Global Energy– Build Bridges, Not Walls*

Scott W. Tinker[1]

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Summary

The bridge from a fossil-energy present to an alternate-energy future will span many decades. As with the building of any bridge, a solid foundation is vital. A well-designed energy bridge will move the world ahead in a reasonable fashion. Accelerating an energy transition as the result of a poorly informed public enabling politically naive policies could—likely would—lead to global energy, economic, and consequently environmental instability.

Building the energy bridge will not be simple; tough challenges rarely are. The process will involve:

1) The delicate interplay among energy, environment, economy, and public energy policy;
2) A necessary partnership among government, industry, academia, and non-government organizations;
3) Parallel investments in and favorable policies towards fossil energy *and* alternatives;
4) Compromise and wisdom from leadership.

The Three E Waltz

Energy, economy, and the environment are inextricably linked. Oil price, as a historical proxy for energy price, has a known relationship to economic health. In the U.S., significant oil price increases are often followed by economic recession, as observed following the oil price spikes in 1973, 1979, 1990 and 2008. Further, global data show a strong positive correlation between per-capita energy consumption and per-capita income.

Energy price has a known impact on consumer behavior. Using oil as an example, when the price of oil is high, demand for oil dampens. This was most notable from 1973 through 1984, when global oil demand, which had been rising steadily in prior decades, was dampened considerably as a result of steep oil price increases driven by the OPEC supply cutoff to the United States. Although global demand for oil again increased from 1985 through 2005, the rate of increase was considerably lower than prior to 1973. In other words, the oil price shock of the early 1970s changed consumer behavior. Importantly, oil, as a *percentage* of global energy, peaked in 1979 at just below 50% and has been decreasing since that time.

The world went through another significant oil price increase from 2002 through 2008, this time driven largely by investor speculation combined with increased demand from developing nations, and as expected, in 2007 and 2008 global demand for oil dampened. It is likely that the slope of the forward demand curve for oil, relative to the 1980s and 1990s, will again decrease, perhaps even plateau, as consumer behavior surrounding energy changes and oil continues to decline as a percentage of global energy.

A lesser known relationship is between energy and the environment. When the world is in recession, as it is today, less money is spent on environmental action. Just read the paper. In various ways nations are saying, “We cannot afford environmental investments, especially those related to atmospheric reduction of anthropogenic carbon.” Healthy energy systems are related to healthy economies, which in turn allow environmental investment. Unbalanced attention, positive or negative, on any of the three E’s, will throw the system out of balance.

The Energy Bridge

Today, fossil fuels represent 87% of the global energy mix. Under any stable scenario the foundation of an alternate, lower carbon energy future will be built with fossil fuels. The irony should be very apparent. Those nations that do not understand, or choose to reject, this reality will be left behind.

Looking out to 2030, I call for the percentage of fossil fuels to decrease to 80%, with a greater proportion of natural gas and lower proportion of oil relative to today. Forecasts, simple or elaborate, require fundamental underpinnings. My simple forecast is underpinned by resource estimates and economics; we have the coal, oil, natural gas, water, and uranium resources to support my forecast to 2030, and these sources of energy will likely remain the most affordable. New *conventional* oil and natural gas frontiers include ultra-deep water, the Arctic, and other extreme operational environments. As existing and new conventional reserves begin to decline, *unconventional* oil and natural gas resources, perhaps someday including natural gas hydrates, will represent a growing part of the future fossil-energy mix. Clean and economic extraction of these new reserves will be enhanced by industry-governmentacademic partnerships.

The fossil bridge must embrace energy efficiency, including cars and light trucks, insulation and lighting, appliances, industrial uses, and beyond. Net energy savings is not one-for-one with efficiency owing to the rebound effect—we tend to use more units as each unit becomes more efficient—but that effect diminishes with scale and time.

Diversification of the global energy portfolio is critical, particularly in the area of transportation. Options to conventional oil include unconventional oil, coal and natural gas converted to liquids, and certain biofuels. In addition, there will likely be a growing electrification of the vehicle fleet. Although it is difficult to know, thoughtful studies indicate that plug-in hybrid vehicles represent a reasonable transition path to a more efficient car and light-truck future.

Increased electricity diversity is important. Cleaner baseload generation options include coal and natural gas with sequestration (CCS), offering the greatest promise for large-scale removal of carbon from carbon-fueled, stationary sources of CO_2. Nuclear technology has advanced significantly, thanks to progress in Europe and Japan, and nuclear energy will play an important global role. This will require existing and new uranium feedstocks, policy that reduces the regulatory and permitting roadblocks in some geopolitical regions, real options for waste storage, and the will to address the legal challenges designed simply to add costly delays.

My forecast accelerates the growth of non-nuclear, non-hydro renewable energy more quickly than any other source, doubling in output approximately every 7 years: no simple task. Renewable energy is not limited by resource—there is plenty of wind and sun—but rather by energy density. Quite simply, wind, waves, tides, biomass, and solar are low-density “fuels,” and they require a tremendous amount of infrastructure and earth surface area, given current technology.

A grand challenge in energy involves step changes in energy (electricity) storage and transmission. Battery technology has advanced, but batteries are still relatively inefficient, expensive, and chemically intensive, and thus they represent an environmental challenge, in terms of both manufacturing and ultimate disposal. Other renewables, such as large-scale solar PV (photovoltaic), face environmental challenges related to the chemical manufacturing processes and large-scale disposal challenges. Large, non-chemical “batteries” such as pumped water and compressed air offer interesting promise and opportunity for geological input, but are still regionally constrained in terms of access to subsurface caverns or adequate water supplies.

Technology advancements required to scale-up alternative energy sources to meet massive and growing global electricity demand will most certainly continue to develop. Many great ideas are being considered and nanotechnology research offers new frontiers, but it is vital to recognize that large-scale advances will require invention, new materials, substantial investment and well considered policy to foster private-sector, cost-competitive solutions. Markets have and will continue to weigh heavily on commercial deployment.

Policy for Security

Alternate energies represent only a small percentage of the energy mix today, not because of lack of political will or subsidies, but instead because of the fundamentals of economics, kinetics, thermodynamics, and technology. Policies, and policy makers, that attempt to overly accelerate these limiting fundamentals have fallen, and will continue to fall, short.

In terms of energy policy, energy security should not be confused with energy independence, which hints of unhealthy nationalism. Secure energy is affordable, available, reliable, and clean. A global international energy roadmap to achieve security will:

1) Address energy efficiency and infrastructure;
2) Diversify fuel options;
3) Integrate energy, economy, and the environment into policy;
4) Strengthen global energy trade and investment;
5) Broaden dialogue between developing and developed nations;
6) Enable global workforce balancing opportunities.

If a price is to be set on carbon, that price must be transparent, predictable, reasonably stable, and coordinated among major developing and developed nations, especially in terms of wise use of carbon-derived revenues. Cap-and-trade schemes struggle to meet these criteria; a carbon tax comes closer.

The challenges facing the world are great. Wise leaders will build technological, scientific, economic, political, cultural, and social bridges, remove walls that inhibit progress, embrace scientific debate, and create policy that is guided, but not dictated, by scientific forecasts. I am confident that visionaries will rise to meet these challenges, and among these will be geoscientists! That thought motivates me daily.

AAPG Presidential Address 2009

Global Energy
Build Bridges, Not Walls

100 Years of Scientific Impact

1909-2009

Dr. Scott W. Tinker
Director

Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin

Tinker, 2009

Concepts

1. Energy is the engine of modern economies
2. Energy transitions take time
3. Electricity provides the opportunity to deal with carbon
4. Build bridges for energy security

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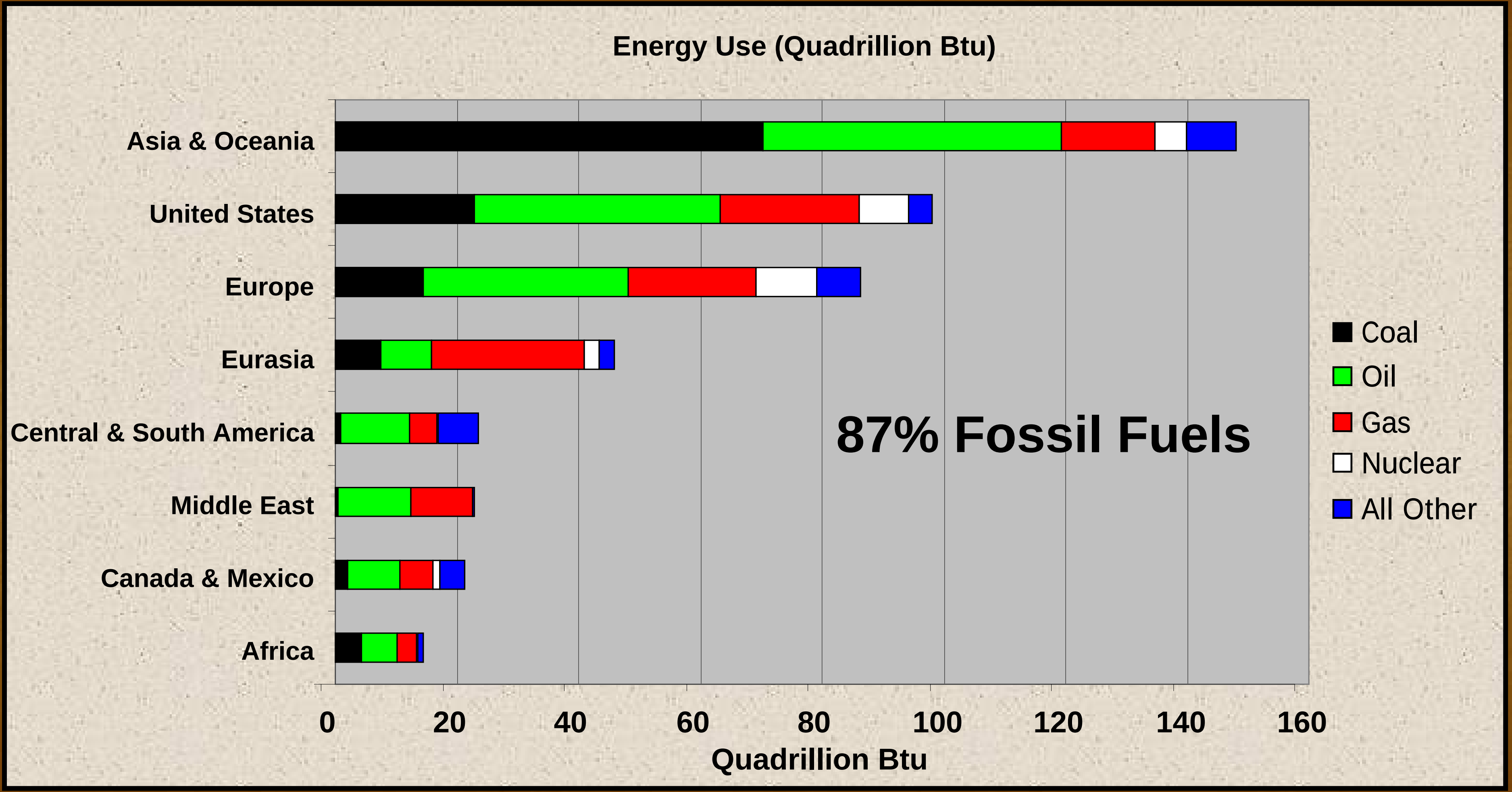
Global Energy Use



1 Quad ~ 1 Exajoule ~ 1 Tcf ~ 170 mmbo

Data: EIA, October 2007

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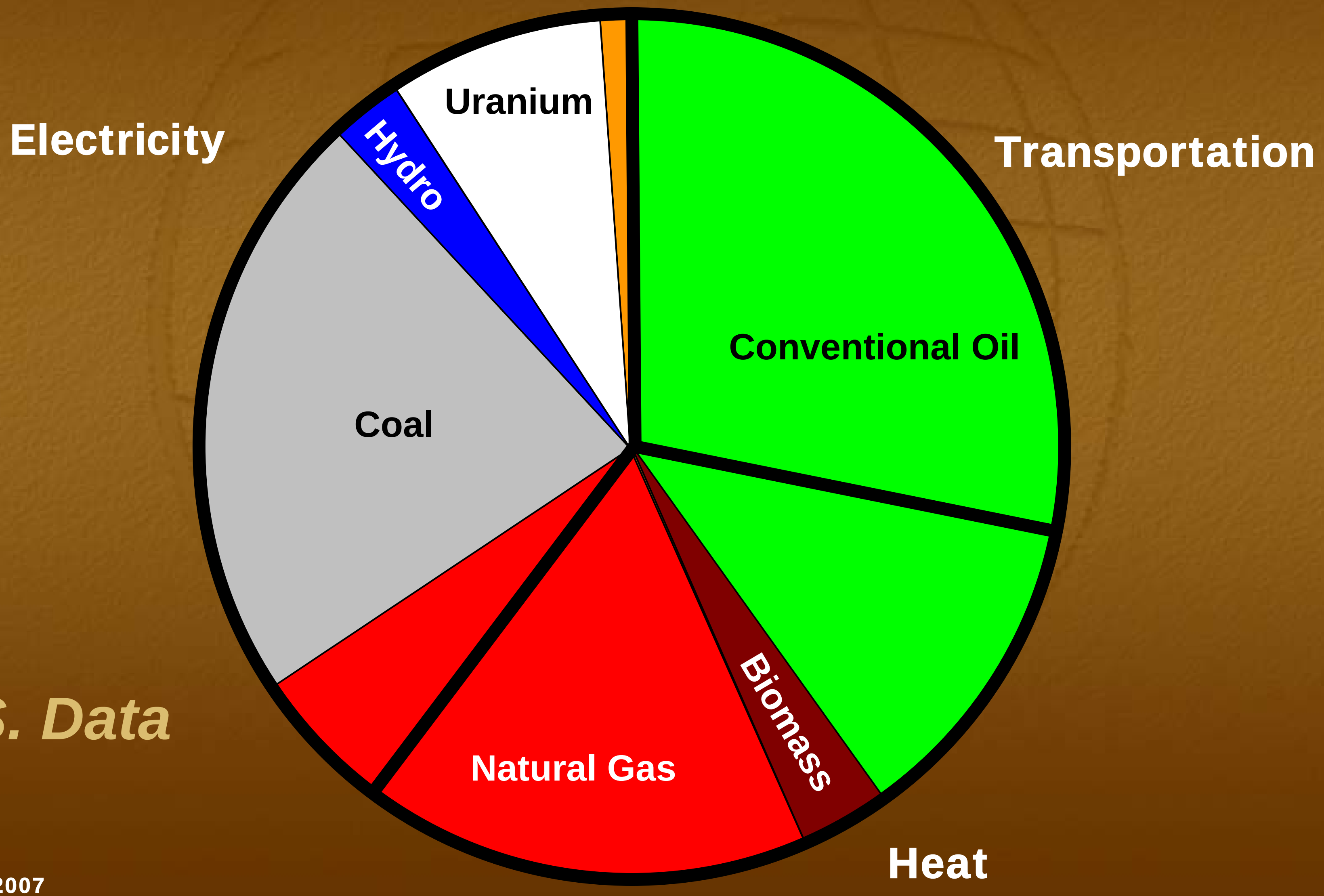
Energy End Use



U.S. Data

Data: EIA 2007

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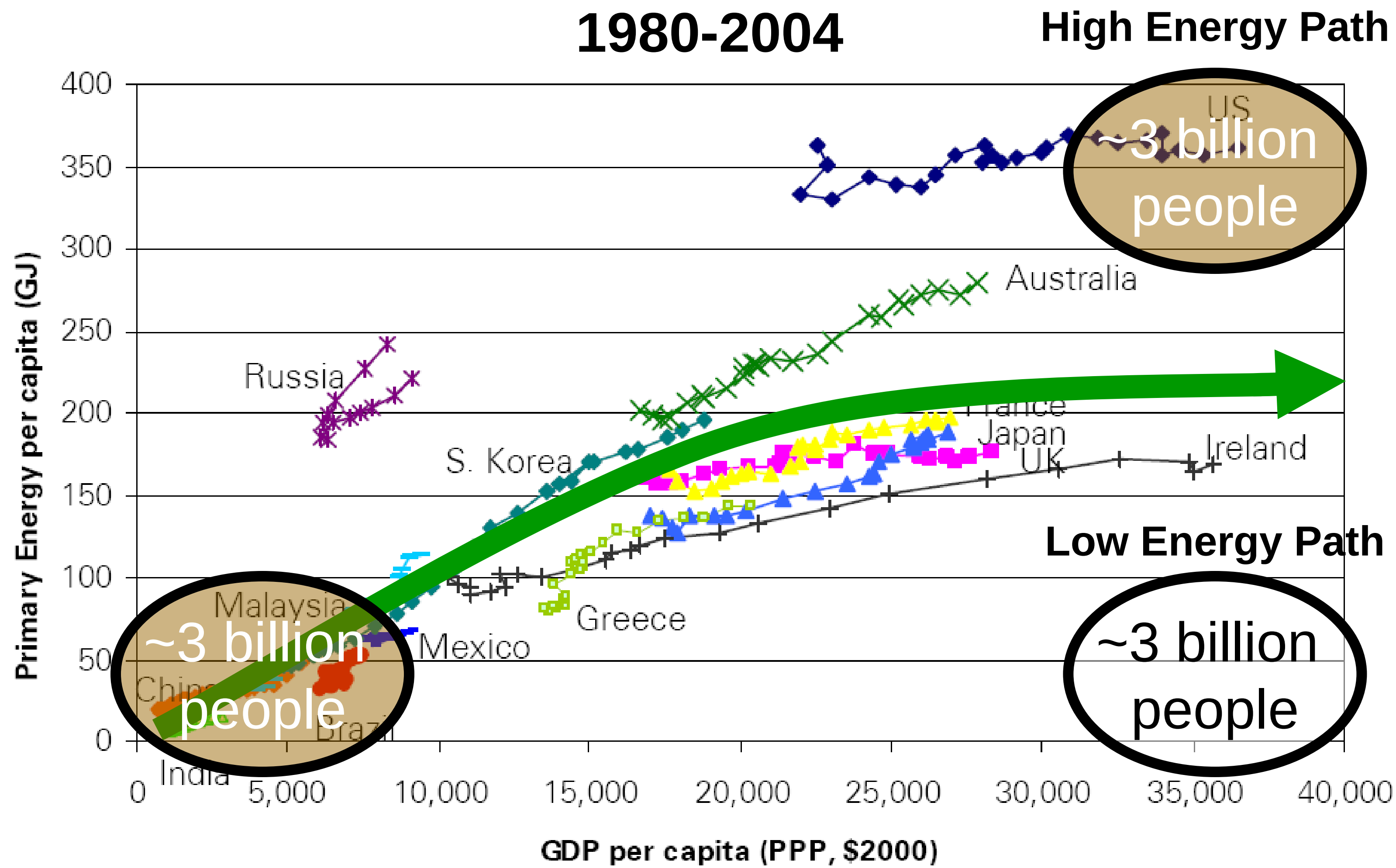
Energy Underpins Economies



Source: UN and DOE EIA
Russia data 1992-2004 only

After: Koonin, 2008

U.S. Economy and Oil Price

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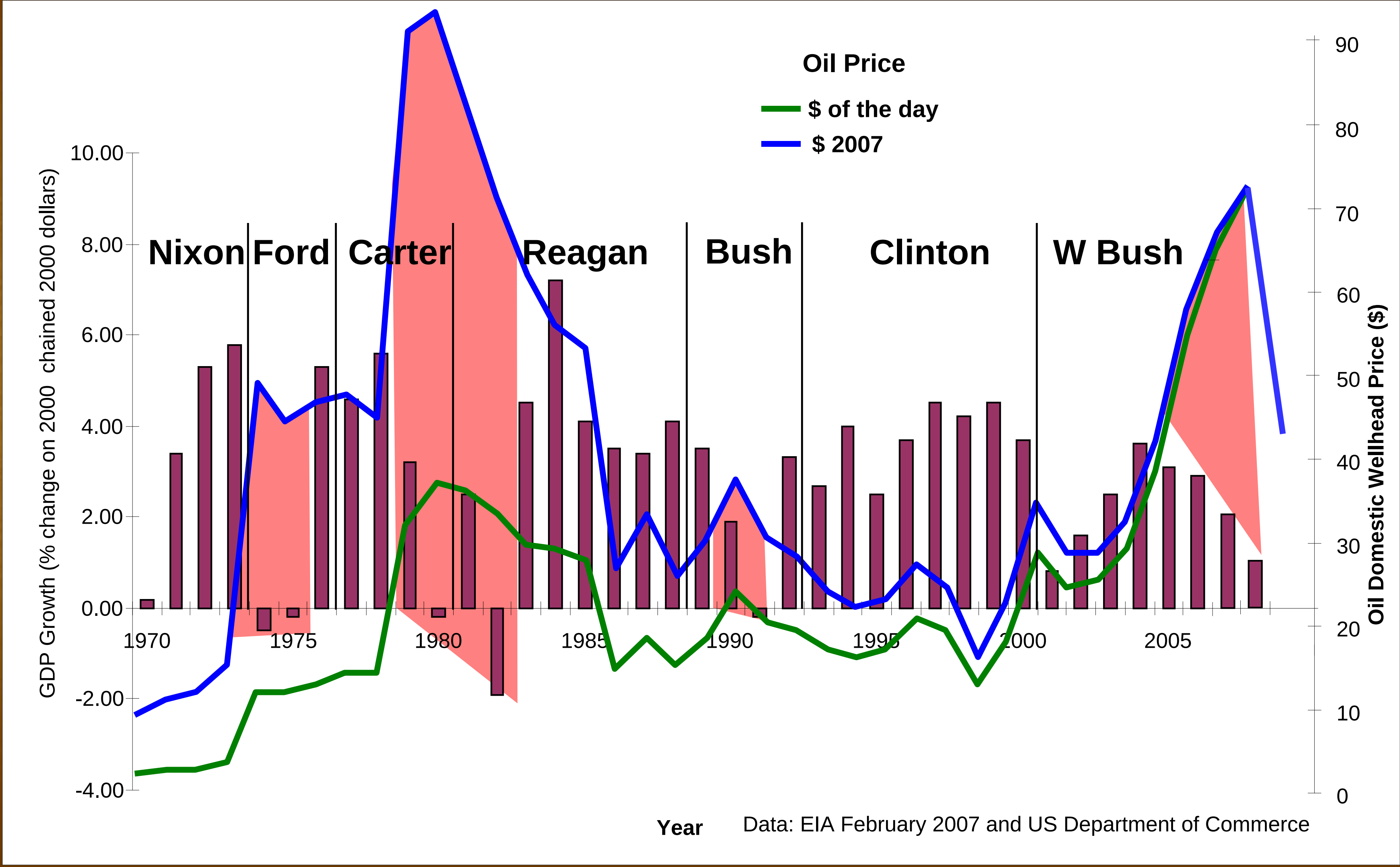

Data: EIA February 2007 and US Department of Commerce

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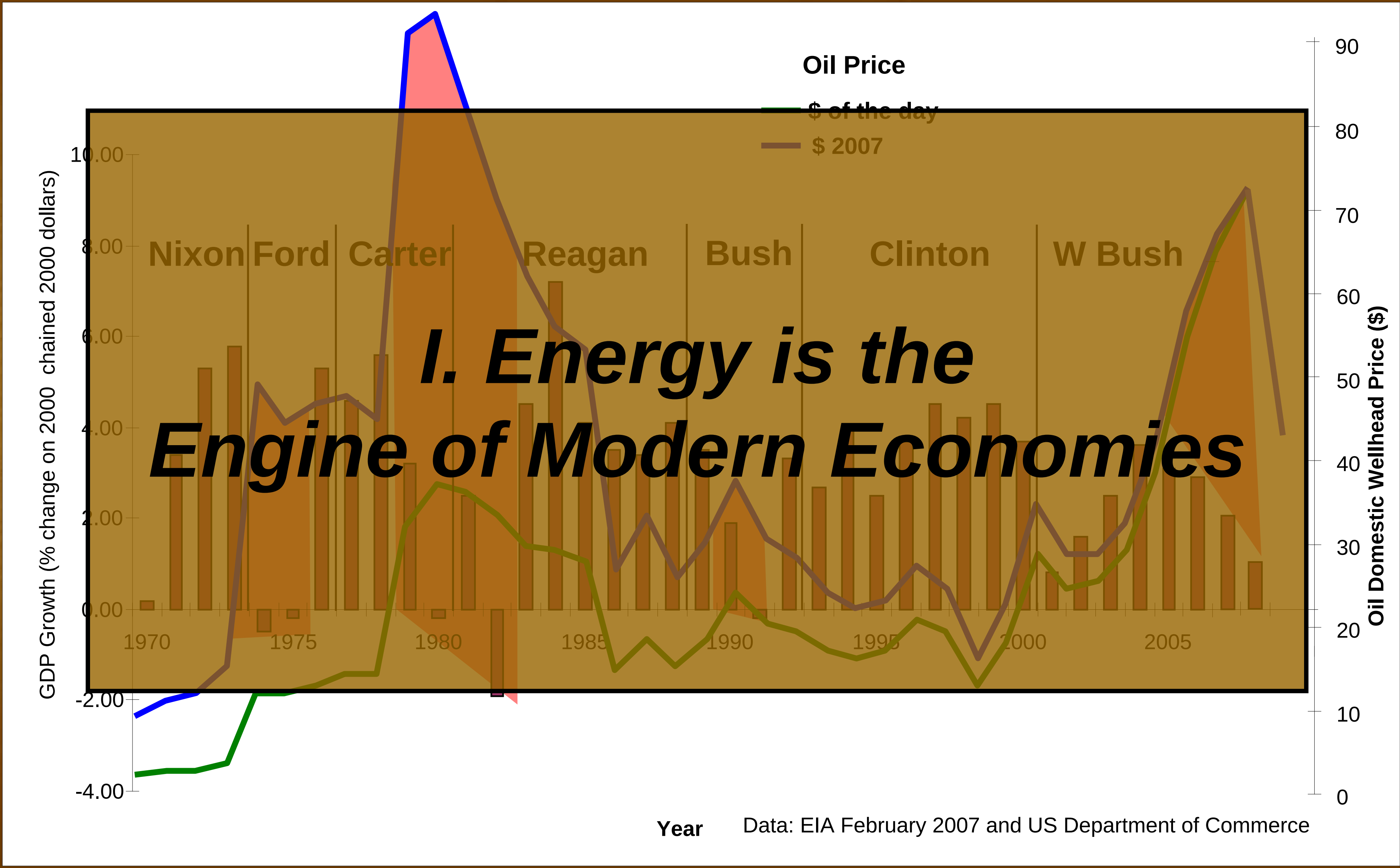
U.S. Economy and Oil Price



I. Energy is the Engine of Modern Economies

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Concepts

I. Energy is the engine of modern economies

II. **Energy transitions take time**

III. Electricity provides the opportunity to deal with carbon

IV. Build bridges for energy security

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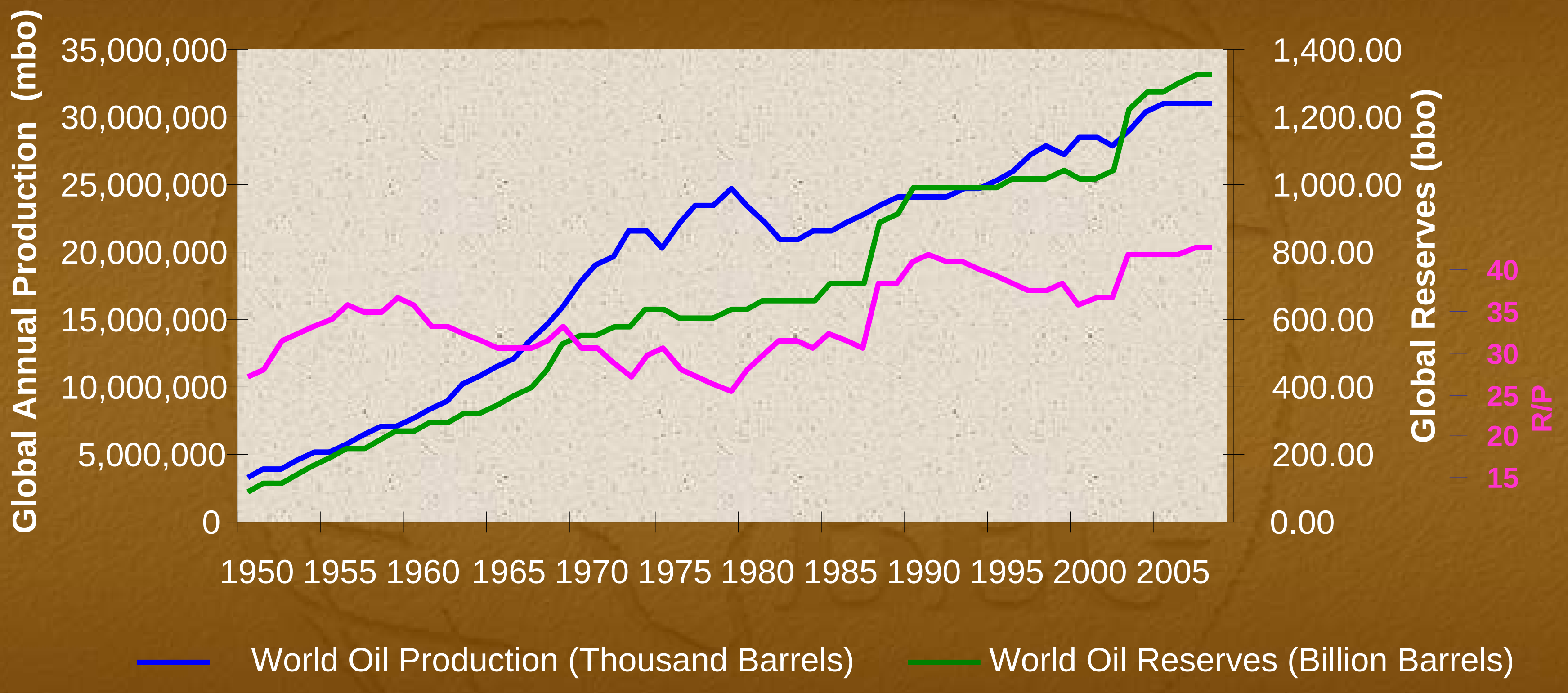
Global Oil Reserves & Production



Source: 1980-2007 Energy Information Administration As of January 2008 (www.eia.doe.gov/pub/international/iealf/crudeoilreserves.xls), 1950-1980 OPEC (http://www.opec.org/library/)

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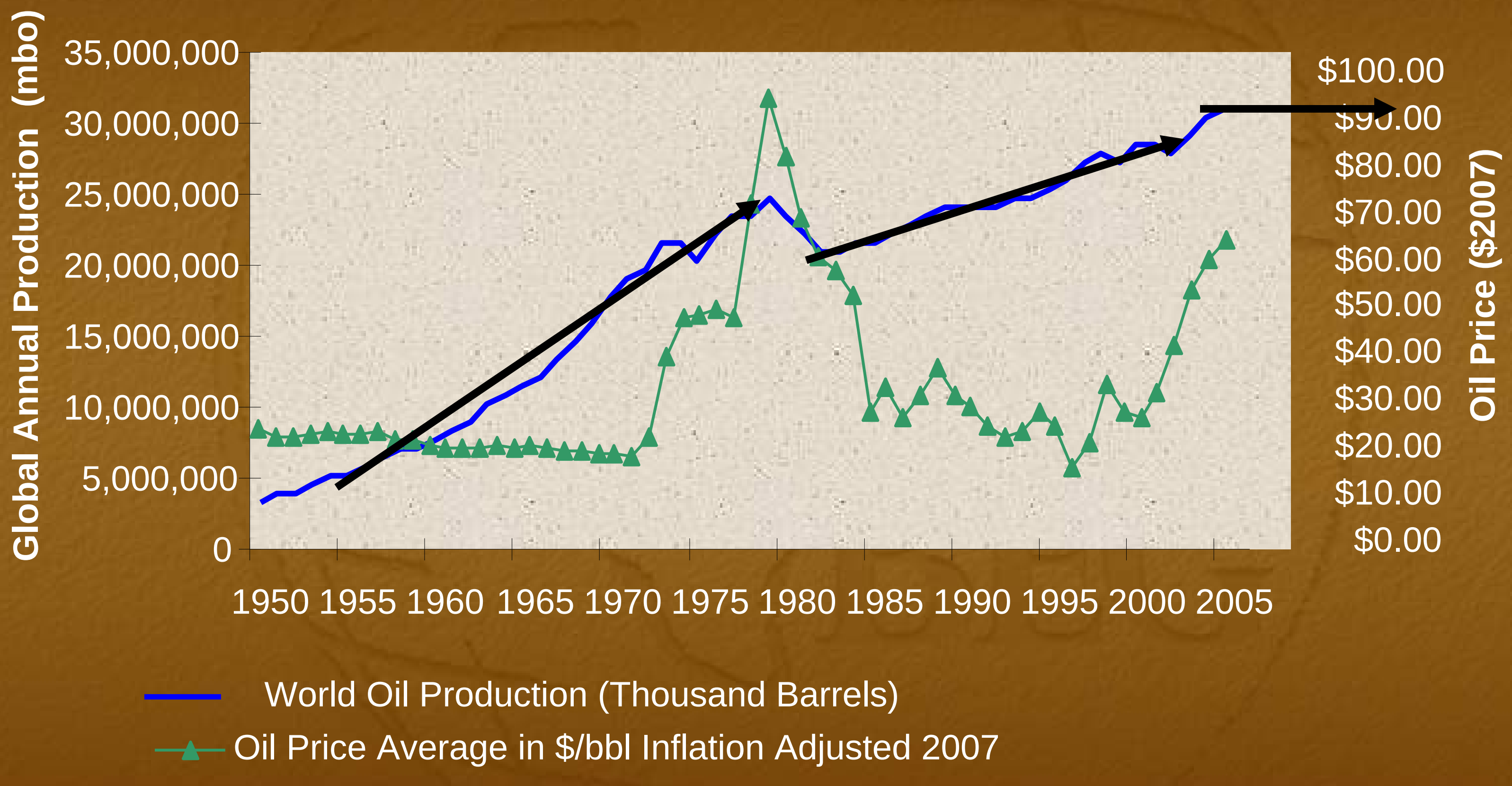
Global Oil Reserves & Production



Source: 1980-2007 Energy Information Administration As of January 2008 (www.eia.doe.gov/pub/international/iealf/crudeoilreserves.xls), 1950-1980 OPEC (http://www.opec.org/library/)

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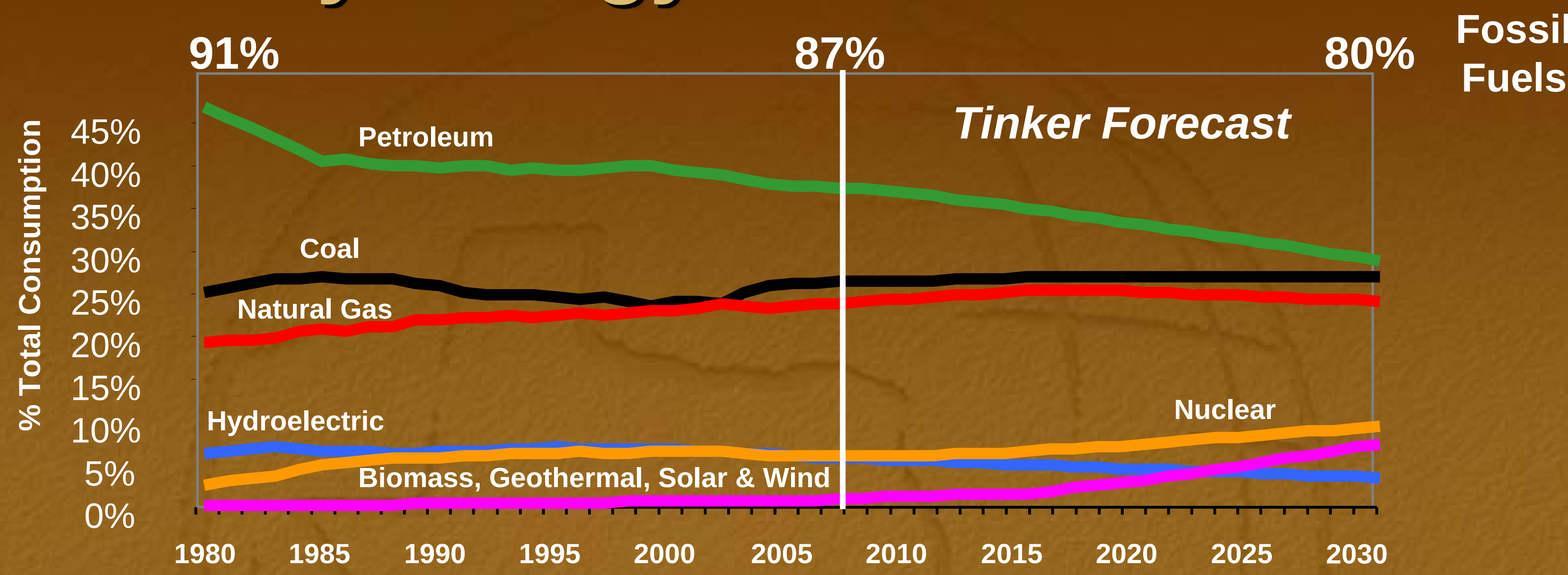
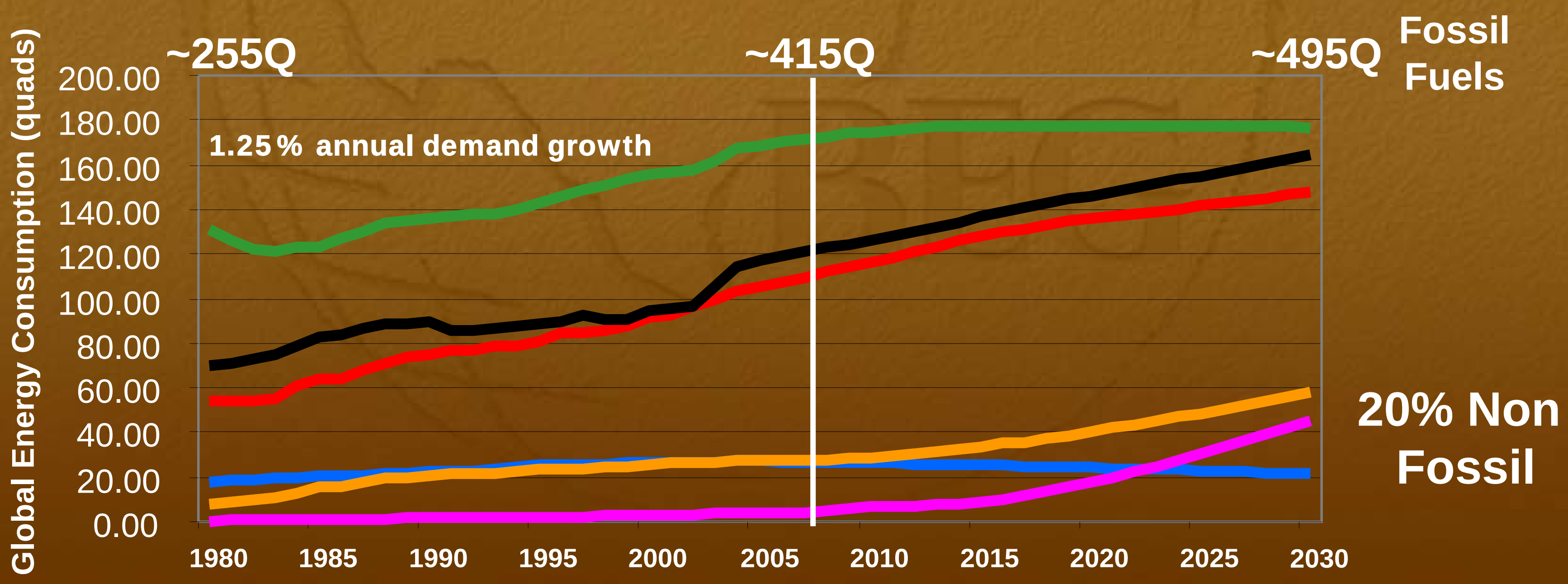
Primary Energy Demand Forecast





Historical Data: EIA October 2007

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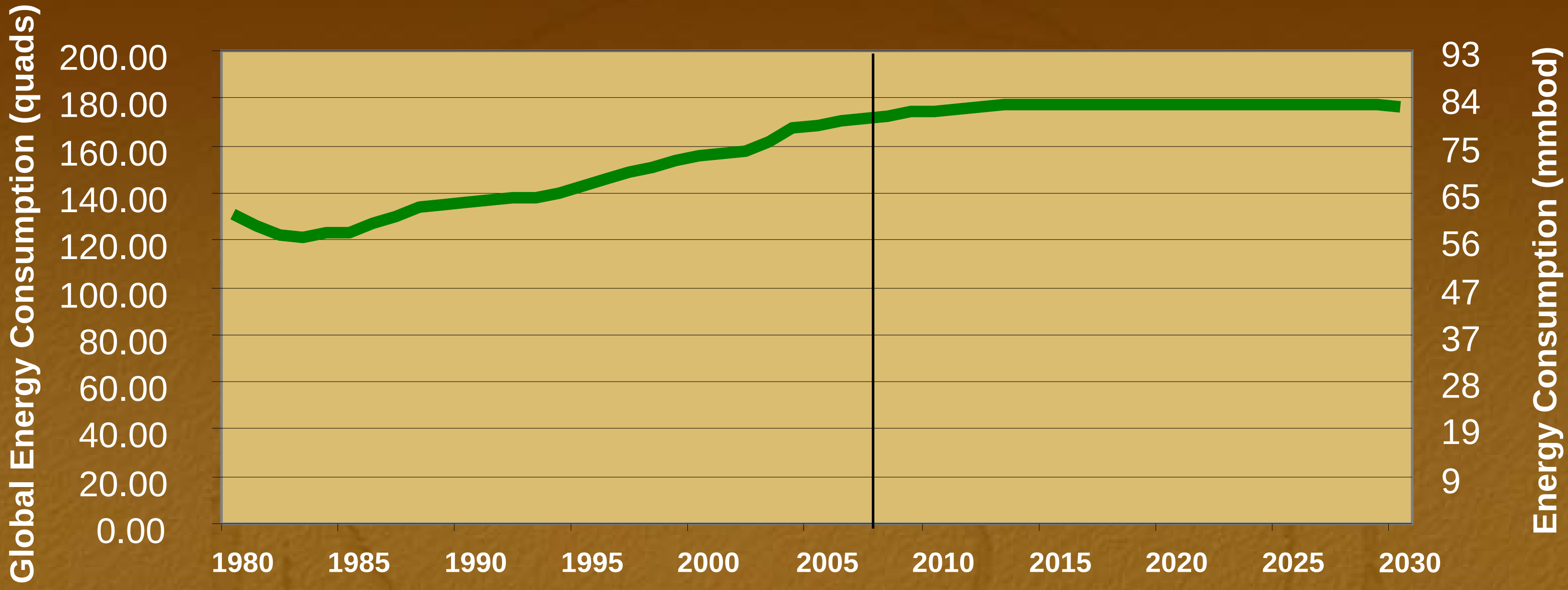
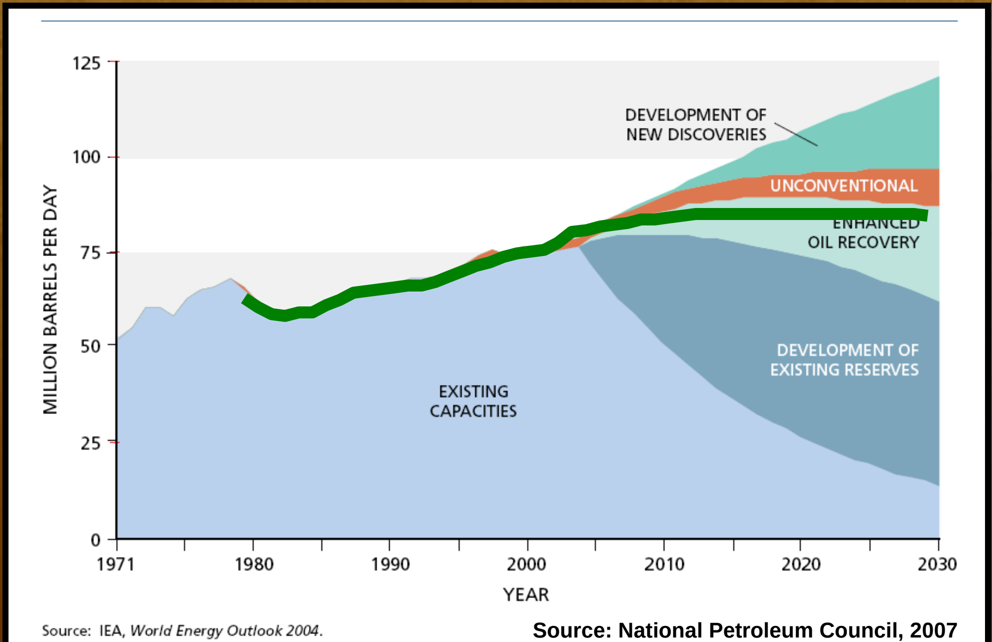
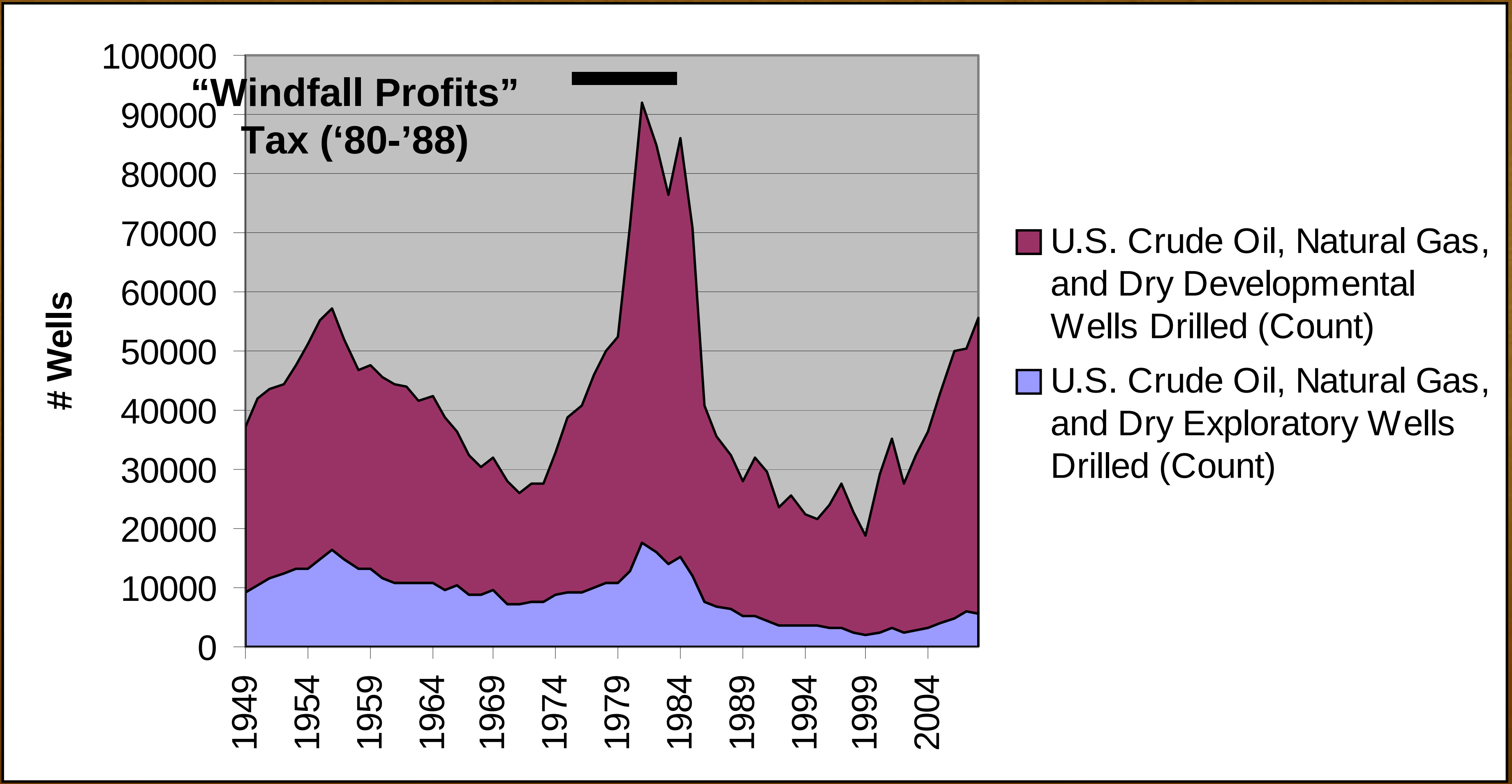
Oil Forecast





Source: National Petroleum Council, 2007

U.S. Oil and Natural Gas *Drilling Activity*



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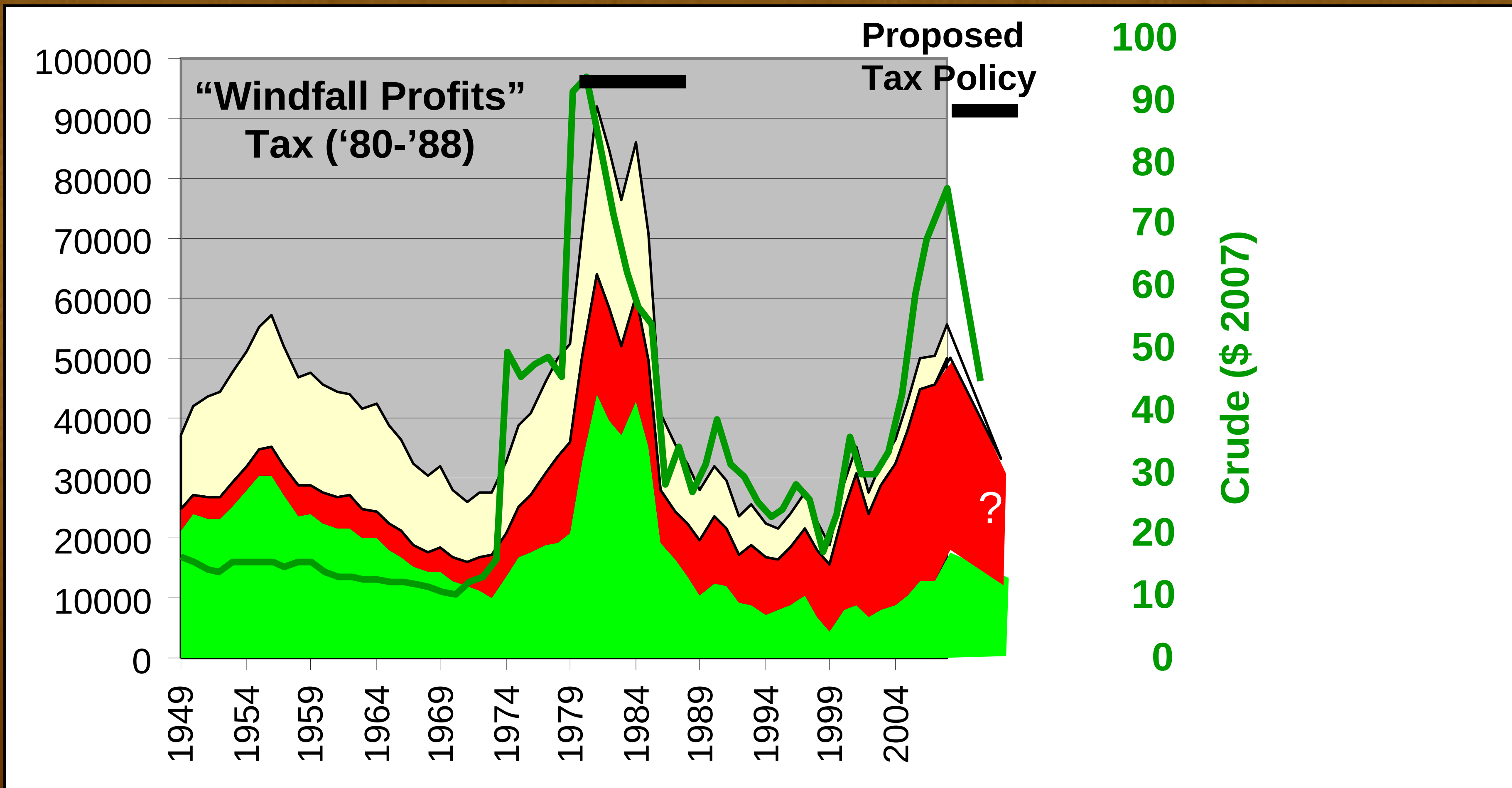
U.S. Oil and Natural Gas
Drilling Activity



Natural Gas Forecast

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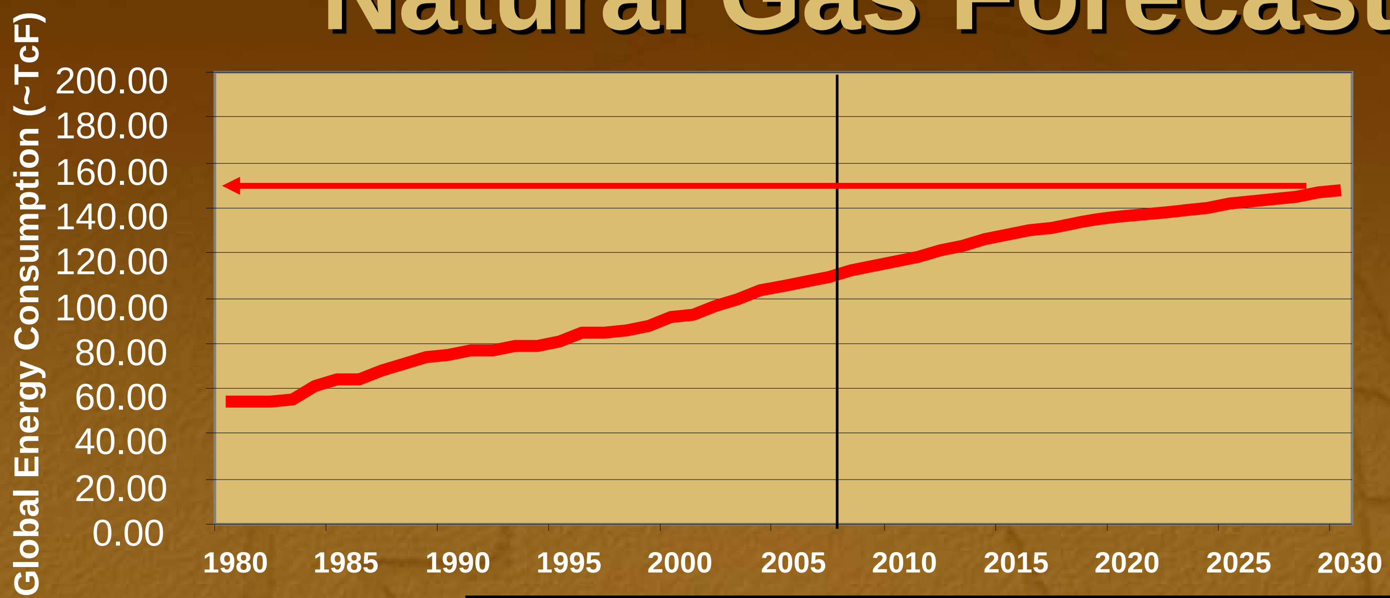
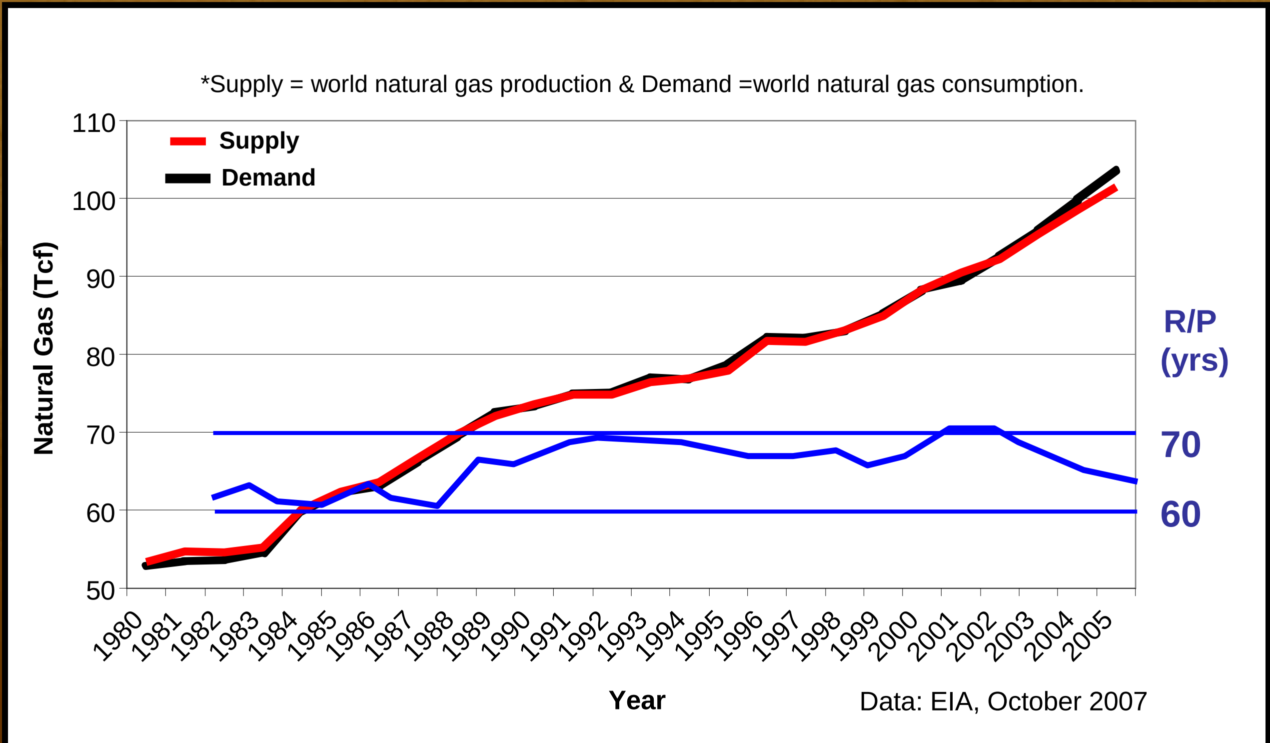
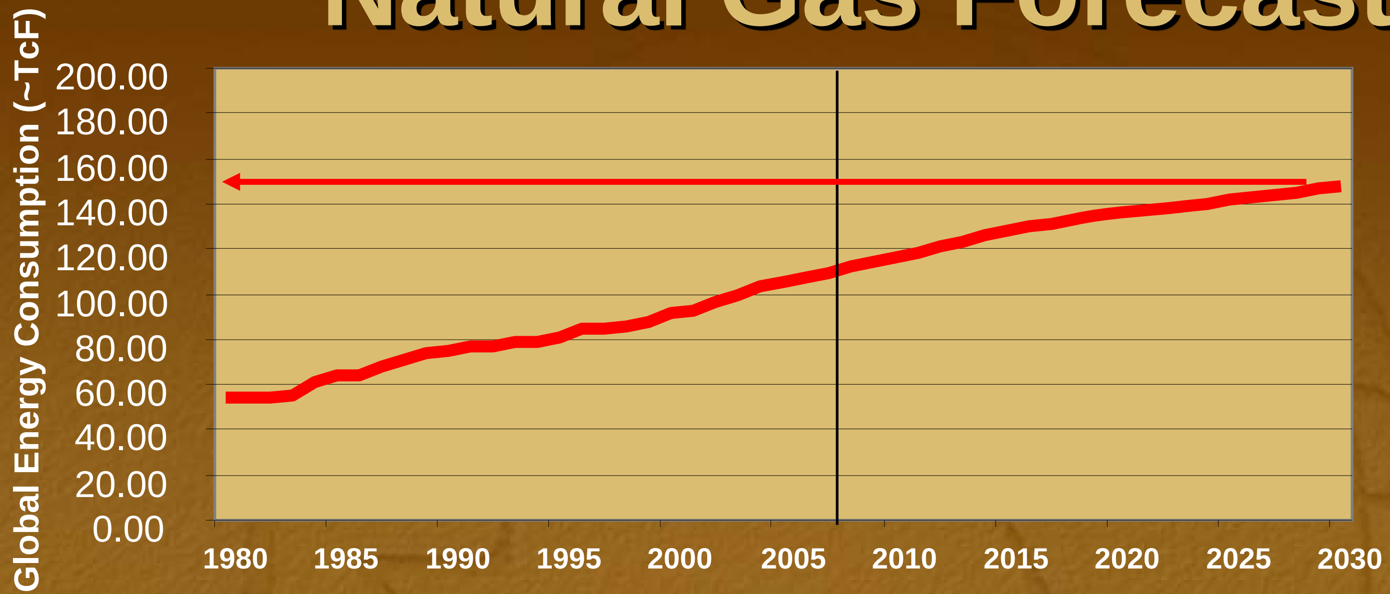




Source: SPE Paper 68755,
National Petroleum Council, 2007

Natural Gas Forecast

Tinker, 2009



32,560 TcF resources

~ 200 years resources at 150 TcF year

Region	Coalbed Methane	Shale Gas	Gas in Tight Sands	Total
North America	3,017	3,840	1,371	8,228
Latin America	39	2,116	1,293	3,448
Western Europe	157	509	353	1,019
Central and Eastern Europe	118	39	78	235
Former Soviet Union	3,957	627	901	5,485
Middle East and North Africa	0	2,547	823	3,370
Sub-Saharan Africa	39	274	784	1,097
Centrally Planned Asia and China	1,215	3,526	353	5,094
Pacific	470	2,312	705	3,487
Other Asia Pacific	0	313	549	862
South Asia	39	0	196	235
World	9,051	16,103	7,406	32,560

Source: SPE Paper 68755, National Petroleum Council, 2007

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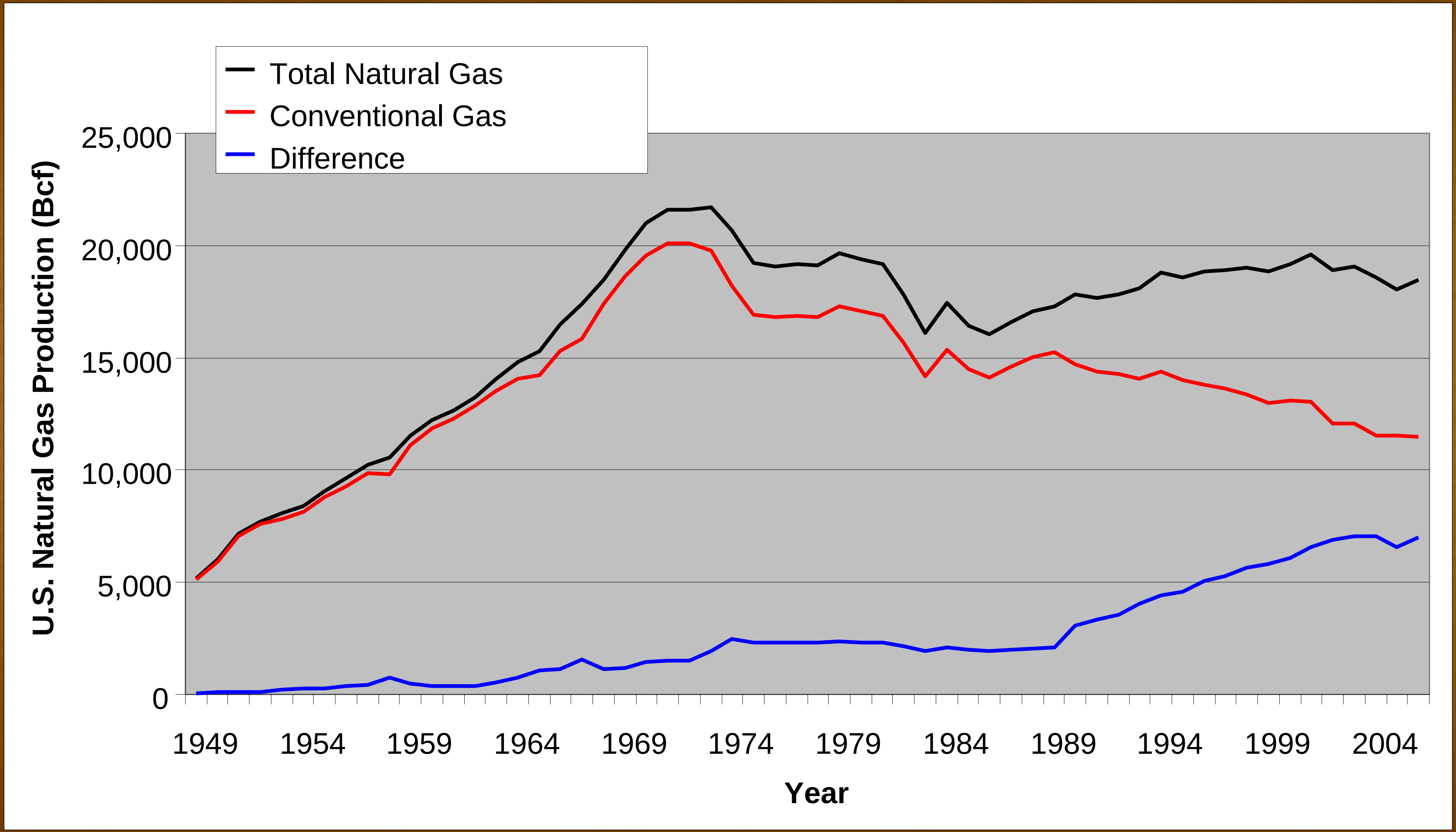
U.S. Natural Gas Production



Conventionals: EIA (1949-1990) and NPC (1991-2015)
Unconventionals: 1970-1988 data from GRI, 1999. Updated data from 1989-2005 is from EIA, 2007

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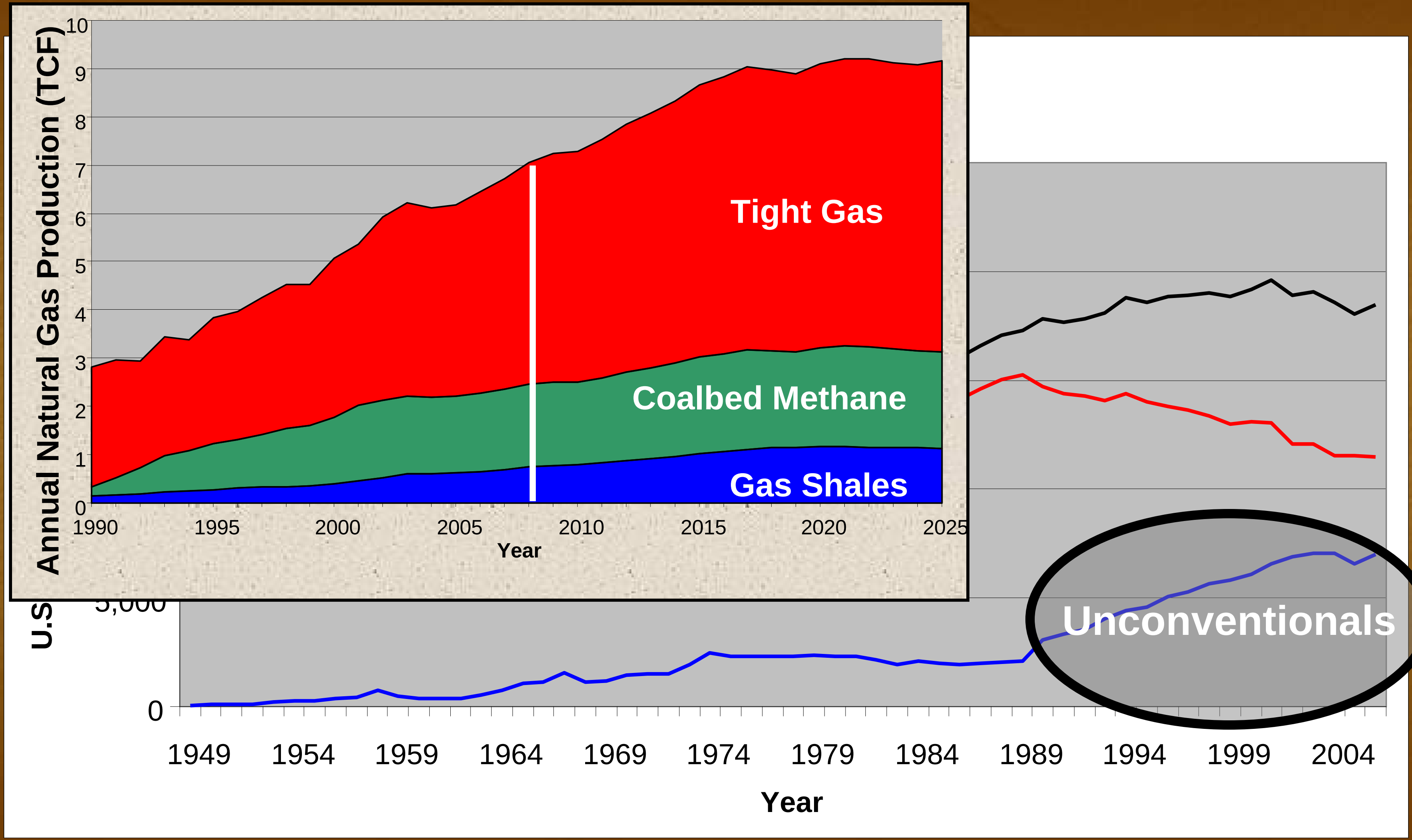
U.S. Natural Gas Production



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Shale Gas Pores

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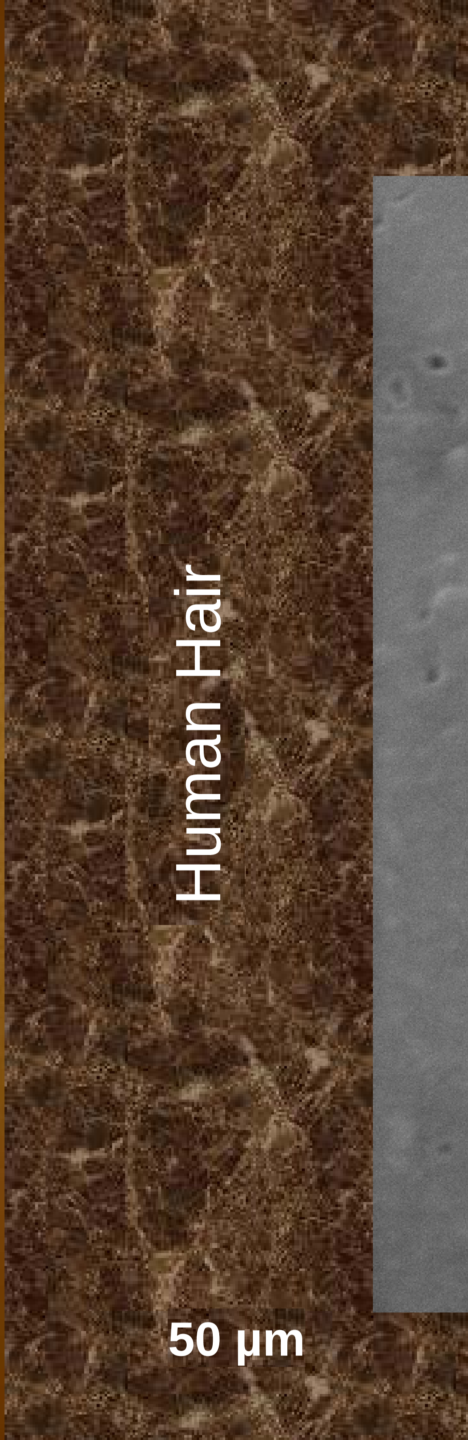

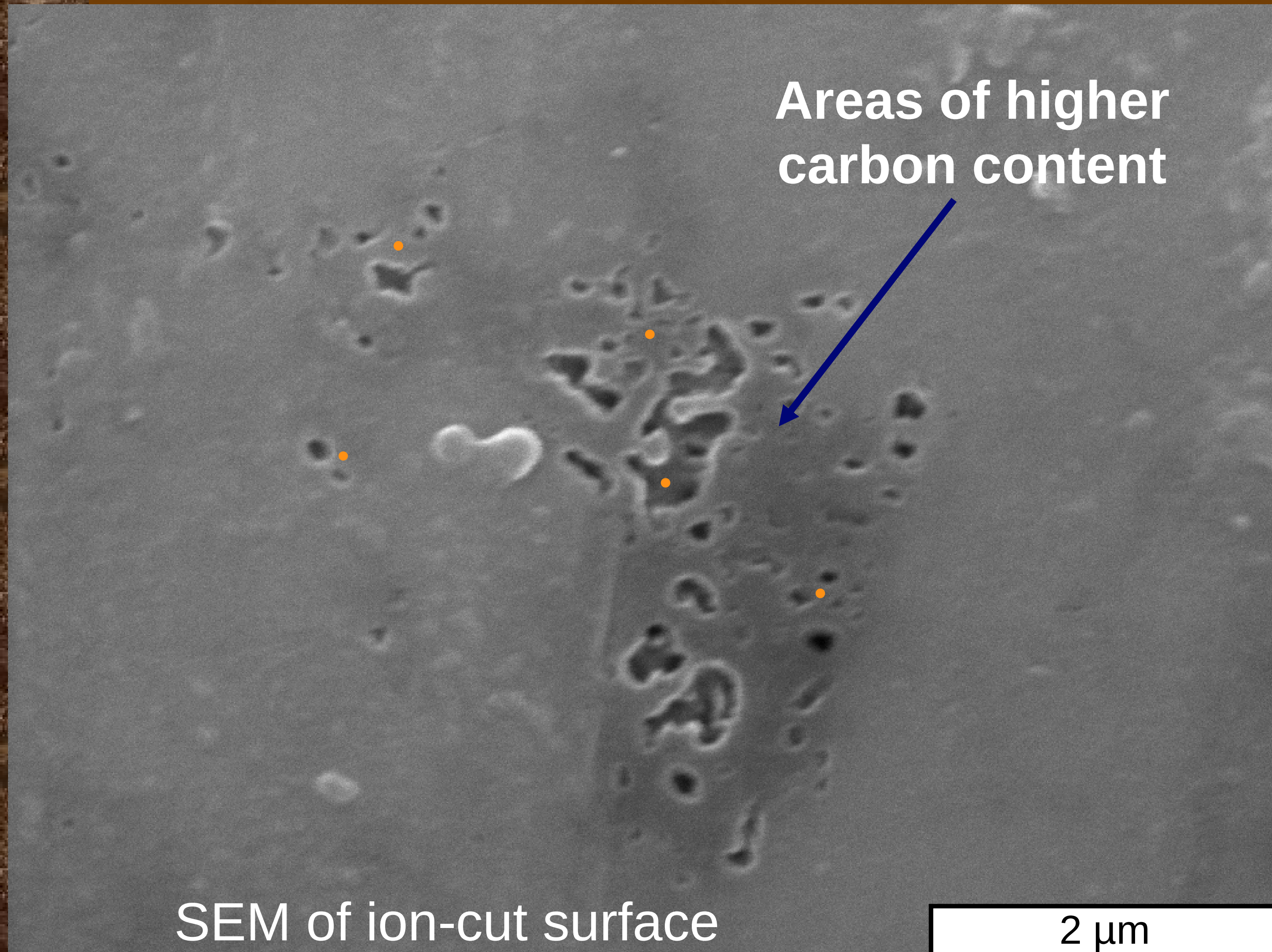

SEM from Reed and Loucks

Blakely Well, 7,111’

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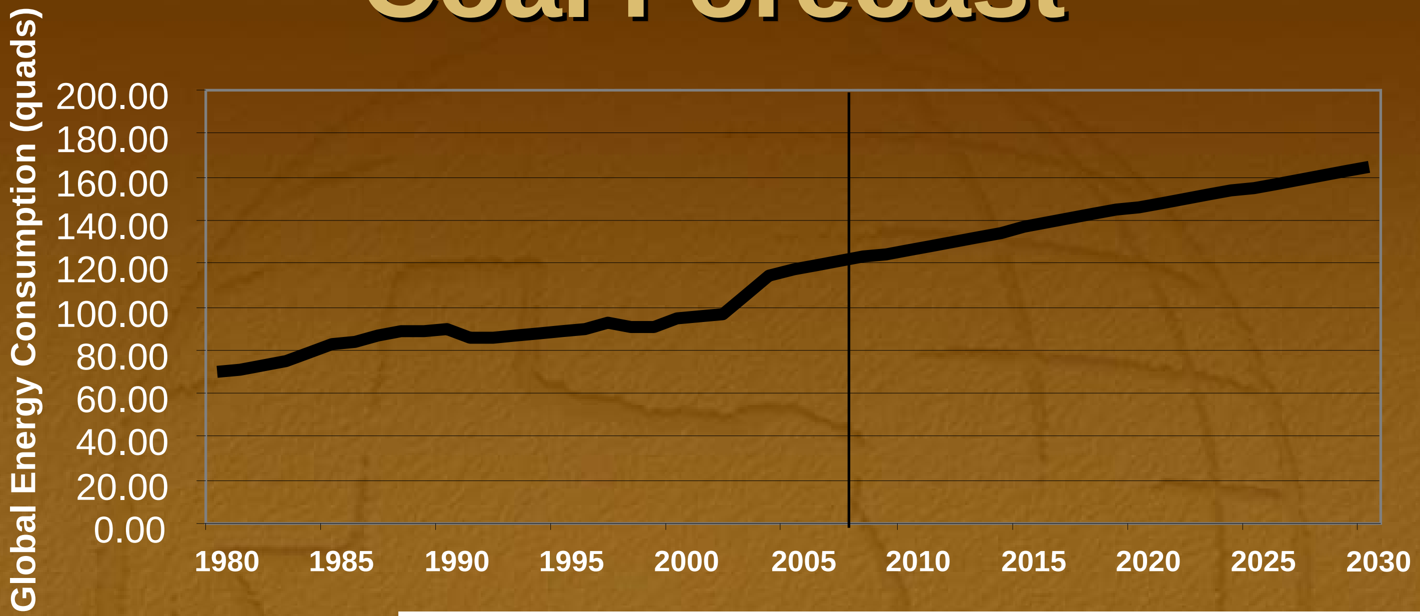
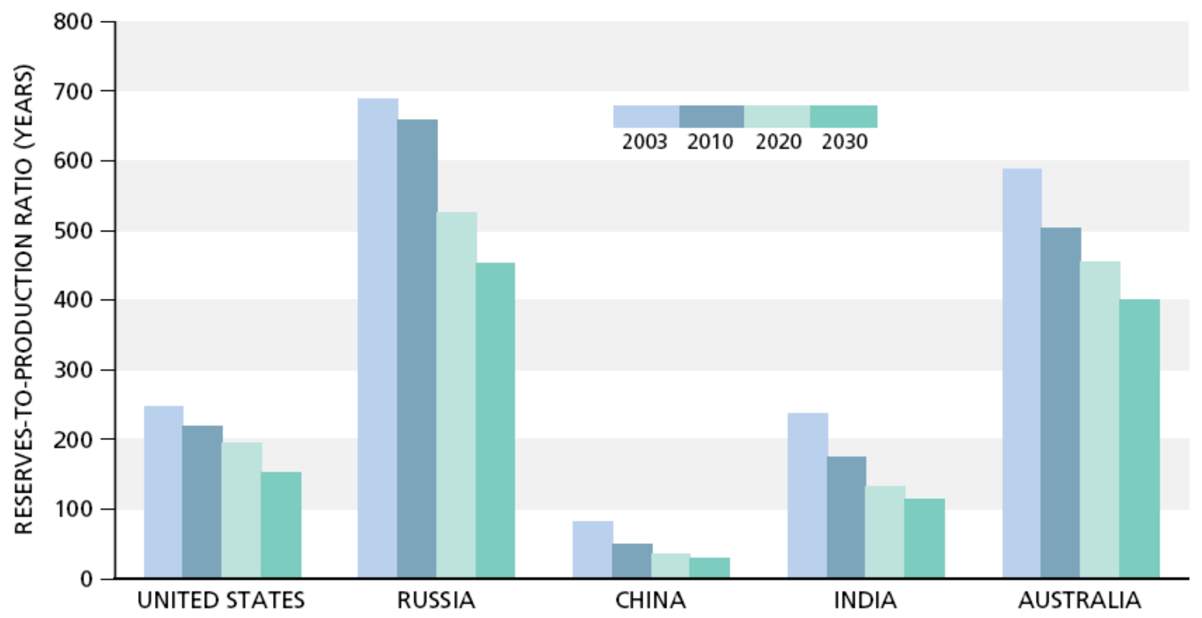
Coal Forecast





Sources: World Energy Council 2006; and Energy Information Administration, *International Energy Outlook 2006*.

Source:
National Petroleum Council, 2007

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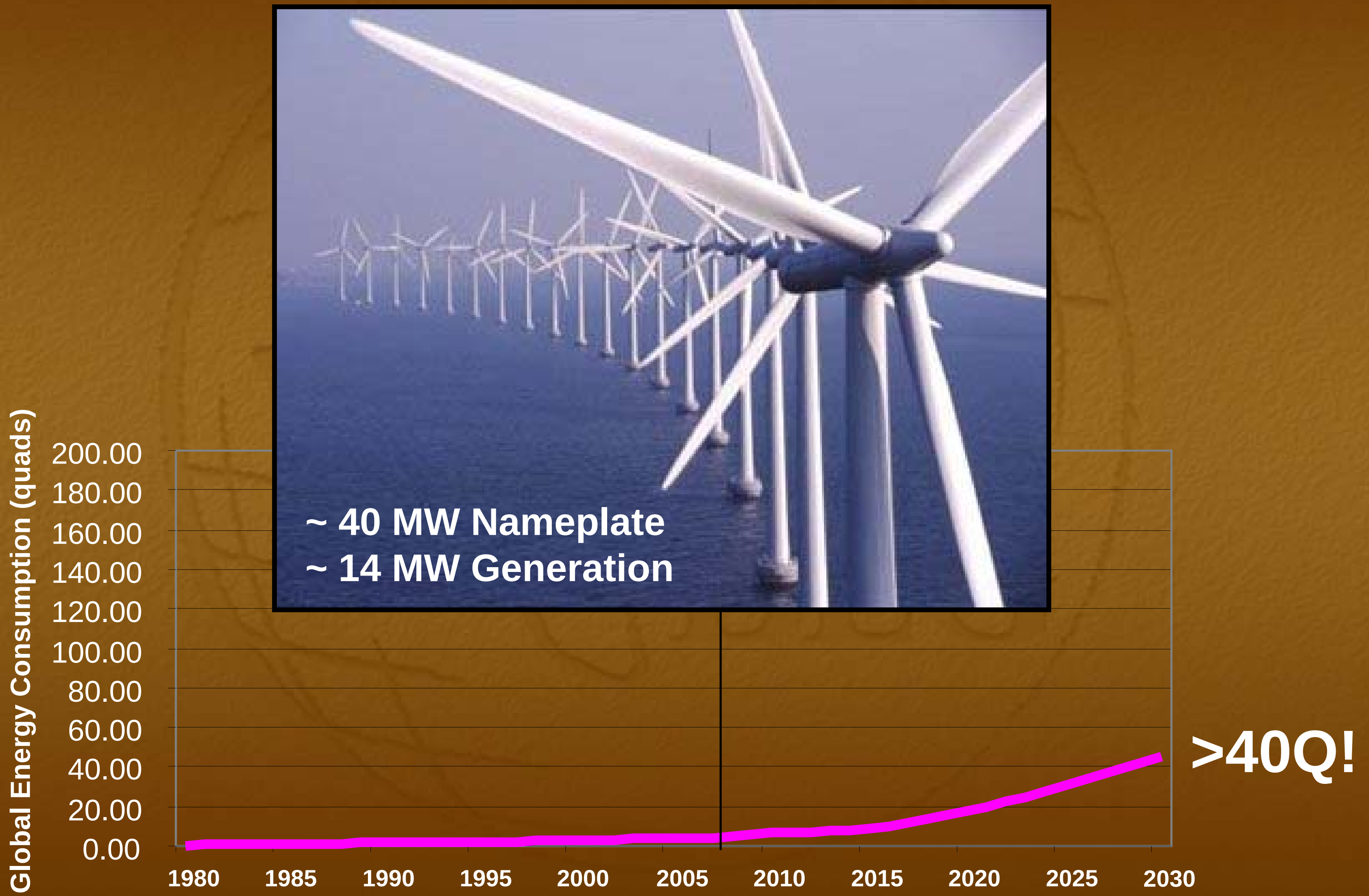
Renewables Forecast



Historical Data: EIA October 2007

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One Large Coal Power Plant

San Gorgonio Pass Wind Farm, California

619 MW Nameplate ~ 216 MW Generation

Horse Hollow Wind Energy Center, Texas

291 1.5 MW and 130 2.3 MW turbines

47,000 acres (190 km^2)

735.5 MW nameplate ~ 258 MW Generation

One Large Coal Plant ~ Four Horse Hollows

47,000 * 4 = 188,000 acres = 294 sq mi

Chicago = 228 square miles

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With Current Technology

~25,000 Offshore 4 MW Turbines

~100,800 MW *Nameplate*

35% Capacity Factor

~35,000 MW Actual

~ 1 Quad

(~170,000,000 BOE)

2008 U.S. Wind Capacity

~22,000 MW *Nameplate*

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Renewables Forecast

42 Q !

~ 7% of 2030 Global Energy Demand

~ 17% of 2030 Electricity Demand

II. Energy Transitions Take Time

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Concepts

I. Energy is the engine of modern economies

II. Energy transitions take time

III. **Electricity provides the opportunity to deal with carbon**

IV. Build bridges for energy security

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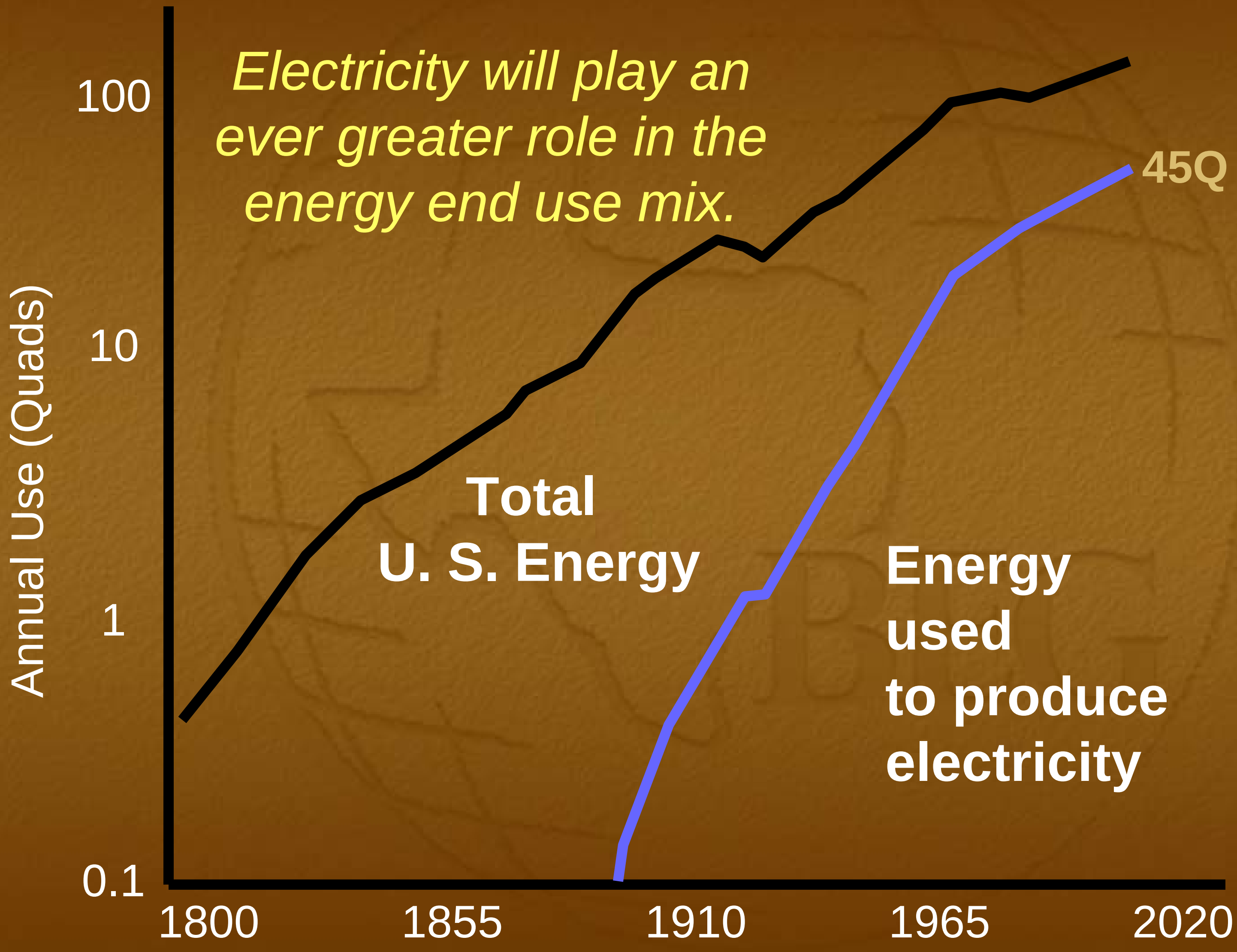
Electricity's Role



After Huber and Mills, 2005.
Data: EIA, Annual Review, 2003. US Census Bureau, Historical Statistics of the US Colonial Ties to 1970

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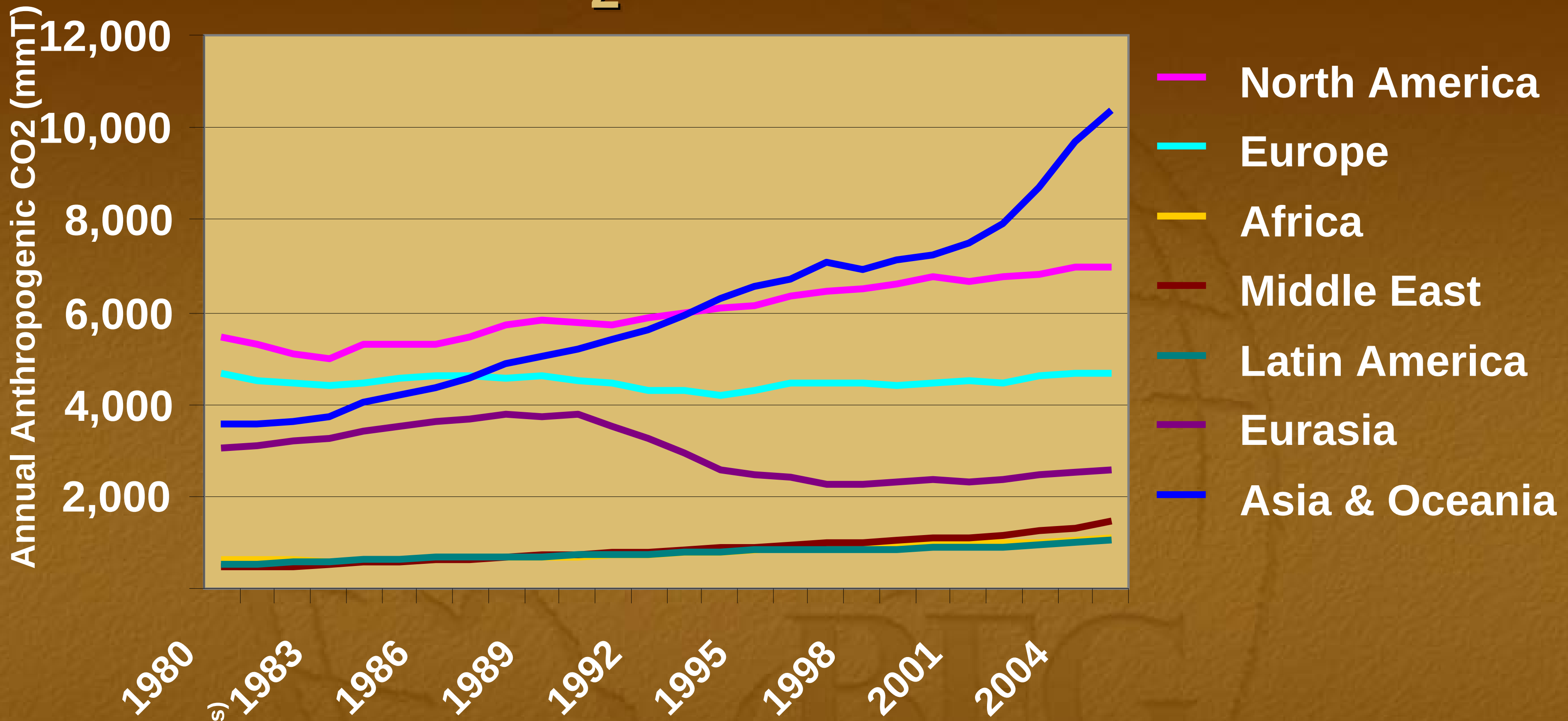
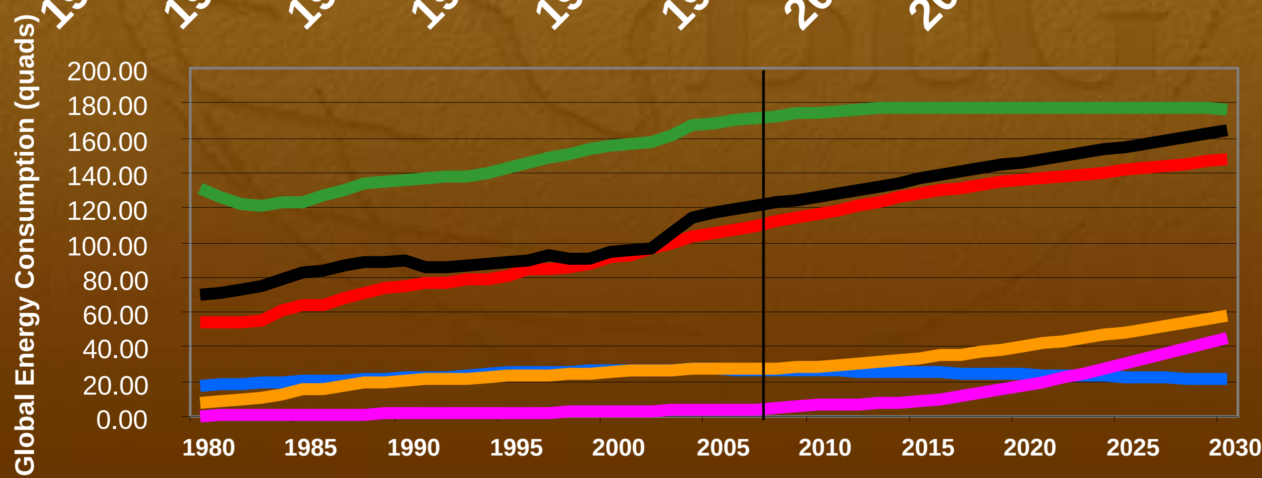
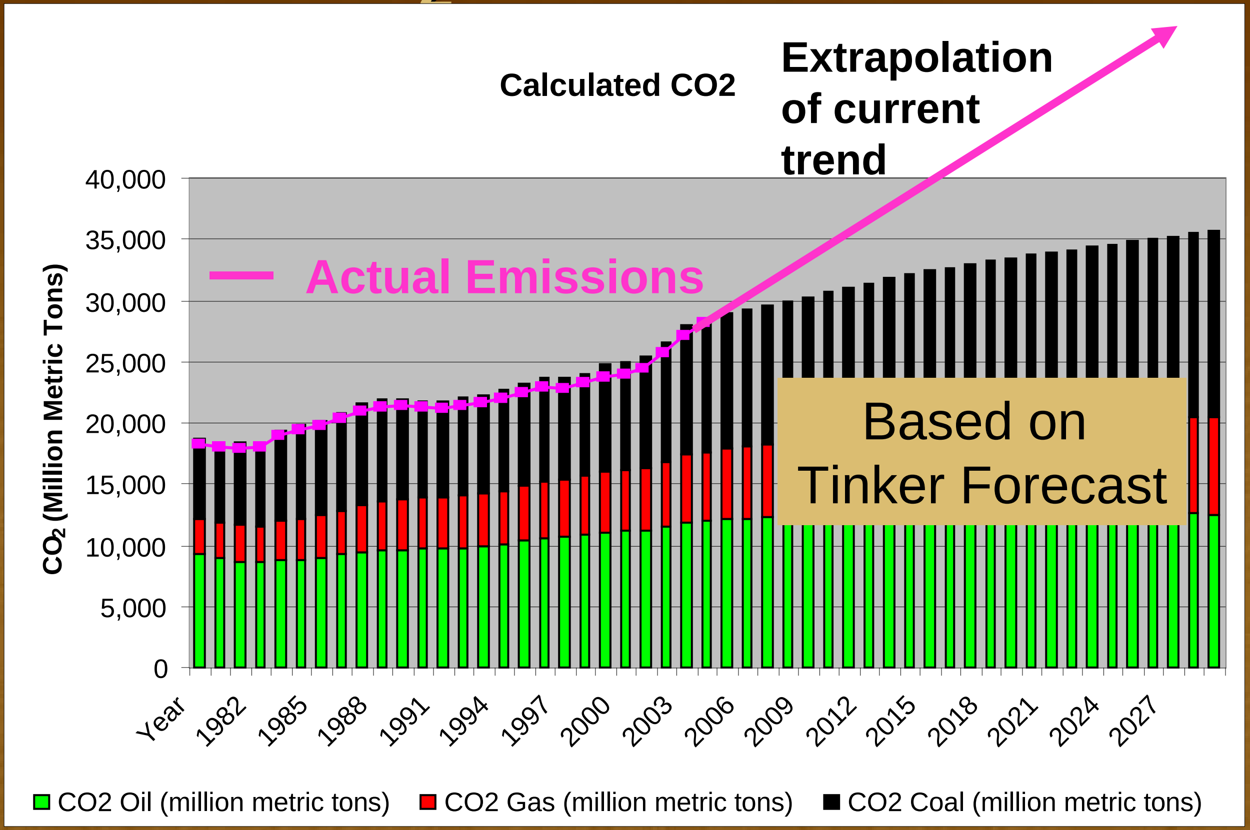
CO_2 Emissions

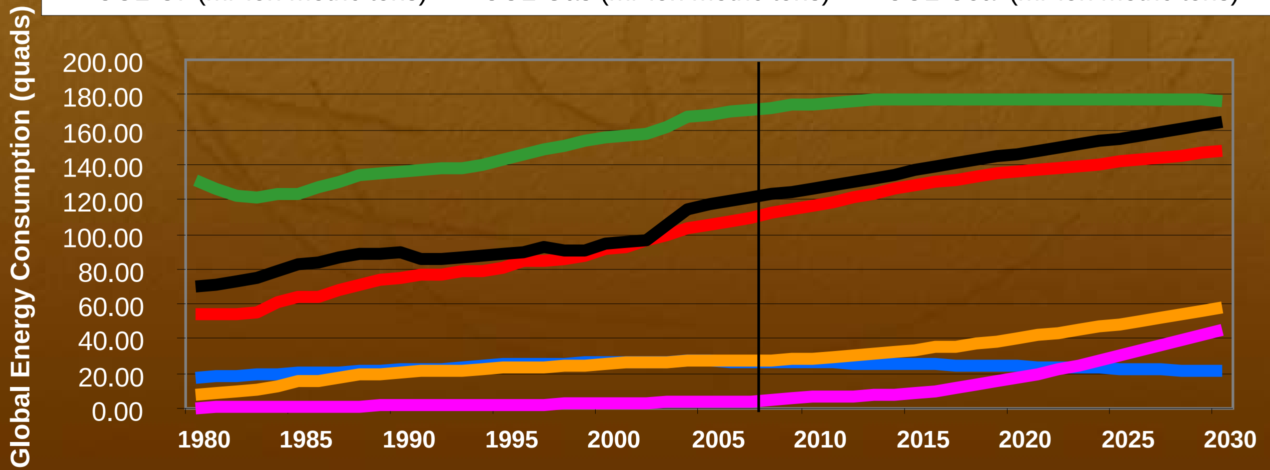




Historical Data: EIA October 2007

CO_2 Emissions





Historical Data: EIA October 2007

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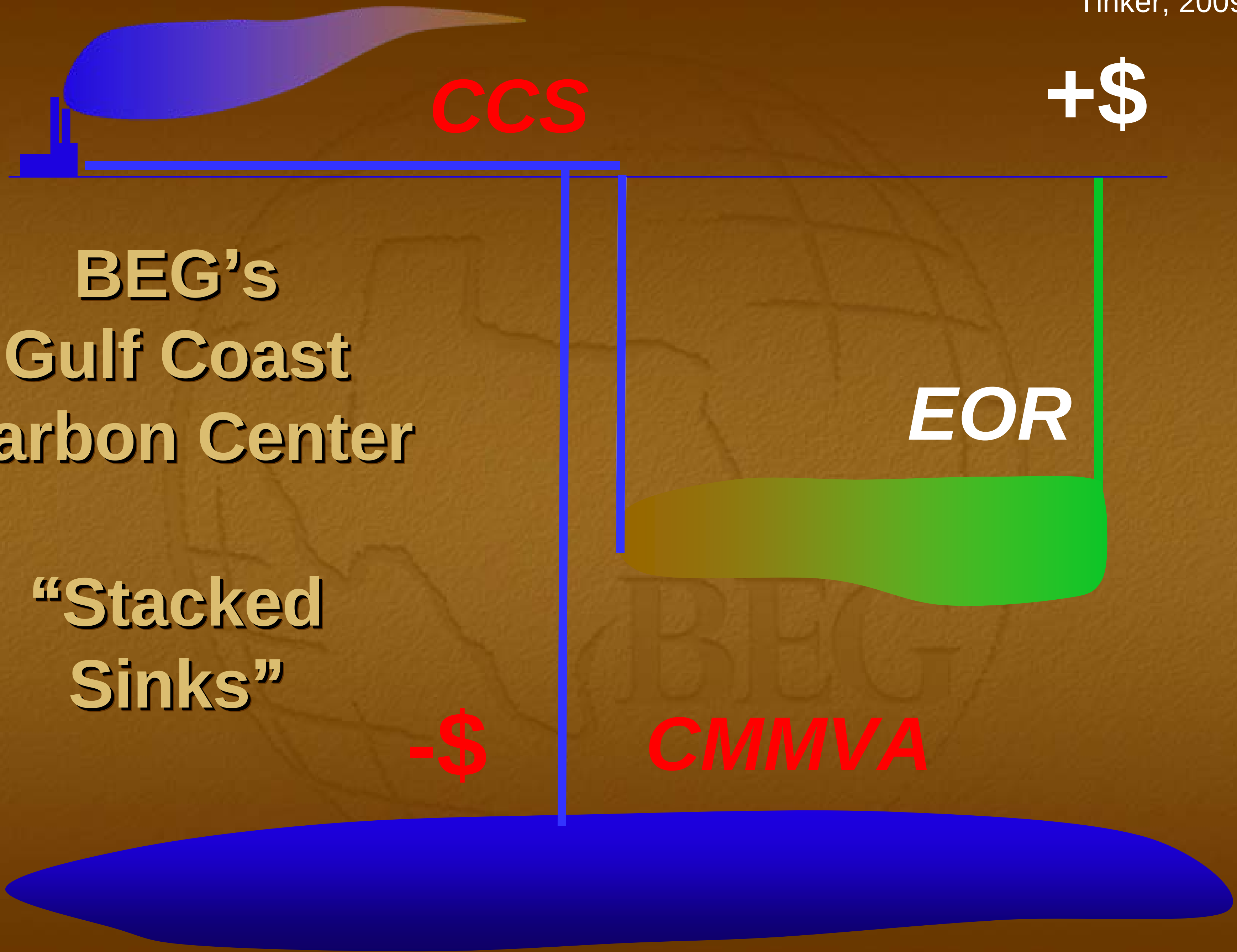
BEG's Gulf Coast Carbon Center

"Stacked Sinks"



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Electricity Options

- Efficiency
  - Fuel, lighting, electronics, insulation
  - *Challenge: Rebound effect*
- Natural Gas
  - Abundant, reliable, price volatile, and cleaner
  - *Challenges: Global deliverability (LNG) and Access*
- Coal
  - Abundant, reliable, cheap, and dirty
  - *Challenge: Sequestration (IGCC w/CCS), financing, public perception*
- Nuclear
  - Abundant, reliable, moderately priced, and cleaner
  - *Challenges: Waste disposal, security, public perception*
- Alternatives
  - Cleaner, less reliable, and more expensive
  - *Challenge: Capacity impacts cost and reliability*

Electricity Options

III. Electricity Provides the Opportunity to Deal with Carbon

A Grand Challenge: Electricity Storage and Transmission

Concepts

I. Energy is the engine of modern economies

II. Energy transitions take time

III. Electricity provides the opportunity to deal with carbon

IV. **Build bridges for energy security**

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Parameters for Energy Security

- **Available**
- **Affordable**
- **Reliable**
- **Clean**

Policy for Energy Security

- Increased **Efficiency**
- **Diversify** the global energy portfolio
- Improved energy **Infrastructure**
- **Carbon Price** that is transparent, economy-wide, global, not wasteful. Cap and Trade is none of these.
- Strengthen global **Energy Trade**
- **Dialog** between Developed and Developing Nations
- Balance global **Workforce Demographics**
- Global **Policy** that engages Energy, Economy and Environment

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Key Global Bridges for Energy Security

- **Energy, Economy, Environment**
- **Industry, Government, Academe**
- **Developed and Developing Nations**

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Summary Concepts

I. Energy is the engine of modern economies

- fossil fuels provide 87 % of today's energy

II. Energy transitions take time

- fossil fuels are the stable bridge to an alternate-energy future
- pace of change is limited by scale

III. Electricity use is growing

- Provides the opportunity to deal with carbon

IV. Build bridges for energy security

Respect those who seek the truth, but be wary of those who claim to have found it…

Mark Twain