The Shift from the Static Hydrocarbon Model (Hubbert) to a Dynamic Model: Re-Evaluating the Hubbert Curve and the Global Petroleum Revolution: A New Era*

Thomas Ahlbrandt[1]

Search and Discovery Article #70116 (2012)
Posted February 13, 2012

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Abstract

Why have the predicted global oil and natural gas shortages and demise of civilization by 2010 related to these vanishing supplies not occurred? The static view has created a pessimistic outlook based on historical perspective, such as the Hubbert curve analysis, which results in the inescapable and inevitable depletion that will result in catastrophic consequences for civilization. A new paradigm, a dynamic or petroleum system view, demonstrates a different and more optimistic hydrocarbon scenario. Evidence for this new view was initially demonstrated for natural gas. Natural gas was thought to be in critical shortage a decade ago, but is now plentiful in the U.S. and globally, so much so that gas prices are falling and the debate currently centers around a 100- or 200-year supply? This can be explained by a global revolution in petroleum and engineering sciences to explain a new paradigm which has completely altered how and where we find and develop petroleum. Most hydrocarbons (75% or more) have remained in the source rock (where thermally mature), yet developing them relies on new technologies not available until the last decade. The conventional (or static) approach to exploration is rapidly changing to the dynamic (petroleum system) approach, and this transformation is the most profound shift in the petroleum business in a century. Molecular-level studies of petroleum now abound, requiring wholly new techniques and evaluation parameters to determine economic viability. This in turn requires new research and educational pathways, and conversely some geosciences research areas will likely atrophy in the light of a new set of paradigms. This revolution has now extended to unconventional (also called resource) plays which are economically preferable to natural gas resource plays in the current market. The significance of an oil resource play is the Devonian Bakken play in the Williston Basin which in the past five years has catapulted the basin from the 98th ranked oil province in the world to 25th (and soon to 13th). Are we really in the sunset of the petroleum age or a new era?

Selected References

Ahlbrandt, T.S., R. Gajdica, R. Harrell, and S. Khurana, D. Elliott, 2005, Oil and gas reserve estimates: Offshore Technology Conference, Proceedings, May 2-5, 2005, Houston, Texas, CD-ROM, 10 p.

Ahlbrandt, T.S., R.R. Charpentier, T.R. Klett, J. Schmoker, C.J. Schenk, and G. Ulmishek, (eds.), 2005, Global Resource Estimates from Total Petroleum Systems: AAPG Memoir 86, 324 p.

Al-Husseini, M., 2009, World production of conventional petroleum liquids to 2030: A comparative overview: GeoArabia, v. 14/1, p. 215-267.

Borowitz, S., 1999, Farewell Fossil Fuels: Reviewing America's Energy Policy: Plenum, New York, 220 p.

Campbell, B., 2000, Outlook 2000: American Oil and Gas Reporter, v. 43/1, p. 48-50.

Campbell, B.S., 1994, Induced polarization anomalies associated with hydrocarbon reservoirs: three case studies: Association of Petroleum Geochemical Explorationists Bulletin, v. 10, p. 49-60.

Campbell, C., 1989, Oil Price Leap in the Early Nineties: Noroil, p. 35-38.

Campbell, C.J., 2003, The Essence of Oil and Gas Depletion: Multi-Science Publishing Co., Essex, England, 342 p.

Campbell, C.J., 1997, The Coming Oil Crisis: Multi-Science Publishing Co. & Petroconsultants, 210 p.

Charpentier, J.-C., 2005, four main objectives for the future of chemical and process engineering mainly concerned by the science and technologies of new materials production: Chemical Engineering Journal, v. 107, p. 3-17.

Deming, D., 2001, Oil: Are we running out?, *in* M.W. Downey, W.A. Morgan, and J.C. Threet, (eds.), Petroleum Provinces of the 21st Century: Second Wallace E. Pratt Memorial Conference, January 12-15, 2000, San Diego, California: AAPG Memoir 74, p. 45-55.

Duncan, R.C., 1997, Olduvai theory: Sliding toward a post-industrial Stone Age, *in* C.J. Campbell, (ed.), The Coming Oil Crisis: Multi Science Publishing Co., Essex, England, p. 106-107.

Deffeyes, K.S., 2001, Hubbert's peak-the impending world oil shortage: Princeton University Press, 208 p.

Goodstein, D.L., 2004, Out of Gas: The End of the Age of Oil, 1st ed.: W.W. Norton, New York, 140 p.

Hubbert, M.K., 1938, Determining the most probable: Technocracy, Series A, No. 12 (June 1938). Web accessed 9 February 2012, http://www.technocracy.org/technical-alliancetn/17-m-king-hubbert/205-hubbert

Klett, T.R., D.L. Gautier, and T.S. Ahlbrandt, 2005, An evaluation of the U.S. Geological Survey World Petroleum Assessment 2000: AAPG Bulletin, v. 89/8, p. 1033-1042.

Newell, R., 2010, Annual Energy Outlook 2010: U.S. Energy Information Administration (EIA), December 14, 2009. Web accessed 9 February 2012, http://www.ascension-publishing.com/BIZ/HD18-2010.pdf

Odell, P.R., 1998, Changing the face of the international oil market: Petroleum Review, v. 52/613, p. 22-24.

Thomasson, M.R., 2000, Petroleum geology; is there a future?: AAPG Explorer, v. 21/5, p. 3, 6, 9-10.

White, D., 1919, Unmined Supply of Petroleum in the United States: Journal of the Society of Petroleum Engineers, v. 12/5, p. 361-363.

The Shift from the Static Hydrocarbon Model (Hubbert) to A Dynamic Model:

Re-Evaluating the Hubbert Curve and the Global Petroleum Revolution: A New Era

AAPG 31st Annual Leadership Days
August 13, 2011
Tulsa Geological Society
February 7, 2012

Thomas Ahlbrandt

Thanks to Pete McCabe; Pete Stark IHS; APEX Engineering

The Petroleum Revolution:

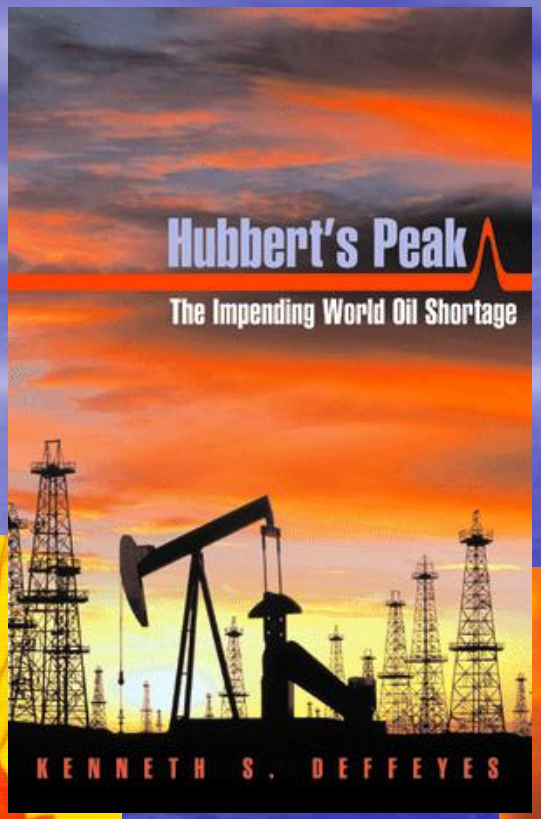
- The Static View—some history
- The Dynamic View—we are witnessing the paradigm shift from rocks to petroleum
- Demand constraints (OPEC got it right)
- Shift to unconventional natural gas and now to oil resource plays
- All conventional petroleum systems have large unconventional for BCGA and BCOA—shortage of these professionals—requires new skills, training and technology
- Are we really running out of petroleum?

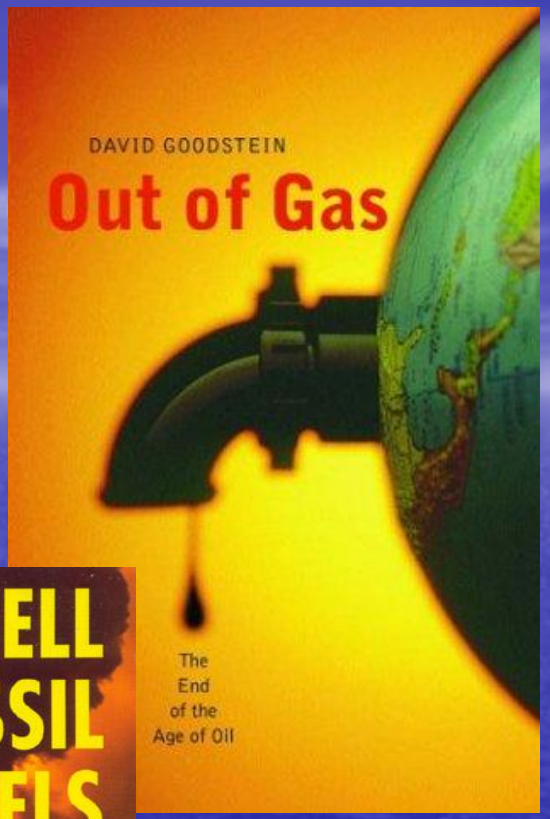
The Static View:

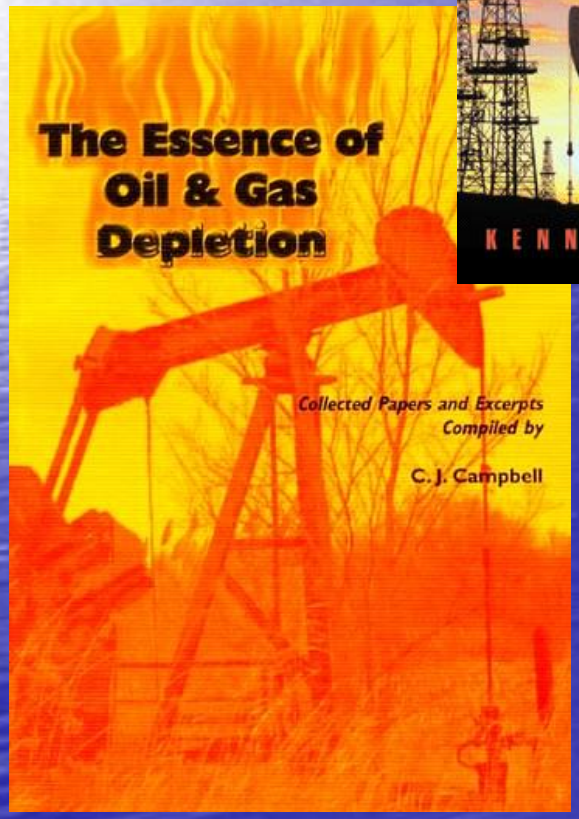
- Rock focused and Static (Plays)
- Technology is Reservoir focused
- Hydrocarbon composition in reservoirs is static; prediction of petroleum is commonly unexpected
- Reservoirs are on structure; off structure is less favorable
- Unconventional resources are curious developments but far less significant than conventional resources
- Source rocks are largely the expended remnants of an existing play
- Inescapable Conclusion That We are Near the End of Hydrocarbon Era

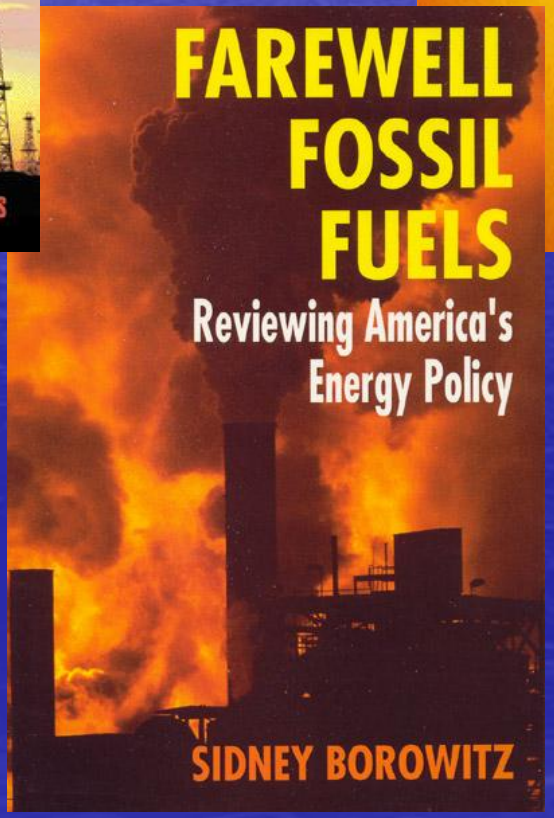
The Coming Oil Crisis?

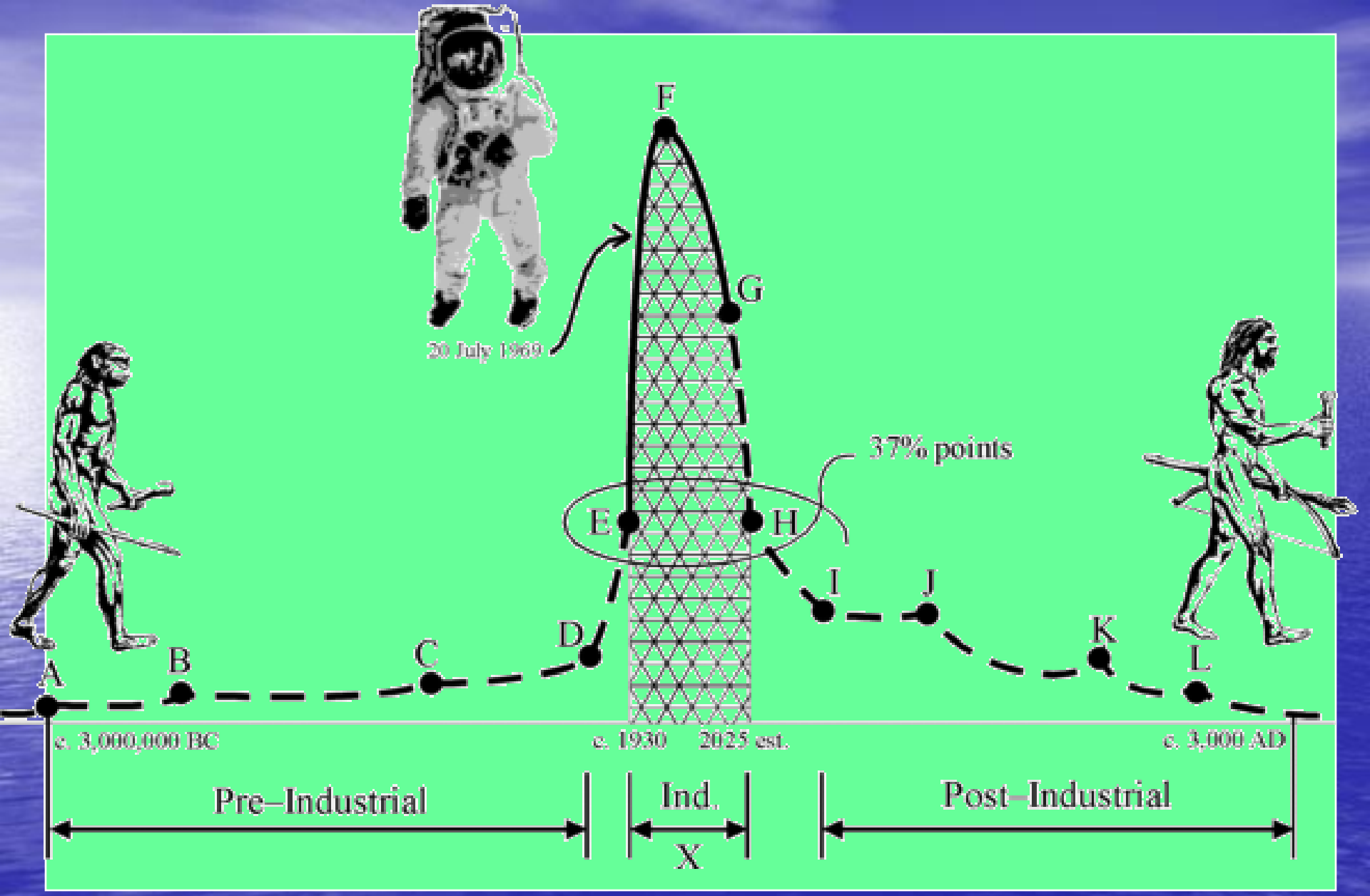
- **"..the peak of production will soon be passed—possibly within three years—Dave White, Chief Geologist, USGS, 1919**
- **"the peak of production will be reached in 1989, Campbell, 1989; prior to 2000"—Campbell, 1994; Duncan, 1997;"in 2004"—Campbell, 1997; "in 2010", Campbell, 2000--subsequently very dire consequences—most people die, we return to caves-- "Olduvai Theory"**


Hubbert's Peak
The Impending World Oil Shortage
KENNETH S. DEFFEYES


DAVID GOODSTEIN
Out of Gas
The End of the Age of Oil


The Essence of Oil & Gas Depletion
Collected Papers and Excerpts
Compiled by
C. J. Campbell

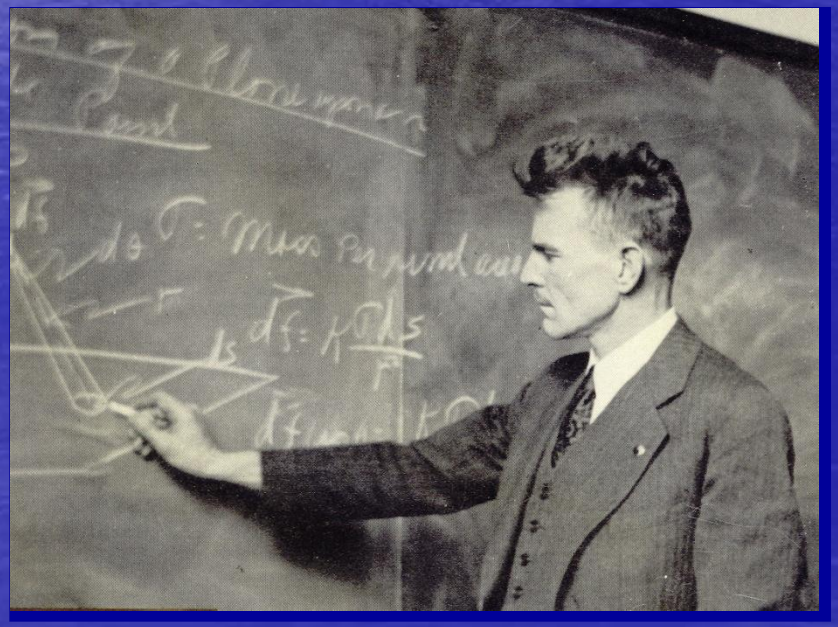

FAREWELL FOSSIL FUELS
Reviewing America's Energy Policy
SIDNEY BOROWITZ



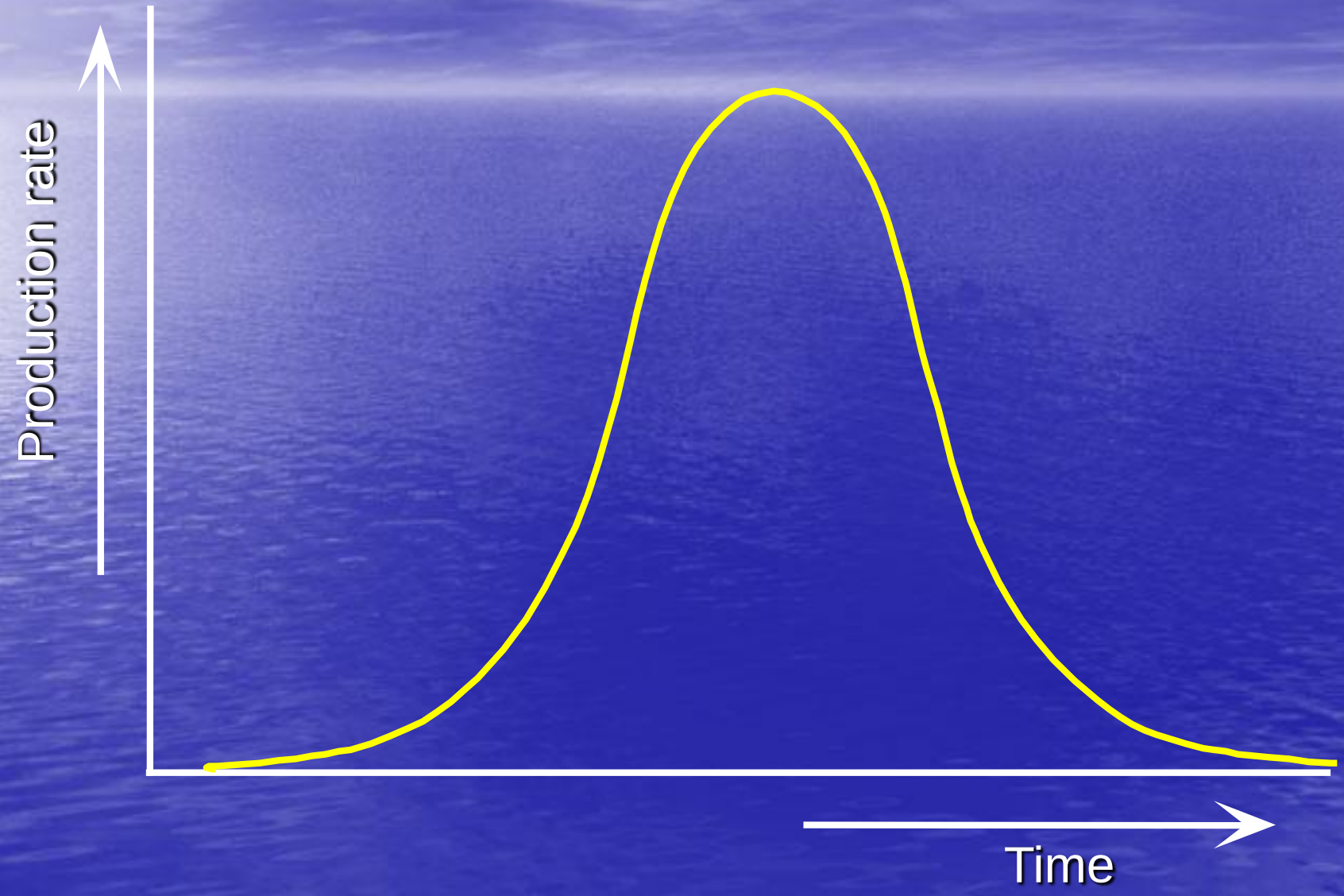
The Olduvai Theory of Industrial Civilization by R.C. Duncan (1997)
As posted on oilcrisis.com

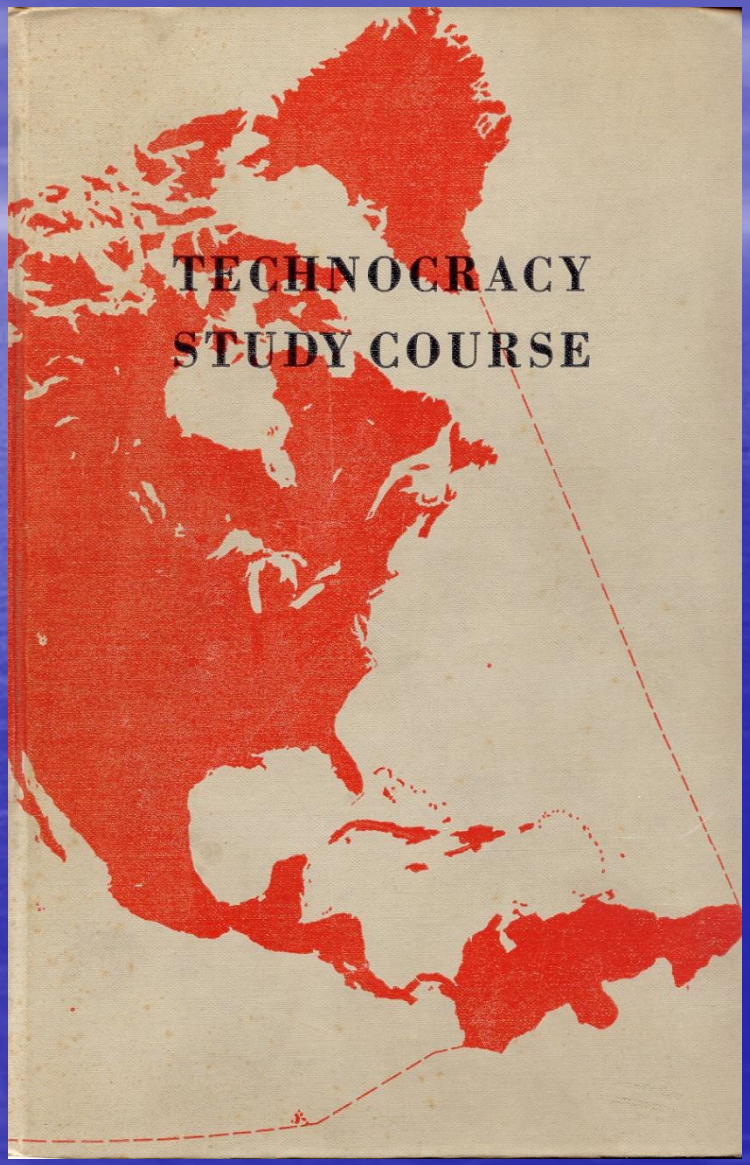
The Rise and Fall of the Hubbert Curve: Its Origins and Current Perceptions

Peter J. McCabe



Hubbert's Curve




TECHNOCRACY
STUDY COURSE

TECHNOCRACY

Technocracy

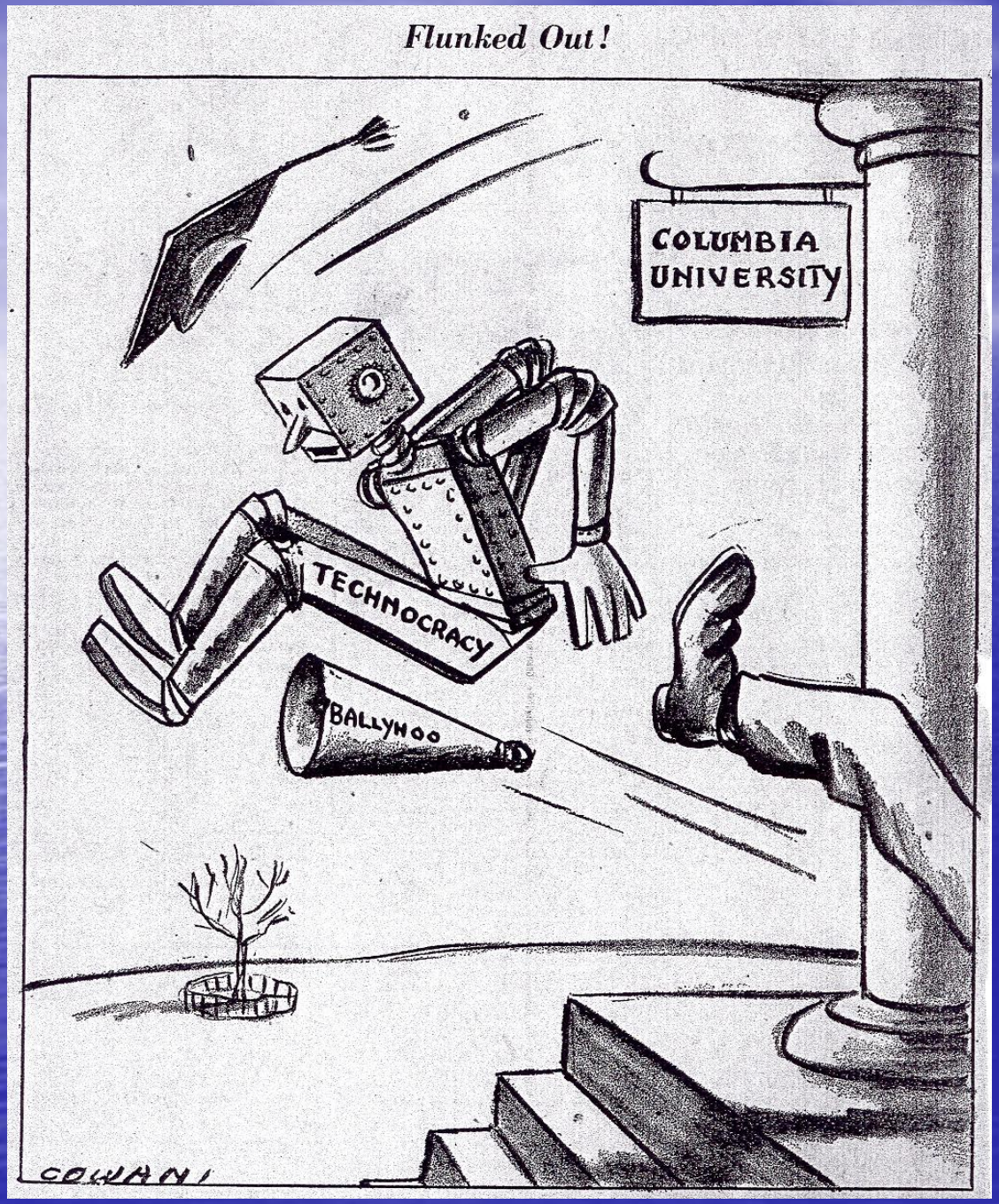
A self-sufficient North American state
Abolish political system.
State run by scientists and engineers.
Abolish money – institute a system of energy unit certificates.
Abolish unemployment.
Abolish liberal arts education.

Statistical trends can be used to scientifically anticipate the future needs of society.

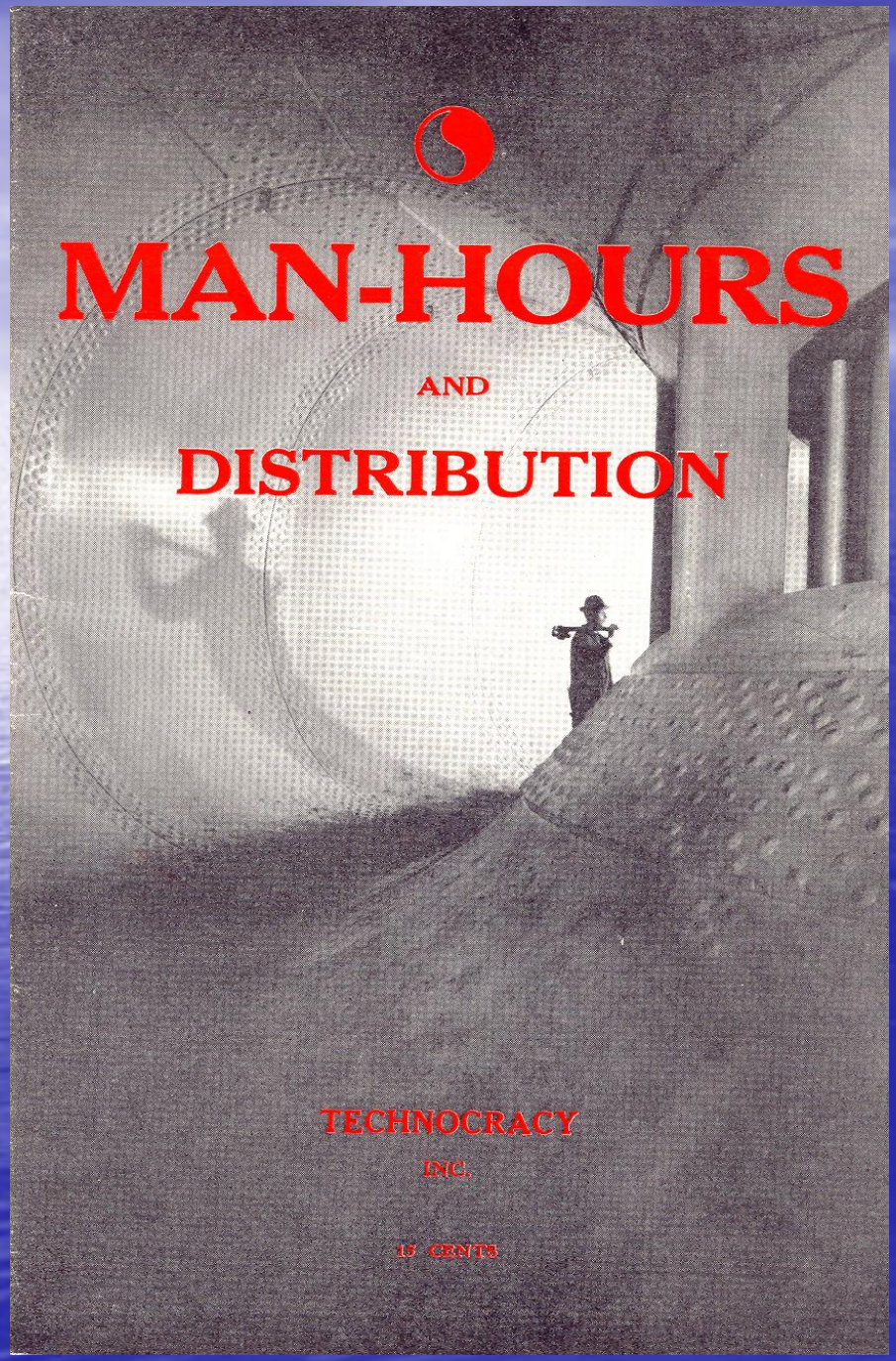
Howard Scott
1890 - 1970

Those technocrats you're heard so much about are right here at the Morrison Hotel today. Howard Scott (left) is the kingpin; Dorothy Crozier is secretary, and M. King Hubbert is assistant director. (Chicago American photo.)

June 29, 1933



Boston Transcript
January 27, 1933

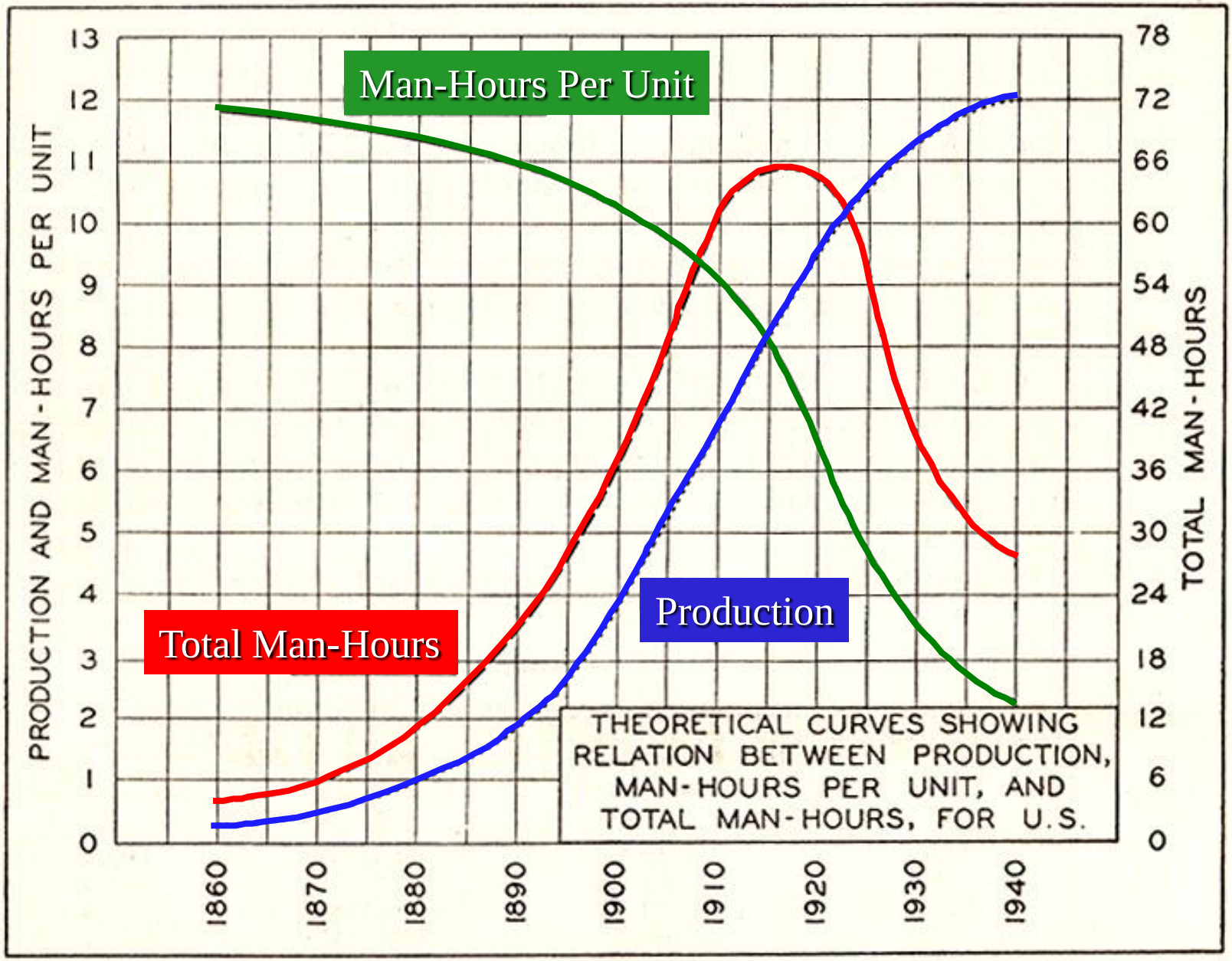


MAN-HOURS

AND

DISTRIBUTION

By M. KING HUBBERT
Director, Division of Education, Technocracy Inc.



M. King Hubbert, Director, Division of Education, Technocracy, August 1936

Hubbert Oil Supply Views Through Time

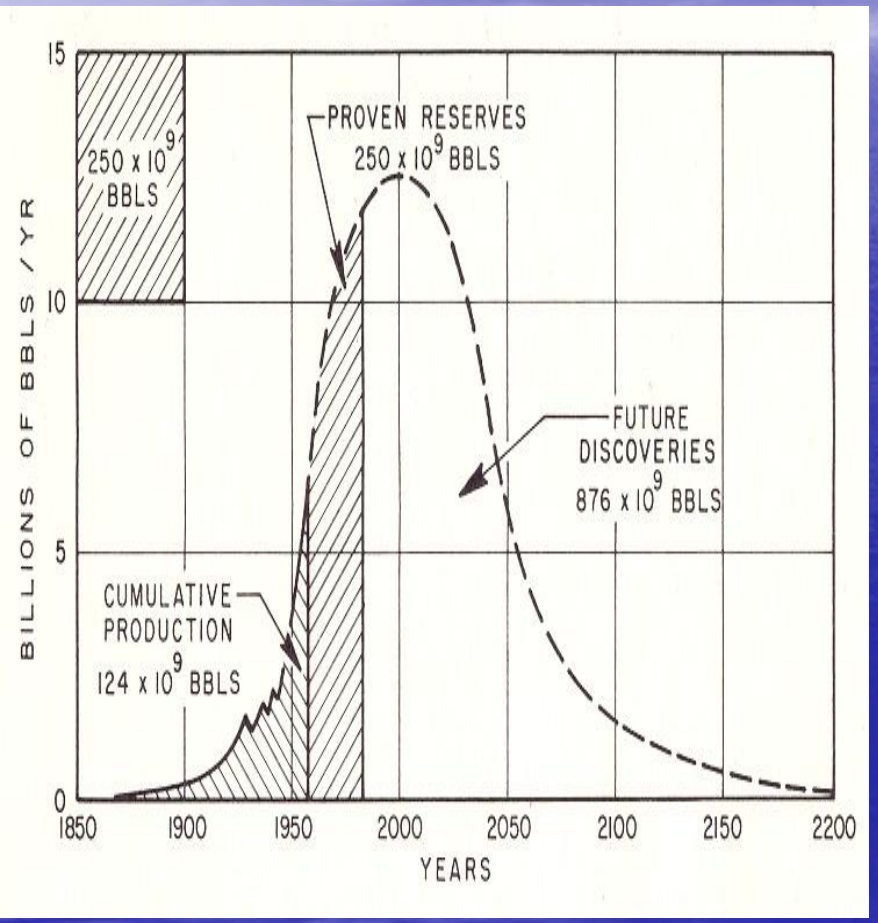
"While we do not know exactly how much oil remains undiscovered, we do know that it is a limited supply…Furthermore, the easy discoveries have already been made and only the difficult ones remain."

"It is certain that the production of oil will reach one or more peaks and finally decline.

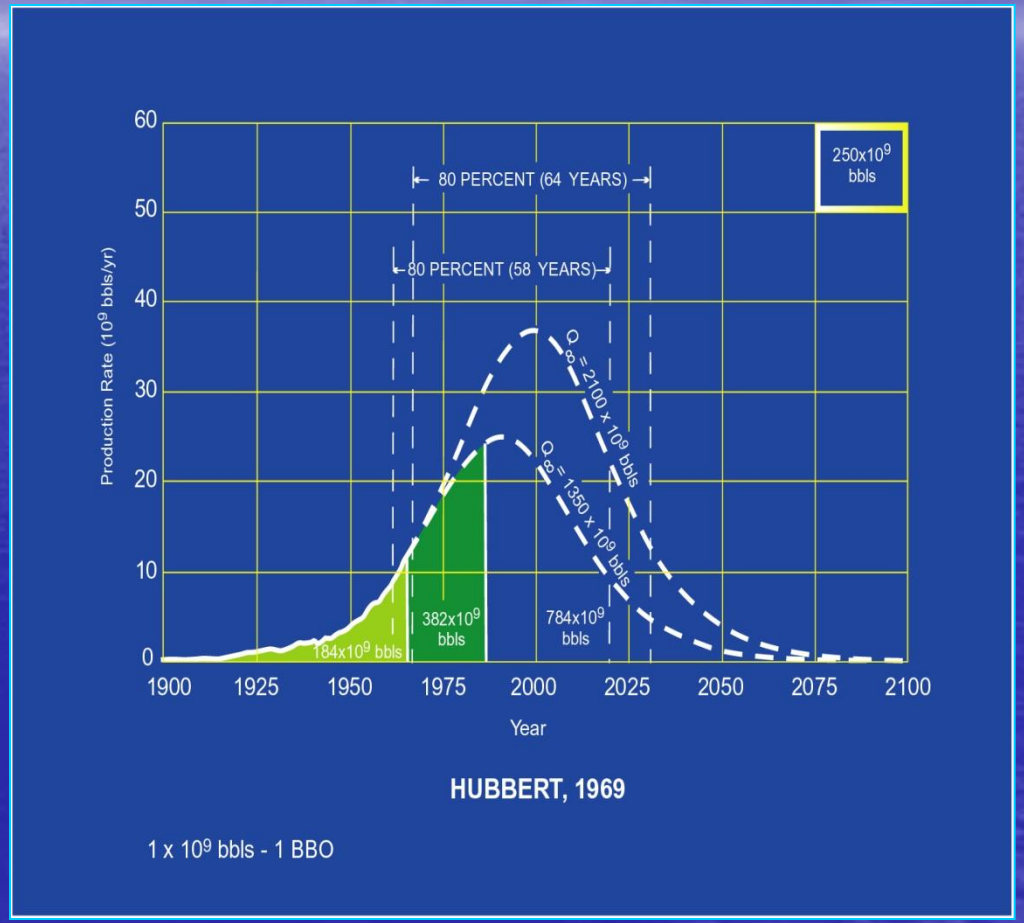
The time of this decline in the United States is somewhat uncertain, yet it seems doubtful that it can be postponed any later than 1950."

M. King Hubbert, 1938

Hubbert's World Oil Supply Views Through Time

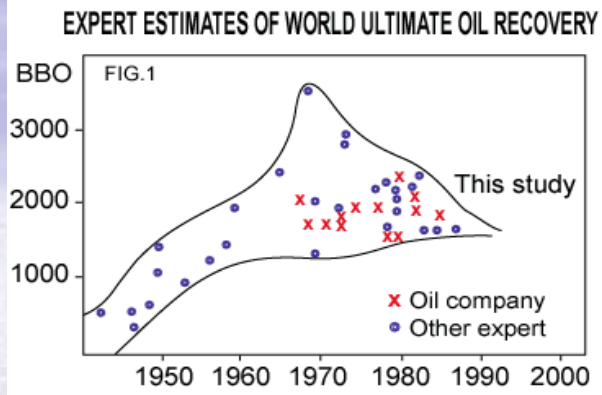


1,250 BBO
Hubbert, 1956



1,350 BBO—2,100 BBO
Hubbert, 1969

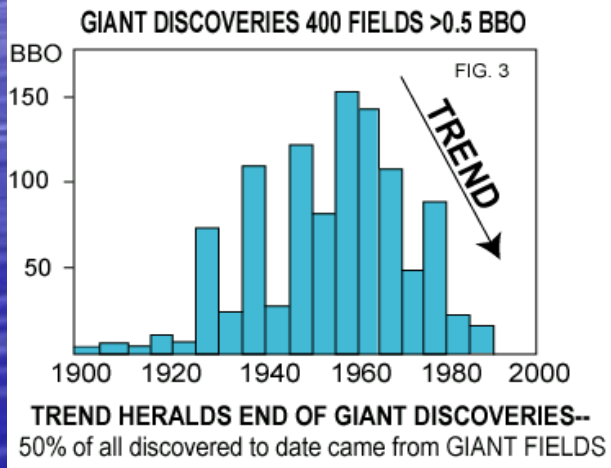
Predictions Based on the Static View



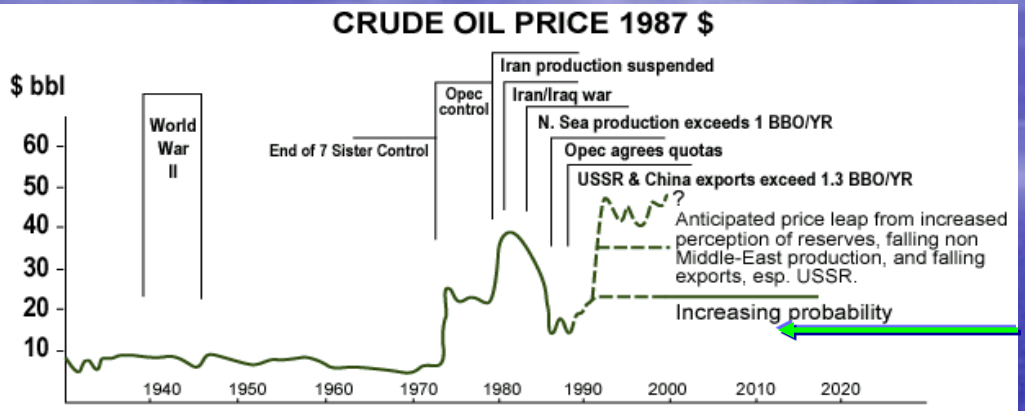
CONVENTIONAL OIL ONLY

Ignores:

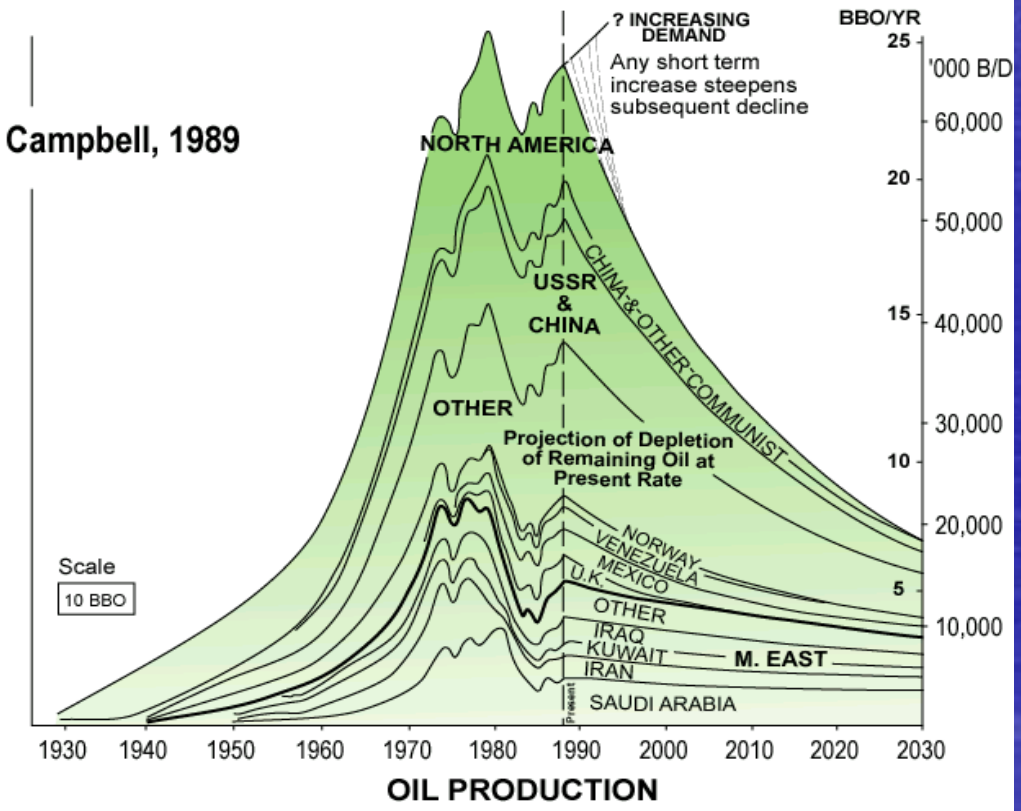
- "Unconventional" enhanced recovery
- Tar sands
- Oil shales
- Gas liquification advances



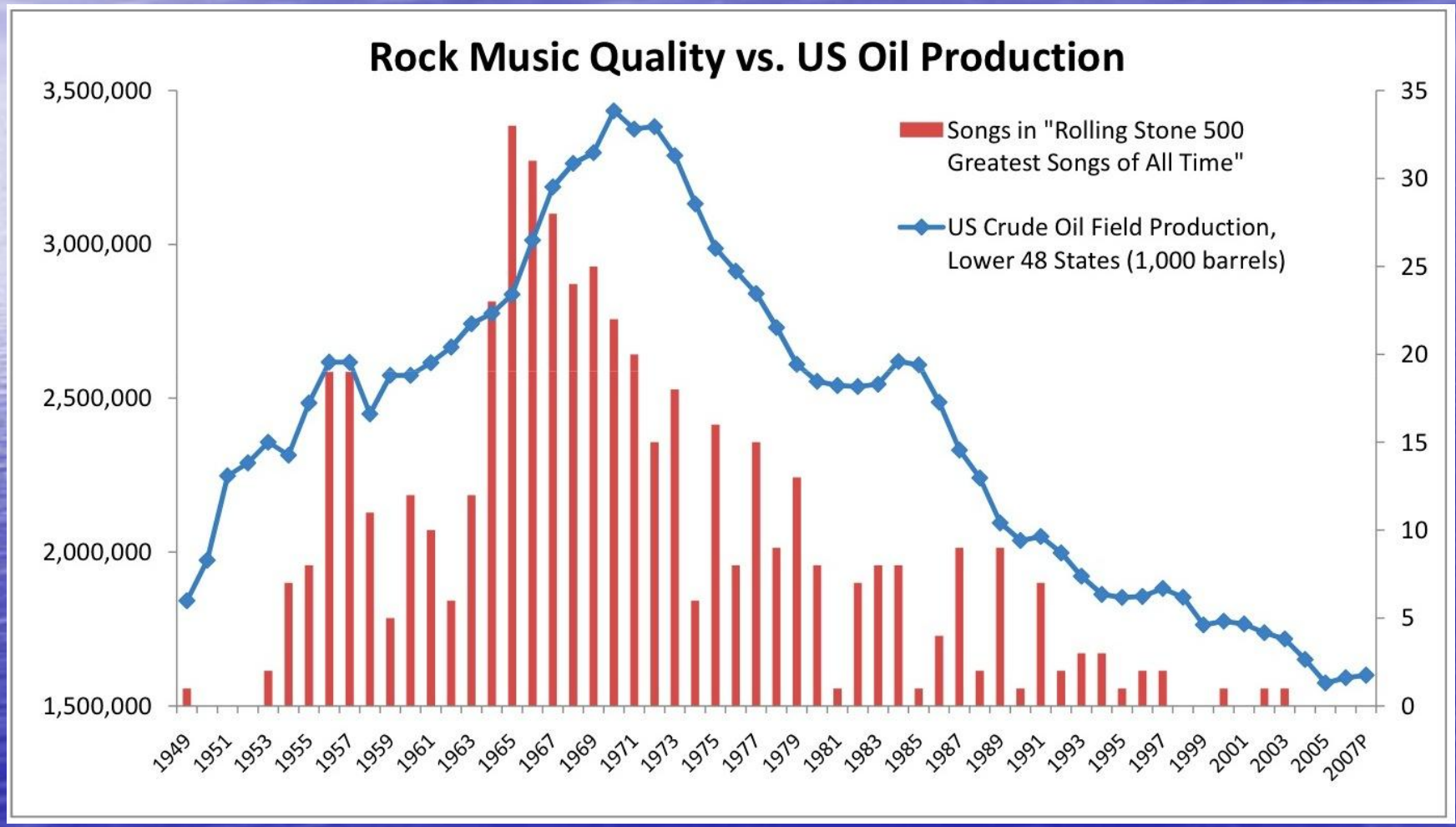
TREND HERALDS END OF GIANT DISCOVERIES--
50% of all discovered to date came from GIANT FIELDS



Current Production

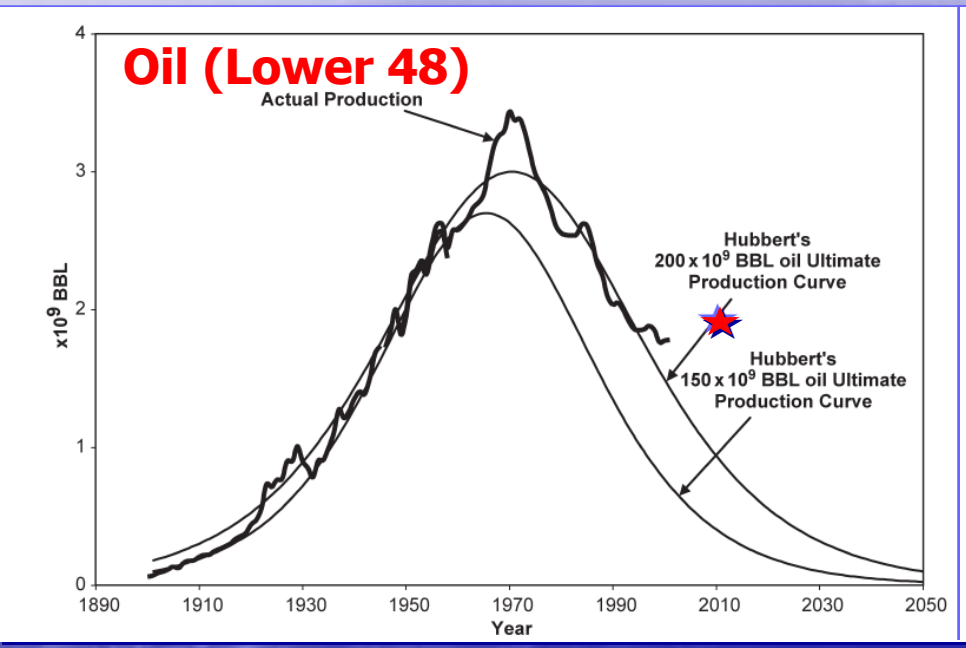


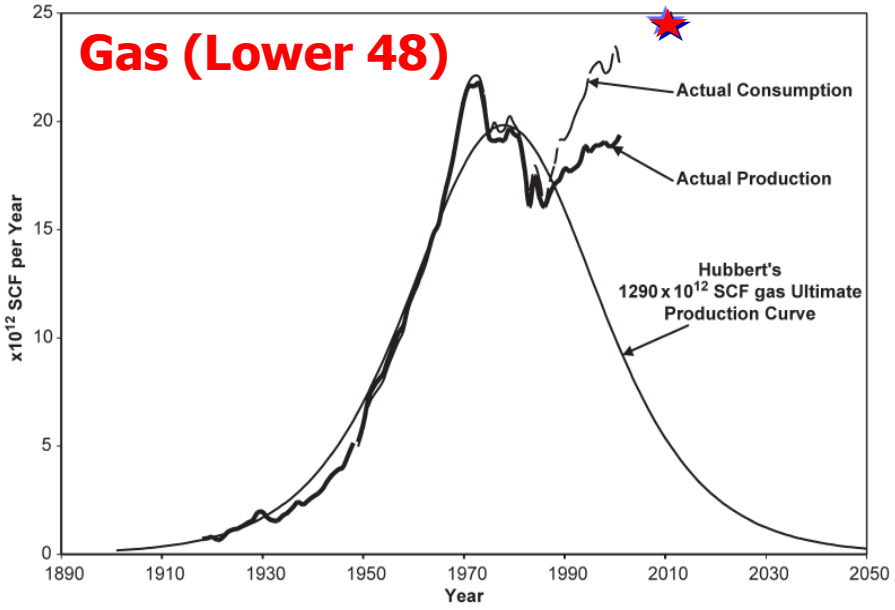
The Oil Crisis Causes the Decline of Many Things



Rolling Stone Magazine, EIA, 2008

Hubbert's U.S. Production Peaks

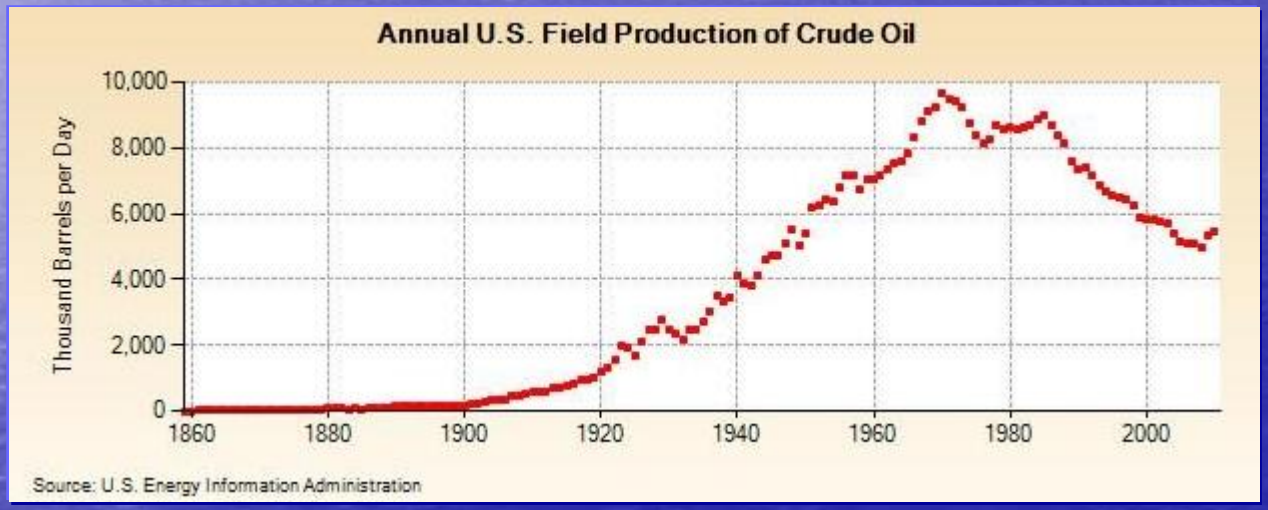




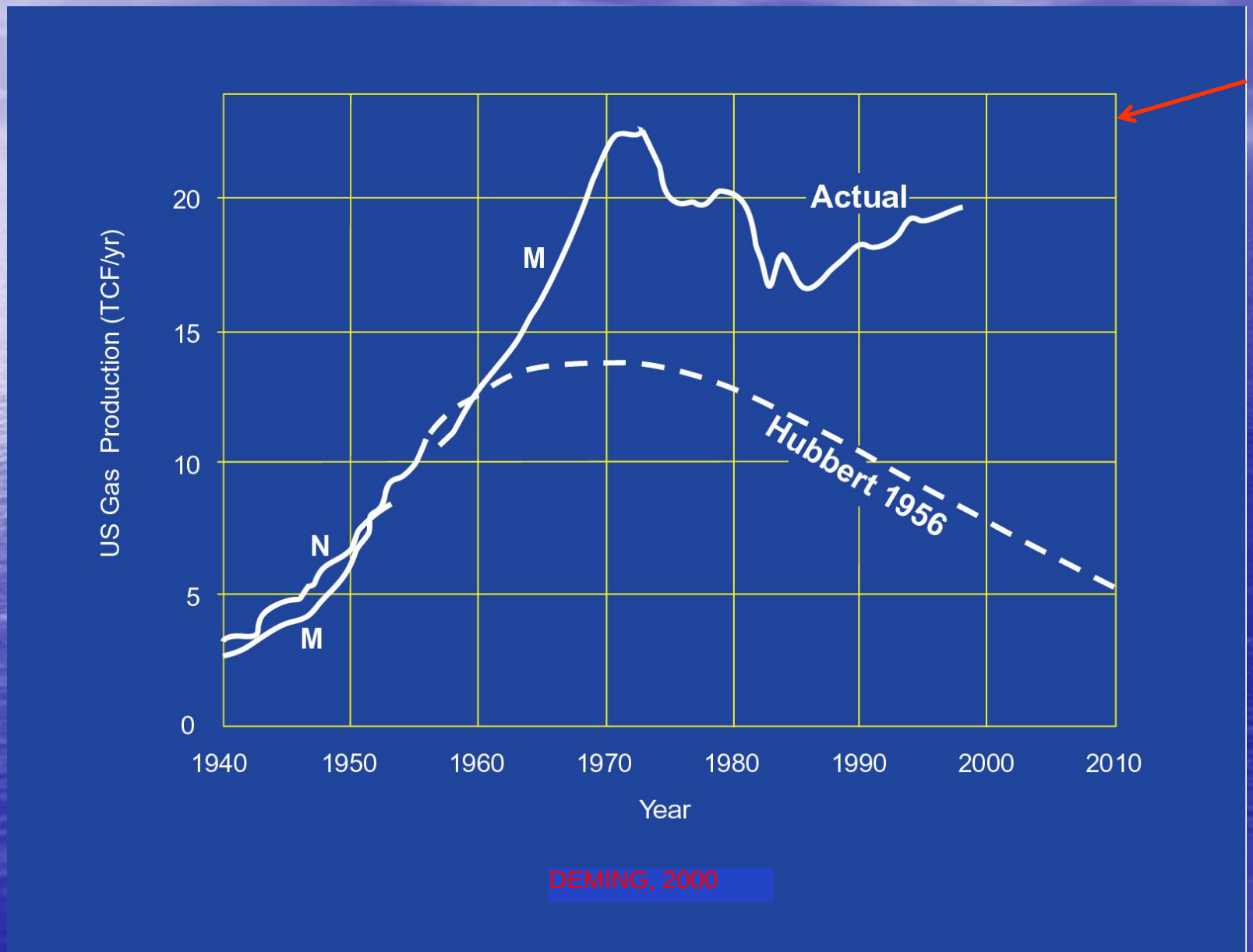
Charpentier, 2005

★ 2010 Production, EIA

U.S. Oil Production is Increasing

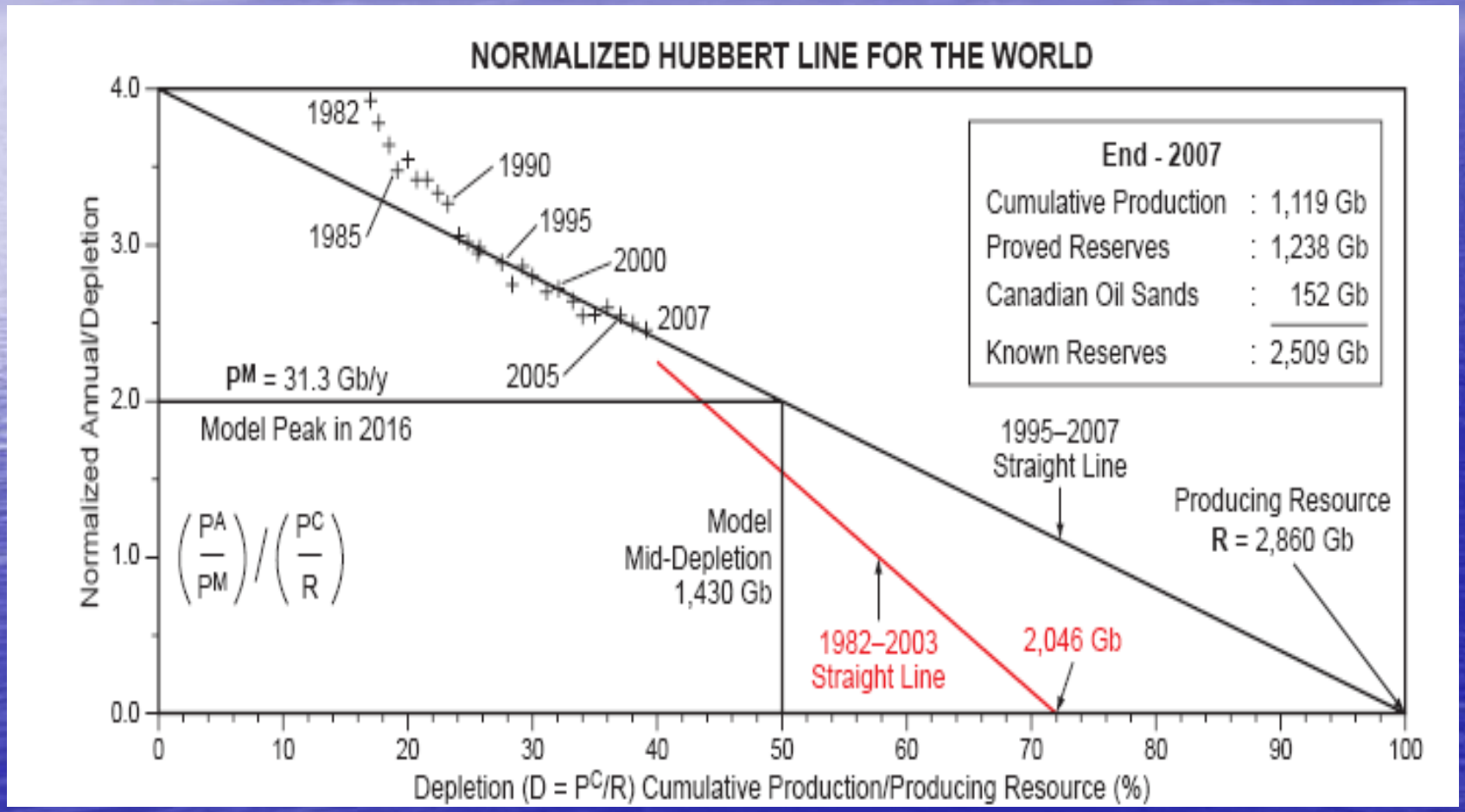


U.S. Gas Production is Increasing



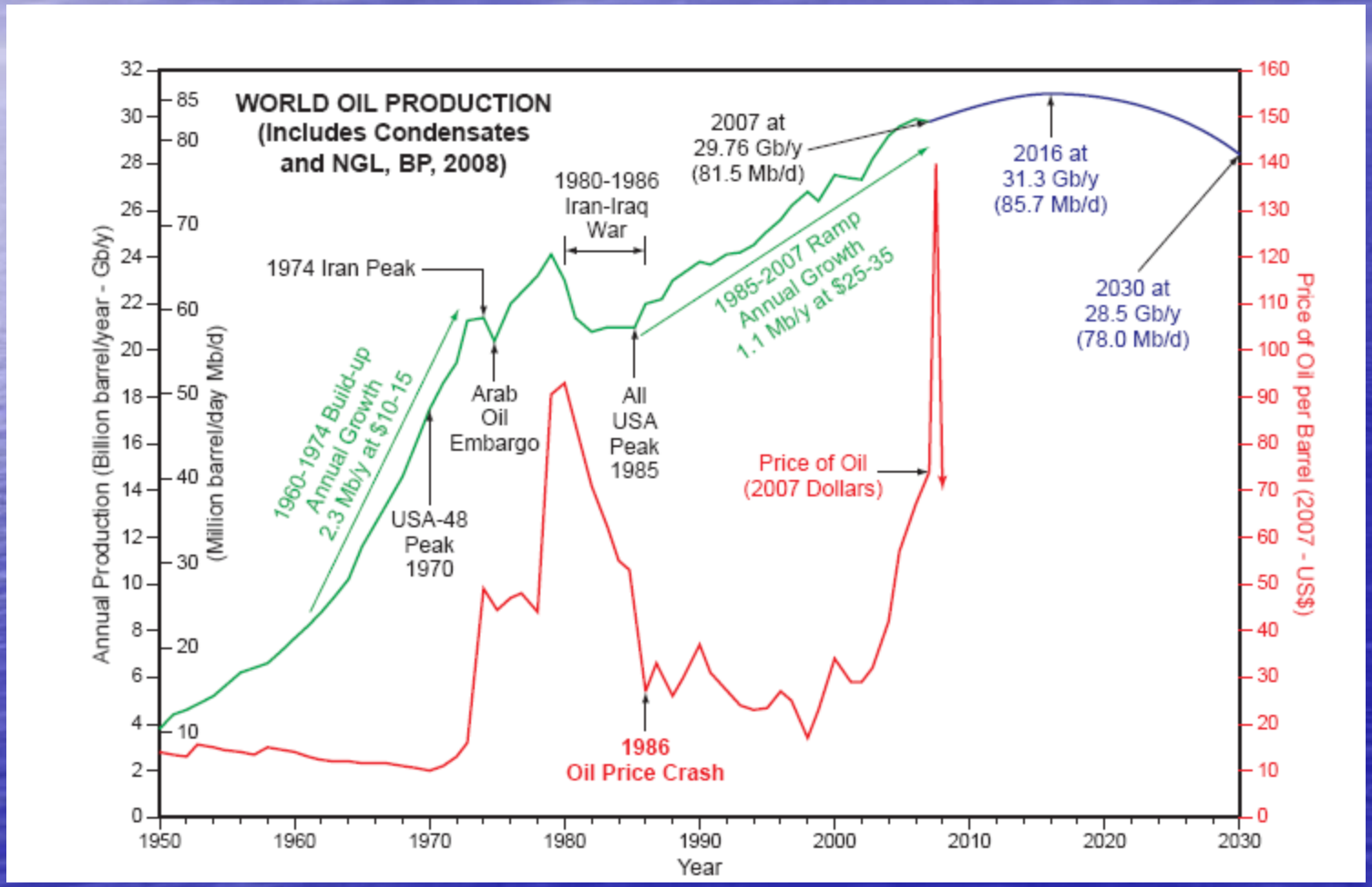
DEMING, 2000

2008 Data Show Problems with Previous Hubbert Curves for World Oil Producing Resource Now 2,860 Billion Barrels



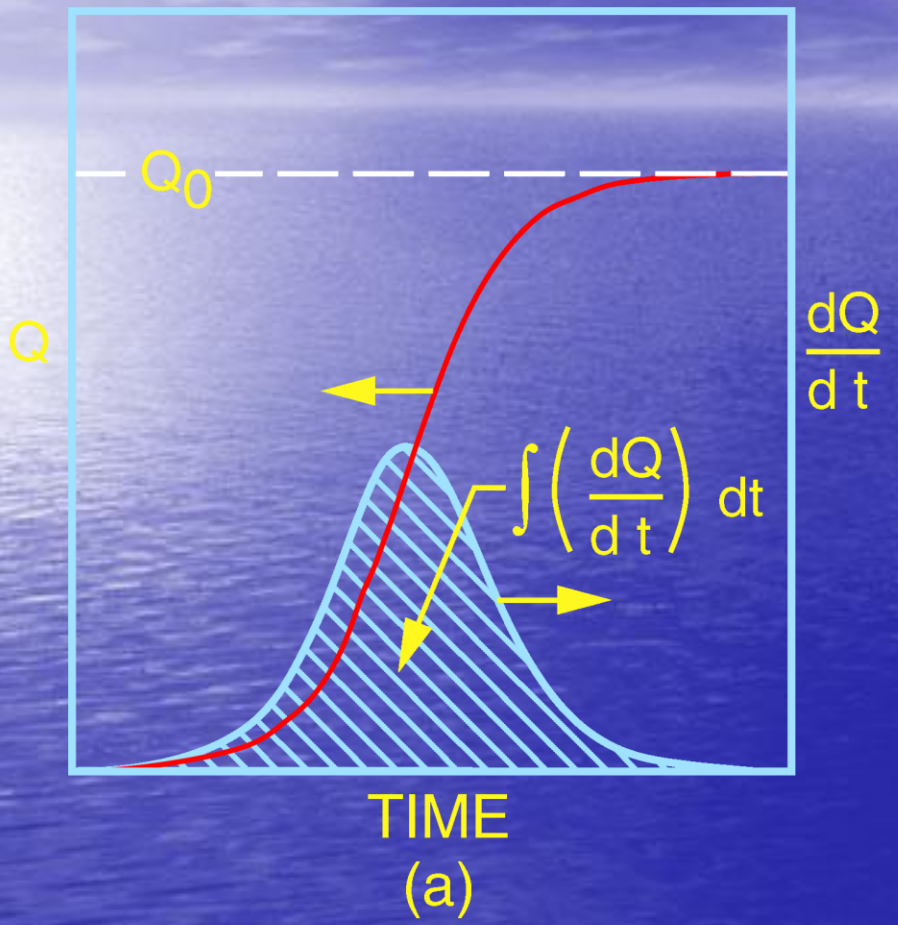
Al-Husseini, 2009

2009 View -World Producing Resource

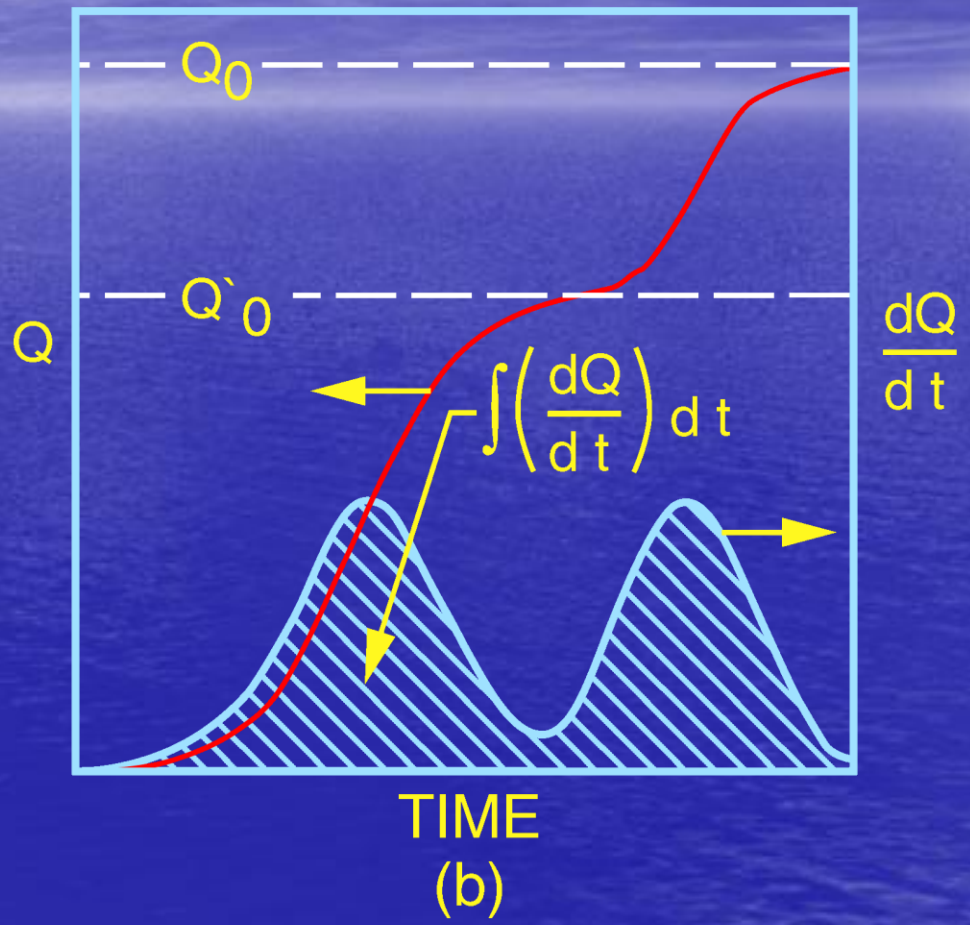


Al-Husseini, 2009

Recognition of the Effects of Secondary Recovery-- Logistic growth curves of cumulative production and their derivatives which give the rates of production



(a) single-cycle curve

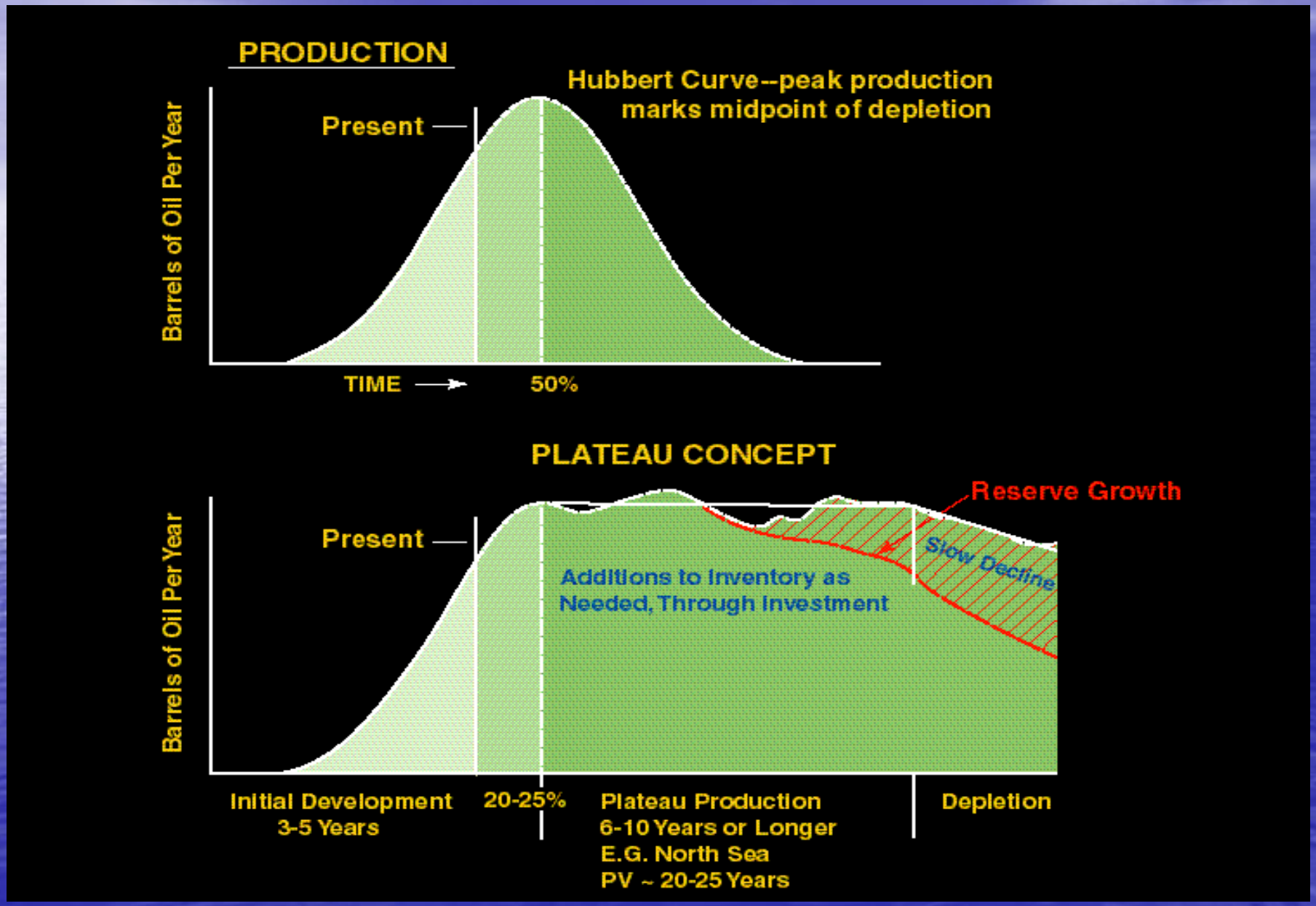


(b) multiple-cycle curve

Hubbert, 1959

The Dynamic or System View:

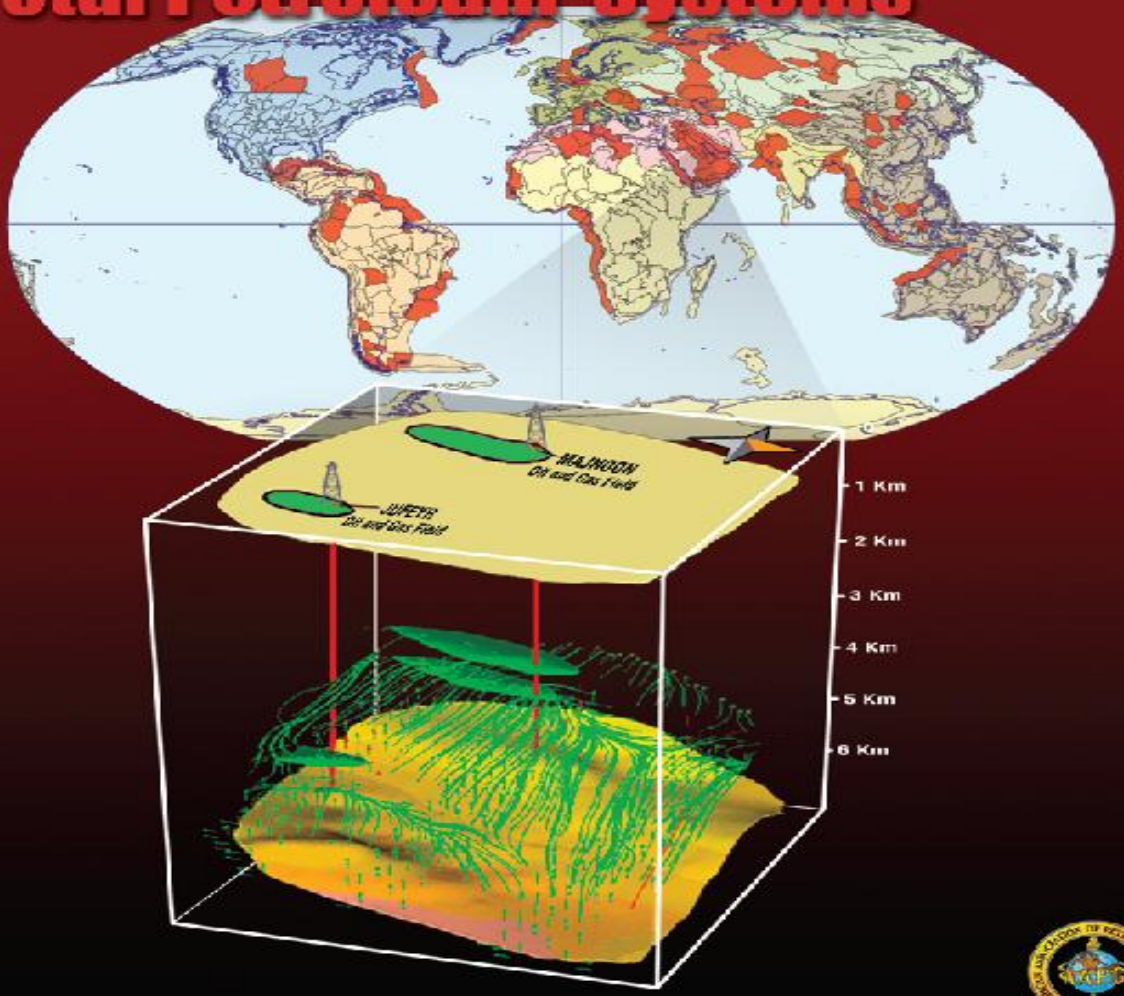
- Fluid focused and unstable (dynamic) (Petroleum Systems)
- Basins are complex non-linear, dynamic systems trying to maintain equilibrium but are thrown in and out of thermodynamic and pressure equilibrium
- Petroleum is constantly in a state of flux in response to burial, uplift and is essentially responding to changing PVT conditions
- Source rocks are the critical element and are cyclic (rejuvenated) and may be the reservoir (self-containing)
- Unconventional and conventional petroleum are linked; very large resources actually "kitchen" related, off structures
- Systems have life cycles —young, middle-aged and old, which link conventional and unconventional resources



Ahlbrandt, 2005

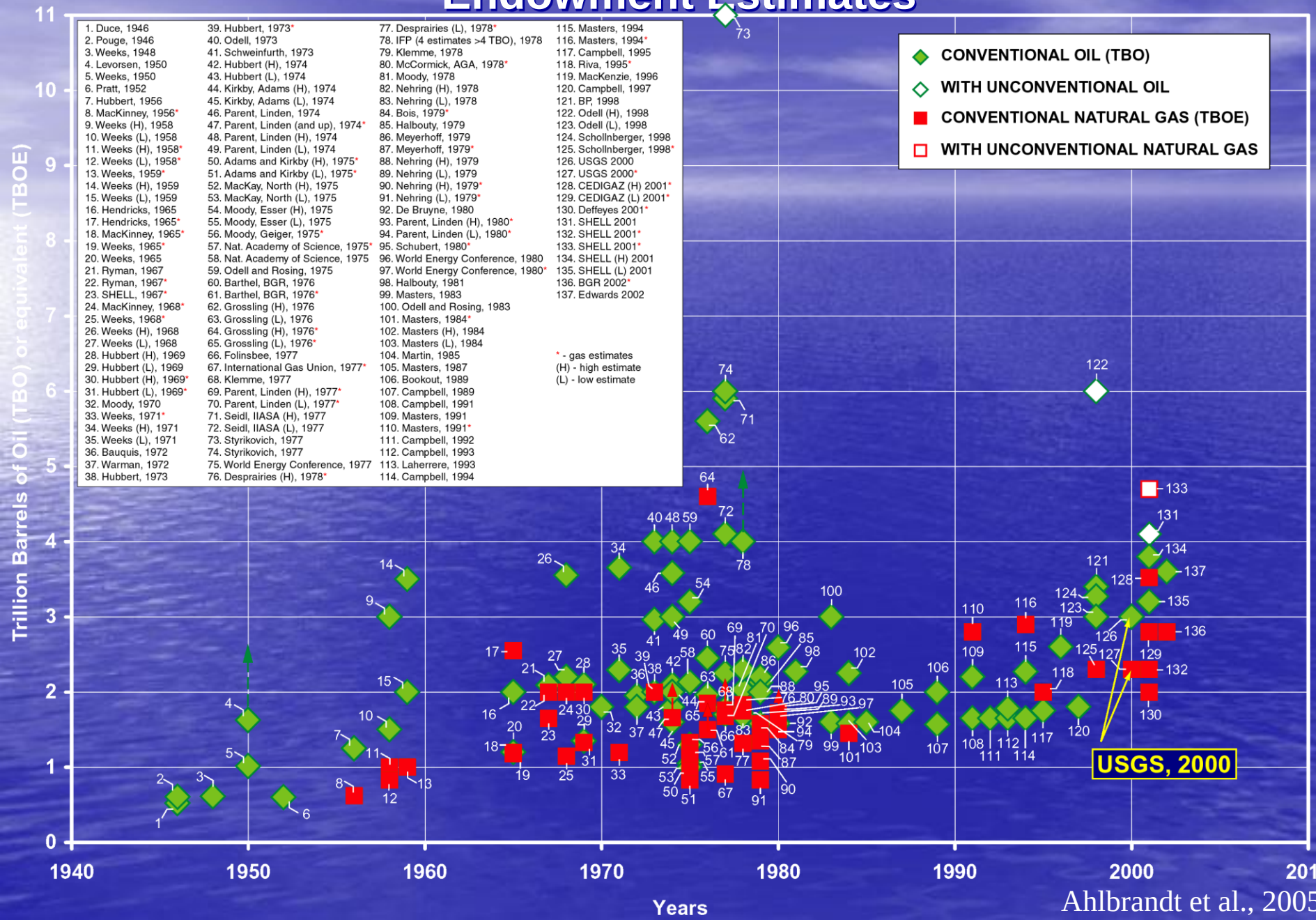
AAPG Memoir 86

Global Resource Estimates from Total Petroleum Systems



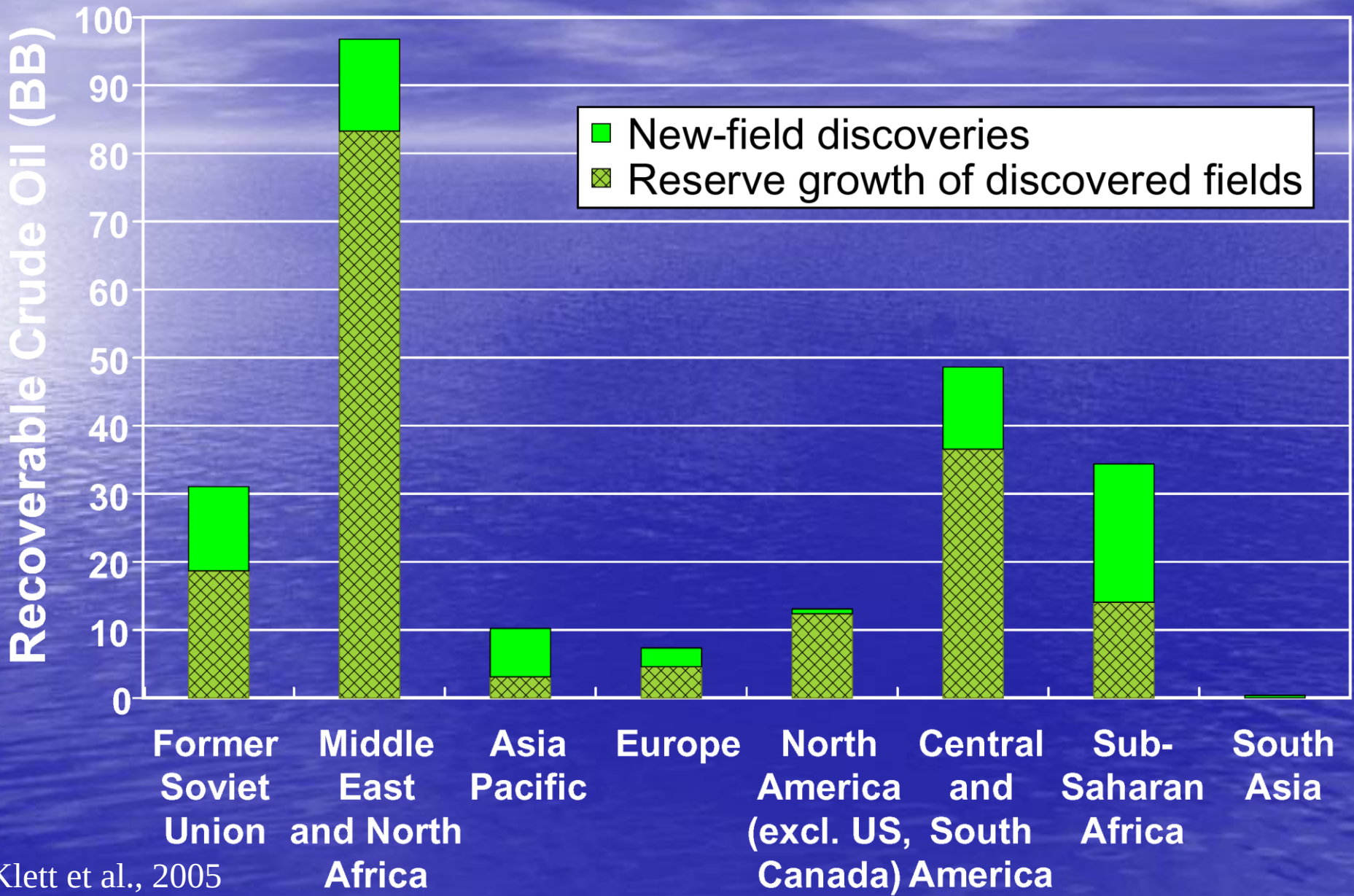
Thomas S. Ahlbrandt, Ronald R. Charpentier, T.R. Klett,
James W. Schmoker, Christopher J. Schenk and Gregory F. Ulmishek

Comparison of World Oil and Natural Gas Resource Endowment Estimates



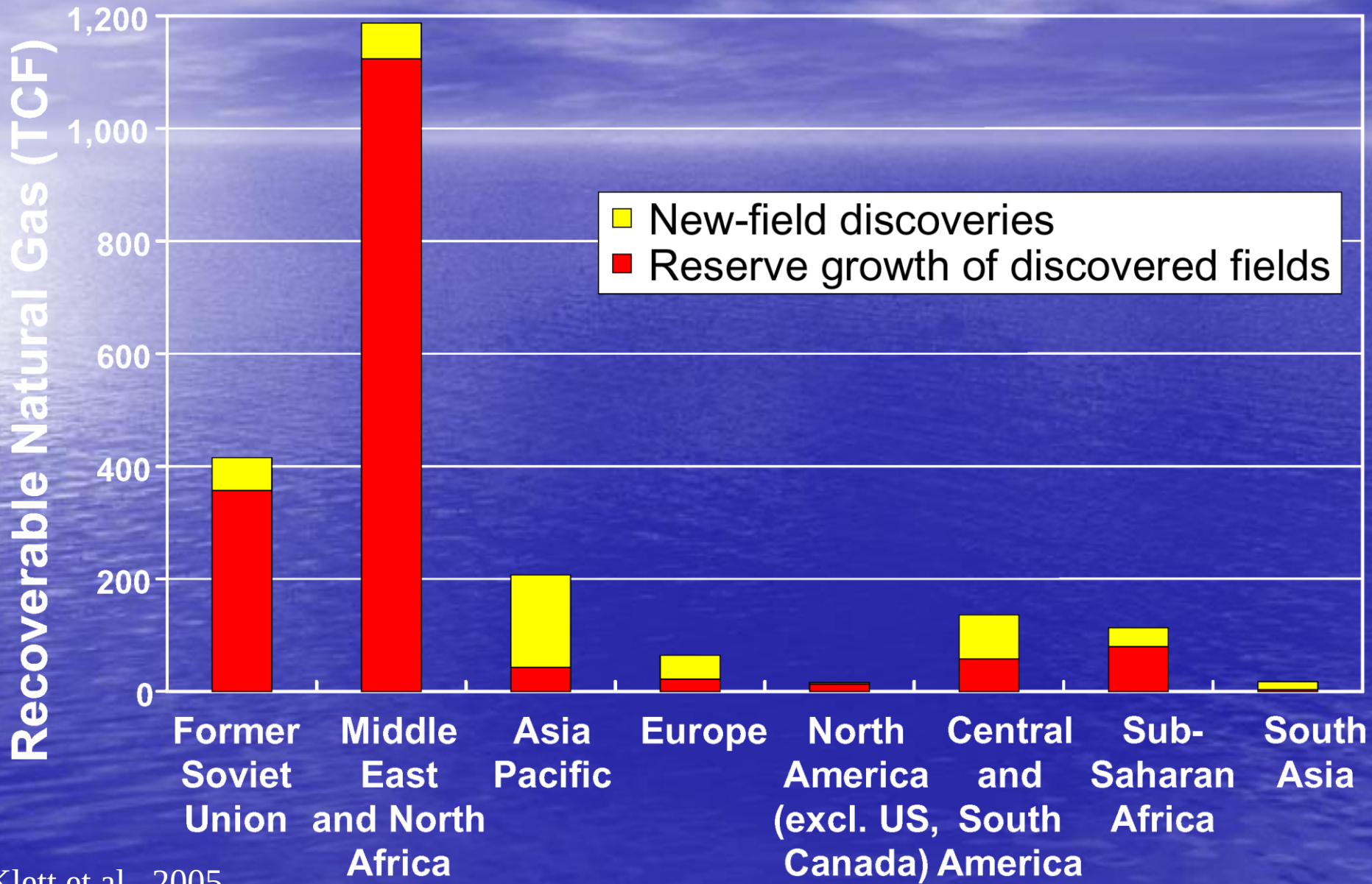
Ahlbrandt et al., 2005

Oil Reserve Additions: Reserve Growth vs. Undiscovered



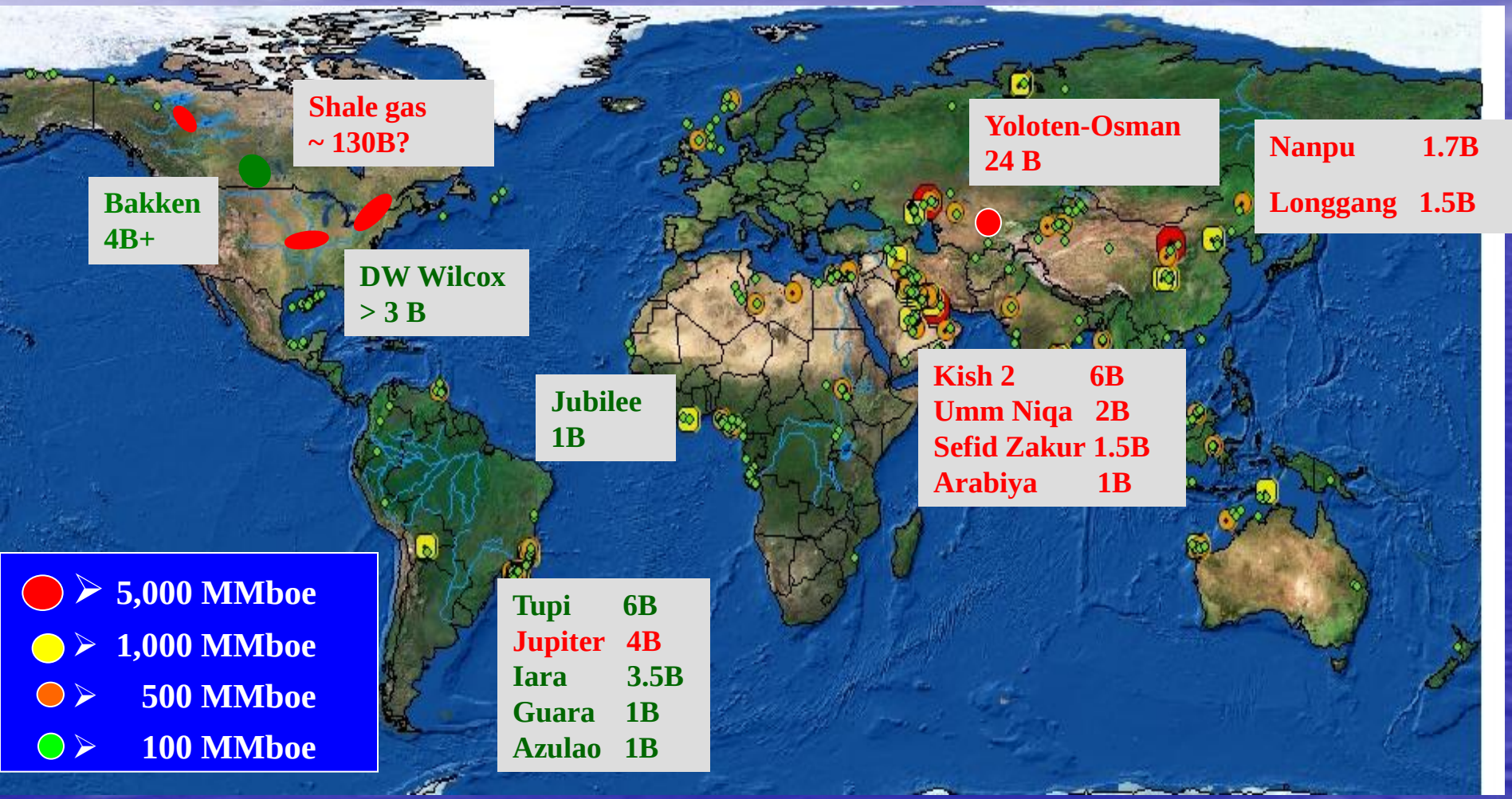
Klett et al., 2005

Natural Gas Reserve Additions: Reserve Growth vs. Undiscovered



Klett et al., 2005

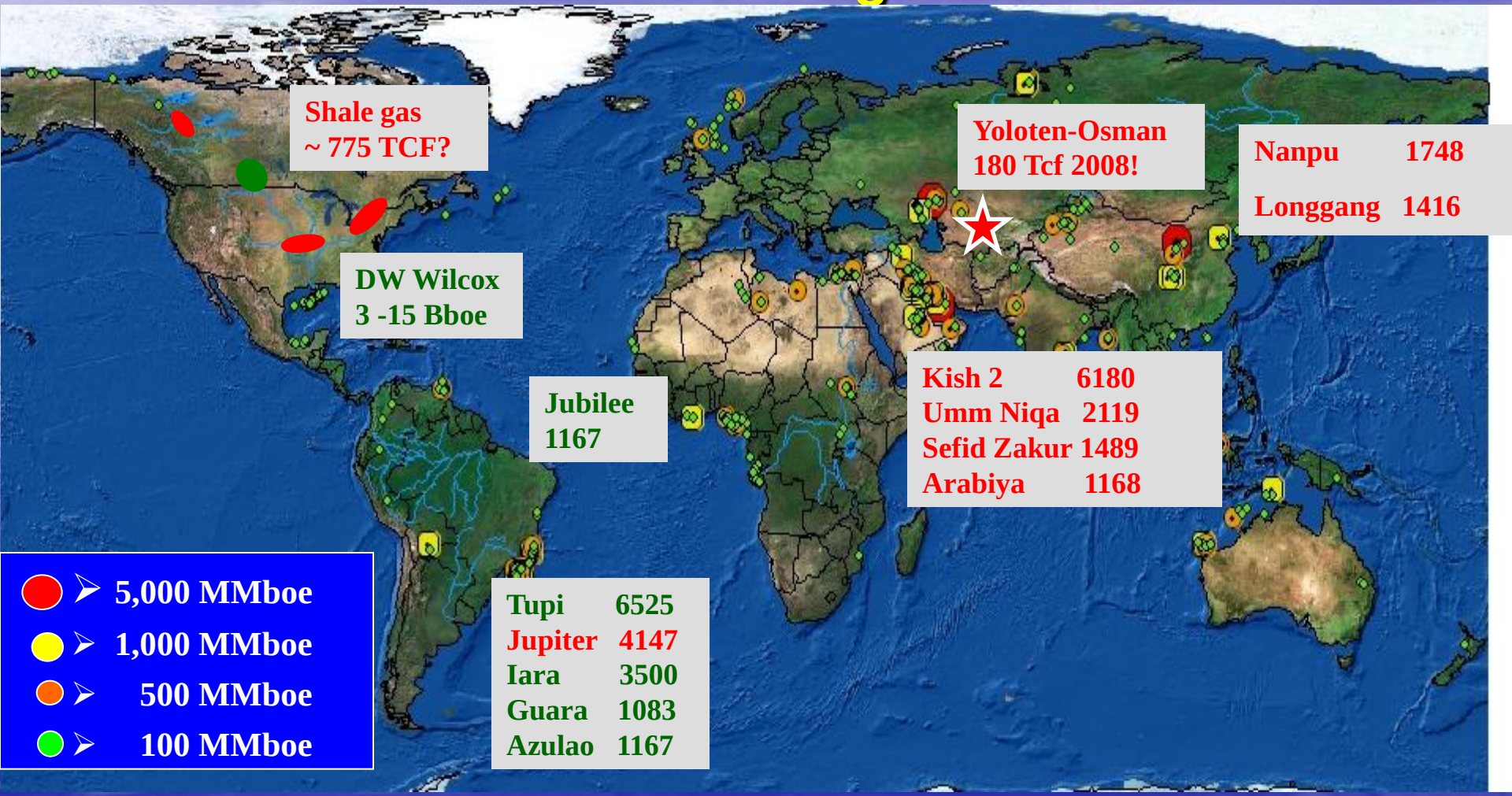
Discoveries > 100 MMboe 2000 – 2008> 1000 MMboe 2005-2008 Annotated



IHS 2009

Discoveries > 100 MMboe 2000 – 2008 > 1000 MMboe 2005-2008 Annotated

140 BBO Discovered in Last Decade—Not Yet Producing

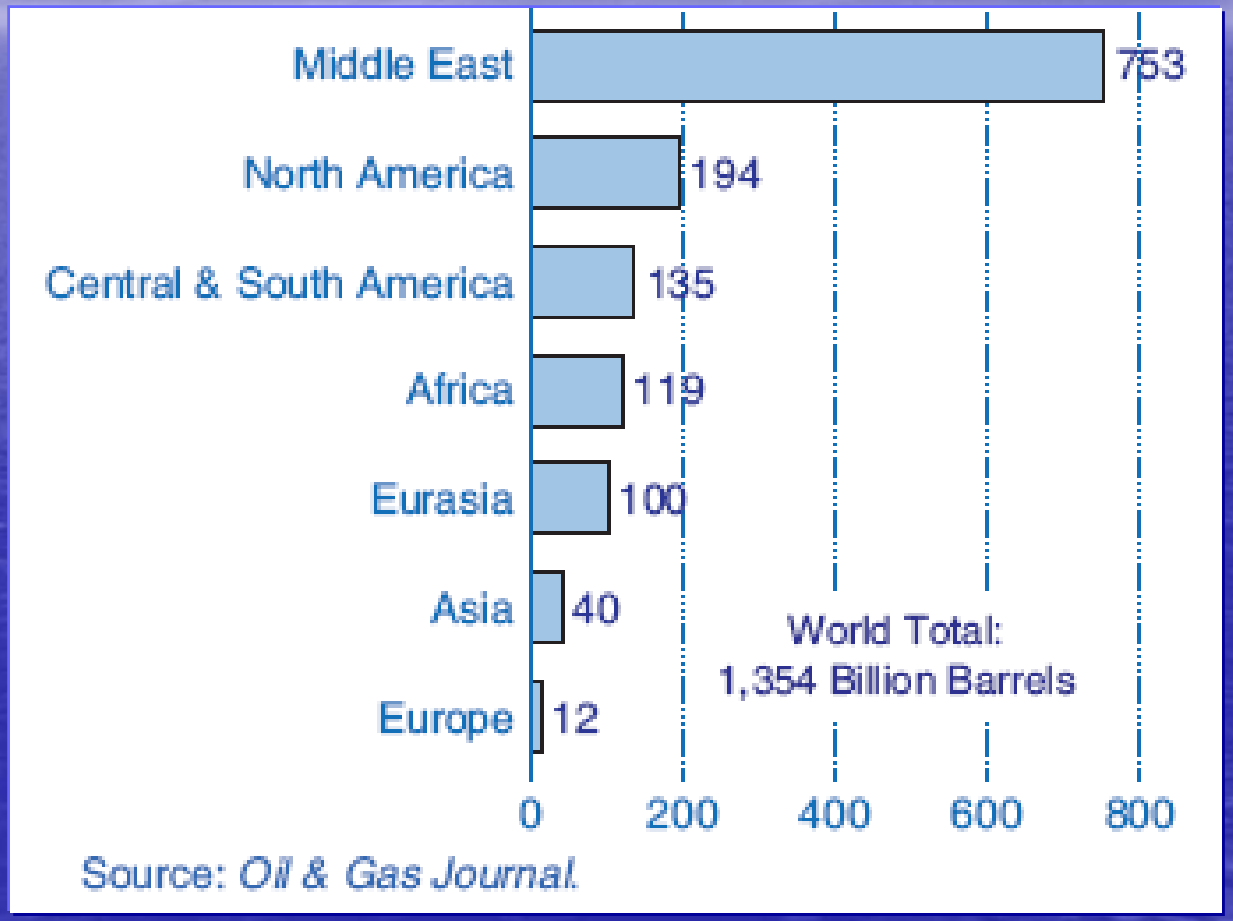


IHS 2009

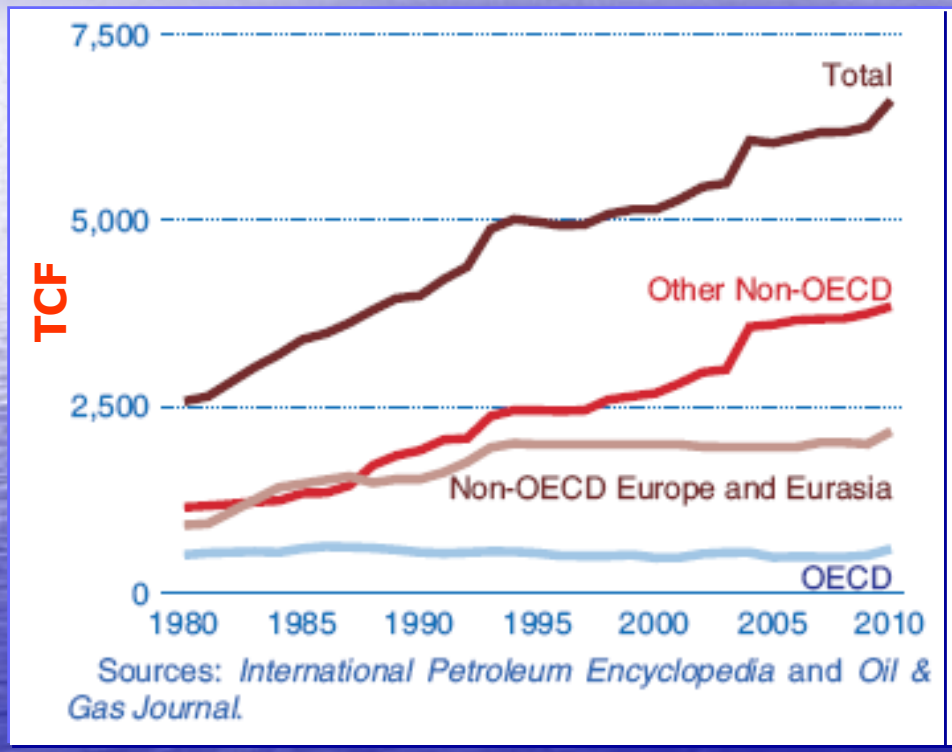
World Oil Reserves at New High
U.S. Oil Production is Increasing
~44 Year Supply at current consumption

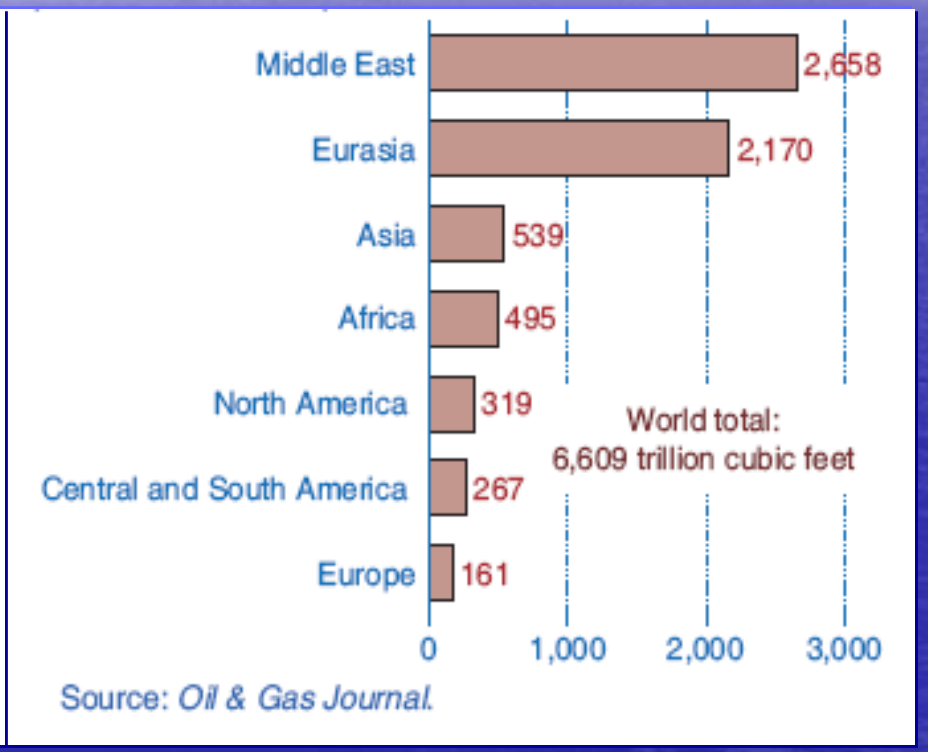
Country	Oil reserves	Percent of world total
Saudi Arabia	259.9	19.20
Canada	175.2	12.94
Iran	137.6	10.16
Iraq	115.0	8.50
Kuwait	101.5	7.50
Venezuela	99.4	7.34
United Arab Emirates	97.8	7.22
Russia	60.0	4.43
Libya	44.3	3.27
Nigeria	37.2	2.75
Kazakhstan	30.0	2.22
Qatar	25.4	1.88
China	20.4	1.51
United States	19.2	1.42
Brazil	12.8	0.95
Algeria	12.2	0.90
Mexico	10.4	0.77
Angola	9.5	0.70
Azerbaijan	7.0	0.52
Norway	6.7	0.49
Rest of World	72.2	5.33
World Total	1,353.7	100.00

Source: *Oil & Gas Journal.*

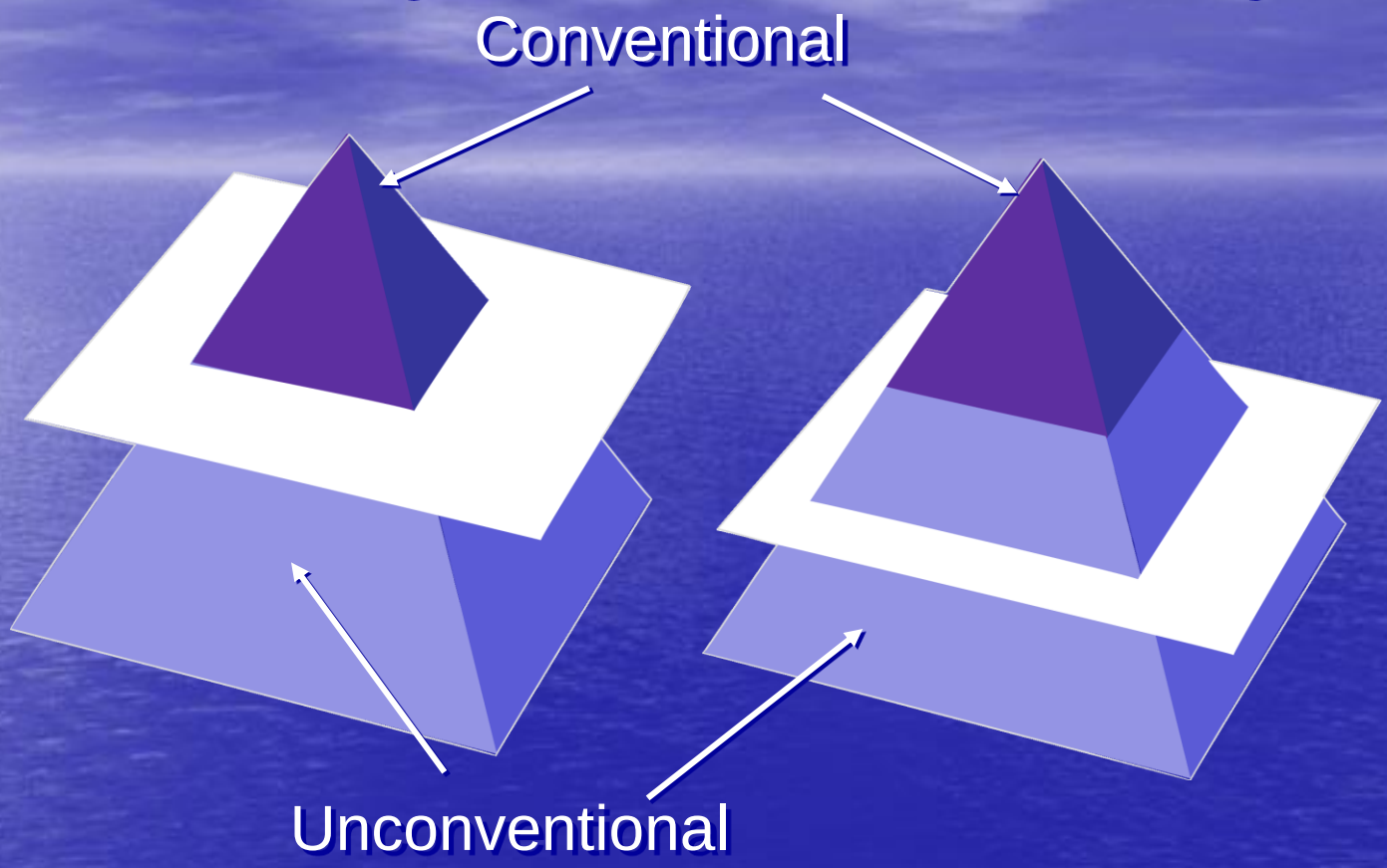


World Gas Reserves at New High ~53 Year Supply at Current Consumption



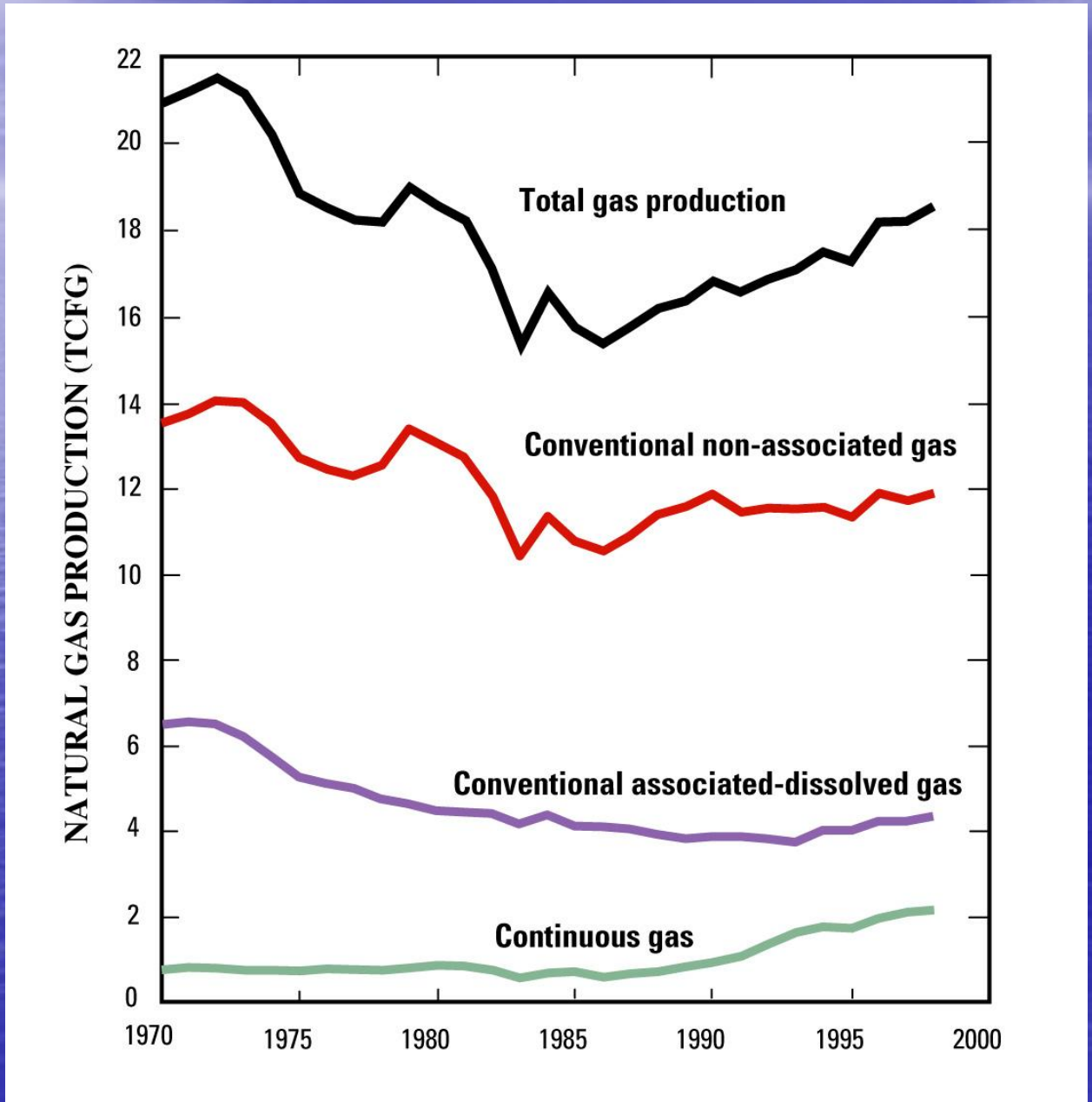


What Is Happening Now?
The Inversion of the Hydrocarbon Resource Pyramid



(After Thomasson, 2000)

U.S. Natural Gas Predictions in 2001

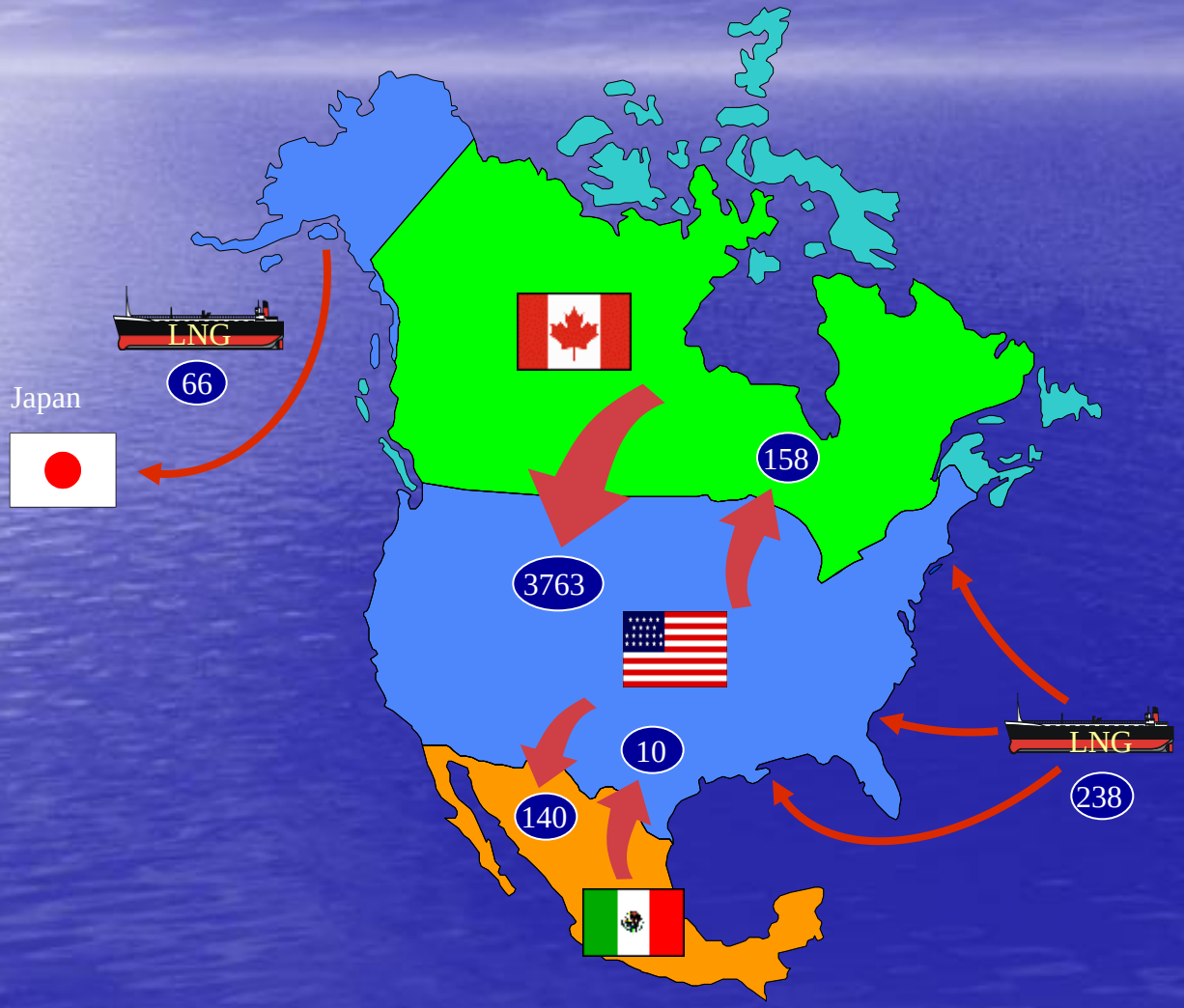


29.5 TCF Discovered in 2008- EIA

20.5 TCF Used 2008

EIA, 2001

Natural Gas Imports & Exports, 2001 (BCF)



Algeria
65

Australia
2

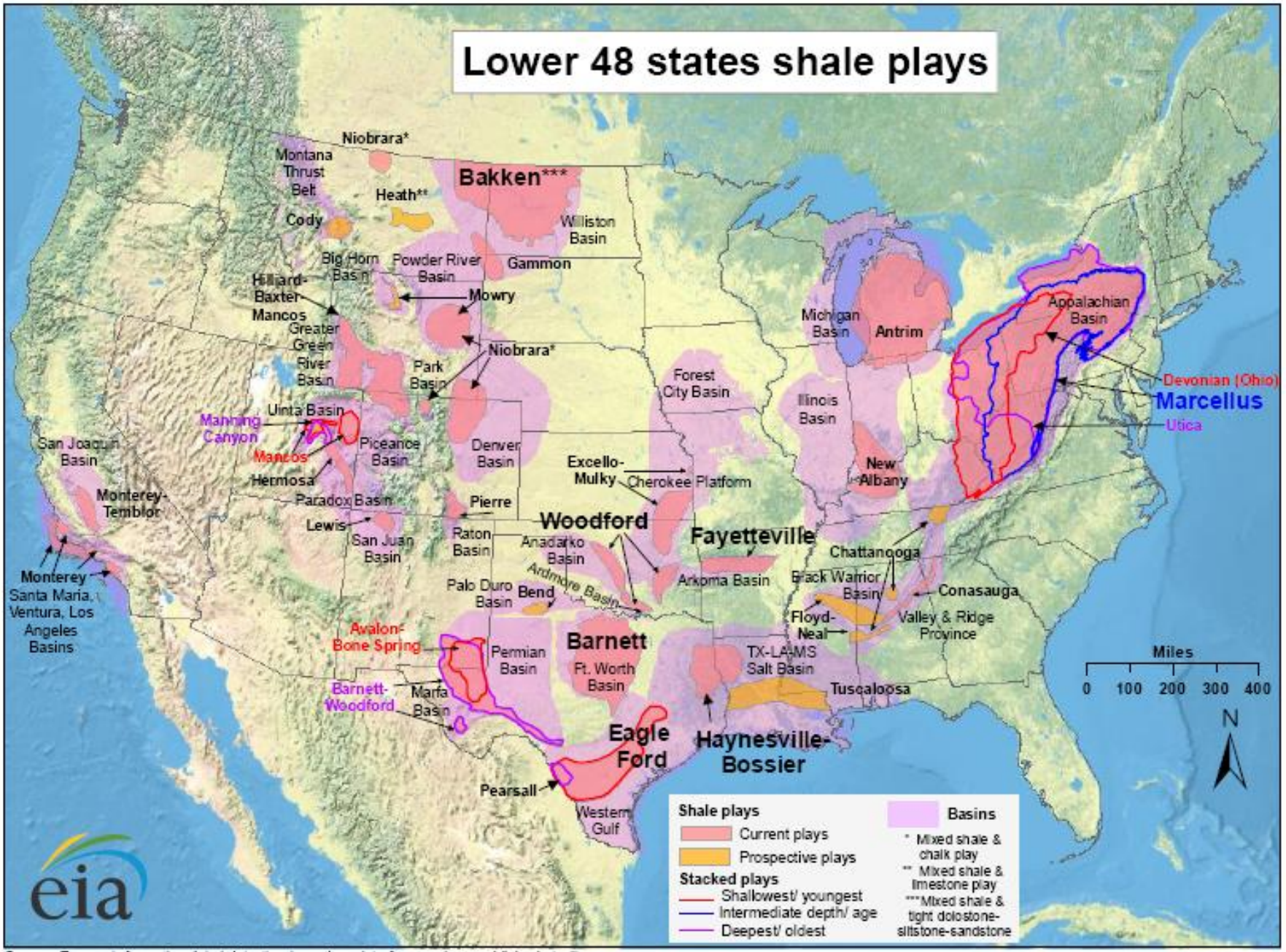
Nigeria
38

Oman
12

Qatar
23

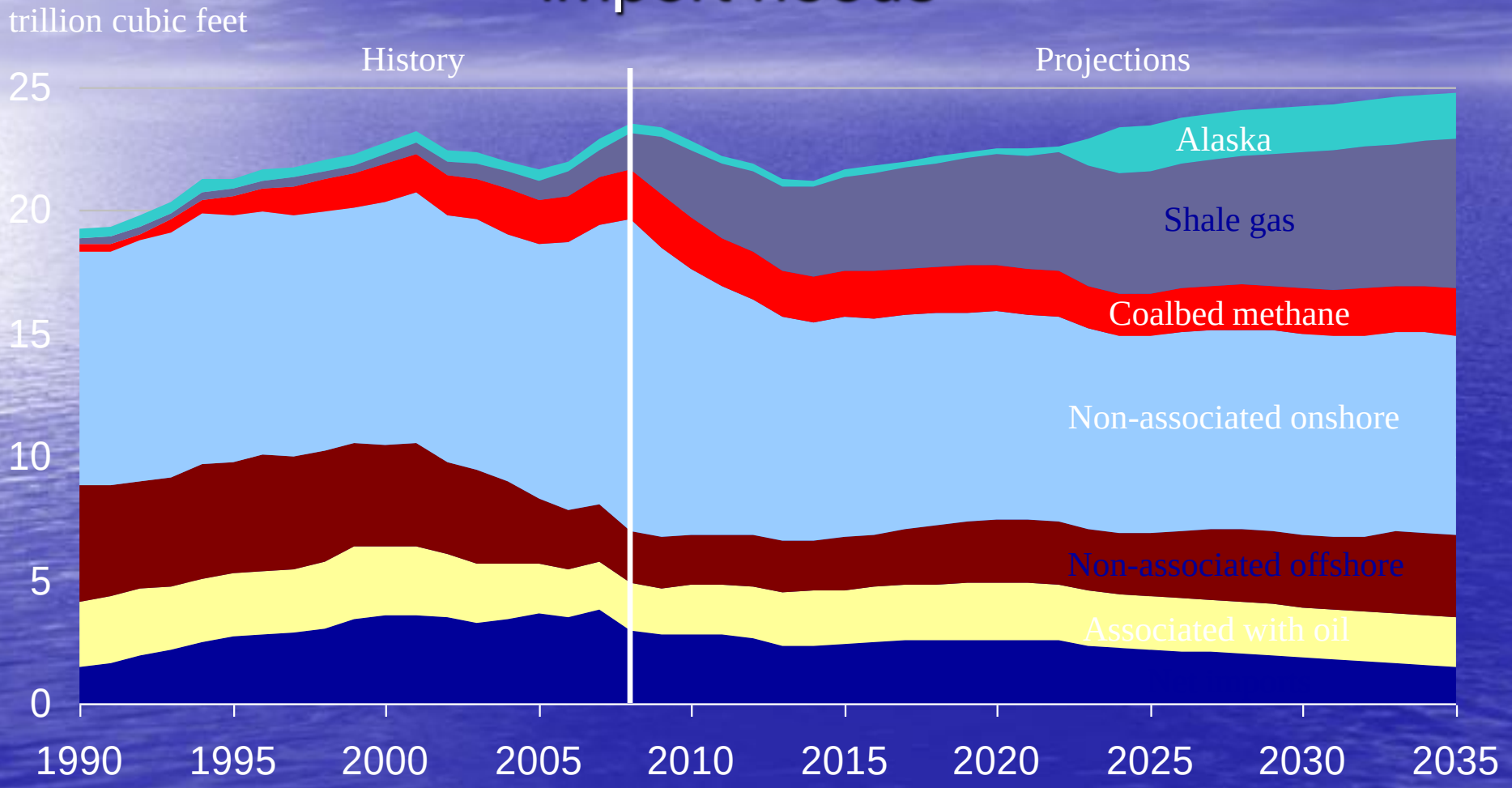
Trinidad and Tobago
98

DOE, 2002



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

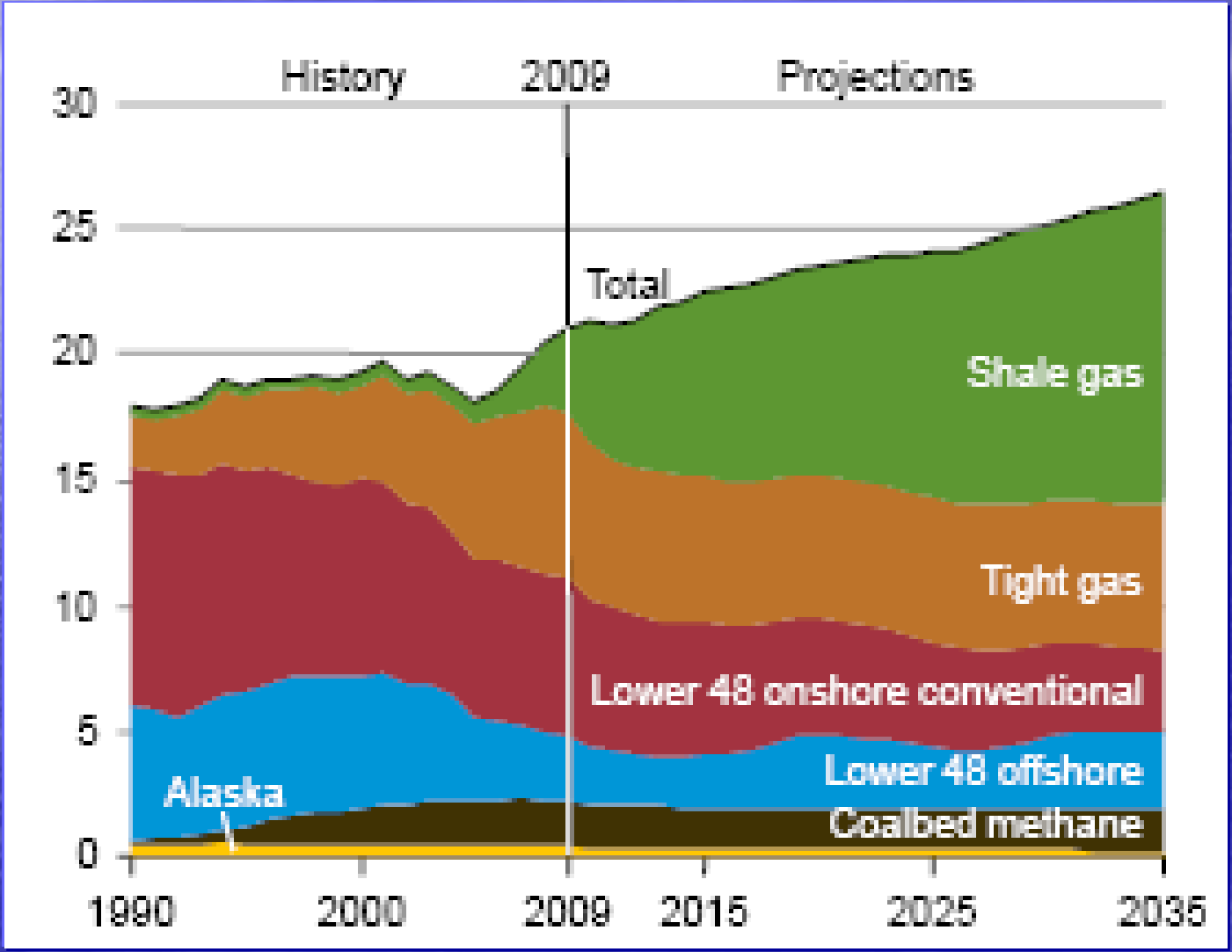
Shale gas and Alaska production offset declines in supply to meet consumption growth and lower import needs



Richard Newell, SAIS,
December 14, 2009

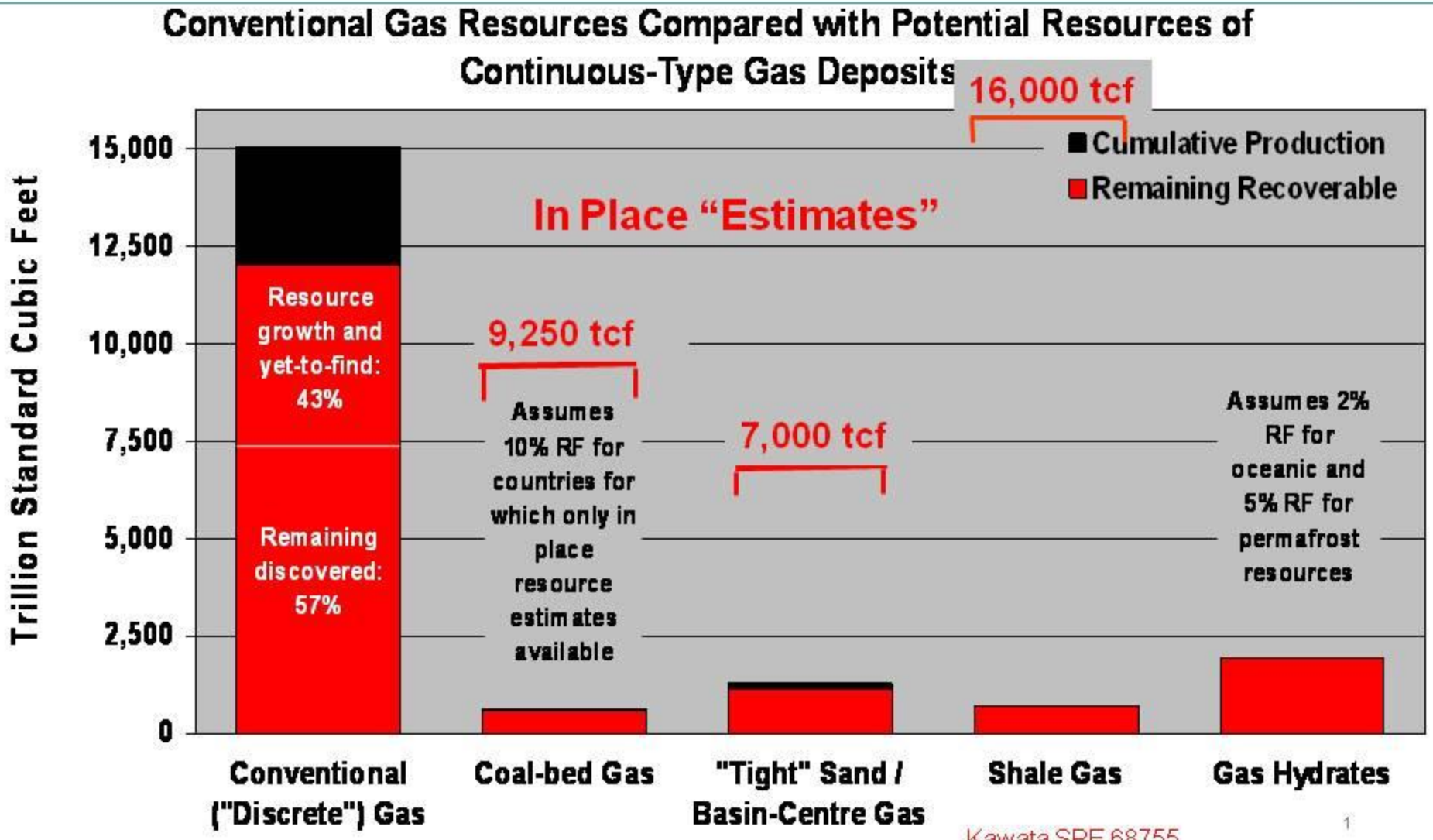
Source: *Annual Energy Outlook 2010*

The Perception Change in One Year—2009 to 2010



EIA, 2011

Global Gas Resources
Conventional & Unconventional



Kawata SPE 68755

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Resource Plays Turn From Gas to Oil

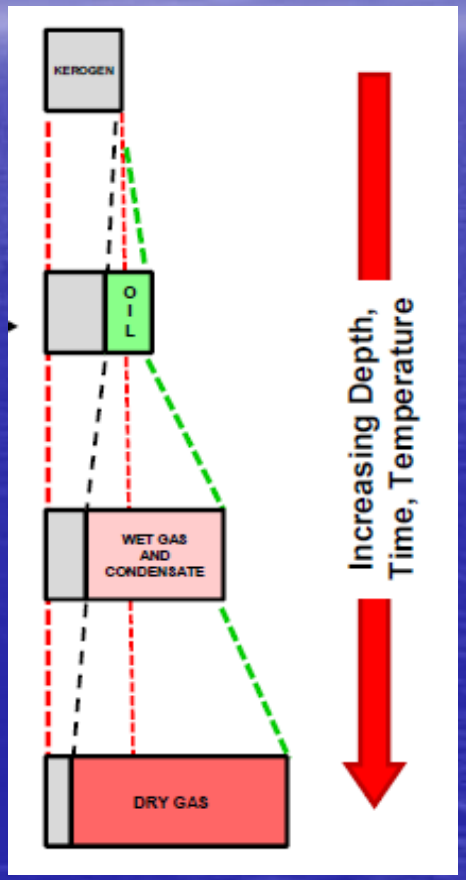
- Resource plays are widely distributed; i.e., many jobs and political support
- Gas abundance (reserves per year 4 times oil adds) now disrupts LNG and long distance markets—the debate is now over a 100 or 200 year U.S. supply
- Three times the number of gas wells are being drilled in the U.S. compared to oil—the gas revolution has been occurring over the last decade
- Gas prices fall dramatically as gas supply increases ($11 to $4/Mcf or lower)
- On a BTU basis, oil is now worth about several times more than gas and this is causing an expansion of oil resource plays (Bakken, Eagle Ford, Niobrara, Monterrey)

Shale Oil Historical Back Drop

- *Same concept as Shale Gas except the organic material is only partially cooked*

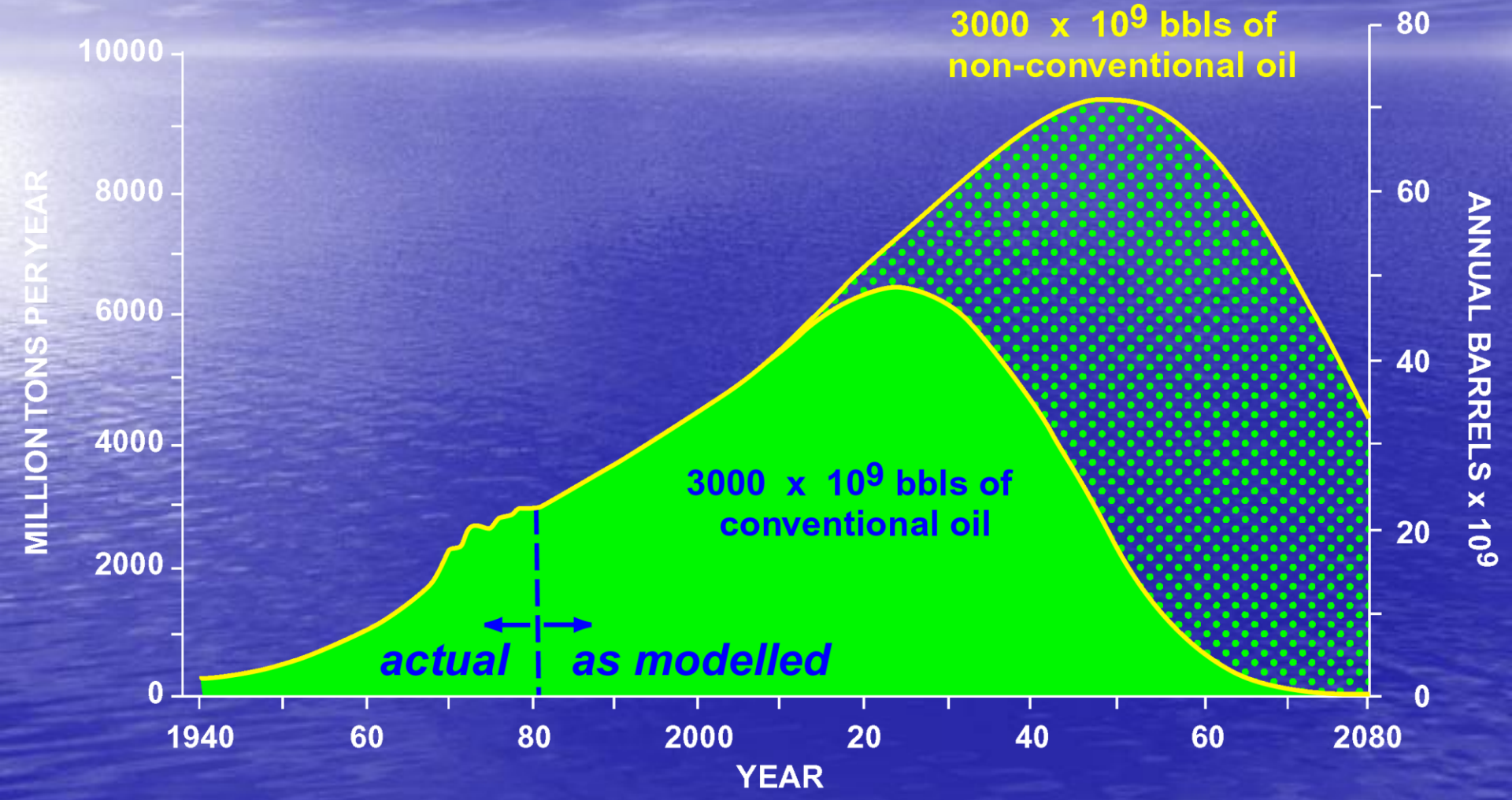
- *Same drilling and completion concept*
  - *Rubblize the rock to increase rock volume connected to the wellbore*
  - *Very low permeability can be produced economically*

- *75% of generated oil is still located in the source rock*



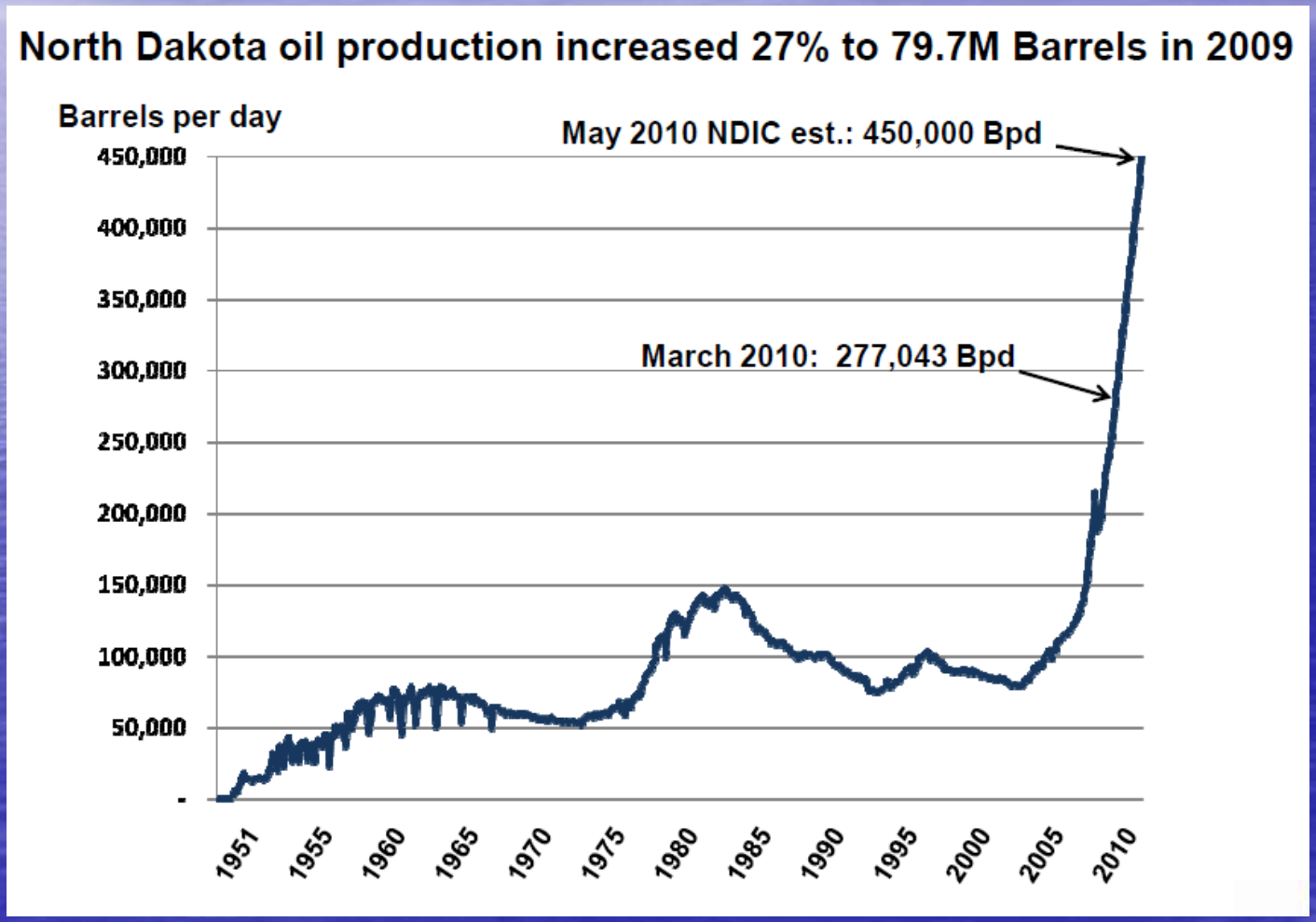
EOG, 2009

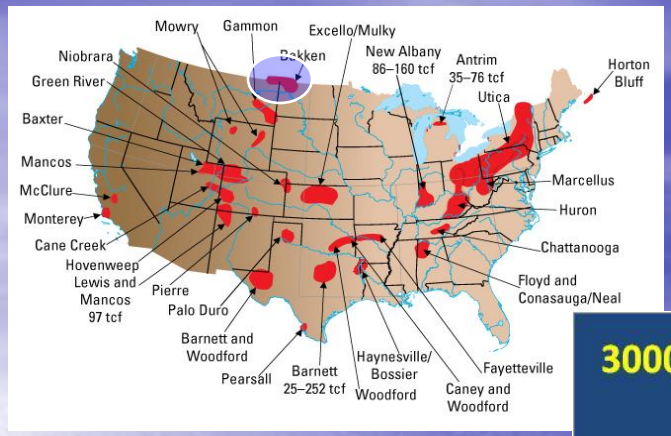
A Prospective Depletion Curve for the World's Conventional and Non-Conventional Oil to 2080



Odell, 1998

The Williston Basin was 98th Oil Province in the World, Now it is the 50th (in 5 years) due to the Bakken Oil Resource Play and is estimated to go to 1 million barrels of oil per day soon, 25th or better in the world





Typical Bakken Decline

2005-2007:

250-350 Bopd

2008

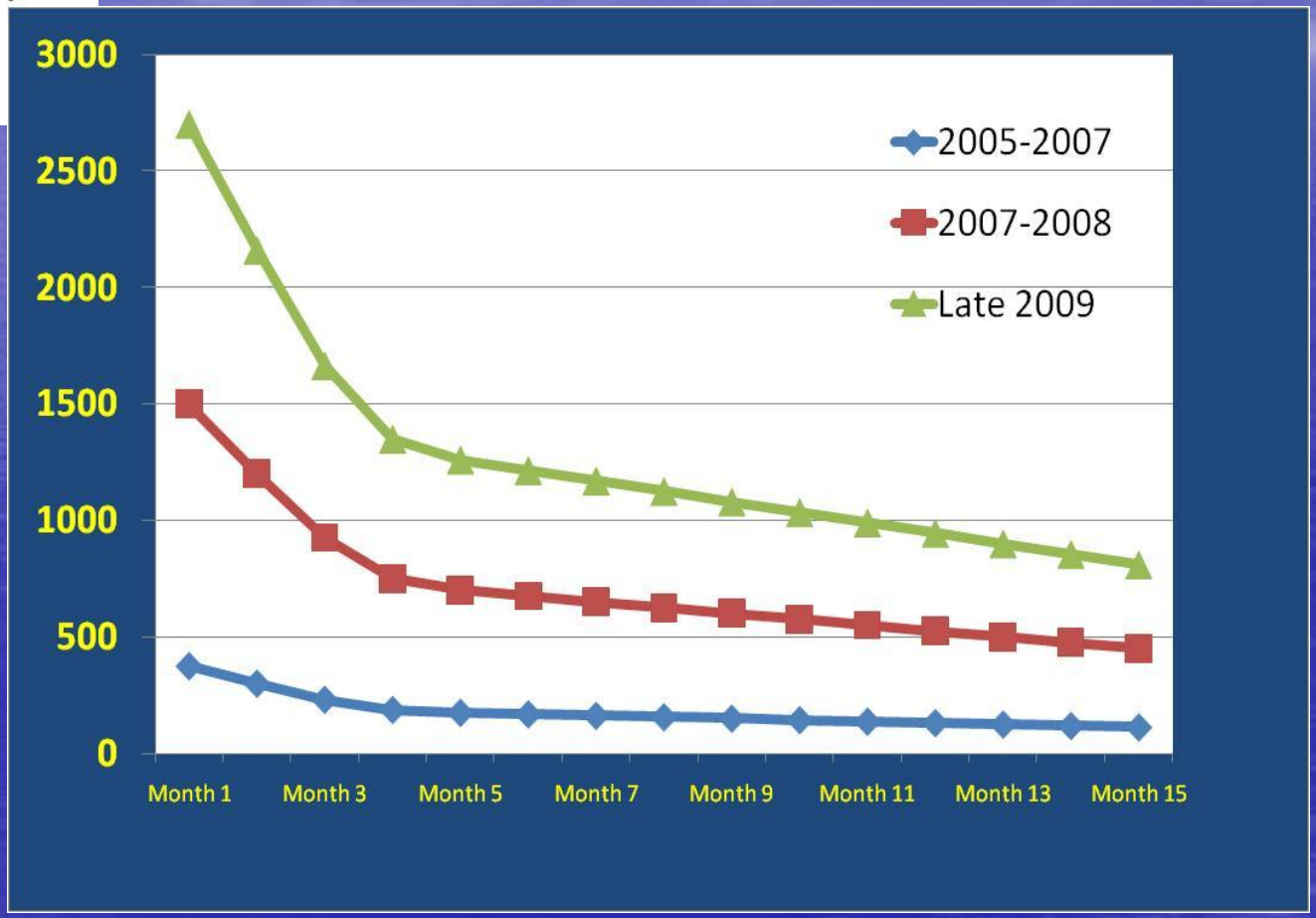
500-750 Bopd

2009

1500-3000 Bopd

2010

4000-5000+ Bopd



APEX Engineering, 2010

New Technologies Bring Change

- Drilling and Completion Procedures
- Petroleum System Modeling The vocabulary and concepts have shifted to the source rocks- seems simple—it is not
  - Reservoir Scales (nanodarcies vs. millidarcies)
  - TOC's, Brittleness (Poisson's ratio, Young's Modulus) much more laboratory focused, pressure regimes and identification
  - New training is required for modern resource plays

Conclusions

- We know and have successfully developed most technology for the Static Petroleum Resources
- We are just beginning to develop technology and get a glimpse of the Dynamic Petroleum System View
- Each view drives your effort where you explore, and the Paradigms of Petroleum one believes to be true
- Are we really at the end of petroleum in a static world or the beginning of a revolution into a dynamic system view first in natural gas and commencing in oil?

  140 BBO found but not developed in last decade; World Oil and Gas Reserves at all time highs, U.S. production is rising

- The New Petroleum ERA began in earnest about 25 years ago for natural gas and about 5 years ago for oil and their effect is changing if not dominating the U.S. industry (e.g., Mesoproterozoic—1.4 Ga)
- Demand, price maintenance and qualified professionals are the primary concerns