

LONE PEAK OR MOUNTAIN RANGE?

Challenges for Forecasting Peak World Oil Production

Presentation to EIA

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**A SPECTRE IS HAUNTING THE
WORLD OF ENERGY
FORECASTING -**

**THE SPECTRE OF
PEAK OIL!**

WHY DOES PEAK OIL POSE SUCH A CHALLENGE?

- **Current forecasting models faithfully reflect past reality**
 - Demand-constrained energy system
 - Incremental changes with low uncertainty
- **Peak oil forces us to envisage a different future**
 - Supply-constrained energy system
 - Discontinuous changes with high uncertainty

PRESENTATION OUTLINE

- **Hubbert's Peak – the dominant model**
- **World Oil Resources – how much?**
- **Non-resource constraints on world oil production**
- **Guidelines for traversing this mountain range**

THE HUBBERT MODEL

- **Based on changes in annual rates of discovery and production**
- **Key postulates of the model**
 - **Production follows discovery**
 - **Both peaks are symmetrical**
 - **Each peak marks the halfway point in cumulative discovery and production**

A BEWITCHING MODEL

- **Elegant simplicity of his model is irresistible**
- **All imminent peakists use it**
- **Predicted peak years are a function of postulated ultimate resources**

A BADLY FLAWED MODEL

- **Key assumptions are wrong**
 - **Discovery curve is always asymmetrical to the left**
 - **When production follows discovery is highly variable**
- **Model itself provides no means of reliably estimating ultimate recovery**
- **Model cannot accommodate recovery growth or unconventional oil**

ULTIMATE WORLD OIL POTENTIAL

	<u>Low</u>	<u>Medium</u>	<u>High</u>
	(billion barrels)		
Cumulative Production	1080	1080	1080
Proved Dev. Reserves	715	715	715
Recovery Growth	815	1195	1685
Future Discoveries	350	780	1310
Unconventional	<u>340</u>	<u>550</u>	<u>860</u>
World Total	3300	4320	5650

WORLD OIL POTENTIAL

- **These estimates are not pessimistic**
 - Low estimate = emerging minimum consensus
 - High estimate = highest recent maximum
- **Large range of uncertainty still exists**
- **Differing views about the composition of increases are clearly legitimate**

RECOVERY GROWTH (1)

- **The increase in estimates of ultimate recovery in known fields over time**
- **Paradox of recovery growth - most important source of recent reserve additions, yet the least understood and appreciated source of these additions**
- **Basic assumption for estimating potential: Past field development was economically, technologically, and data constrained**

RECOVERY GROWTH (2)

- **Estimates assume future recovery factors of 35-40-45% of c. 7 trillion barrels of known original-oil-place**
- **Growth will occur primarily through intensive IOR and EOR**
- **Estimate includes 300-390-510 billion barrels from fields under development or planned for development**

FUTURE DISCOVERIES (1)

- **The best understood source of future additions**
- **Potential concentrated in a small number of major and superprovinces**
- **Augmented and modified recent USGS worldwide estimates used**

FUTURE DISCOVERIES (2)

- **Augmented to add major North American basins not in global USGS assessment**
- **Modified to exclude recent discoveries and to reduce potential because of recent exploration failures**
- **Most future discovery potential is 15-50 years from production**

UNCONVENTIONAL OIL RESOURCES (1)

- Limited to naturally occurring liquid hydrocarbons
- Three types included:
 - Extra-heavy oil/bitumen (tar sands)
 - Oil from mature source rocks
 - “Oil shale”
- Immense in-place resources - at least 3-4 trillion barrels from each source

UNCONVENTIONAL OIL RESOURCES (2)

- Unconventional due to poor fluid quality, poor rock quality, or both
- Recoverability is thus the central problem for unconventional oil resources
- Estimates of potential assume 10-20% for Alberta and Orinoco, very low recovery for other unconventional
- Energy use and net energy are key issues for unconventional recovery

DO HIGH LEVELS OF WORLD OIL RESOURCES ELIMINATE THE PROBLEMS OF PEAK OIL?

- **Forecasters of continued robust growth think so**
- **Three interrelated reasons why they are wrong**
 - **Large range of uncertainty about resource potential**
 - **High current levels of production**
 - **Major constraints on developing capacity**

LARGE RANGE OF UNCERTAINTY

- Potential additions of 1505 to 3855 billions barrels
- Likely higher if unconventional problems are resolved
- However, current planning must be based on the high confidence (low) estimate, not the median, the mean, or the high
- We will only **begin** to know if higher estimates can be realized 15-25 years from now

HIGH CURRENT LEVELS OF PRODUCTION

- **Profound underestimation of problems of scale**
- **Three orders of magnitude increase in less than one century**
- **Radical transformation of the challenges of increasing production**
- **140+ years to produce the first trillion barrels - 30 years to produce the next trillion**

MAJOR CONSTRAINTS ON DEVELOPING NEW CAPACITY

- The inexorable decline rate
- High rates of capacity additions required to keep production constant
- Constraints on new capacity permeate the system
 - Resource quality
 - Political
 - Economic

WHAT IS THE CURRENT DECLINE RATE?

- **Key factor for forecasting**
- **Differing standards of reserve determination complicate understanding – need proved developed reserves**
- **Use 4% worldwide (same as IEA)**
- **Consistent with a weighted average of widely varying decline rate in major producing countries**

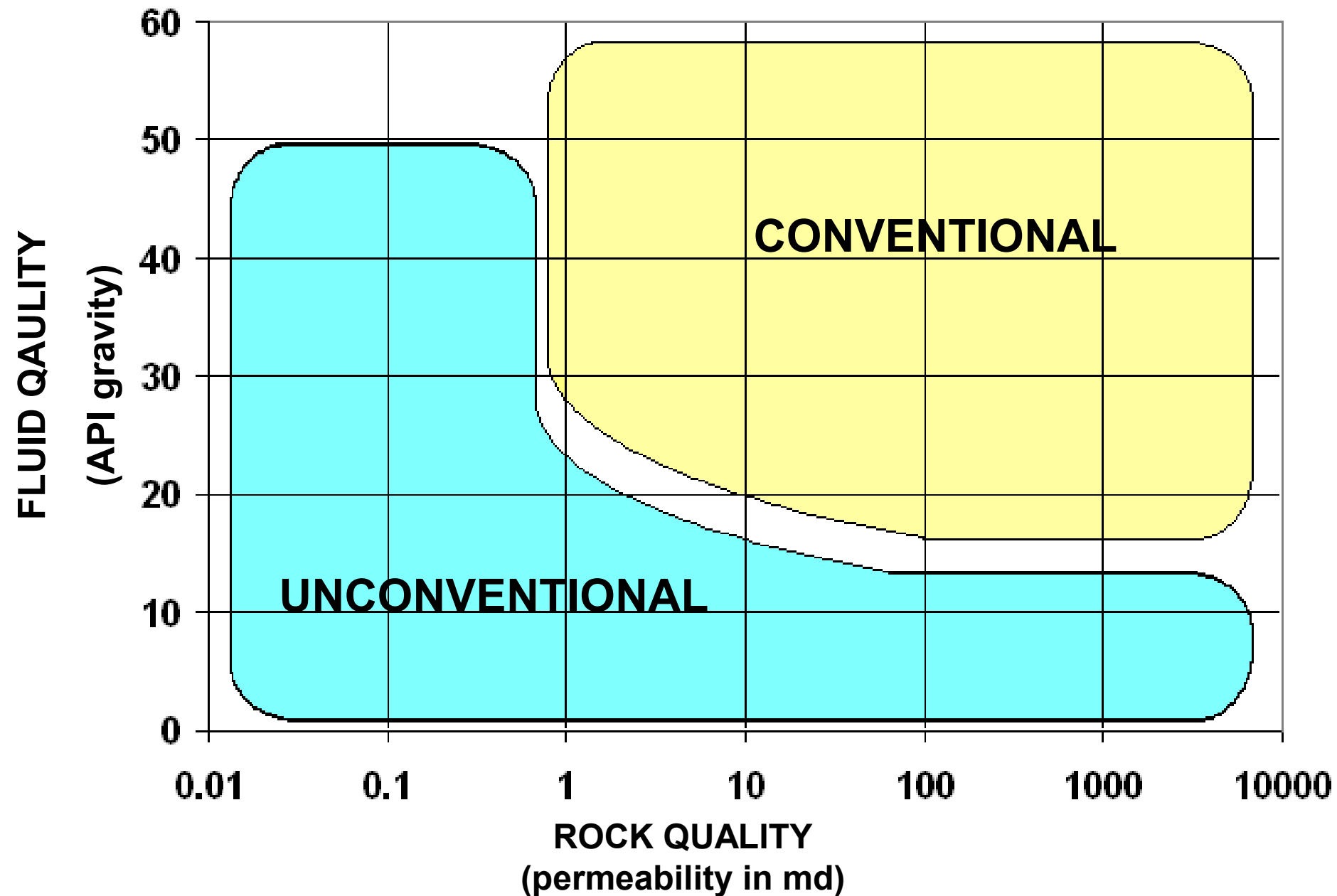
THE RATE OF CAPACITY ADDITIONS

- **Fundamental problem in forecasting future world oil production**
- **Simply maintaining current production requires adding 3.4 million b/d of new capacity each year (31 billion barrels committed reserves)**
- **Growing production is even more difficult**
 - **1% growth: 4.25 million b/d new capacity**
 - **2% growth: 5.1 million b/d new capacity**

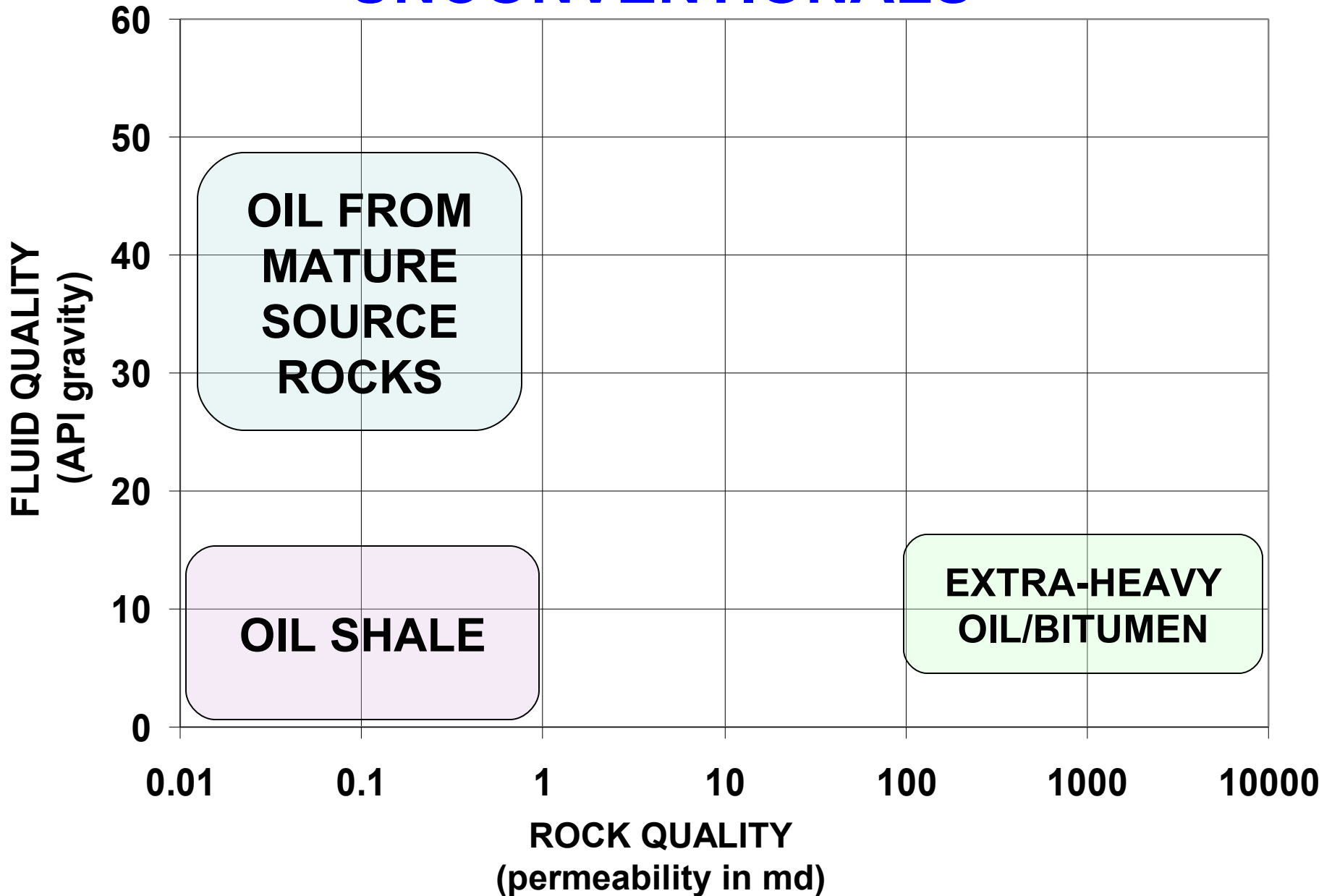
QUALITATIVE CONSIDERATIONS IN OIL RESOURCE ASSESSMENT

- Focus on quality measures that affect discovery, development, and producibility
- Multiple measures are available - three are particularly useful
 - Reservoir rock quality
 - Reservoir fluid quality
 - Resource location
- Relevant to many aspects of understanding world oil resources

RESOURCE QUALITY AND RESOURCE TYPE



RESOURCE QUALITY AND UNCONVENTIONALS



QUALITATIVE CONSTRAINTS

- **Rock Quality - low productivity**
 - Tight carbonates
 - High heterogeneity
- **Fluid Quality – high energy input**
 - Heavy oil
 - EHO/Bitumen
 - High Metals
- **Location – long lead times, technology**
 - Deepwater
 - Arctic

POLITICAL CONSTRAINTS

- **Several different political constraints shaping world oil production**
- **Chavez's/Putin's Peak**
- **Mars' Peak**
- **Prudential Plateau**
- **NIABY's Peak**

CHAVEZ'S/PUTIN'S PEAK

- **Fundamental characteristic – treating the oil industry as a cash cow for the government and those who control it**
- **The inevitable consequence – insufficient investment in new capacity**
- **The Chavez/Putin amplification – reducing organizational capability for new capacity additions (e.g., PDVSA and Yukos)**

MARS' PEAK

- **Conflict as a constraint**
 - Conventional and counterinsurgency war (Iraq)
 - Civil war (Nigeria)
 - Strong diplomatic sanctions (Iran)
- **Potential major effects**
 - Limiting production
 - Destroying existing facilities
 - Curtailing new investment

THE PRUDENTIAL PLATEAU

- **An emerging problem after 2010**
- **Countries with large reserves and resources (e.g., Abu Dhabi, Qatar, and Saudi Arabia) decide to maintain, but no longer increase production**
- **Two-edged sword: sustains the base, but no longer contributes to increasing capacity**

NIABY'S PEAK

- **Exploration and development of promising areas precluded due to alleged potential for major environmental damage**
- **Applies mainly to highly developed importing countries with substantial domestic production**
- **U.S. is the prime example**

ECONOMIC CONSTRAINTS

- **Economic constraints are general oil and energy market constraints**
- **Two general types**
 - **Lovins' Peak (demand)**
 - **Schumpeter's Peak (supply/substitution)**

LOVINS' PEAK

- **Behavioral changes, capital stock turnover, and demand transformation come to dominate the world oil market**
- **Return to a demand-constrained market**
- **Could such changes happen fast enough to precede resource-driven peaks?**

SCHUMPETER'S PEAK

- **“Creative destruction” of demand for oil by substitute sources of fuel supply**
- **Do relatively inexpensive substitutes even exist?**
- **Chemical, physical, and geological attributes of oil hard to beat**

EFFECTS OF NON-RESOURCE CONSTRAINTS

- Reduce rate of annual capacity additions
- Lengthen lead times to first production
- Eliminate resources from potential

- Each of these reduces the maximum level of production and/or postpones the time when this maximum will be reached

TRAVERSING THE MOUNTAIN RANGE

- **Move from aggregate to country-specific analysis**
- **Central elements**
 - **Resources**
 - **Projects**
 - **Politics**
 - **Market forces**

RESOURCES

- **Discovered and yet-to-find**
- **In-place: produced, developed, undeveloped, and contingent**
- **Current intensity of development**
- **Resource quality**

PROJECTS

- **Source of future capacity additions**
- **Focus on mega-projects ($> 50,000$ b/d)**
- **Redevelopment cannot be ignored**
- **Should be updated regularly**

POLITICS

- **National goals and policies**
- **Fiscal terms and costs of opportunities**
- **Industry capability**
- **Rates of investment and activity**

MARKETS

- **Price regimes (subsidies and penalties)**
- **Structure of oil demand**
- **Economic culture**
- **Development of substitutes and net energy**