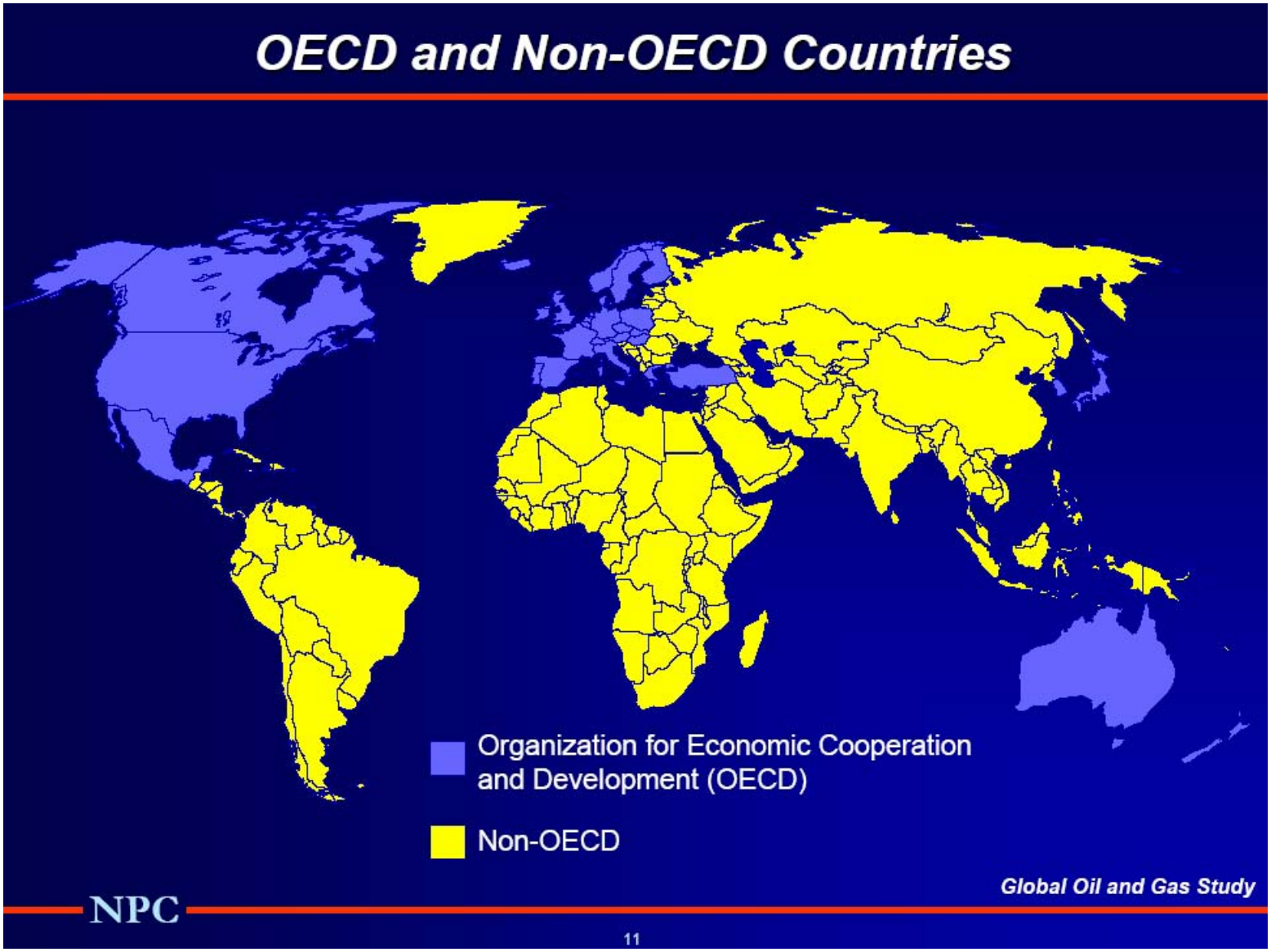
MIDWEST AREA

BIOENERGY RESEARCH FORUM

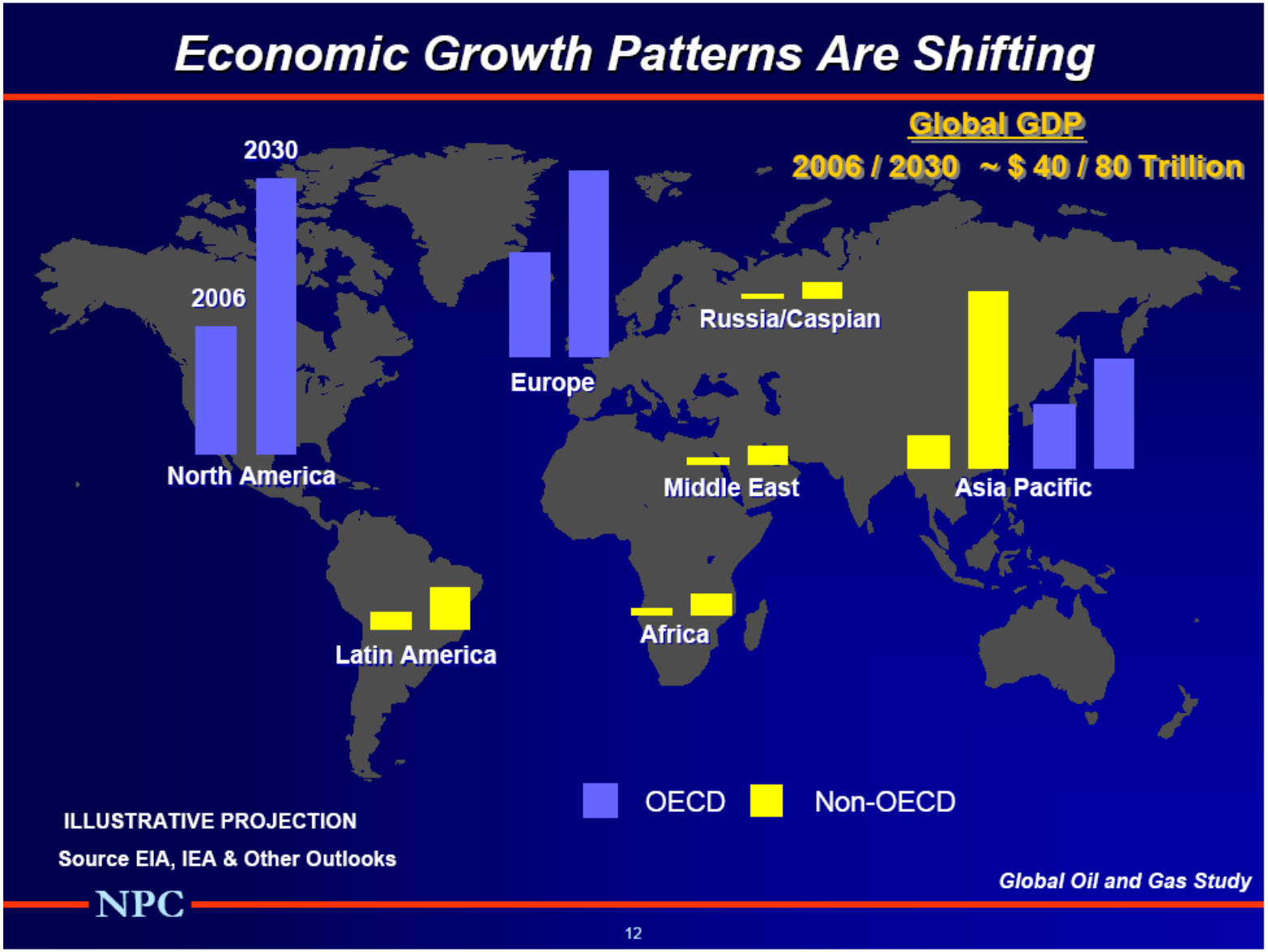
Challenges & Opportunities in Bioenergy

Thomas P. Binder

Archer Daniels Midland Company



Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007



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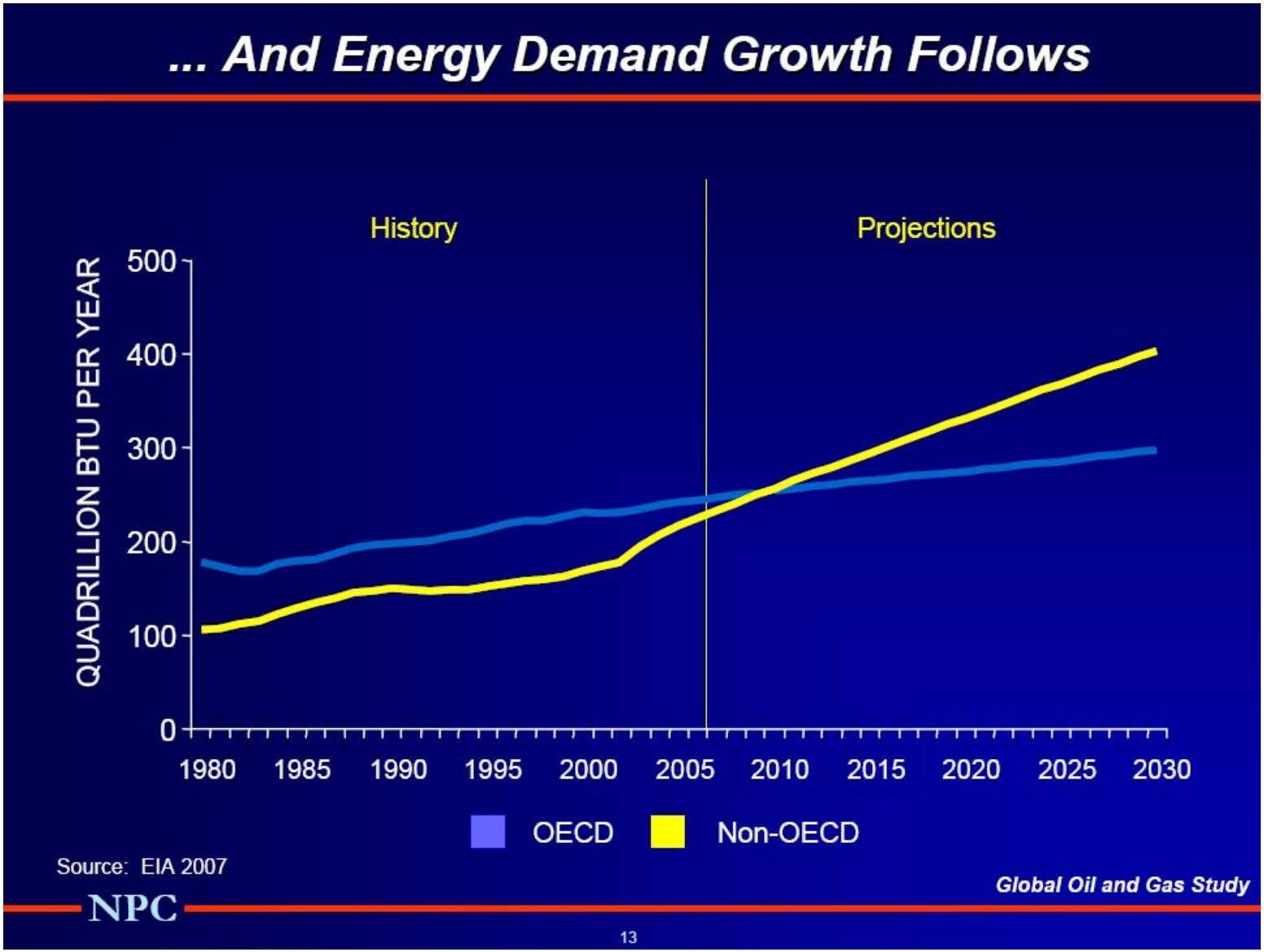

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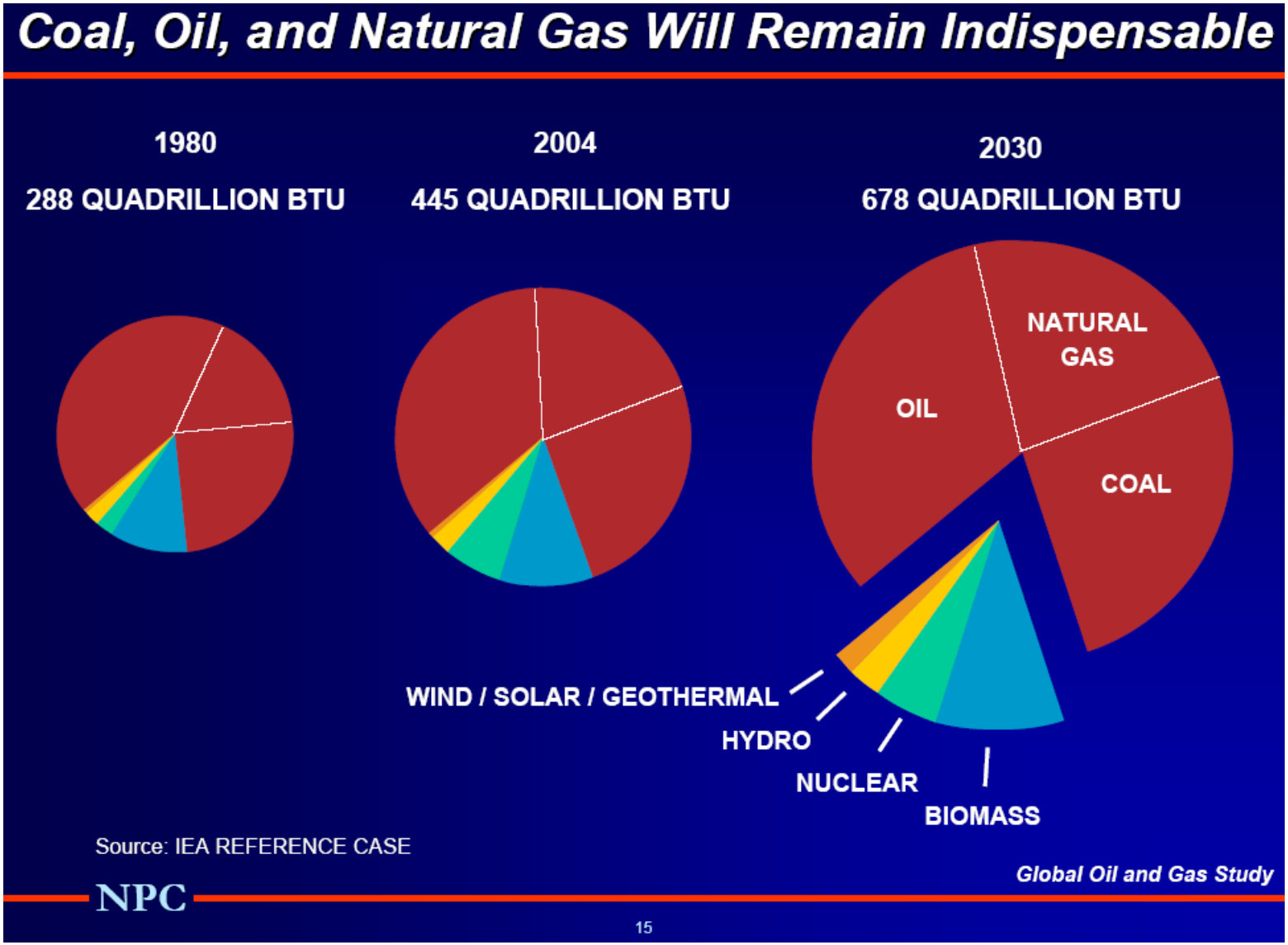

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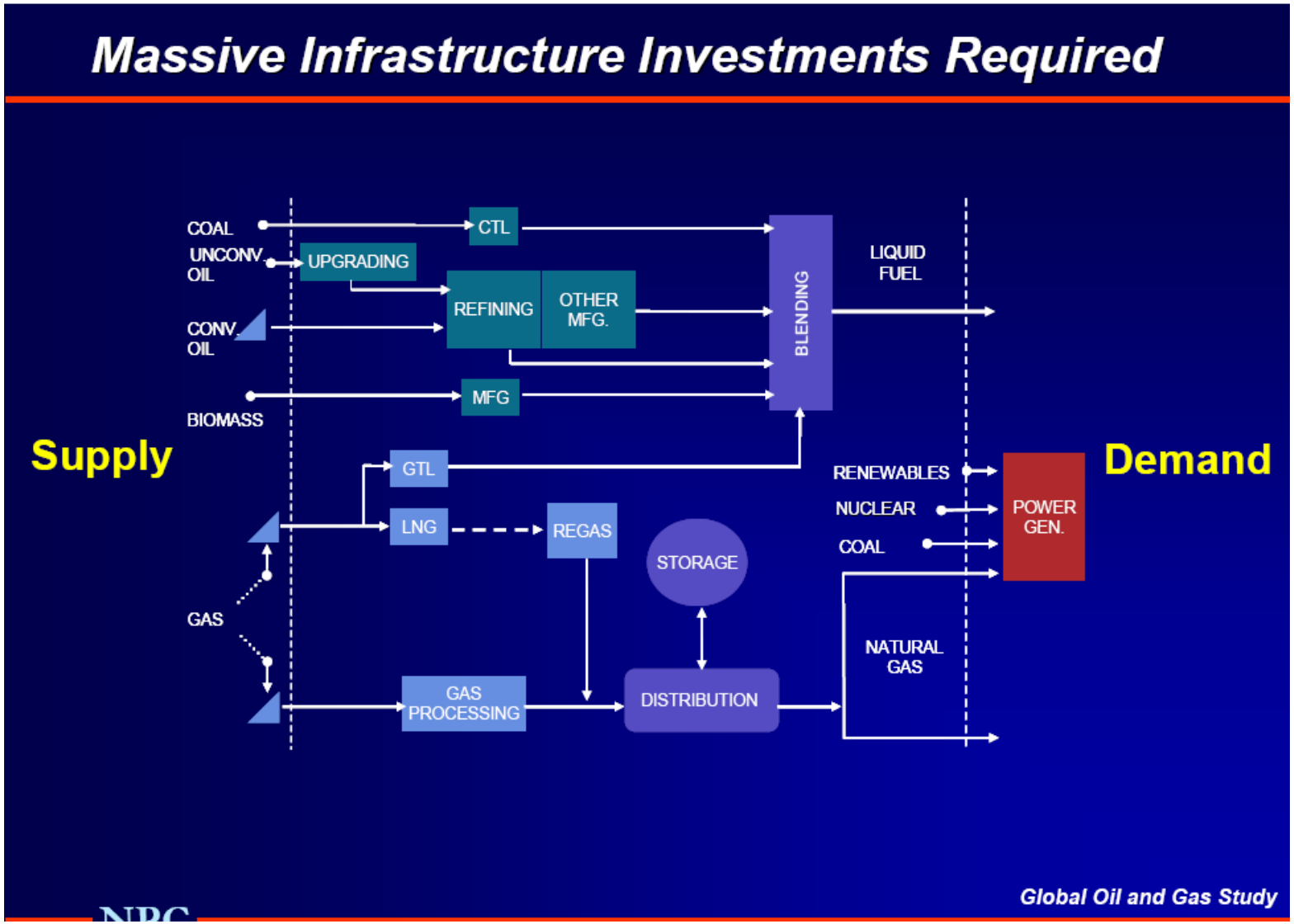

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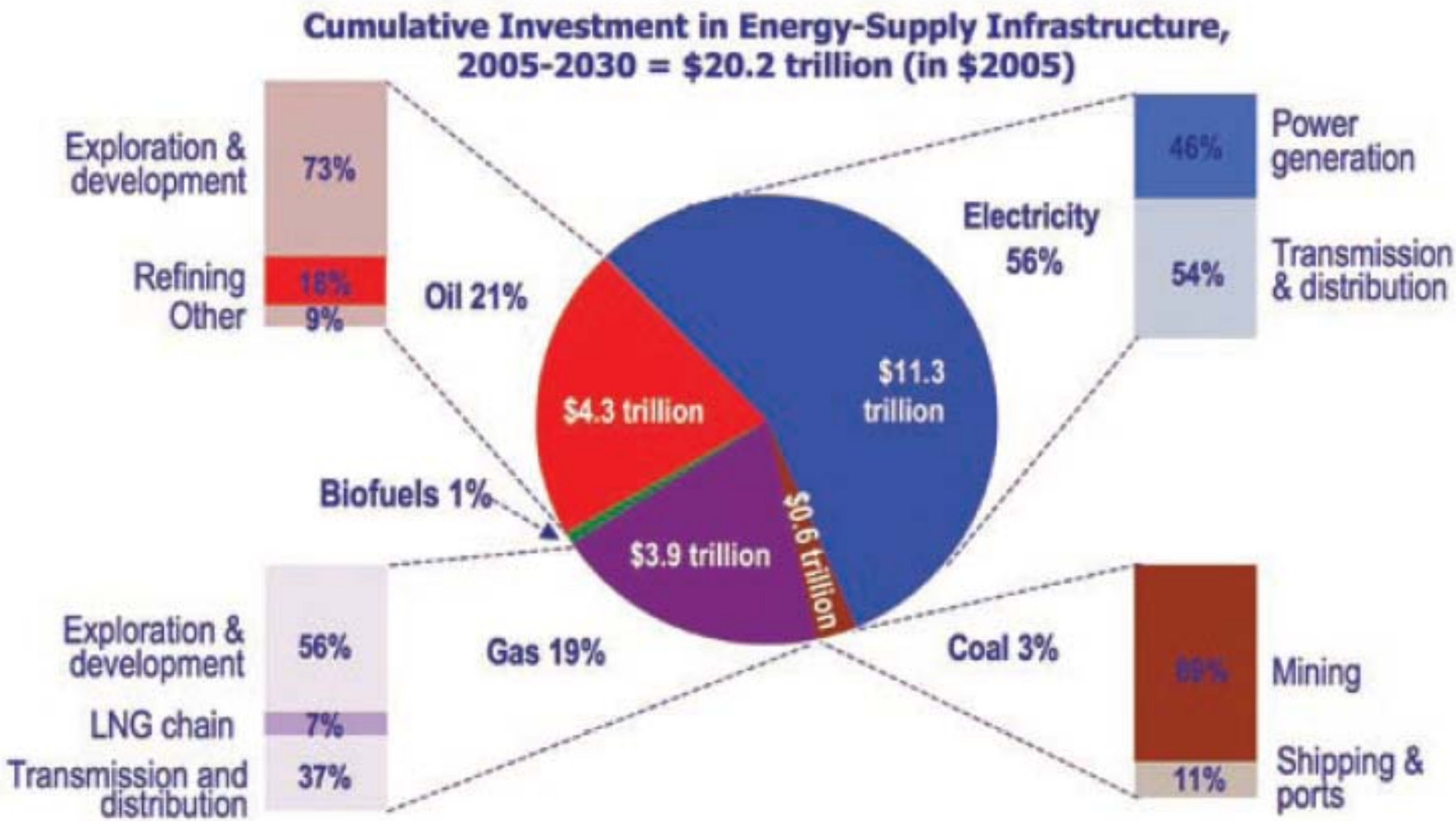
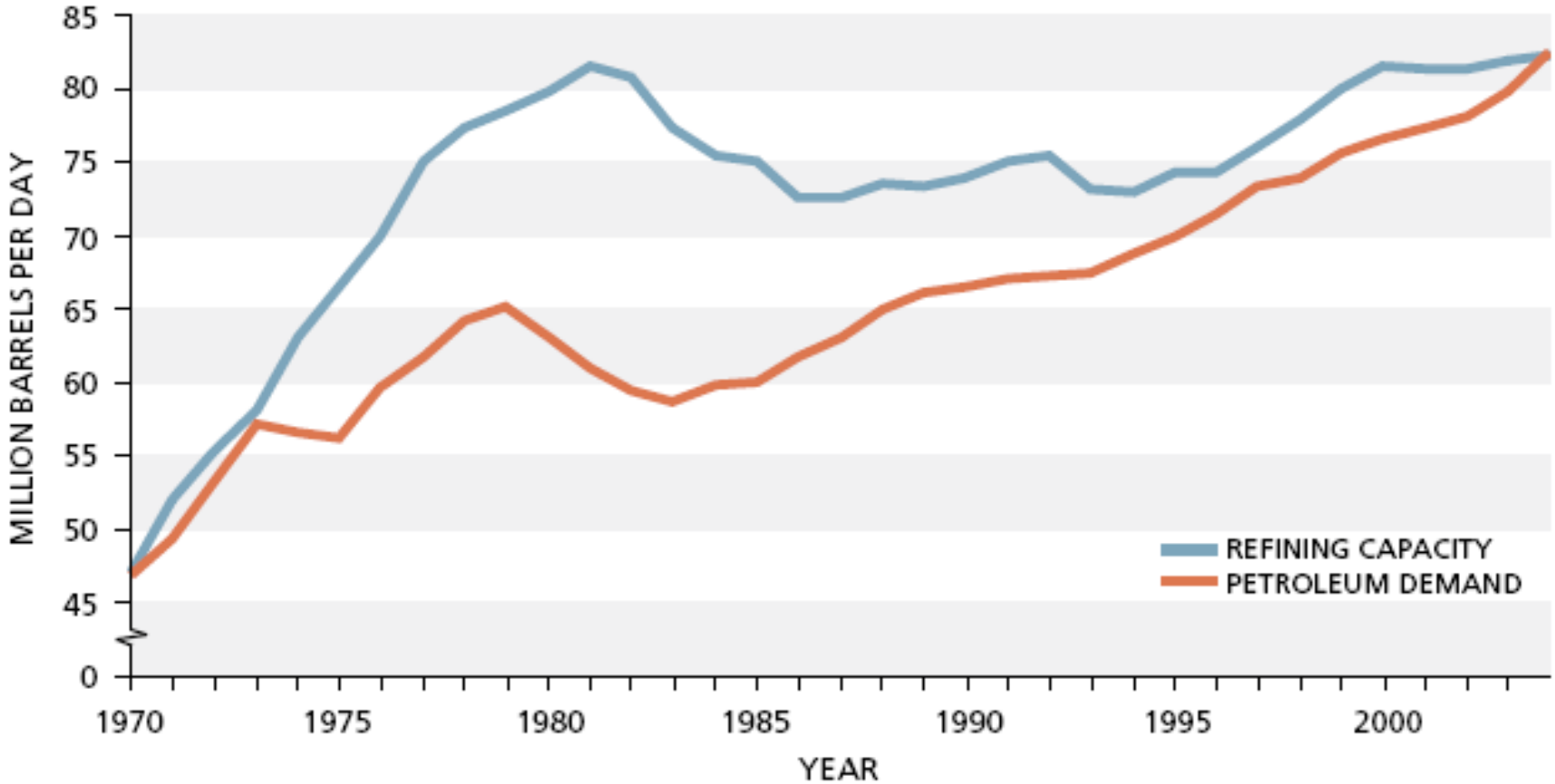


Source: IEA, World Energy Outlook 2006.

Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007



Sources: Refining Capacity: eia.doe.gov/international/iealf/table36.xls; Petroleum Demand: eia.doe.gov/emeu/ipsr/t46.xls.

FIGURE 2-78. Global Historical Refining Capacity

Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007

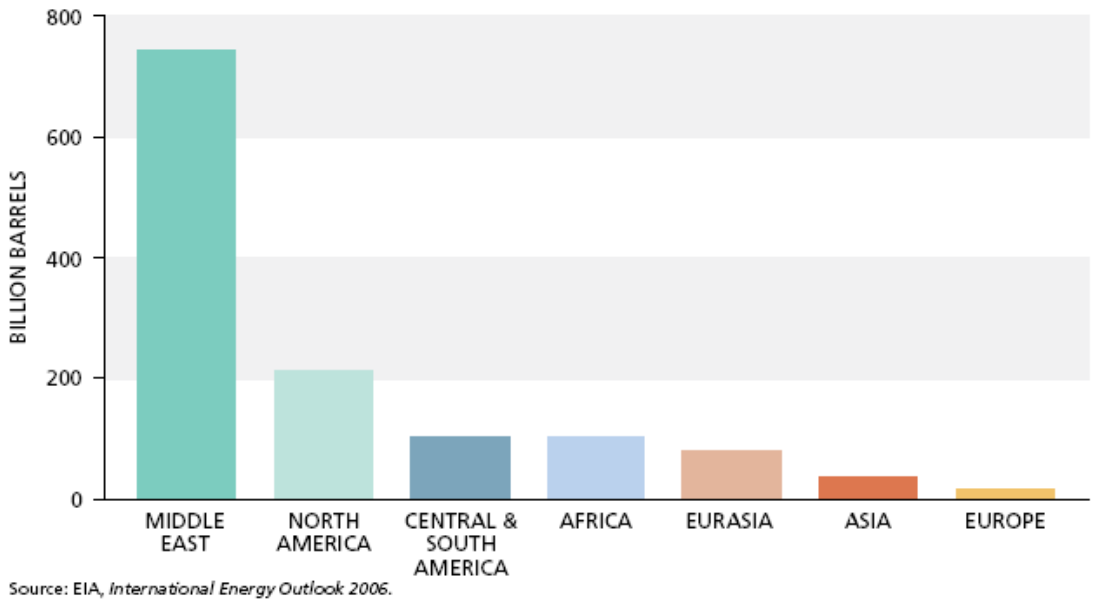


FIGURE 4-4. World Crude Oil Reserves — Regional Shares

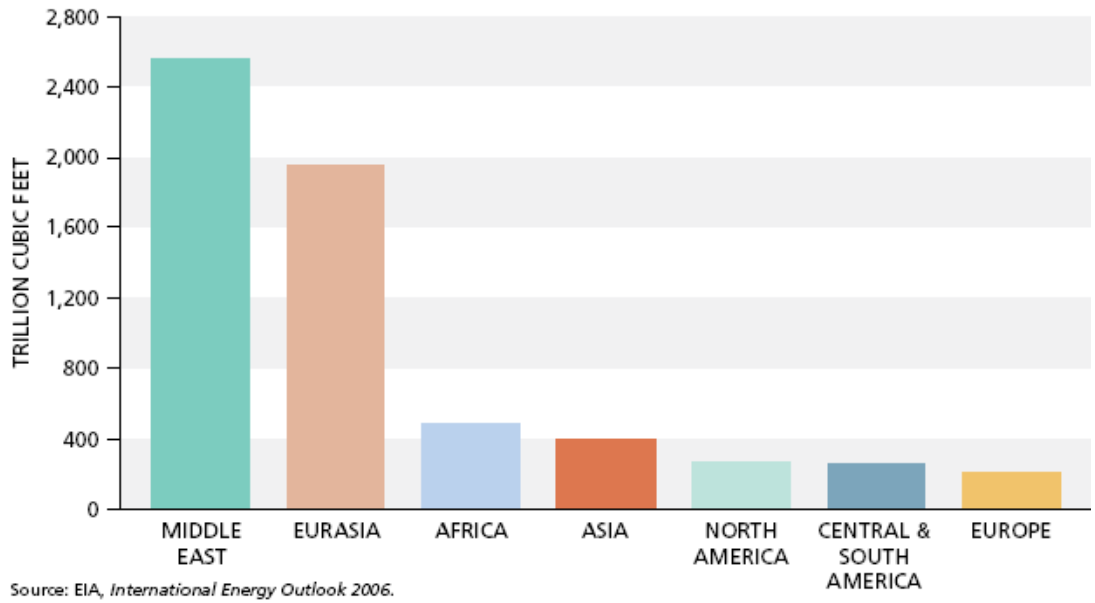
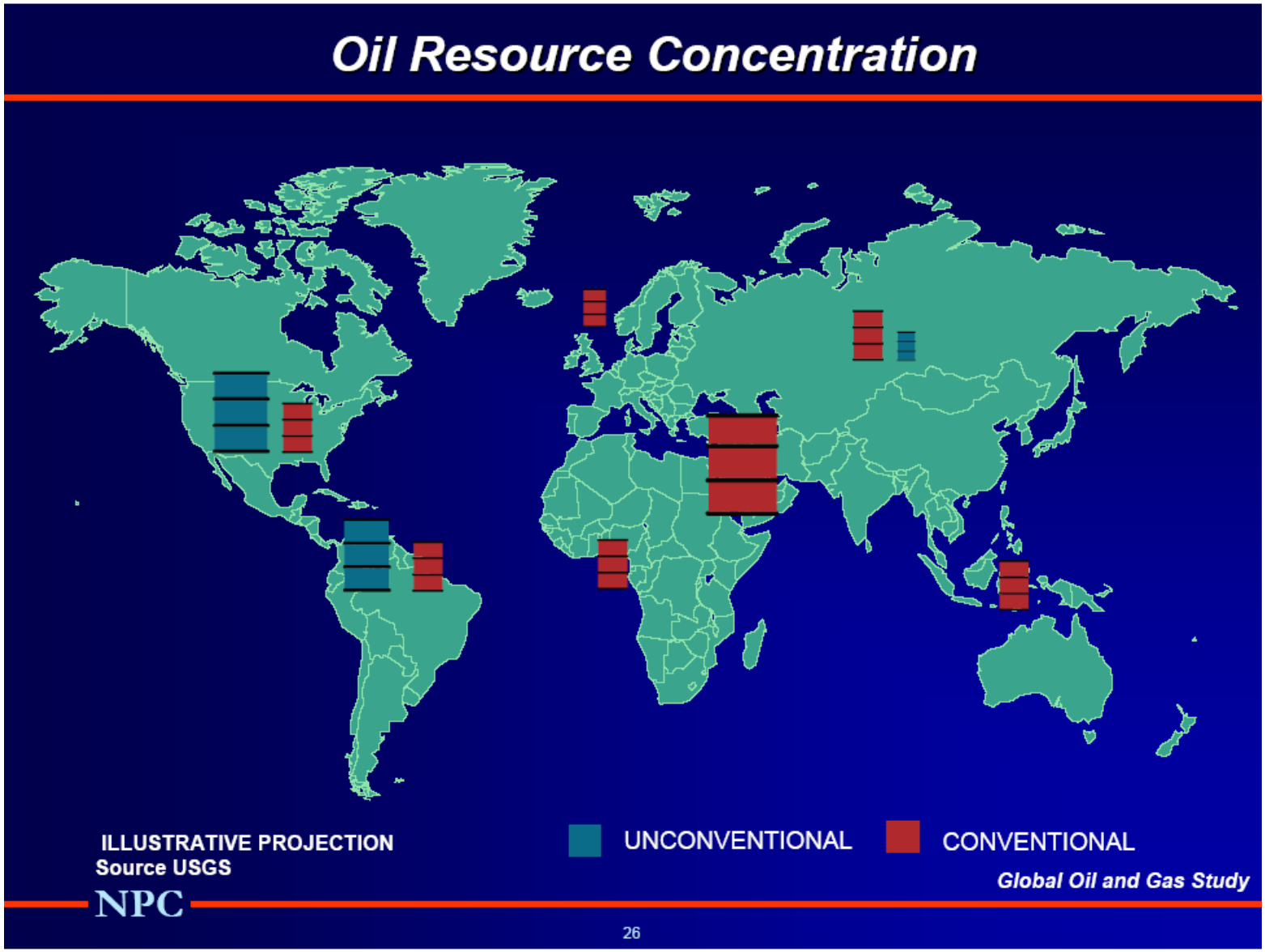


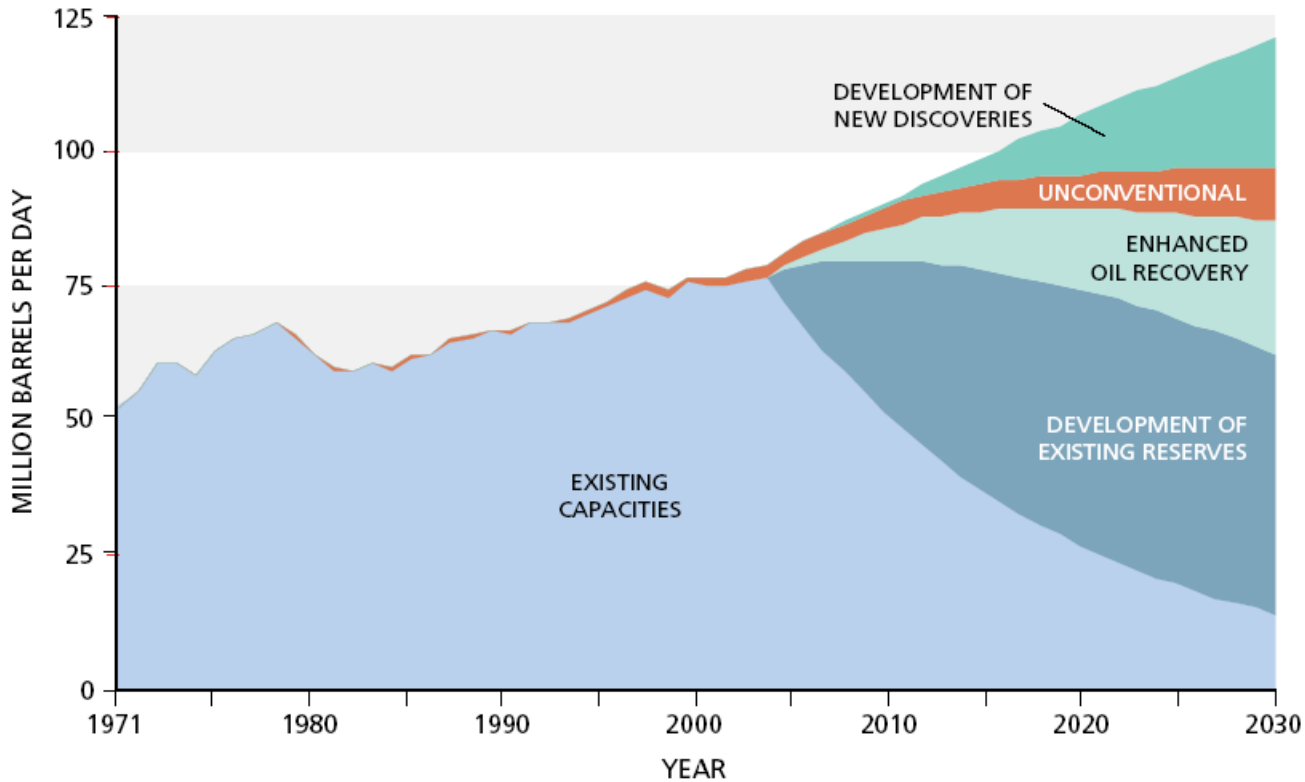
FIGURE 4-5. World Natural Gas Reserves — Regional Shares

Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007



Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007

Projected oil production: Existing capacities are rapidly being depleted and will require development to maintain production. Sustaining production growth requires enhanced production.

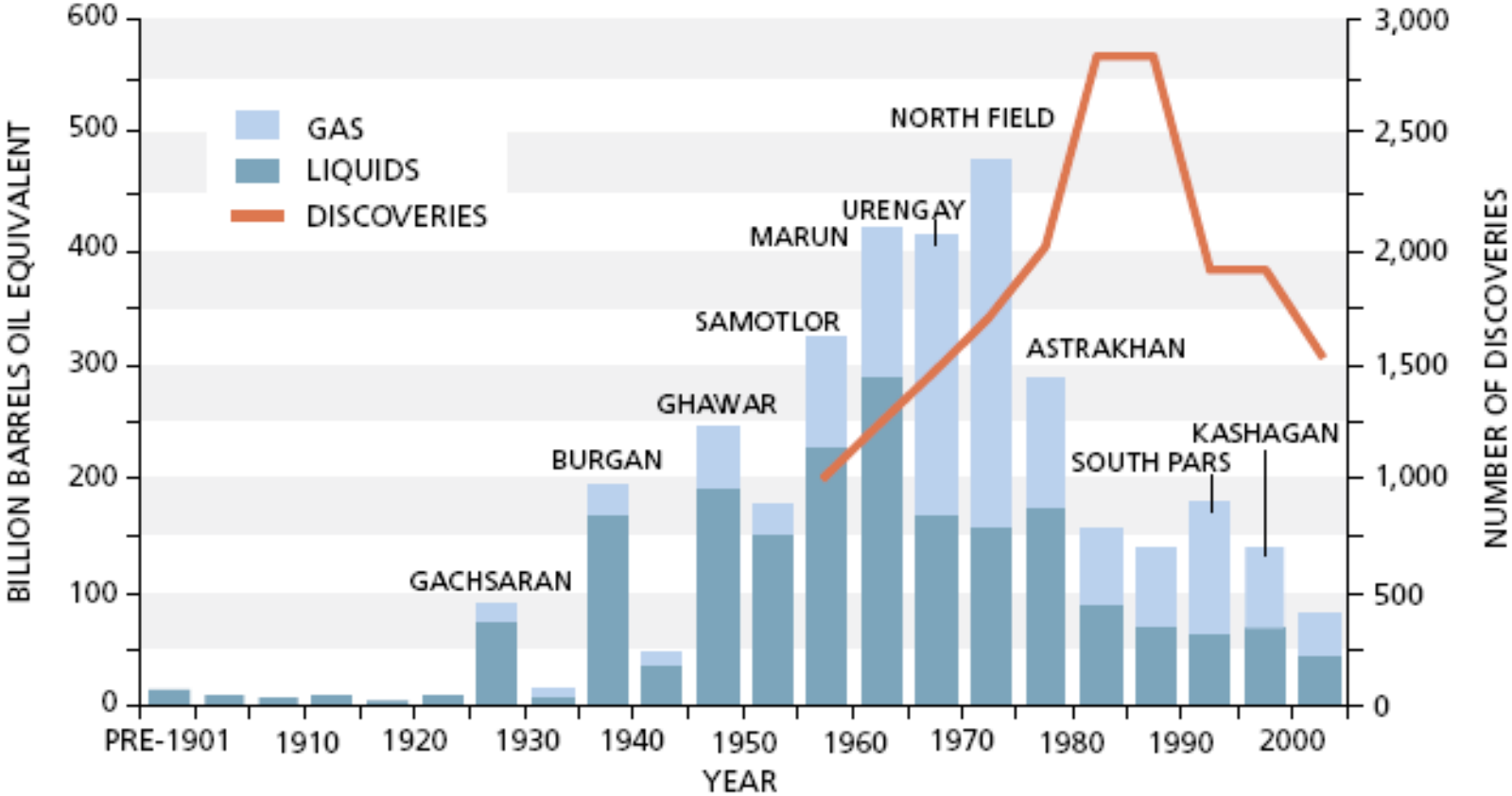


Source: IEA, *World Energy Outlook 2004*.

FIGURE ES-5. *Illustrative Total Liquids Supply*

Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007

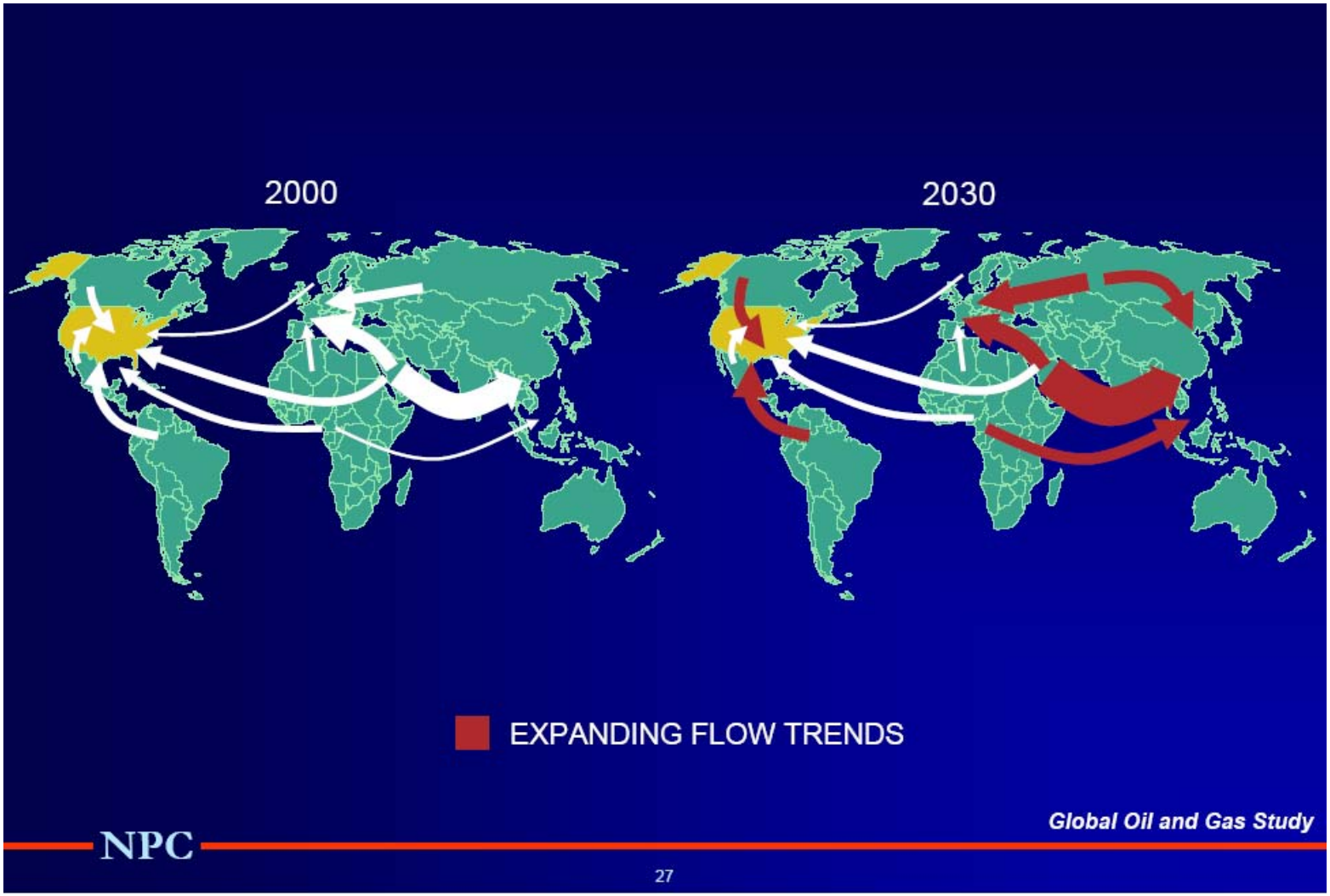
Will new discoveries keep up with demand?



Source: IHS Energy (Bahorich, 2006).

FIGURE 3-10. Evolution of Oil Discovery Volumes with Time
(Total Discovered Resources to End-2004, excluding United States and Canada)

Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007



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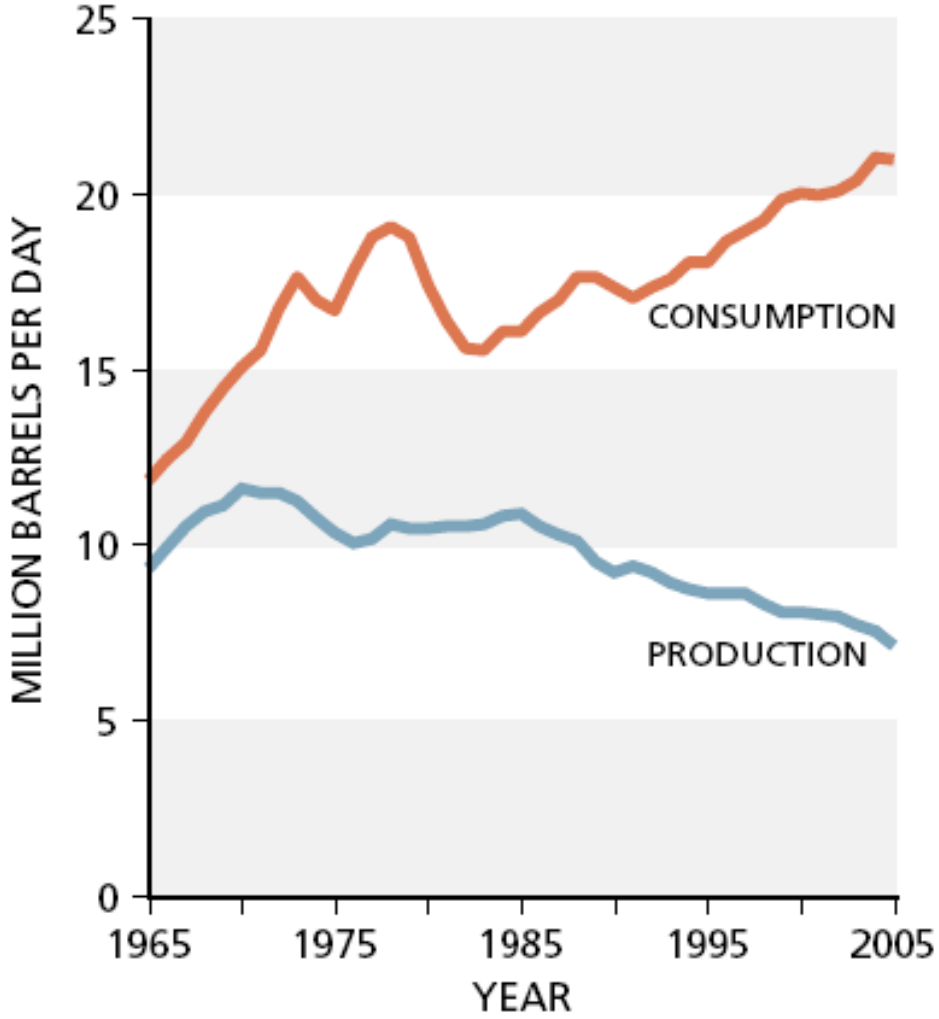


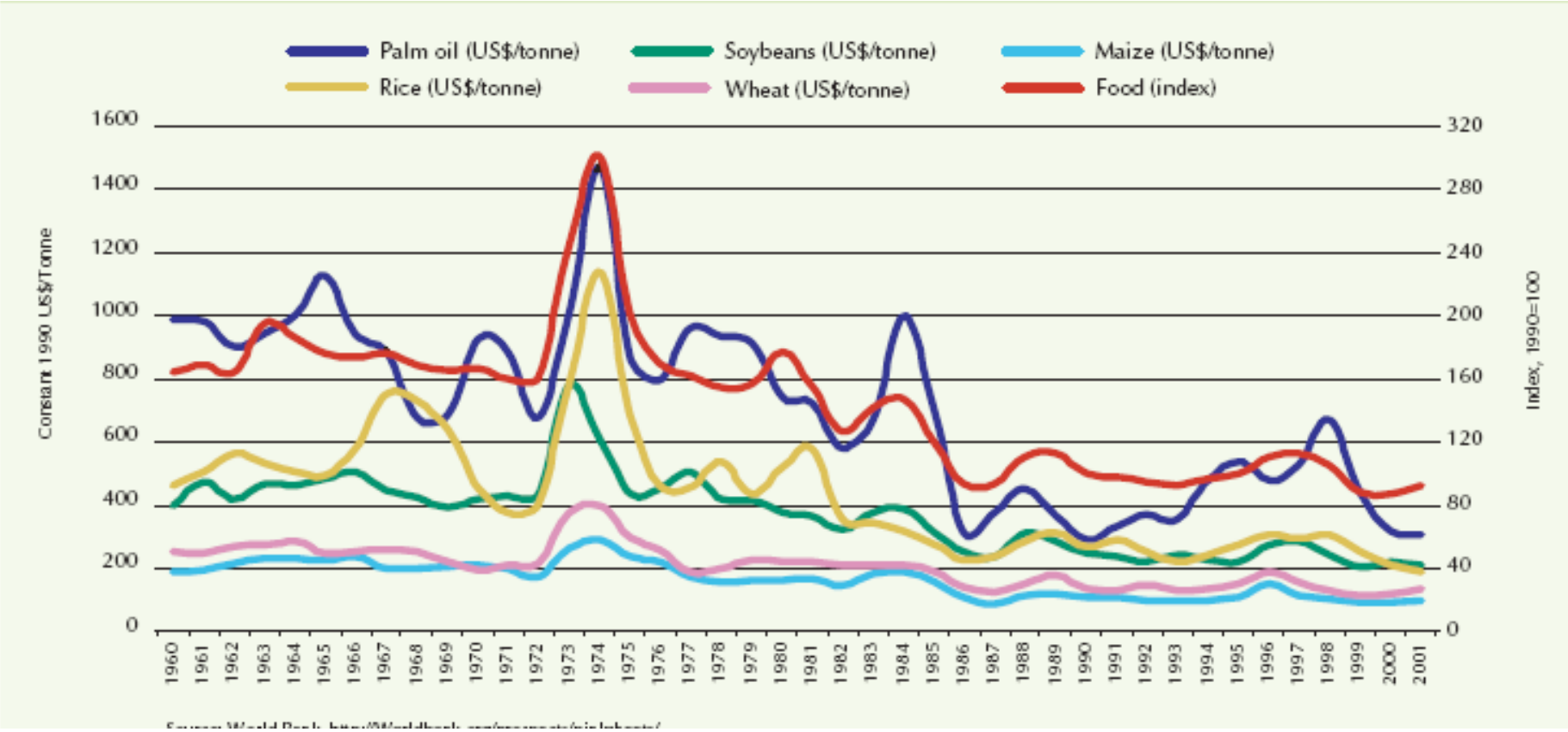
Source: *BP Statistical Review of World Energy 2006.*

FIGURE ES-10. *U.S. Oil Production and Consumption*

Hard Truths, Facing the Hard Truths About Energy. National Petroleum Council, Washington DC, 2007

Agriculture’s Role

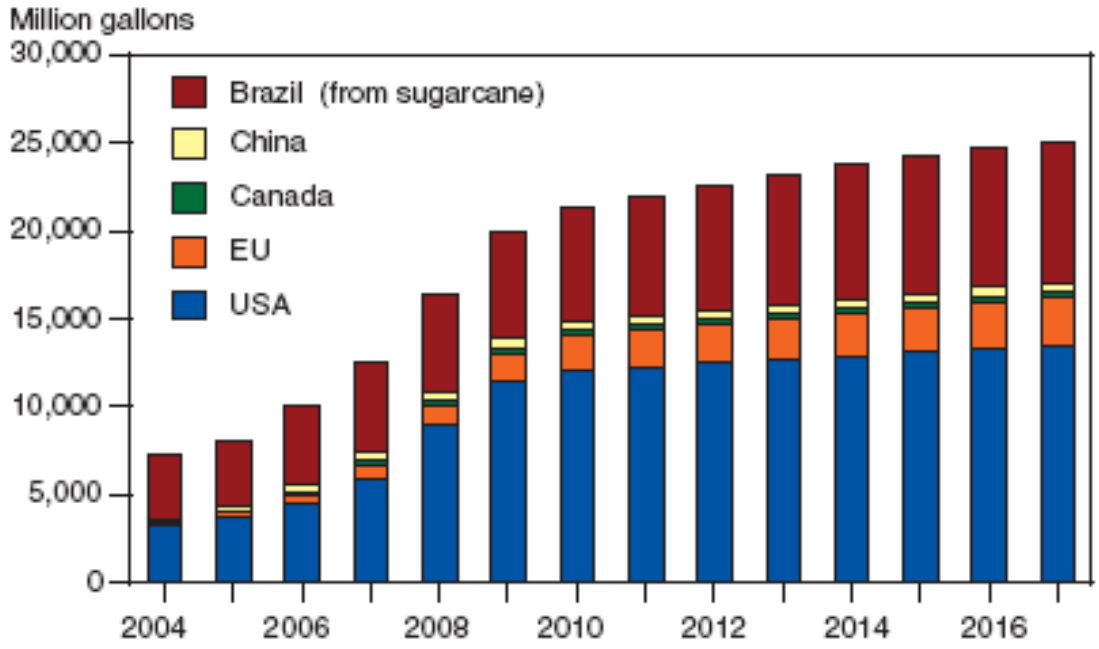
Agricultural Production was Demand Driven



WORLD AGRICULTURE : TOWARDS 2015/2030
AN FAO PERSPECTIVE, Edited by Jelle Bruinsma, 2003

Ethanol production trends

Figure 17
Ethanol production
Mostly from grain feedstocks except for Brazil

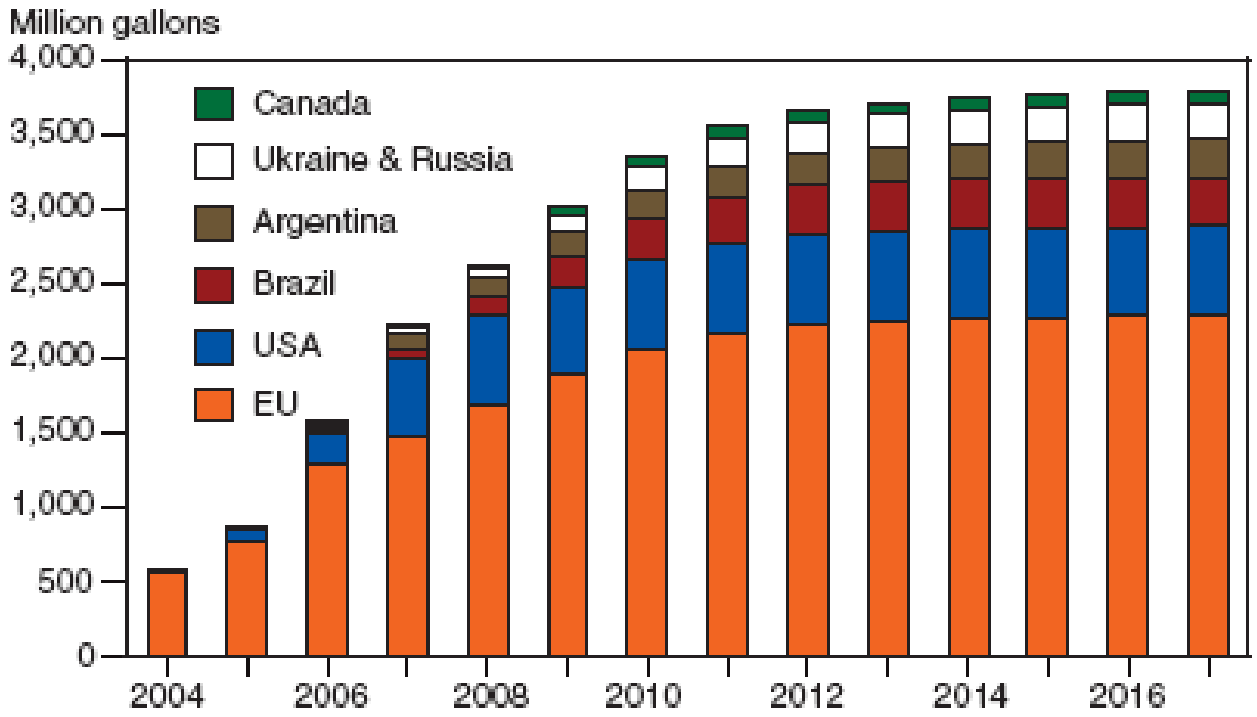


Source: USDA Agricultural Projections to 2017.

Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices/ WRS-0801
Economic Research Service/USDA

Biodiesel production trends

Figure 18
Biodiesel production



Source: USDA Agricultural Projections to 2017.

Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices/ WRS-0801
Economic Research Service/USDA

With no changes food production and population growth are balanced

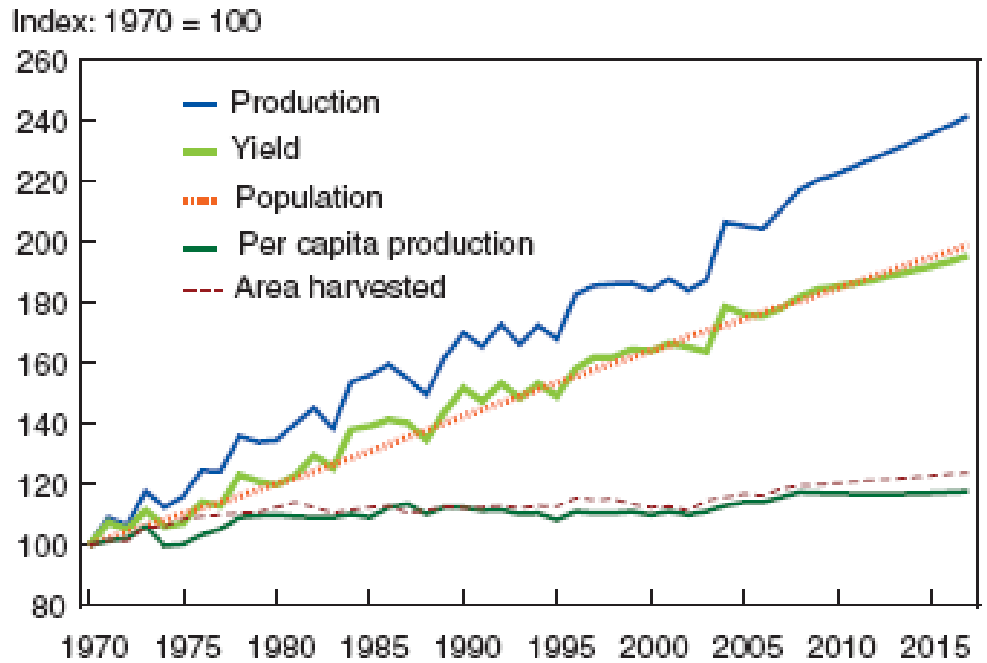
Figure 4

Total world grain & oilseeds[1]

Production, yield, area harvested, population & per capita production

Exponential trend growth rates:

	1970-90	90-07	2009-17
Production	2.2	1.3	1.2
Yields	2.0	1.1	0.8
Area	0.15	0.14	0.39
Population	1.7	1.4	1.1
Per capita production	0.56	0.11	0.02



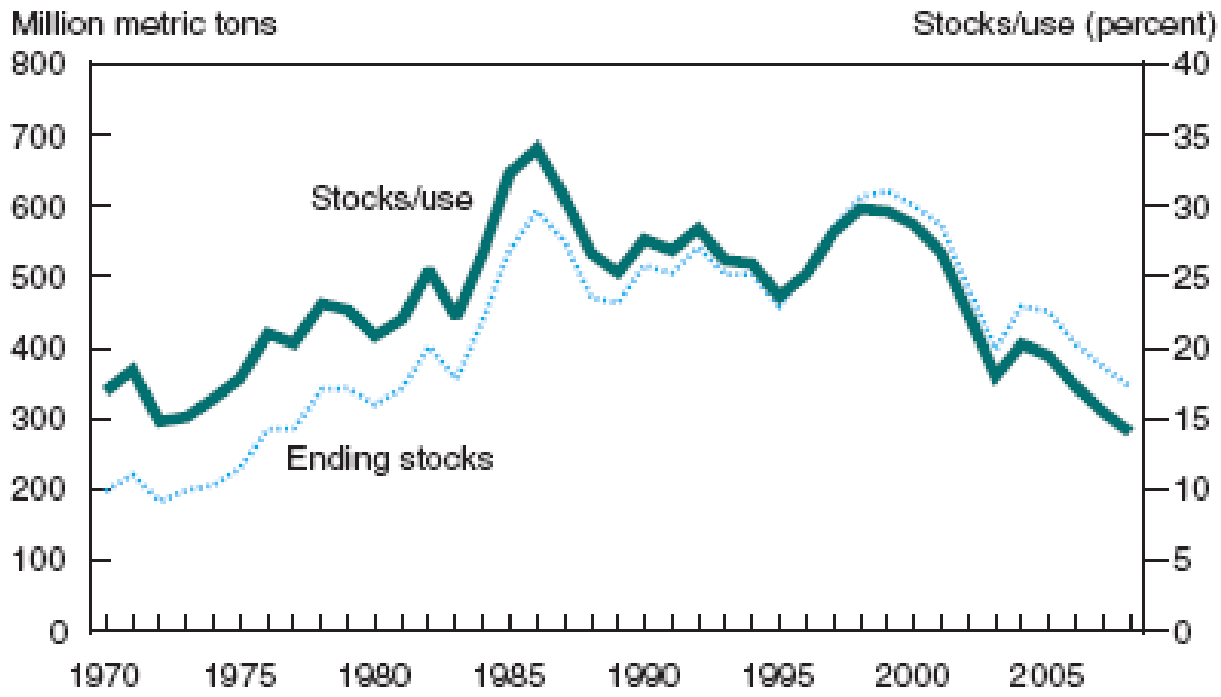
[1]Total oilseeds = soybeans + rapeseed + sunflowers.

Source: USDA Agricultural Projections to 2017.

Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices/ WRS-0801
Economic Research Service/USDA

Ending stocks have fallen

Figure 15
Total world grain & oilseeds
Stocks and stocks-to-use ratio



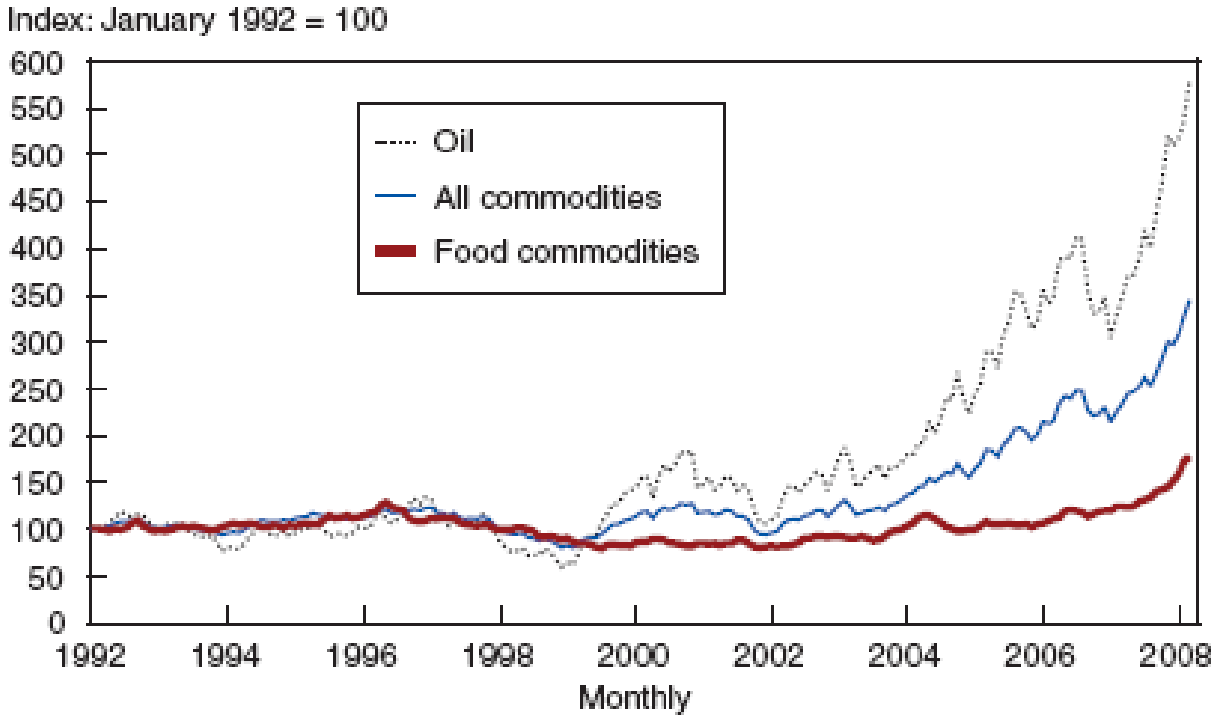
Source: USDA PS&D Database.

Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices/ WRS-0801
Economic Research Service/USDA

All commodities have risen in the past year

Figure 3

Prices of many commodities rose

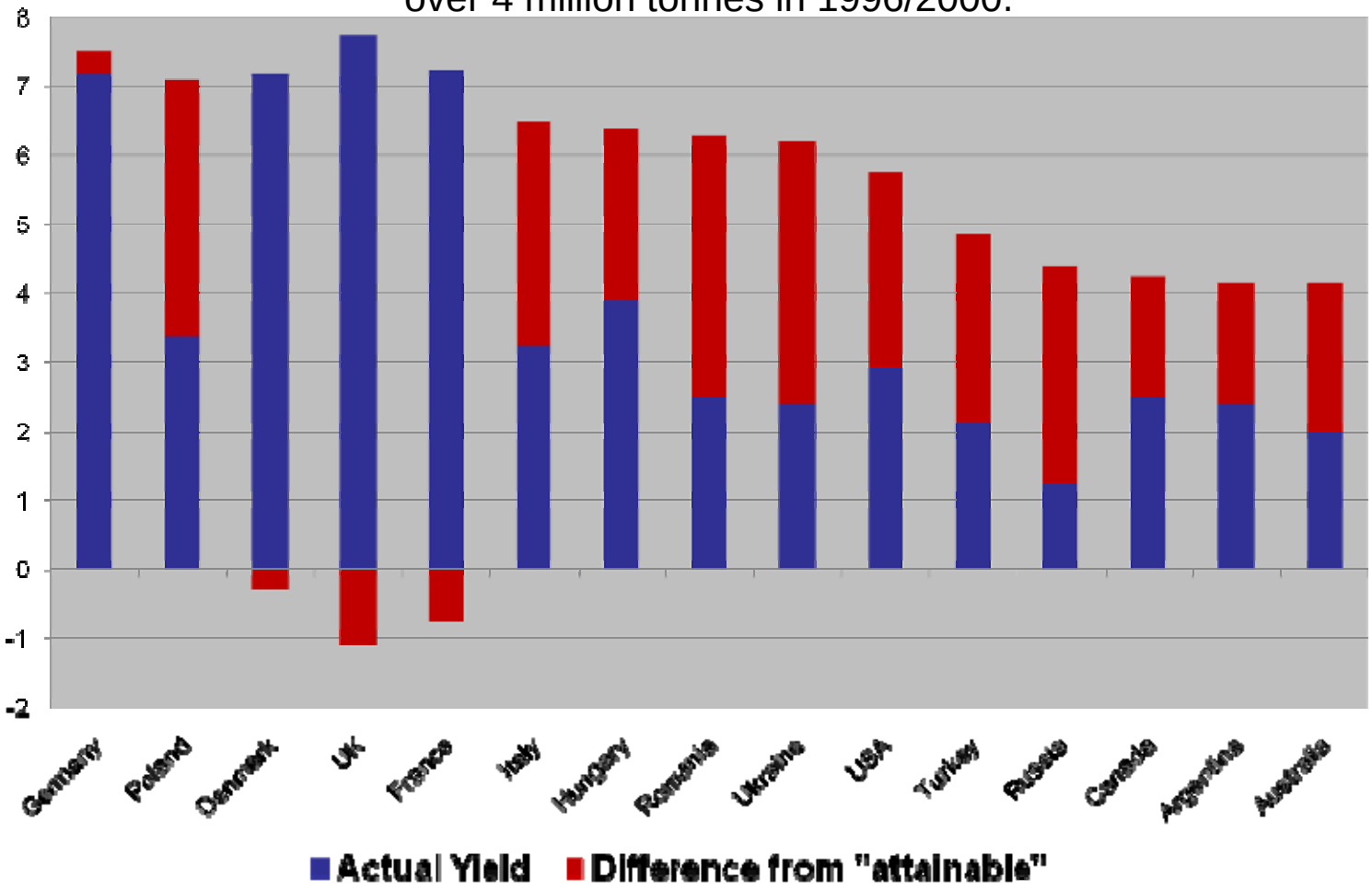


Source: International Monetary Fund: International Financial Statistics.

Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices/ WRS-0801
Economic Research Service/USDA

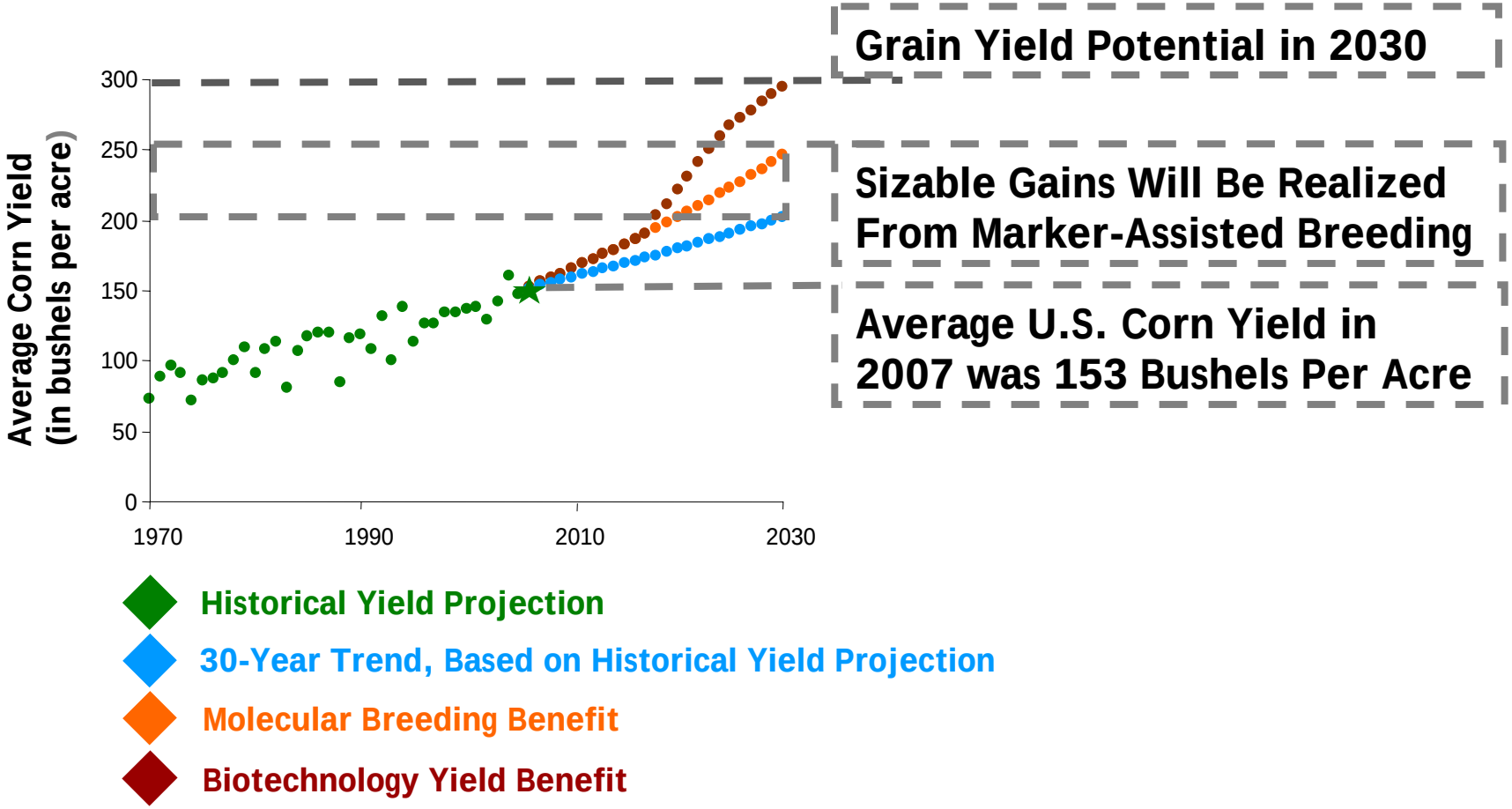
Higher Yields Are Attainable

Wheat: actual and agro-ecologically attainable yields (rainfed, high input)
Fifteen countries with a predominantly rainfed wheat production of over 4 million tonnes in 1996/2000.



World Agriculture: Towards 2015/2030 An FAO perspective,
SELECTED ISSUES IN AGRICULTURAL TECHNOLOGY

The Combination of Biotechnology and Breeding Will Increase Corn Supply as a Feedstock



Source: Monsanto

Lignocellulosic opportunity

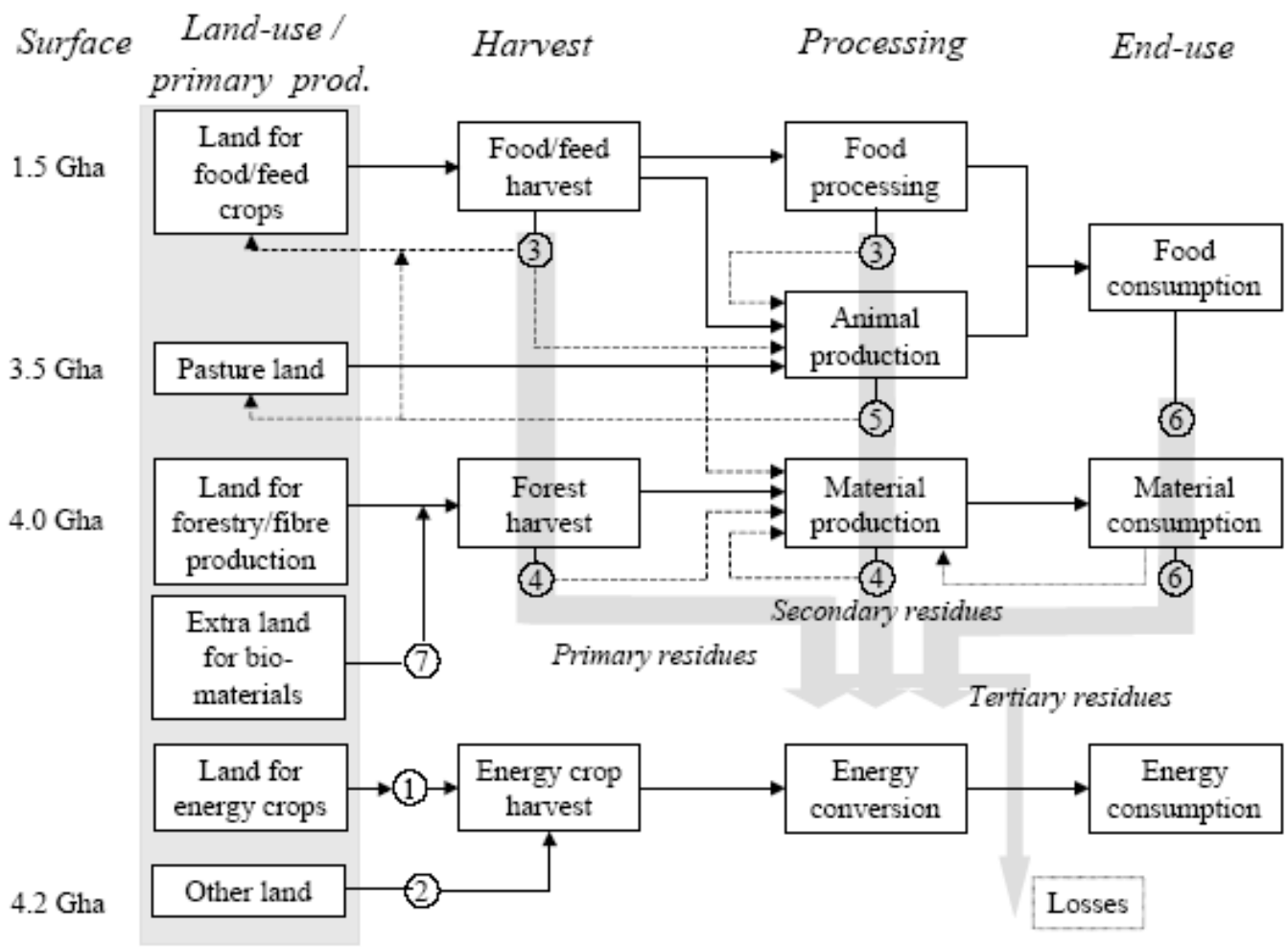


Fig. 1. Overview of various types of biomass flows and the global land surface (Based on: [1,22]). The black arrows indicate the main product flows, whereas the dotted lines show potential non-energy applications of various residue categories. The gray arrows represent the potential energetic use of the resources (1 = energy crops, 2 = energy crops at degraded land, 3 = agricultural residues, 4 = forest residues, 5 = animal manure, 6 = organic waste, 7 = bio-material).

. Edward M.W. Smeets, André P.C. Faaij, Iris M. Lewandowski, Wim C. Turkenburg, A quickscan of global bio-energy potentials to 2050. (In Press: Progress in Energy and Combustion Science, 2006).

Table 2. Overview of the four systems included in this study.

Factor	System 1	System 2	System 3	System 4
Animal production system used (pastoral, mixed, landless)	mixed	mixed	landless	landless
Feed conversion efficiency	high	high	high	high
Level of technology for crop production	very high	very high	very high	super high
Water supply for agriculture (rain-fed = r.f., irrigated = irri)	r.f.	r.f./irri.	r.f./irri.	r.f./irri.

. Edward M.W. Smeets, André P.C. Faaij, Iris M. Lewandowski, Wim C. Turkenburg, A quickscan of global bio-energy potentials to 2050. (In Press: Progress in Energy and Combustion Science, 2006).

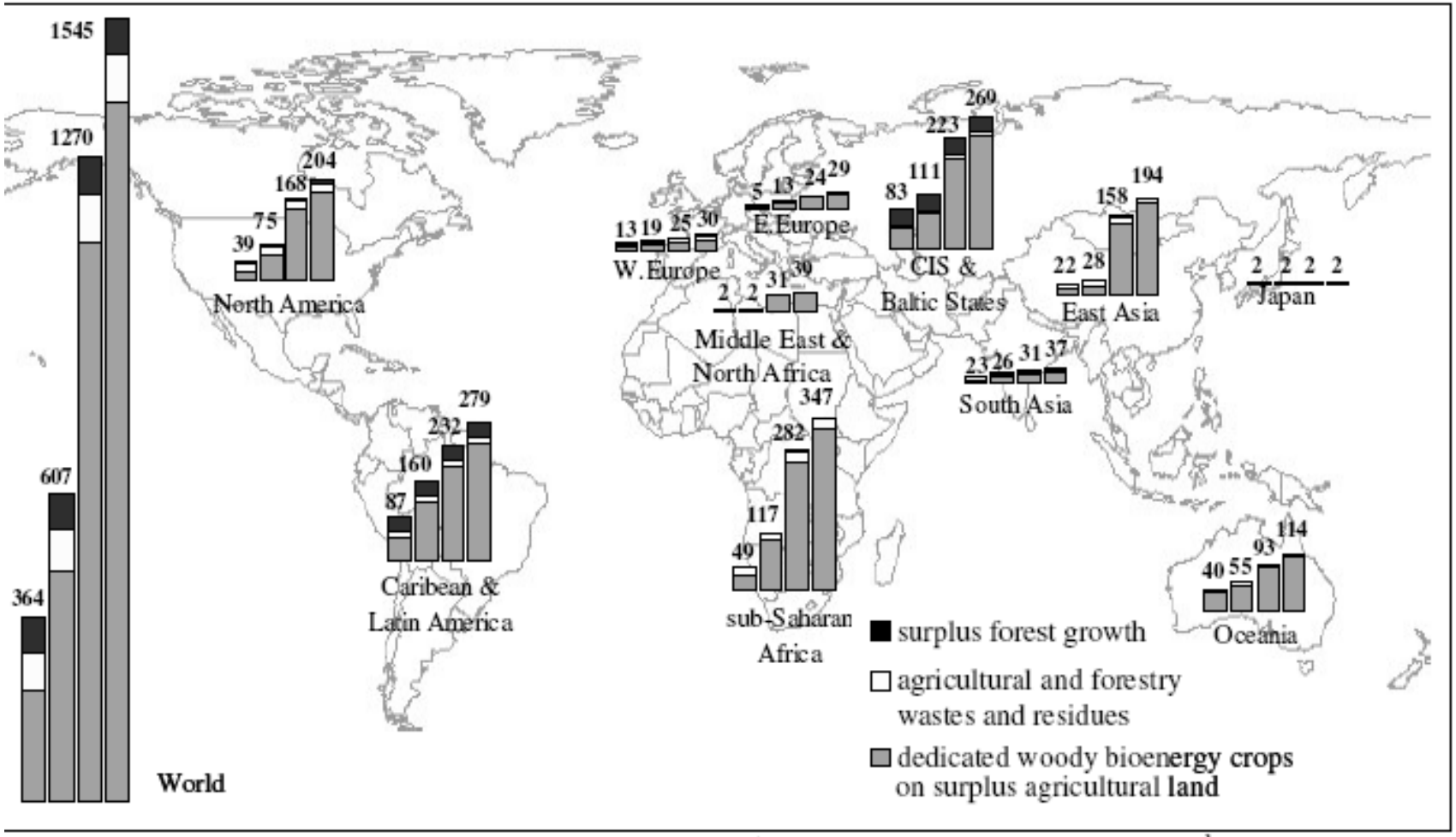


Figure 7. Total bioenergy production potential in 2050 based on system 1 to 4 (EJy^{-1}; the left bar is system 1, the right bar is system 4).

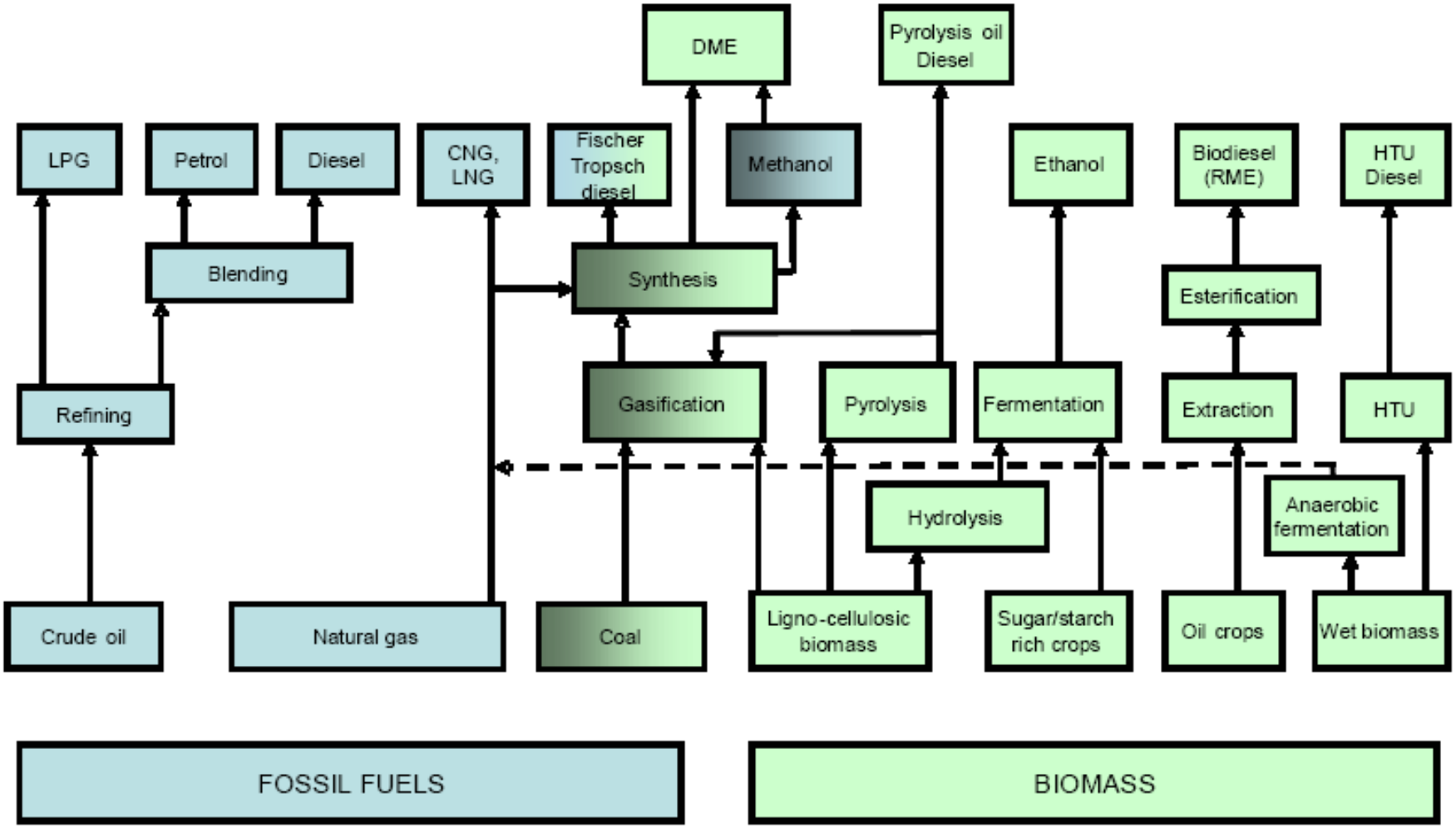
. Edward M.W. Smeets, André P.C. Faaij, Iris M. Lewandowski, Wim C. Turkenburg, A quickscan of global bio-energy potentials to 2050. (In Press: Progress in Energy and Combustion Science, 2006).

% of land within radius required to feed plant
Plant size tons/day at 90% capacity
At 12 tons per acre yield

Distance from facility in miles

Tons per day	500	1000	5000	10000	20000
10	6.5	13.1	65.5	-	-
20	1.6	3.3	16.4	32.7	65
30	0.7	1.5	7.3	14.6	29
40	0.4	0.8	4.1	8.2	16.4
50	0.3	0.5	2.6	5.2	10.5
60	0.2	0.4	1.8	3.6	7.3
70	0.1	0.3	1.3	2.7	5.3
Million gallons Per year at 70 Gallons per ton	12	24	122	244	488

N. Greene, et al. "How Biofuels Can Help End America's Oil Dependence." National Resources Defense Council: Dec. 2004.



Van Thuijl E., Roos C.J., Beurskens L.W.M. – “An overview of biofuel technologies, markets and policies in Europe” ECN-C-008 January 2003.

Gasification

- Several types, direct, indirect, oxygen fed
- Technology for syn gas production in pilot/demonstration phase
- Complete package of alcohol or FT diesel production may be limited by size of plant for economies of scale and availability of enough feedstock

Pyrolysis

- Technology practiced in forming charcoal
- Potential method of making bio-oil for refining
- Requires development of uses for co-product gas and char
- May be a means of converting biomass to easily transported form

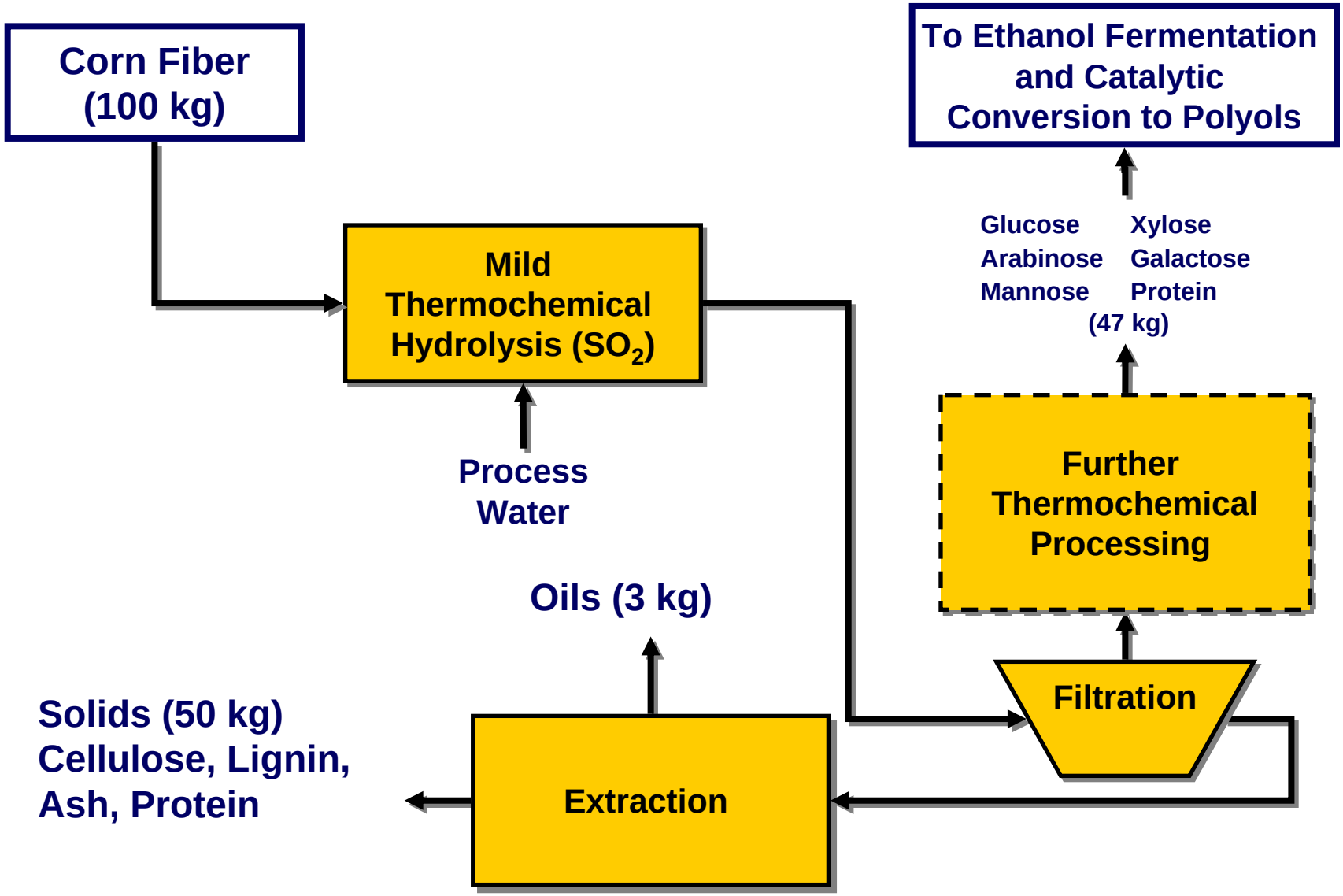
Hydrolysis and fermentation

- Needs to have micro-organism developed to efficiently convert all sugars to ethanol
- Inhibitors formed during hydrolysis are a problem for fermentation
- Dilute nature of hydrolysis conditions may be an energy issue in ethanol recovery.
- Fermentations currently are fairly slow to accommodate enzyme hydrolysis rates

ADM Research Initiatives

- Corn fiber conversion for higher valued products
- Corn stover and wheat straw conversion to higher valued animal feed with DDGs
- Improved ethanol fermenting yeasts for production from lignocellulose
- COP/ADM joint research to develop a refinery feedstock from lignocellulose

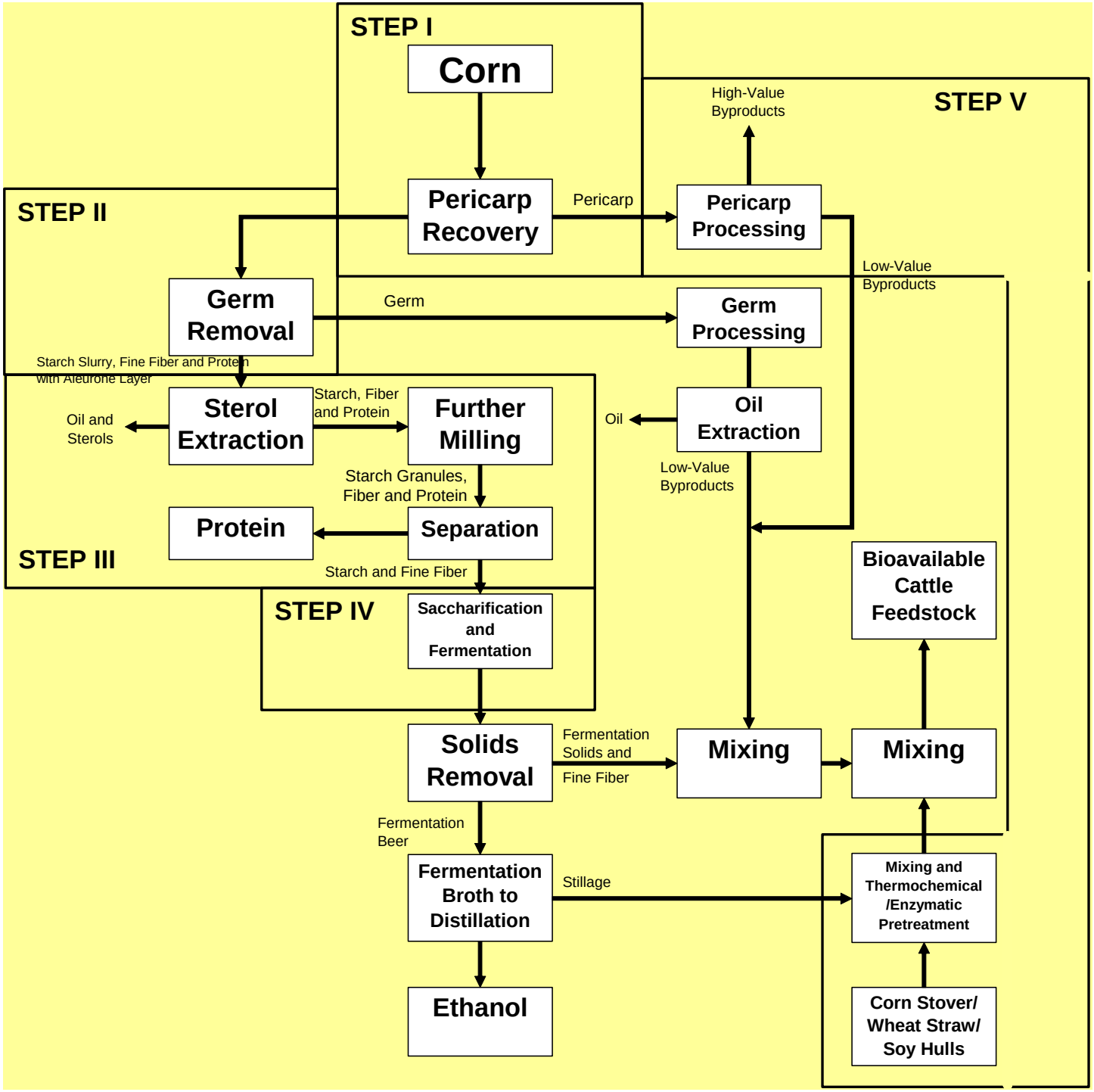
Current Process Flowsheet



Objectives

- Create a higher digestible feed from crop residues
- Assess thermochemical treatment methods on dry matter digestibility
- Evaluate performance of growing ruminants fed treated residues

USDA Corn Processing and Cattle Feed Overall Process



Crop Residue Digestibility

- Much lower than grain
  - Corn Stover 55% (TDN)
  - Wheat Straw 40% (TDN)
- Chemical pretreatments used to increase enzyme digestibility for ethanol fermentations
- What treatments could be used for ruminent feeds
- Carried out research under a USDA grant with Dr. Larry Berger at the University of Illinois

Holstein Steer Diets

Ingredient % DM	Treatment			
	1 Control	2 50% CFWC CRP	3 50% Wheat Straw CRP	4 50% NAT Wheat Straw
Corn Silage*	**15**	**15**	**15**	**15**
Corn	**50**	**0**	**0**	**0**
DDGS	**25**	**25**	**25**	**25**
CRP (3:1 residue:DDGS)	**0**	**50**	**50**	**0**
Native residue	**0**	**0**	**0**	**50**
Supplement	**10**	**10**	**10**	**10**
Intake kg	**7.1**	**8.7**	**7.9**	**8.2**
ADG/apparent digestibility%	**1.35/66**	**1.38/60**	**1.44/62**	**0.92/42**

* Corn silage used is a by-product of the seed corn industry containing husks, grain, cobs, and minimal stalk

Dr. Larry Berger, 2008 CUTC

Summary

- Agriculture has the potential to supply a significant amount of global energy (400-500 Ejoules)
- US has considerable potential with corn, energy crops, and forestry/agricultural residues
- No commercial technologies for converting lignocellulosics to liquid fuels developed yet
- Many different opportunities at higher commodity price levels
- Logistics may be a key factor in the technology deployed in the future.

Biorefining Depends on Feedstock