GLOBAL SUPPLY AND DEMAND*

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Conclusions

- Coal, oil and natural gas will remain indispensable to meeting total projected energy demand growth (NPC).
- There are accumulating risks to continued expansion of oil and natural gas production from conventional sources relied on historically (NPC).
- To mitigate these risks, expansion of all energy sources will be required, including coal, nuclear, solar, wind, biomass and other renewables and advanced production of unconventional oil and gas. How we manage this energy mix and the historic breach between producers and consumers will determine the rhythm of our lives in the future.
- We are experiencing political and geographic power shifts in oil and gas production and consumption that will impact nations, world stability and our modern civilization as we have known it.
- With a rapidly growing world population and global economic development, we must meet the energy challenges, while preserving the complex and delicate environment of our beautiful blue planet for all creatures great and small.

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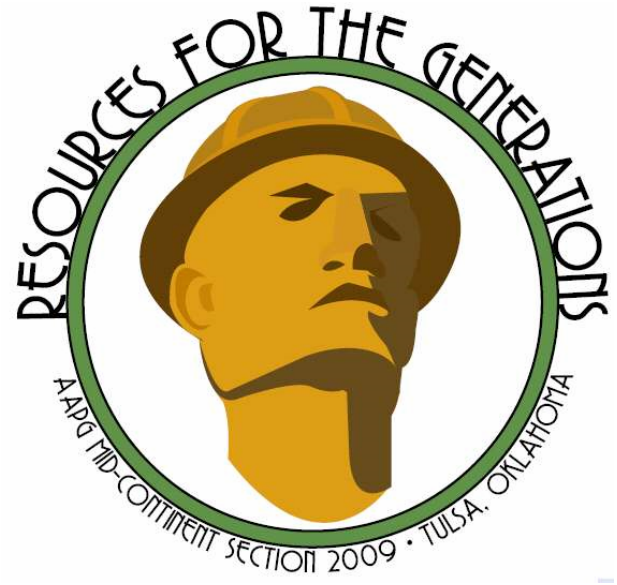

A Look at Global Supply and Demand

Arthur R. Green, ExxonMobil (retired)

AAPG Mid-Continent Section Meeting

October 13, 2009

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A Look at Global Supply and Demand

- The Hard Truths about supply and demand
  - Facts and Figures, in an historic review
- Projections into the future to 2030
  - National Petroleum Council Study

We are experiencing major changes in both the production and consumption of energy that fuels our global economy. These changes will cause power shifts that will, in turn, have a profound impact on individuals, societies, international businesses and nations.

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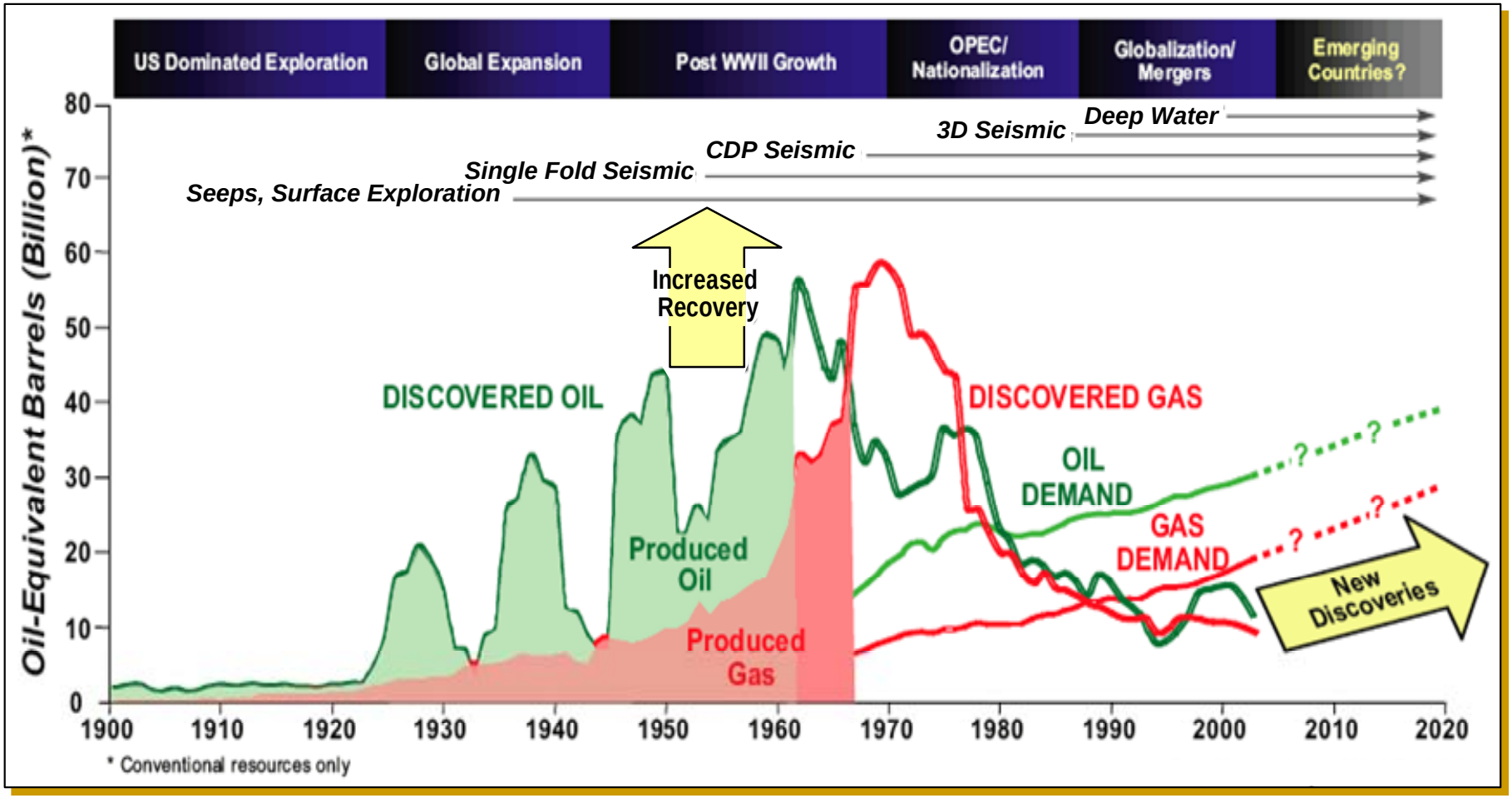
Historical Perspective



Graphic courtesy of Kurt Rudolph / ExxonMobil

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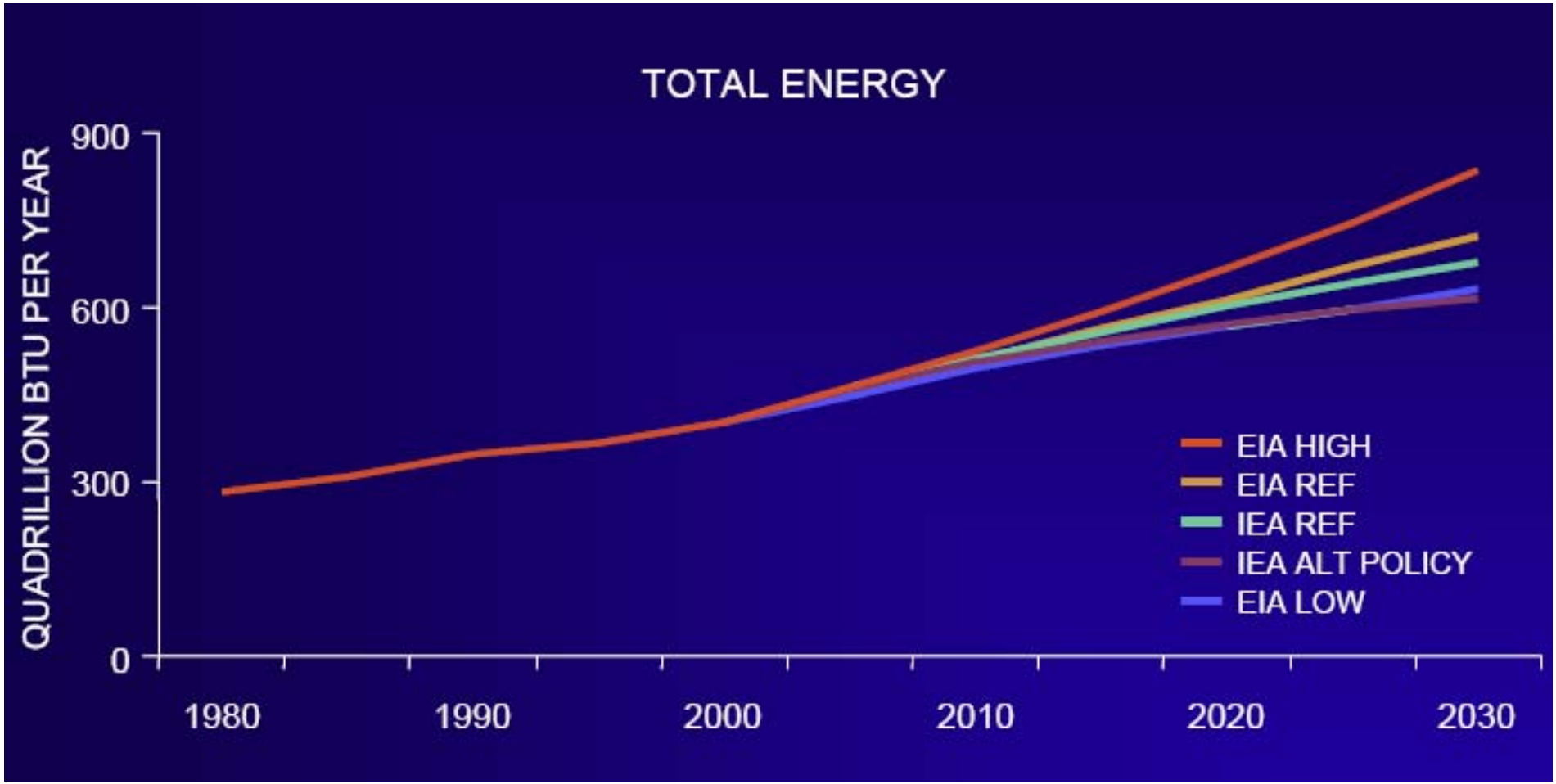
Range of Projections Point to Growing Demand



NPC Global Oil and Gas Study

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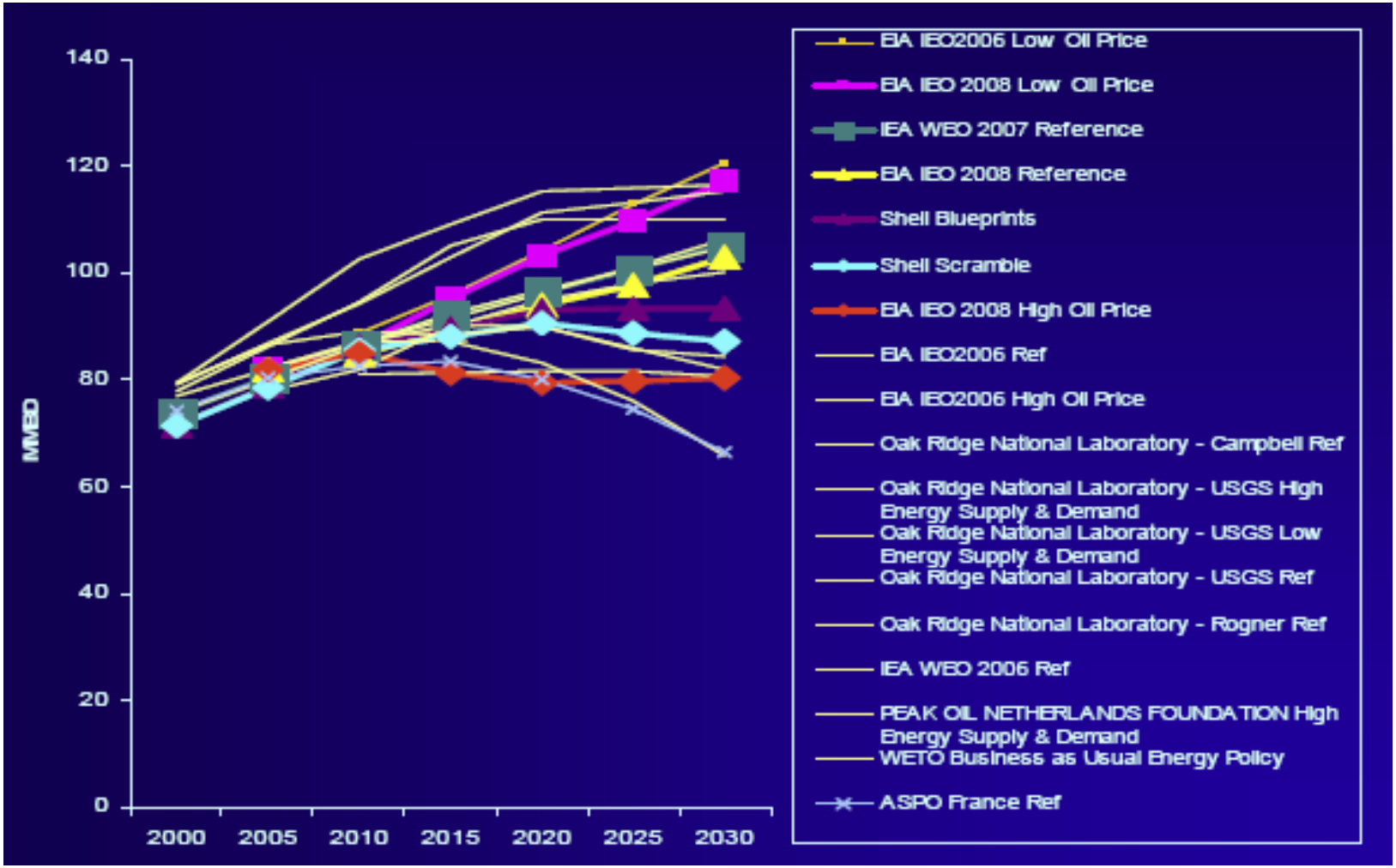
Projected Conventional Oil Production Including Condensate and NGL production



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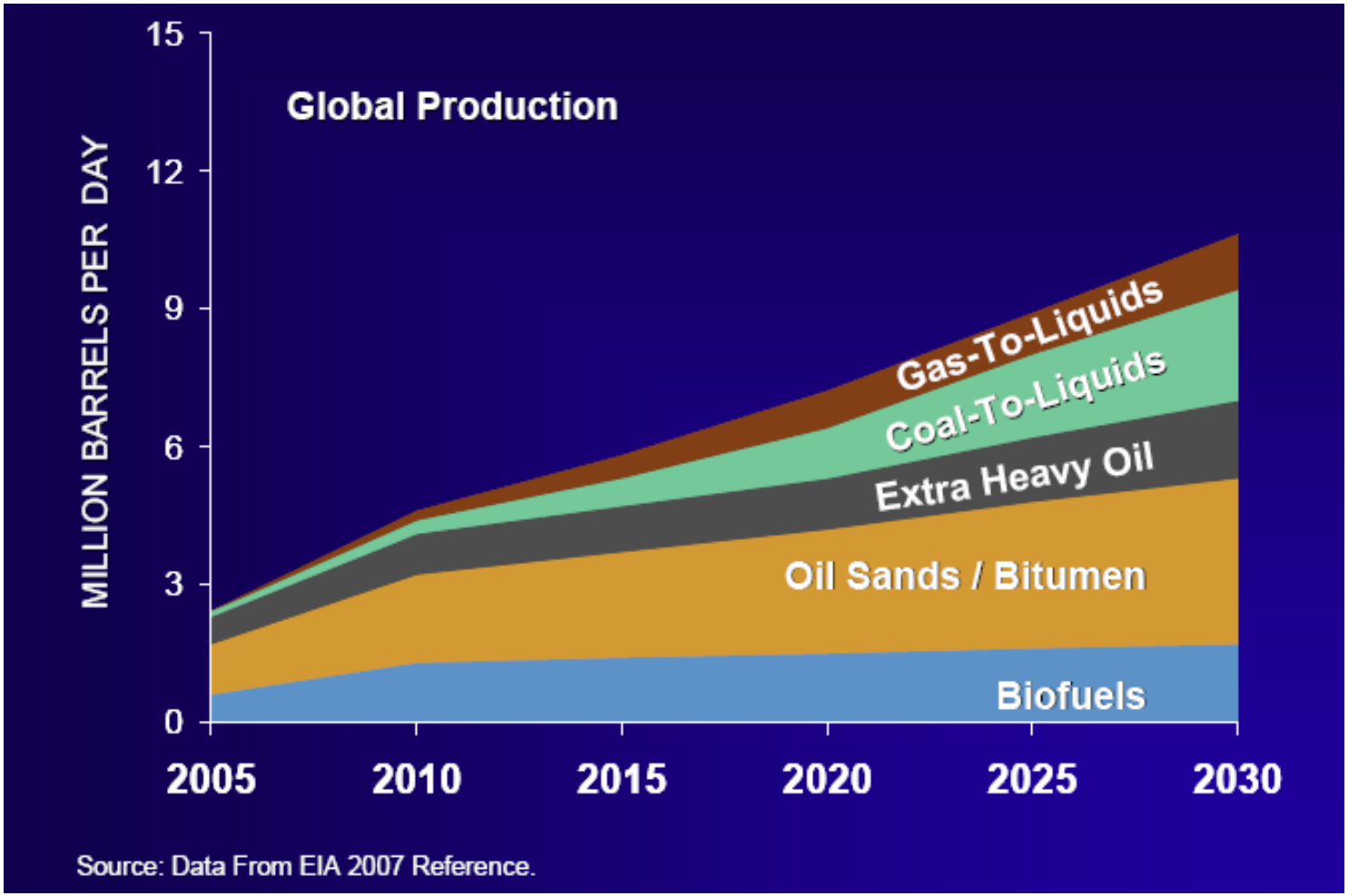
Contribution of Unconventional Liquids



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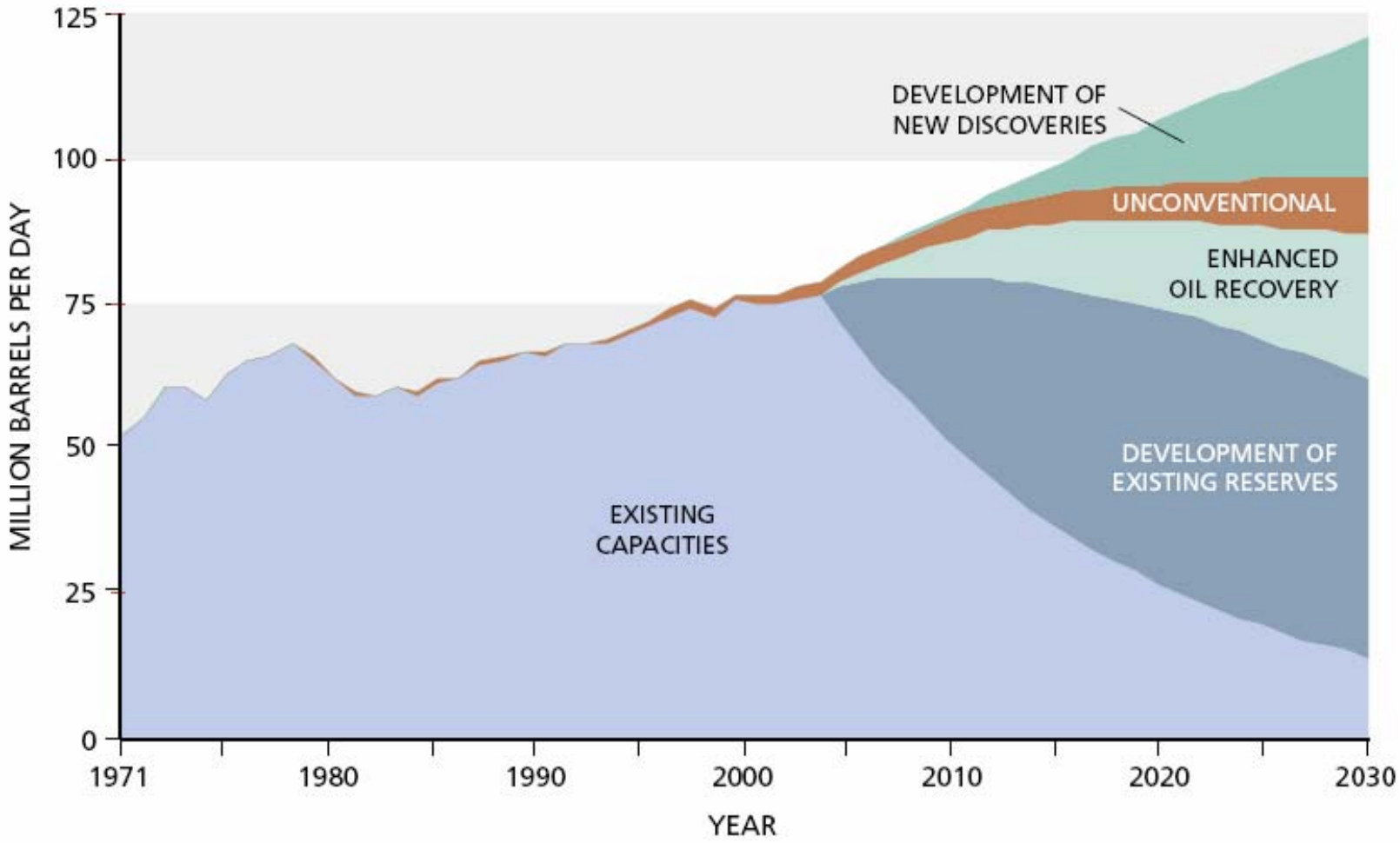
Total Liquids Supply



Source: IEA, *World Energy Outlook 2004*.

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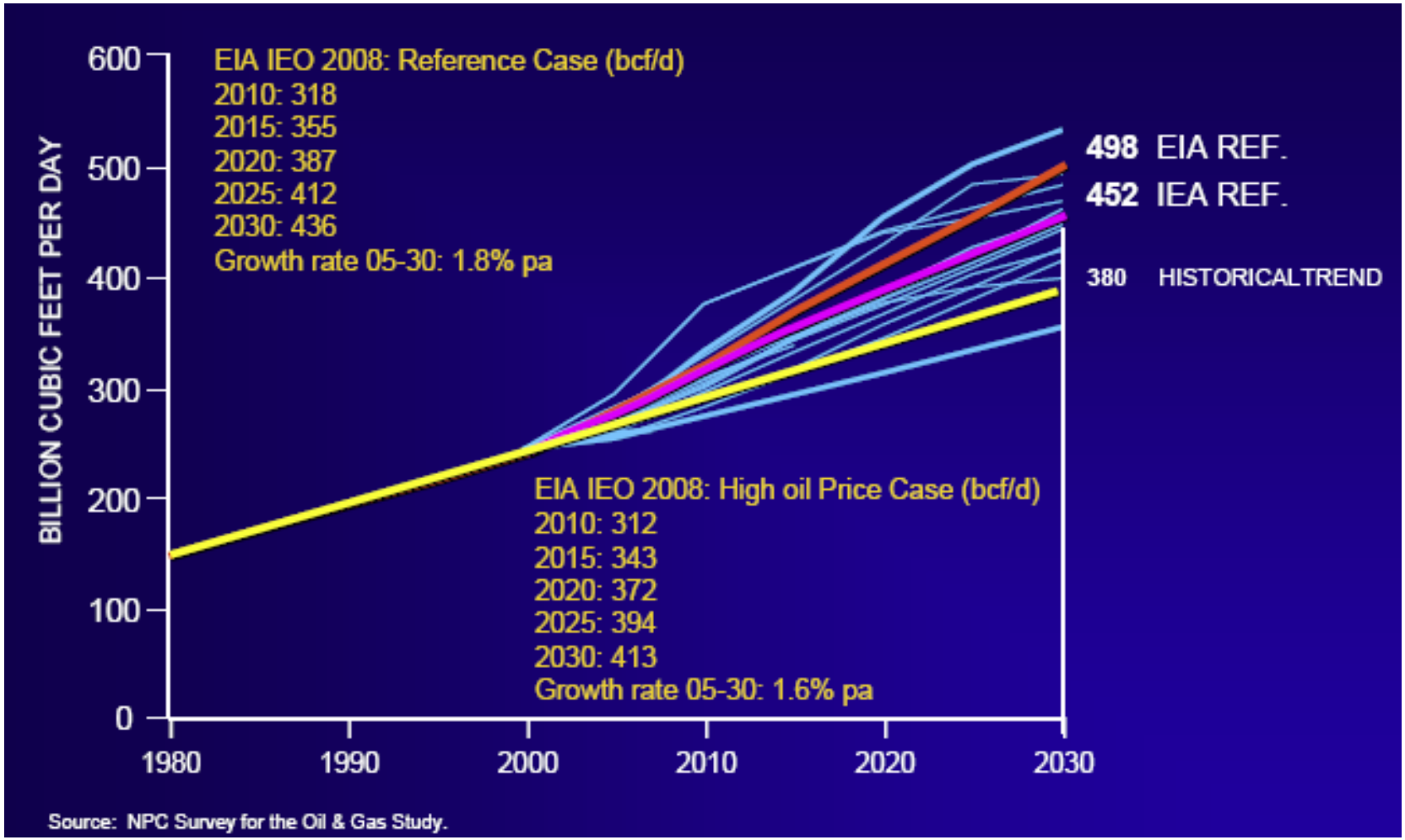
Projected Global Gas Supply



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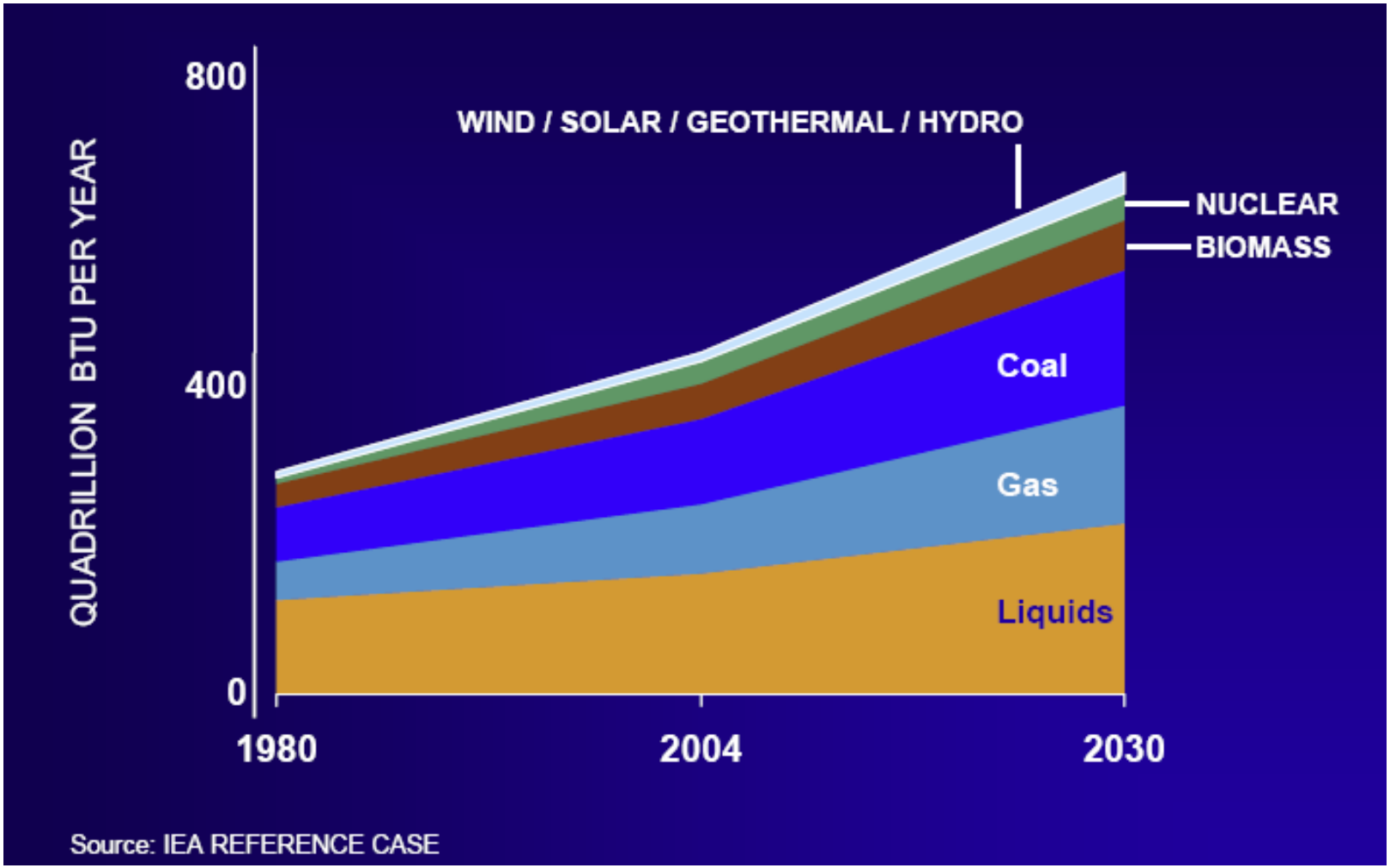
All Sources of Energy Will Be Needed



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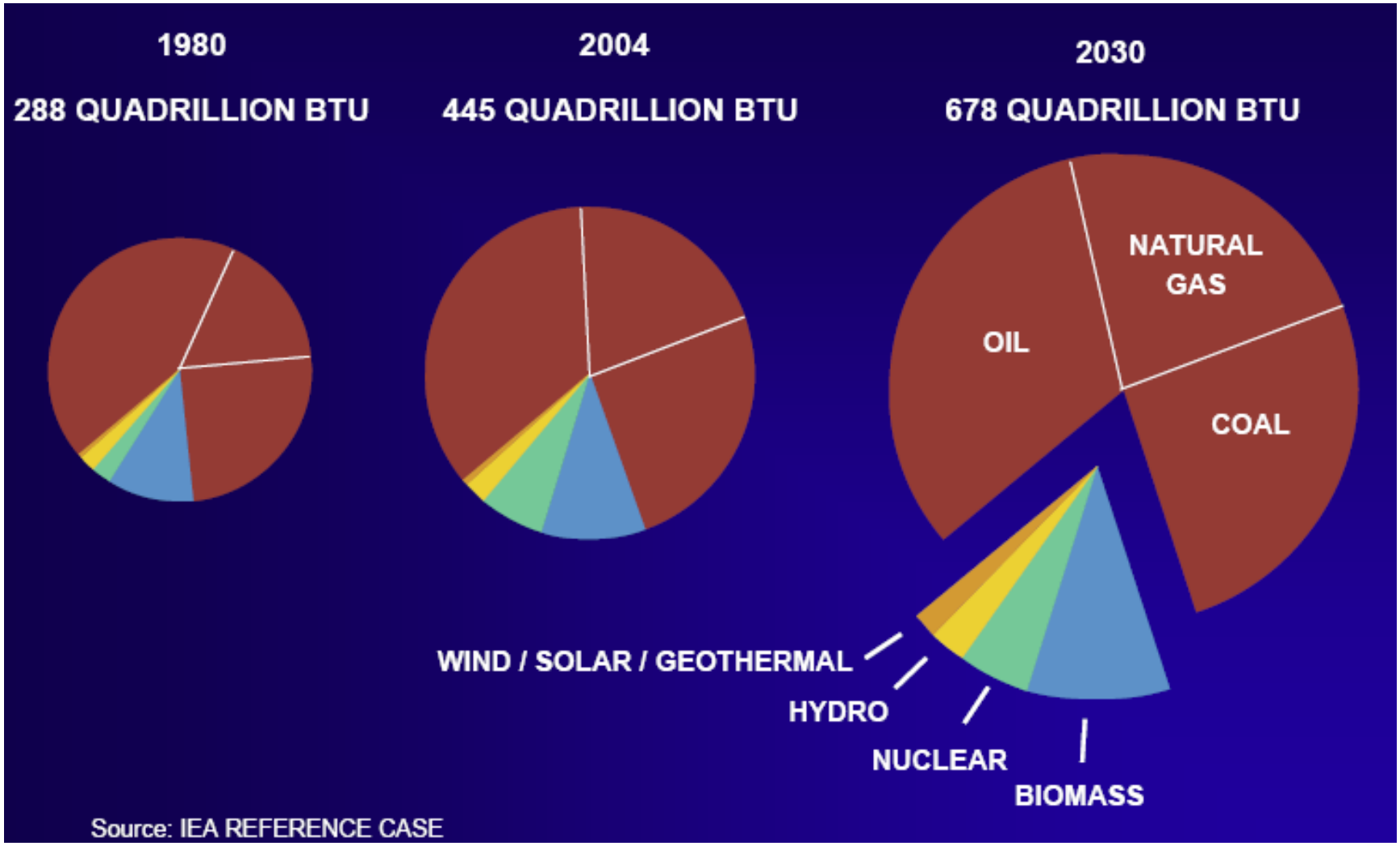
Coal, Oil &Natural Gas Will Remain Indispensable



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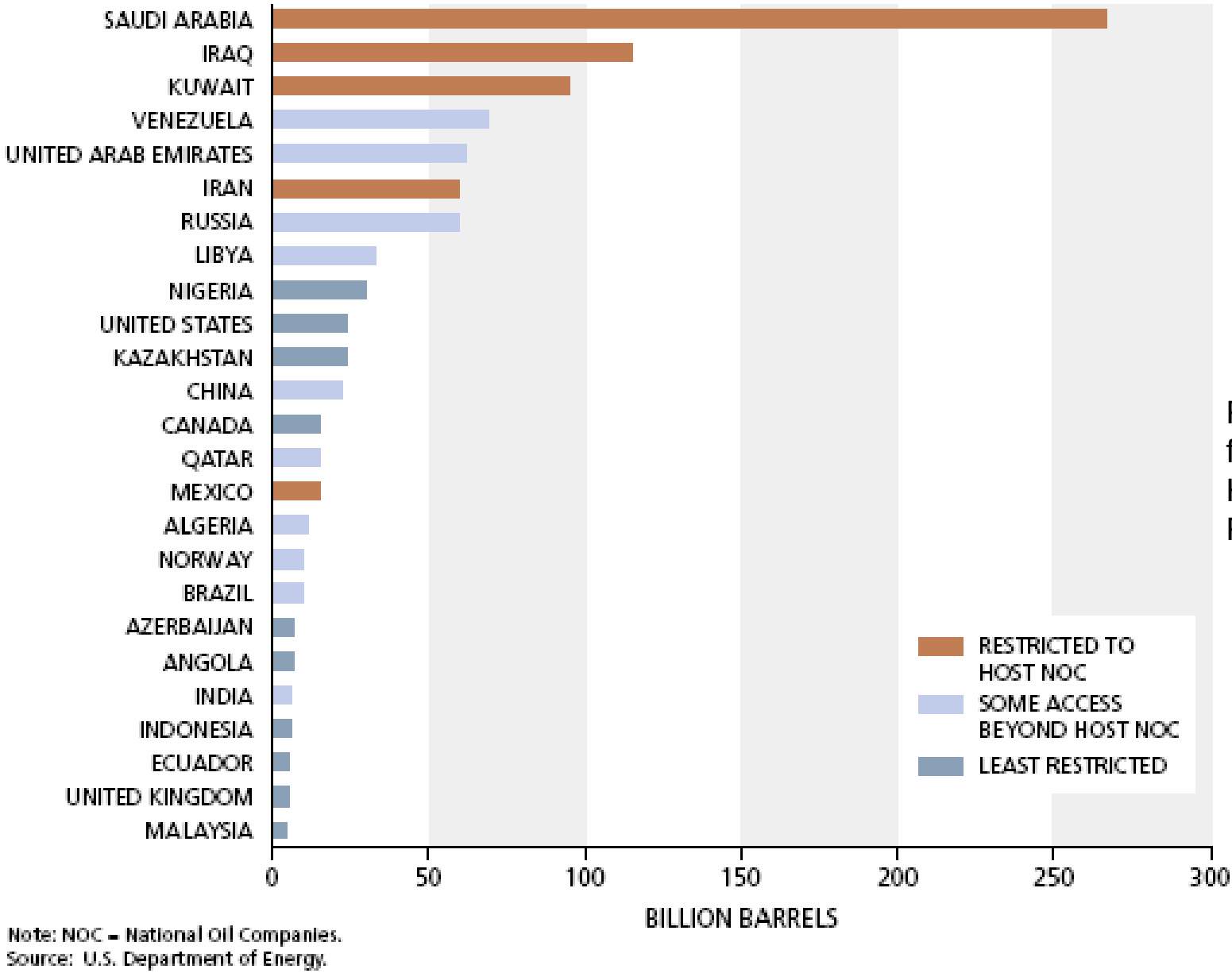
Access to World Proved Oil Resources



Note: NOC = National Oil Companies.
Source: U.S. Department of Energy.

Figure 2-80 from the NPC Hard Truths Report (2007)

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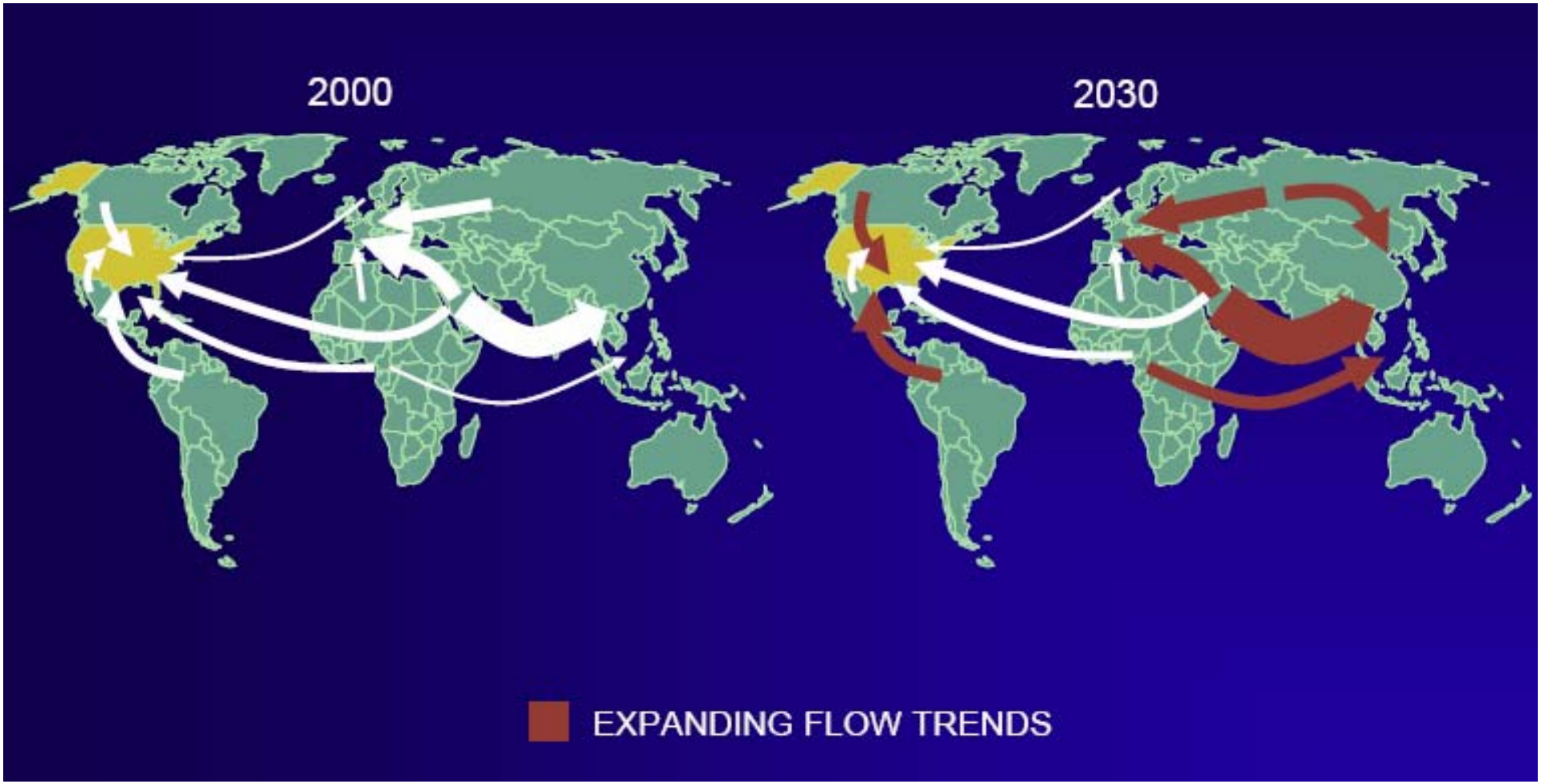
Global Oil Trade



NPC Global Oil and Gas Study

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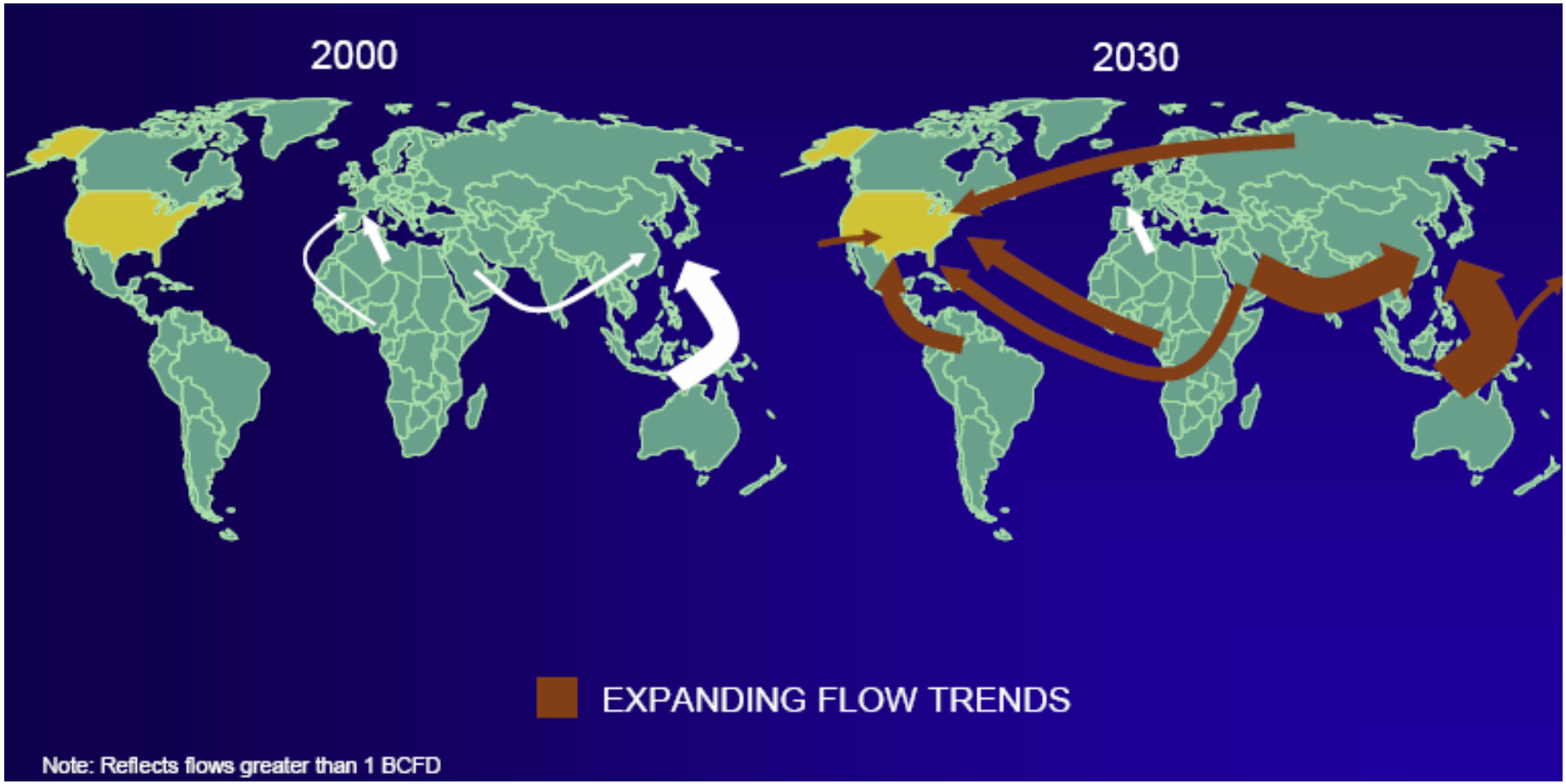
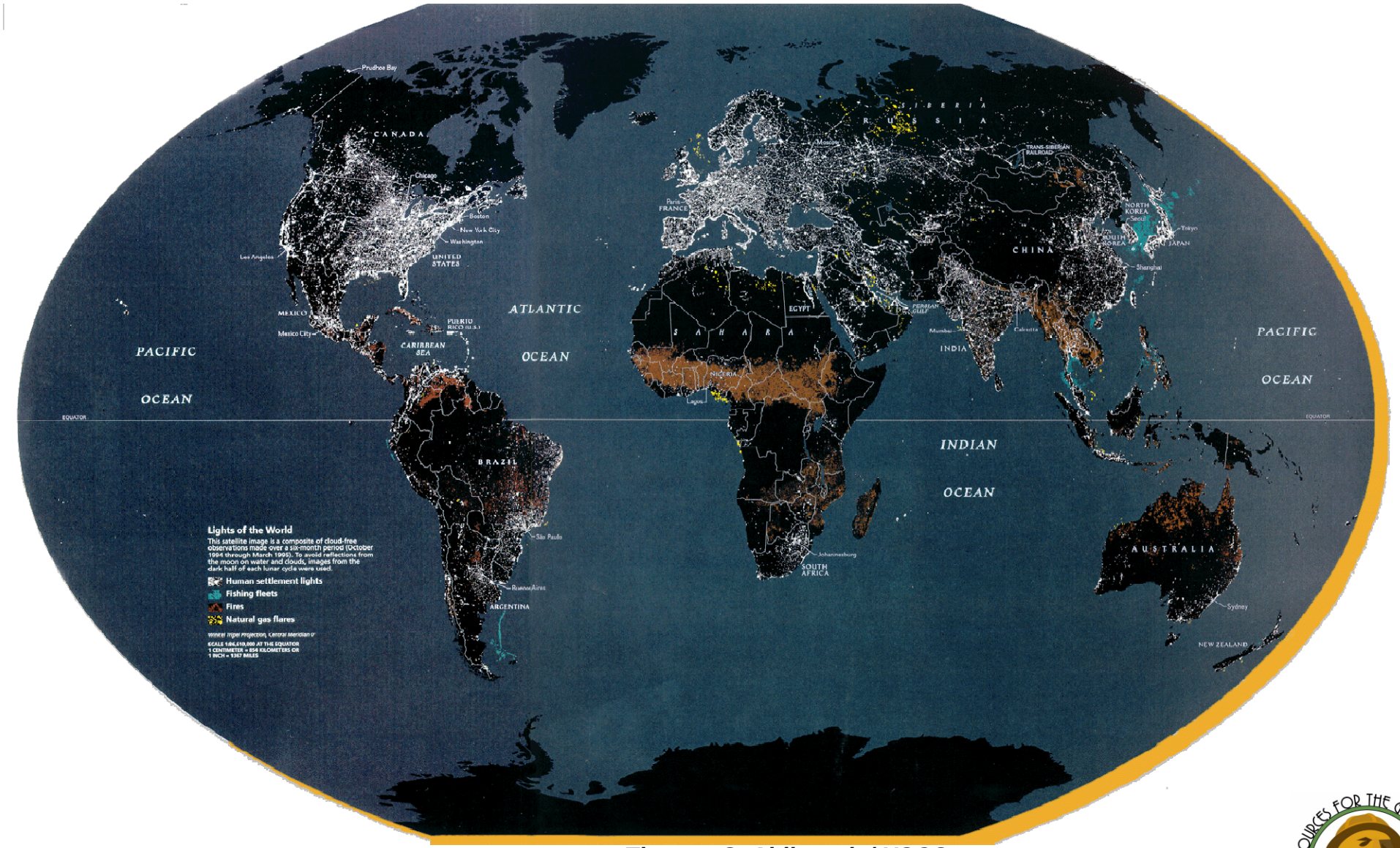
Global LNG Trade



NPC Global Oil and Gas Study

World Population and Energy Consumption



Thomas S. Ahlbrandt / USGS

America's Energy Heartland

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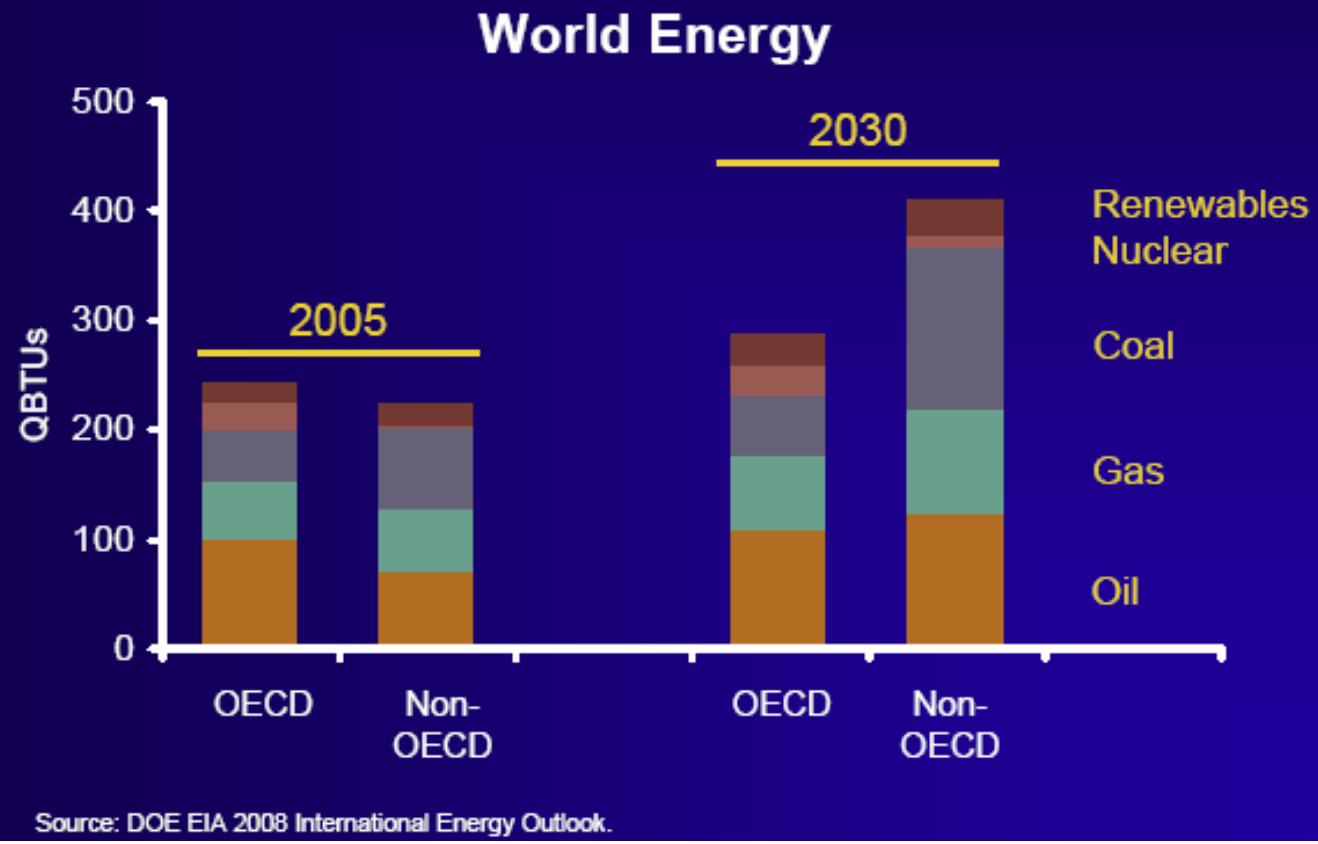
Projected Demand Increase

- Developing world projected to drive the demand increase
- Coal, oil, and gas continue to supply ~80% of total energy



NPC Global Oil and Gas Study

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CO_2 Emission Limits Will Alter Energy Strategies

- Growing concern that climate is warming and CO_2 concentrations in the atmosphere play a role.
- The challenge of significantly reducing CO_2 emissions is unprecedented and will require:
  - Global, broad actions on multiple fronts
  - Long time horizons
  - Major additional investments

Taken from the NPC Global Oil and Gas Study

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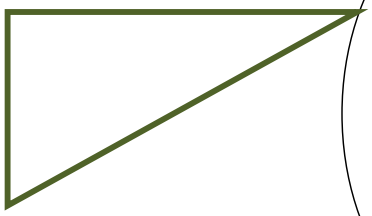
Global Energy Supply and Demand Dynamics and Power Shifts

SUPPLY

- Multinational and Domestic Oil and Gas Companies
  - Declining reserves
  - Access to leases to explore declining



- Technology – Exploration-Production and Refining
  - Unconventional petroleum resources
  - Flat Earth
  - Work force changing

PRODUCING NATIONS
•NOC and OPEC
•Control – leases, production &pricing

GEOPOLITICAL &ECONOMIC NON-LINEAR FILTERS & CATALYSTS
+ AND -

- Oil as a political tool of power
- Sovereign wealth funds
- Investment banks
- Speculation- hedge funds
- Corruption – ethics and trust
- Embargoes
- Terrorism – wars
- Environmental factors
- Stranded resources
- Geographic settings –harsh and land-locked
- Drill and water depth
- Political
- International trade relations
- Regulations and contracts
- Advances in technology
- Cartels – OPEC quotas and price

DEMAND
+ AND -

- PRICE
- Increased energy efficiency
- Alternative energy resources
- Population increase
- Shifting demographics
- Level of industrialization
- GDP – imports vs. exports

NET EFFECTIVE OIL & GAS CONSUMING NATIONS
•Civilization
•Standard of living

- Emerging power-nations (BRIC's)
- Environmental concerns- clean air, water, climate change, and CO2
- Cultural (tribal) and religious values
- Oil storage - hoarding

GEOPOLITICS -------- FUNDING -------- EXPLORATION -------- PRODUCTION -------- TRANSPORTATION -------- REFINING -------- DISTRIBUTION & USE

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Global Supply and Demand Conclusions

- Coal, oil and natural gas will remain indispensable to meeting total projected energy demand growth (NPC).
- There are accumulating risks to continued expansion of oil and natural gas production from conventional sources relied on historically (NPC).
- To mitigate these risks, expansion of all energy sources will be required, including coal, nuclear, solar, wind, biomass and other renewables and advanced production of unconventional oil and gas. How we manage this energy mix and the historic breach between producers and consumers will determine the rhythm of our lives in the future.
- We are experiencing political and geographic power shifts in oil and gas production and consumption that will impact nations, world stability and our modern civilization as we have known it.
- With a rapidly growing world population and global economic development, we must meet the energy challenges while preserving the complex and delicate environment of our beautiful blue planet for all creatures great and small.

Notes

Slide 1. Title and author
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Slide 2. A Look at Global Supply and Demand
We are going to discuss the global supply of energy to the world. Because of time constraints, I am going to focus on oil and gas, but I will touch on the other sources as well.

The presentation will cover three aspects of the subject:

1. The facts and figures of supply and demand –figures of where we have been.
2. Projections into the future to 2030, when many of the students here will be in the middle of their careers.
3. I will propose that the international oil and gas business is experiencing a fundamental change (after 100 years) that will have a profound effect on the wealth and poverty of nations and the lifestyles of each and every one of us.

I have drawn heavily from the statistics in the National Petroleum Council report, NPC of 2007, that has been updated in 2008 and 2009.
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Slide 3. Historical Perspective
This chart shows the years of the discovery of the oil and gas that the world is running on today. When I went to work in the early 1960's, it was an exciting time to be in exploration, and we could not handle all the opportunities that were being handed to us from around the world – The North Sea, Australia, The North Slope and, of course, starting to drill offshore in water over 200 feet deep.

Along with the new basins opening up, there were new tools of perception that let us "see" into the subsurface – CDP seismic, and gravity and magnetics, etc. In some new basins we only had one seismic line to "see" its depth and architecture for the first time.

Then in the 1980's the discovery of giant fields dropped-off – while the demand for oil and gas increased. The deep water, plus new tight gas technology and enhanced recovery, is now helping to bring on additional production. We have also seen some large new discoveries and the discovery curve is rising again.
However, we can see that much of the oil and gas found has already been consumed (oil in solid green and gas in solid red), and at 84 million barrels of oil a day even with increased recovery, it will not be long until it is gone – then the concern about "Peak Oil," increasing costs, and national security.

This last year's global economic downturn has caused gas prices to slump and oil use to level off at approximately 84 millions barrels per day. Economic recovery, China's growth, and an increasing world population should cause the consumption to rise even with increased efficiency.

We have just completed a period of globalization and mergers of oil companies and are now in a phase where emerging countries will play a larger role in both the production and consumption of oil and gas. We shall discuss the ramifications of that later.
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Slide 4. Projected Worldwide Energy Demand
With a growing world population and the rise of the economies in the rapidly developing nations, such as the BRICS (Brazil, Russia, China, and India), we shall likely be using more energy from all sources in the future.
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Slide 5. Oil Production Forecast
While estimates of future oil production are extremely variable, the reference case is for production to rise from about 84 million barrels per day to over 100 million barrels per day by 2030. However, the high price case actually shows a decline; consequently, predictions should be made with humility.
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Slide 6. Unconventional Liquids
By 2030 our production from unconventional liquids will have to double to over 9 million barrels per day. This should create a number of opportunities, but also challenges including environmental concerns, economic hurdles, and infrastructure development at considerable cost.
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Slide 7. Total Liquids Supply
Here we are in 2009 with our production capabilities flattened out – In order to meet the future demand, we will have to use enhanced oil-recovery methods, develop the unconventional resources, as just noted, and find new oil at an increasing pace. We are adding about 80 million people a year to the planet, or about the population of San Francisco every 48 hours. The world daily oil production capacity is constrained near its present levels because of both geologic and above-ground realities.
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Slide 8. Gas Supply
While projections of gas supply show continued growth, they were reduced in the EIA 2008 outlook due to infrastructure risks and uncertainties in Nigeria, Russia, Iran, and Venezuela.
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Slide 9. All Sources of Energy Will Be Needed.
So while oil and gas and coal supplies will need to be increased, we must also increase energy production from biomass, nuclear, wind, solar, geothermal and hydroelectric power -- plus, inventive new sources such as harnessing the jet stream at 40,000 feet, using oceanic thermal hyaline currents, spaced-based solar energy and the heat from the bottom of our sedimentary basins – and ---?
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Slide 10. Coal, Oil &Natural Gas Will Remain Indispensable.
As the world's population increases and as we hope the standard of living continues to increase, the energy pie will get larger. Wind, solar, etc. will have to grow, and conventional oil, gas and coal will have to increase just to keep up with the demand for energy. It is difficult to grasp the immense SCALE of global energy use, and, as a result, some suggest one or two new energy sources will fix all our energy problems – in a few years' time.
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Slide 11. Access to World Proved Oil Resources
Let us look where the big oil is by volume. Read from top. The red color indicates that operations from outside companies are restricted. Considering recent events, we shall add Venezuela and Russia. The gas chart shows Iran and Russia with huge reserves, and both are somewhat restricted. Thus, there are concerns about secure energy supplies and diminished opportunities for stock holder-owned companies and energy security for the United States. If restricted access to prospective areas of the world continues, the vast amount of capital required to find and build the infrastructure to produce the oil and gas will not be available from the free market.
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Slide 12. Global Oil Trade
How will that oil get moved from the producing countries to the consuming countries? It is shown here that more oil will be imported to the U.S. from Canada and Mexico. Huge new flows will go to Asia to support its large and growing population and its rapid industrialization.
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Slide 13. Global LNG Trade

The global LNG trade will become a major source of energy for the world by 2030. While flows will increase to the U.S., even greater flows will go to China and the other Asian nations. This will be an important part of the increasing energy portfolios for the rising economies of the Asian nations.

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Slide 14. World Population and Energy Consumption

This map with the lights on is indicative of a world going through a major fundamental change. Since WWII the two areas lit-up and consuming energy in large amounts were the U.S. and Europe (the G-8). Now a third area of Asia (China-India-Korea) can be seen. This developing user-nation cluster will import huge energy flows and continue to increase its total consumption from a large variety of energy types.

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Slide 15. Projected Demand Increase

Here we see the predicted change from the major demand of energy by the OECD (Organized Economic Cooperation for Development) to the non-OECD nations. This shift in demand and consumption of energy will have a major impact on the world economy.

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Slide 16. CO_2 Emission Limits Will Alter Energy Strategies.

CO_2 emissions and how to handle them will be a major concern in the energy business from now on. There are actually many opportunities here, but that is a subject by itself. I hope the efforts will expand to include clean air and water and a discussion of population growth.

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Slide 17. Global Energy Supply and Demand Dynamics and Power Shifts

This chart shows the flow of energy supplies from the producer nations to the consumer nations on the right. The flow of oil and gas to the world can be thought of in three parts. The supply part of the equation on the left, the geopolitical and economic factors in the middle and the demand and consumption on the right.

Supply

For nearly 100 years the three factors that controlled the flow of oil to markets were multinational oil companies, the evolving technology they used to find, produce, transport, and refine oil and the producing countries and their governments. The international companies served as a buffer between the producing and consuming nations.

The oil markets were ruled by free play, open markets, open acreage for exploration, and competitive business. The dynamics for the flow of oil from producers to consumers were comparatively straight forward, if not filled with intrigue (Anthony Sampson, *The Seven Sisters*, 1975; Daniel Yergin, *The Prize*, 1990).

With the formation of the Organization of Producing and Exporting Countries (OPEC), the flow of oil started to fall into the complexity of the geopolitical realm. The list of some of the factors that must now be considered when predicting future oil and gas flow is shown in the center column.

The shift in power was not immediate, however, for a number of reasons. The companies and their technical contractors were masters of oil field technology. The western world was the primary consumer of the product and, following World War II, held the bulk of sovereign wealth and corporate funds that made exploration and development possible. The shift in the control of the world's volume of oil and access to the most prospective sedimentary basins for future resources has now shifted to the national oil companies. With events in Venezuela and Russia the control of resources by national oil companies is becoming even greater. No matter what one believes about the merits of such a shift, one thing is certain. As geopolitics becomes a major factor in the equation of supply and demand, it becomes infinitely more complex.

Geopolitical and Economic Non-linear Filters and Catalysts

When analyzing the future status of supply meeting demand, the primary consideration of some economists is often the assessment of the total amount of oil and gas reserves remaining in the world. While this is certainly a good starting point for calculating long-term future supply, it is not sufficient for the prediction of the NET EFFECTIVE OIL AND GAS that will be available to the consuming nations and the prediction of the market price in the near- to mid-term -- over the next 5-10 years. This Net Effective Oil and Gas is now determined by a complex of geopolitical and economic parameters, many of which are "above ground" factors beyond the risks of finding and producing the oil and gas. These many parameters interact with each other as an organic non-equilibrium system.

Complex, self-organizing adaptive systems possess a kind of dynamism that makes them qualitatively different from just complex, multifaceted linear systems (M. Mitchell Waldrop, *Complexity*,1992). The critical skill in making predictions in such complex systems is insight, the ability to see connections between the complex variables, and then making data-based, dispassionate discussions.

The habitat for such insight is not commonly found in committees, international organizations, bureaucratic governmental bodies, or cartels.

Demand

While demand for oil has always had its ebbs and flows with the rise and fall of the global economy, it has now become much more complex.

Beyond simple price swings, we must now consider rapid improvements in efficiency and the rise of alternative energy resources. Human population has increased three hundred percent in 70 years – more than doubled since 1960. If current trends persist, there will be 2.5 billion more people on the planet by mid-century, bringing the total to about 9.2 billion users of energy (The Population Institute, October 2009).

Shifting national power bases have occurred as BRICS (Brazil, Russia, India and China) became major players on the world stage, and they have become active producers and consumers. There are now three major energy consuming clusters in the world and a fourth is developing in South America.

Environmental concerns, legislation (cap and trade), geopolitics, etc., have become more important in the world of oil supply and demand.

Thus, the critical factor of Net Effective Oil and Gas flow and price may be of more immediate importance than total world reserves in the power shift of nations. In the next few decades the "net effective oil and gas flow" will have an often bizarre impact on the environment in which we work, play, marry, raise children, and retire. (after Alvin Toffler, *The Third Wave*, 1980; *Power Shift*, 1990).

Does this mean it is hopeless to try to predict the future of supply and demand of oil and gas? No! However, it suggests that we should expect increasing volatility of oil and gas supply and swings in the price. We should expect emergent events unknown, unknown's (UNK-UNK's) and beware of those experts who predict with certainty future oil and gas supplies and price.

Petroleum brought our global civilization to where it is today. As we change the rules for its use, let us be aware of the impact of our actions. The complex calculus of supply and demand has changed! It has become infinitely more complex.
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18. Global Supply and Demand Conclusions
I must say that in addition to thinking about supply and demand of oil and gas, we had better consider water, soil, food supplies, minerals, and the natural environment as our population reaches toward 7 billion in the next few years.
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