ENERGY SECURITY AND CO_2
Policy Design and Political Challenges

Paul L. Joskow

massachusetts institute of technology

Paris Dauphine

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OUTLINE

- Global energy consumption and production profiles under “Business as Usual” (BAU) policies (where are we? Where are we going?)
- U.S. energy consumption and production profiles under BAU
- Implications for
  - Energy “security”
    - Supply and demand balances
    - Energy imports and trade
    - Energy prices
    - Probability and economic costs of supply “shocks”
  - CO_2 emissions trends
- Global policy challenges
- Current U.S. policies and where they may go

WHAT DOES ENERGY SECURITY MEAN?

- Reflects perceptions that oil and gas supply disruptions will impose large costs on energy importing countries
- Reflects concerns that this in turn will create opportunities for political extortion by exporting countries
- Reflects experience with shortages that emerged in some countries during the first two oil shocks, boycotts targeted at particular countries, and special “political deals” cut with exporting countries by a few importing countries
- A convenient excuse for implementing energy policies reflecting other public interest concerns or to benefit selected private interests

WHAT ARE THE COSTS OF ENERGY SUPPLY DISRUPTIONS?

- The primary economic effects are theoretically associated with sudden large increases in energy prices resulting from a supply disruption (think price increases not “supply gaps”)
  - Prices could rise a lot due to low short-run demand elasticities
  - Dead-weight losses from unanticipated “tax” on an important input to production, including microeconomic adjustment costs
  - Wealth redistribution from consumers to producers
    - Intra-country (Boston to Houston)
    - Inter-country (U.S. to Saudi Arabia)
  - Macroeconomic adjustment costs (aggregate output, unemployment and inflation) arising both from the price shock and fiscal/monetary responses to it. Impacts of recycling of petro-funds
- Putting aside wealth redistribution, the efficiency costs should be relatively small if government policies respond effectively
  - But the domestic political costs of higher prices are not small
- Larger intra-country costs are incurred when governments try to protect consumers from higher prices with price controls, administrative allocations, etc.
- Inter-country wealth redistributions are a relevant cost for energy importing countries as well
- Costs of diplomatic and military initiatives cannot be ignored

CONCLUSIONS

- Under BAU global energy consumption continues to grow rapidly especially in emerging economies (e.g. China and India)
- Under BAU global CO_2 emissions continue to grow rapidly with current Kyoto commitments
- Under BAU global energy trade increases and fraction supplied from the Middle East, North Africa and the FSU grows for both oil and gas (LNG) supplies
  - World natural gas market evolves
- Under BAU energy prices will continue to rise but current prices are at a “local peak” reflecting more than a decade of underinvestment (absent supply disruptions)
- Under BAU large investments in energy supply infrastructure will be required around the world
  - The unsettled state of energy market liberalization and political uncertainty in the Middle East, FSU, Africa and Latin America undermine investment incentives

CONCLUSIONS

- Global competition for “access” to energy resources will continue to increase
  - economic competition
  - political (“feather your own nest policies”) competition
- Credible energy supply and demand policies can (slowly) reduce the rate of growth of dependence on oil and natural gas imports from unstable supply areas but not reverse current trends quickly
- Energy importing countries will have to adapt to relying more on energy imports from unstable areas of the world
  - developed countries can absorb price shocks more easily than 25 years ago
  - The continuing rate of decline in energy intensity will help further to reduce the costs of energy supply disruptions if they occur

CONCLUSIONS

- The world will become more vulnerable to energy supply disruptions as the system operates with “tighter” supply/demand balances and more reliance on unstable supply regions
  - accidental
  - political
- Allowing markets to allocate scarce supplies during energy supply shocks will reduce their economic costs
  - Recent U.S. hurricane experience
  - Price controls and administrative allocation rules are costly and don’t work
- Cooperation between energy importing countries can reduce the likelihood and costs of energy supply disruptions including effective use of strategic storage

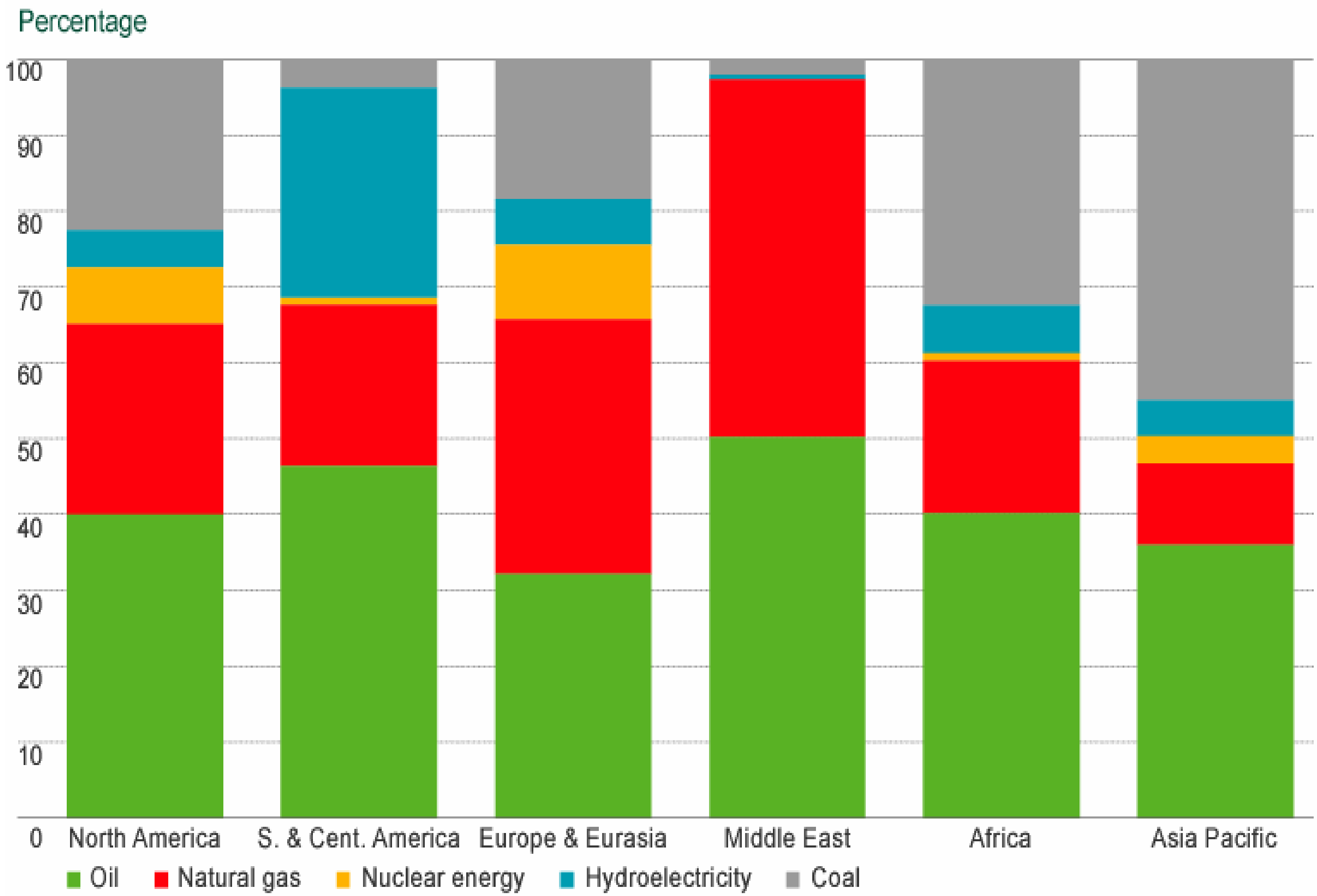
CONCLUSIONS

- Global greenhouse gas emissions stabilization and reduction goals cannot be met without full participation of the U.S., China, India and other emerging economies
- There are no magic bullets at the present time and all options should be kept open, including nuclear and CCS
- Nuclear has CO_2 reduction benefits but little energy security benefit in the U.S., China, and (perhaps) India because it is primarily a substitute for domestic coal supplies rather than gas or oil
  - Significant carbon "prices" will be necessary to stimulate more aggressive nuclear investment in the U.S., China and some other countries
- The U.S., China, India and other countries with domestic coal resources will look for ways to develop economical "clean coal" technologies (e.g. CCS)
- Both a high carbon price (rising to ~$150/ton CO2 by 2050) and expanded nuclear and CCS are likely to be required for CO_2 stabilization by 2050 <u>if and only if</u> emerging economies are fully integrated and all end-uses are covered

Future U.S. Greenhouse Gas Policies

- U.S. has no formal caps on greenhouse gas emissions and has not ratified Kyoto
  - Several U.S. states are adopting CO_2 control policies with the hope of influencing national debate
  - U.S. and state energy efficiency and renewable energy policies are focused on CO_2 emissions control
  - R&D policies are motivated by prospect of future caps on greenhouse gas emissions
- There is substantial support for caps on greenhouse gas emissions but …
  - Doubt that Kyoto targets will be met by many countries
  - Kyoto target timetables are not realistic for the U.S.
  - China and India must be included more directly
  - Portfolio of energy efficiency, nuclear power, renewable energy, carbon capture and sequestration focused on advanced technology
  - Impacts on domestic coal industry, domestic oil/gas producers and electricity prices are major political considerations/barriers affecting speed and direction of climate policies

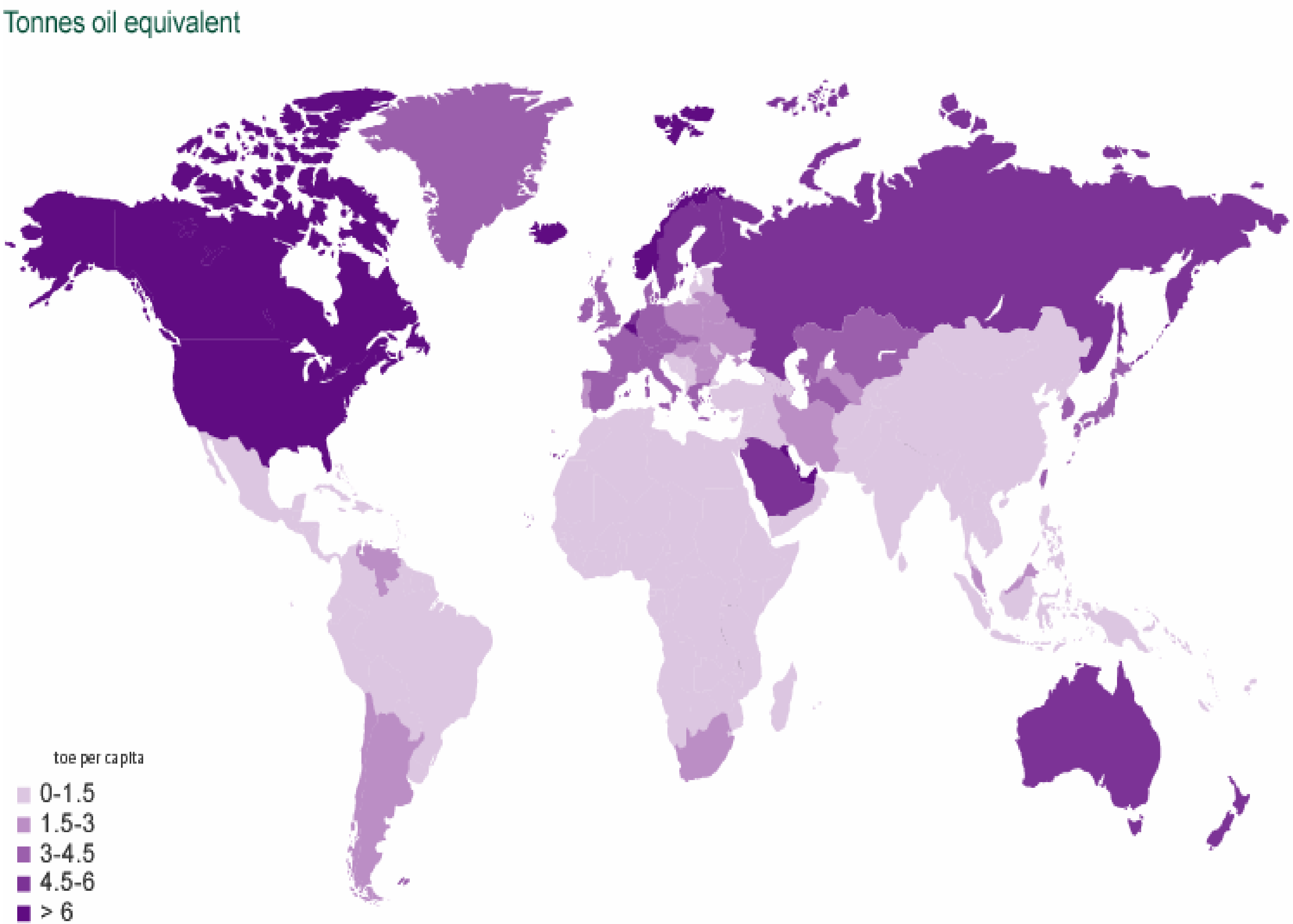
Regional primary energy consumption 2003



Oil remains the largest single source of energy in most parts of the world. The exceptions are the Former Soviet Union, where gas dominates and Asia Pacific where coal is the dominant fuel.

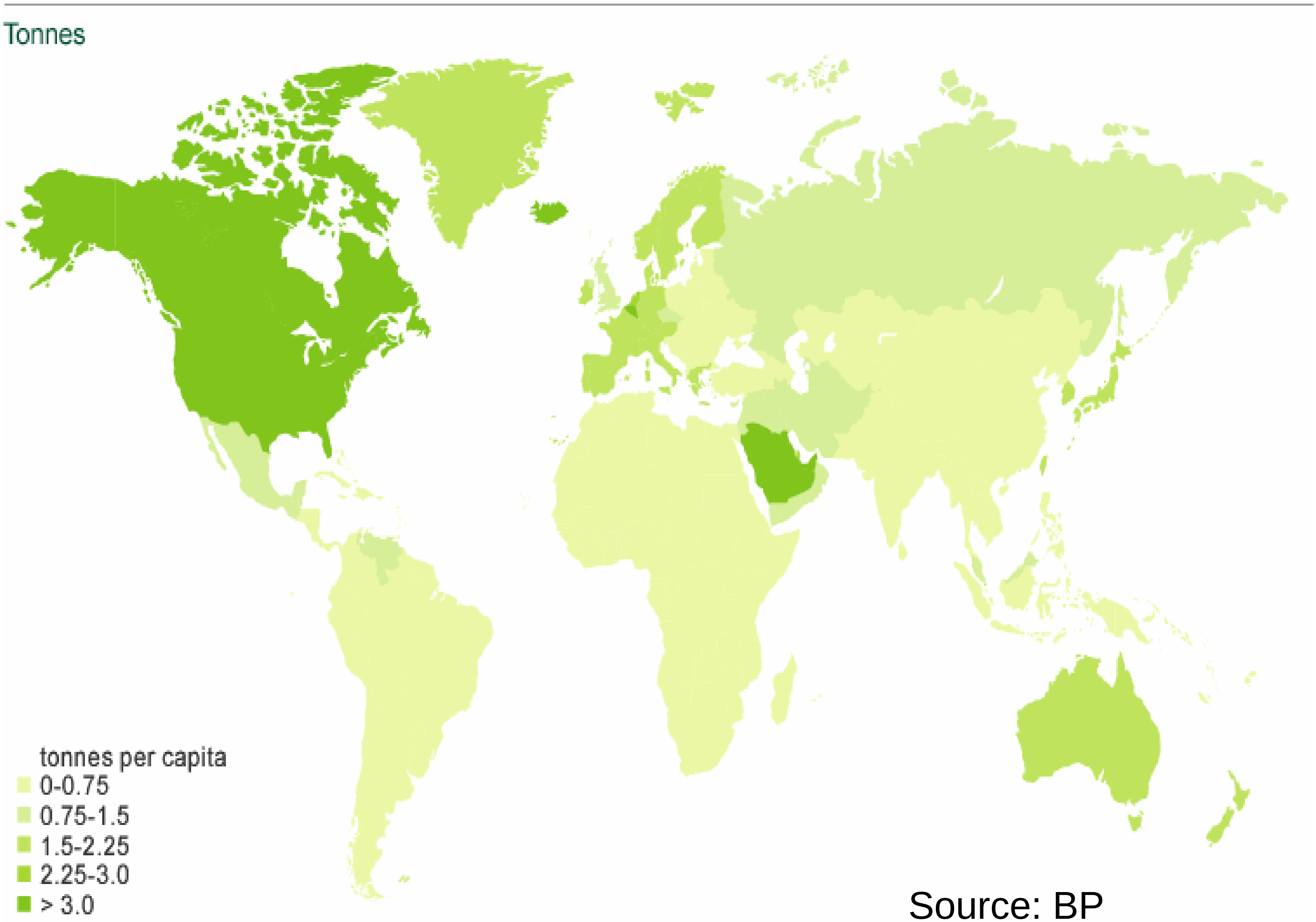
Source: BP

Primary energy consumption per capita

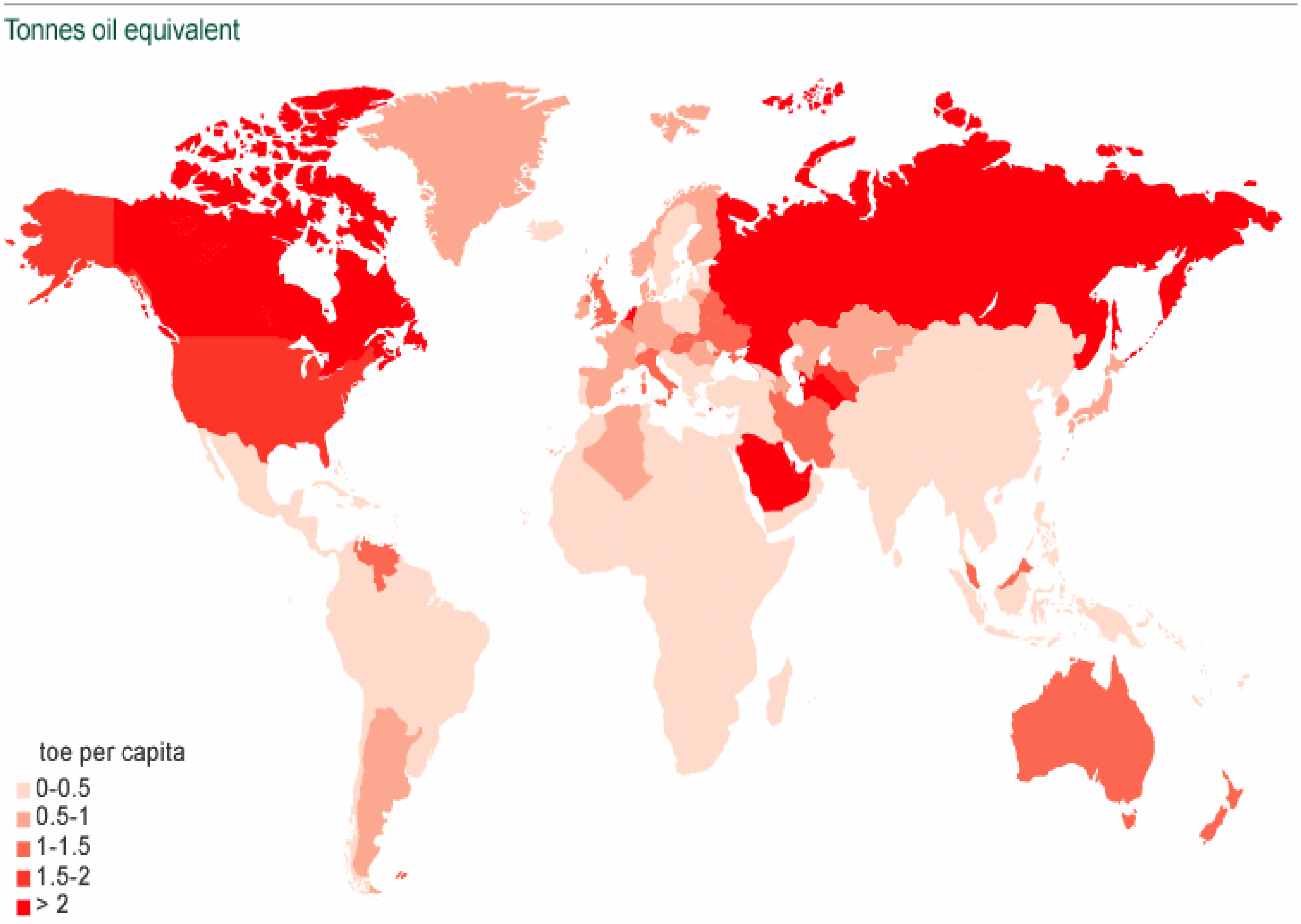


Source: BP

Oil consumption per capita

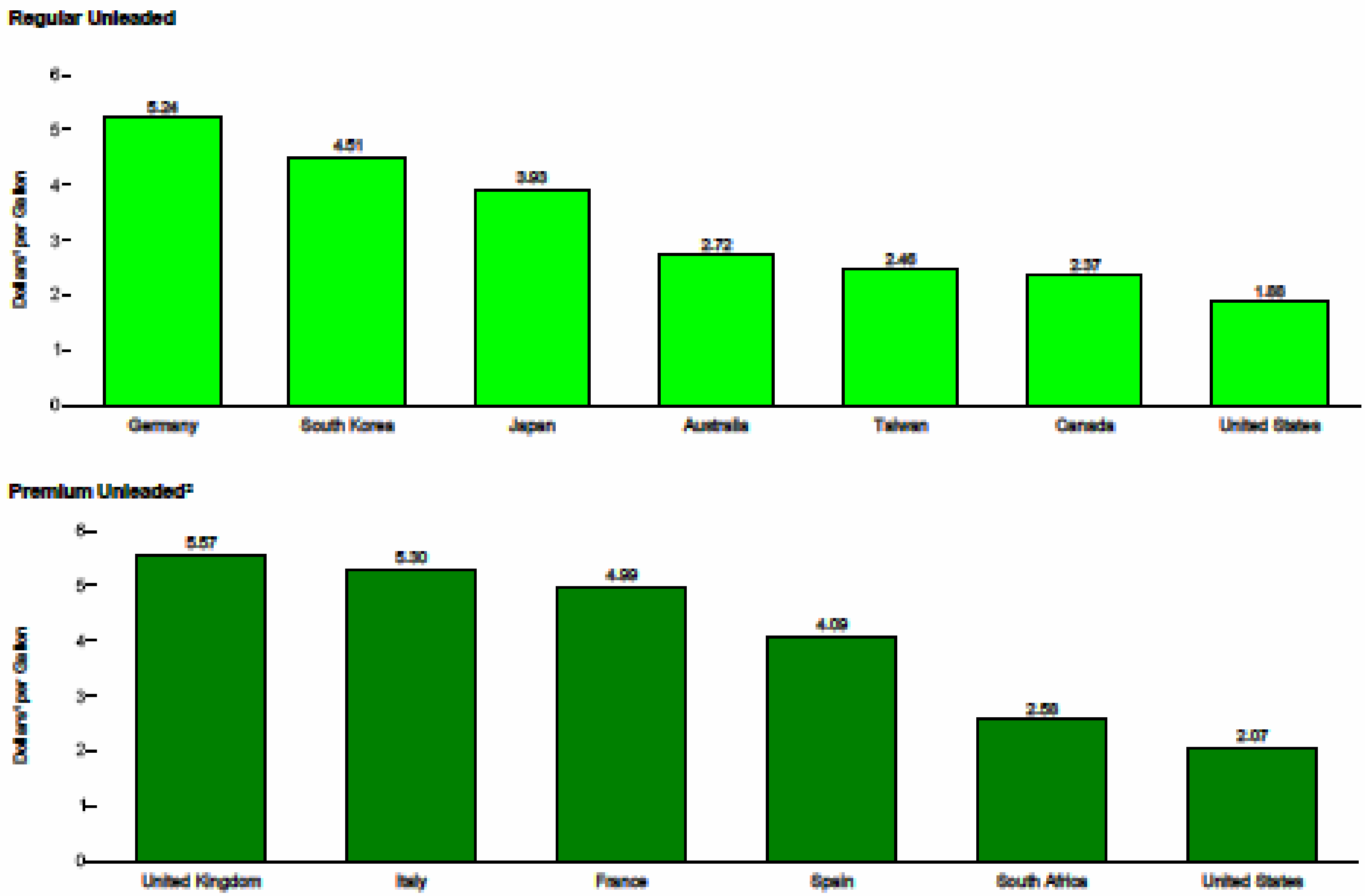


Natural gas consumption per capita



Source: BP

Figure 11.8 Retail Motor Gasoline Prices in Selected Countries, 2004



[1] Nominal dollars.
[2] Research Octane Number (RON) of 95.

Source: Table 11.8.

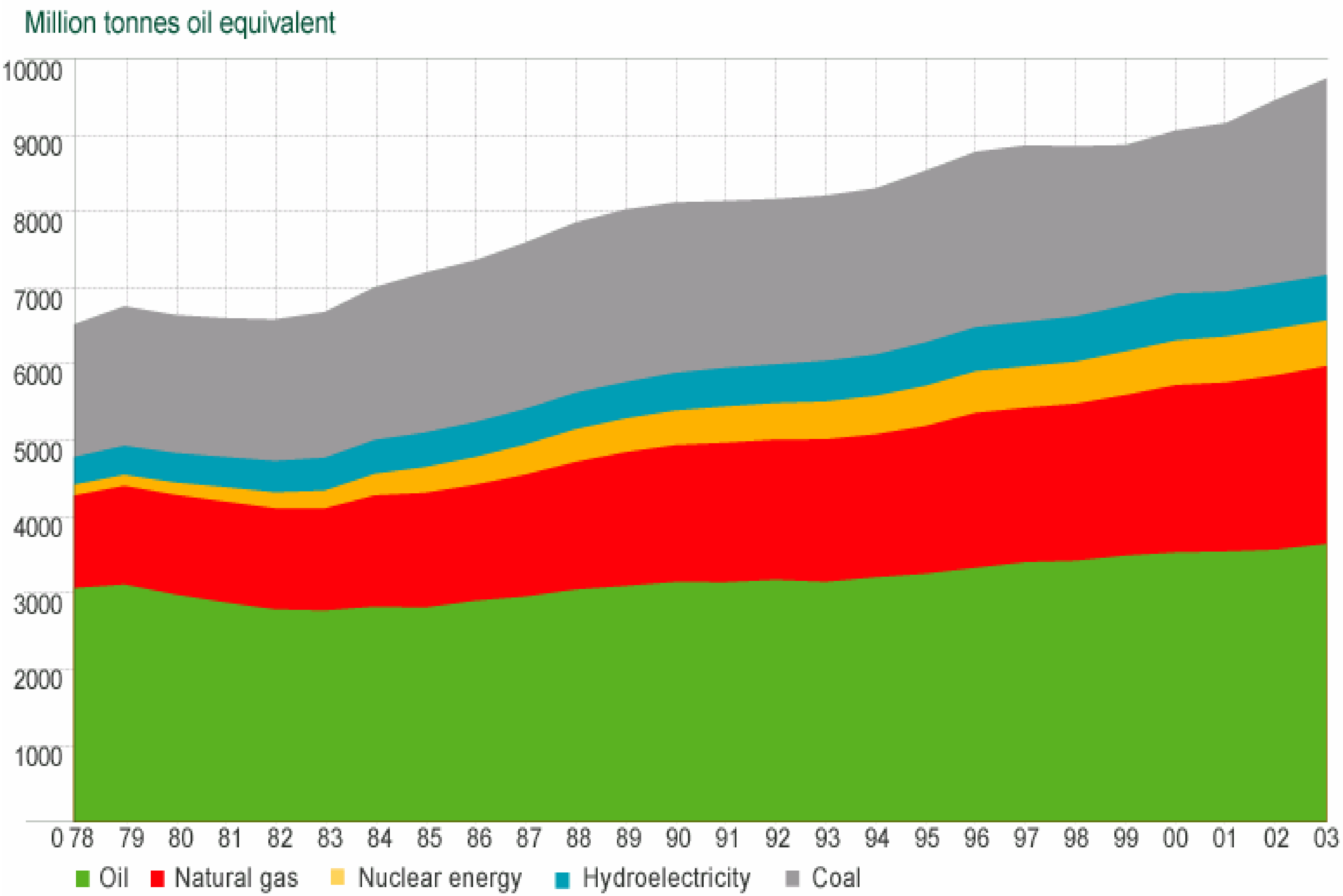
Source: EIA (2005)

AVERAGE PRICE OF ELECTRICITY (2003/2004)

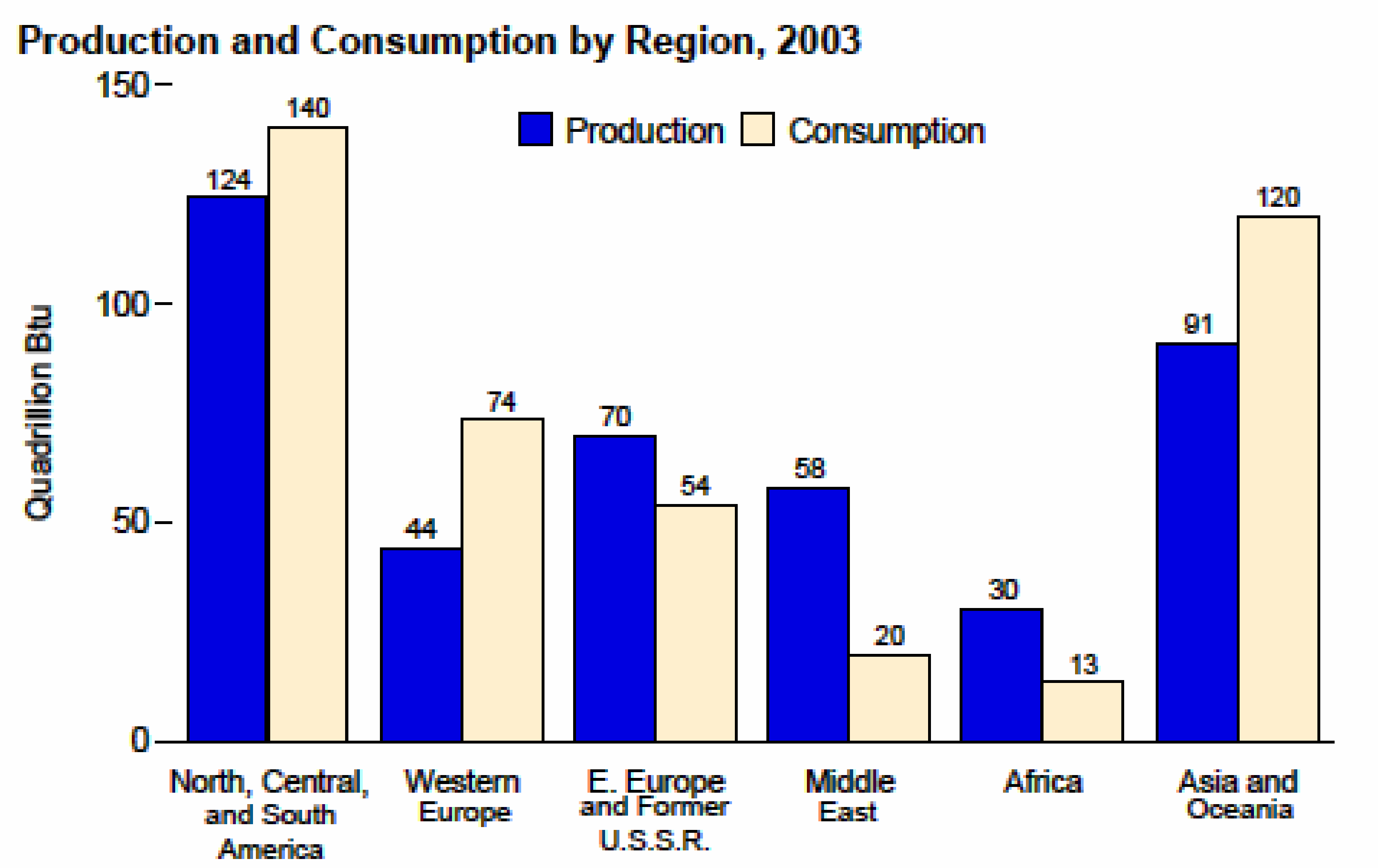
$US cents/kwh

	Domestic	Industrial
USA (2004)	9.0	5.3
USA (2005)	9.4	5.6
USA (MASS 2004)	11.8	8.5
USA (MASS 2005)	13.5	8.8
USA (Georgia 2004)	7.9	4.4
USA (Georgia 2005)	8.7	5.4
France	14.1	5.0
Germany	17.6	6.5
United Kingdom	13.8	6.7
Japan	19.6	12.7
Canada	6.2	4.9
Australia	6.2	3.6
Norway	6.9	4.3
Russia	N/A	2.9
Italy	19.1	16.2
Switzerland	14.3	8.5

World primary energy consumption

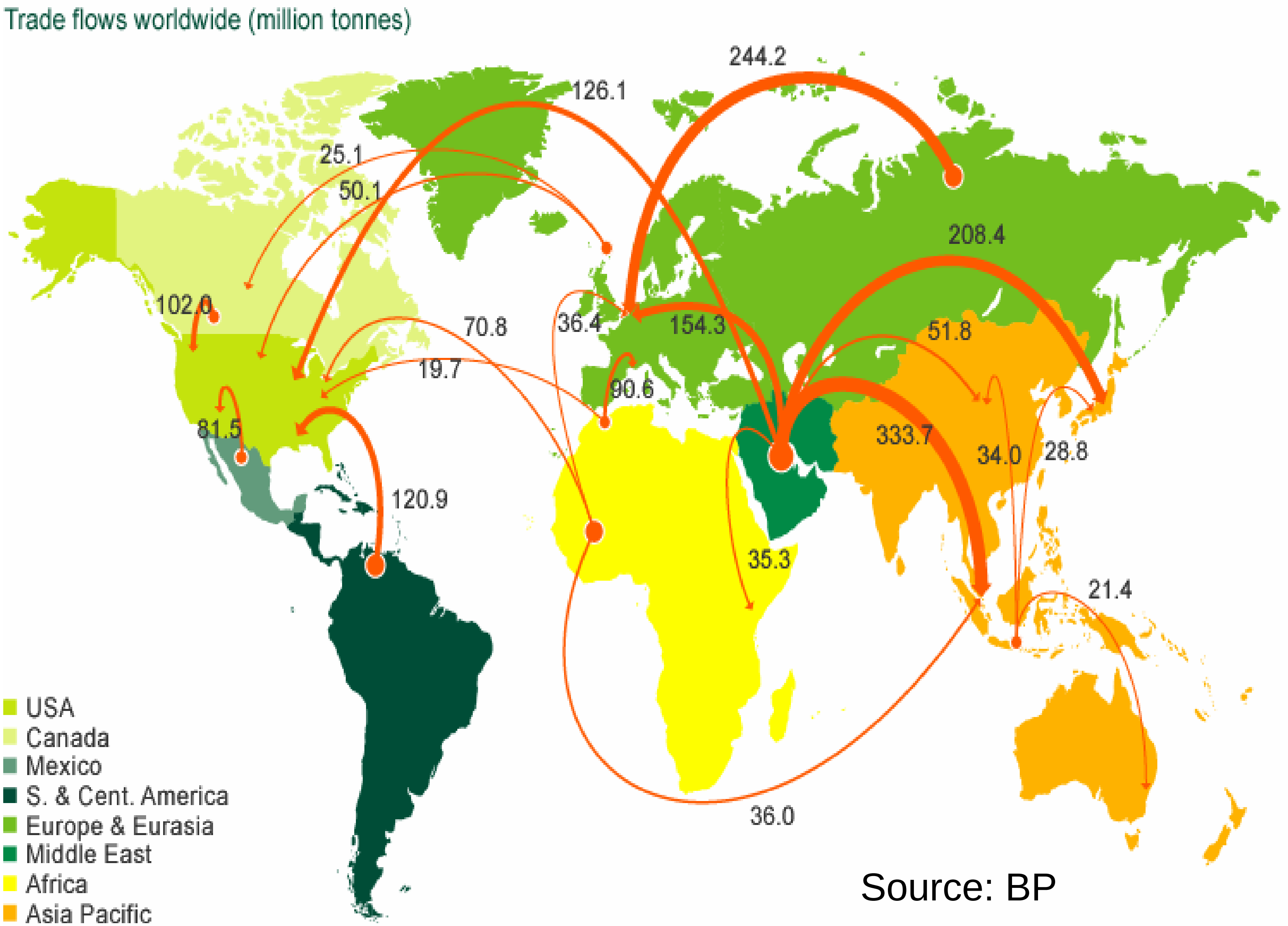


World primary energy consumption grew by 2.9% in 2003, well above the 10-year trend growth rate of 1.7% per annum. As in 2002, the global figure was heavily influenced by China, where reported energy use increased by almost 14%.



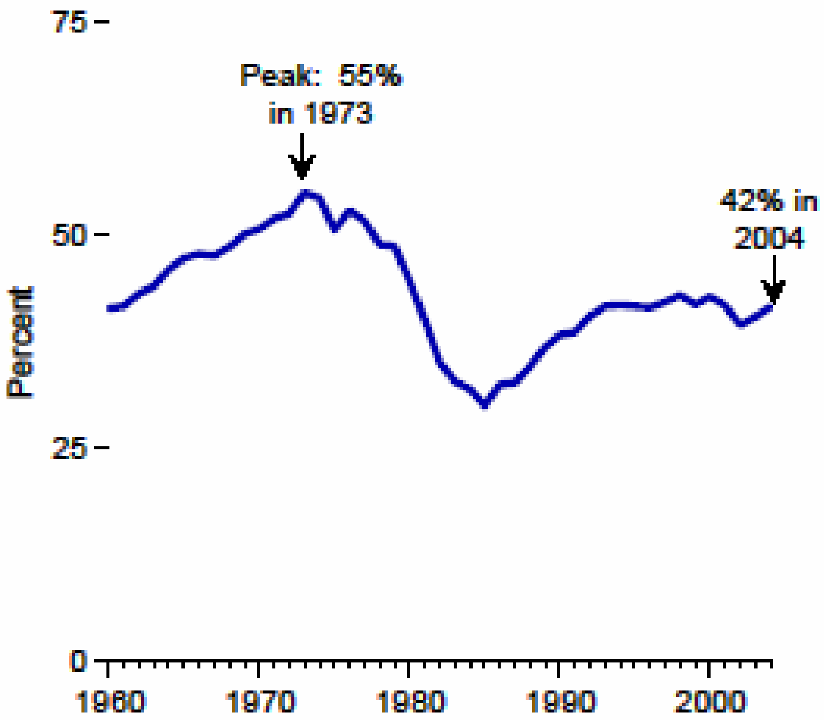
Source: EIA (2005)

Major oil trade movements

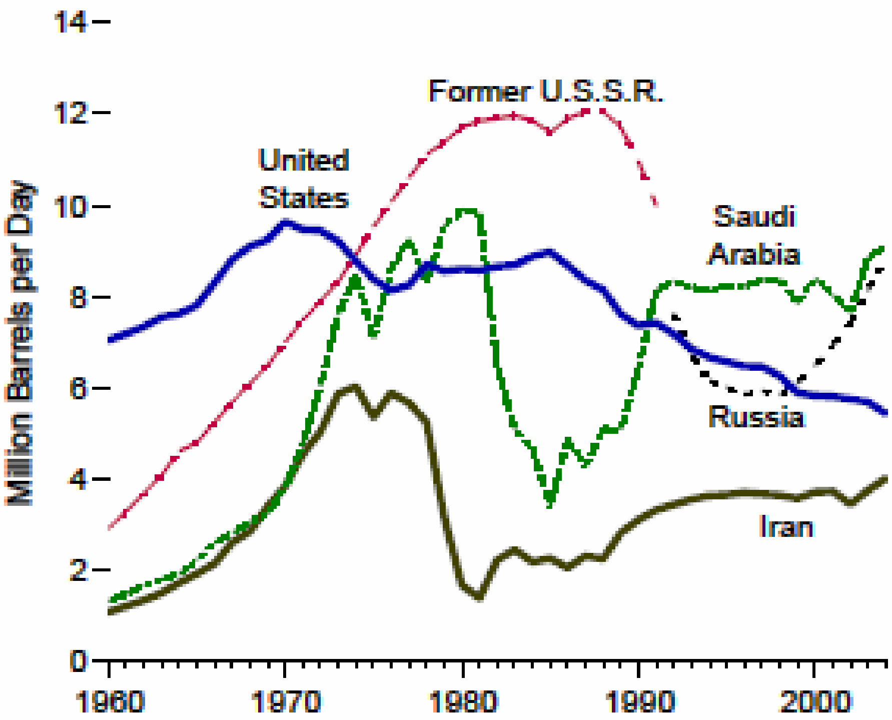


Source: BP

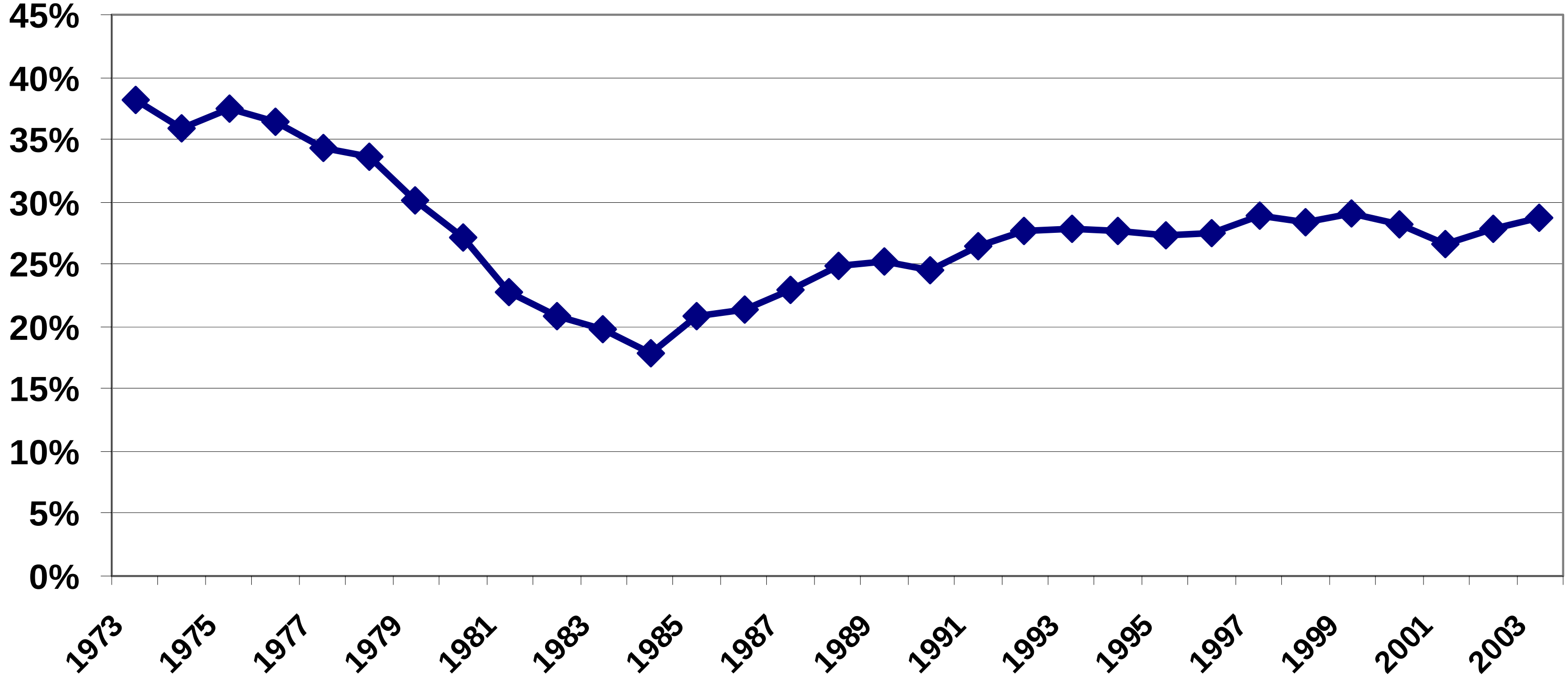
OPEC's Share of World, 1960-2004



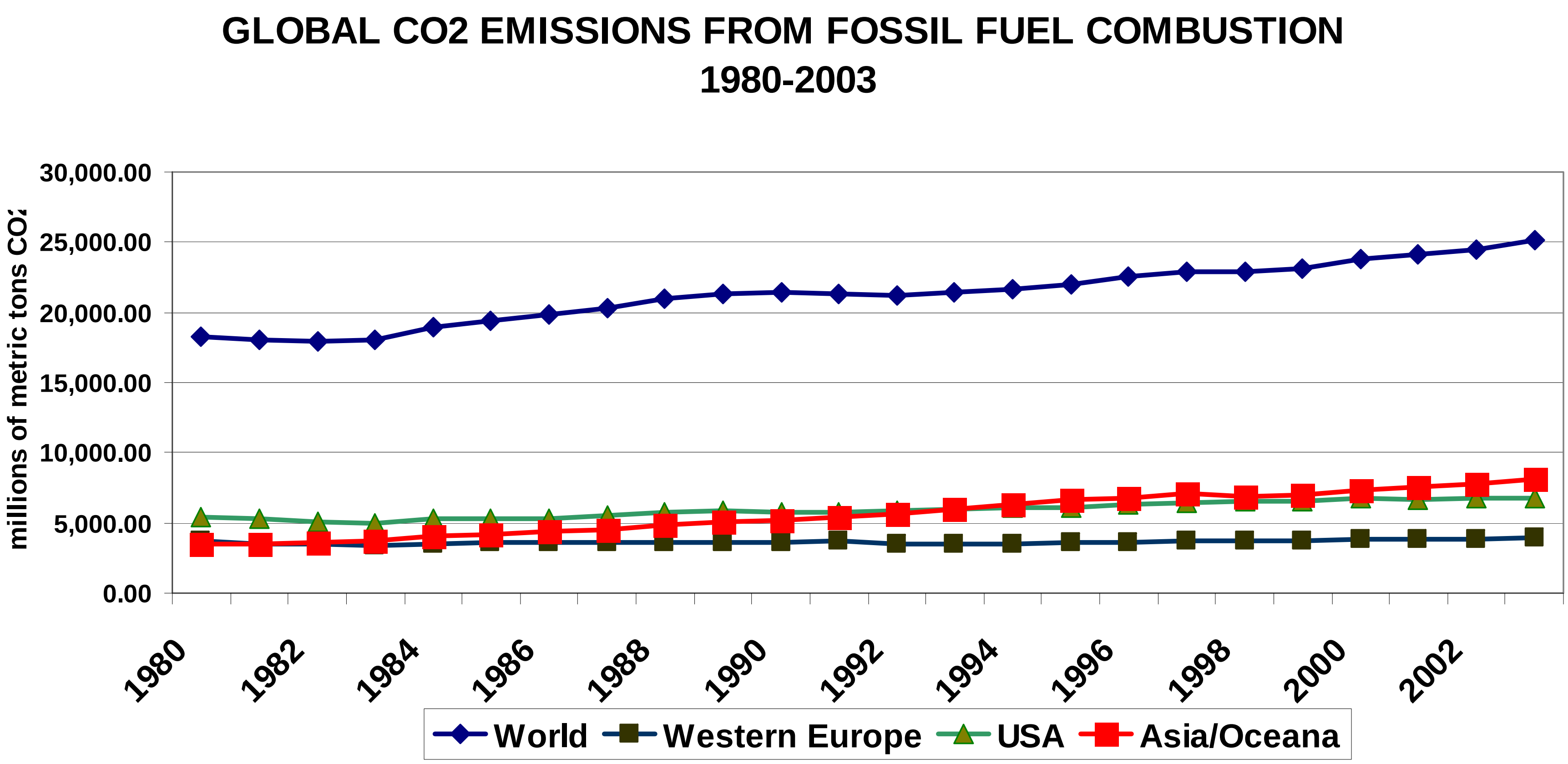
Top Producing Countries, 1960-2004



Persian Gulf Production as a Fraction of World Oil Production (%)



EIA (2005)



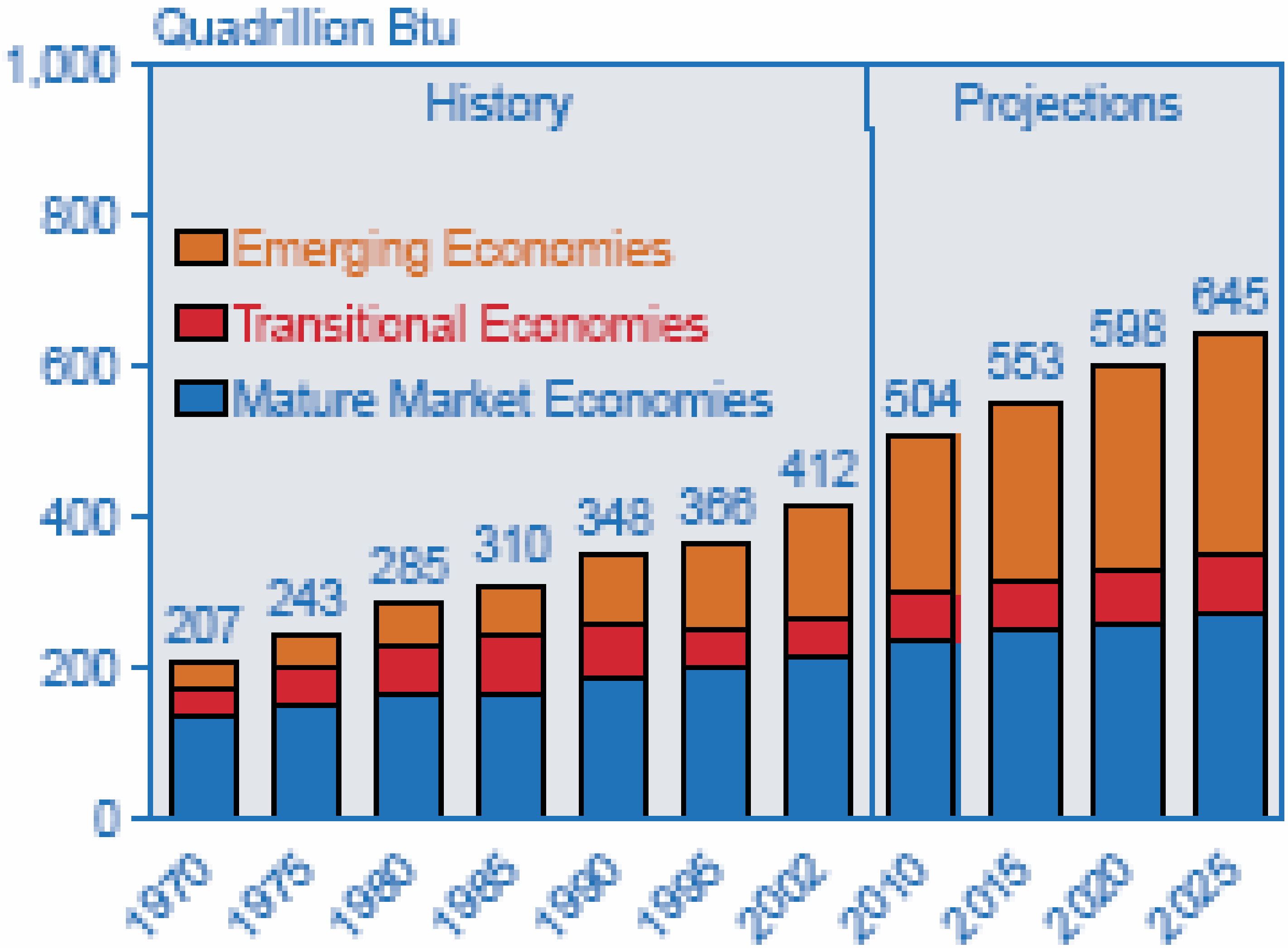
GLOBAL CO2 EMISSIONS FROM FOSSIL FUEL COMBUSTION
1980-2003
millions of metric tons CO2
30,000.00
25,000.00
20,000.00
15,000.00
10,000.00
5,000.00
0.00
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
World
Western Europe
USA
Asia/Oceana

AFTER 25 YEARS OF ENERGY POLICY

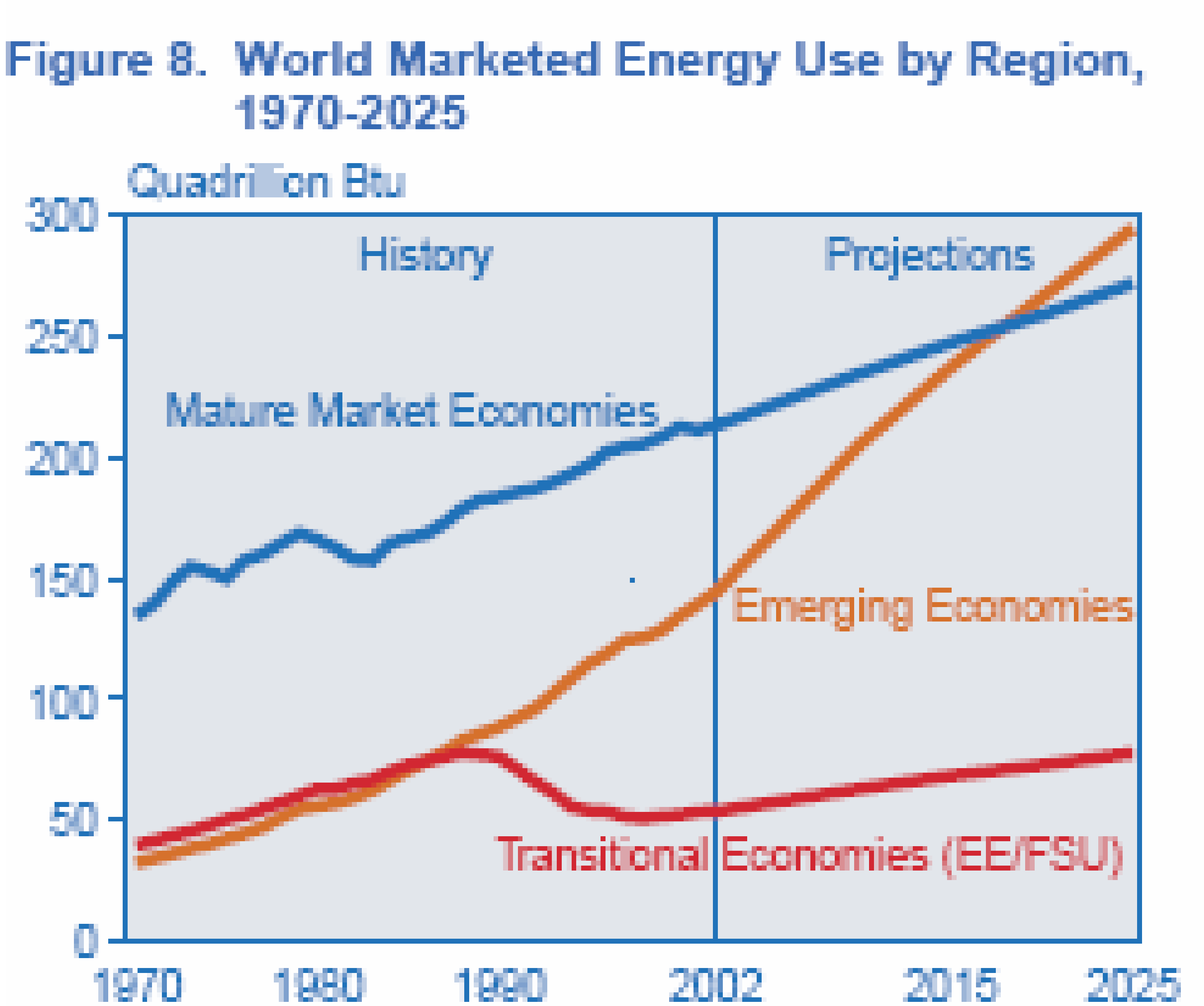
- Many OECD countries have not moved closer to “energy independence” and rely more on imports of oil and natural gas
- Oil supply sources have been diversified but Persian Gulf’s share is now growing
- Energy intensity of most countries has declined, reducing vulnerability to supply shocks
- Real energy prices declined from the mid- 1980s until 2000
- But energy prices have risen rapidly in the last two years as demand growth has exceeded investment in new production capacity
- World energy markets and economies have adapted well to the few energy supply shocks that have occurred
- Political instability in the Middle East has increased
- There are now concerns about greenhouse gas emissions and climate change
- Investment in nuclear generation has been stalled in most developed countries
- Renewable energy supplies have grown but represent a small fraction of the overall supply balance

GLOBAL FORECASTS
BUSINESS AS USUAL

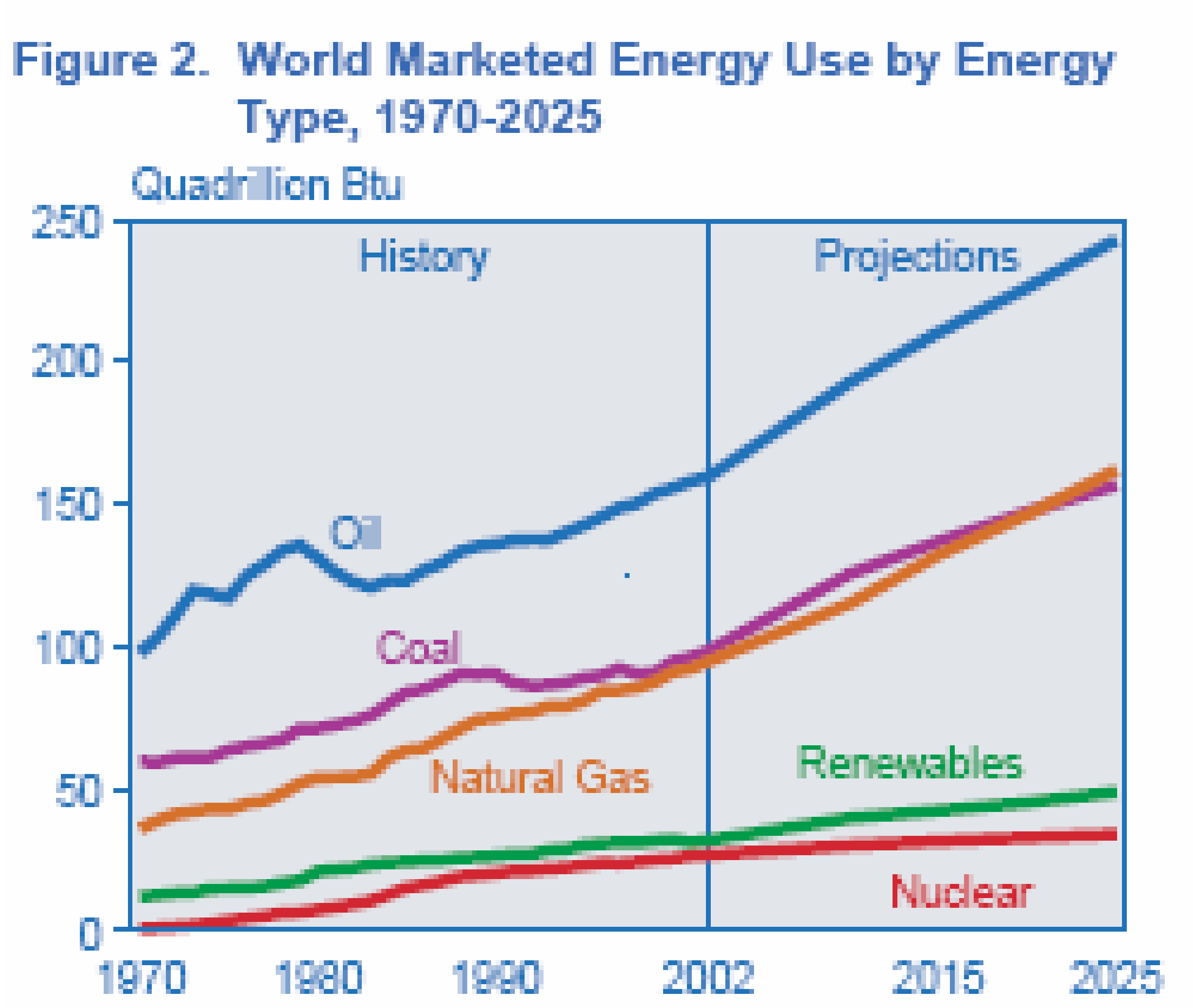
Figure 1. World Marketed Energy Consumption by Region, 1970-2025



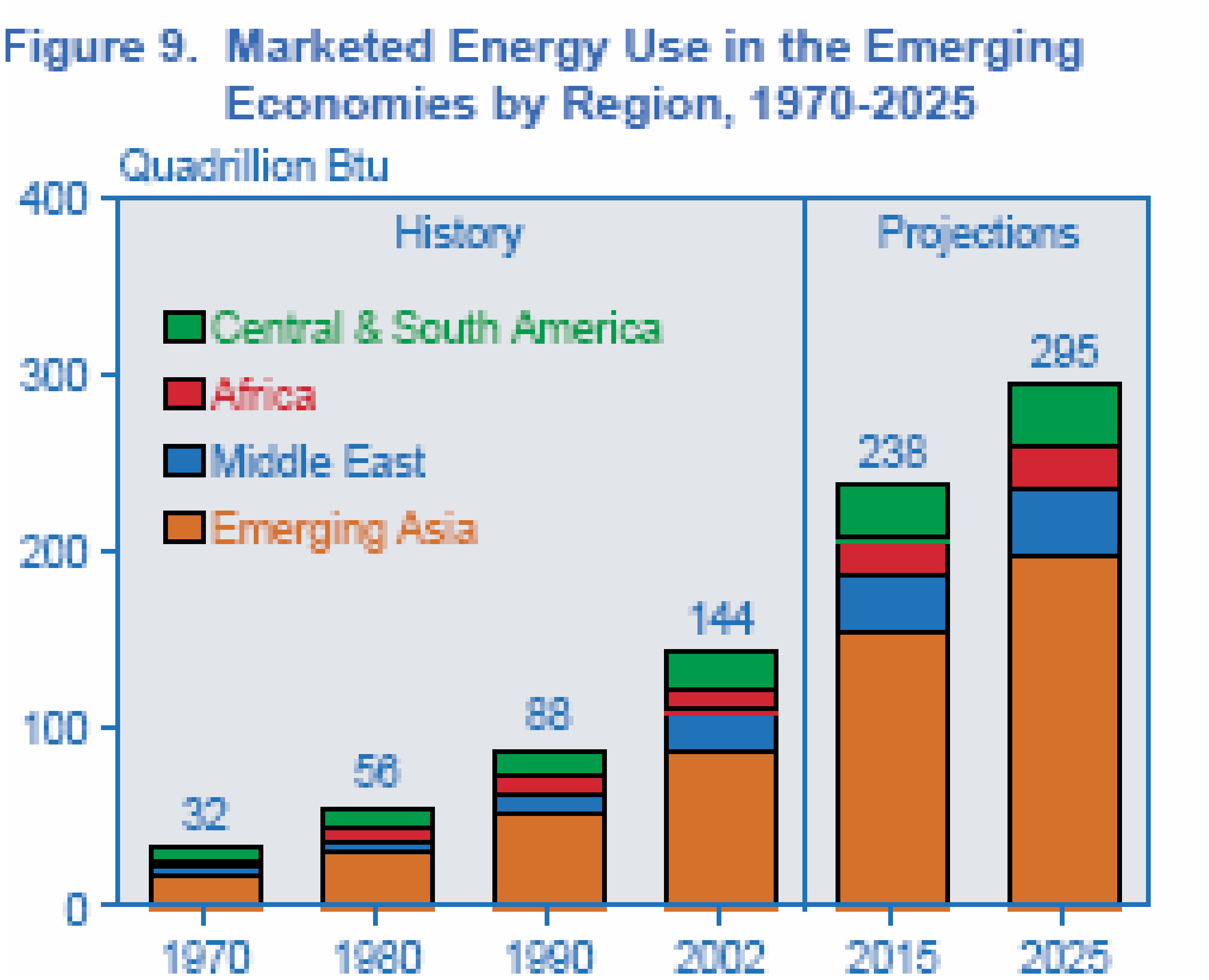
Source: EIA IEO (2005)



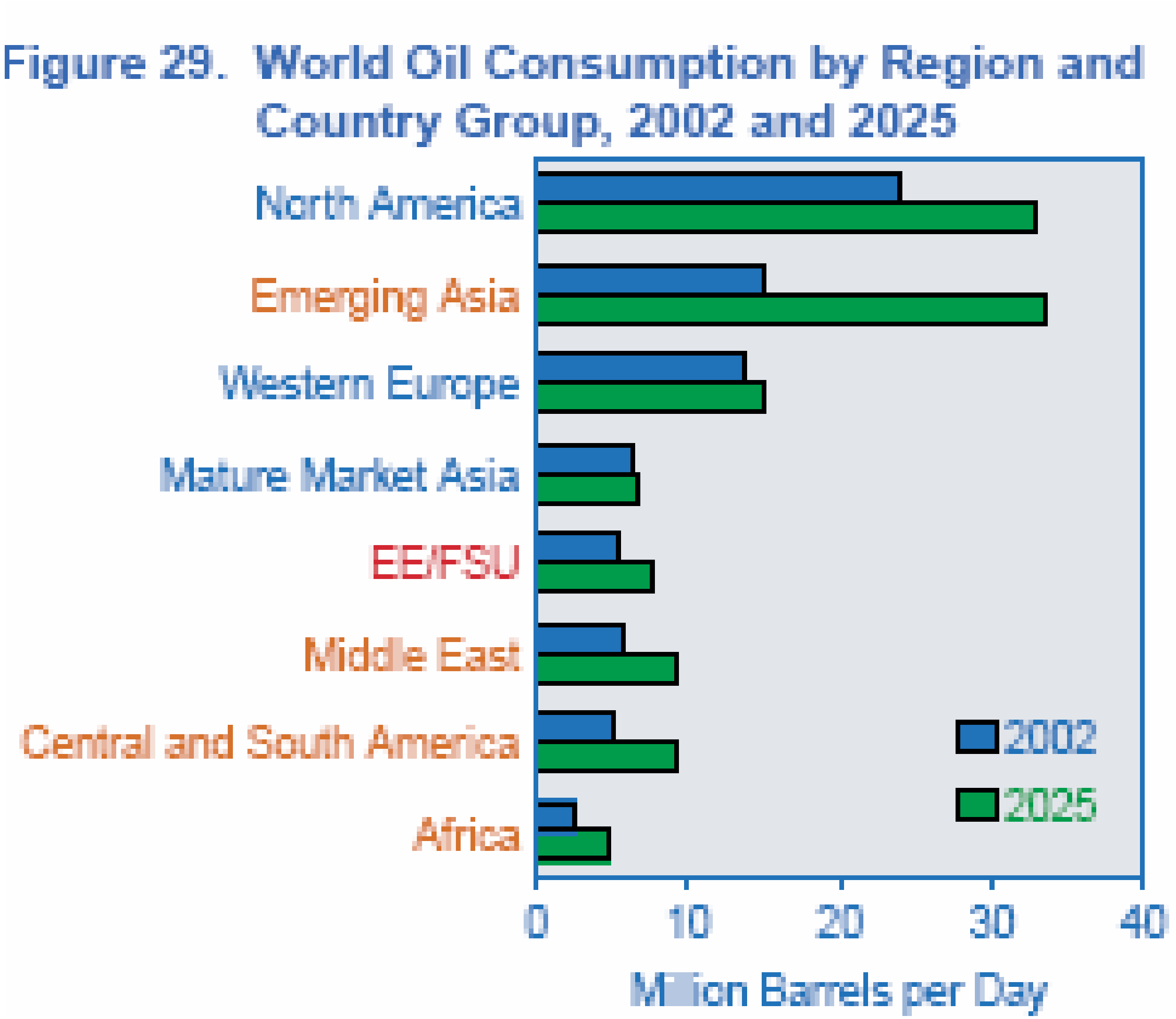
Source: EIA IEO (2005)



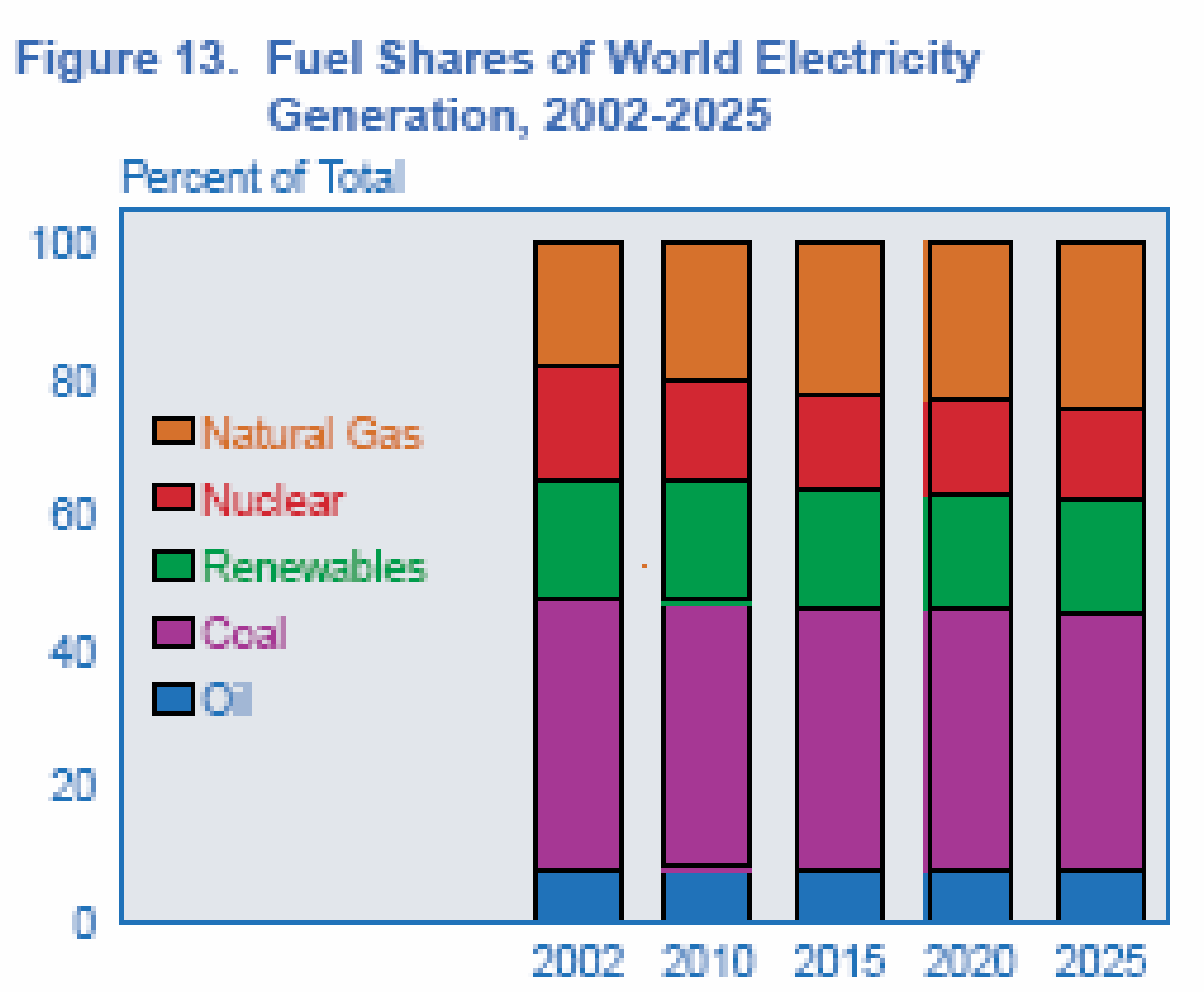
Source: EIA IEO (2005)



Source: EIA IEO (2005)

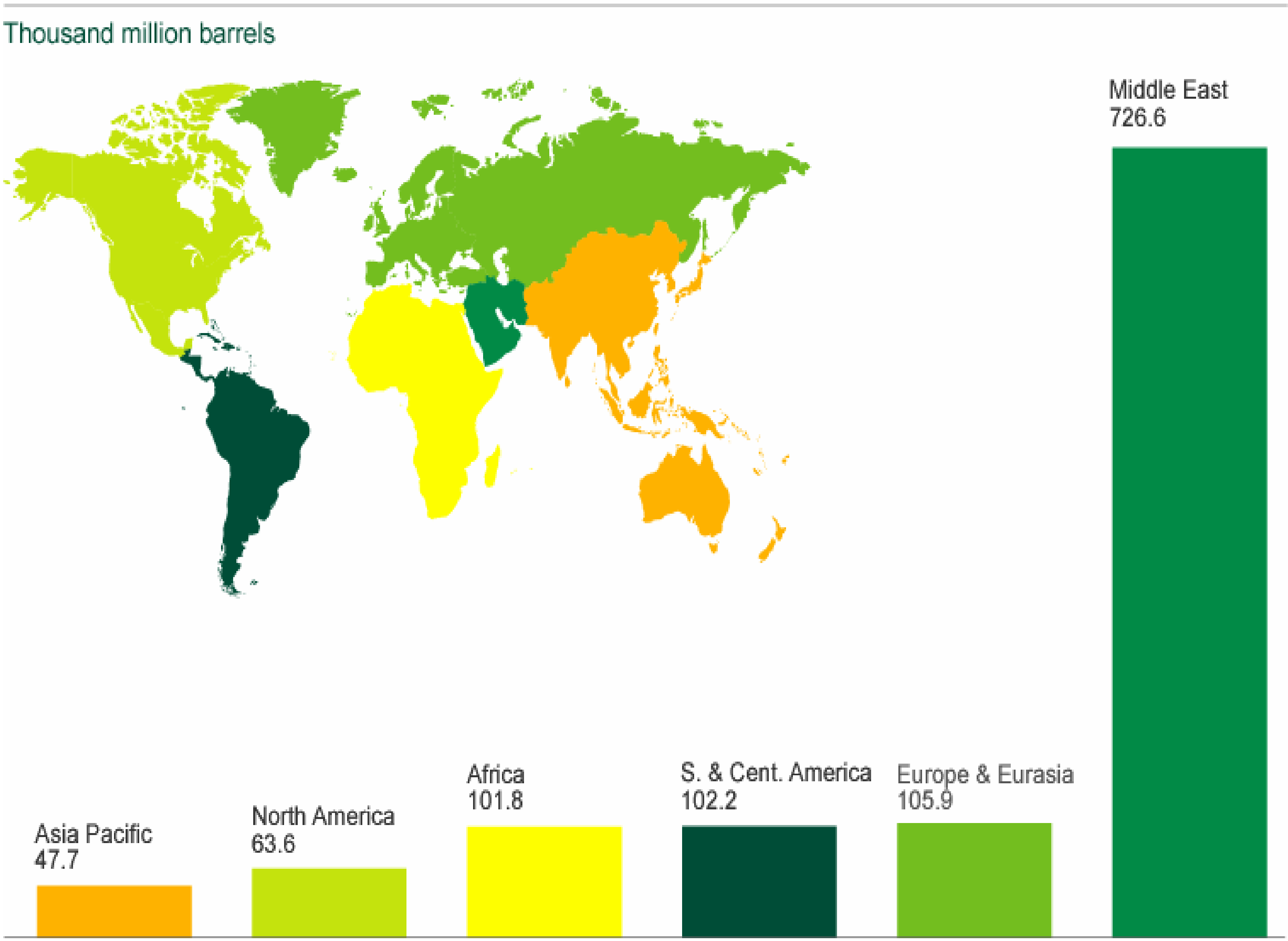


Source: EIA IEO (2005)



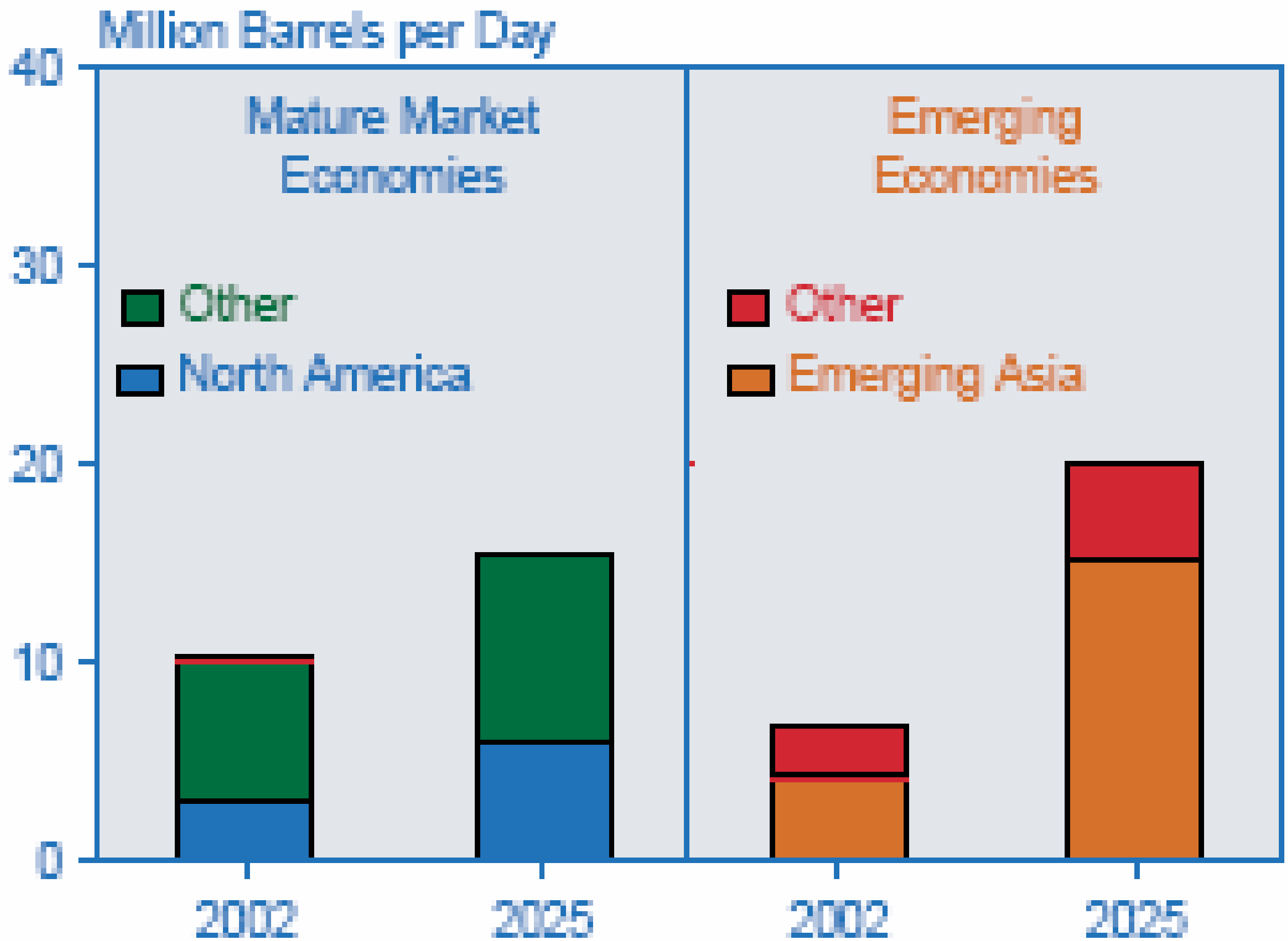
Source: EIA IEO (2005)

Proved oil reserves at end 2003



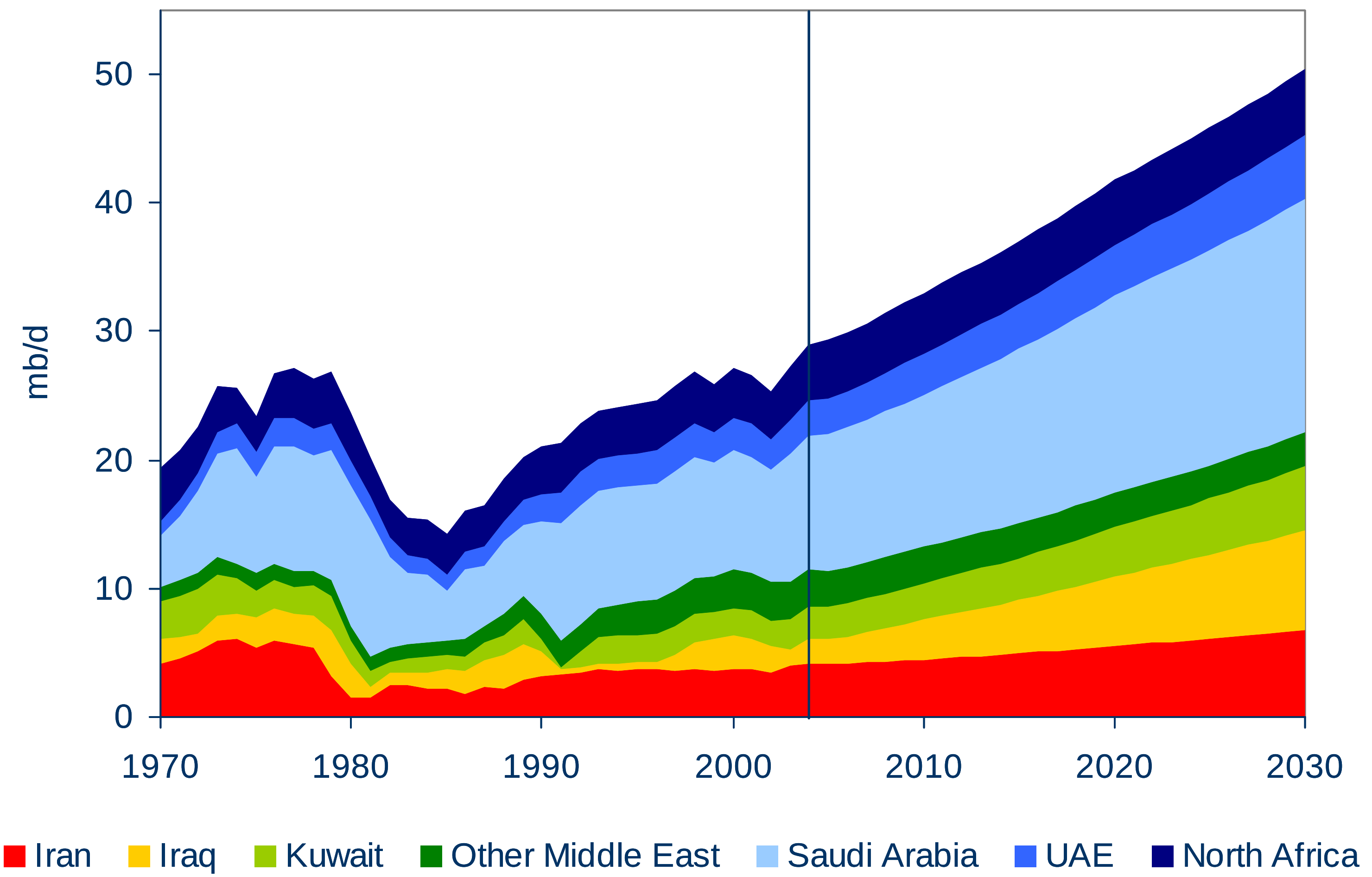
Source: BP

Figure 33. Imports of Persian Gulf Oil by Importing Region, 2002 and 2025



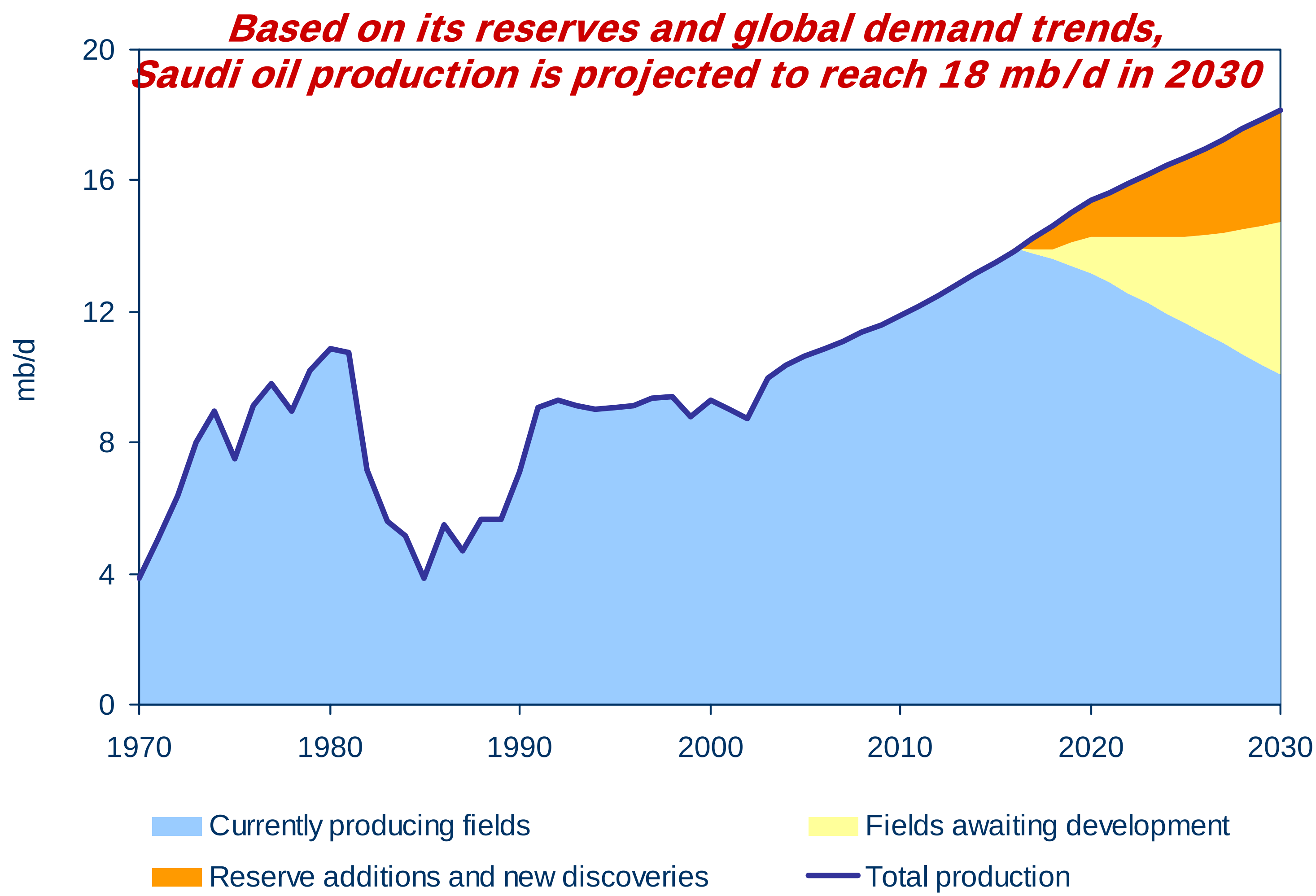
Middle East and North Africa Crude Oil & NGL Production by Country

MENA's share of world oil production rises from 35% in 2004 to 44% in 2030 in the RS, with Saudi production rising to over 18 mb/d



Source: IEA Presentation graphic (2006)

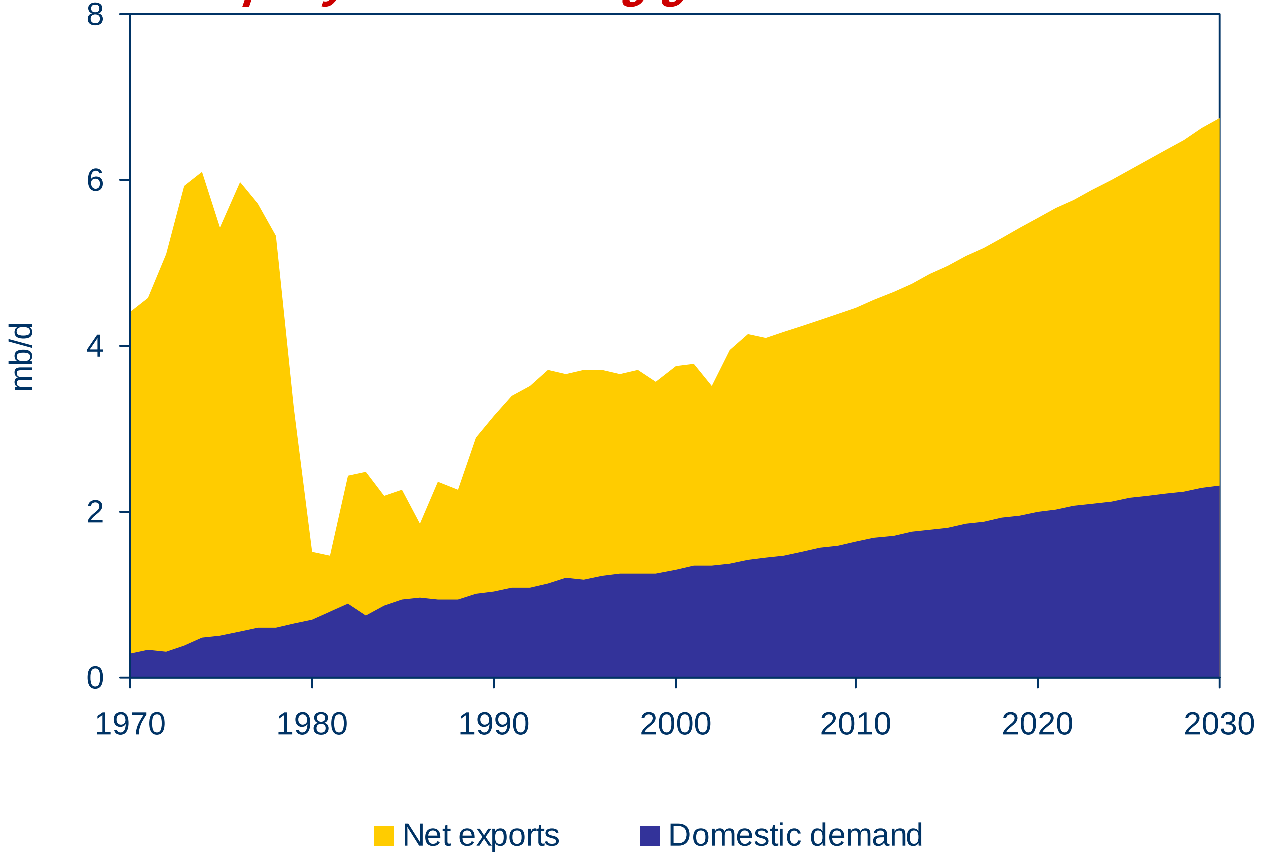
Saudi Arabia's Oil Production by Source in the Reference Scenario



Source: IEA Presentation graphic (2006)

Iran's Oil Balance in the Reference Scenario

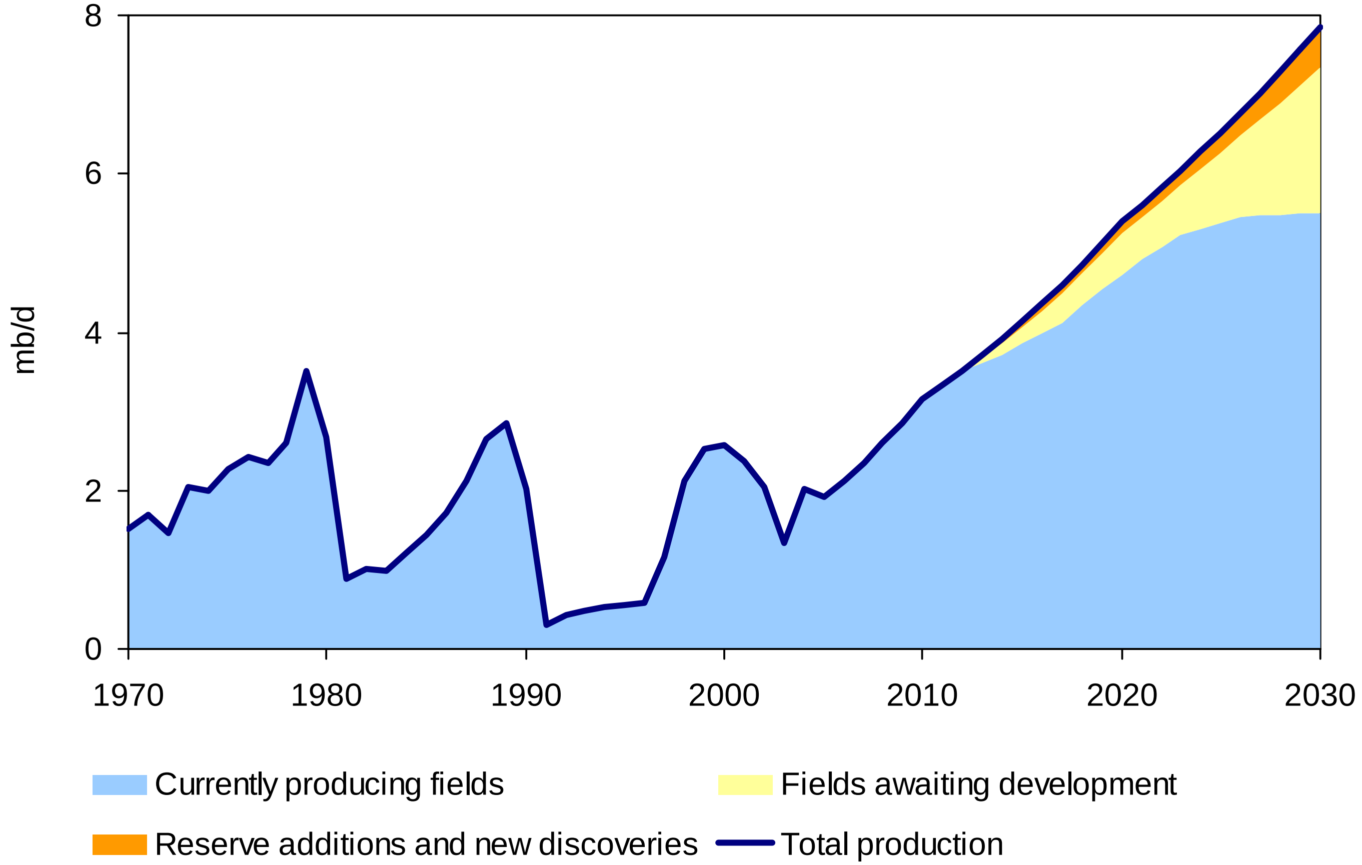
Iran oil production reaches 6.8 mb/d in 2030, but exports increase less rapidly due to strong growth in domestic demand



Source: IEA Presentation graphic (2006)

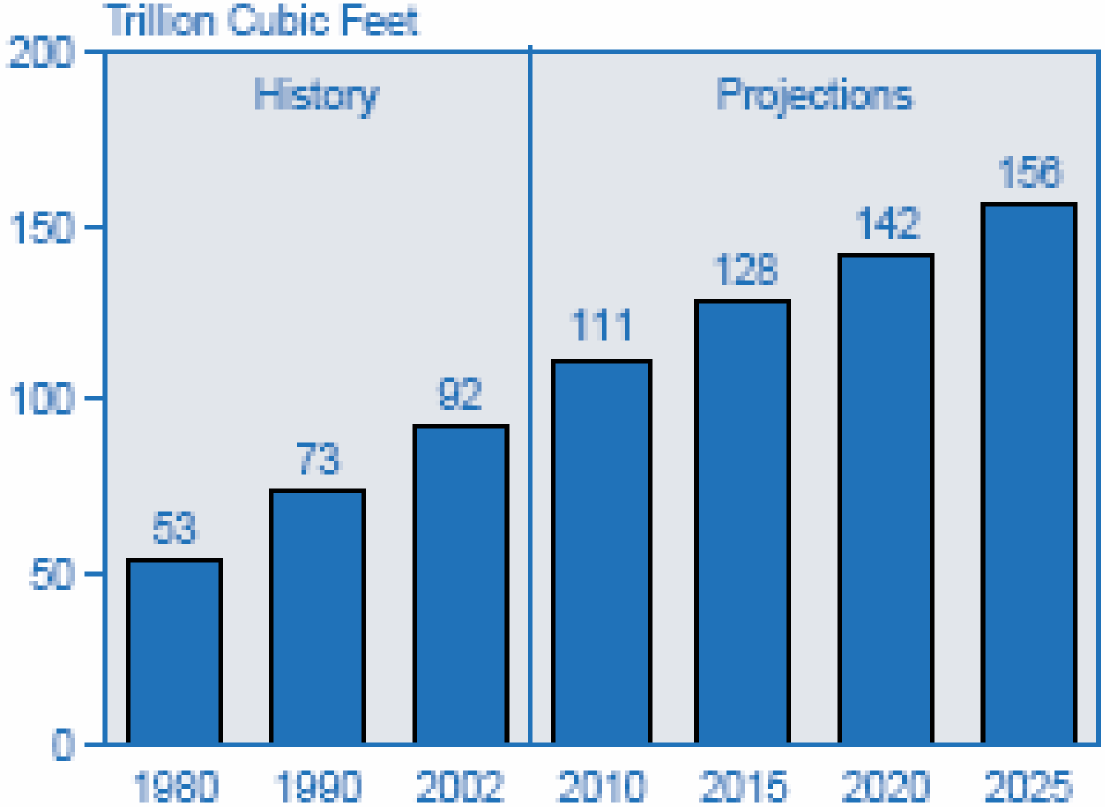
Oil Production Outlook in Iraq in the Reference Scenario

Oil production in Iraq is expected to reach around 3 mb/d in 2010 and 8 mb/d in 2030, provided that stability and security are restored



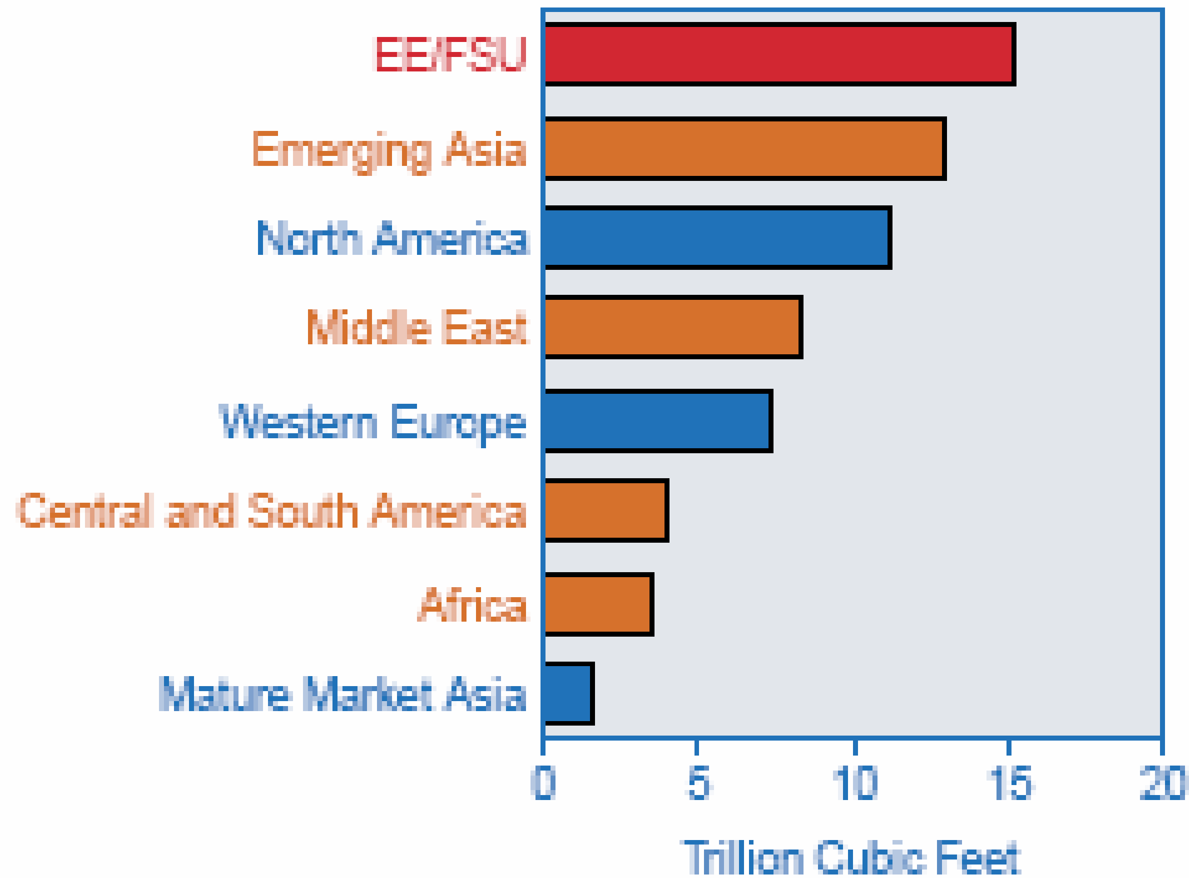
Source: IEA Presentation graphic (2006)

Figure 34. World Natural Gas Consumption, 1980-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 36. Increases in Natural Gas Consumption by Region and Country Group, 2002-2025



Sources: 2002: Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. 2025: EIA, System for the Analysis of Global Energy Markets (2005).

Figure 44. Natural Gas Consumption in Western Europe by Source, 2002-2025

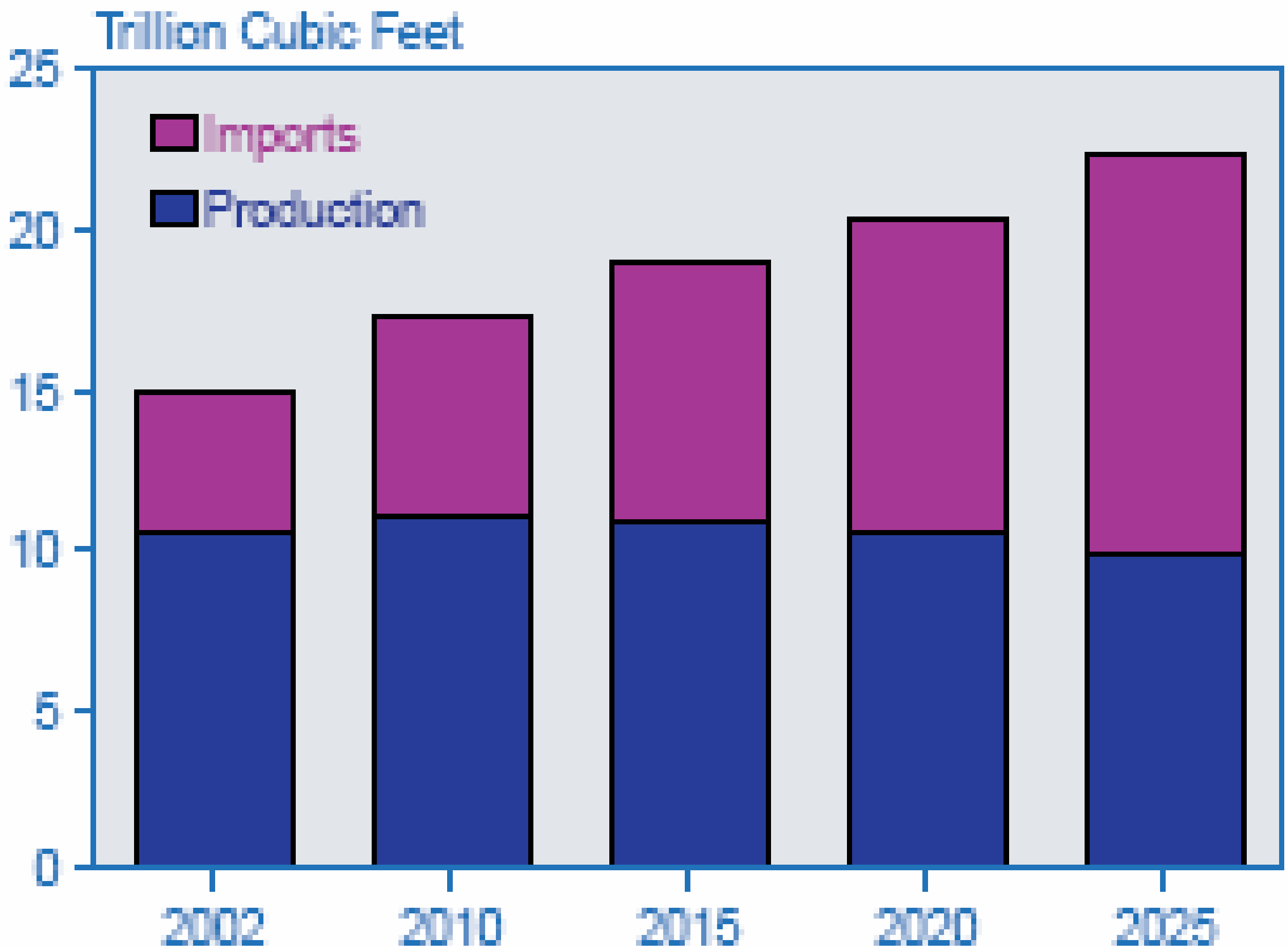
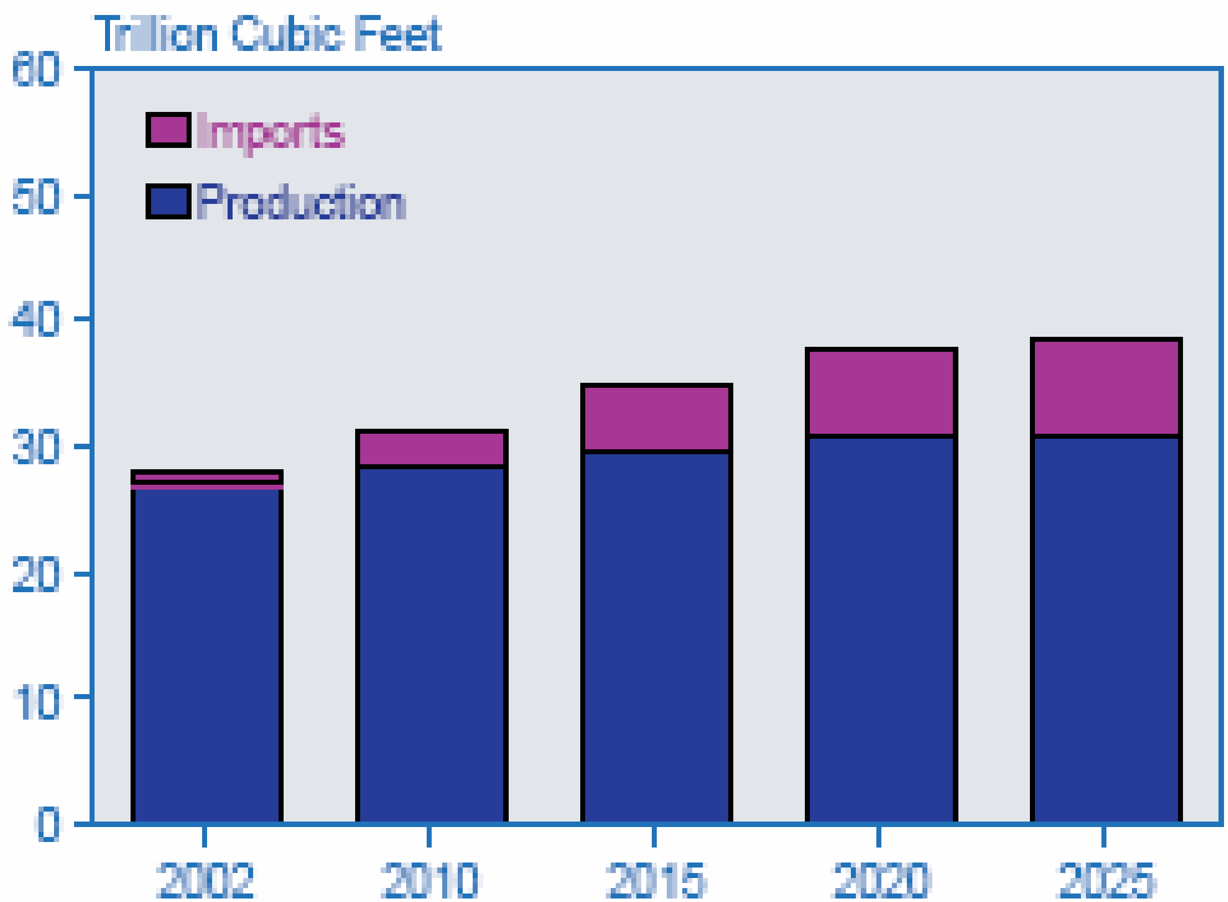
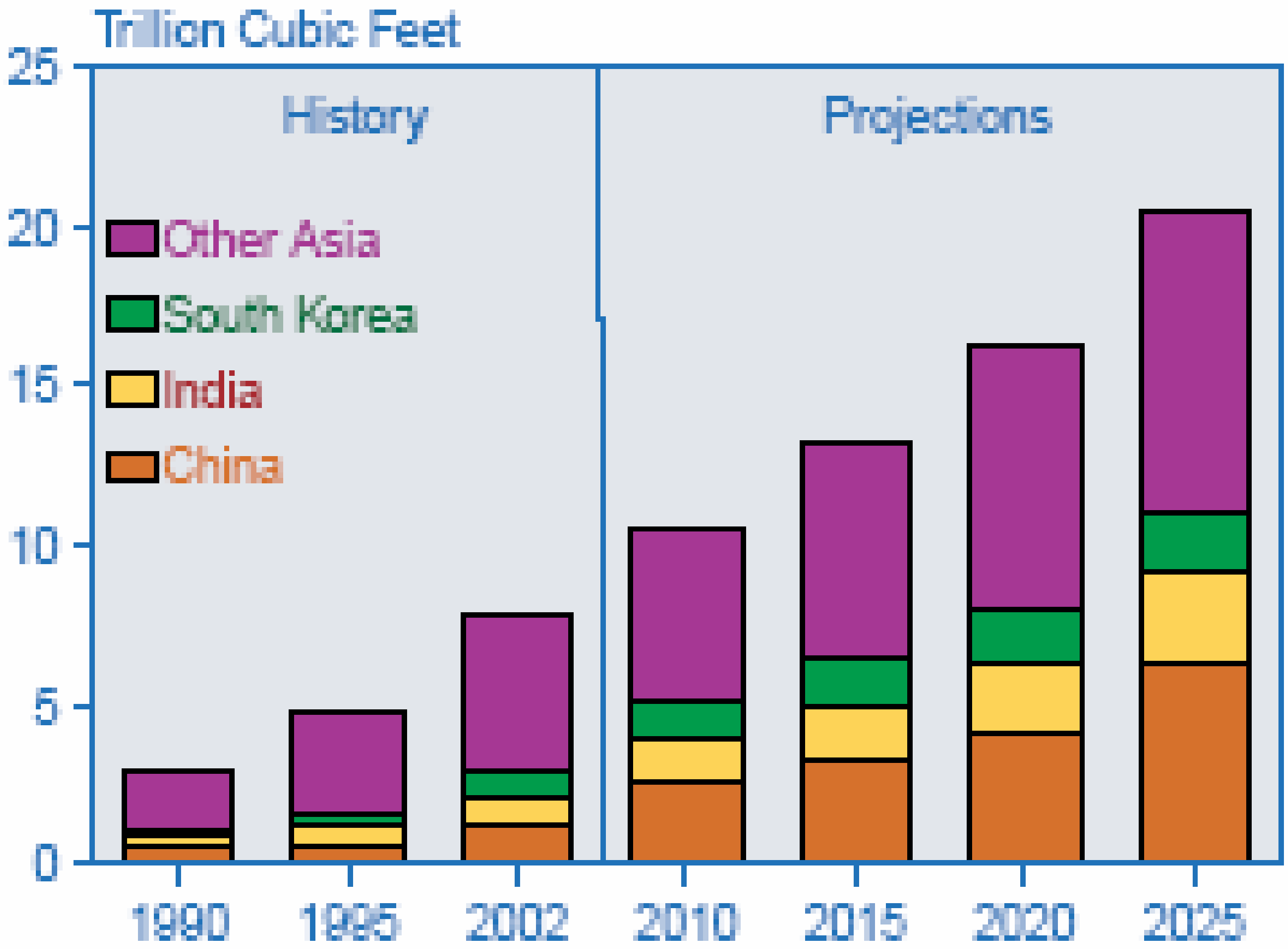


Figure 43. Natural Gas Supply in North America by Source, 2002-2025

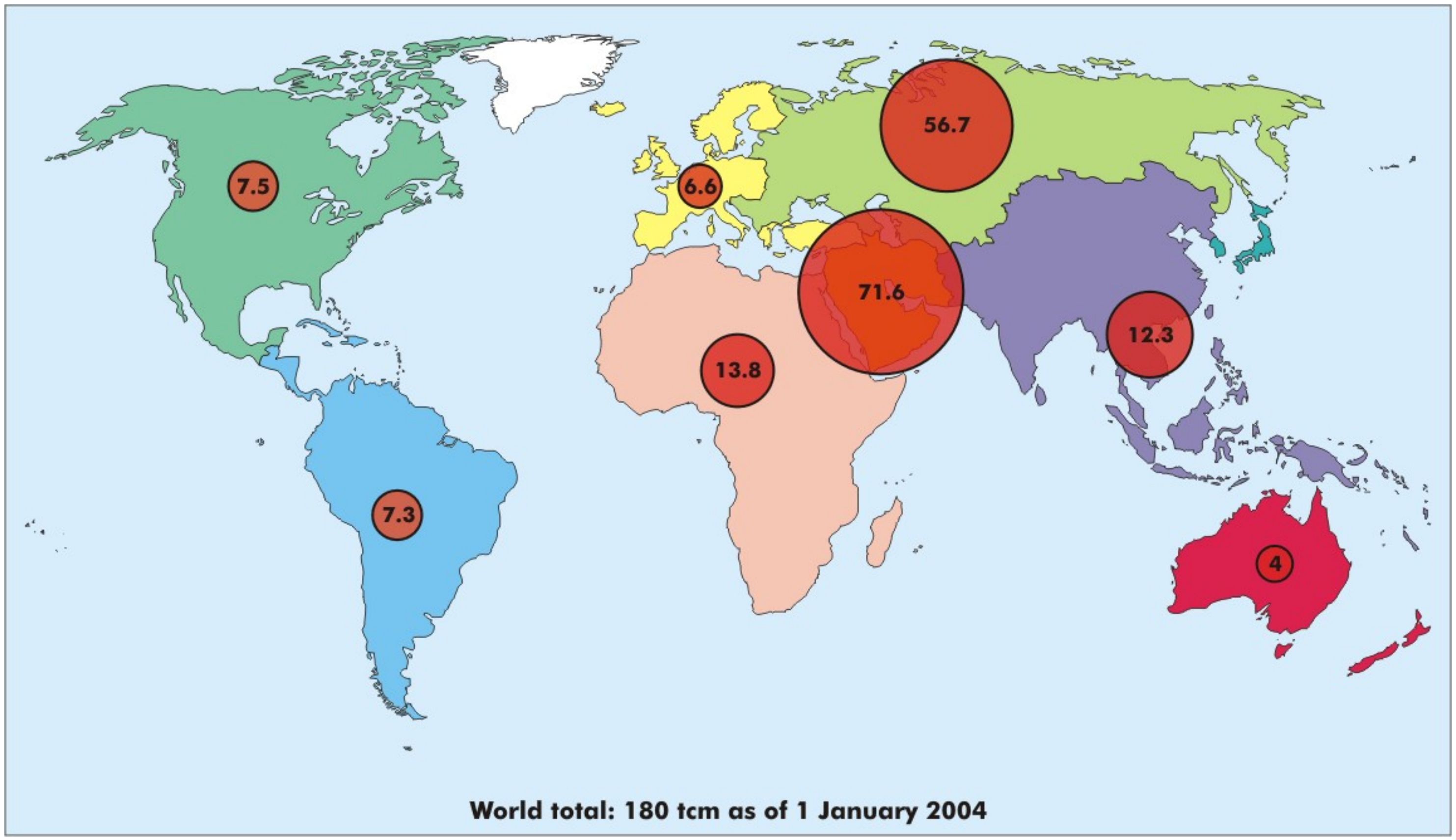


Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

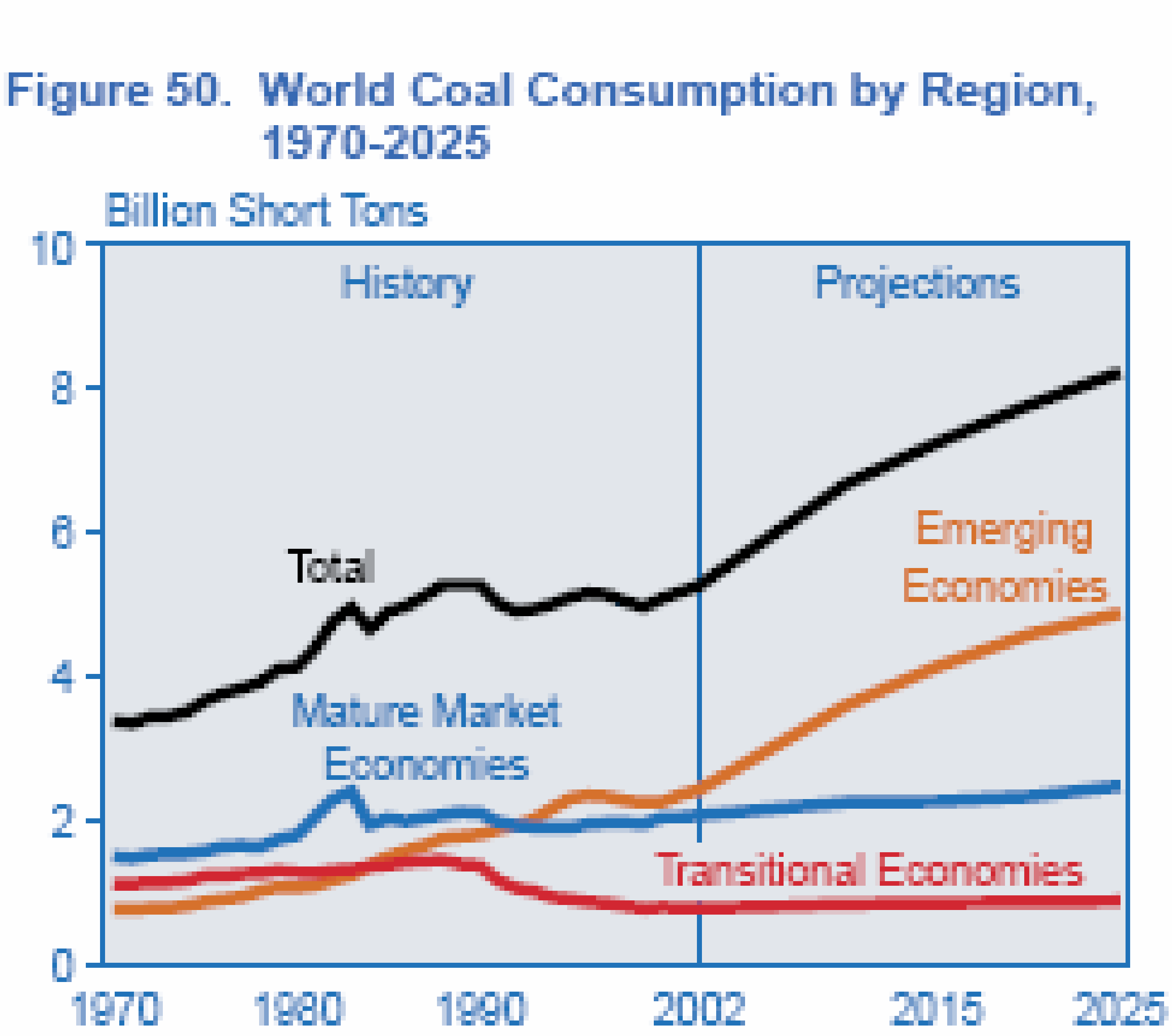
Figure 46. Natural Gas Consumption in Emerging Asia, 1990-2025



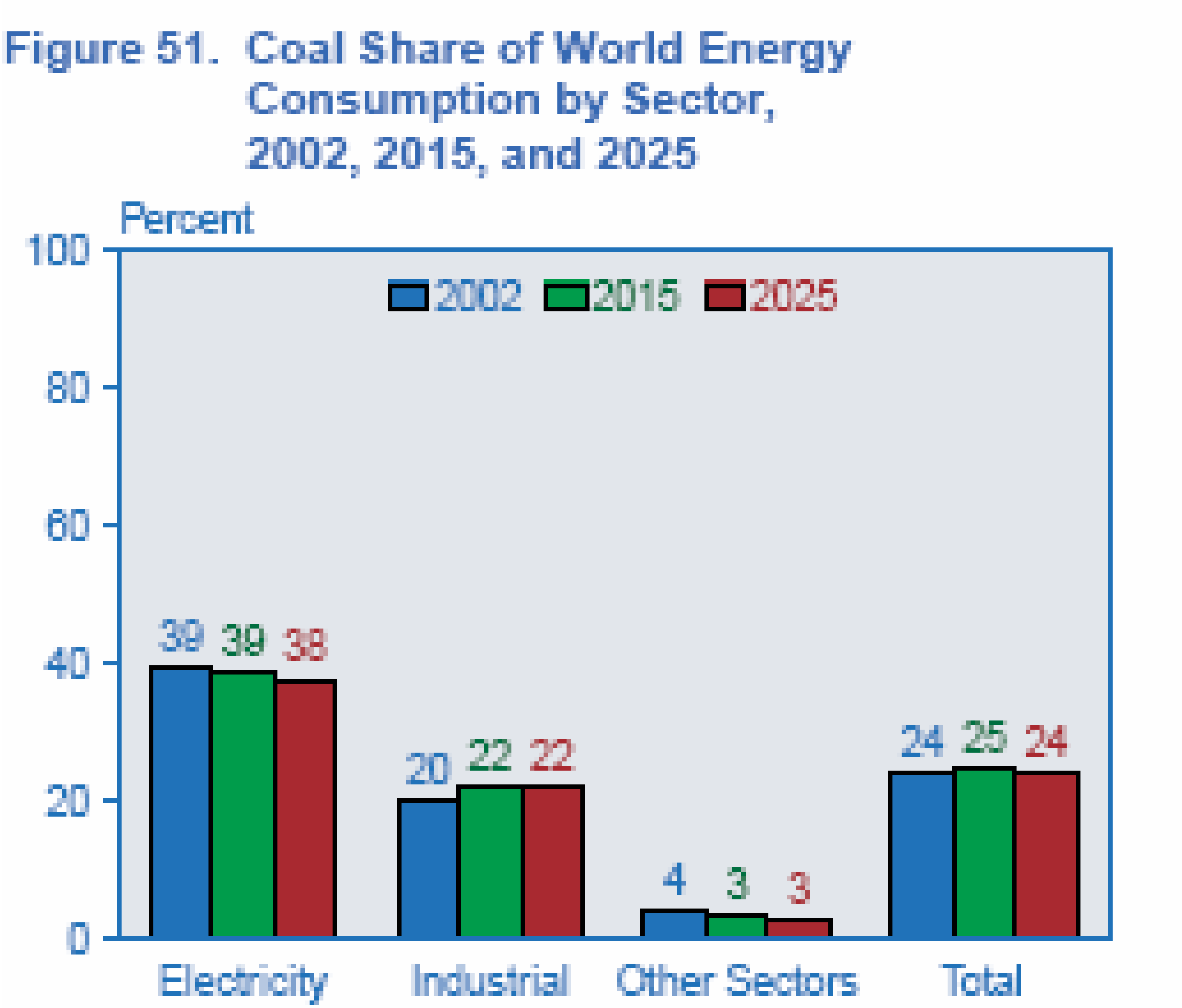
PROVEN NATURAL GAS RESERVES



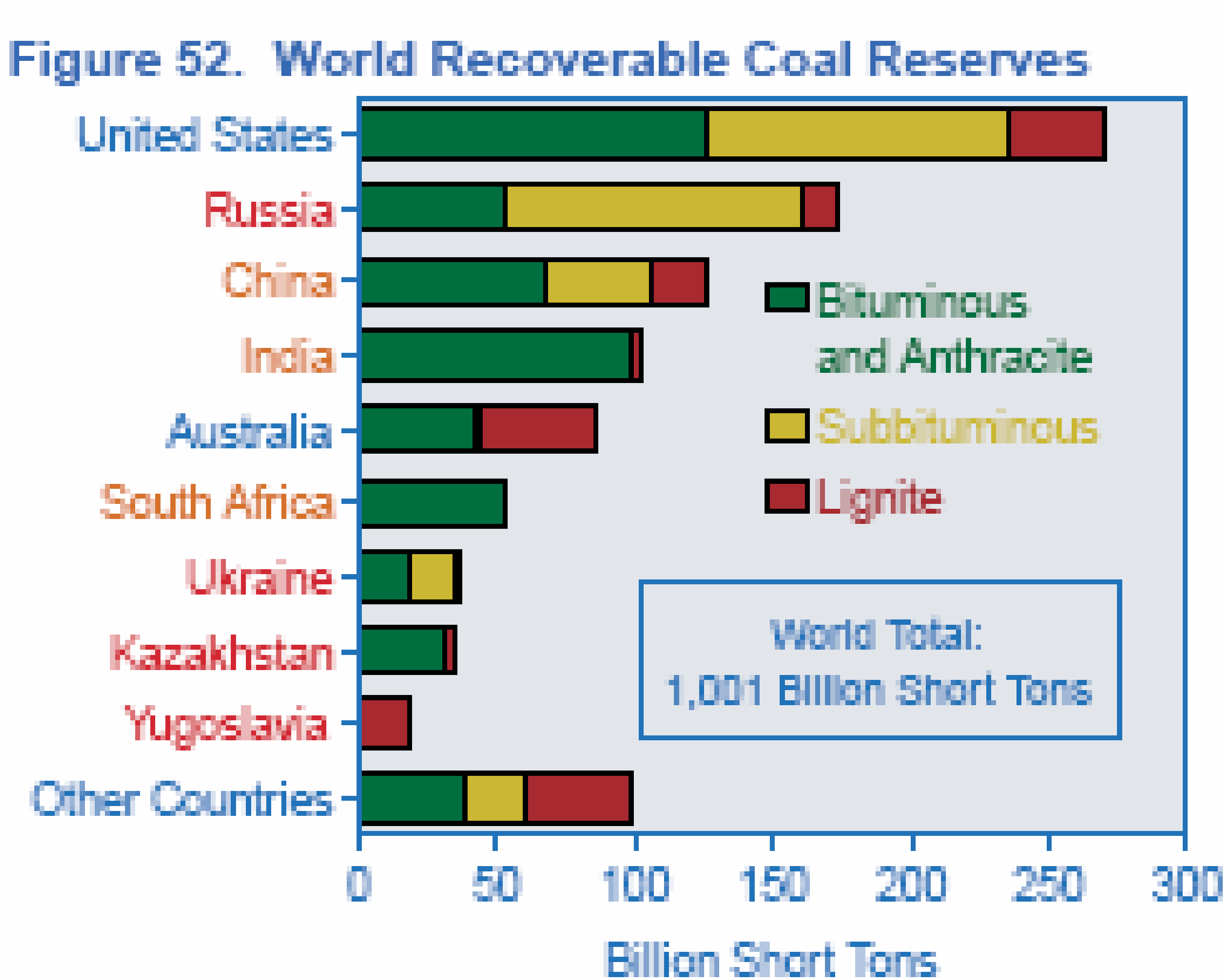
Source: IEA (presentation graphic 2006)



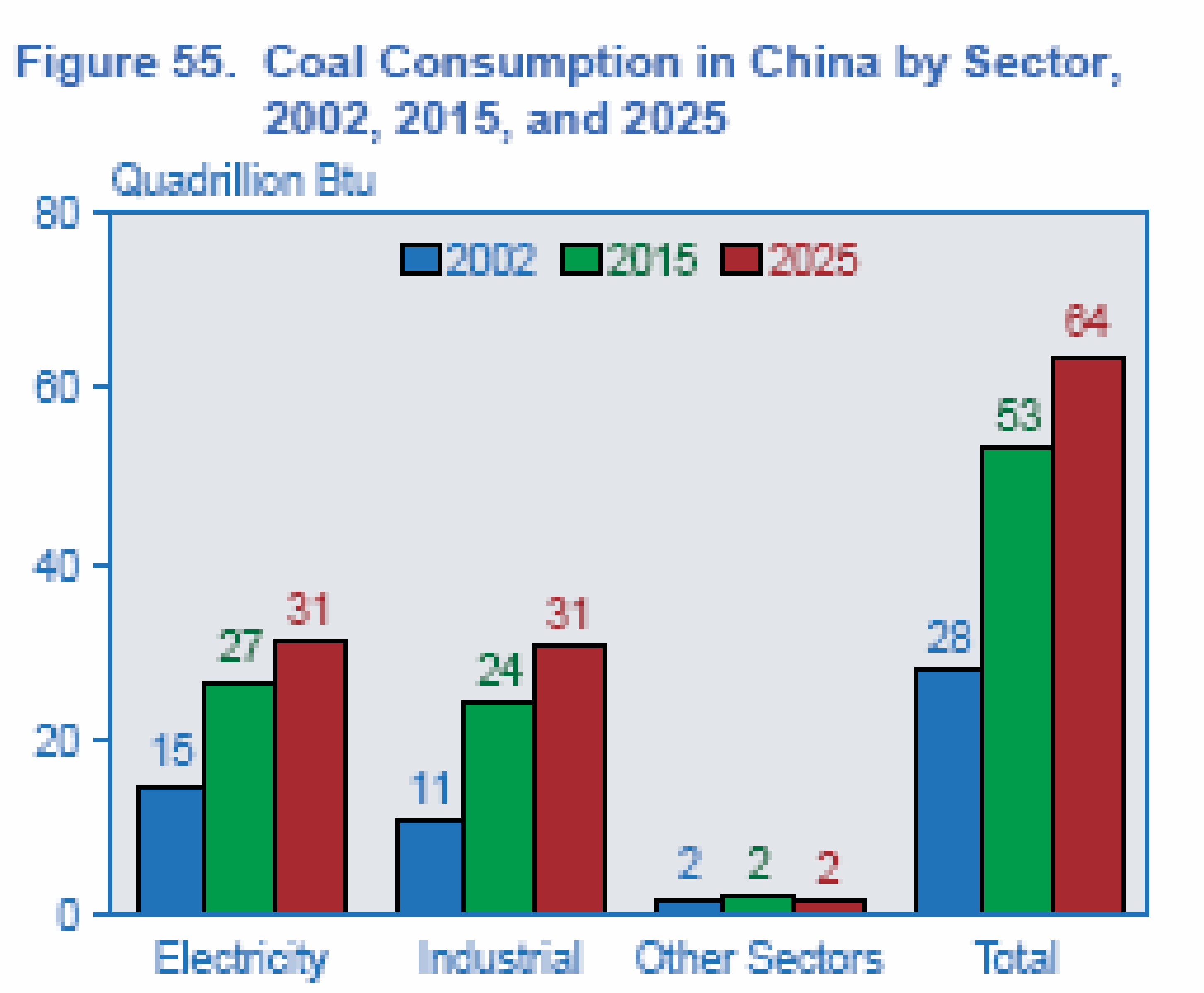
Source: EIA IEO (2005)



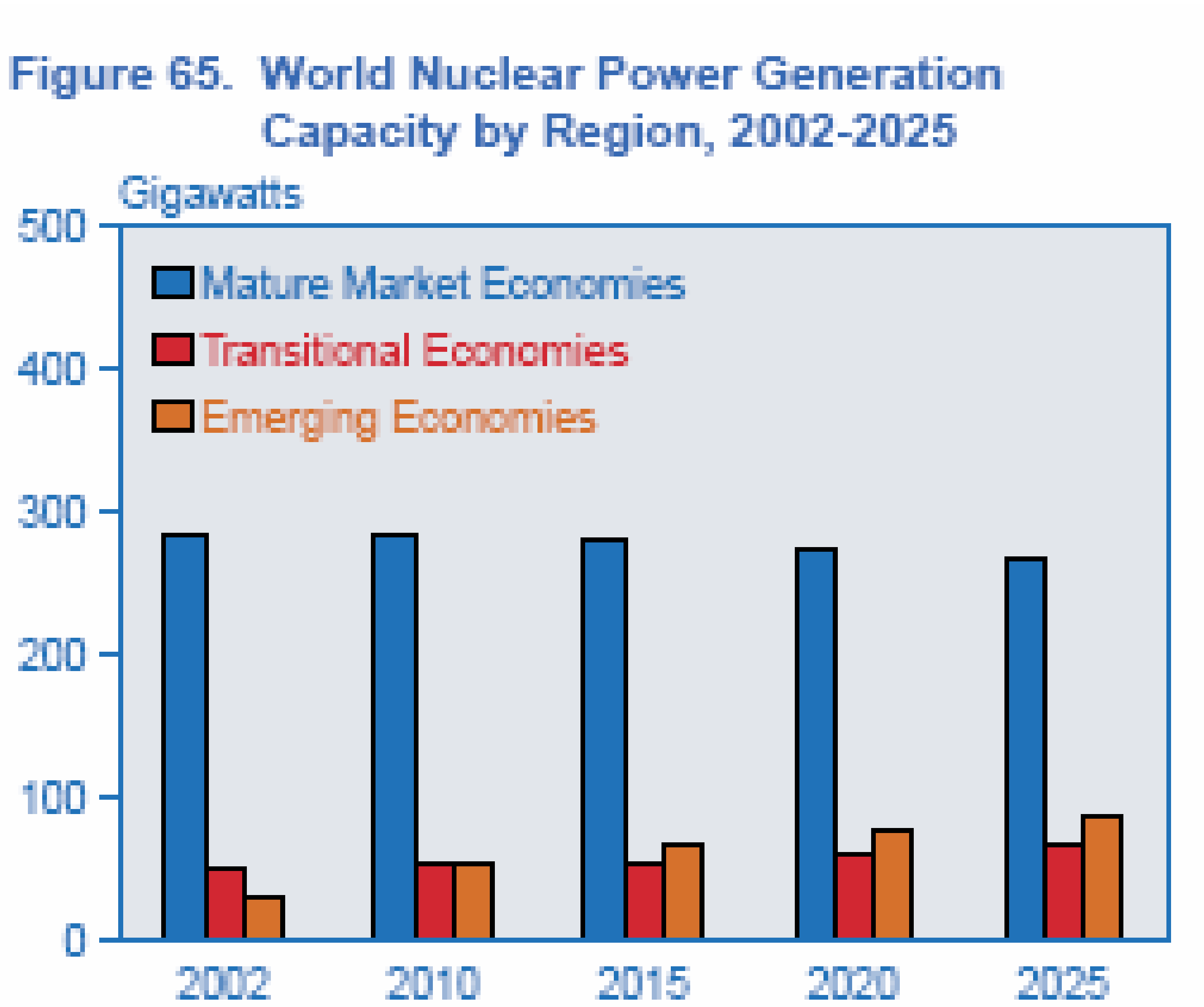
Source: EIA IEO (2005)



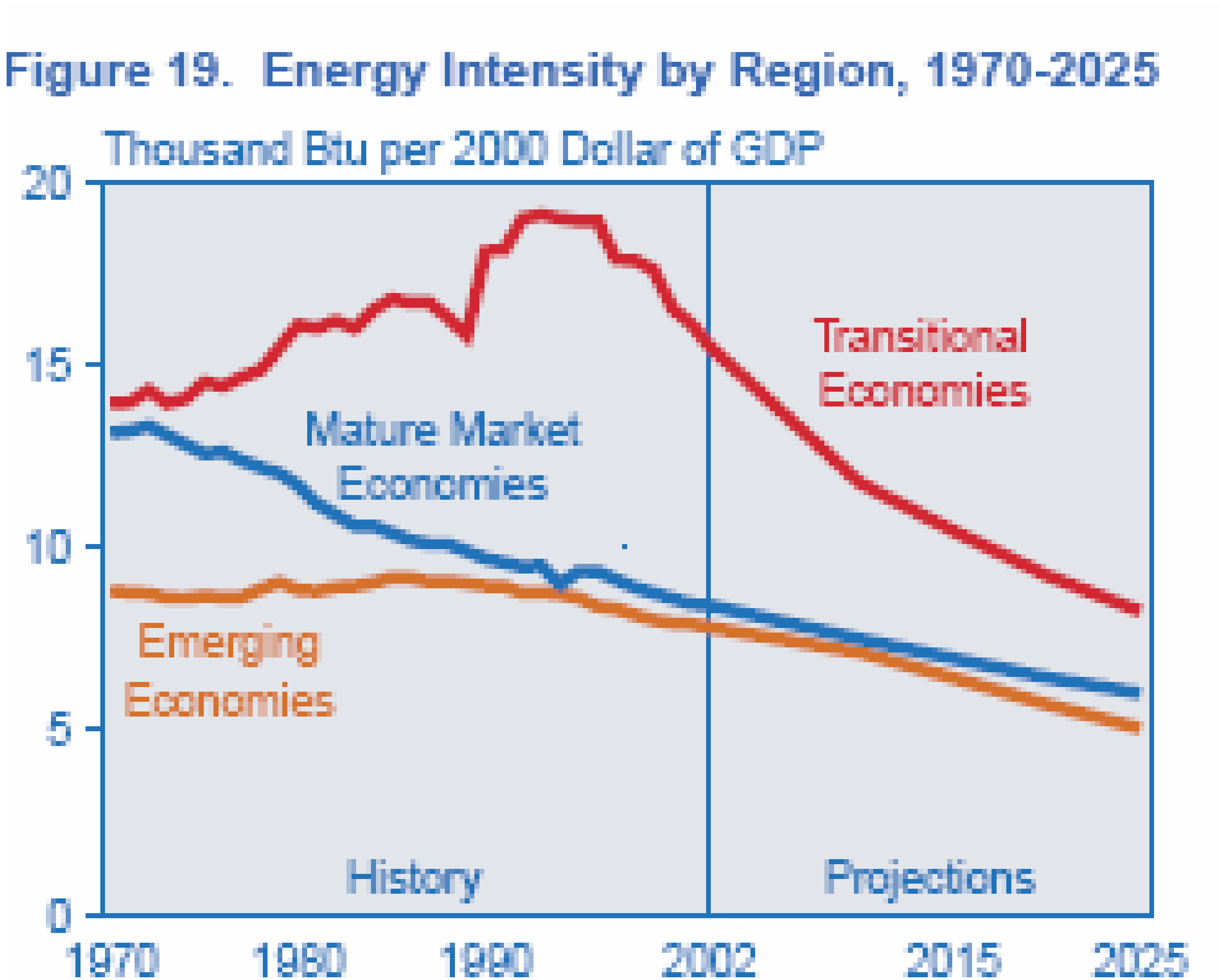
Source: EIA IEO (2005)



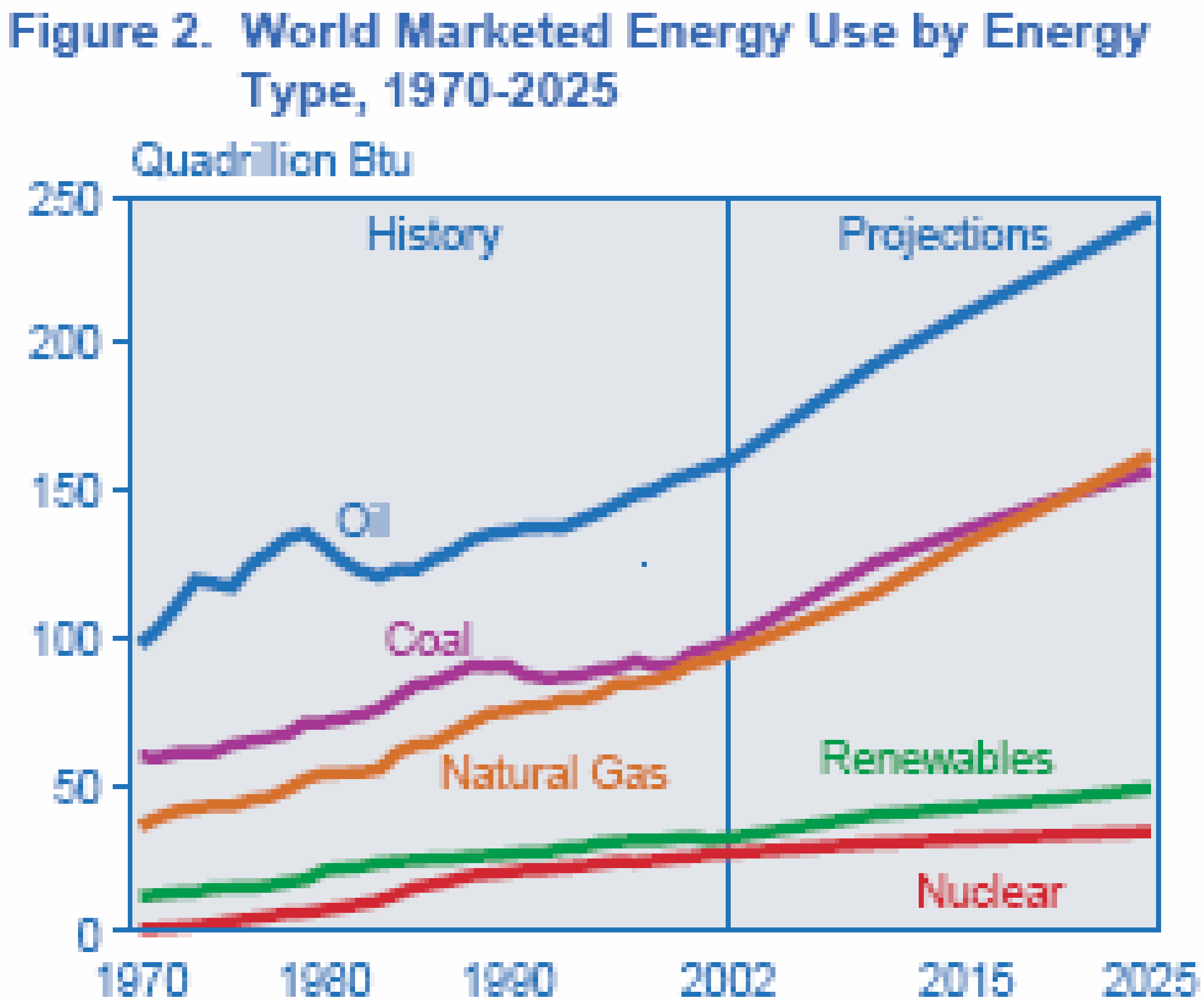
Source: EIA IEO (2005)



Source: EIA IEO (2005)

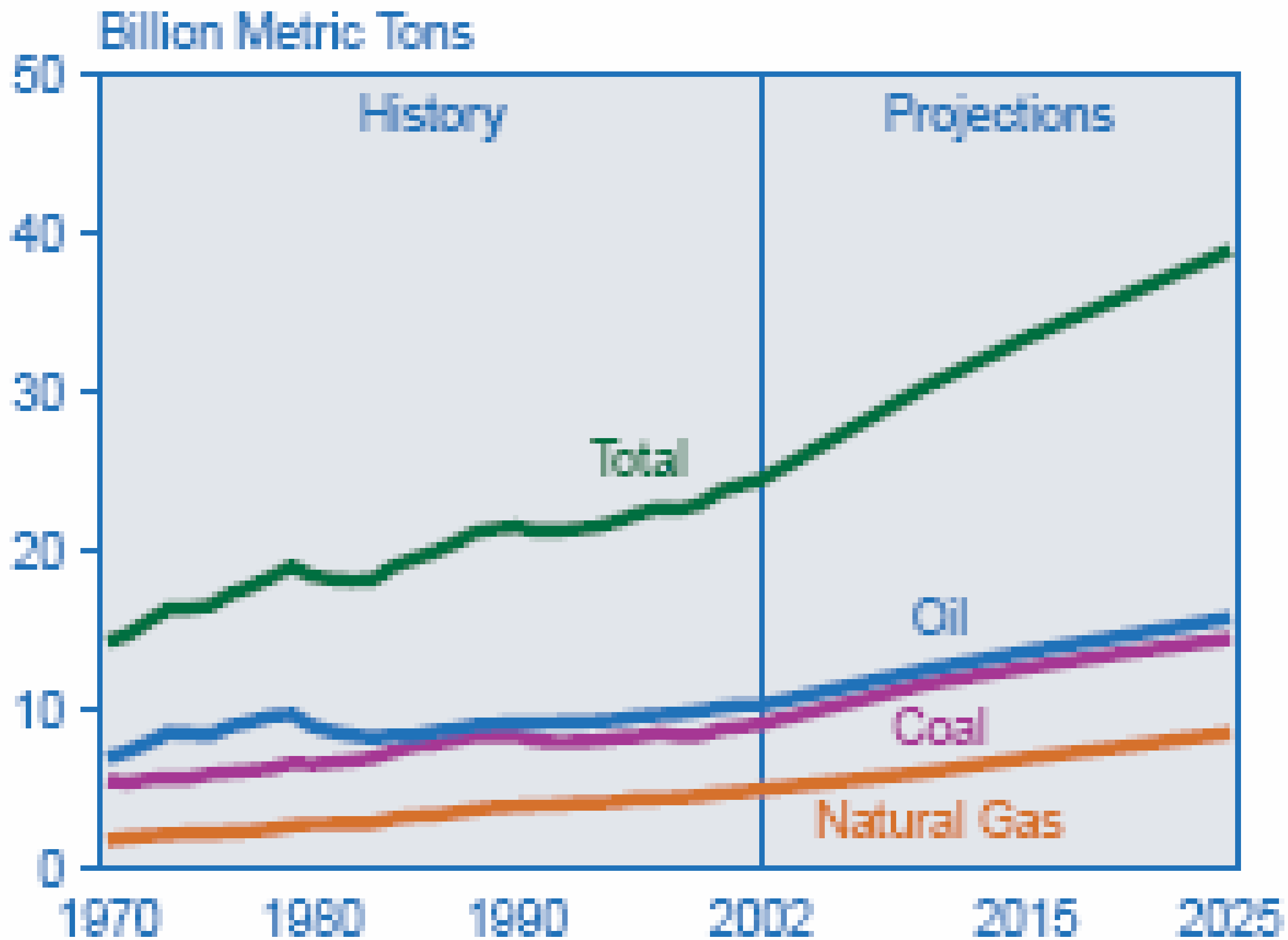


Source: EIA IEO (2005)

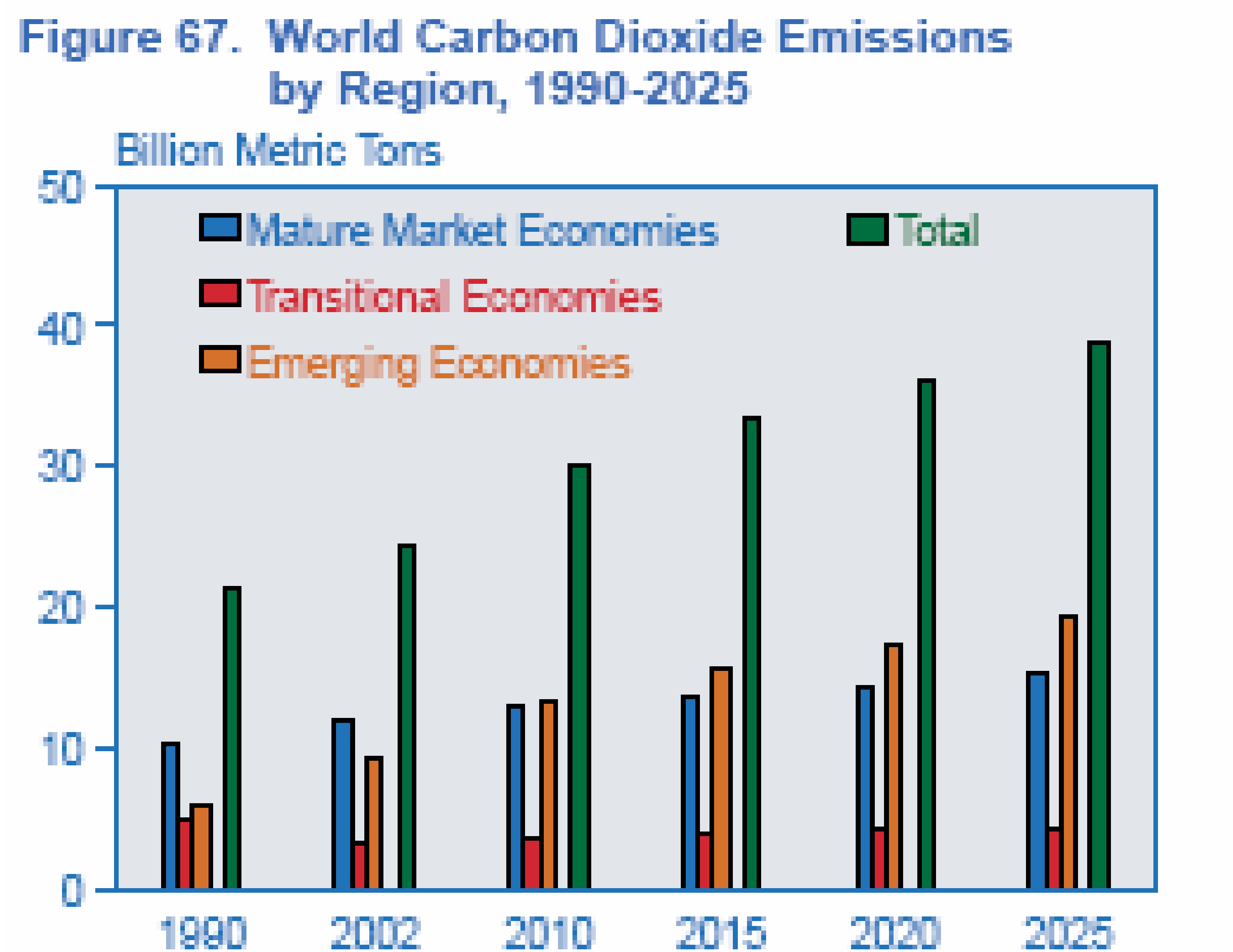


Source: EIA IEO (2005)

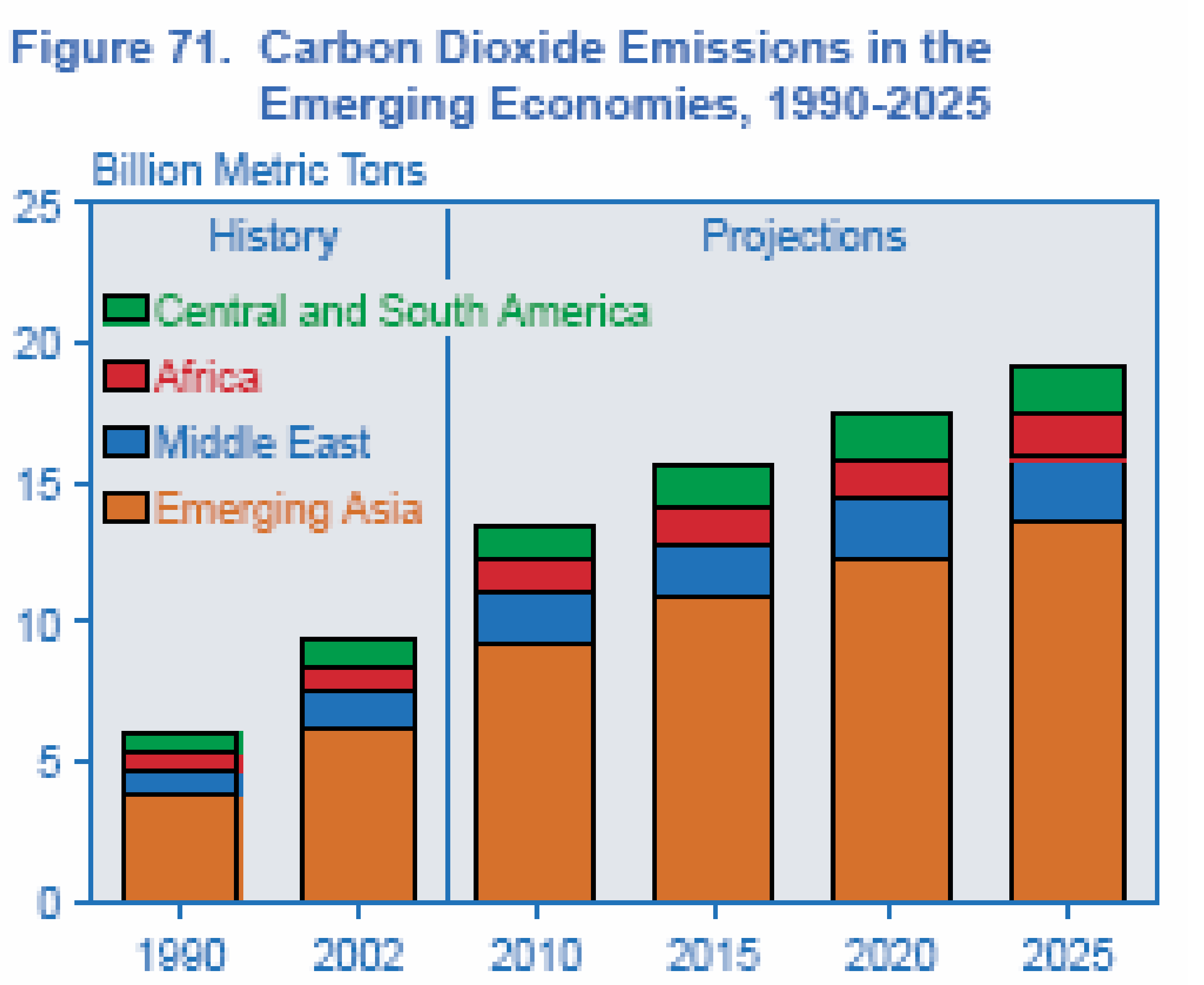
Figure 68. World Carbon Dioxide Emissions by Fuel Type, 1970-2025



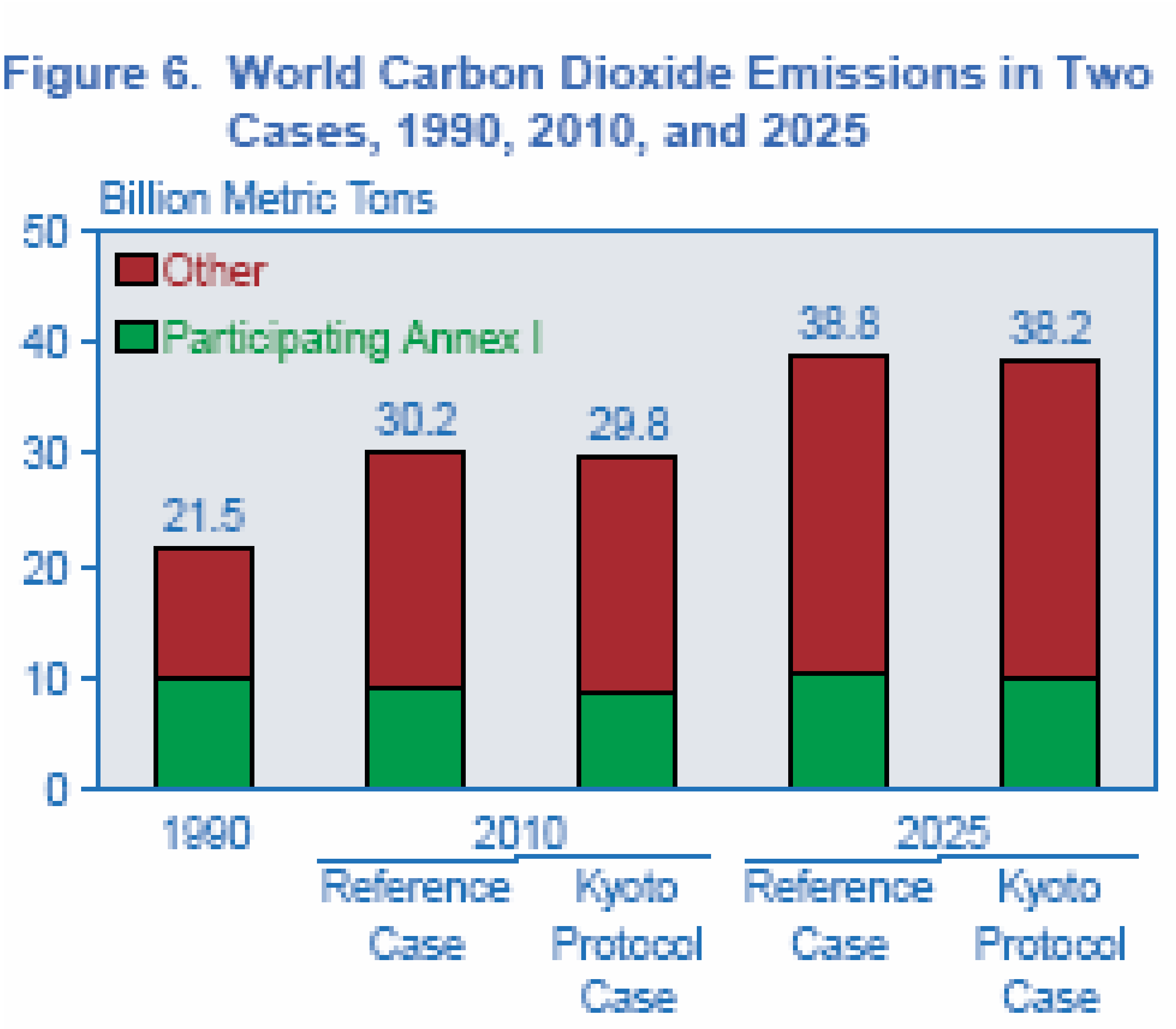
Source: EIA IEO (2005)



Source: EIA IEO (2005)



Source: EIA IEO (2005)



Source: EIA IEO (2005)

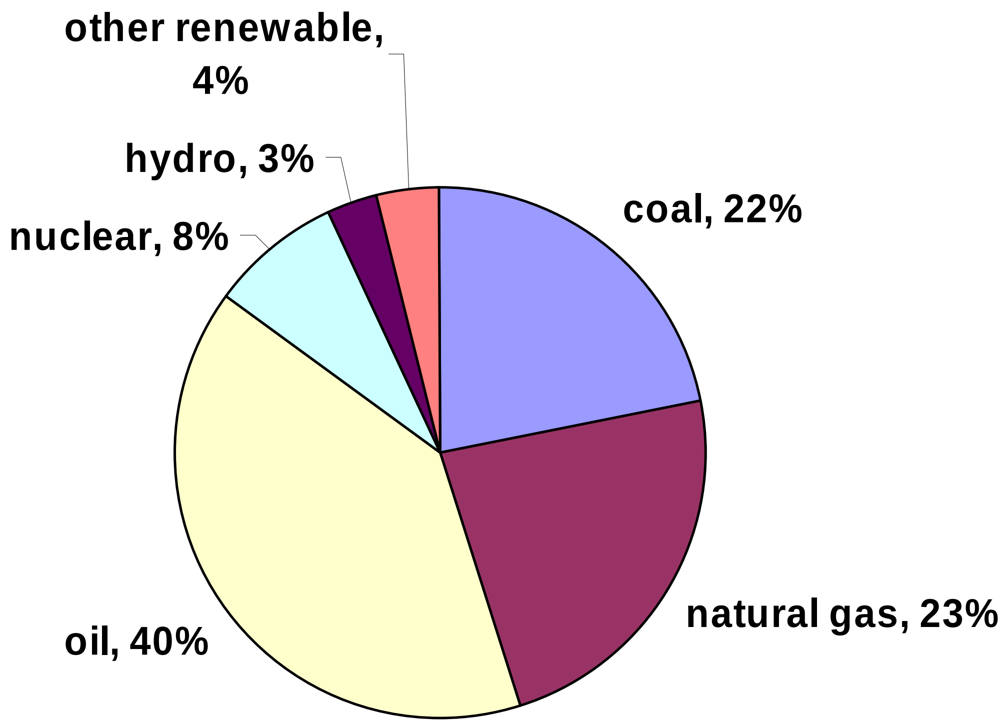
OBSERVATIONS

- Energy trade in oil and gas grows rapidly under BAU with increased exports from ME, NA and FSU
- Emerging economies, especially China and India make a significant contribution to global energy growth
- Coal consumption continues to grow rapidly in the U.S. and China.
- Global CO_2 emissions grow rapidly even with current Kyoto targets, with emerging economies accounting for a large fraction of this growth
- Nuclear supplies grow very slowly and after 2035 begin to decline rapidly as plants are retired
- Renewable energy grows relatively quickly but makes a relatively small contribution over the next 25 years
- Energy intensity declines but rising incomes and population result in growing demand
- From an energy security (broadly defined) and CO_2 emissions perspective this is not a pretty picture

THE U.S. IS A BIG PIECE OF THE GLOBAL ENERGY PICTURE

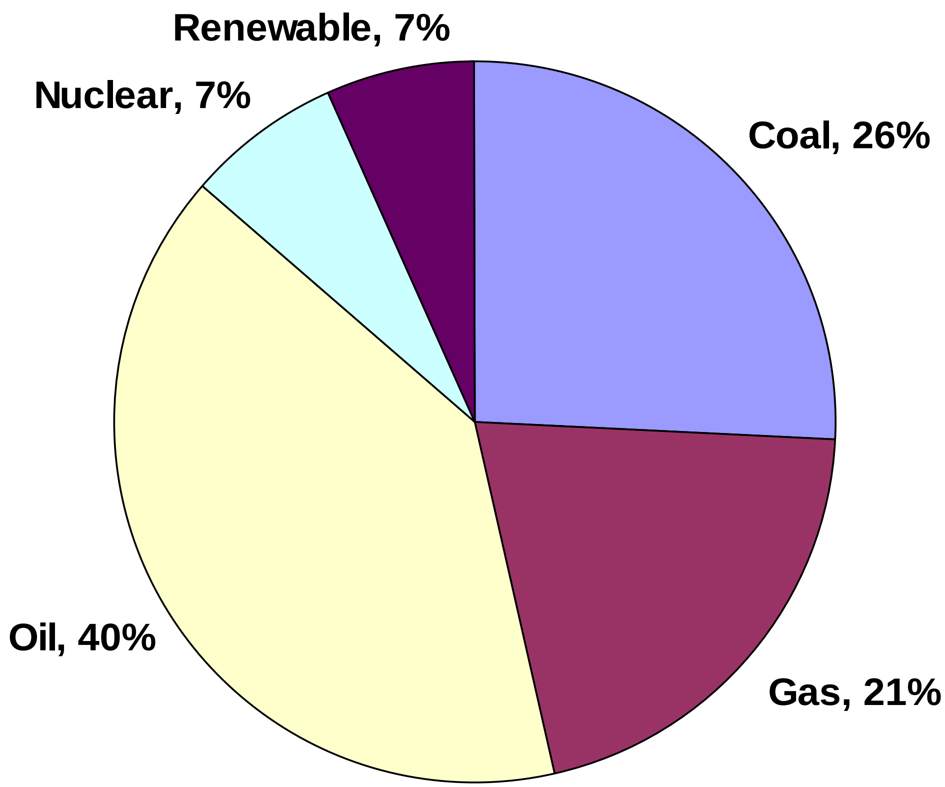
- The U.S. accounts for 23% of world energy consumption
- The U.S. accounts for 17% of world energy production
- The U.S. accounts for 20% of world oil consumption
- The U.S. accounts for 2% of world oil reserves
- The U.S. imports over 50% of its oil supplies
- The U.S. accounts for 23% of world natural gas consumption
- The U.S. accounts for 3% of world natural gas reserves
- The U.S. accounts for 20% of world coal consumption
- The U.S. accounts for 27% of world coal reserves
- The U.S. accounts for 25% of world electricity production of which 50% is coal
- The U.S. accounts for 30% of world nuclear generation
- The U.S. accounts for 24% of world CO_2 production

U.S. Energy Consumption 2004 (%)



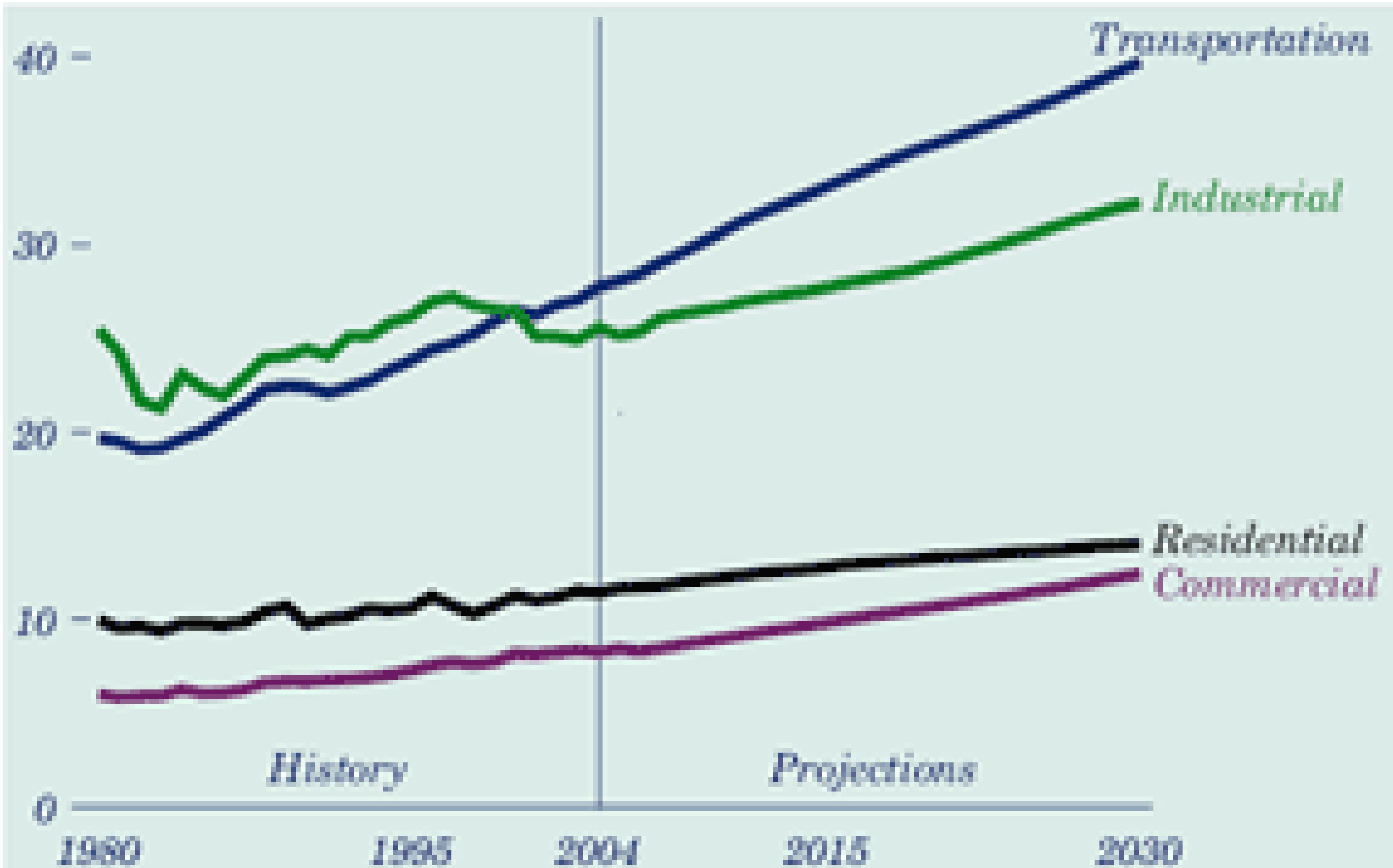
Source: EIA

Projected U.S. Energy Consumption 2030



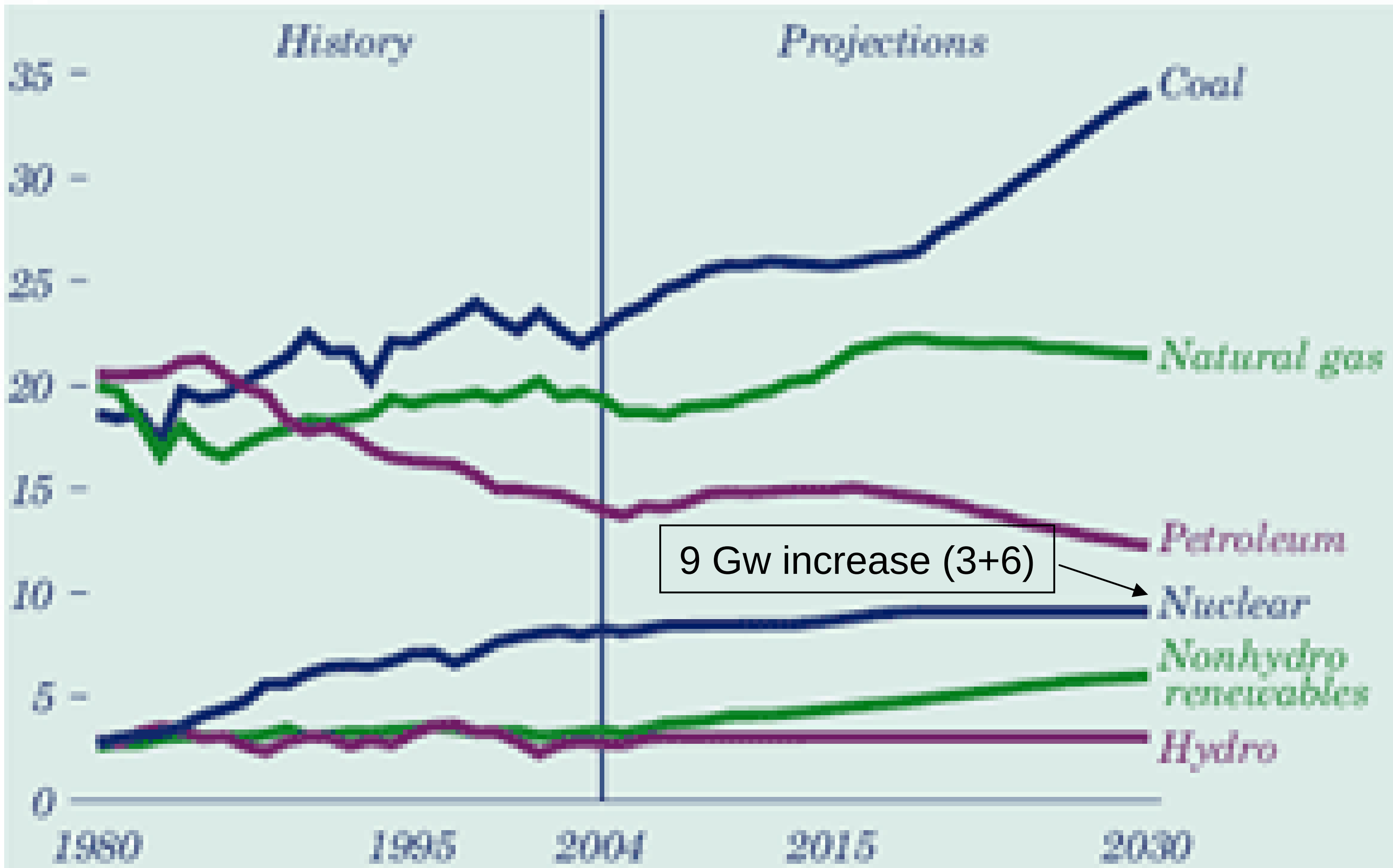
Source: EIA AEO (2006)

Figure 2. Delivered energy consumption by sector, 1980-2030 (quadrillion Btu)



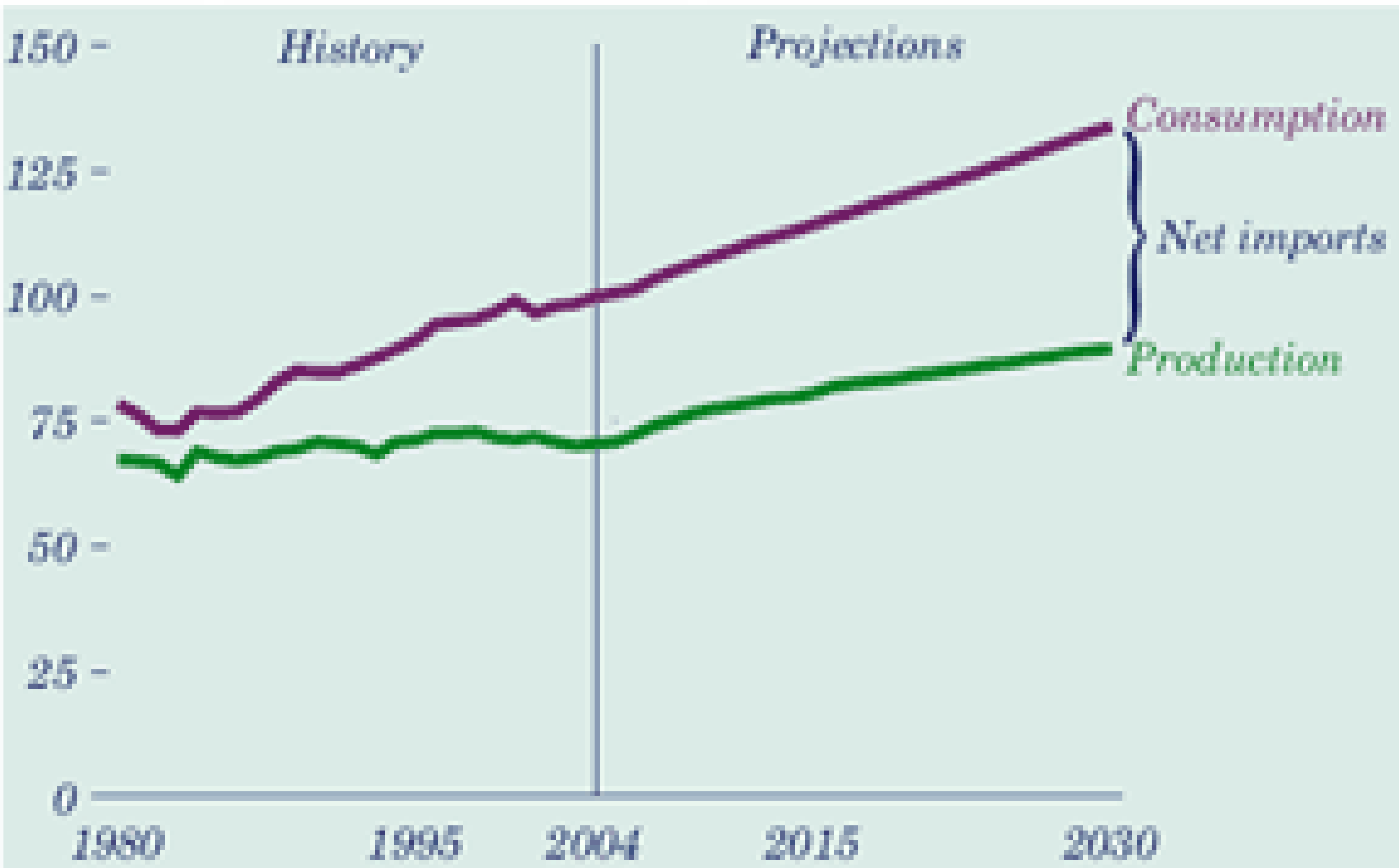
Source: AEO (2006)

Figure 7. Energy production by fuel, 1980-2030 (quadrillion Btu)



Source: AE0 (2006)

Figure 6. Total energy production and consumption, 1980-2030 (quadrillion Btu)



Source: AEO (2006)

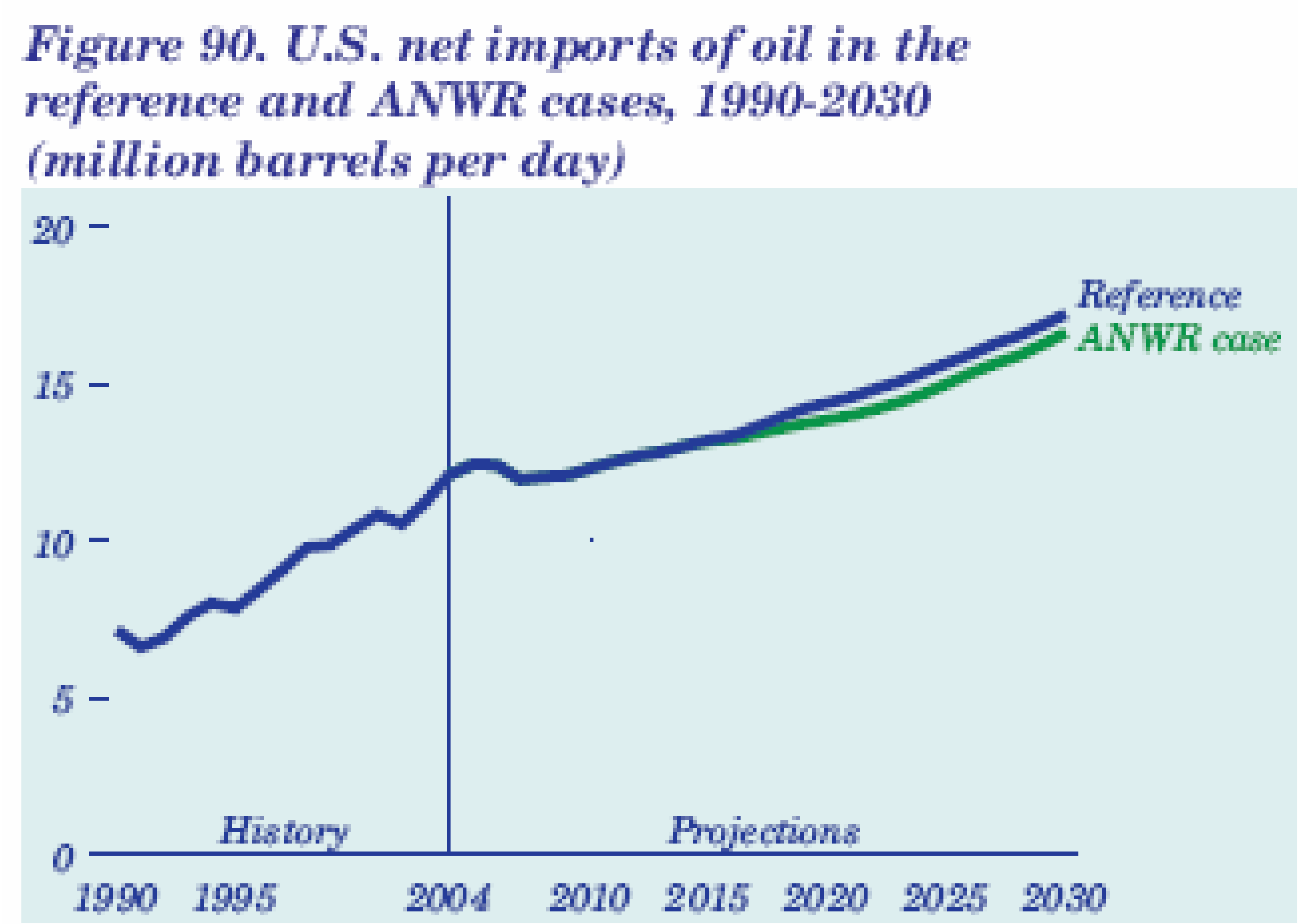
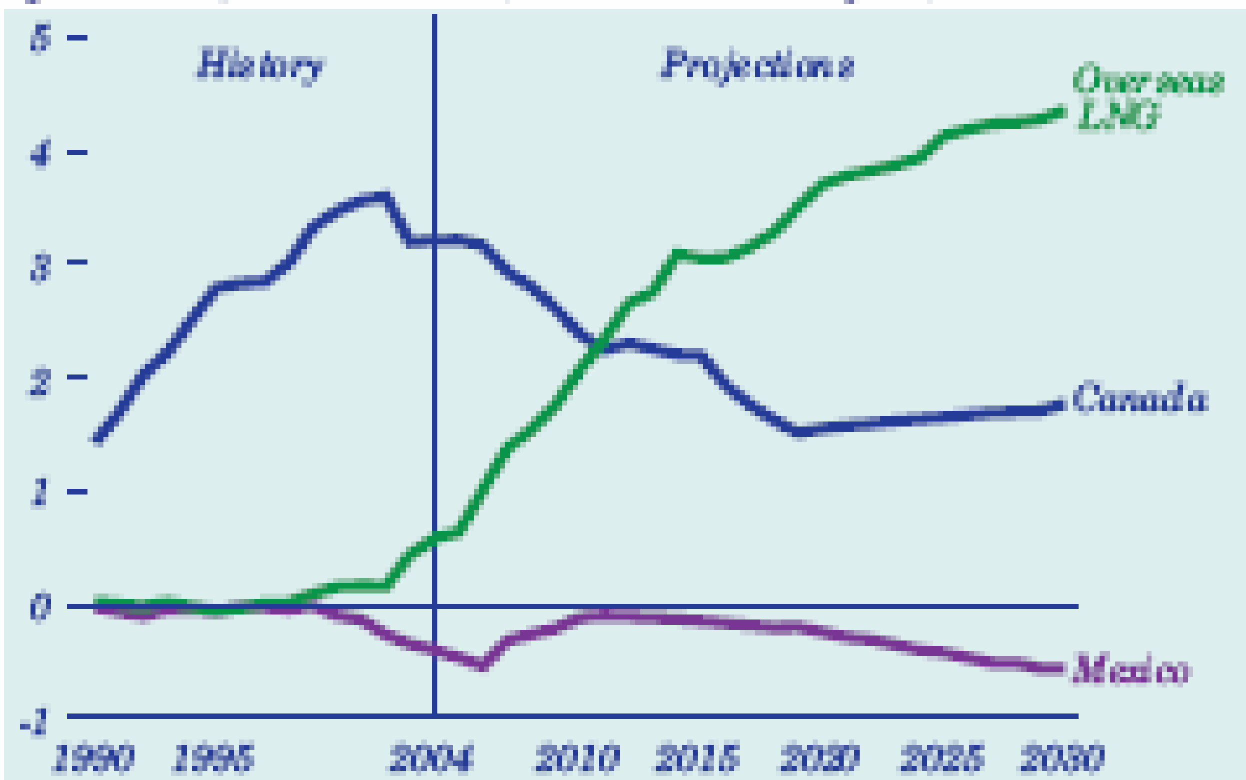


Figure 90. U.S. net imports of oil in the reference and ANWR cases, 1990-2030 (million barrels per day)
20
15
10
5
0
Reference
ANWR case
History
Projections
1990
1995
2004
2010
2015
2020
2025
2030

EIA AEO (2006)

Net Imports of Natural Gas Grow in the Projections

Figure 74. Net U.S. imports of natural gas by source, 1990-2030 (trillion cubic feet)



Source: EIA IEO (2006)

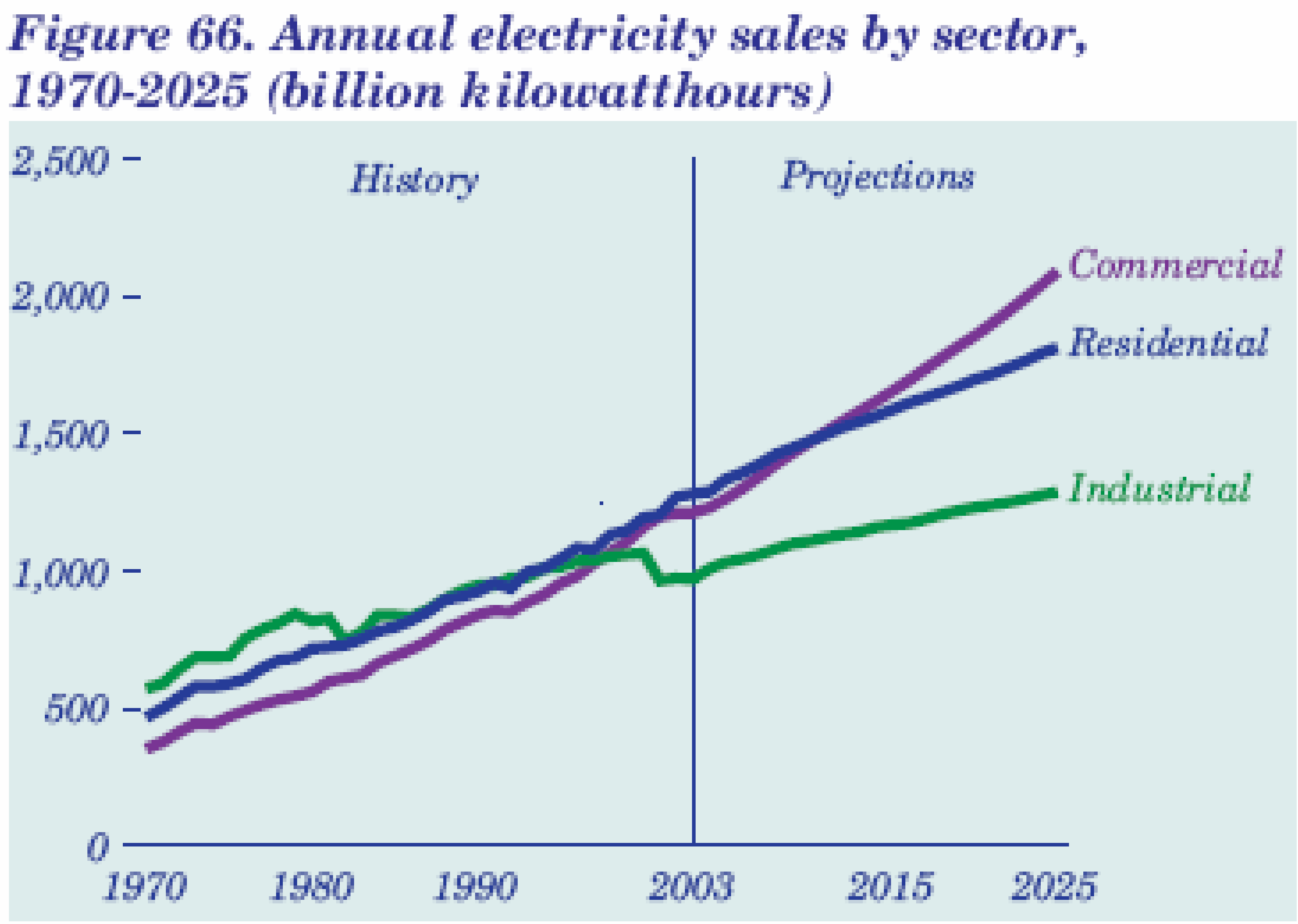
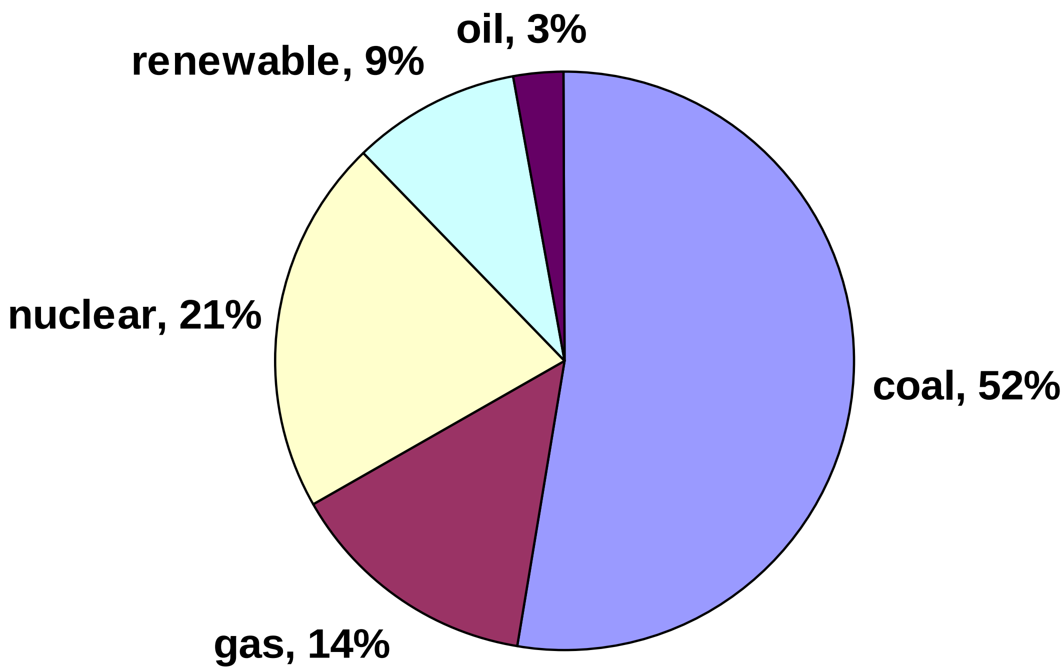


Figure 66. Annual electricity sales by sector, 1970-2025 (billion kilowatthours)
2,500
2,000
1,500
1,000
500
0
History
Projections
Commercial
Residential
Industrial
1970
1980
1990
2003
2015
2025

EIA (2005)

U.S. Electricity Generation 2004



Source: EIA

Forecast Electricity Generation 2030

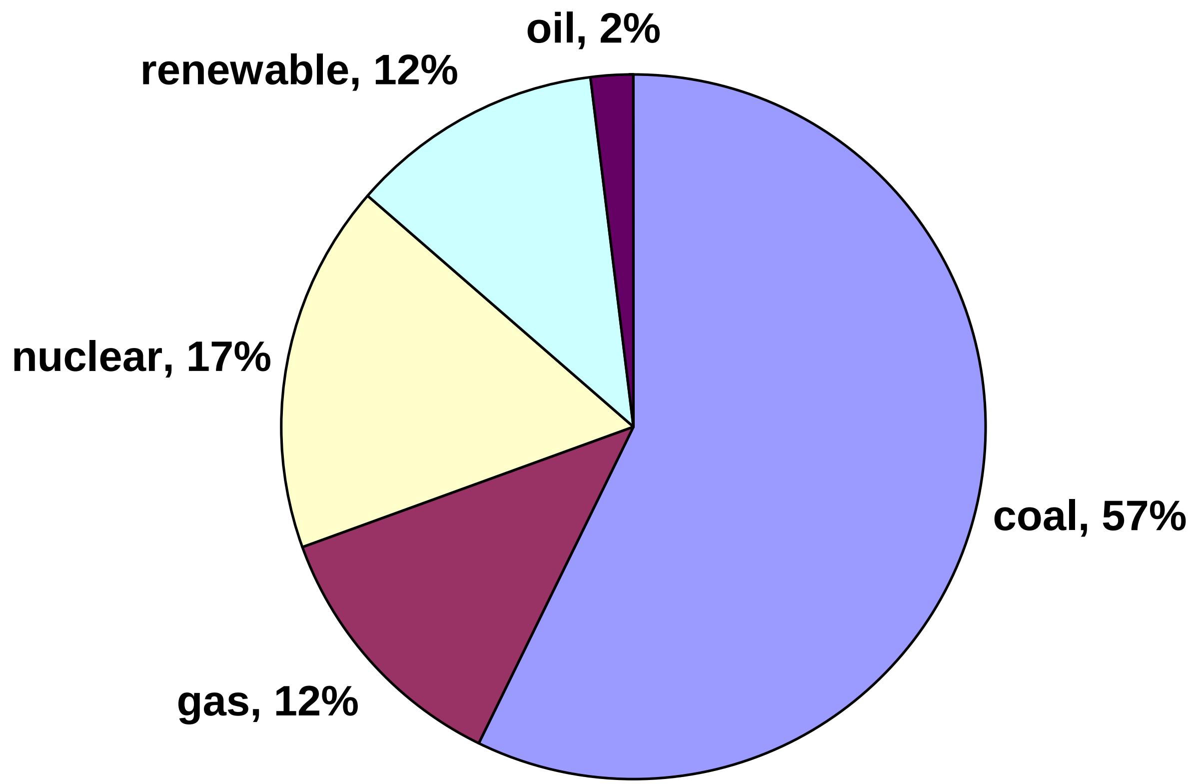
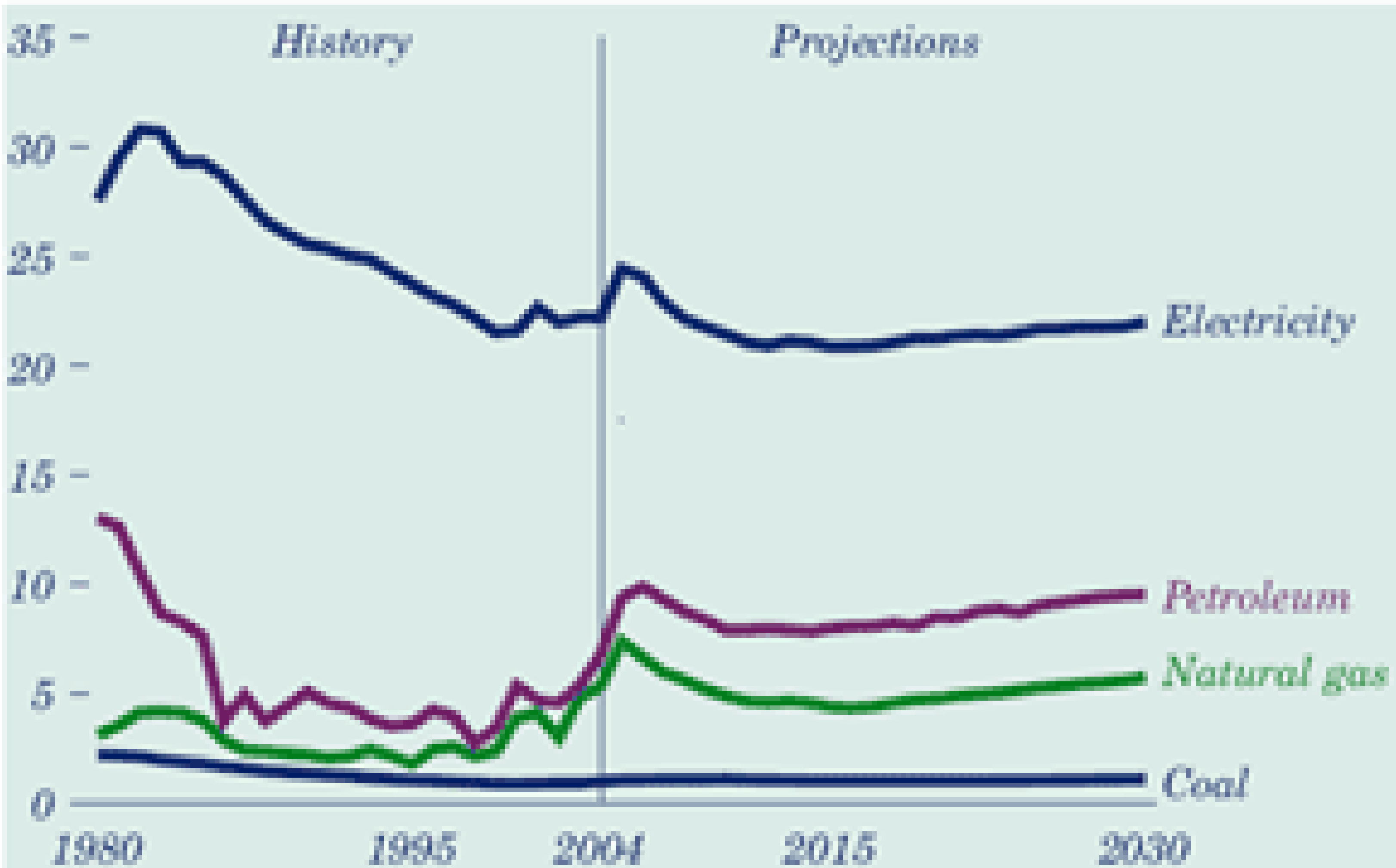
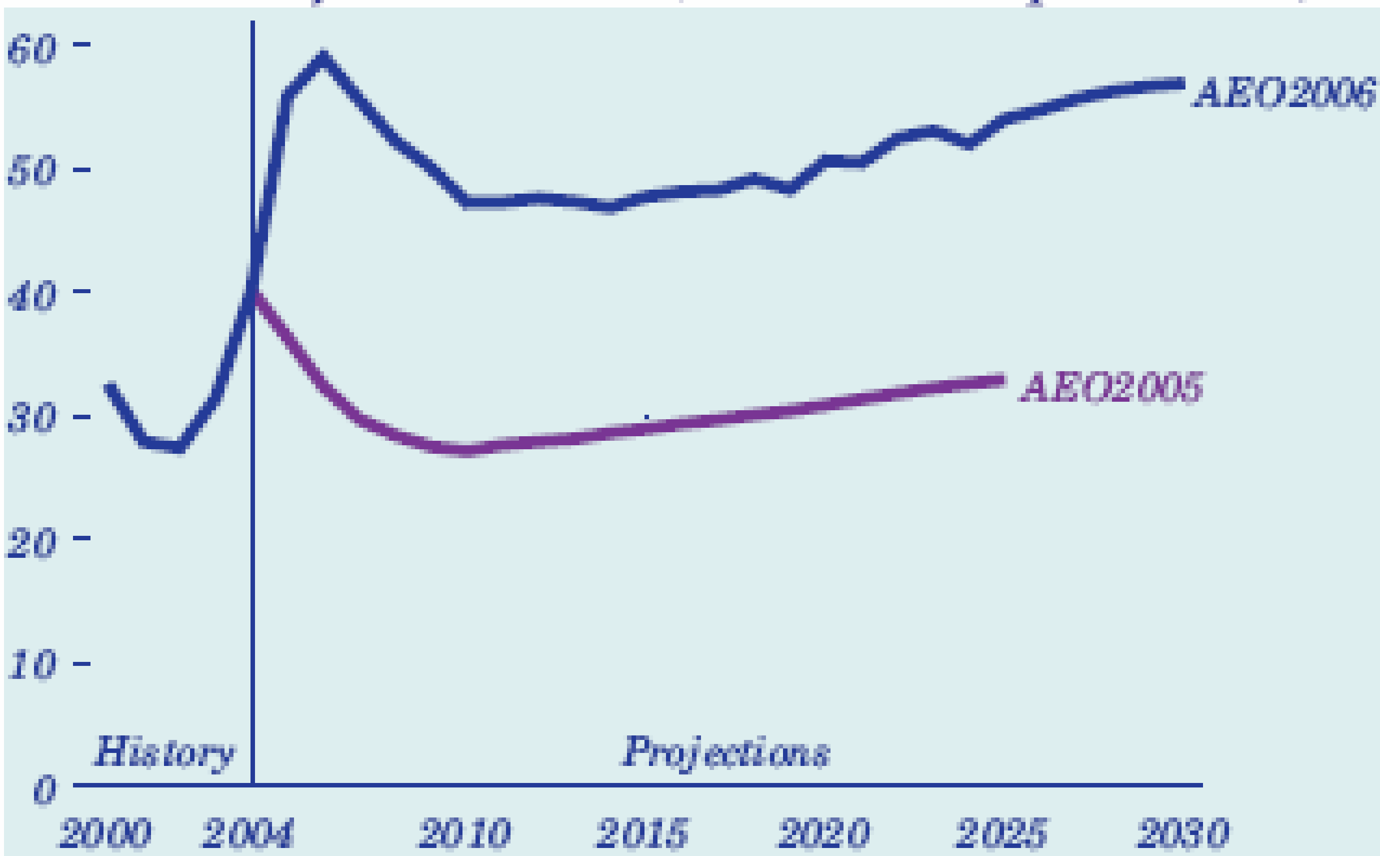


Figure 1. Energy prices, 1980-2030 (2004 dollars per million Btu)



Source: AEO (2006)

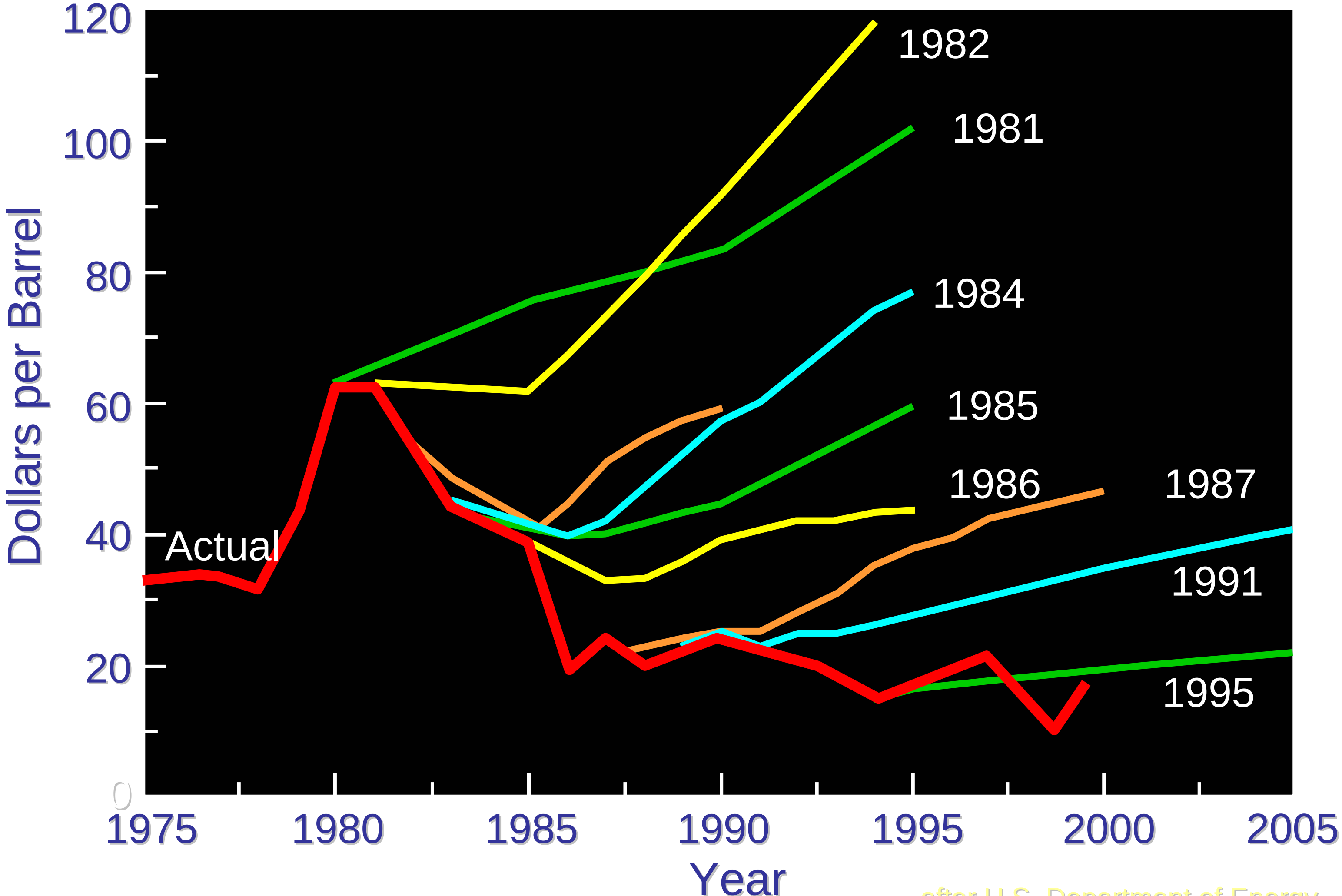
Figure 10. World oil prices in the AEO2005 and AEO2006 reference cases (2004 dollars per barrel)



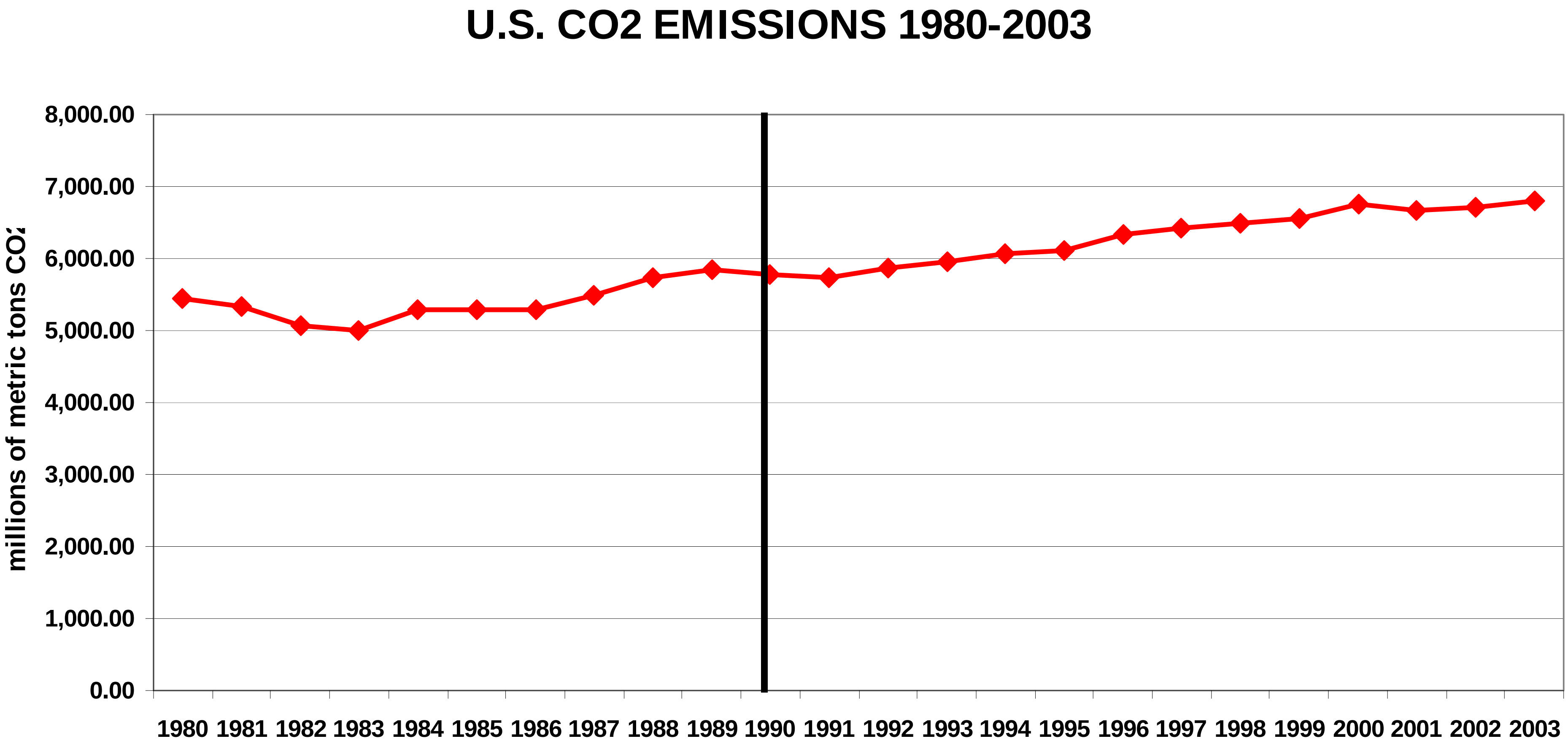
EIA AEO (2006)

DOE Oil Price Forecasts

Linear Trends Predicted Beginning From the Actual Price of Year Listed

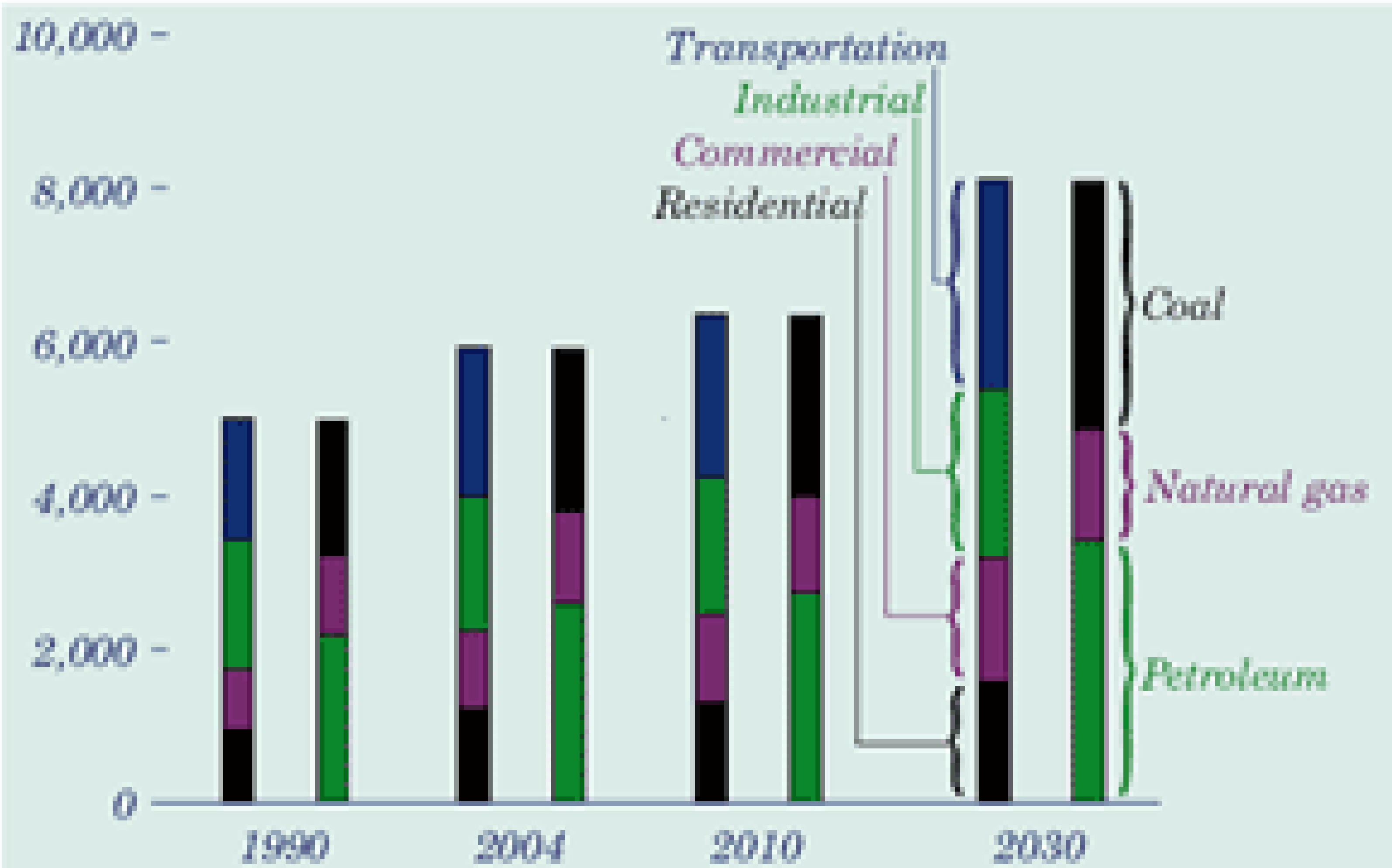


after U.S. Department of Energy, 1998



Source: U.S. EIA

Figure 8. Projected U.S. carbon dioxide emissions by sector and fuel, 1990-2030 (million metric tons)



Source: AEO (2006)

OBSERVATIONS

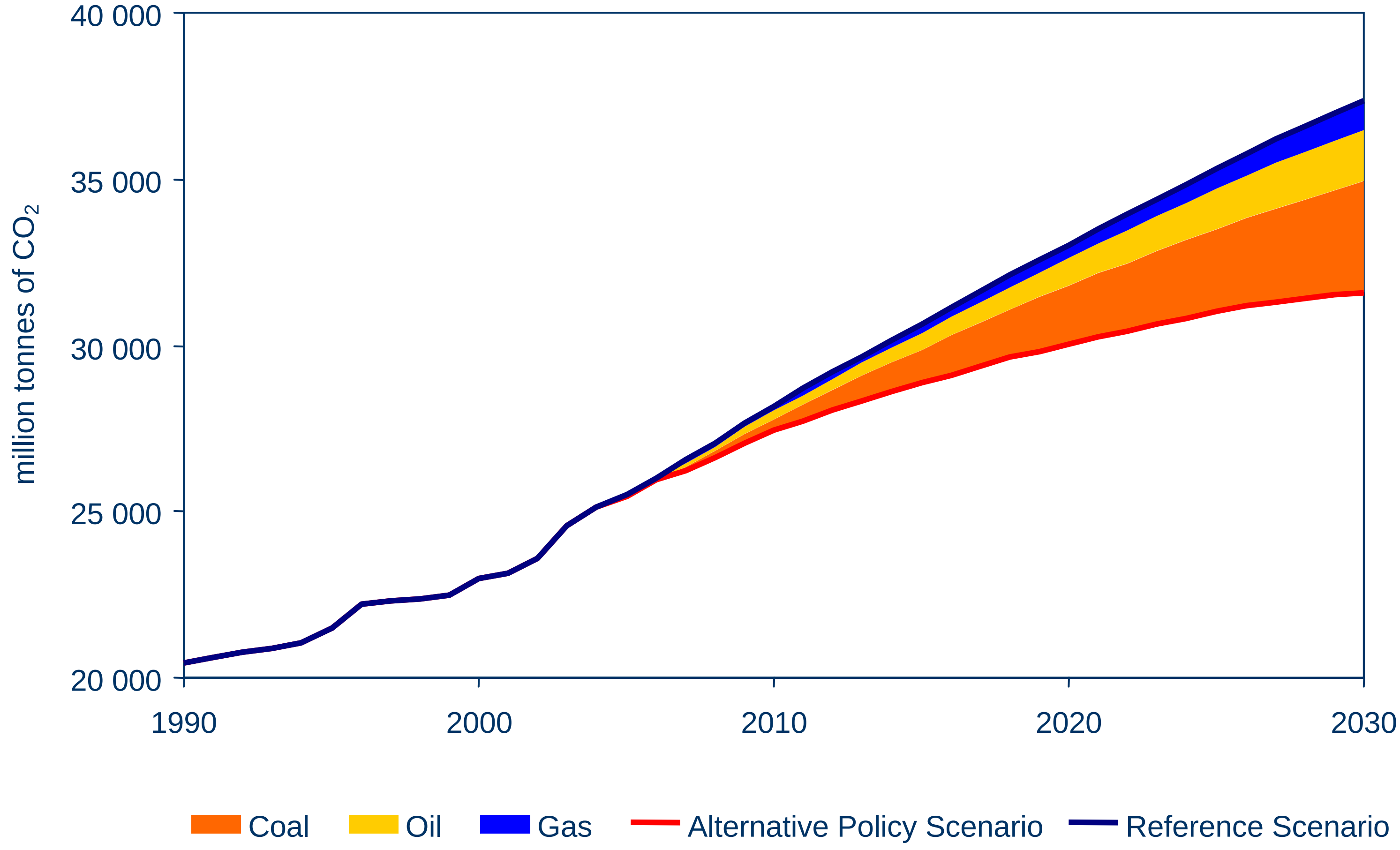
- The U.S. continues to be a very large player in global energy markets
- Imports of oil and LNG will continue to grow
- The U.S. will rely more on coal for generating electricity
- Modest opportunities exist to increase domestic production of oil and gas from forecast levels (offshore, unconventional, Alaska, Canada (tar sands)) with changes in government policies
- U.S. CO_2 emissions continue to increase significantly
- The U.S. must be part of the solution to global energy security and CO_2 emissions problems

RESPONDING TO ENERGY SECURITY AND CO2 CONCERNS

WHAT TO DO?

- Many strategies for responding to energy security concerns are also consistent with reducing CO2 emissions
  - Fundamental changes in energy demand and supply occur slowly
  - Continue efforts to remove barriers and speed diffusion of <u>economical</u> energy efficiency technologies
  - Continue efforts to develop <u>economical</u> renewable energy technologies
  - Continue efforts to expand investment in safe and economical nuclear generation
  - Expand efforts to develop safe and economical carbon capture and sequestration technologies
  - Bring the U.S., China, India and other emerging economies into a long term global CO2 control regime
  - Place a significant price on CO2 emissions
    - A high price (~$30/tonne CO_2 rising to $150 in 2050) will be required for stabilization by 2050
    - It must apply (effectively) globally, especially to U.S. and China

IEA ALTERNATIVE CASE 2005



In 2030, CO_2 emissions are 16% lower than in the Reference Scenario, but are still more than 50% higher than 1990

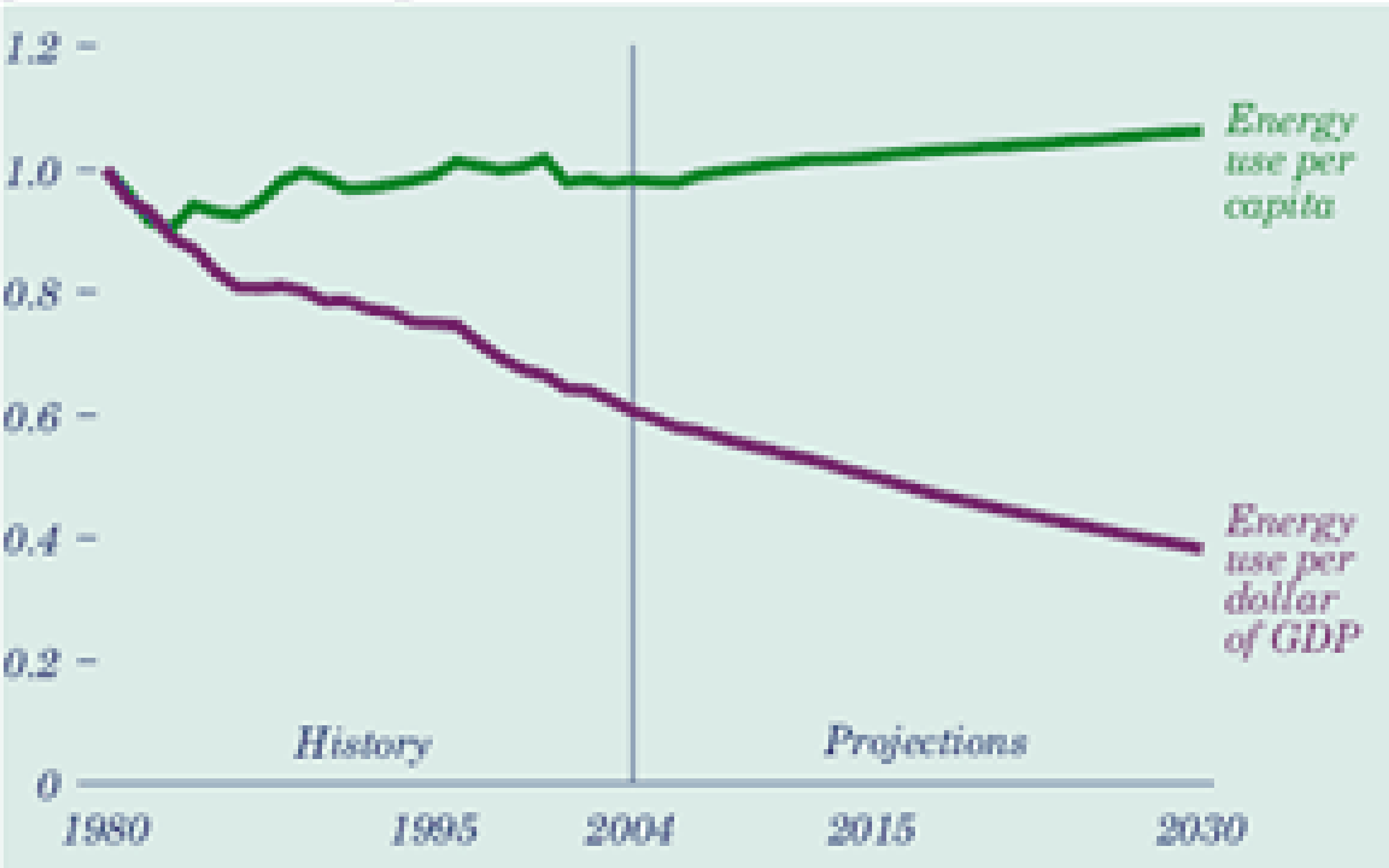
WHAT TO DO?

- Energy security concerns require additional initiatives
  - The world will become increasing dependant on global trade in oil and gas for at least the next 25 years
  - Must adapt to this reality as we try to shift (slowly) to more “radical” alternative energy technologies by the end of the century
  - Diplomatic efforts to reduce tensions in the Middle East and North Africa and mechanisms to protect key infrastructure are important
  - Curb political competition for special “access” to oil and gas resources
  - Promote supply diversity to the extent feasible
  - Allow markets to allocate scarce supplies during emergencies
  - International cooperation through the IEA to respond (carefully) to major supply shocks with strategic storage agreements

CURRENT U.S. POLICIES

- Energy efficiency (homes,businesses, vehicles, etc.)
- Renewable energy focused on
  - electricity production (wind, geothermal, biomass)
  - substitutes for gasoline (hybrid vehicles, ethanol)
- Nuclear Power
  - Life extensions
  - New investment
  - Waste disposal
- Carbon capture and sequestration
- Significant changes in supply/demand profiles take a long time

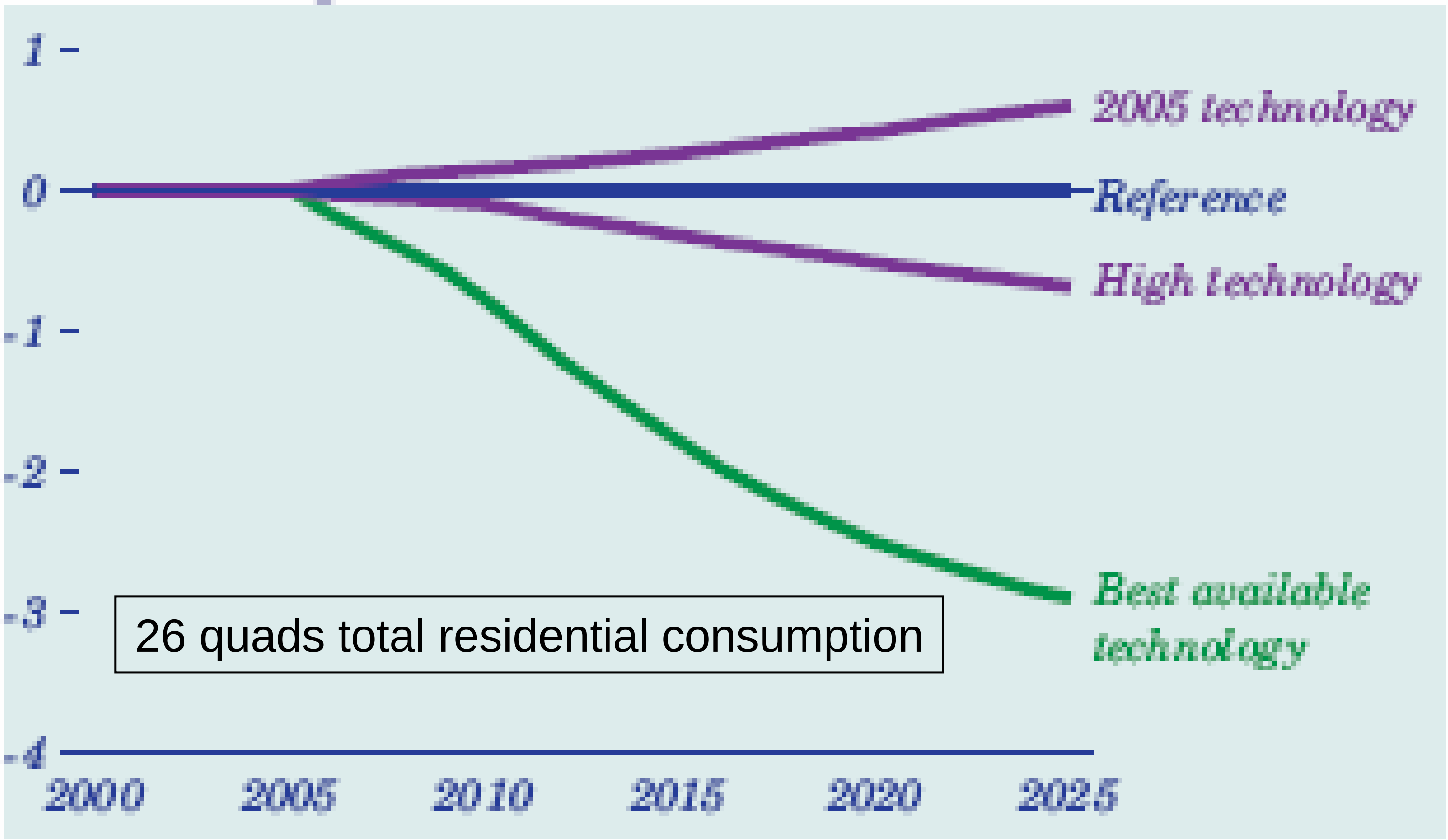
Figure 4. Energy use per capita and per dollar of gross domestic product, 1980-2030 (index, 1980 = 1)



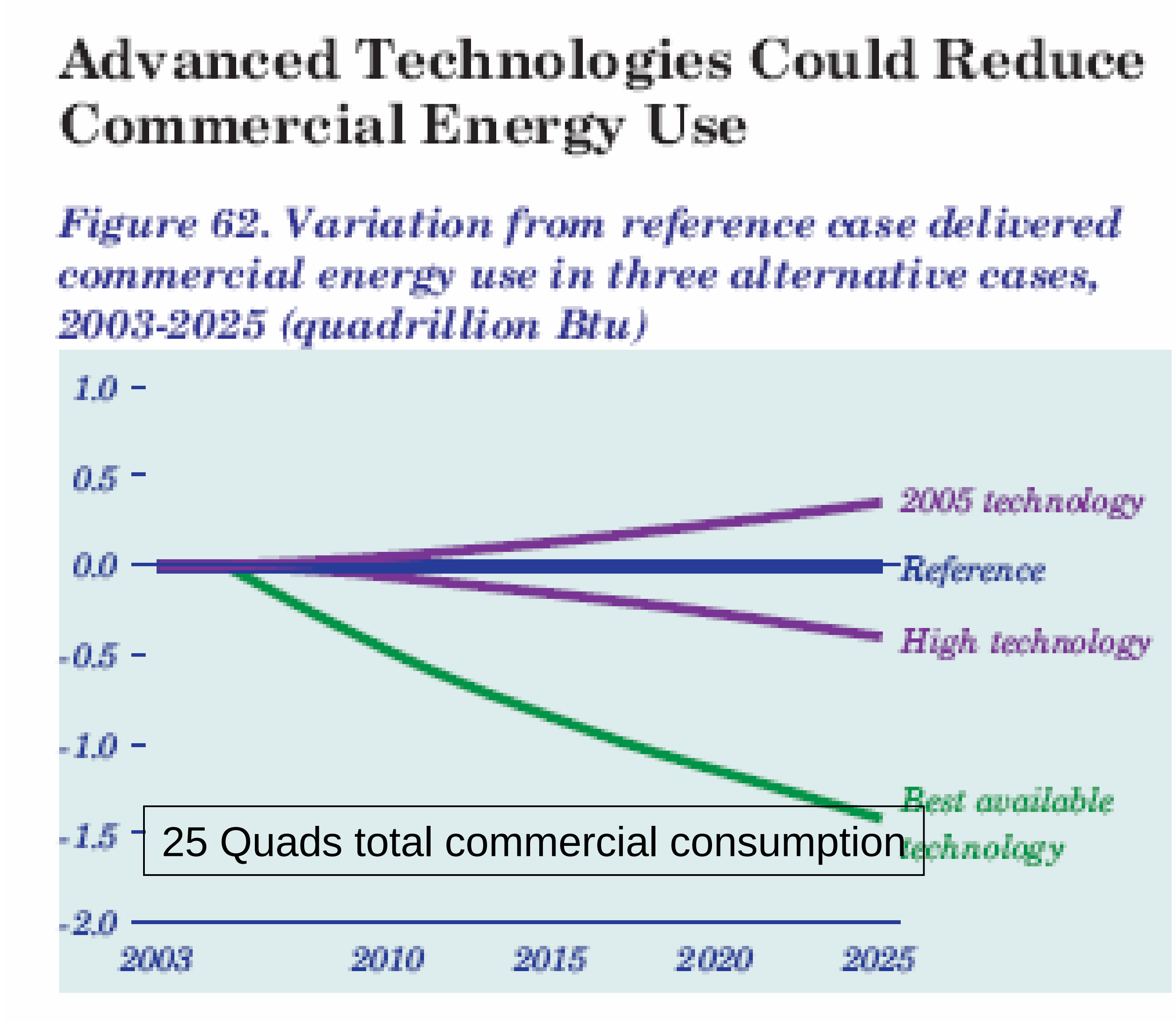
AEO (2006)

Advanced Technologies Could Reduce Residential Energy Use

Figure 60. Variation from reference case delivered residential energy use in three alternative cases, 2003-2025 (quadrillion Btu)



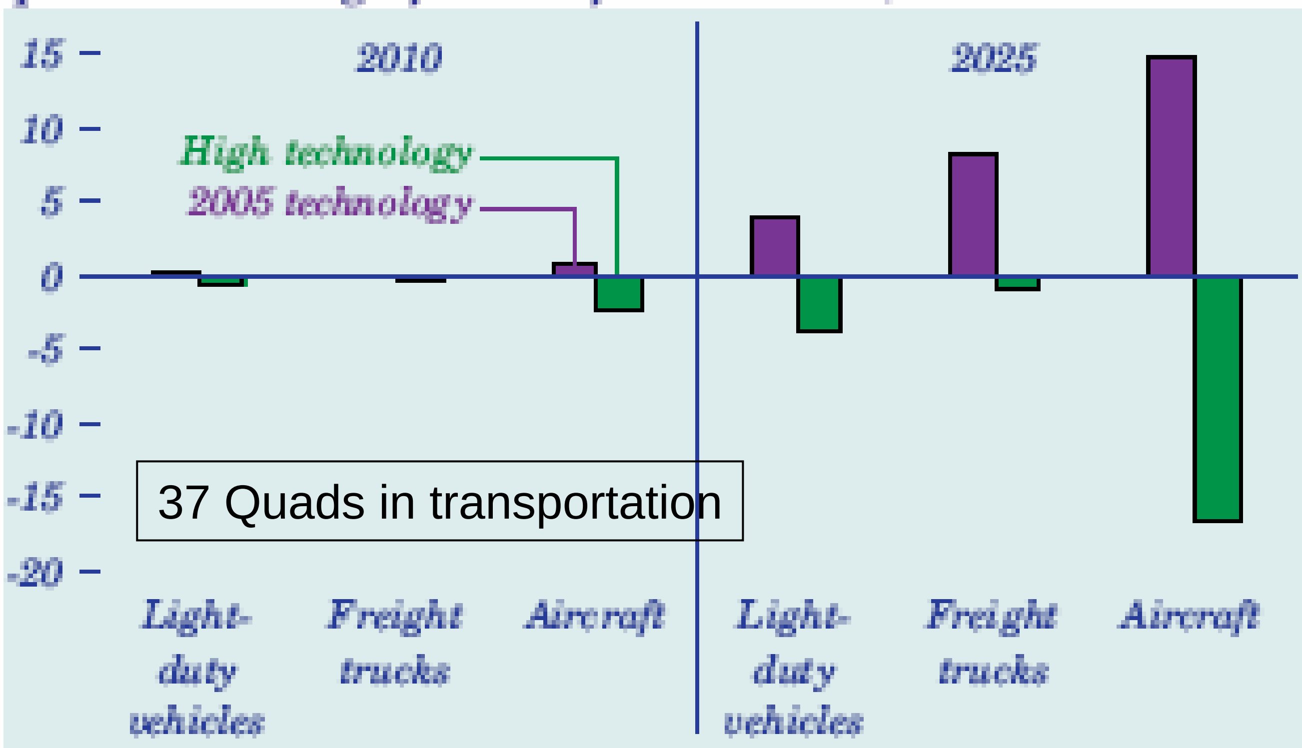
EIA AEO (2005)



Source: EIA (2005)

Vehicle Technology Advances Reduce Transportation Energy Demand

Figure 64. Changes in projected transportation fuel use in two alternative cases, 2010 and 2025 (percent change from reference case)

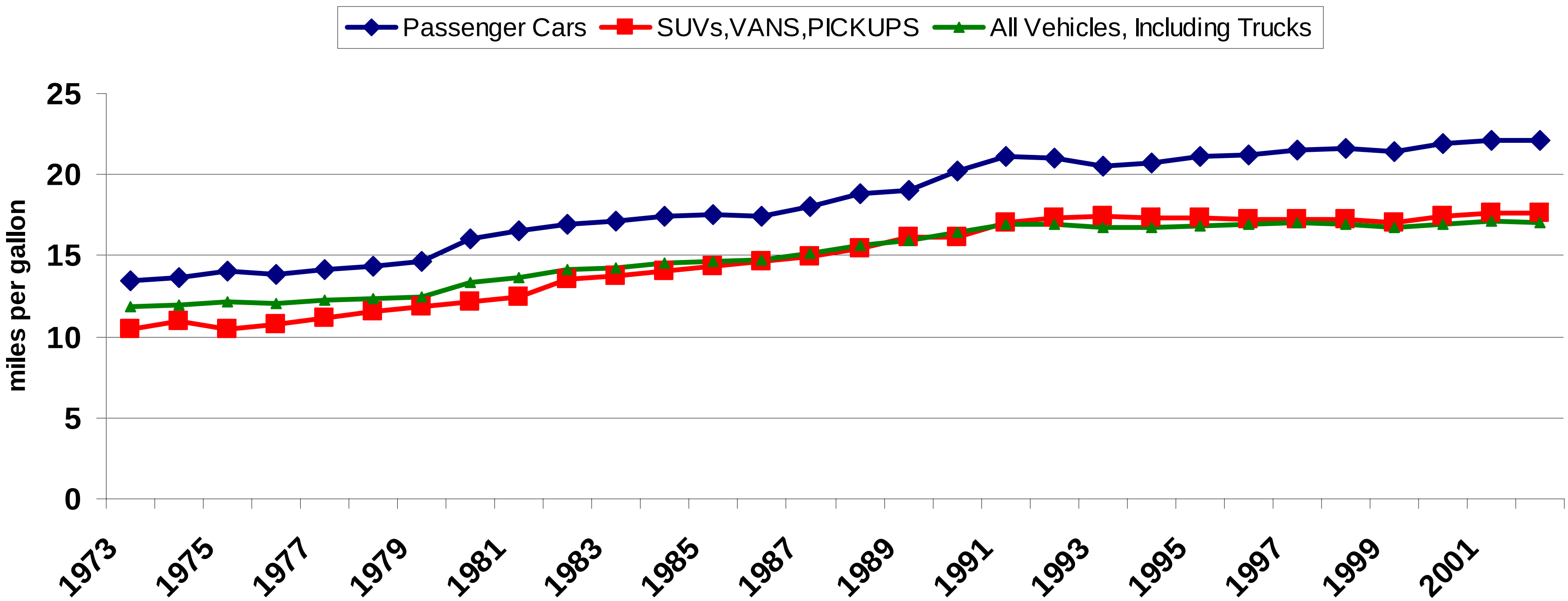


Source: EIA (2005)

U.S. ENERGY EFFICIENCY POLICIES

- Federal appliance efficiency standards
  - 2005 Energy Act tightens standards
- Federal motor vehicle efficiency standards
  - Date to late 1970s
  - Major area of continuing controversy
- Federal and state tax subsidies for residences and business
  - 2005 Energy Act expands tax subsidies
- Federal and state tax incentives for hybrid (gasoline/electric) vehicles
- Electric and gas utility DSM programs funded with surcharges on distribution tariffs

U.S. VEHICLE FUEL EFFICIENCY

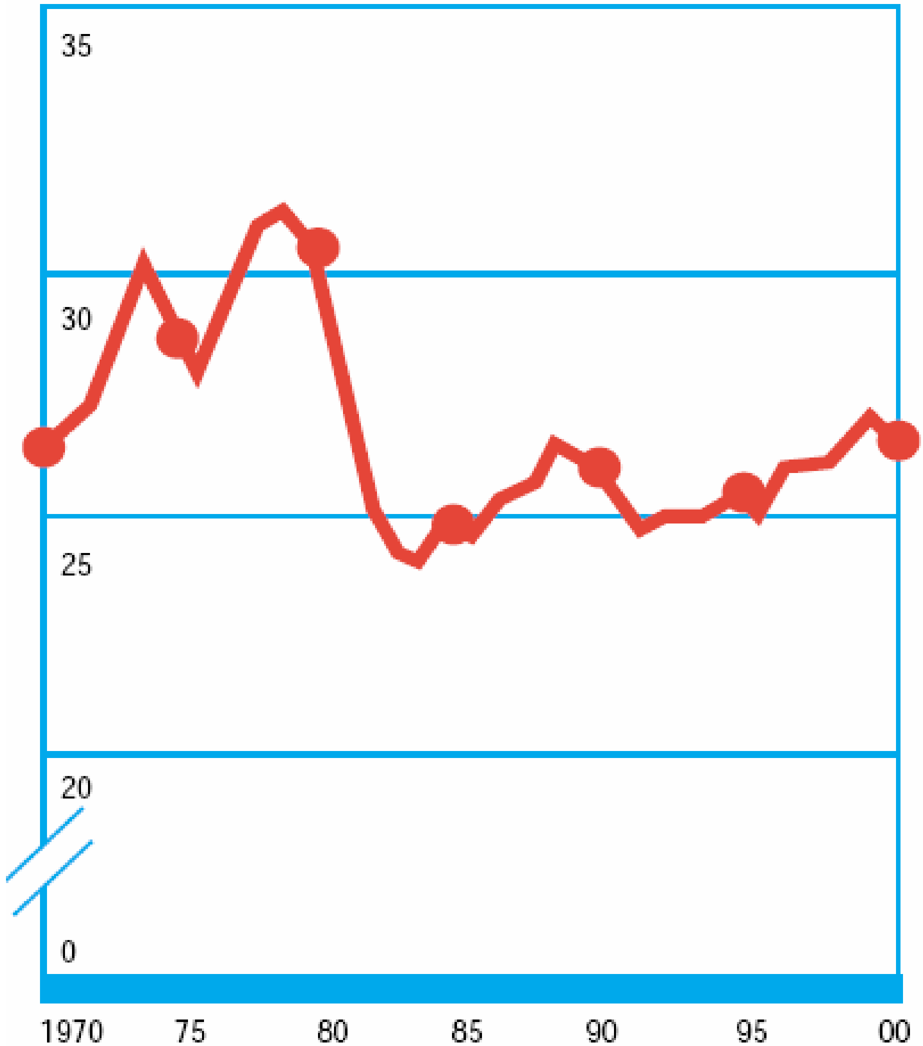


Source: U.S. EIA

Figure 1-4

U.S. Per Capita Oil Consumption: 1970–2000

(Barrels per Year)

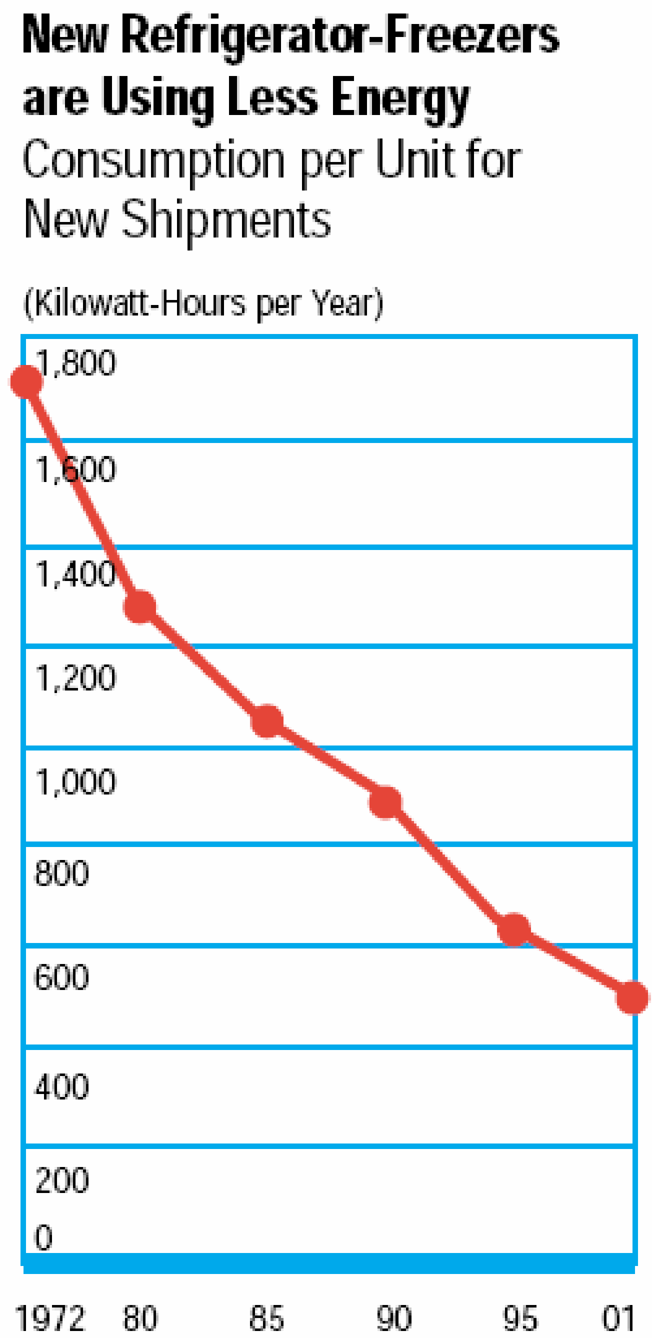


Source: U.S. DOE

Table 13. Technologies expected to have significant impacts on new light-duty vehicles

Vehicle component and technology	Technology description	Expected efficiency improvement (percent)	Initial incremental cost (2000 dollars)
Engine			
Advanced valve train	Four valves per cylinder; variable valve timing and lift; camless valve actuation	2.5-8.0	45-750
Friction reduction	Low-mass pistons and valves; reduced piston ring and valve spring tension; improved surface coatings and tolerances	2.0-6.5	25-177
Cylinder deactivation	Reduced cylinder operation at light load, lowering displacement and reducing pumping losses	4.5	250
Lean burn	Direct injection fuel system, enabling very lean air-fuel ratios	5.0	250
Transmission			
Control system	Electronic controls, improving efficiency through shift logic and torque converter lockup	0.5-2.0	8-60
Transmission	5-speed and 6-speed automatics; continuously variable transmissions	6.5-10.0	435-615
Accessory load			
Improved pumps	Reduced engine load from oil, water, and power steering pumps	0.3-0.5	10-15
Electric pumps	Electrically powered pumps, replacing mechanical pumps	1.0-2.0	50-150
Body			
Improved materials	High-strength alloy steel; aluminum castings; lightweight interiors; aluminum body and closures	3.3-13.2	0.4-1.2 dollars per pound of vehicle weight reduction
Unit body construction	Elimination of body-on-chassis structure	4.0	100
Improved aerodynamics	Reduction in drag coefficient, with improvements specific to body type	2.3-8.0	40-225
Drive train			
Advanced tires	Reduced rolling resistance	2.0-6.0	30-135
Improved 4-wheel drive	Reduced weight; improved electronic controls	2.0	100
Independent			
Safety and emissions	Improved safety and emission systems	-3.0	200

EIA AEO (2006)



Source: U.S. DOE

RENEWABLE ENERGY

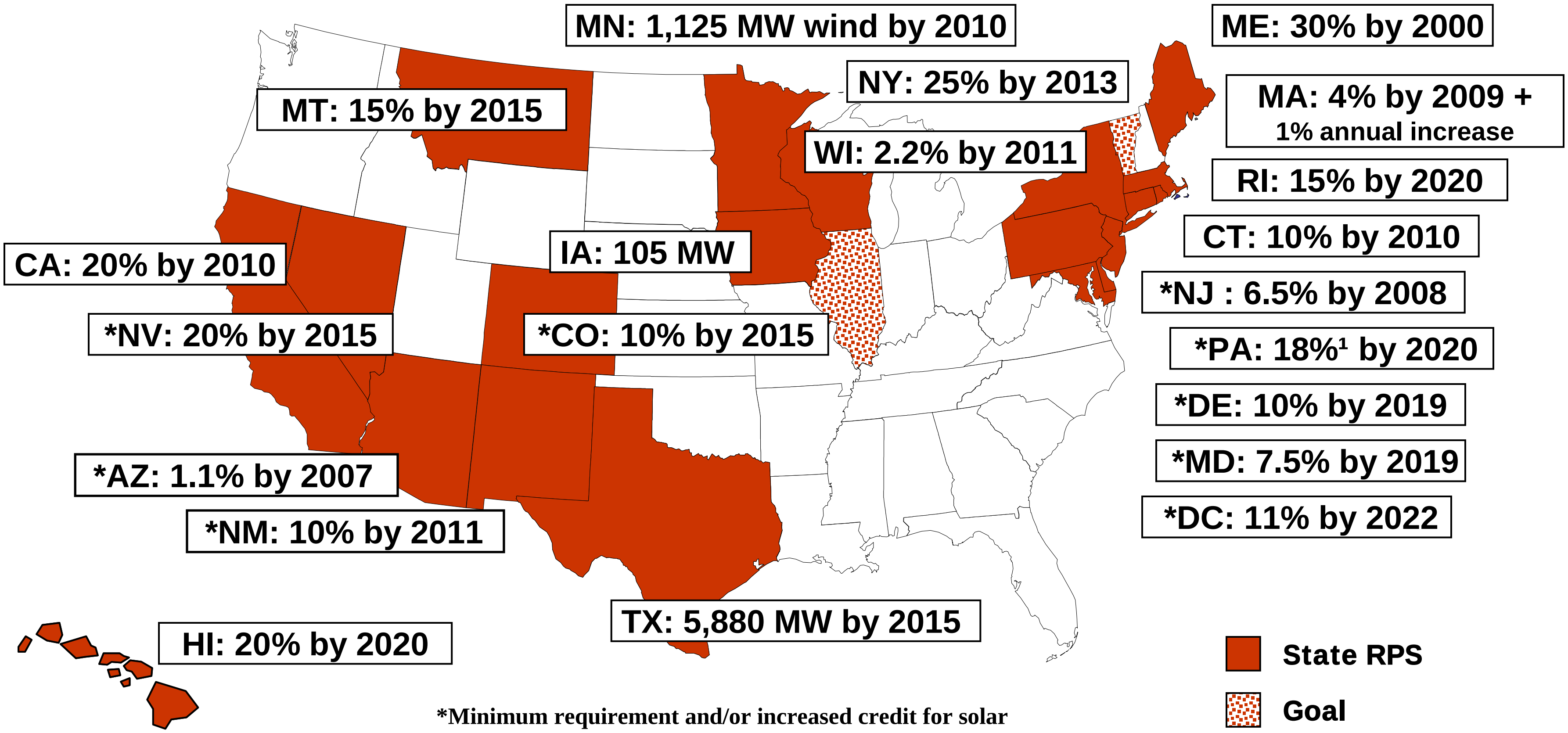
U.S. Renewable Energy Policies

- Federal and state tax subsidies for wind, solar, bio-fuels (primarily ethanol), waste, fuel cells
  - 2005 Energy Act expands tax subsidies
  - Some states have expanded tax subsidies (e.g. $3 billion for solar in California financed as a surcharge on electricity and gas distribution tariffs)
- State renewable Energy Portfolio standards for retail electricity suppliers
  - Efforts to include in 2005 Energy Act failed
- Requirements to blend ethanol and gasoline (2005 Energy Act)
- Special buyback tariffs
  - PURPA 1978 requirements largely gone
- Net-metering increases incentives for distributed generation

DSIRE: www.dsireusa.org

January 2006

Renewables Portfolio Standards



*Minimum requirement and/or increased credit for solar

¹ PA: 8% Tier I, 10% Tier II (includes non-renewable sources)

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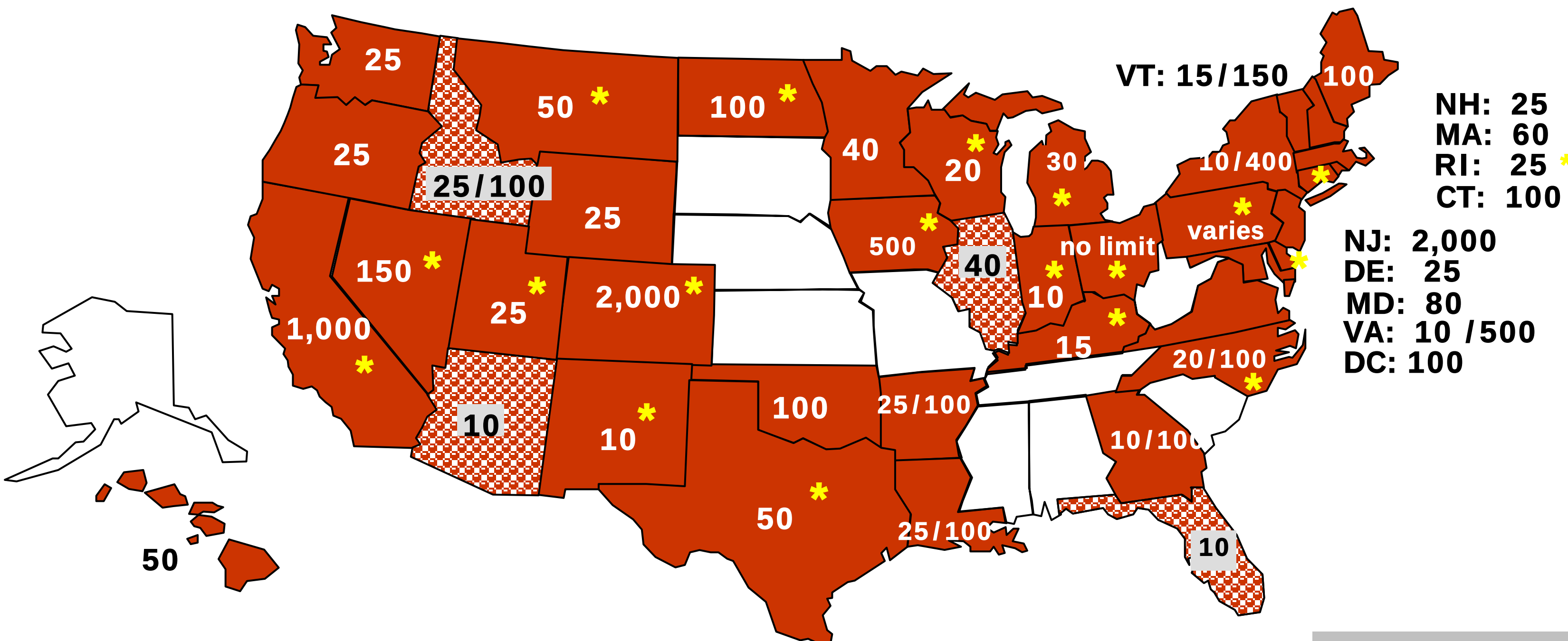
January 2006

Net Metering Rules



Net metering is available in 40 states + D.C.

- State-wide net metering for all utility types
- State-wide net metering for certain utility types (e.g., IOUs only)
- Net metering offered by one or more individual utilities

#s indicate system size limit (kW); in some cases limits are different for residential and commercial as shown

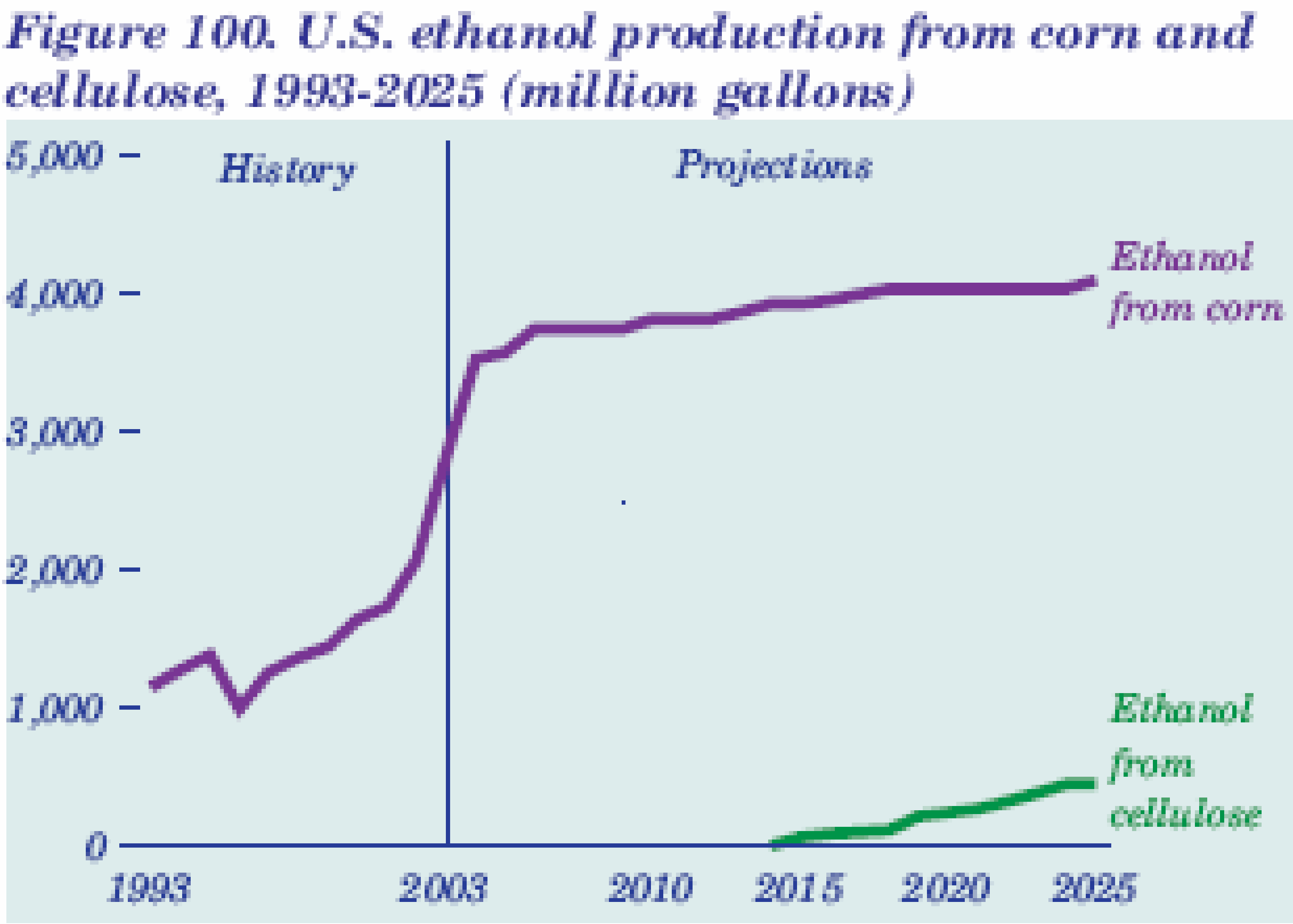


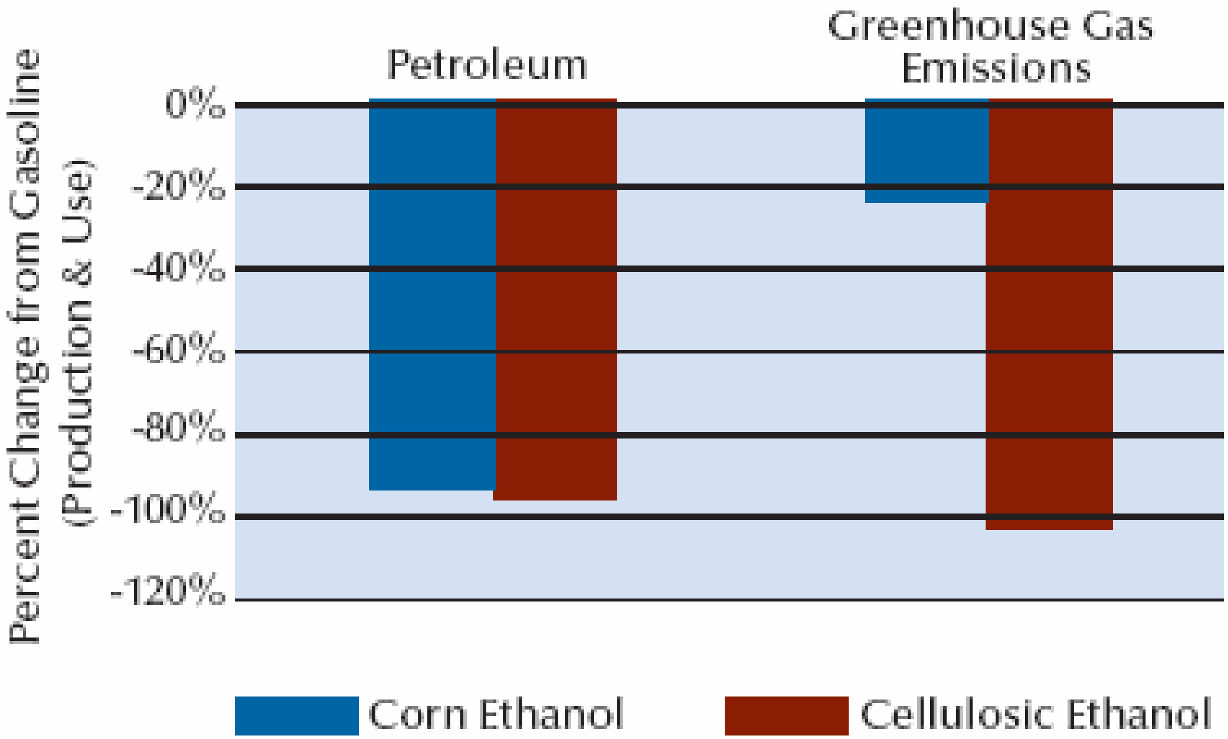
Figure 100. U.S. ethanol production from corn and cellulose, 1993-2025 (million gallons)
5,000
4,000
3,000
2,000
1,000
0
History
Projections
Ethanol from corn
Ethanol from cellulose
1993
2003
2010
2015
2020
2025

EIA AEO (2005)

Figure 4-15

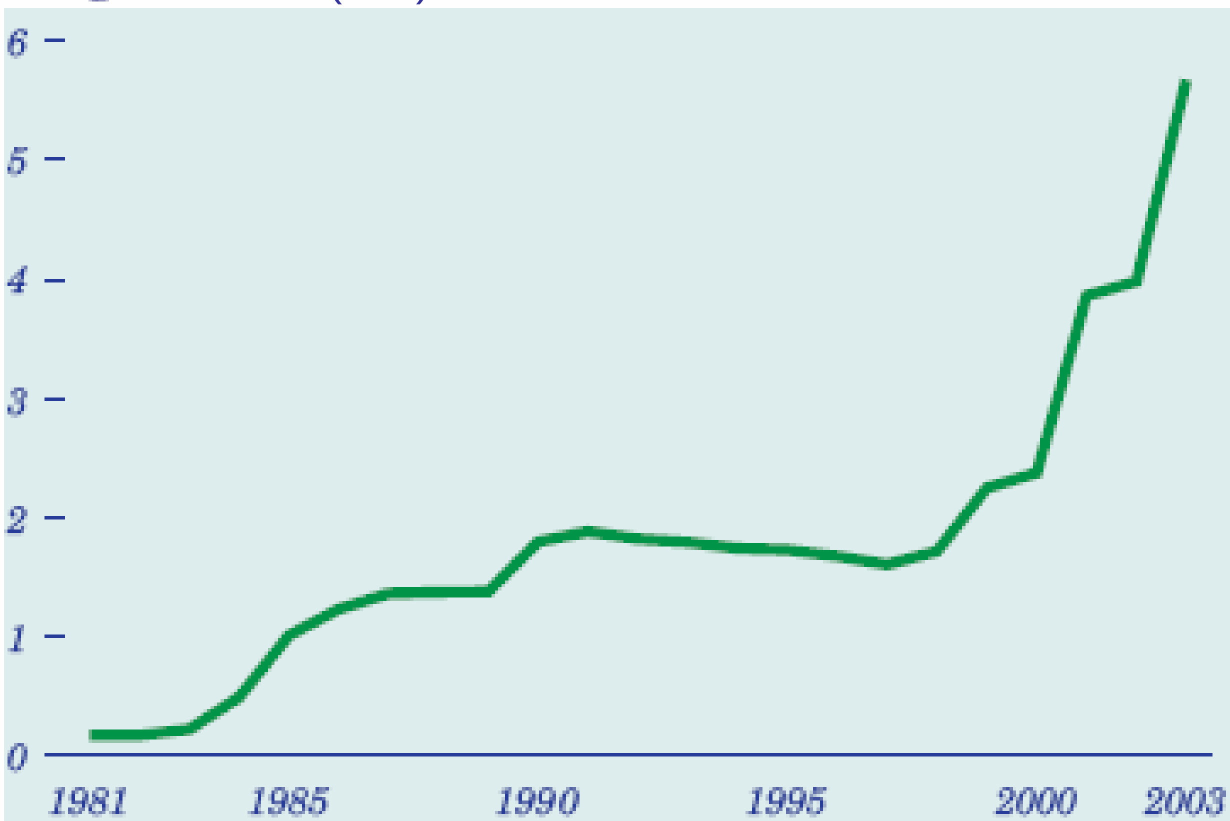
The Attributes of Corn Ethanol and Cellulosic Ethanol

While both corn and cellulosic ethanol are effective at offsetting petroleum consumption, cellulosic ethanol has the added benefit of substantially reduced greenhouse gas emissions.



Data Source: Lynd, Greene, and Sheehan, 2004

Figure 26. U.S. installed wind capacity, 1981-2003
[redacted] (GW)



Source: EIA (2005)

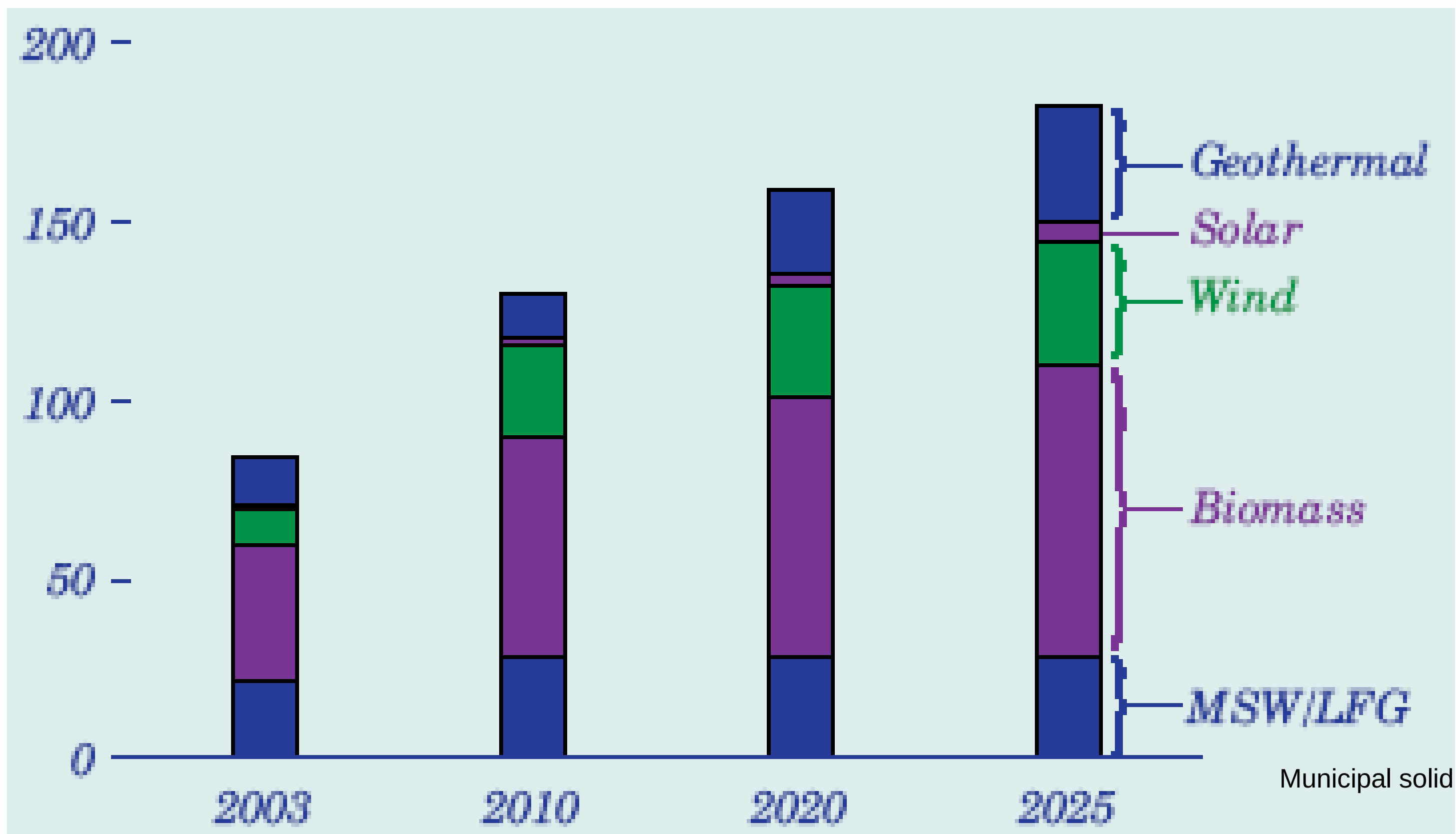


Figure 75. Nonhydroelectric renewable electricity generation by energy source, 2003-2025 (billion kilowatthours)

Municipal solid waste/landfill gas

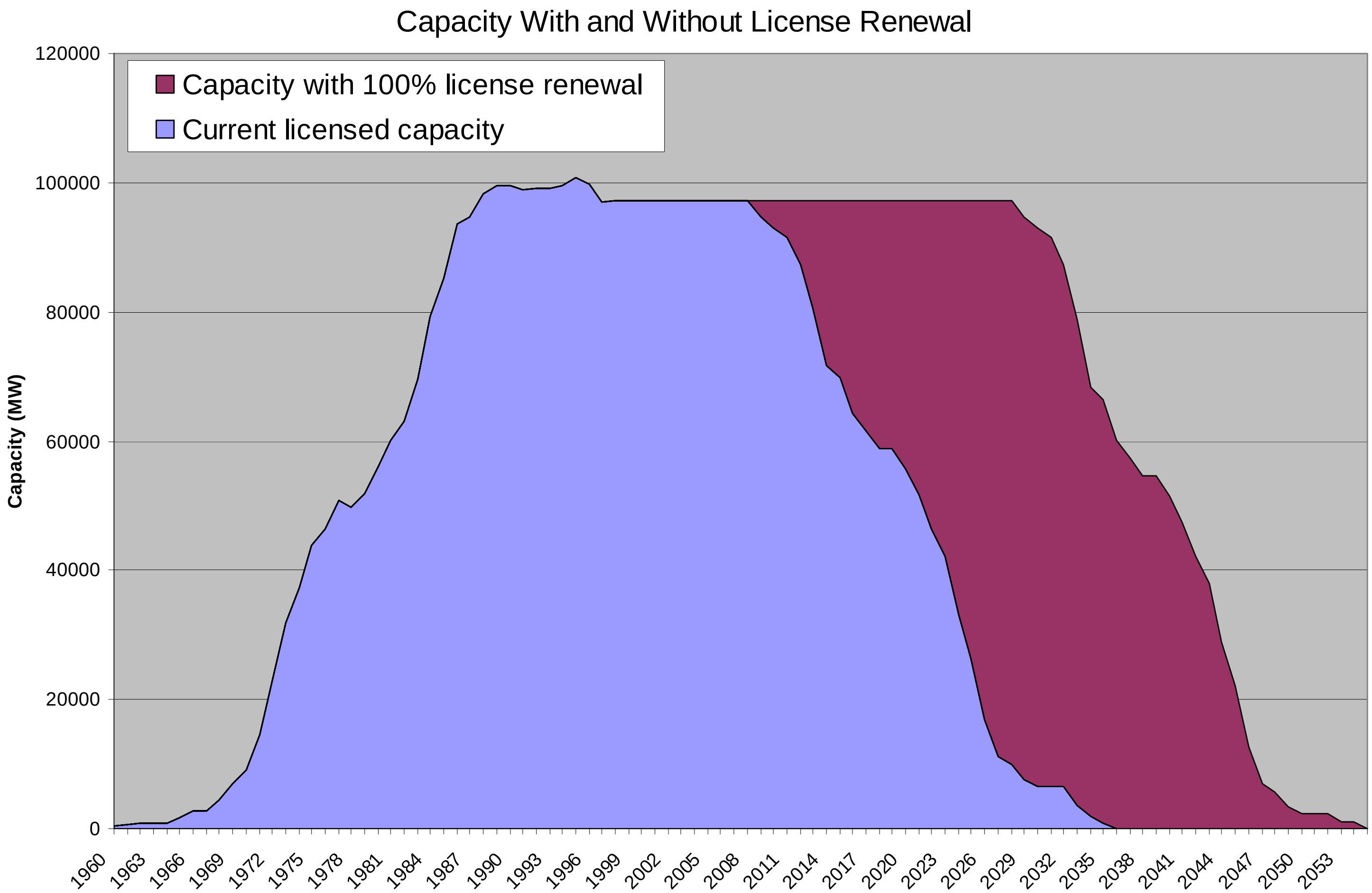
9% of electricity generation in 2004
12% in 2030

Source: EIA (2005)

U.S. NUCLEAR POWER

- U.S. has 100 GW of nuclear capacity (20% of US electricity generation)
- Performance has improved dramatically over time in all dimensions
- It is economical to extend the life of the existing fleet and "uprate" some units to increase capacity (+ 3GW)
- Strong interest in the U.S. in promoting investments in new nuclear capacity
- 2005 Energy Act contains financial incentives (production tax credits, other subsidies) to encourage "first-movers" to build new plants
  - 6 GW of nuclear capacity additions forecast between 2015 and 2030
- Licensing changes and efforts to resolve waste disposal issues also support new investment

Without New Investments U.S. Nuclear Capacity Declines



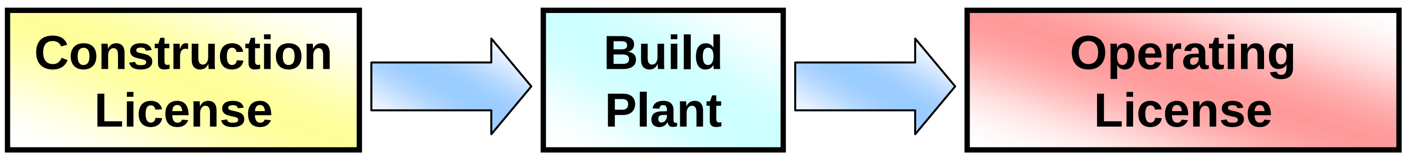
Source: Dominion Resources, 2005

WHAT IS NEEDED TO RE-LAUNCH NUCLEAR INVESTMENT?

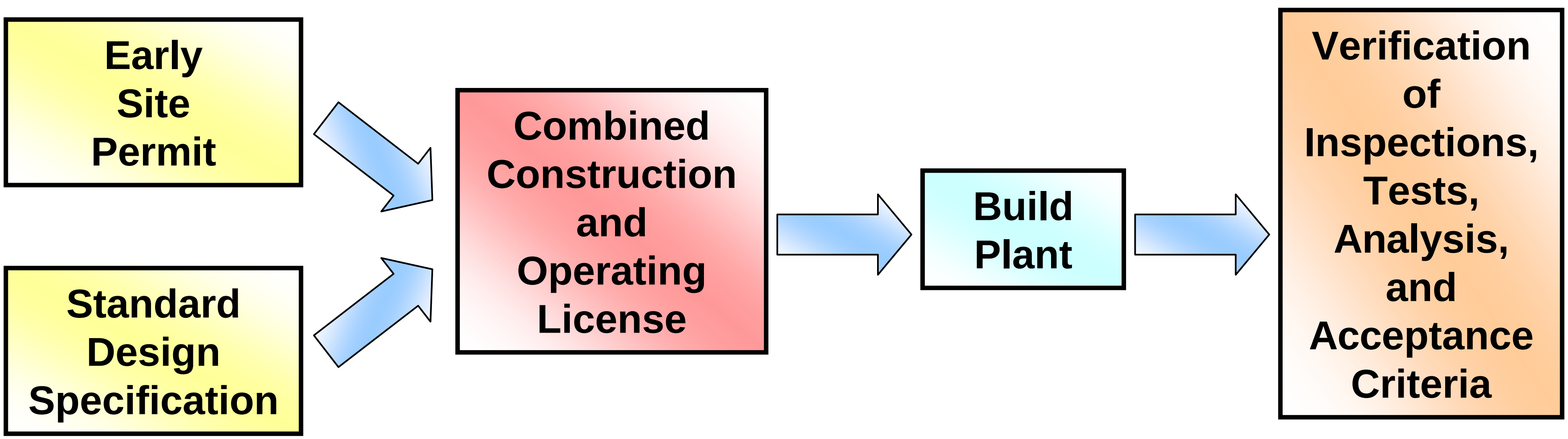
- Stable regulatory, competitive and commercial framework that will support capital intensive projects with relatively long construction expenditure cycles
- Stable and efficient nuclear plant licensing framework
- Achieve credible $1500/kW overnight cost including all relevant owner's costs, 5-year construction period and $\geq$ 85% life-time capacity factor
- Place a significant "price" on carbon emissions
- Realize credible and economic nuclear waste disposal policy

New U.S. Reactor Licensing Process

Old Process: The two-step licensing process (10 CFR 50)



New Process: Combined licensing process (10 CFR 52)



Commercial Tests of the New Licensing Process

- Three companies have applied for Early Site Permits
  - Dominion (North Anna)
  - Entergy (Grand Gulf)
  - Exelon (Clinton)
- Three consortia will test the COL (combined construction and operating license) process
  - Dominion (preparing COL for 2007 filing)
  - NuStart (preparing COLs for 2007 filing)
    - ESBWR at Grand Gulf
    - AP1000 at Bellefonte
  - TVA (feasibility study of new nuclear plant at Bellefonte)
- Duke Energy considering COL

Energy Policy Act of 2005

- Loan guarantees for up to 80% of project cost
  - Valid for all GHG-free technologies
  - Higher leverage, lower debt cost reduces overall project cost
- Production tax credit of $18 per MWh for new nuclear capacity through 2021, subject to 2 limitations:
  - $125 million per 1,000-MW per year
  - 6,000-MW eligible, allocated among available capacity
- Insurance protection against delays during construction and until commercial operation caused by factors beyond private sector's control
  - Coverage: $500 million apiece for first two plants, $250 million for next four
  - Covered delays: NRC licensing delays, litigation delays

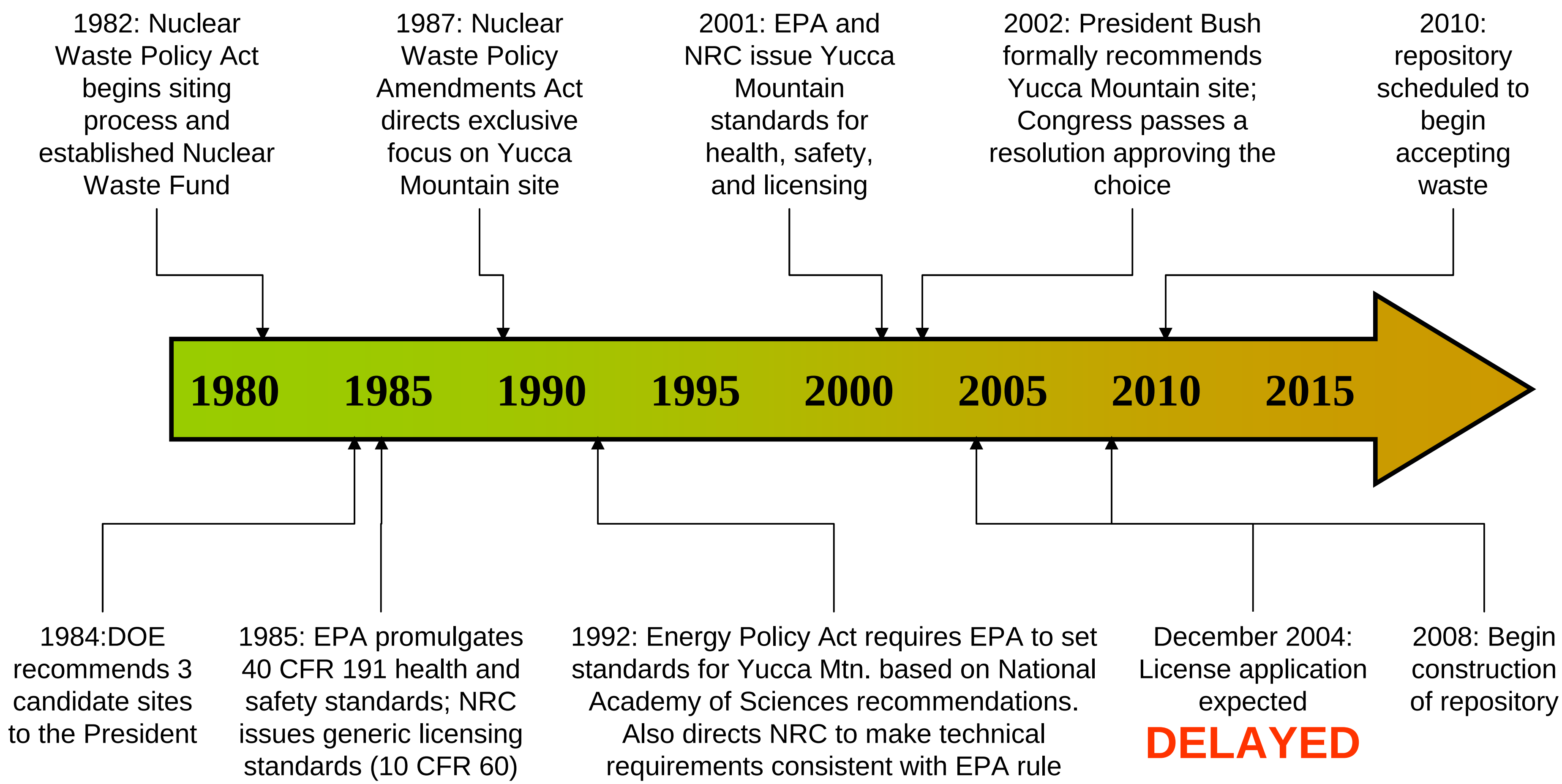
Energy Policy Act of 2005

- Renewal of the Price-Anderson Act of 1957
  - Liability protection extended until 2025
- Legislation updates tax treatment of nuclear decommissioning trust funds to reflect competitive electricity markets
  - All decommissioning trust funds will qualify for tax deductibility (not only those of regulated utilities)
- Federal commitment on R&D portfolio ($2.95 billion authorized)
- Creates Assistant Secretary for Nuclear Energy at DOE

More Power Companies Are Now Considering New Builds

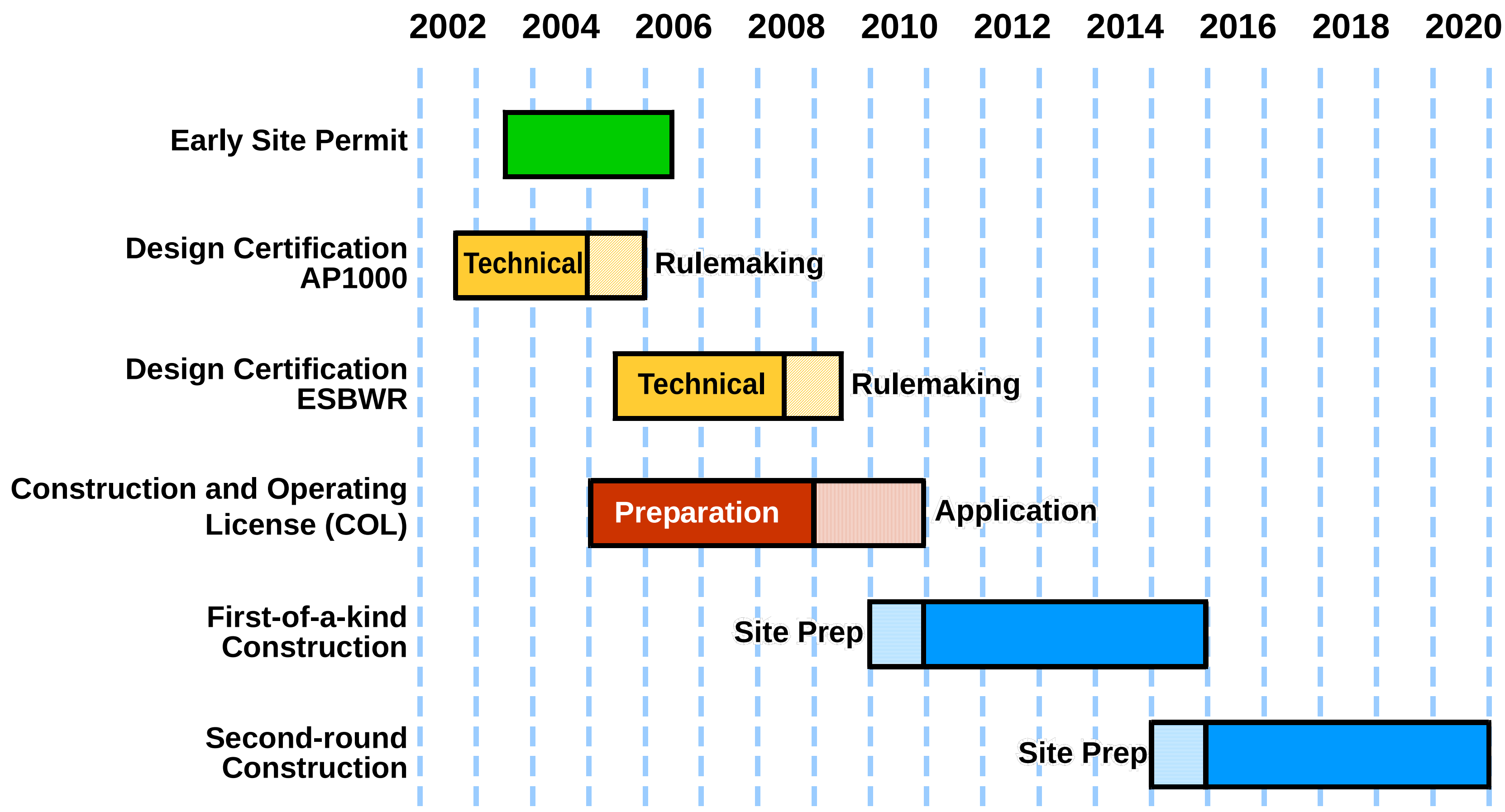
- Progress
  - Considering COL application in 2008, evaluating sites and reactor vendors
- Southern Nuclear
  - In 2006, will file ESP application or preliminary data for COL application for Vogtle site
- South Carolina E&G/Santee Cooper
  - Considering COL
- UniStar Nuclear
  - Joint initiative by Constellation and Areva to develop projects on own account, or in partnership with other companies
- Entergy
  - COL for ESBWR at River Bend

US Nuclear Waste Repository Development



Source: Cambridge Energy Research Associates, 2005

In Best Case Scenario, First New Plants Would Be Online Around 2015



Source: Cambridge Energy Research Associates, 2005

CARBON CAPTURE AND SEQUESTRATION

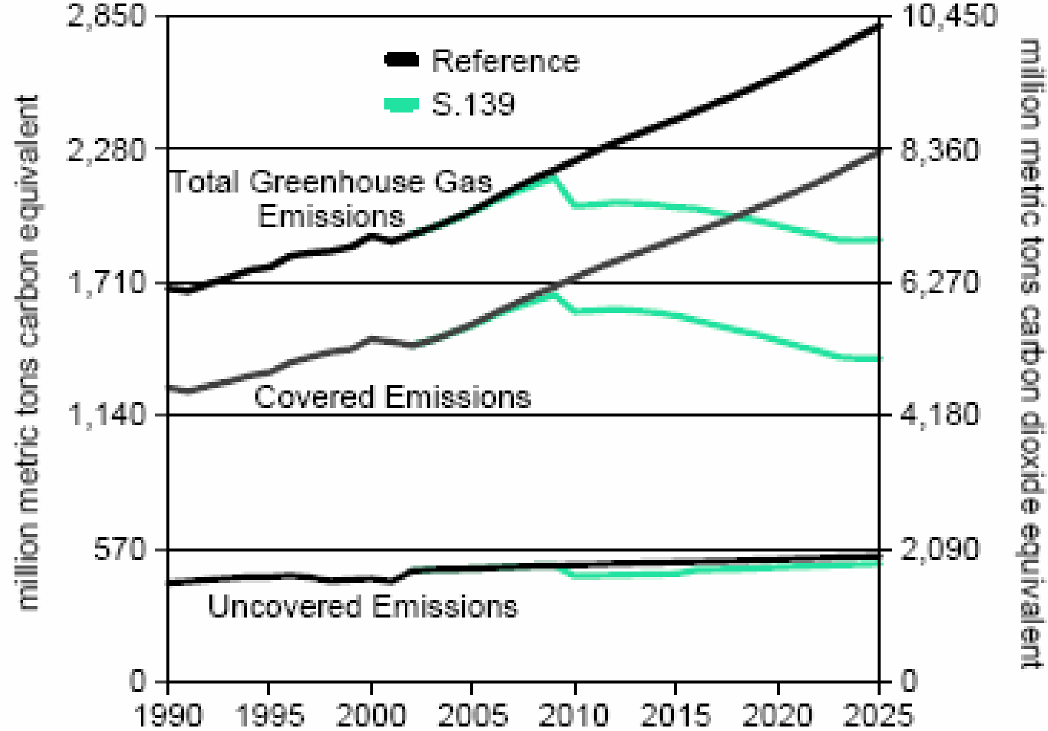
- 2005 Energy Act provides financial incentives for the construction of IGCC's which are advertised as being "capture ready"
  - But they are not really "capture ready" and will not capture any CO2
  - A better program would provide subsidies only if carbon capture is included in the project
- Federal financial incentives ($700 million) to build a coal-based demonstration power plant with "zero emissions," carbon capture and sequestration, and production of hydrogen ("Future Gen")
- More serious effort needs to be devoted to demonstrating the feasibility and costs of transporting and storing large volumes of CO_2 and keeping it there
- It will be expensive – equivalent to about $25/tonne CO_2 plus costs of compression, transportation and storage

Future U.S. Greenhouse Gas Policies

- U.S. has no formal caps on greenhouse gas emissions and has not ratified Kyoto
  - Several U.S. states are adopting CO_2 control policies with hope of influencing national debate
  - Energy efficiency and renewable energy policies are focused on CO_2 emissions control
  - R&D policies are motivated by prospect of future caps on greenhouse gas emissions
- There is substantial support for caps on greenhouse gas emissions
  - Doubt that Kyoto targets will be met by many countries
  - Kyoto targets are not realistic for the U.S.
  - China and India must be included more directly
  - Portfolio of energy efficiency, nuclear power, renewable energy, carbon capture and sequestration focused on advanced technology
  - Impacts on domestic coal industry, domestic oil/gas producers and electricity prices are major political considerations/barriers affecting climate policies

McCain-Lieberman Bill

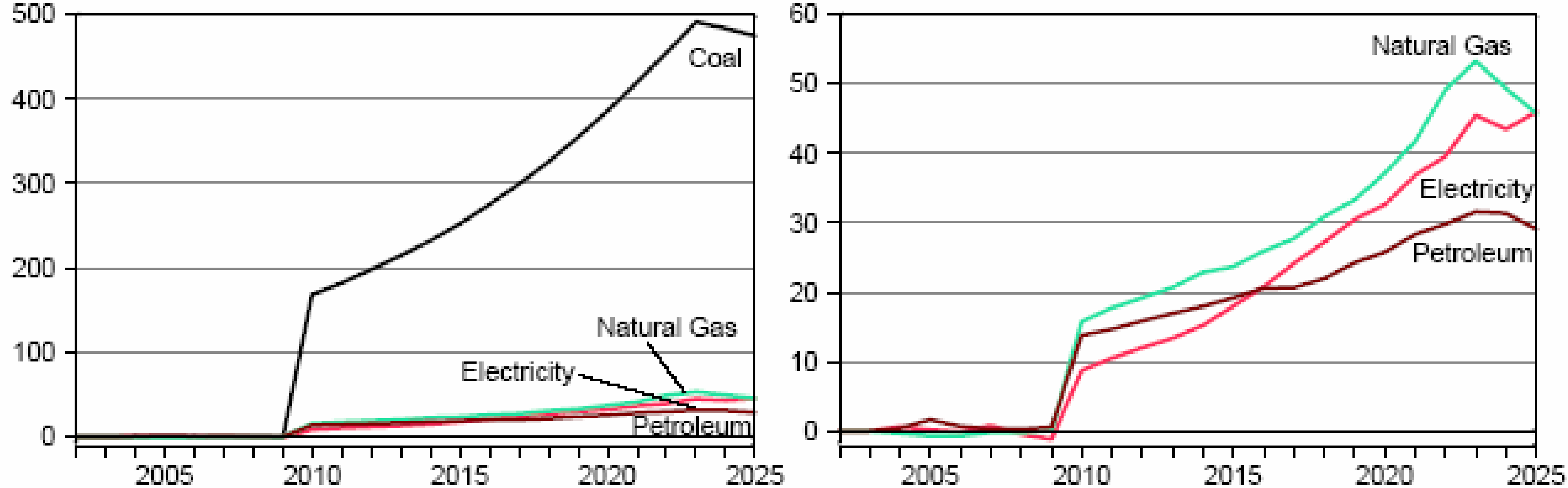
Figure S.2. U.S. Greenhouse Gas Emissions in the Reference and S.139 Cases, 1990-2025



Source: EIA (2003)

McCain-Lieberman Bill

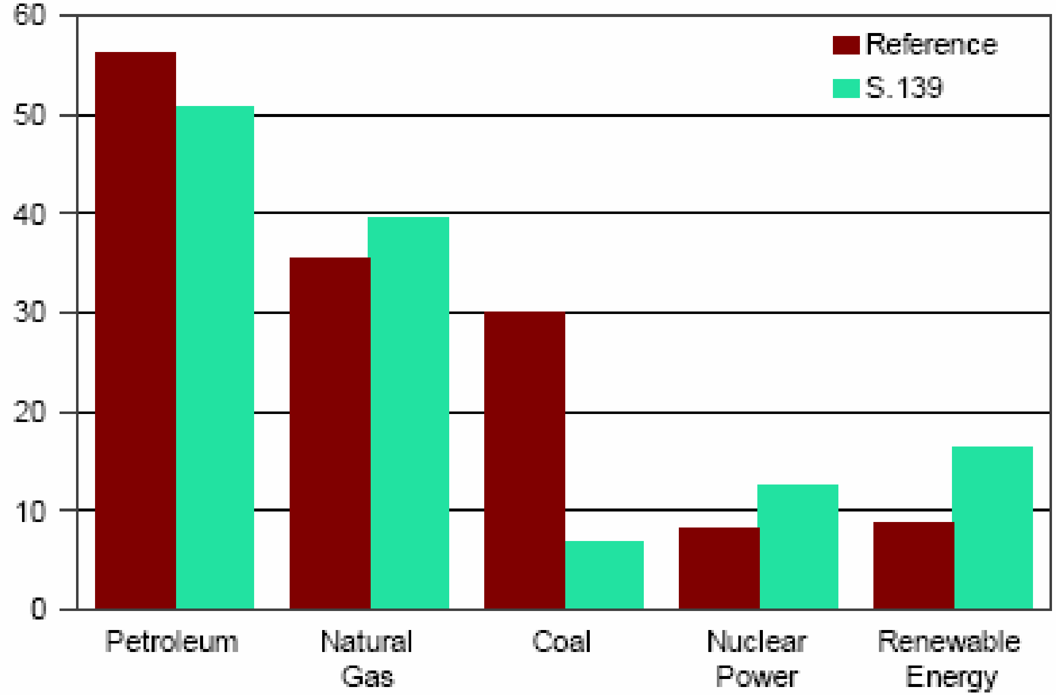
Figure S.4. Effective Delivered Energy Prices in the S.139 Case: Change from Reference Case (percent)



Source: EIA (2003)

McCain-Lieberman Bill

Figure S.5. Primary Energy Consumption by Fuel in the Reference and S.139 Cases, 2025 (quadrillion Btu)



Source: EIA (2003)