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# Global Crude Oil and Natural Gas: Geology, Geography, and Geopolitics

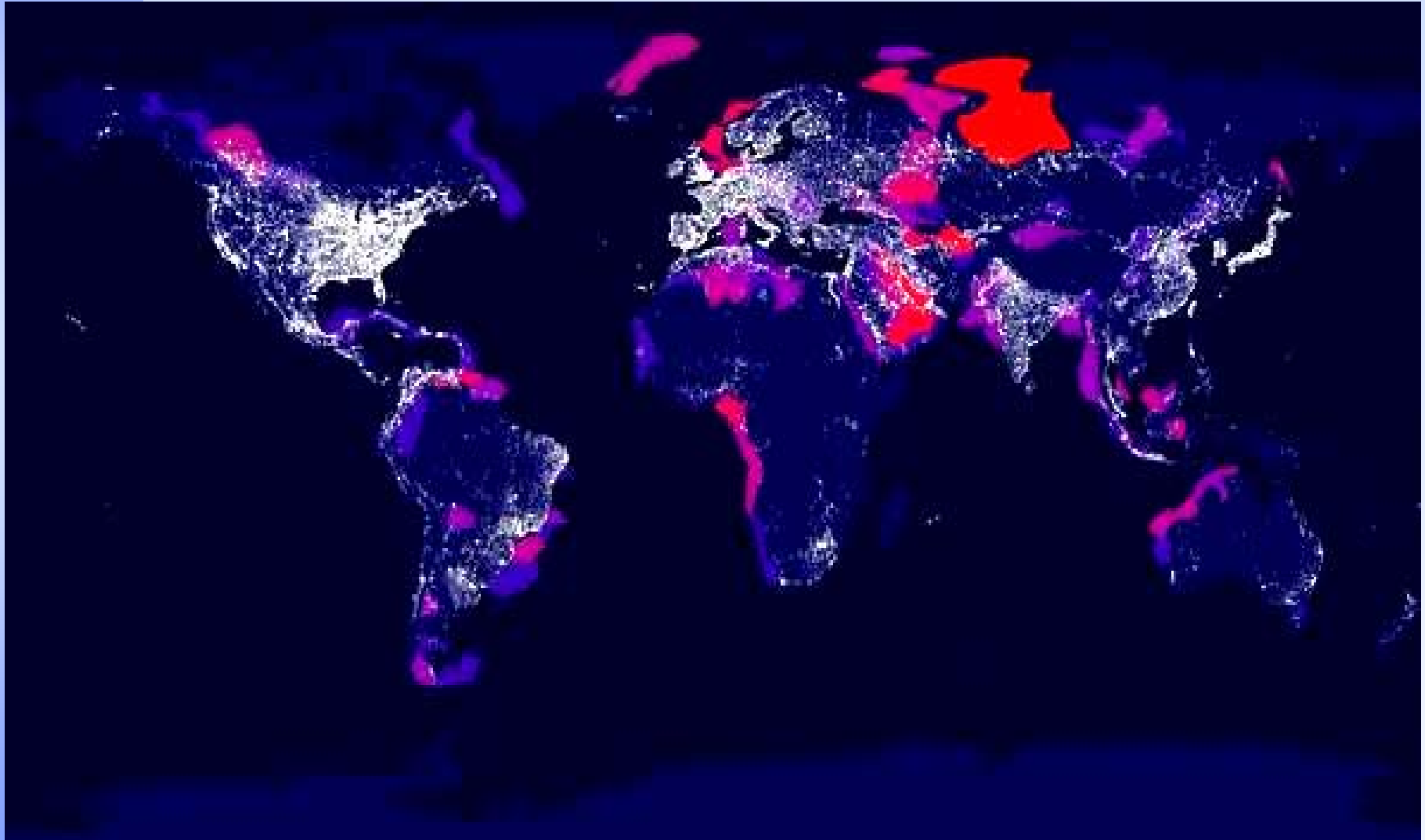
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Geology dictates that oil and gas come from historically volatile regions.



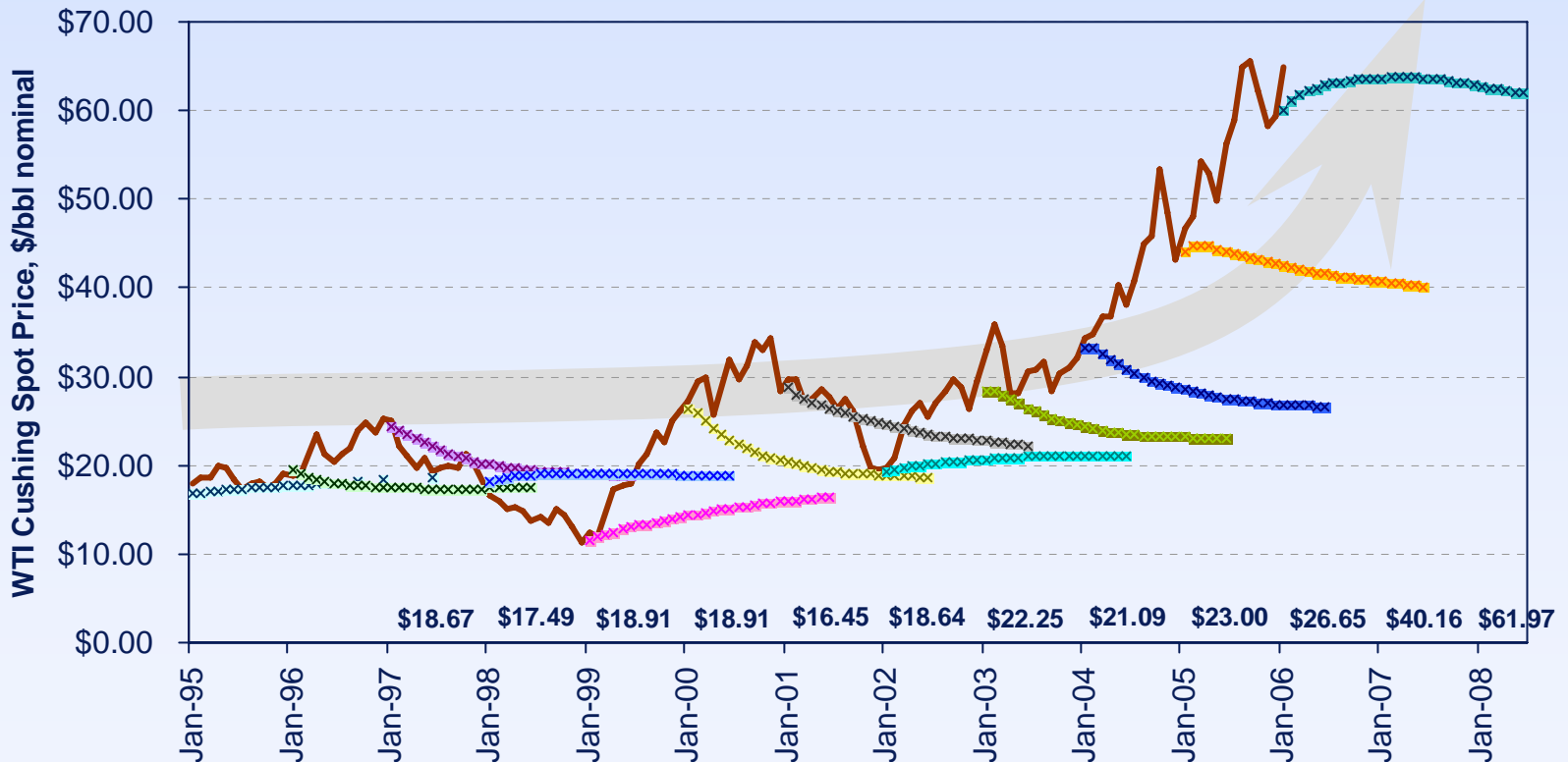


# Some Facts about Crude Oil Markets



# Current State: High Crude Prices

- Crude prices have risen substantially since late 1999
  - ◆ WTI largely traded in the \$20 range throughout the 1990s
  - ◆ WTI has since risen to more than \$70 per barrel
    - ❖ 2005 average = \$56.64
    - ❖ January 2006 = \$64.95; Currently in the mid \$70s.



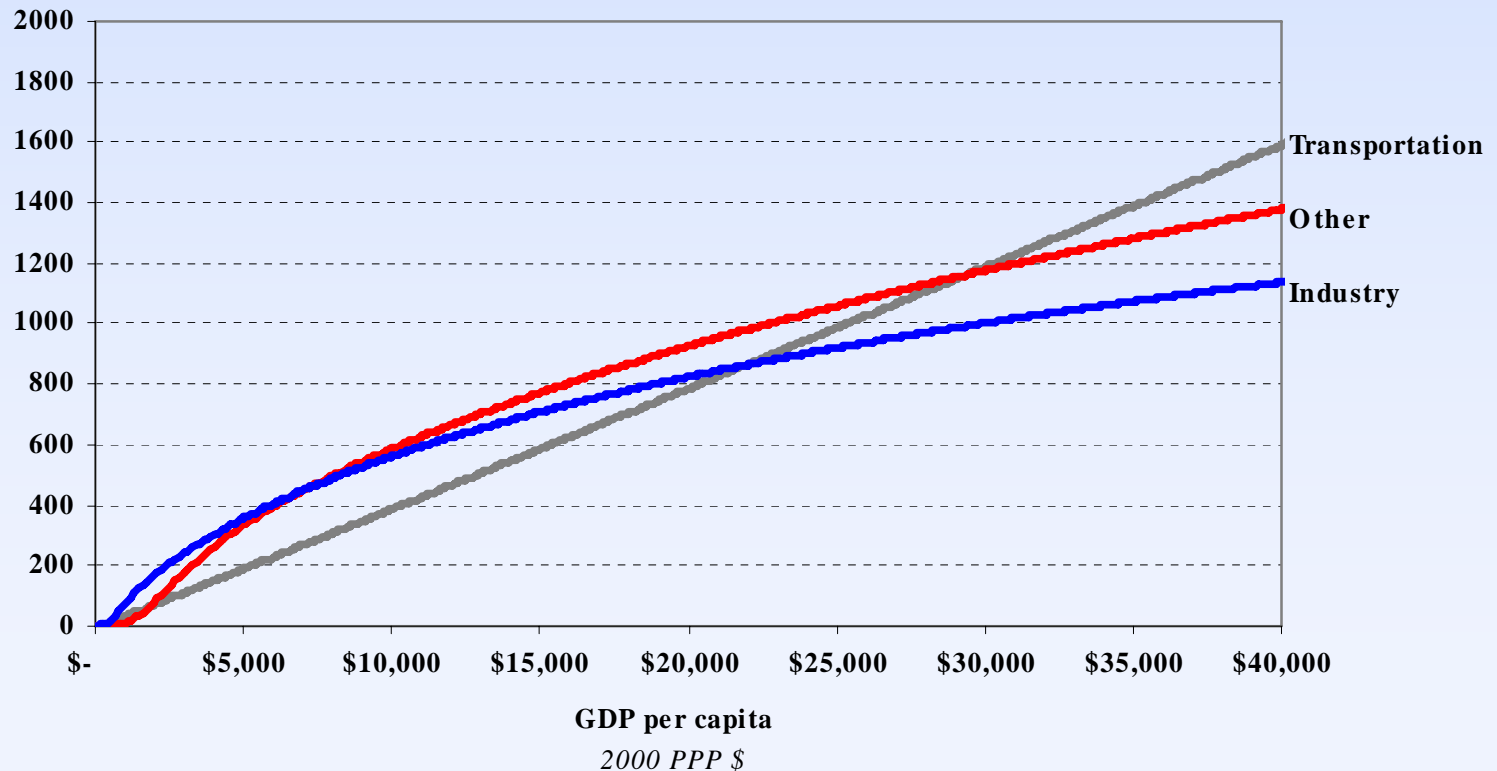
Source: slide from "Geopolitics in Oil and Gas", Jaffe and Medlock (2006), presentation to the Dallas Federal Reserve Bank



# Demand and Economic Growth

- Energy use tends to rise with per capita income, but intensity of use tends to decline. However, the transportation sector continues to grow (at least beyond what has been observed). Thus, oil demand will continue to climb.
- China and India are at the lower end of this scale ... the U.S. and E.U. are at the top end. Will China and India look like the U.S. or the E.U.?

Units: mtoe



Source: BIPP research (Medlock, 2005)

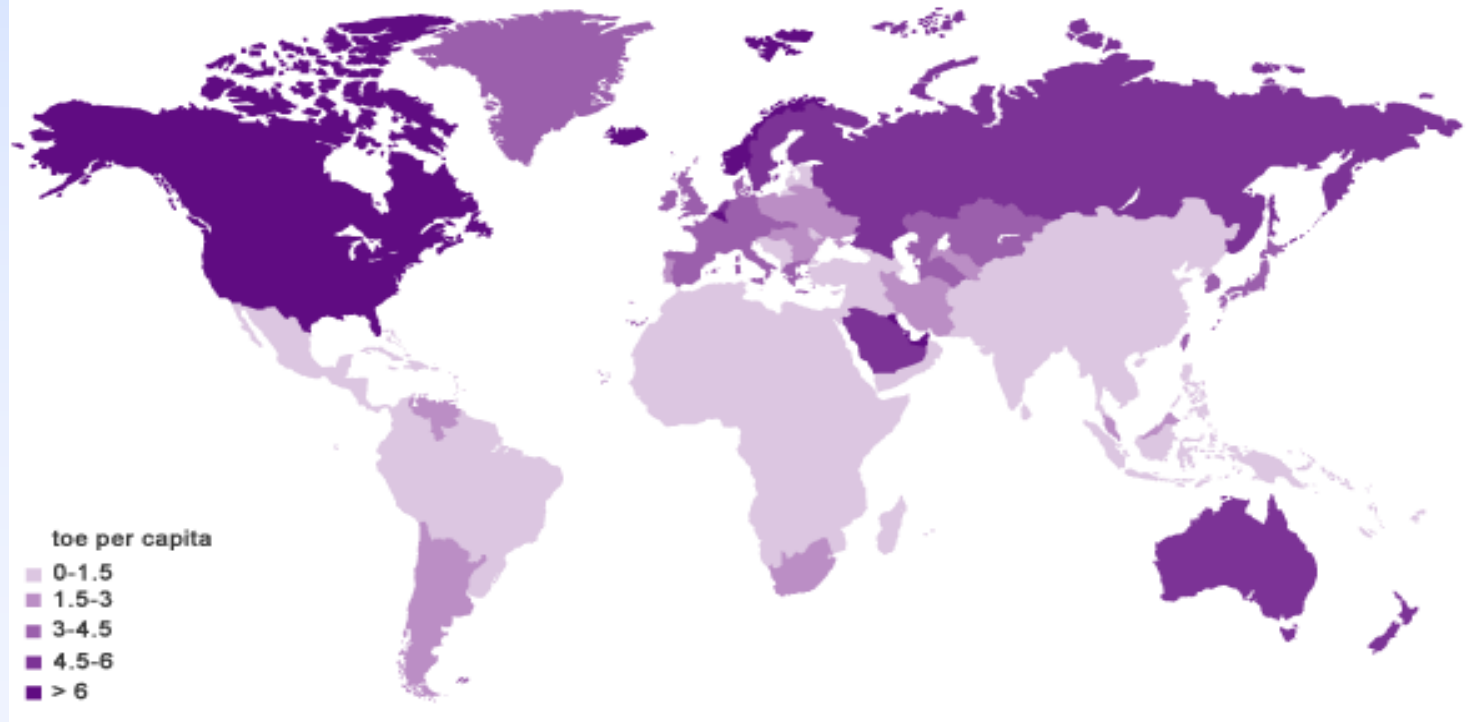


**Country** **Total Primary Energy Consumption Per Person  
(2002) (Million BTU)**

Brazil	48.7
China	33.3
Germany	173.1
India	13.3
Japan	172.3
United States	339.1

Source: EIA

Primary energy consumption per capita  
Tonnes oil equivalent



Source: BP, slide taken from "Geopolitics in Oil and Gas", Jaffe and Medlock (2006), presentation to the Dallas Federal Reserve Bank



# Projections

- The “Call on OPEC” -- EIA projects oil production capacity to significantly expand in OPEC. This facilitates a decline in price longer term. But, is this realistic?
  - ◆ Most growth projected to come from Saudi Arabia and Venezuela.
    - ❖ Saudi Arabian capacity has not materially changed in 30 years.
    - ❖ Venezuelan expansion requires capital inflow.

	1990	2003	2010	2030	%Growth (2003-2030)
<b>OPEC</b>	<b>27.1</b>	<b>33.0</b>	<b>39.9</b>	<b>50.7</b>	<b>1.60%</b>
Saudi Arabia	8.6	10.6	14.4	17.1	1.79%
Venezuela	2.4	3.0	4.1	5.9	2.54%
<b>Non-OPEC</b>	<b>42.4</b>	<b>49.3</b>	<b>54.4</b>	<b>72.6</b>	<b>1.44%</b>
North America	14.7	15.7	17.5	20.5	0.99%
Caspian	0.0	1.9	3.0	7.5	5.22%
Brazil	0.8	1.8	2.7	4.5	3.45%
Africa	2.2	3.2	3.8	8.6	3.73%
<b>Total World</b>	<b>69.5</b>	<b>82.3</b>	<b>94.3</b>	<b>123.3</b>	<b>1.51%</b>

- Notice that growth occurs in high risk areas. This foretells a growing likelihood for geopolitically motivated oil market disruptions.
- Greater risk means higher prices are needed to support the necessary investments.



# OPEC capacity has fallen, not increased, since 1979

OPEC Production and Spare Capacity, 1979-2003 (mmbbl/d)

Member Country	1979	1983	1990	1997	1998	2000	2001	2003	2005
Saudi Arabia	10.84	11.30	8.00	9.65	9.80	9.50	9.90	10.15	10.30
Iran	7.00	3.00	3.10	3.70	3.70	3.75	3.80	3.80	4.00
Iraq	4.00	1.50	3.60	2.30	2.80	2.90	3.05	2.20	1.80
Kuwait	3.34	2.80	2.40	2.40	2.40	2.40	2.40	2.50	2.60
UAE	2.50	2.90	2.20	2.40	2.40	2.40	2.45	2.50	2.40
Qatar	0.65	0.65	0.40	0.71	0.72	0.73	0.75	0.75	0.82
Venezuela	2.40	2.50	2.60	3.45	3.30	2.98	3.10	2.50	2.50
Nigeria	2.50	2.40	1.80	2.00	2.05	2.10	2.30	2.30	2.30
Indonesia	1.80	1.60	1.25	1.40	1.35	1.35	1.30	1.15	0.90
Libya	2.50	2.00	1.50	1.45	1.45	1.45	1.45	1.45	1.60
Algeria	1.23	1.10	0.75	0.88	0.88	0.88	0.88	1.15	1.35
<b>Total</b>	<b>38.76</b>	<b>31.75</b>	<b>27.60</b>	<b>30.34</b>	<b>30.85</b>	<b>30.44</b>	<b>31.38</b>	<b>30.45</b>	<b>30.57</b>
<b>Call on OPEC</b>	<b>34.01</b>	<b>16.65</b>	<b>22.20</b>	<b>27.59</b>	<b>25.85</b>	<b>30.04</b>	<b>28.23</b>	<b>29.20</b>	<b>29.87</b>
<b>Spare Capacity</b>	<b>4.75</b>	<b>15.10</b>	<b>5.40</b>	<b>2.75</b>	<b>5.00</b>	<b>0.40</b>	<b>3.15</b>	<b>1.25</b>	<b>0.70</b>

Opec can replace all Iraqi/Kuwait oil in 1990      Asian economic crisis leaves extra capacity in 1998      Demand bumps up against capacity

Source: slide from "Geopolitics in Oil and Gas", Jaffe and Medlock (2006), presentation to the Dallas Federal Reserve Bank



# The Emergence of Natural Gas



# A global market emerges...

## ■ Demand trends...

- ◆ Natural gas use doubled from 1980-2004
  - ❖ Demand growth rate of 2.5% per annum – 3x oil and 2x coal
- ◆ Share of natural gas in primary energy supply has been rising
- ◆ Demand is predicted to grow faster than other fossil fuels (IEA)
  - ❖ 2.4% per annum with oil at 1.8% and coal at 2.0%
- ◆ Why?
  - ❖ Environmental pressure for cleaner fuels
  - ❖ Deregulation of wholesale electricity markets
  - ❖ Transportation fuel needs (GTL, oil shale, fuel cell)
  - ❖ Economic development in Asia

## ■ Supply trends...

- ◆ Increased development in North and West Africa, Qatar, Australia, and Russia, with a tilt toward LNG.

## ■ Storage and LNG arbitrage

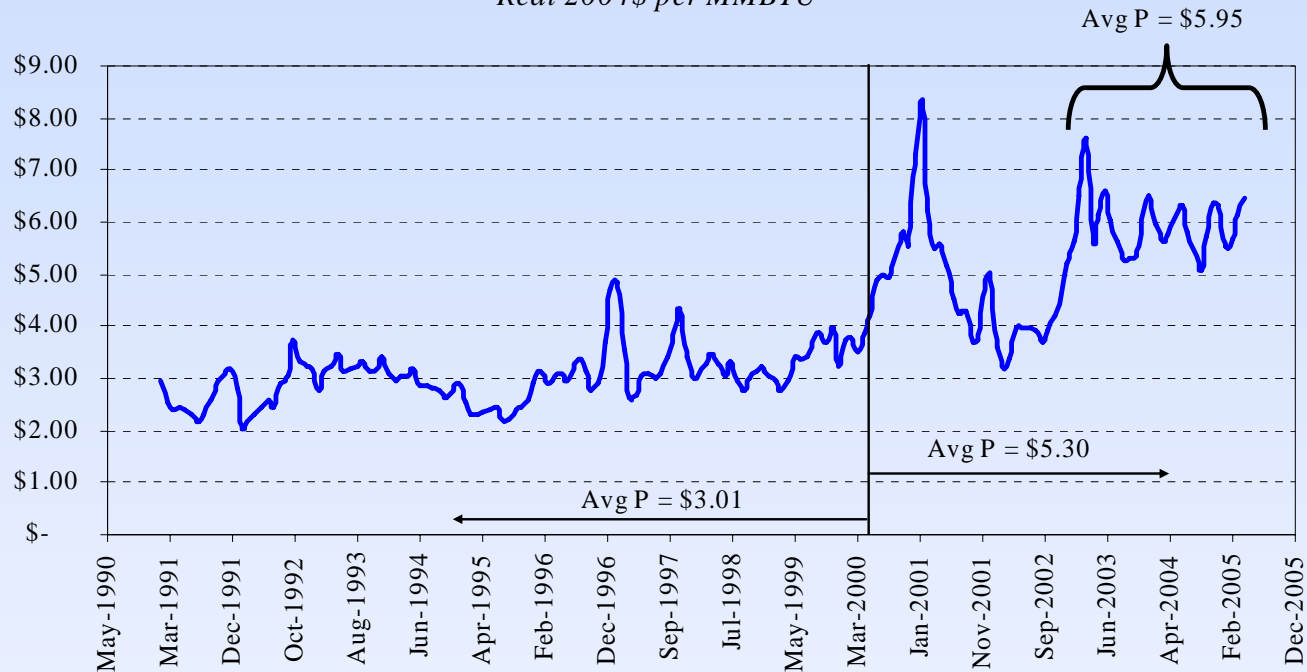
- ◆ US storage market could emerge as vital to balancing Atlantic basin LNG market



# Natural Gas Price driving globalization...

## US Henry Hub Price

Real 2004\$ per MMBTU



- **Dramatic change in the US natural gas market...**
  - ◆ **New supplies are more expensive**
    - ❖ lower production rates imply reserve replacement must be greater to maintain production
  - ◆ **Growing demand (power generation) is not fuel-switchable**
  - ◆ **Promise of LNG may limit development of frontier supplies**
- **... higher prices are here for a while.**



# Some facts regarding supply

- US and Russia are the two largest producers of natural gas today.
- US producing basins are mature.
  - ◆ Decline rates are increasing as production comes from mature fields.
  - ◆ Reserve growth is primarily on frontier regions. Lower production rates from frontier supplies mean reserve replacement must be greater to simply maintain production.
    - ❖ Reserves have grown each year for the past 5 years yet production is flat to declining.
- Russian production is mature, but untapped potential remains extremely large... proved plus potential resource is larger in Russia than in any other country
- Global gas supply potential is large, but:
  - ◆ It is concentrated in areas remote from markets
  - ◆ Production and transport infrastructure is required
  - ◆ Unstable political regimes may make investments unattractive
  - ◆ Prices need to rise in real terms to finance the investments



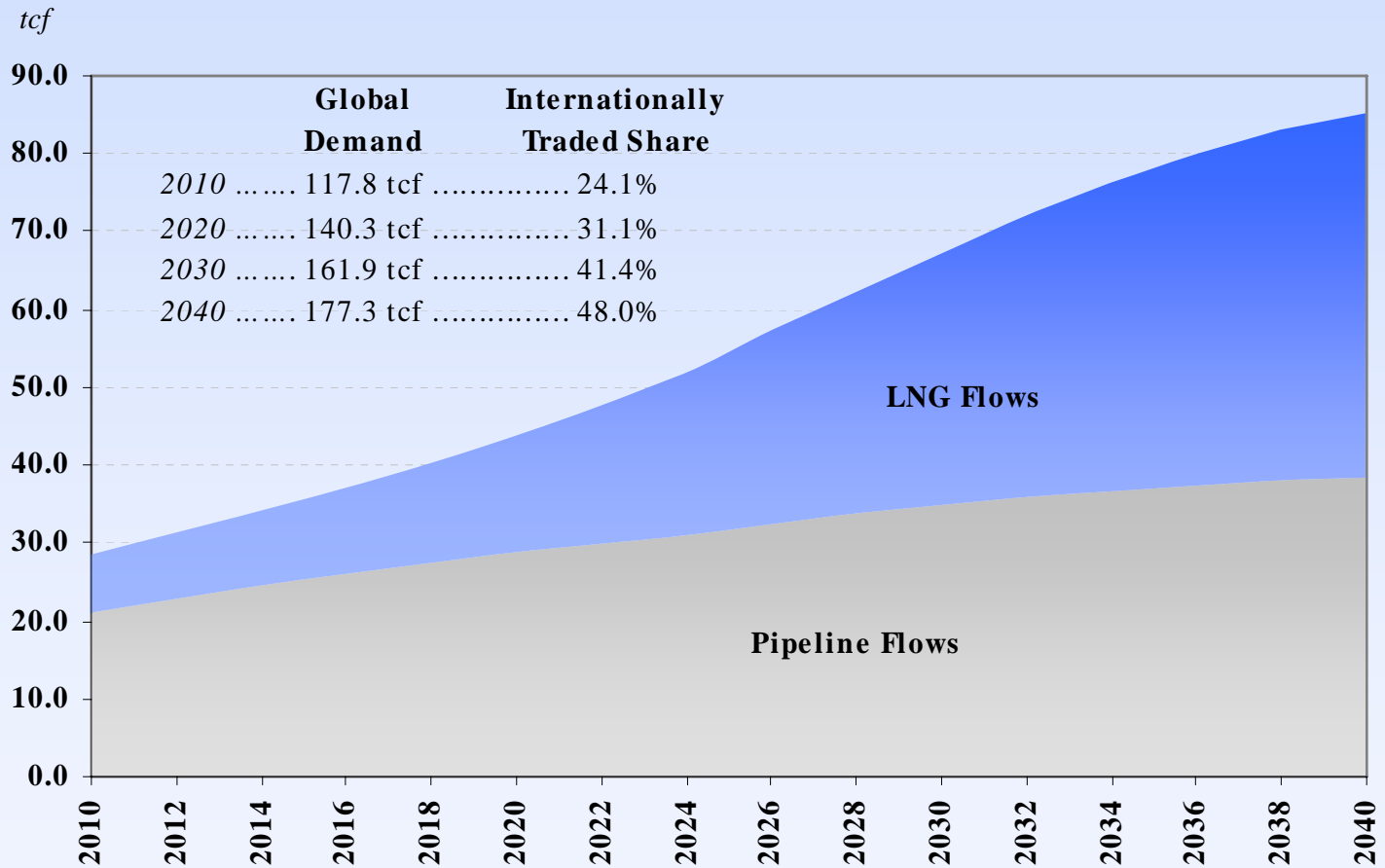
# RWGTM: One Possible Future

- Russia becomes the dominant exporter in the global gas market
  - ◆ Pipelines to Europe
  - ◆ Sakhalin gas to Japan and the Korean peninsula
  - ◆ East Siberian gas to China
  - ◆ Atlantic Basin LNG beginning in the 2020s from the Barents Sea region.
- The Middle East also becomes an important supply region
  - ◆ Qatar is largest exporter in the region
  - ◆ Growth post-2025 from Iran and later Saudi Arabia
  - ◆ Iran and later Iraq are the primary sources of regional pipeline gas exports
- European LNG imports eventually exceed those of Northeast Asia
- North America becomes the largest importing region of LNG
  - ◆ Growth in the GoM and Rockies abates the need for LNG in the near term.
  - ◆ Alaska offsets declines in other NA production with little effect on price.
  - ◆ LNG imports into Mexico grow substantially, with terminals on all coasts.
  - ◆ LNG imports into the US grow substantially, but development on the West Coast is cost prohibitive.
  - ◆ Gas prices in North America eventually exceed prices in Europe and Asia.
- South American gas is consumed primarily in South America
  - ◆ Trinidad LNG export growth is limited to the near term
  - ◆ Peruvian LNG exports begin next decade, primarily to Mexico
  - ◆ Venezuelan LNG is significant in later time periods



# RWGTM: One Possible Future (cont.)

- LNG will become a larger share of an increasingly traded market.



Data compiled from RWGTM-Base Case (2/16/2006)



# RWGTM: One Possible Future (cont.)

- Russia becomes the single largest exporter
- Australia becomes prominent in LNG
- The Middle East emerges into a prominent role post-2020 via LNG.
- Traditional LNG exporters lose market share.

	2010	2020	2030	2040
<b>Russia</b>	19.20%	17.07%	17.54%	19.63%
<b>Other FSU</b>	13.37%	10.44%	7.75%	7.50%
<b>Canada</b>	7.17%	5.21%	2.45%	0.65%
<b>Algeria</b>	10.01%	7.26%	2.98%	0.62%
<b>Other North Africa</b>	3.72%	4.60%	2.96%	1.40%
<b>Nigeria</b>	2.84%	3.49%	5.62%	5.19%
<b>Other West Africa</b>	1.35%	3.02%	3.20%	2.64%
<b>Indonesia</b>	5.72%	4.97%	5.29%	3.96%
<b>Malaysia</b>	5.15%	3.58%	1.16%	---
<b>Australia</b>	3.80%	4.80%	9.26%	11.34%
<b>Iran</b>	---	---	2.61%	5.76%
<b>Qatar</b>	3.21%	4.41%	5.67%	7.20%
<b>Saudi Arabia</b>	---	---	1.81%	5.22%
<b>Norway</b>	6.73%	7.24%	6.91%	5.53%
<b>Trinidad &amp; Tobago</b>	1.27%	2.32%	1.27%	0.12%
<b>Venezuela</b>	---	---	2.33%	2.90%
<b>Rest of World</b>	16.48%	21.60%	21.20%	20.34%



# A Global Gas Future

## Baker Institute Research: RWGTM

- Demand is projected to grow substantially, coming largely from the US, Europe, and developing Asia (China and India).
- Incremental global supplies will come from Russia, Qatar, Iran, Australia, Indonesia and countries in North and West Africa.
- Developments in Russia and Middle East are critical to meeting long term demands in Europe, North America and the Far East.
  - ◆ Russian supplies access European and Asian markets, via pipelines. Access to North America and Pacific markets via LNG.
  - ◆ Middle East exports will most likely manifest as LNG due to destination flexibility and distance from large end-use markets.
- Geopolitics loom large...
  - ◆ Regional volatility a source of concern... energy security policy.
    - ❖ End-user cooperation?
    - ❖ Alternative technologies?
  - ◆ Is there potential for a “Gas-OPEC”?
    - ❖ The GECF is real, but currently unorganized with no collective goal.
    - ❖ Might we regulate ourselves into a corner? (CO<sub>2</sub> and energy security).



# The Long Term Price of Gas

- Supply response is evident
  - ◆ Activity leads to discovery
    - ❖ e.g. - Barnett Shale (2002 = 7 tcf, 2005 = 28 tcf), Fayetteville Shale (???)
  - ◆ Acceleration of activity in Rockies and Deepwater GoM
  - ◆ Larger push for Alaska, access to OCS, etc.
- Demand response is evident
  - ◆ Slower than expected growth in power generation
  - ◆ Interest in Coal, Nuclear, and IGCC
  - ◆ Industrial demand reductions
    - ❖ BIPP research indicates there may be a limited decline due to sector-specific responses
  - ◆ Efficiency improvements in new construction (Energy Star standards, tax incentives for upgrades)
- LNG will flow as long as the price supports it. Current cost concerns are primarily short term in nature.
- RWGTM suggests that economic drivers support an expectation of a Henry Hub price of \$5.50-\$6.50/mmbtu
  - ◆ BUT... Political forces and random shocks can cause dislocations



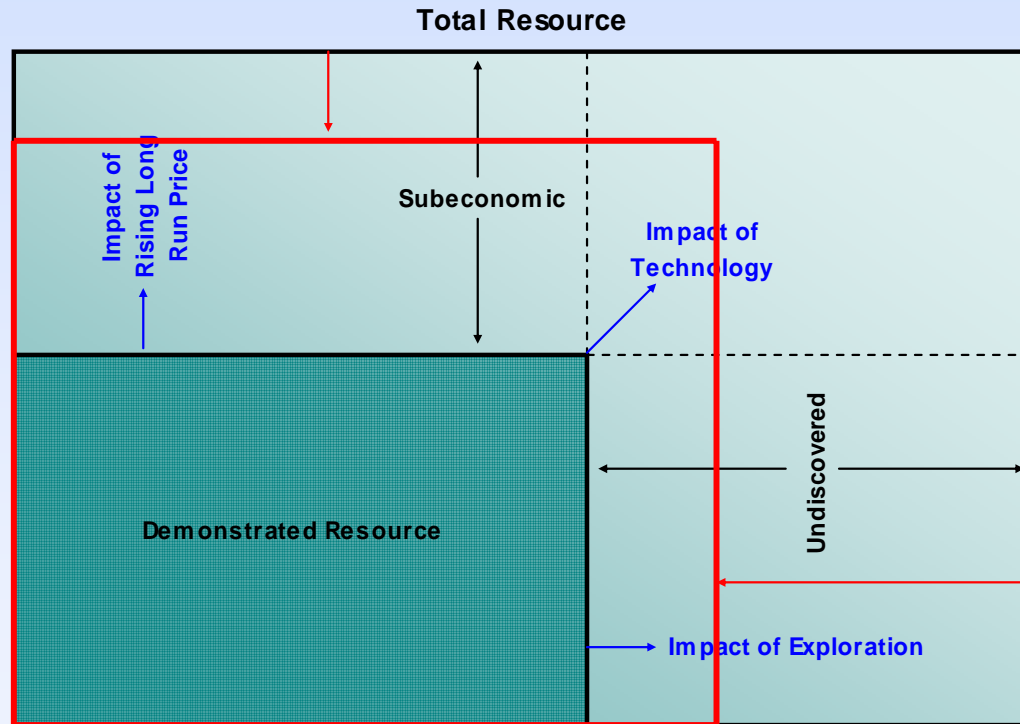
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# Geopolitics



# What Do Geopolitics Mean for Supply?

- Geopolitics can present barriers to investment (risk premiums, limited access), effectively shrinking the size of the Total Resource box.
  - ◆ Barriers to investment reduce the impact of exploration, limit the ability to respond to higher long run prices, and limit the impact of innovation



- A smaller Total Resource box is equivalent to a supply constraint that is realized more readily. The scarcity of resource available for development places a premium on demonstrated resources. This premium can fluctuate in the short run depending on how market participants view geopolitical factors.



## Areas to Watch: Asia

- Tensions with North Korea will prohibit the development of infrastructure. This will ultimately raise prices, particularly in South Korea, but also in China.
  - ◆ BIPP modeling indicates that economics support extensive pipeline networks connecting East Siberia, China, the Koreas and Japan. The price impact of geopolitical constraints barring such development is substantial.
- Chinese demand is expanding rapidly, commensurate with its pace of economic development. This creates competition for scarce resources with other large consuming nations.
- India and Pakistan have an expanding need for energy due to economic growth and population growth.
  - ◆ The most economic source of supply is Iran.
  - ◆ This is at odds with the political will of the U.S.
  - ◆ Short of choking these economies, something has to give.



# Areas to Watch: Middle East

## ■ Iran

- ◆ According to the USGS, Iran holds the second largest natural gas resource potential in the world. According to the Oil and Gas Journal, Iran also holds the second largest oil reserves (not including non-conventional oil). However, much of that resource may never reach major markets. If, for example, nuclear proliferation conflicts escalate, sanctions could effectively strand Iran's resources.

## ■ Iraq

- ◆ Some conflict domestically over control of oil producing regions – reminiscent of the days prior to the control of production in Texas by the Texas Railroad Commission.
- ◆ Potential for civil war and dissolution of the state.

## ■ Saudi Arabia

- ◆ Genuine fear that Iraq will escalate into a regional conflict.
- ◆ Western concerns that expansion of oil production capacity may be near impossible.

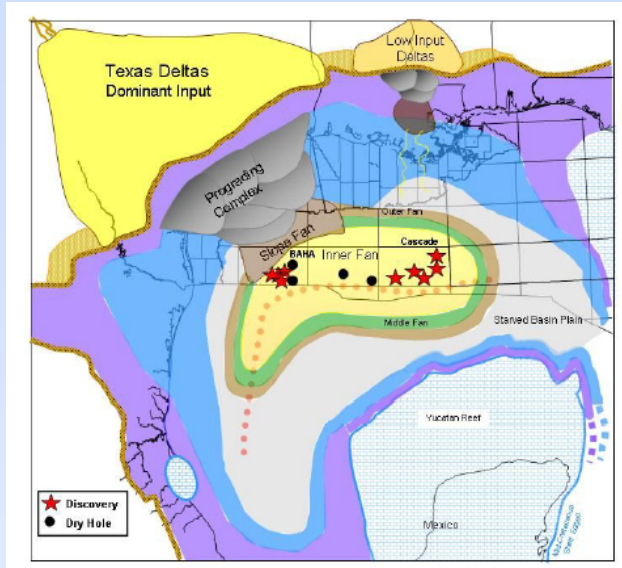
## ■ Israel

- ◆ Tensions with surrounding nations can limit market development, affecting regions far beyond the Middle East.

- **If any war breaks out, it could create choke points for the flow of oil and gas (Strait of Hormuz), particularly if Iran is involved.**

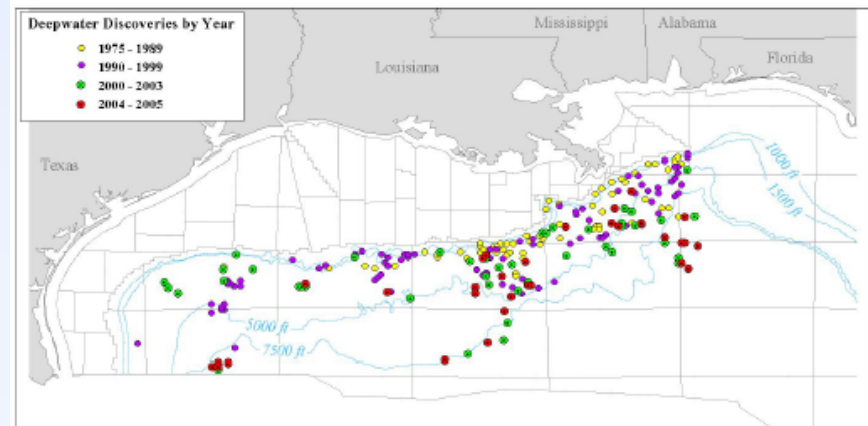
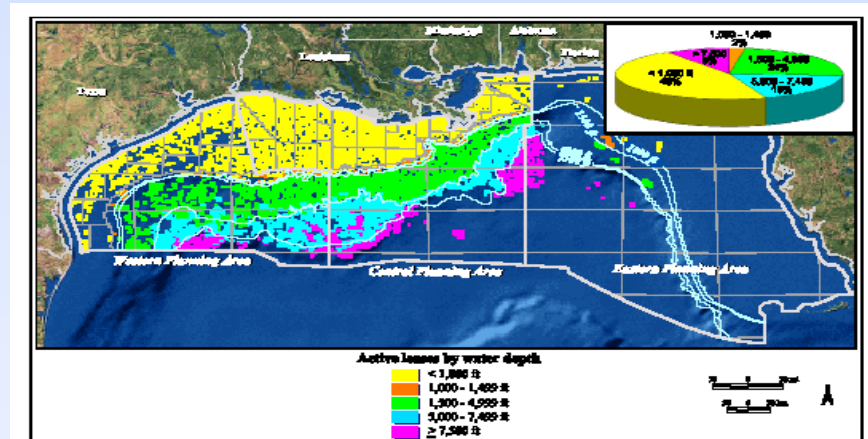


# Areas to Watch: The Gulf of Mexico



- Firms are discovering resource in deepwater locations. Some of the locations are at the boundary of US-Mexico waters, raising the potential for joint development of fields. But, will geopolitics effectively shrink the size of this resource?
- MSCs are not conducive to attracting foreign investment. Granting equity share or developing lease agreements similar to those in the GoM would be.

- Geology in the GoM is conducive to substantial deepwater resource that extends beyond US waters.
- The US MMS indicates that the number of active leases in deepwater locations is rising.





# Areas to Watch: Others

## ■ Russia

- ◆ Disputes over rents to transit countries (Ukraine) could limit European willingness to rely on Russian pipeline supplies.
- ◆ Russian handling of Western interests in existing projects could jeopardize future capital flows.

## ■ West Africa

- ◆ Civil strife can disrupt supplies (in fact it has). In a tight market, this has significant implications.

## ■ South America

- ◆ Venezuela holds a large potential, but nationalism and provocation of the U.S. will likely limit the availability of those supplies.
- ◆ Bolivia has resource, but it is far from markets. Nationalization will likely do more harm than benefit by discouraging capital inflow.

## ■ North America

- ◆ Environmental objections keep resource untapped – OCS, Rockies, Gulf of Mexico, ANWR.
- ◆ “Rent” negotiations continue to push Arctic gas infrastructure development into the future.



# Geopolitics, Oil and Natural Gas

- Geography and geology indicate a likely concentration of supplies in the future. This brings geopolitics to the forefront of uncertainties that could alter otherwise economic outcomes.
- In Europe, energy security concerns about heavy reliance on Russian supplies that must transit multiple borders prior to reaching the end-user could push more rapid development of LNG and/or adoption of alternatives to gas.
- Any force that inhibits the development of pipelines from Russia to the Far East will effectively strand those resources until prices rise enough to force transport west. This will dramatically shift global flows as Asian consumers increasingly compete for LNG and seek alternatives. Modeling suggests that prices in China and South Korea are substantially impacted.
- Is there potential for a “Gas-OPEC”? Gas Exporting Countries Forum has met numerous times, and while no concrete plans are in place for production agreements, the possibility remains.



## Geopolitics, Oil and Natural Gas (cont.)

- Conflict within the Middle East is at odds with future globalization of gas markets. Interestingly, however, European fears of Russian market power are actually accelerating globalization of the market.
- Environmental considerations are also important, as regulation with respect to CO<sub>2</sub> and other pollutants could encourage gas consumption despite any energy security concerns.
- Proactive policies (rather than reactive) can be engaged to mitigate geopolitical risks. For example, countries where coal reserves are large are most likely to seek coal-based gas import mitigation strategies. The US is home to roughly 27% of the world's proven coal reserves, Russia 16%, China 12%, India 8%. Might this common thread encourage energy cooperation in the long term for clean coal technologies?
  - ◆ Note: Countries need not employ coal alternatives to benefit from their use.
- Demand mitigation policies can be very important.

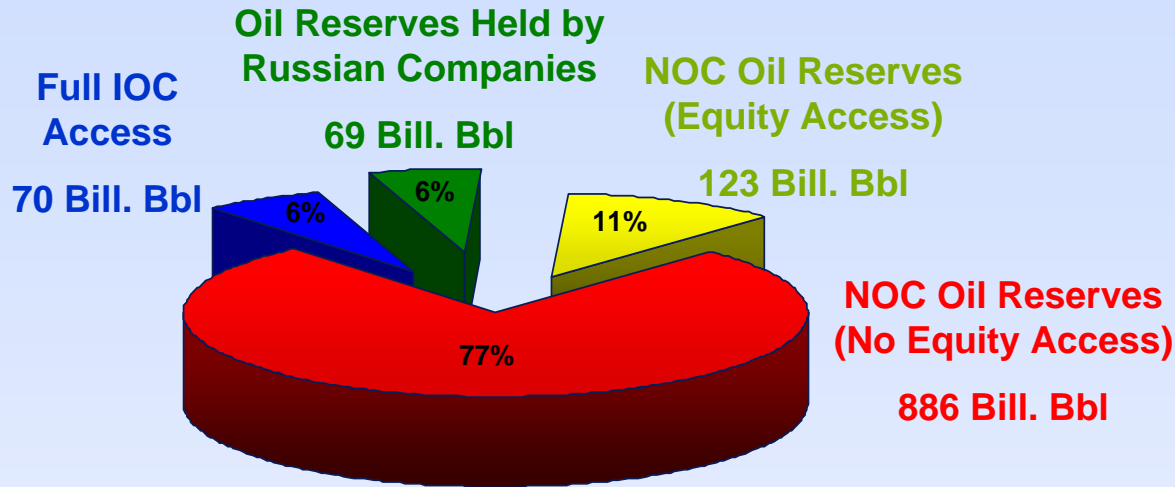


# The Role of the National Oil Company

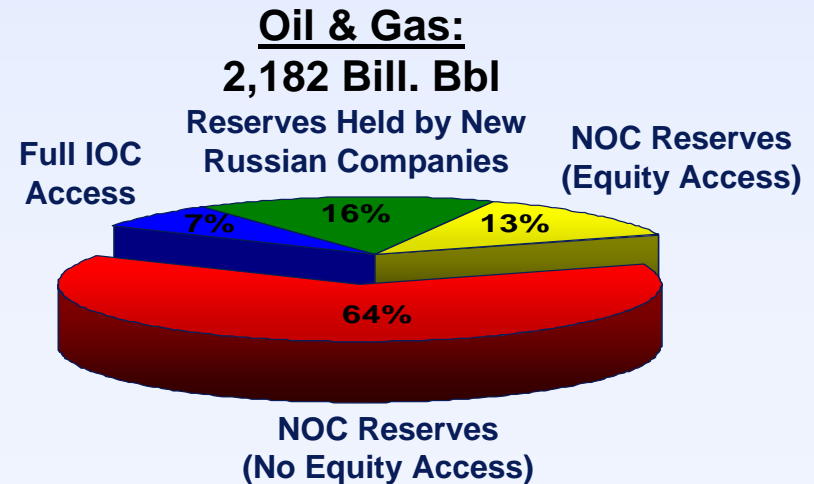


# National Oil Companies on the Rise

## They Control the Resources



**Global Proven Oil Reserves:  
1,148 Bill. Bbl**





# NOC Study Structure

- Case studies covering:
  - ◆ Saudi Aramco; Nigerian National Petroleum Corporation (NNPC); India's ONGC; Russia's Rosneft; Russian privately held firm, LUKOIL; Malaysia's Petronas; Indonesia's Pertamina; Iraq's Oil Ministry; The National Iranian Oil Company (NIOC); Venezuela's PDVSA; China's firms China National Petroleum Corporation (CNPC), Sinopec and China National Offshore Oil Company (CNOOC); Norway's Statoil; and Kazakhstan's Kazmunaigaz.
- Economic modeling of NOC behavior and empirical analysis of NOC relative revenue efficiency using a sample of 80 firms over a period of three years (2002-2004)

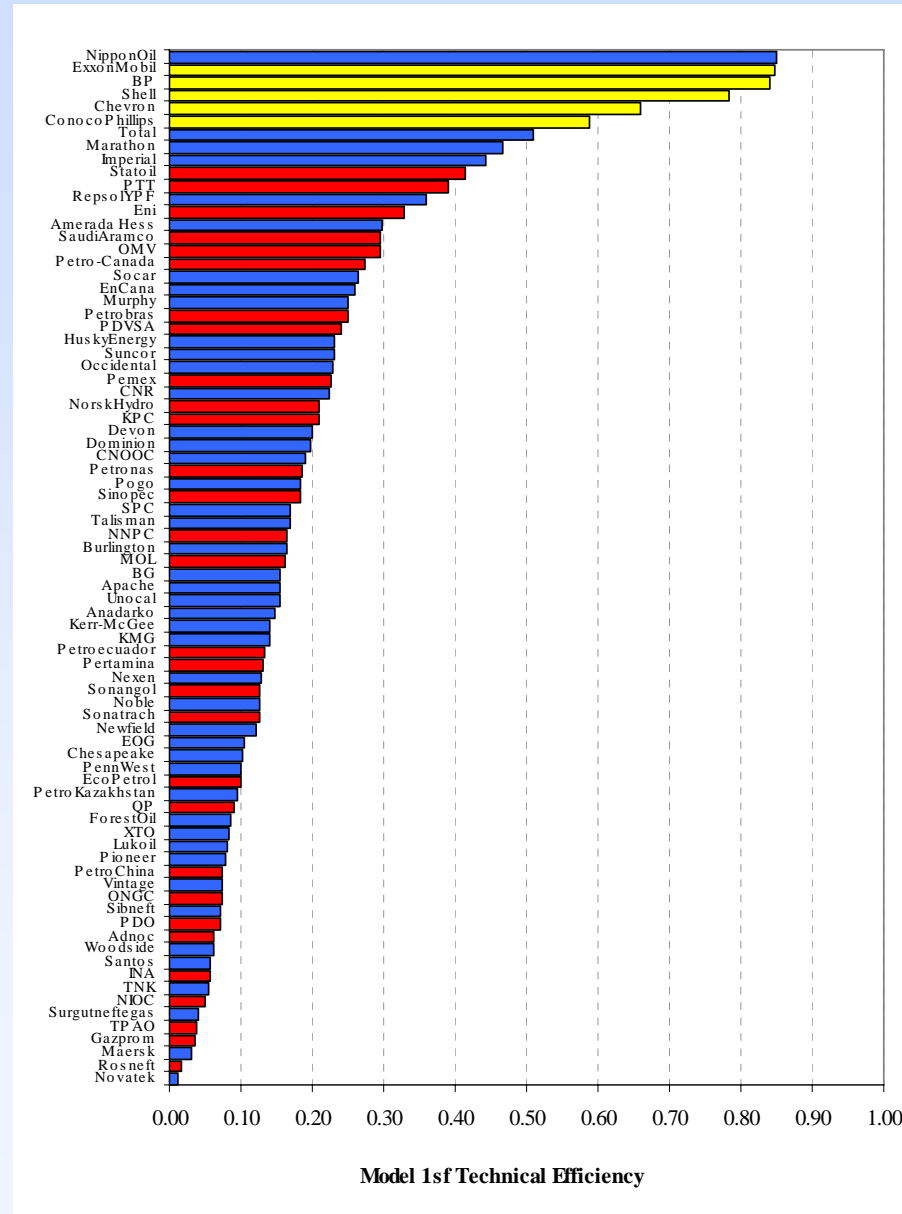


# Summary of Results

- Many governments use NOCs as a tool to achieve wider socio-economic policy objectives, including income redistribution and industrial development. Thus, the NOCs have a variety of objectives other than maximizing profits from oil production.
- These non-core, non-commercial obligations have imposed costs upon the NOC, and in some cases, dilute the incentive to maximize profits, hindering the NOC's ability to raise external capital and to compete at international standards.
- The result has been stagnation in capacity growth and an inability to maintain or grow the countries' oil production capacity. The absence of explicit pressure to earn a return on capital, often coupled with inadequate financial transparency, has in many cases resulted in the inefficient or wasteful allocation of already scarce investment resources
- All together, this means an NOC will generally tend to produce less for a given quantity of reserves and employment than another oil and gas firm.



# Relative Revenue Efficiency





# Explaining the differences

- NOCs are influenced by:
  - ◆ Share of government ownership
  - ◆ Fuel subsidies to domestic consumers
  - ◆ Employment policies
  - ◆ Degree of involvement in international capital markets
- When accounting for these variables, we find that NOCs, in many cases, may actually be acting economically efficient (in the sense that they are maximizing their objective). But, the alternative objectives result in lower production for a given employment and reserve capacity.



# An Example: Explaining Inefficiency through Domestic Fuel Prices

