

IMPLICATIONS OF FOSSIL FUELS PRODUCTION PEAKING FOR FORECASTS OF WORLD CO₂ EMISSIONS AND ATMOSPHERIC CONCENTRATIONS

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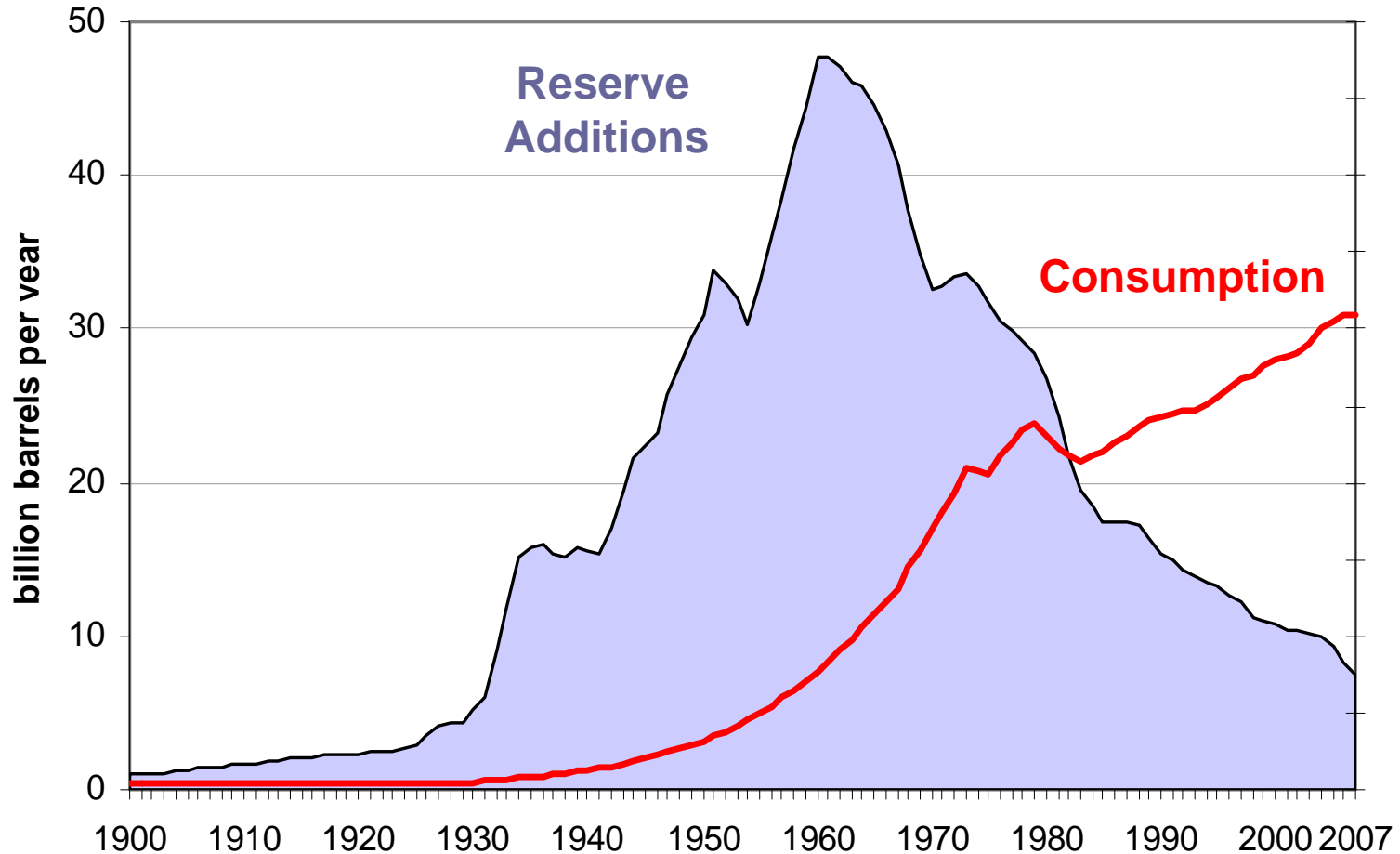


THIS PRESENTATION

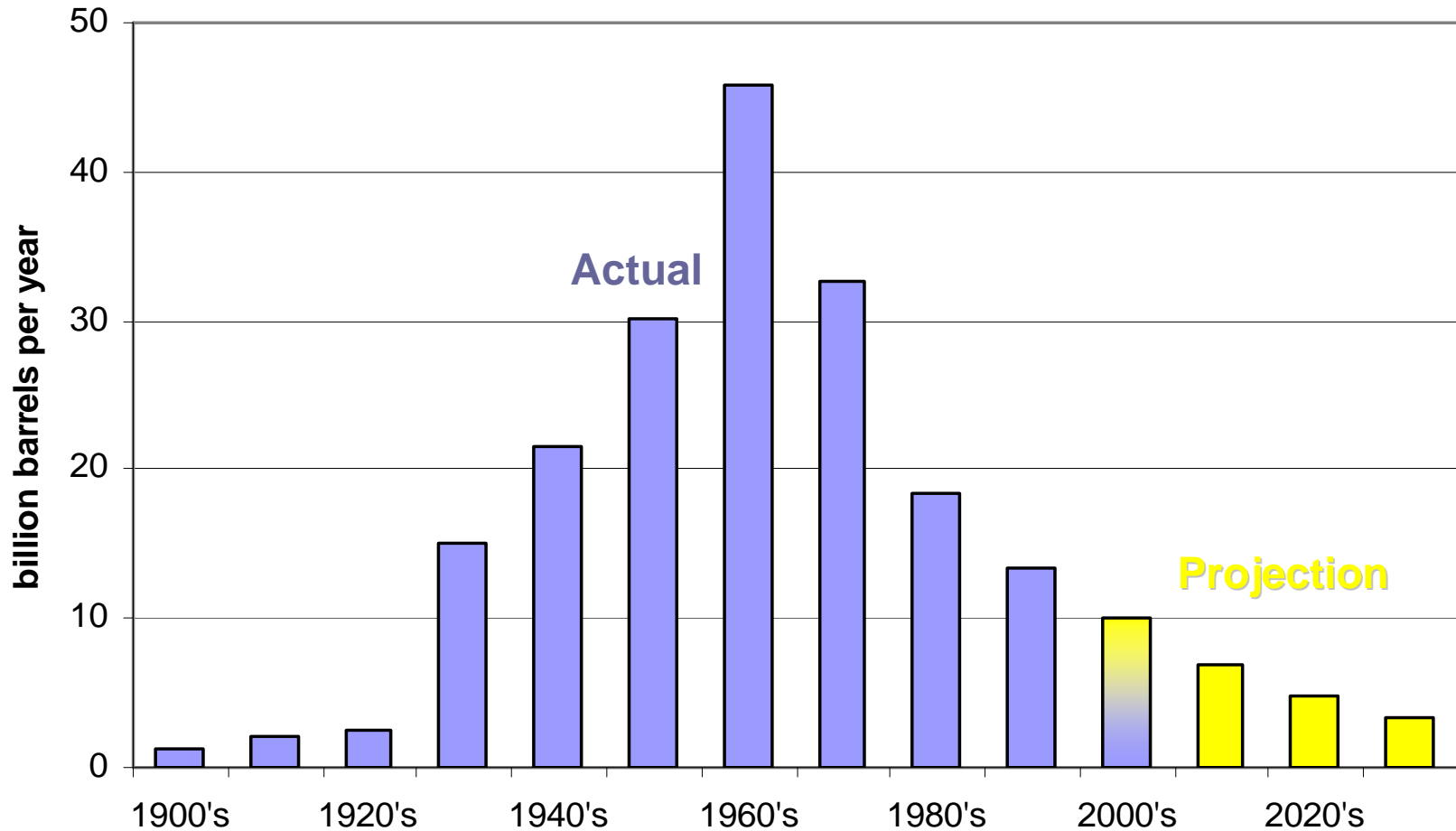
- Peak oil
- Peak natural gas
- Peak coal
- Peak fossil fuels
- CO₂ emissions forecasts
- CO₂ concentration forecasts
- Findings
- Conclusions
- Implications
- The real problem
- Recommendations



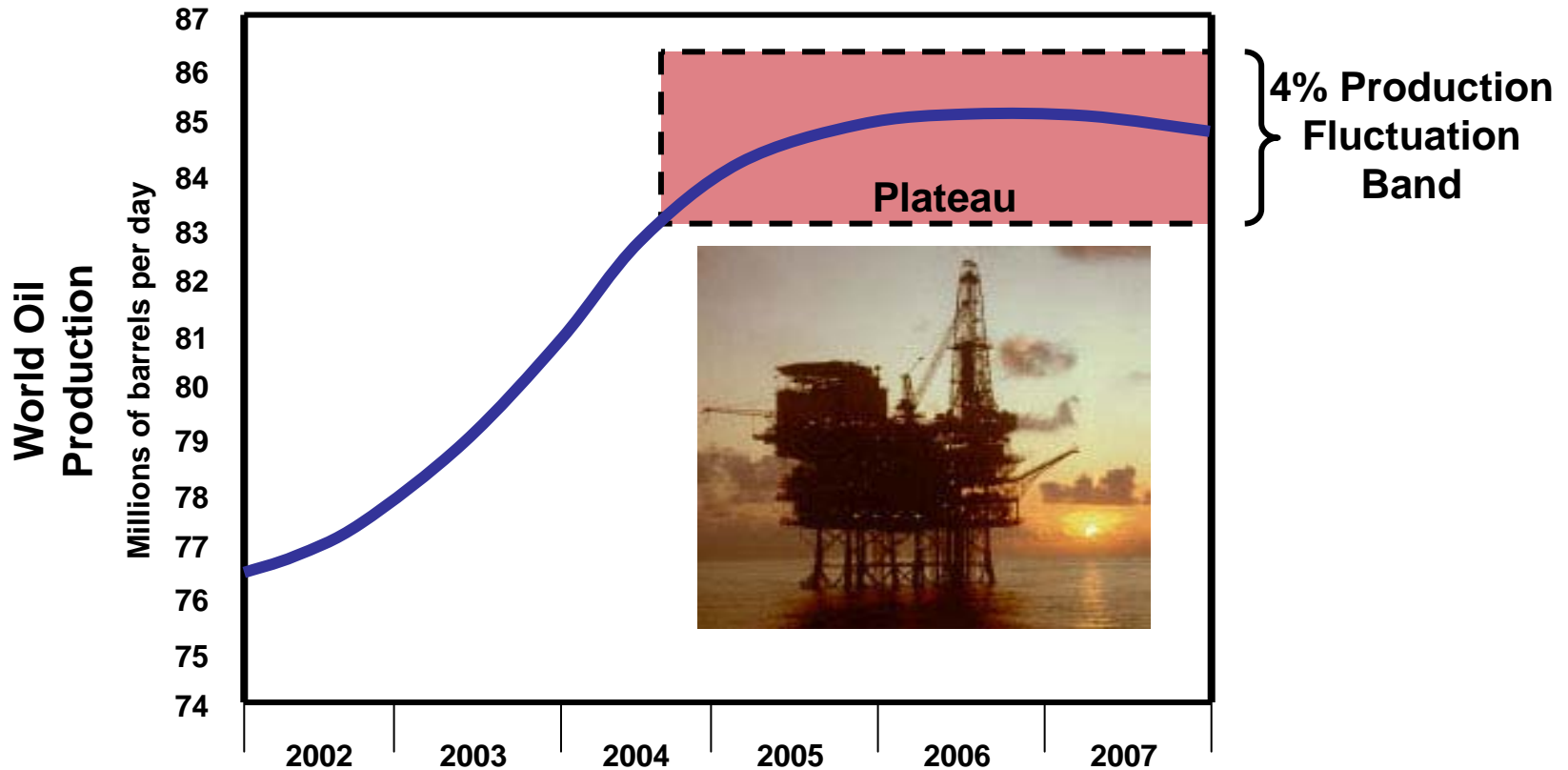
PEAK OIL: WORLD HAS BEEN CONSUMING MUCH MORE OIL THAN IT HAS BEEN FINDING



PEAK OIL: AND THIS TREND WILL CONTINUE (Actual and Projected World Oil Reserve Additions)



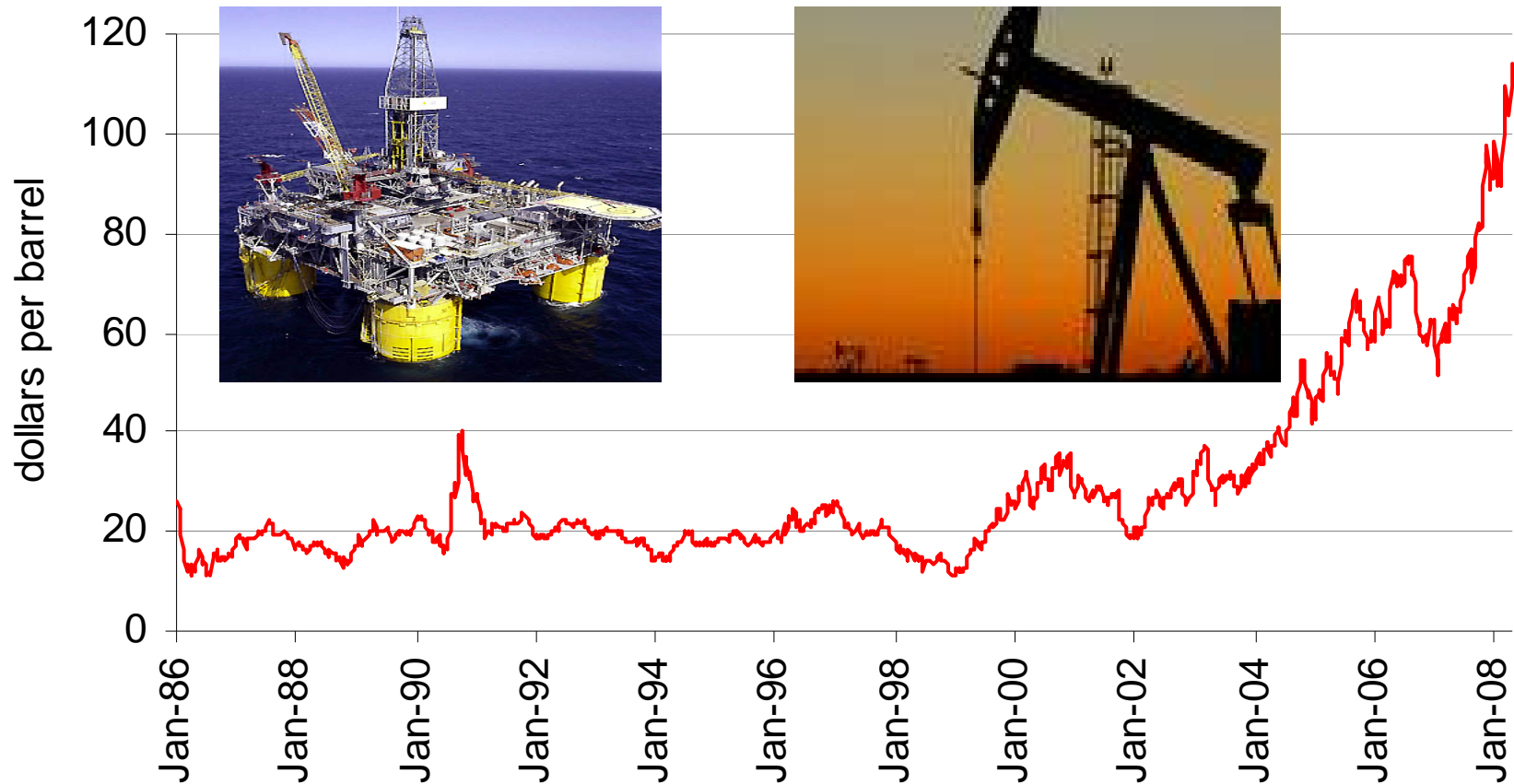
WORLD LIQUID FUEL PRODUCTION HAS PLATEAUED



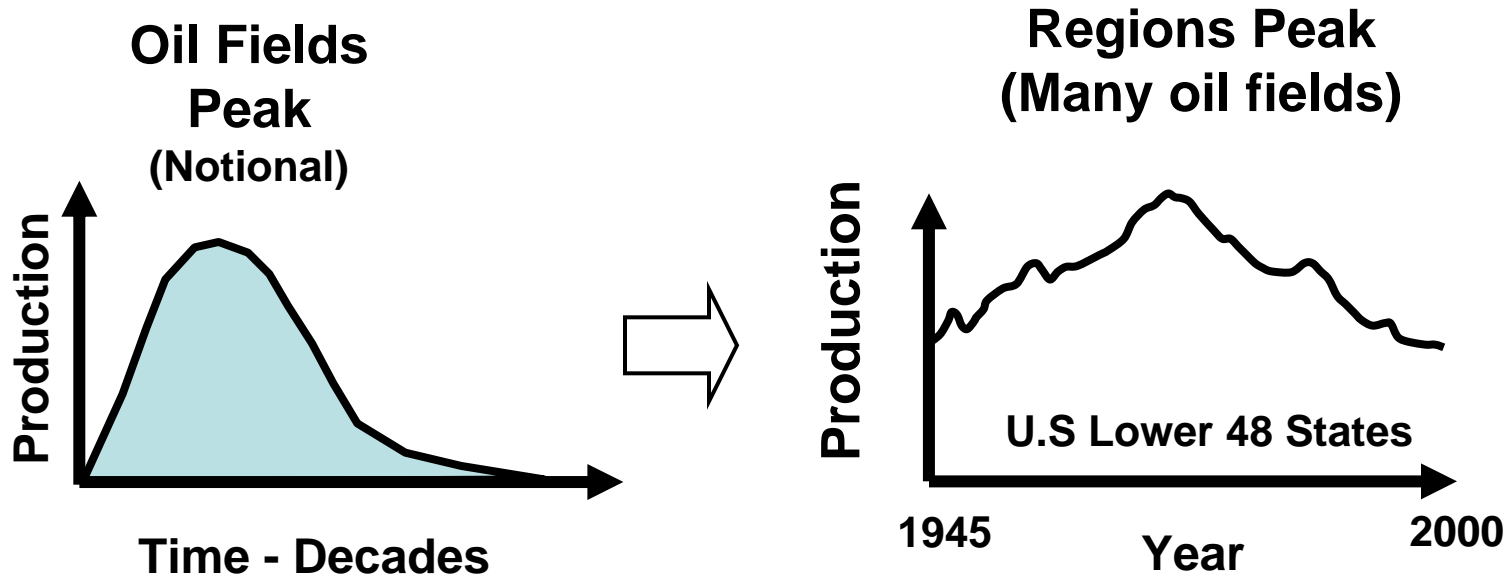
President Bush: "If they [Saudi Arabia] don't have a lot of additional oil to put on the market, it is hard to ask somebody to do something they may not be able to do."

OIL PRICES AT TRIPLE DIGITS

Weekly Price of West Texas Crude, 1986 – 2008



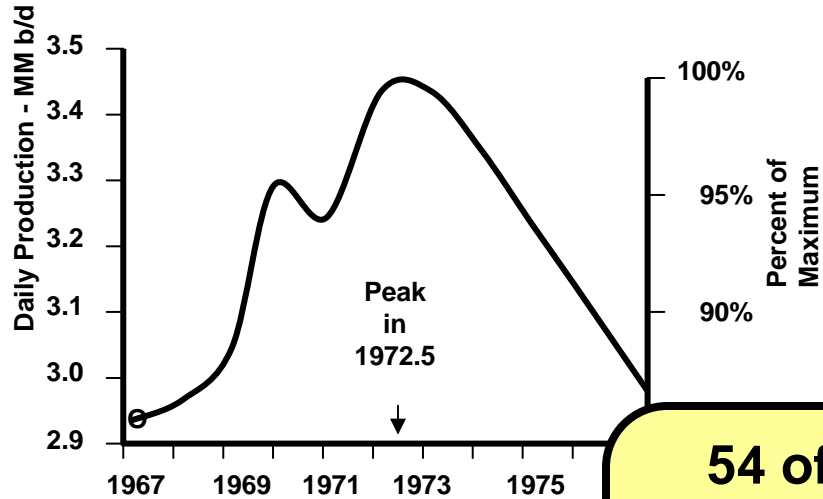
PEAKING IS NATURAL



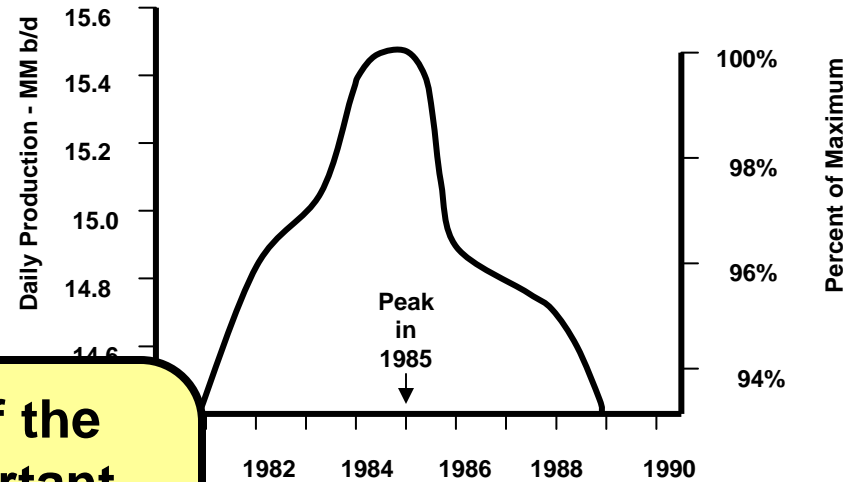
The world will peak (All regions)

EXAMPLES OF OIL PEAKING

Texas

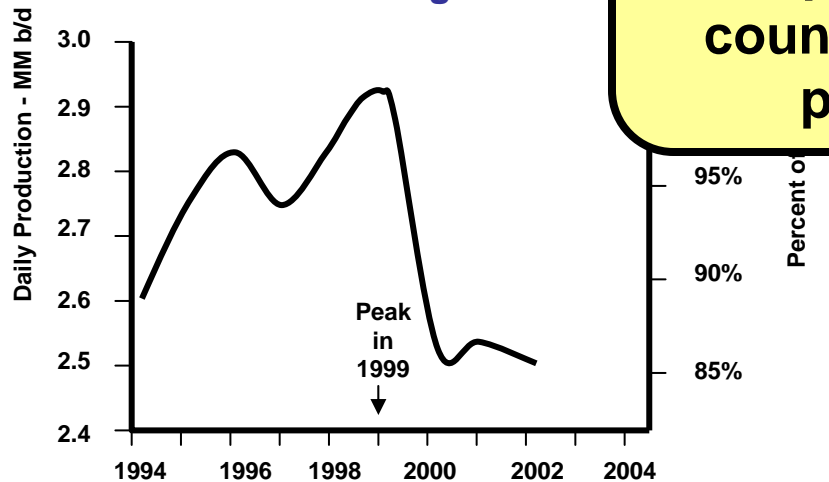


North America

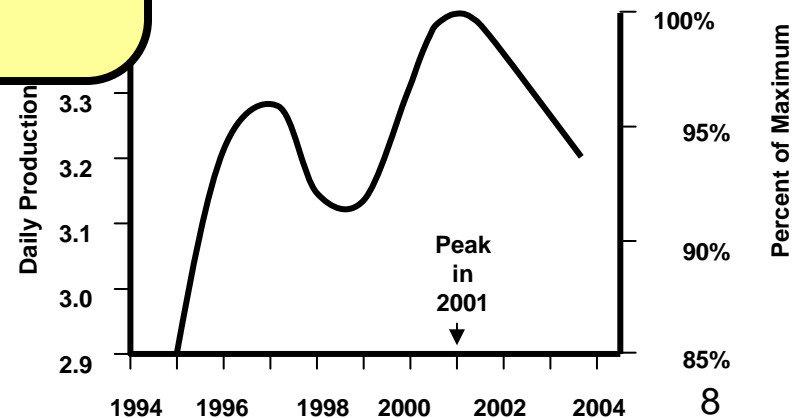


54 of 65 of the most important oil-producing countries have peaked

United Kingdom



Norway



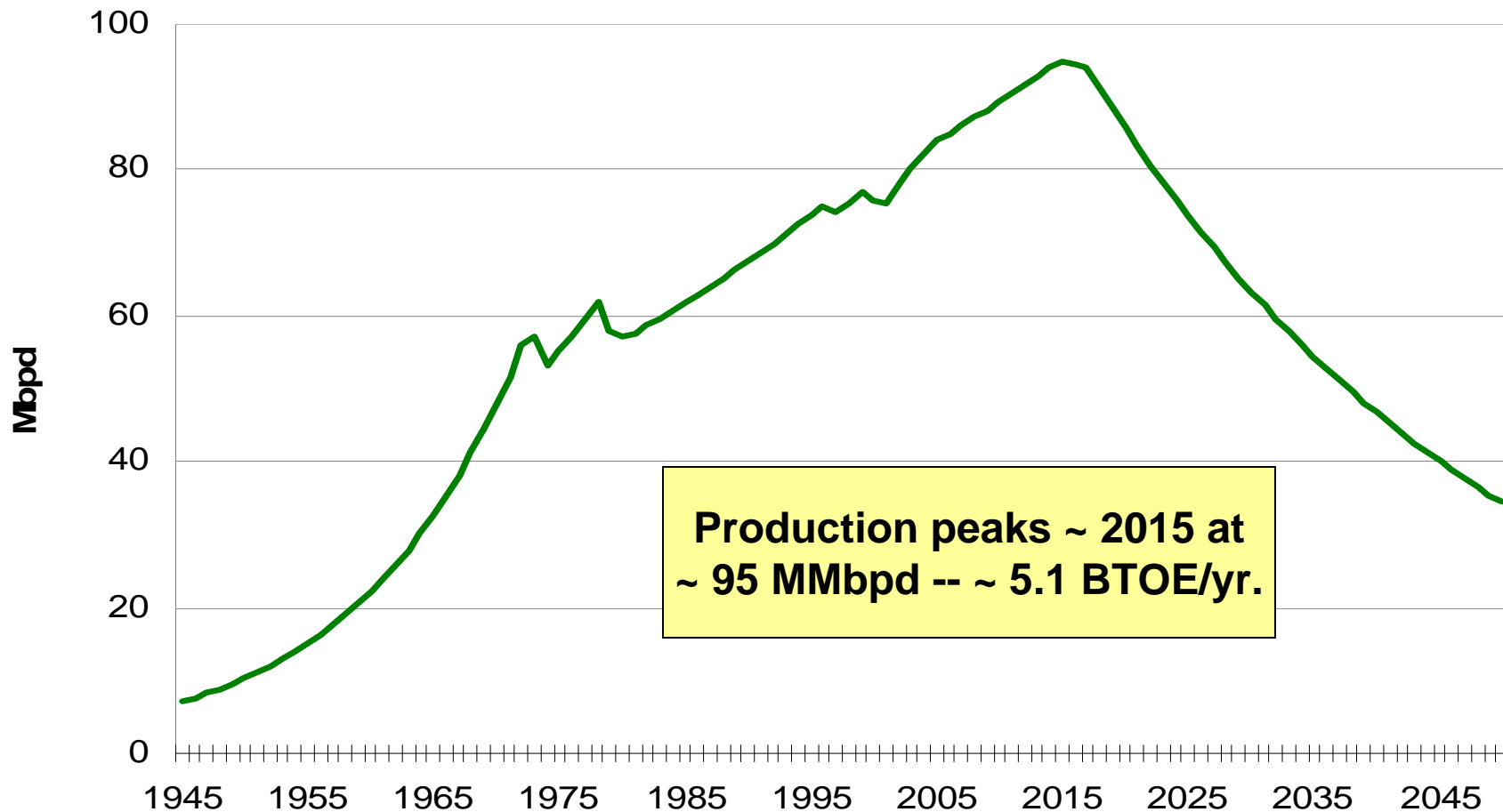
WORLD OIL PEAKING FORECASTS

(Most Forecasters Expect Peak at < 100 MMbpd)

Forecaster	Date
K. Deffeyes, (retired professor & retired Shell)	2005
M. Simmons, M. (oil expert & businessman)	2005
E.T. Westervelt, et al. (U.S. Army Corps of Engineers)	2005
Energy Watch Group (research organization)	2006
S. Husseini, (retired Saudi Aramco executive)	2007/08
S. Bakhtiari, (Iranian National Oil Co. planner)	2007/08
T. Boone Pickens (oil & gas investor)	2007/08
D. Goodstein, (Vice Provost, Cal Tech)	By 2010
C.T. Maxwell, Weeden & Co. (brokerage)	By 2010
D. Strahan (energy analyst)	By 2010
R. Bentley, (university energy analyst)	2010
C. Campbell, (retired oil company geologist)	2010/11
C. Skrebowski, (editor of <i>Petroleum Review</i>)	2010/11
L.M. Meling, (Statoil oil company geologist)	2011
X. Pang, (China Petroleum University)	2012
International Energy Agency	2012
Merrill Lynch (Brokerage/Financial)	2015
J.R. West, PFC Energy (Consultants)	2015
Shell	2015
Volvo Trucks	By 2017
C. de Margerie (Oil company executive)	By 2017
Wood Mackenzie (Energy consulting)	By 2020
CERA (Energy consulting)	After 2030
U.S. Energy Information Administration	After 2030
ExxonMobil	After 2030

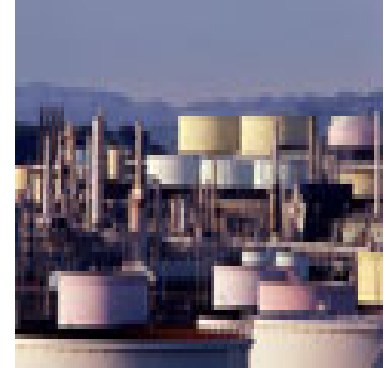
Source: Management Information Services, Inc., 2008.

MISI FORECAST OF WORLD LIQUID FUELS PRODUCTION



PEAK NATURAL GAS

- **Data on worldwide NG reserves & resources even less reliable than for oil**
- Much disagreement among experts
- Reasonable figure for ultimate recoverable conventional gas in world is ~ 10,000 tcf
- An additional ~ 2,500 tcf of unconventional gas
- $\frac{3}{4}$ the world's NG reserves located in the Middle East and Eurasia
- Russia, Iran, and Qatar combined account for ~ 60% of the world's NG reserves
- NG much more difficult & expensive to transport than oil

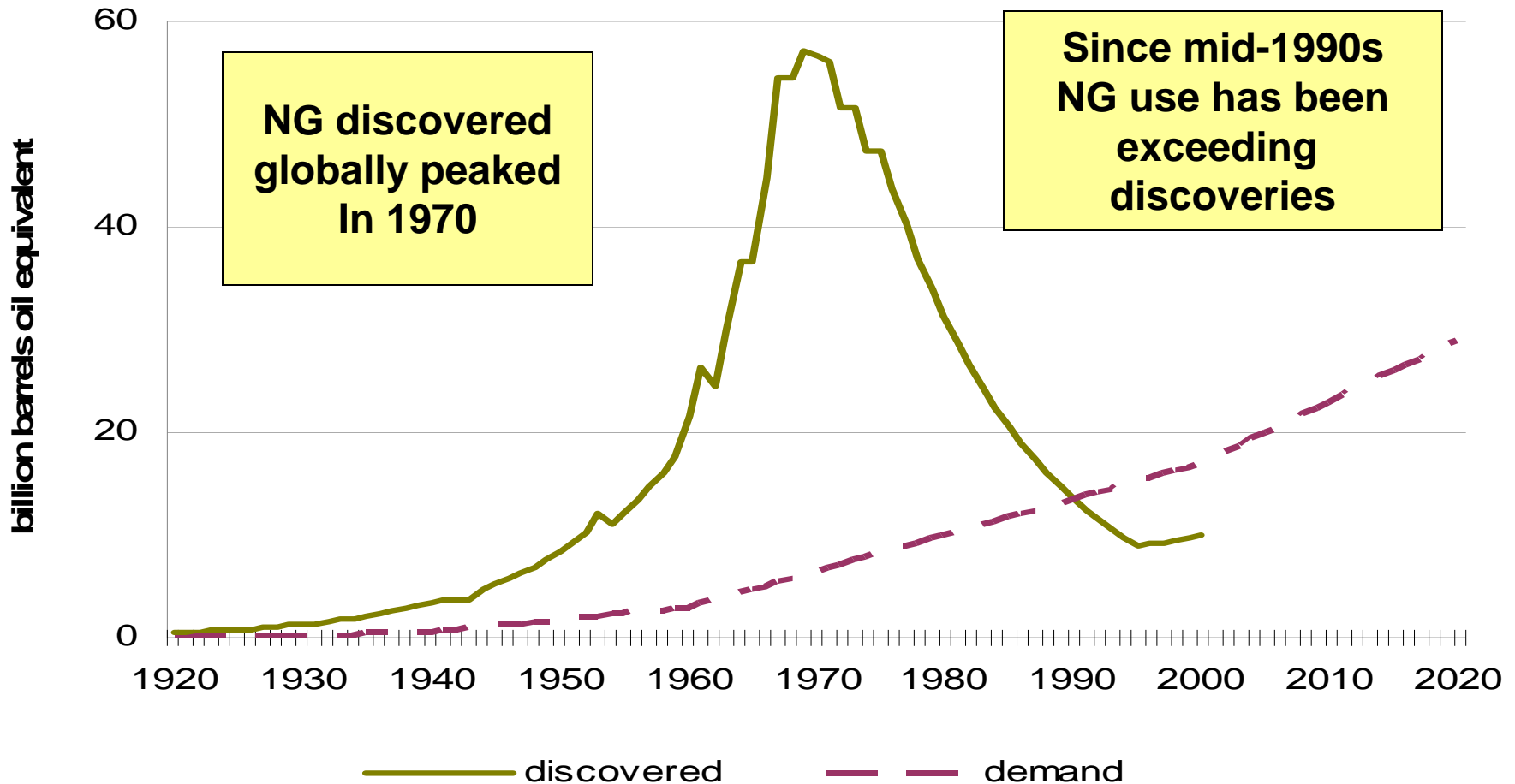


CONVENTIONAL NG ULTIMATE RESERVES (Mean Values)

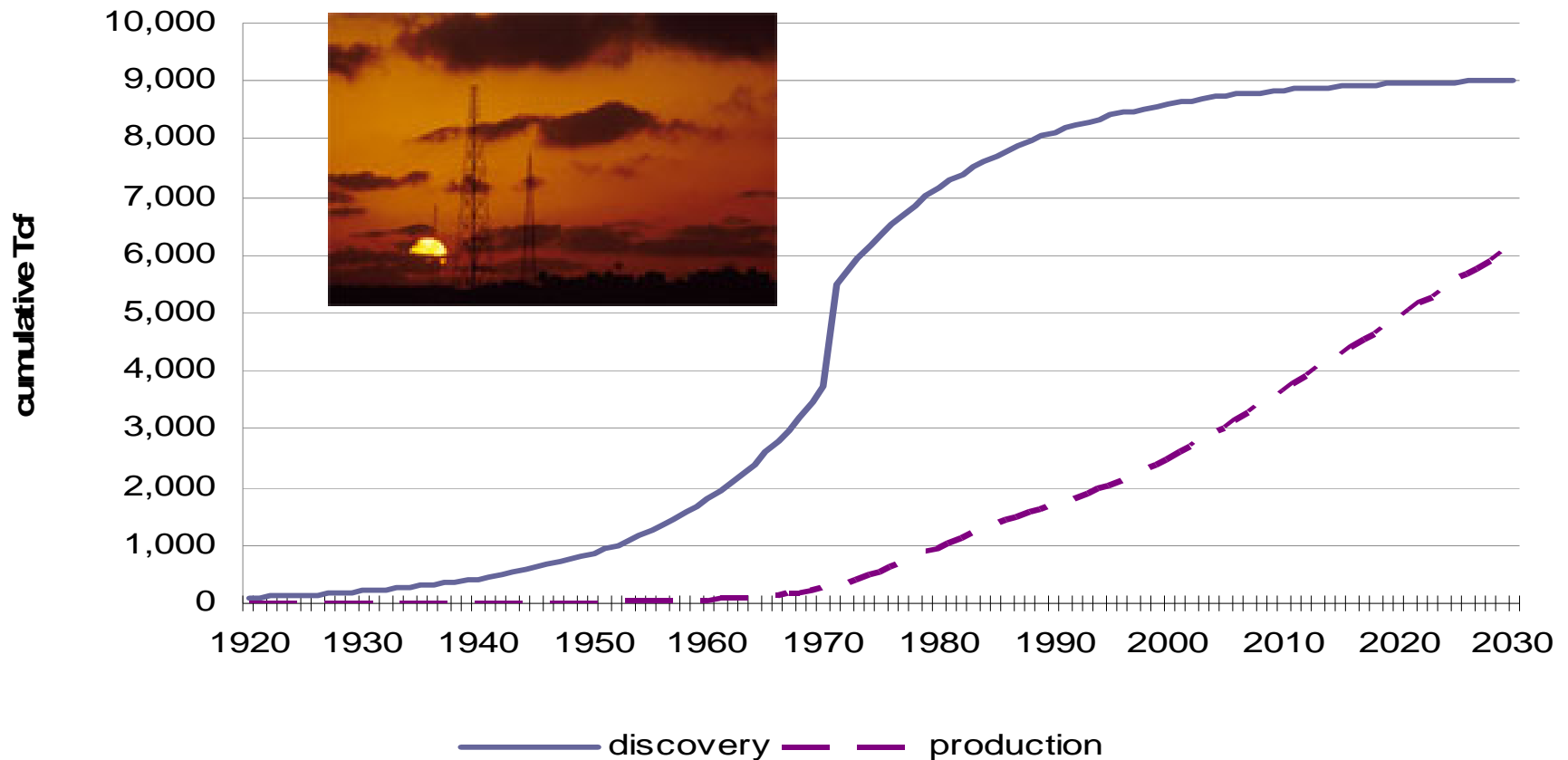
	Ultimate	Found	Produced	Remaining Known Reserves
	TCF			
Middle East	3,000	2,860	200	2,660
CIS	2,000	1,830	700	1,100
US	1,250	1,200	960	240
Asia	1,150	920	180	740
Africa	800	620	100	520
Latin America	800	580	150	430
Europe	800	620	300	320
Canada	250	215	155	60
World	10,000	8,800	2,700	6,100
OPEC	3,600	3,500	400	3,100

Source: Jean Laharrere, derived from the *Oil and Gas Journal*, *World Oil*, American Petroleum Institute, *BP Statistical Review*, OPEC, and IHS, Inc.

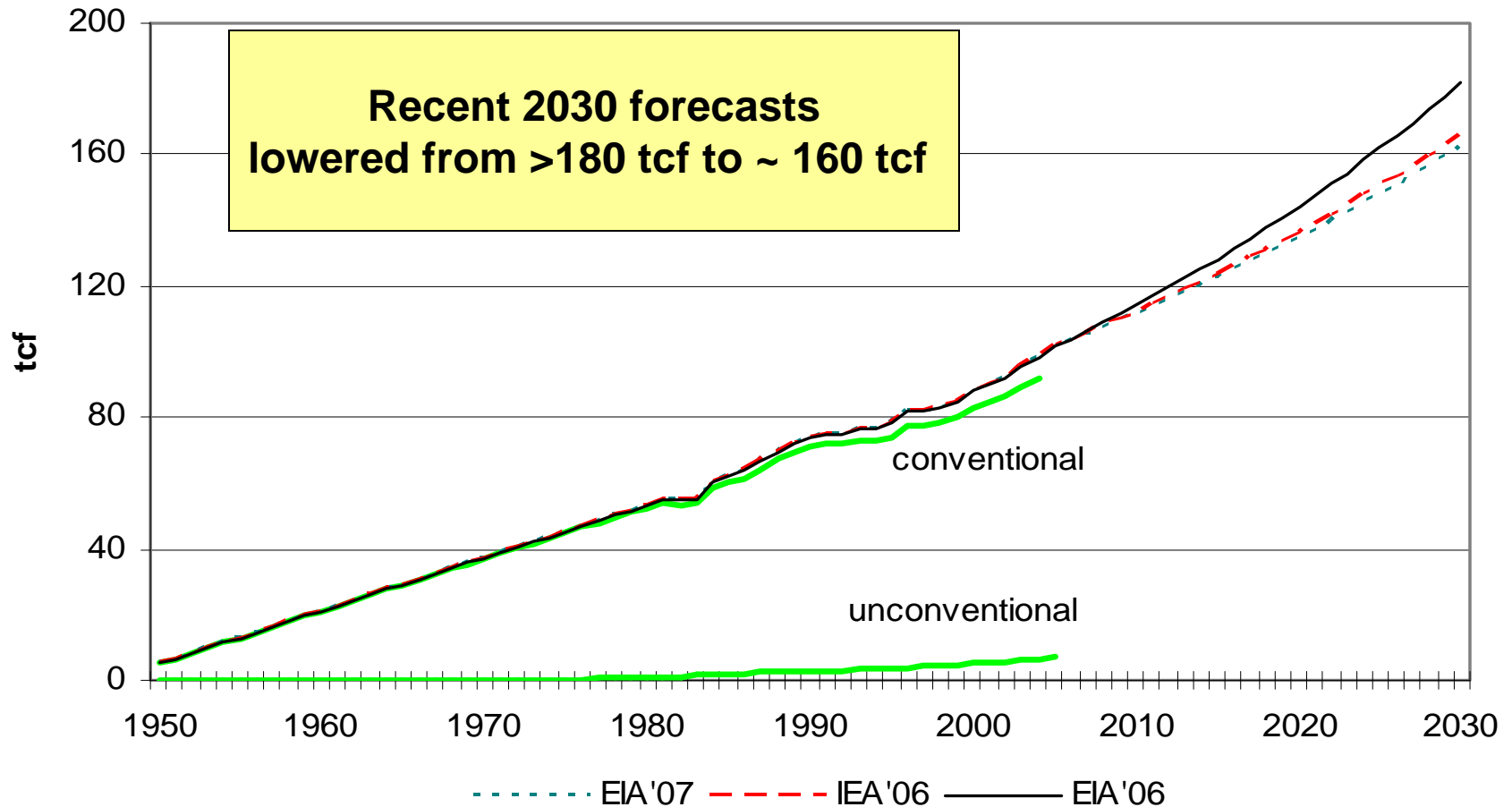
NATURAL GAS DISCOVERY AND FORECAST CONSUMPTION THROUGH 2020



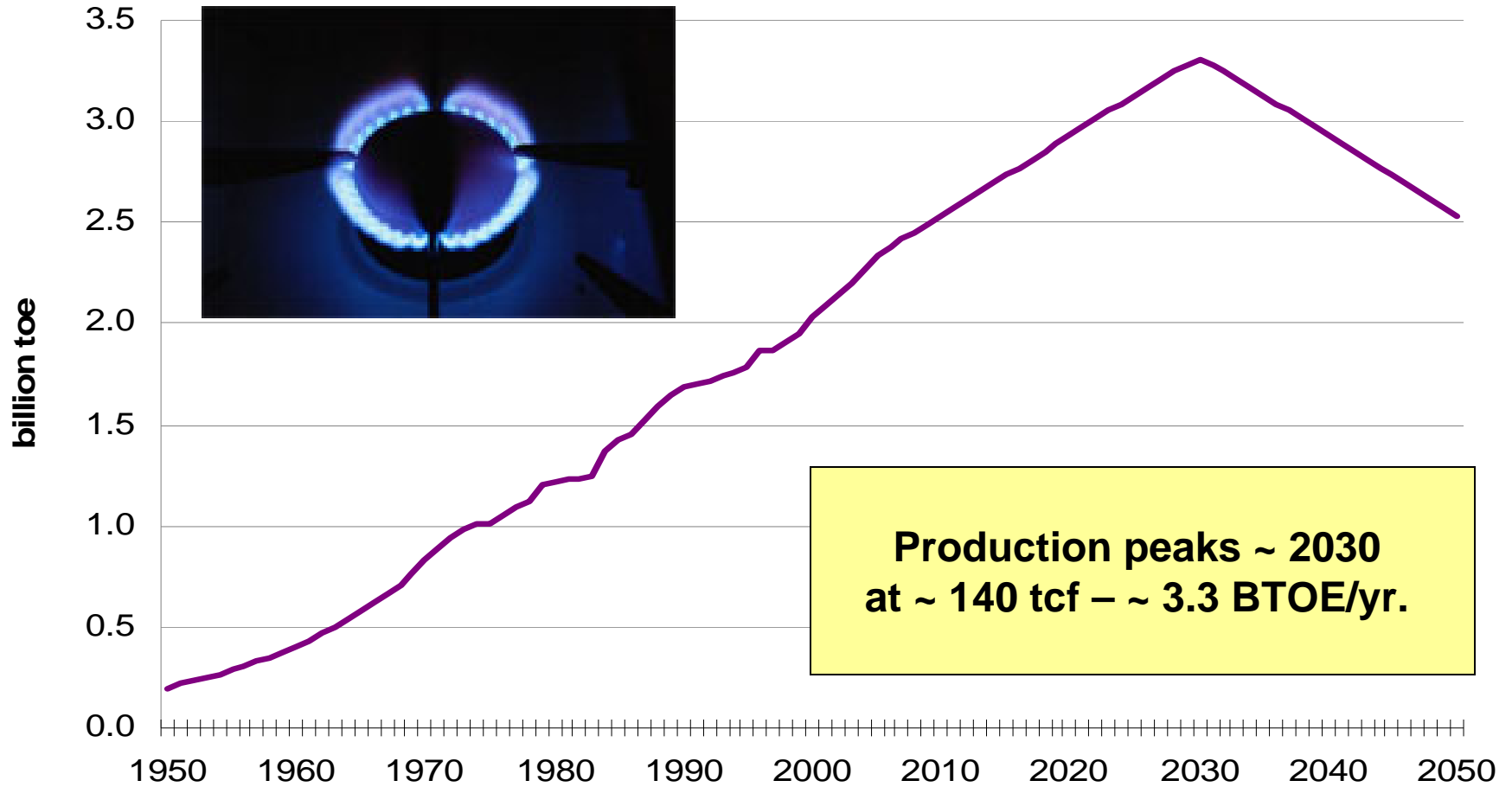
CUMULATIVE WORLD NG DISCOVERY AND PRODUCTION



NG PRODUCTION FORECASTS BEING LOWERED



MISI NATURAL GAS PRODUCTION FORECAST



Source: Management Information Services, Inc., 2008.

PEAK COAL

- **Concept of peak coal as viable as peak oil and peak NG**
- Difference is amount of reserves and extraction methods
- Some nations already passed “peak coal,” e.g., UK, Germany, Japan – 20 in all
- However, some major coal producing nations have young coal industry that is in beginning of production curves
- Some analysts pessimistic about future world coal production
- Strong arguments also made that world coal resources and production potential under-estimated

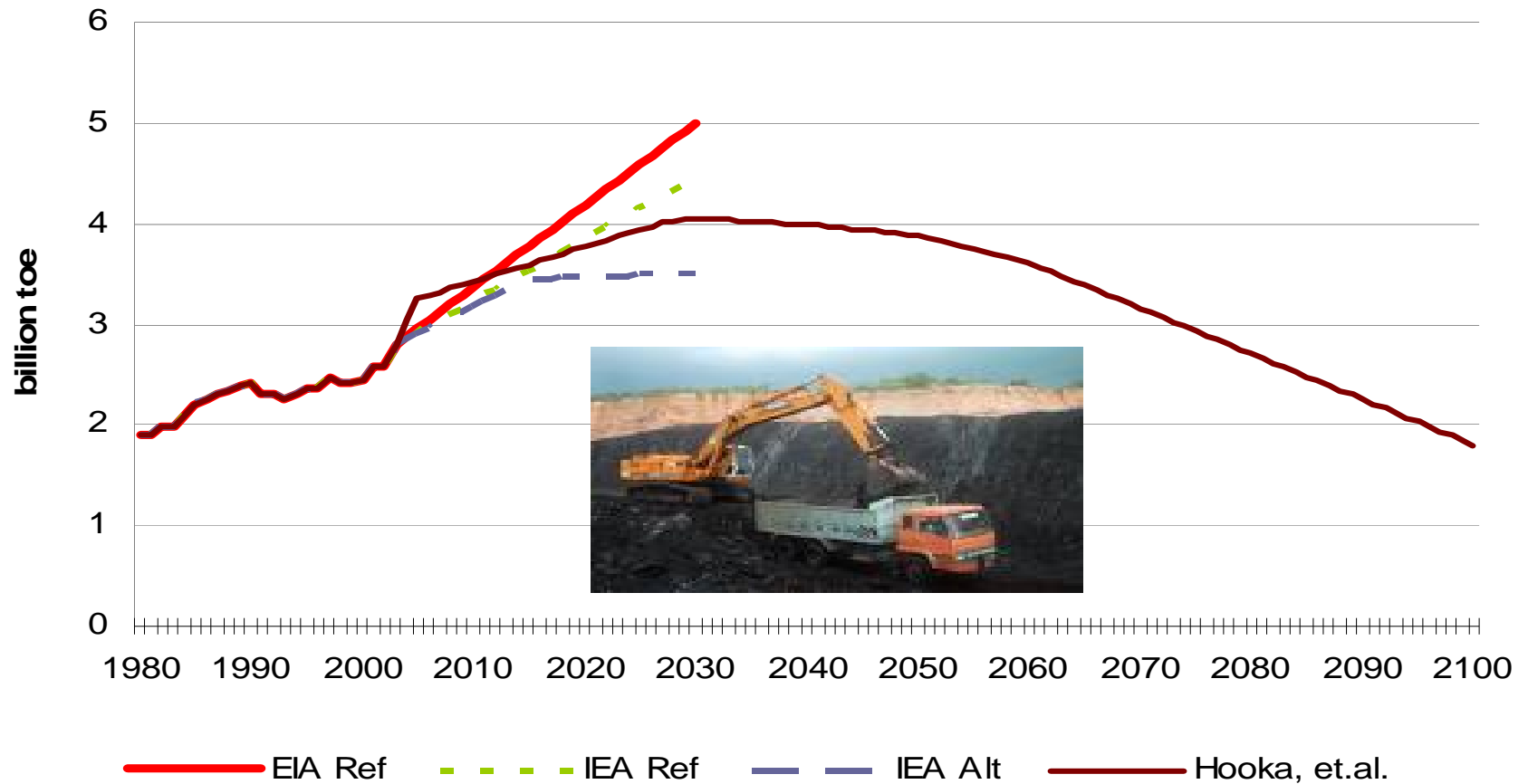


SOME RECENT PEAK COAL ESTIMATES

Forecaster	Date	Level
National Coal Council	No U.S. peak prior to 2030	None given
Southern States Energy Board	No U.S. peak prior to 2030	None given
Energy Watch Group	World peak in 2025	6.4 billion tons (world)
Mikael Hööka, Werner Zittelb, Jörg Schindlerb, Kjell Alekletta	World peak in 2030	8.3 billion tons (world)
Gregson Vaux, NETL energy researcher	U.S. peak in 2032	3.3 billion tons (U.S)
Jean Laherrere, energy analyst	World peak in 2050	3.6 Btoe (world)
Pushker Kharecha and James Hansen, energy researchers	World peak in 2077	None given
Thomas Thielemann, Sandro Schmidt, and J. Peter Gerling, energy researchers	No world physical coal constraints through 2100	None given

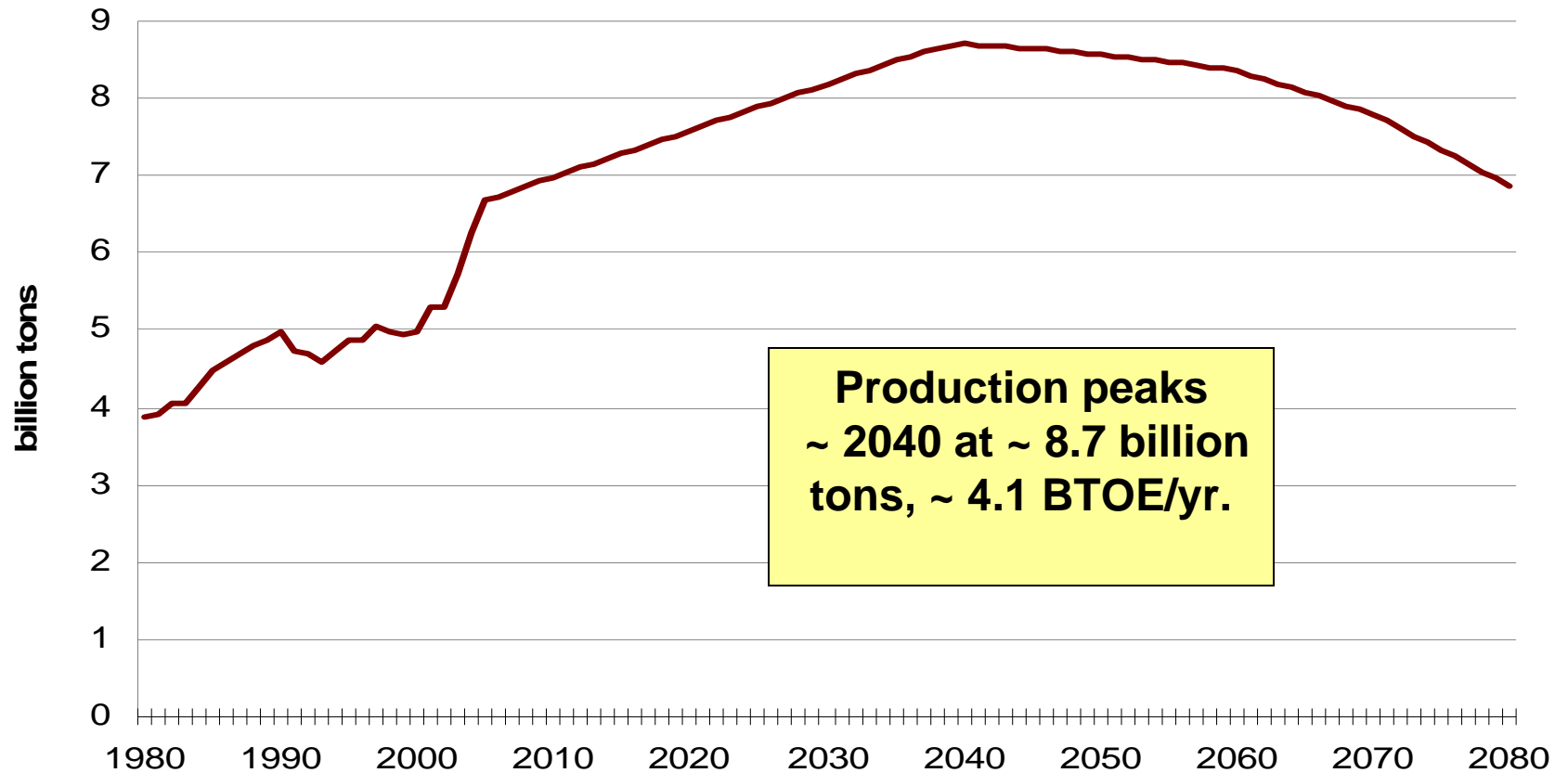
Source: Management Information Services, Inc., 2008.

ESTIMATES OF WORLD COAL PRODUCTION

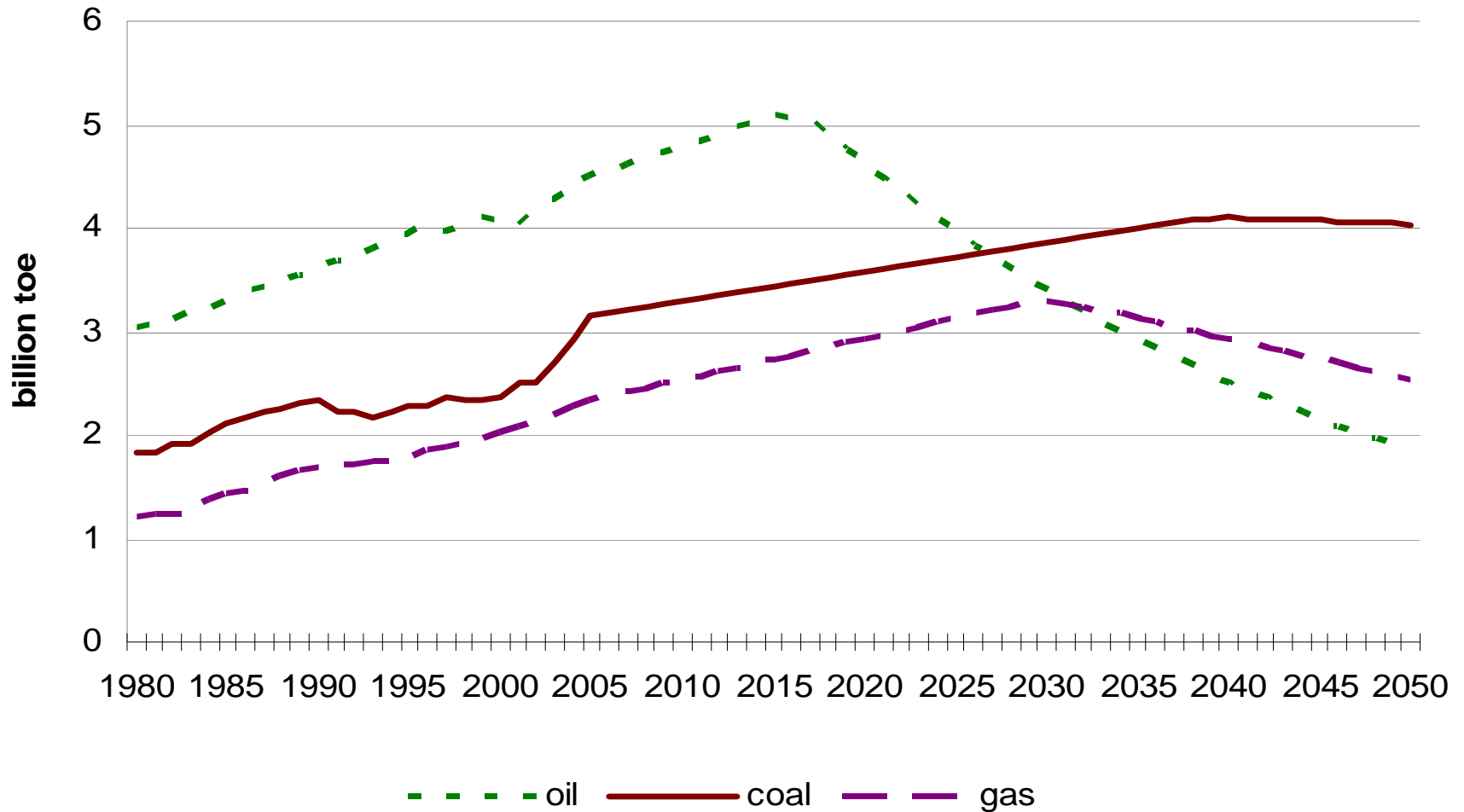


Source: U.S. Energy Information Administration, 2007; International Energy Agency, 2006; and Mikael Hööka, Werner Zittelb, Jörg Schindlerb, Kjell Alekletta, 2007.

MISI WORLD COAL PRODUCTION FORECAST

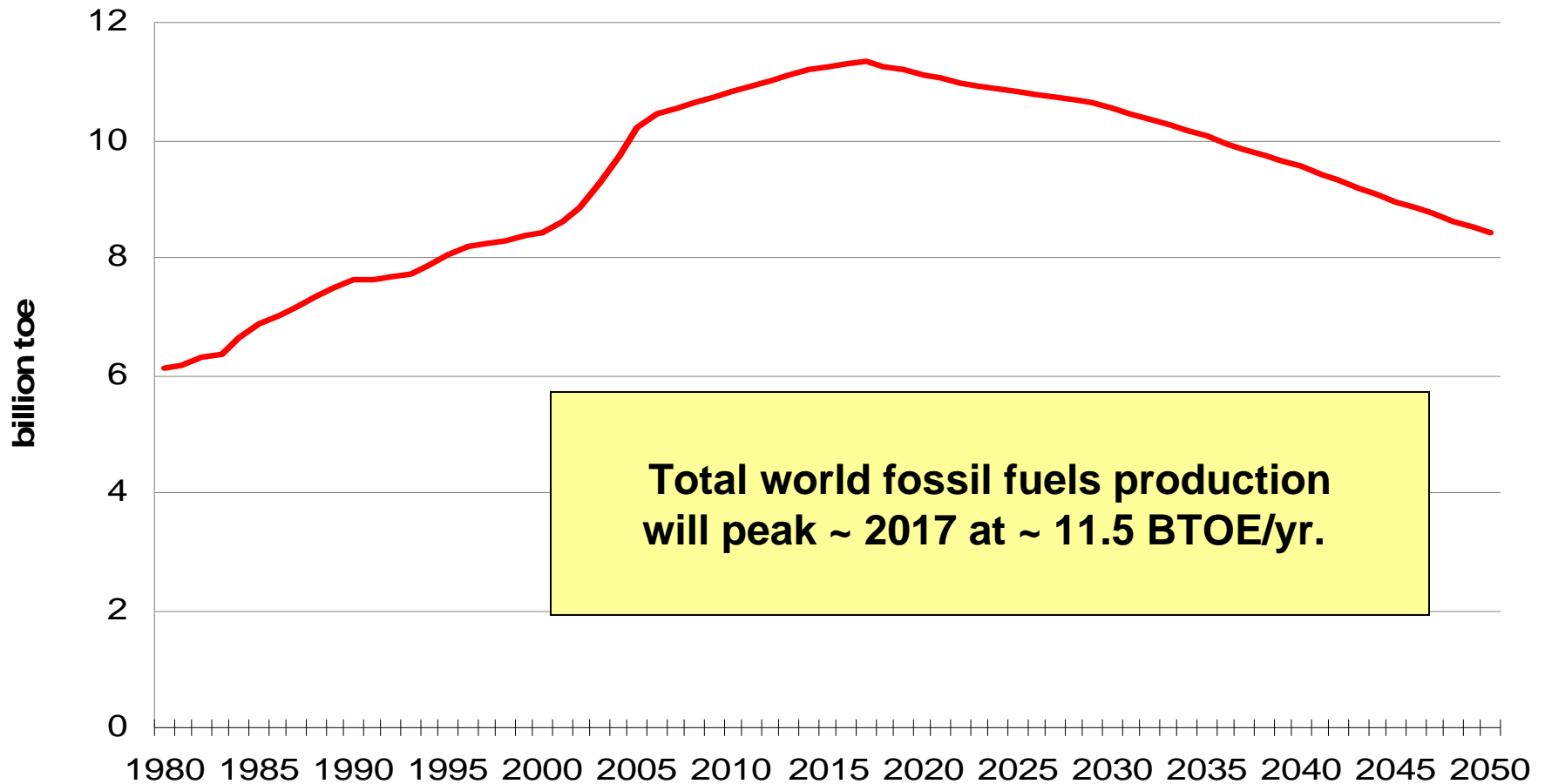


MISI ESTIMATES OF WORLD LIQUID FUELS, NATURAL GAS, & COAL PRODUCTION



Source: Management Information Services, Inc., 2008.

MISI WORLD FOSSIL FUEL PRODUCTION FORECAST



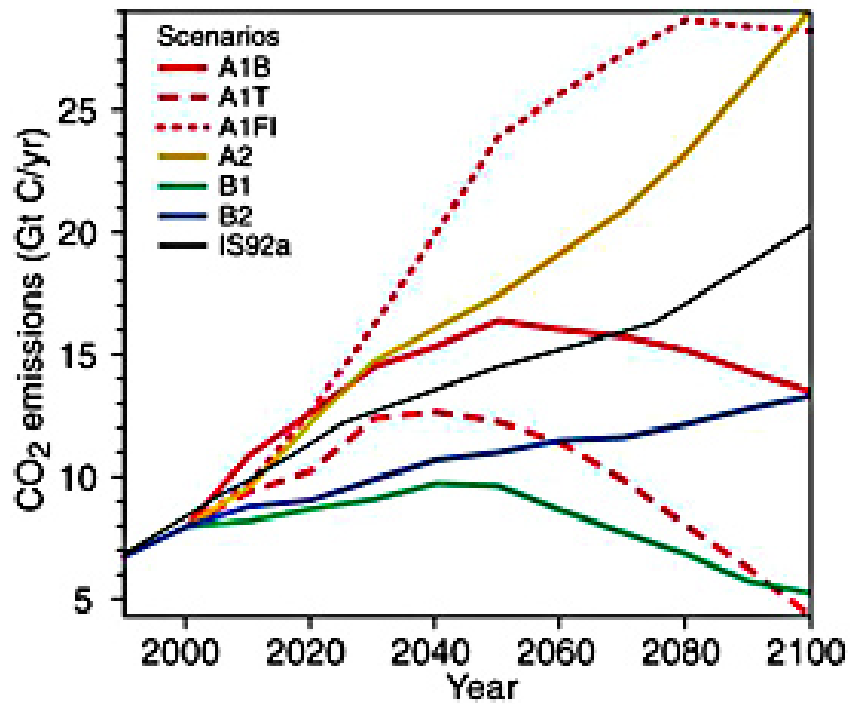
Source: Management Information Services, Inc., 2008.

CARBON DIOXIDE FORECASTS

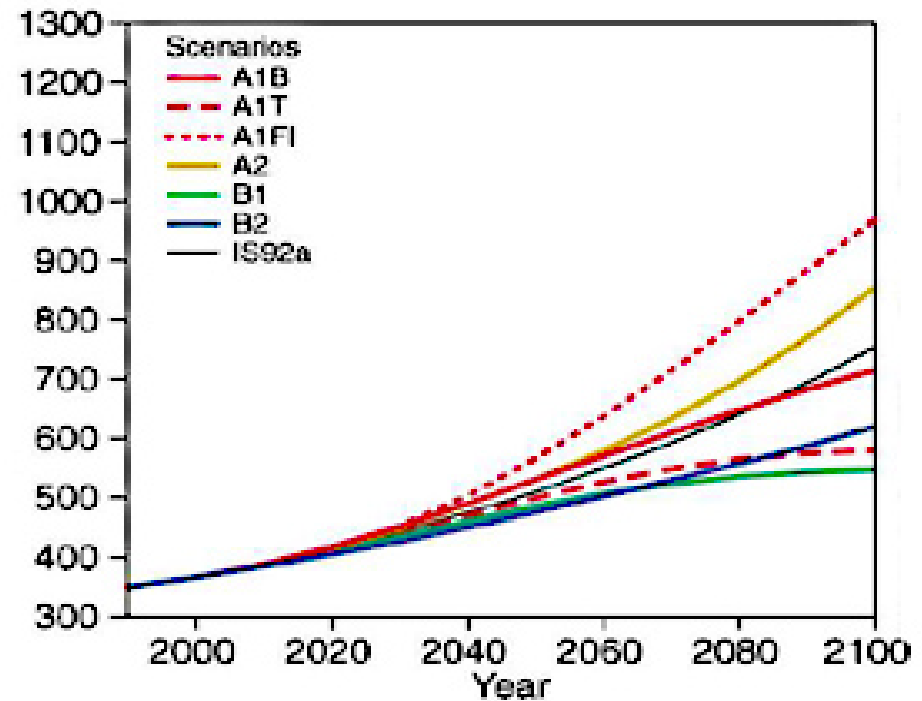
- CO₂ emissions usually forecast over extended time period – often 100 yrs +
- Forecasts include CO₂ atmospheric concentrations
- CO₂ atmospheric concentrations much more difficult to forecast, and forecasts differ widely
- IPCC developed series of 24 climate change projections
- IPCC contends that:
 - World carbon emissions must peak by 2015 to avoid irreversible climate change
 - CO₂ atmospheric concentrations must not exceed 450 ppm

IPCC SCENARIOS THROUGH 2100

(a) CO₂ emissions

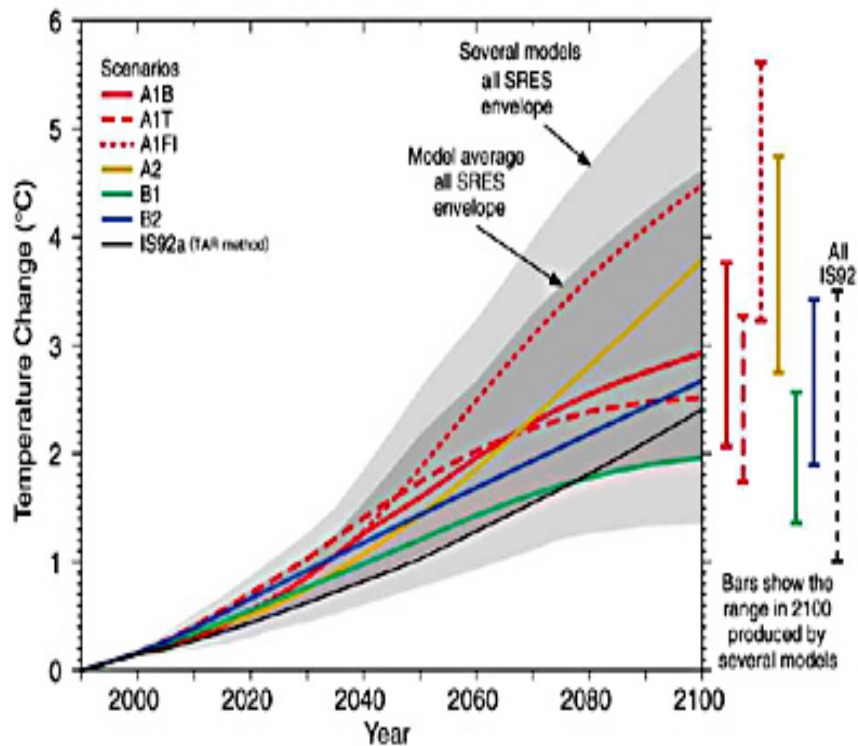


(b) CO₂ concentrations

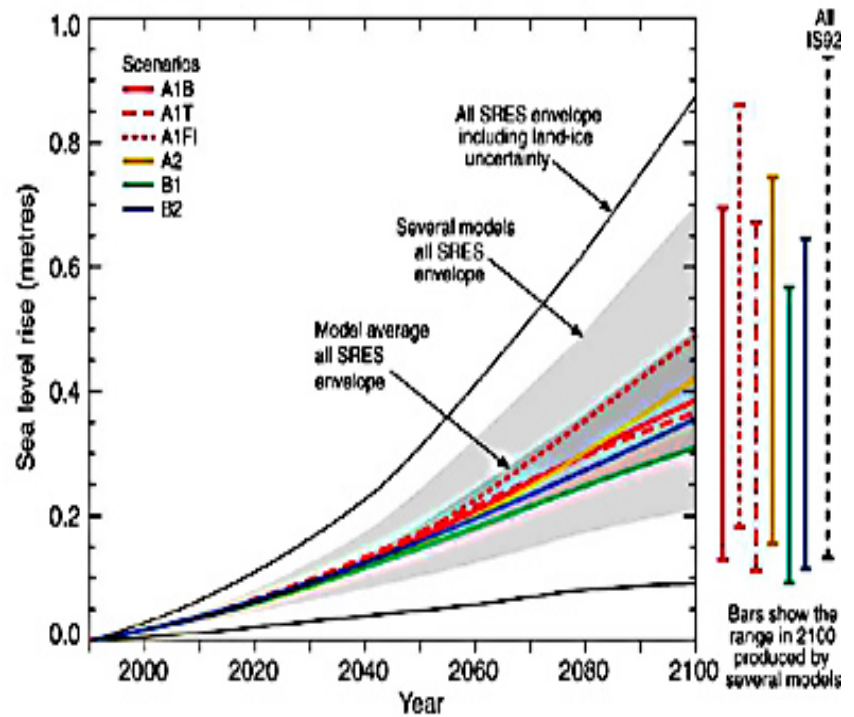


IPCC ESTIMATES OF IMPACTS

(d) Temperature change



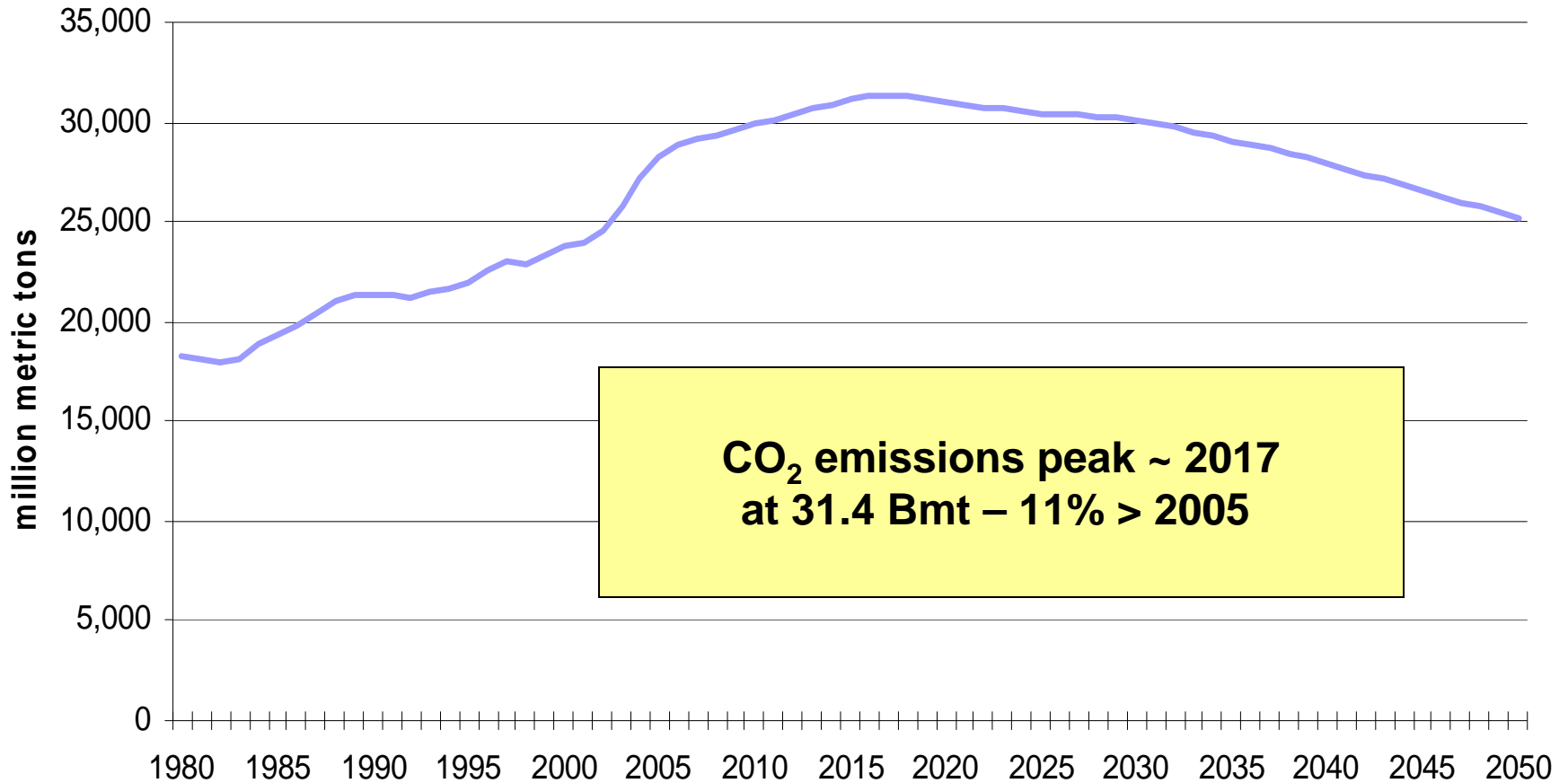
(e) Sea level rise



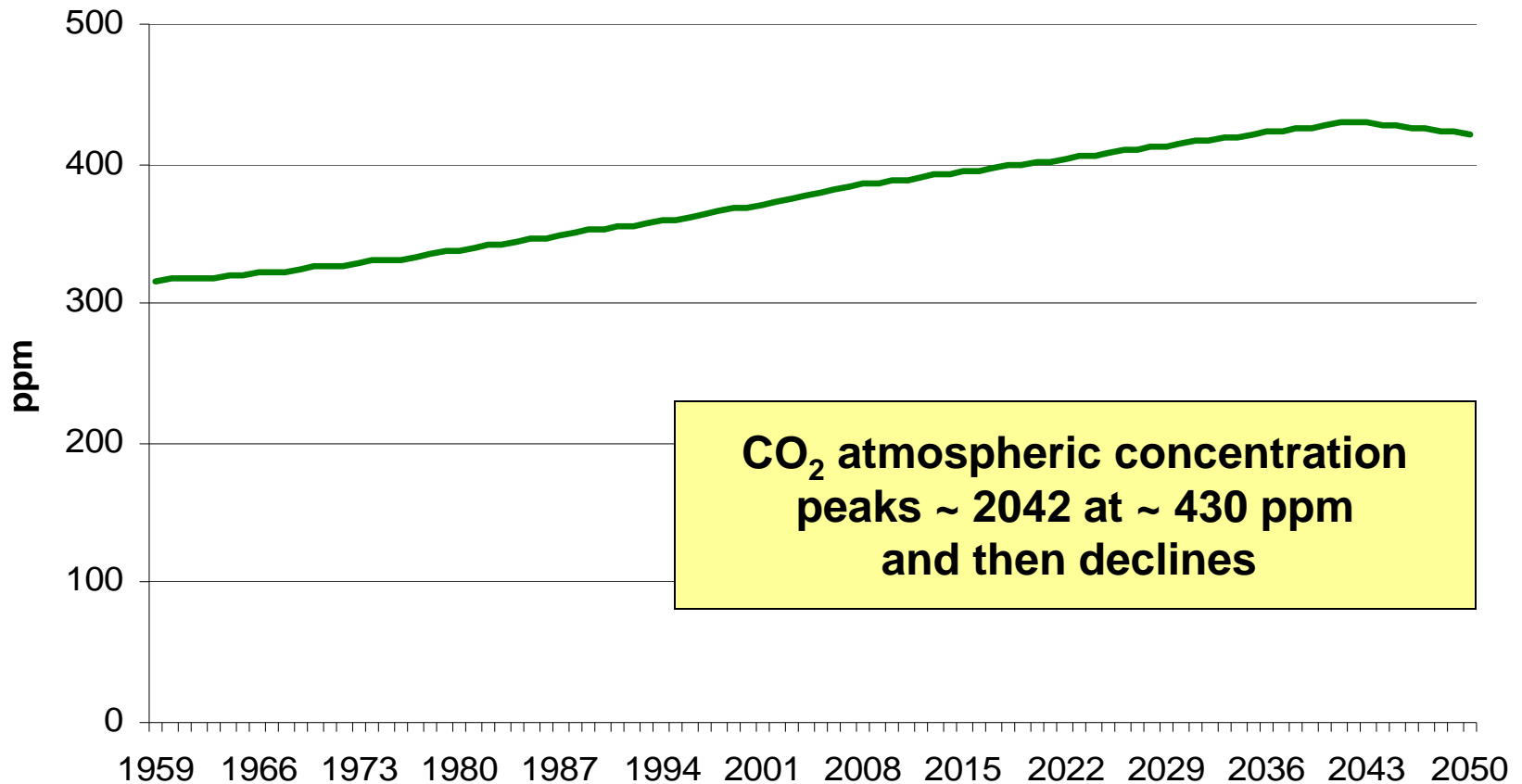
RETHINKING CO₂ FORECASTS

- We used MISI peak fossil fuels forecasts and historical CO₂ emission levels through 2005
- Estimated CO₂ emission levels based on fossil fuels consumption through 2050
- Estimated CO₂ concentration levels based on fossil fuels consumption through 2050
- MISI estimates that:
 - CO₂ emissions will peak ~ 2017 at ~ 31.4 Bmt – 11% higher than in 2005
 - CO₂ atmospheric concentration will peak ~ 2042 at ~ 430 ppm, and will then decline

MISI ESTIMATE OF WORLD CO₂ EMISSIONS, 1980-2050



MISI ESTIMATE OF WORLD CO₂ CONCENTRATIONS, 1960-2050



MISI ESTIMATES MAY BE “WORST CASE”

- MISI estimates may be high:
 - Many analysts contend that oil will peak before 2015 at < 95 MM bpd
 - Our forecast assumes that 2005 GHG controls will remain at same level through 2050
 - However, technology developments will likely lower MISI forecast of CO₂ emissions
 - Further, world economy is becoming less CO₂ intensive per unit of output, and this trend will accelerate

FINDINGS

- Peak oil drives peak fossil fuels and CO₂ emissions/concentrations
- World fossil fuel production peaks ~ 2017, 2 years after peak oil
- CO₂ and carbon equivalent emissions peak ~ 2017
- CO₂ atmospheric concentration peaks ~ 2042 at ~ 430 ppm
- **Fossil fuel peaking will prevent attainment of CO₂ levels forecast by IPCC and others**
- MISI findings are conservative and robust:
 - Oil may peak prior to 2015
 - CO₂ estimates ± 2-3 years do not change conclusions
 - New technologies will further reduce output CO₂

IMPLICATIONS

- IPCC:
 - “World CO₂ emissions must peak by 2015 to avoid irreversible climate change.”
 - “World CO₂ atmospheric concentrations must not exceed 450 ppm.”
- **Peaking of world fossil fuels & CO₂ emissions ~ 2017 will meet IPCC targets without legislative mandates**
- **Fossil fuel peaking will limit CO₂ atmospheric concentration to ~ 430 ppm – well below climate change models forecasts**
- Geologic resource constraints will impact sooner & more severely than legislative GHG control actions
- **Geologic constraints supersede legislative actions in controlling future CO₂ emissions**

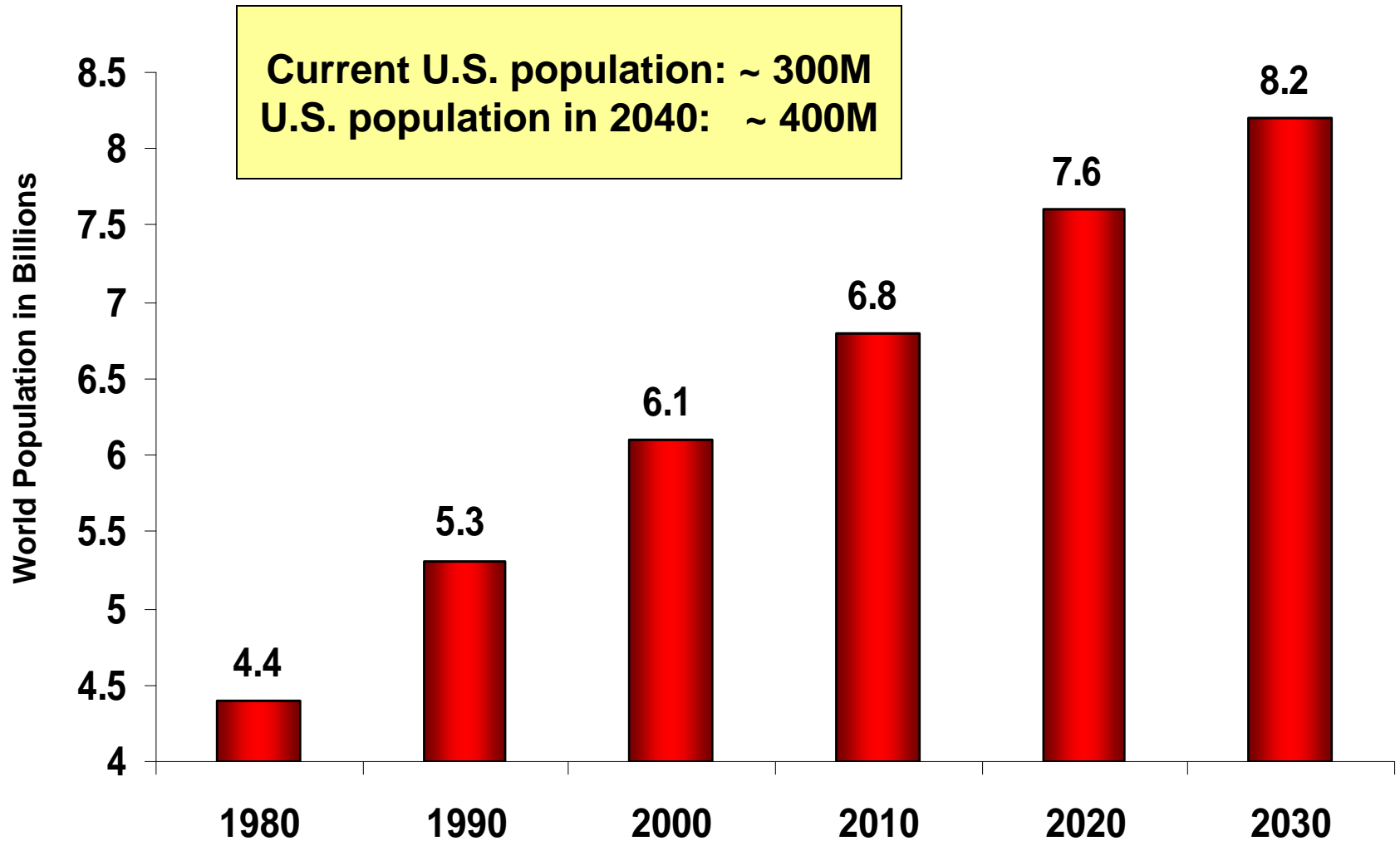
FURTHER IMPLICATIONS

- **World GDP can continue to increase in real terms ~ 2.1%/yr. without increasing carbon emissions**
- Two caveats
- First, world economic growth beyond 2017 requires vast new energy supplies to replace declining fossil fuels
- Ensuring these supplies will require massive efforts beginning at least a decade in advance of fossil fuel peaking – e.g. now
- Second, world population forecast to increase from current 6.7 billion to ~ 9 billion in 2050
- Thus, **to improve living standards, an economic growth rate > the “carbon neutral” rate of ~ 2.1%/yr. required**

REAL PROBLEM WE FACE

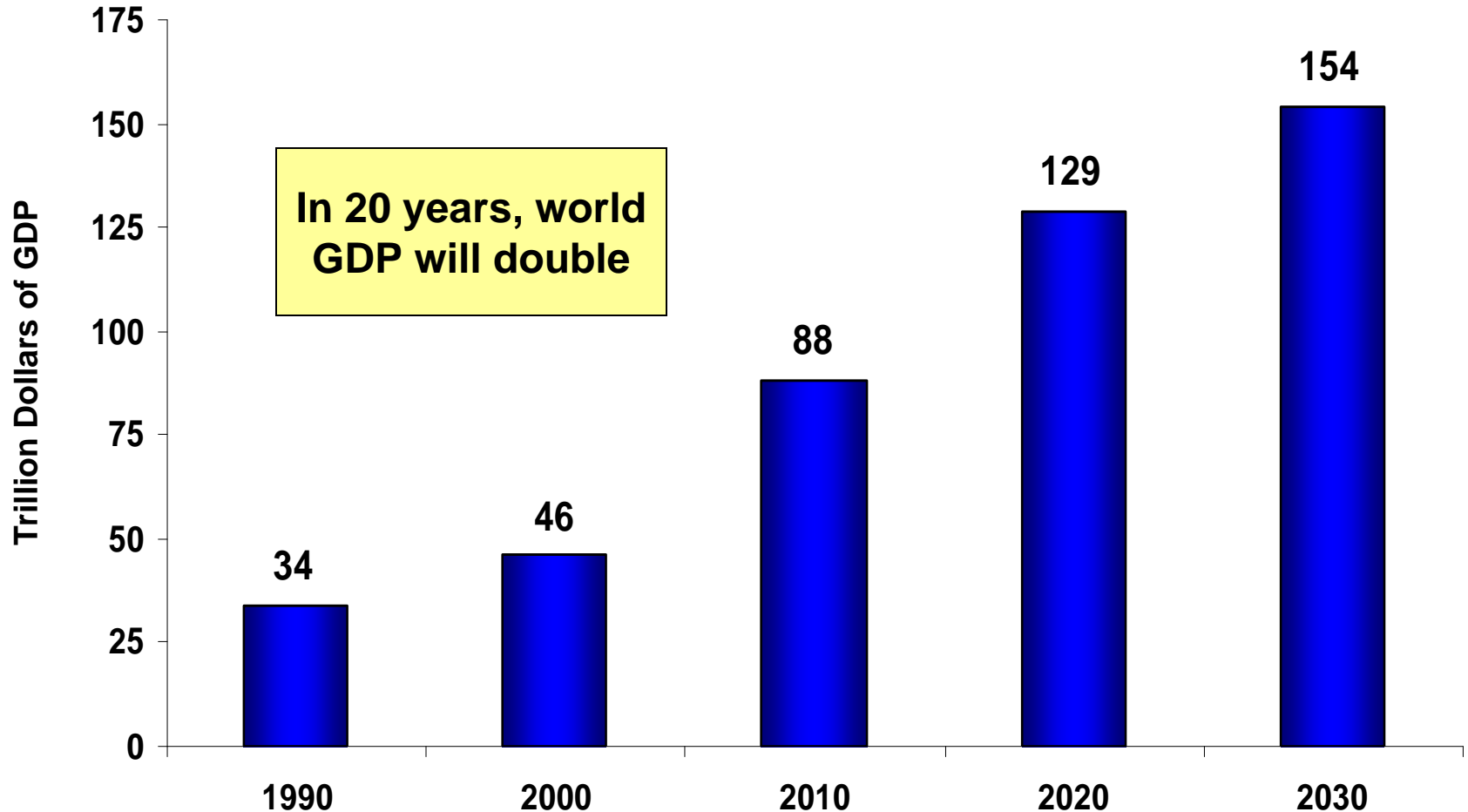
- **Real energy problem world faces is peaking and then decline of fossil fuel production**
- Economic growth & energy requirements closely correlated
- **Major problem for most of world is achieving economic growth** to reduce poverty
- This will **require vastly increased energy supplies for the foreseeable future**
- Most energy available will be fossil and nuclear
- Failure to achieve economic growth will hurt poor nations and poor people the most
- Most nations not ready to go on strict energy diet
- **This may supersede global warming concerns**

POPULATION GROWTH TRENDS

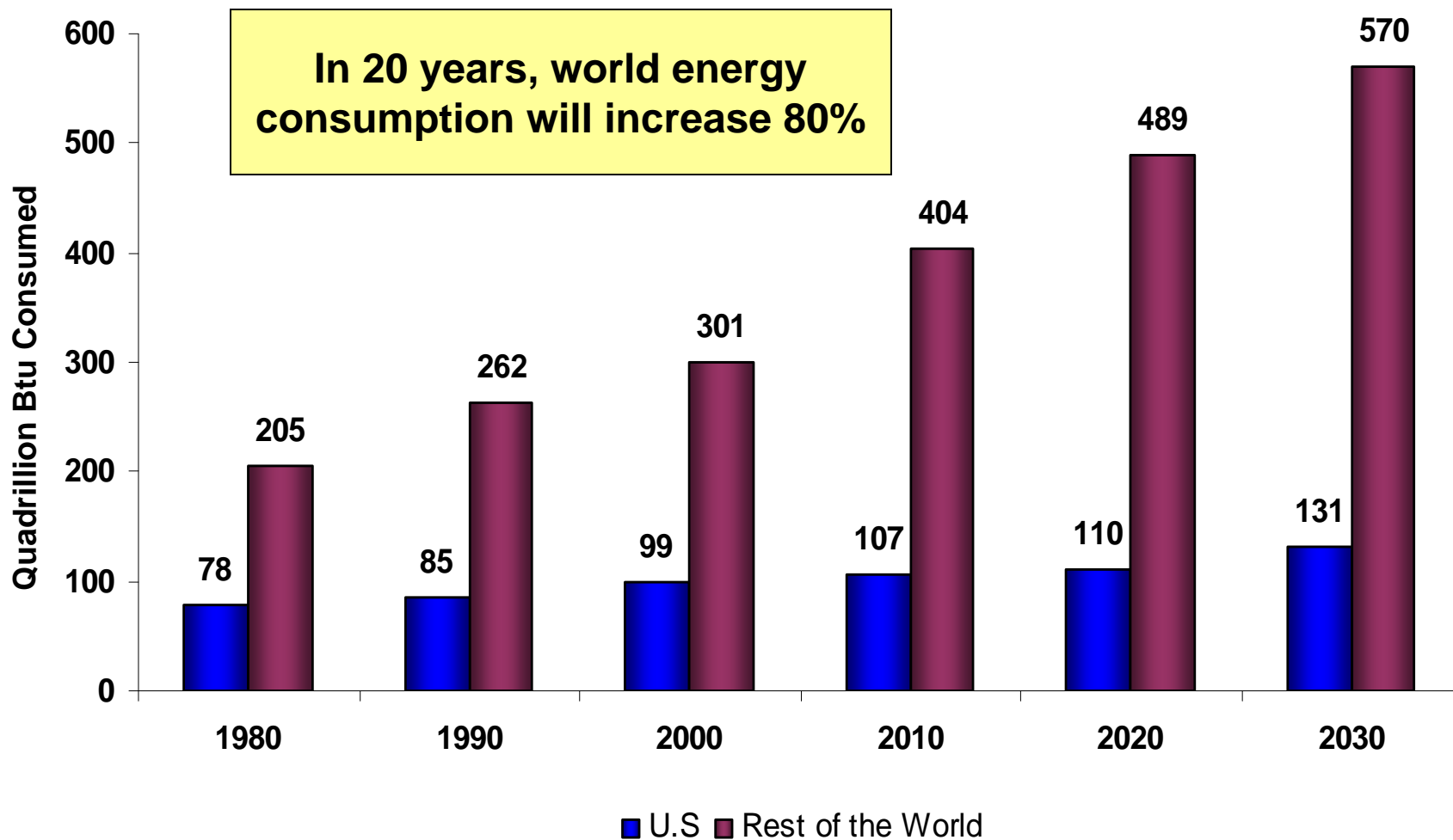


CURRENT ECONOMIC GROWTH FORECAST

World GDP in Trillion 2000 Dollars



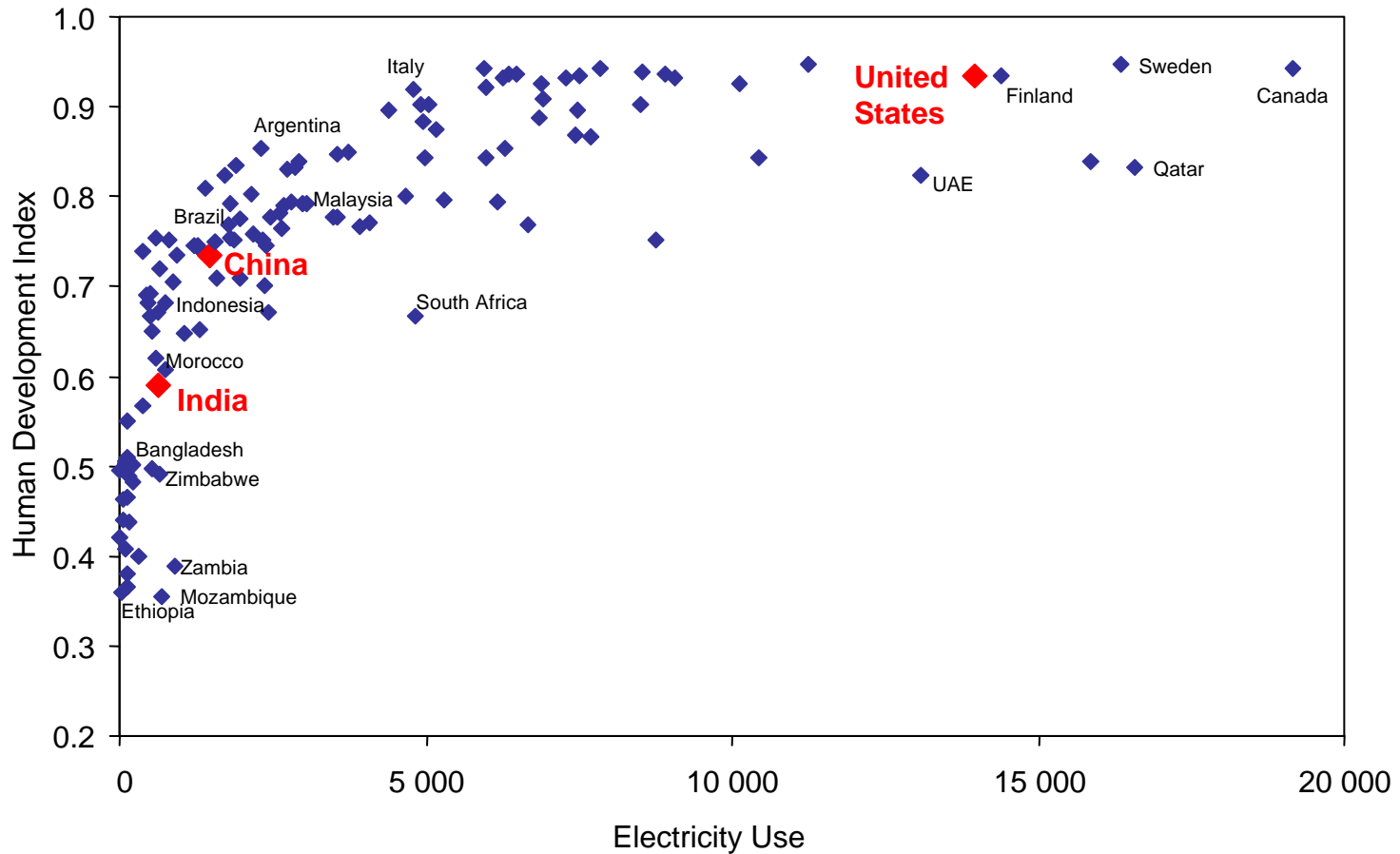
DEMAND FOR ENERGY: THE RISING TIDE



Note: 1.6 billion people currently do not have electricity.

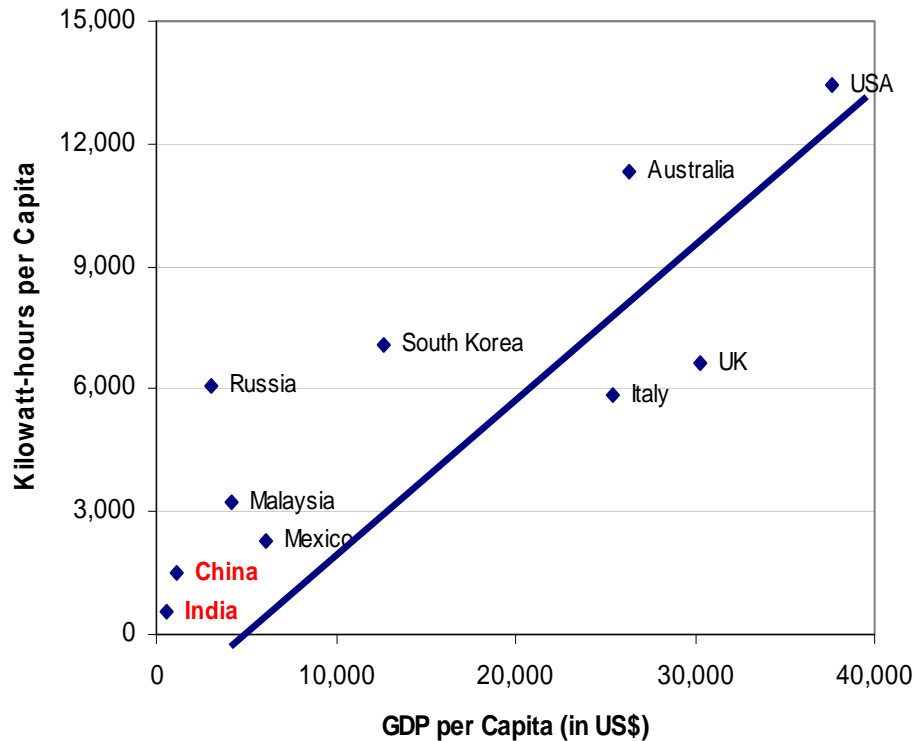
U.N.: ACCESS TO ABUNDANT ENERGY IS KEY TO QUALITY OF LIFE

Electricity Use Per Capita and the U.N. Human Development Index

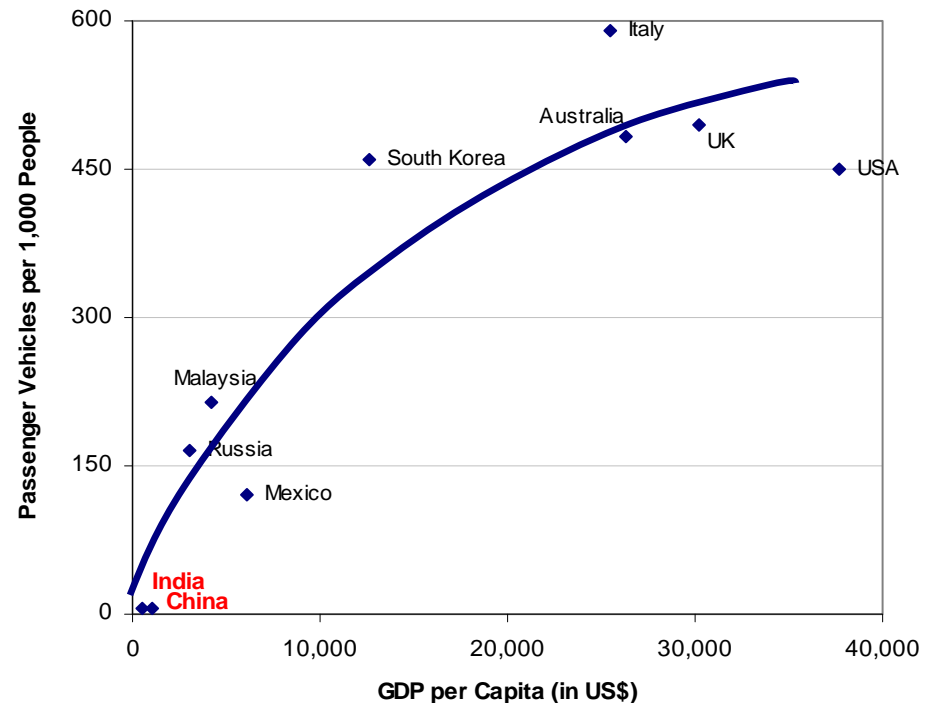


MOST NATIONS STILL AT EARLY STAGES OF MODERNIZATION – AND ENERGY USE

Electricity Usage per Capita



Passenger Vehicles per Capita



Projections assume Chinese consumption remains below current levels in Mexico for next 25 years

CONCLUSIONS

- Data on fossil fuel resources, reserves, availability, & production potential incomplete, of poor quality, & often unavailable
- Data deficiencies for NG & coal more serious than for oil
- World fossil fuel production & CO₂ emissions will peak ~ 2017
- CO₂ atmospheric concentration peaks ~ 2042 @ < 450 ppm
- Fossil fuel peaking with achieve IPCC CO₂ reduction goals without legislation
- **Geologic constraints supersede legislative actions in controlling future CO₂ emissions**
- **Real energy problem world faces is peaking and then decline of fossil fuel production**
- **The challenge is developing the vastly increased energy supplies world requires in coming decades**

RECOMMENDATIONS

- Research required to improve data on fossil fuel resources, reserves, availability, & production potential
- Research priority should be on data deficiencies for NG & coal
- Further research required on relationship between fossil fuel production limitations and CO₂ emissions
- Research should concentrate on post-2017 energy, CO₂, and economic issues and interrelationships
- Credible, comprehensive study required by objective organization independent of IPCC – perhaps the U.S. or Canadian National Research Council