PEAKING OF WORLD OIL PRODUCTION

An Overview

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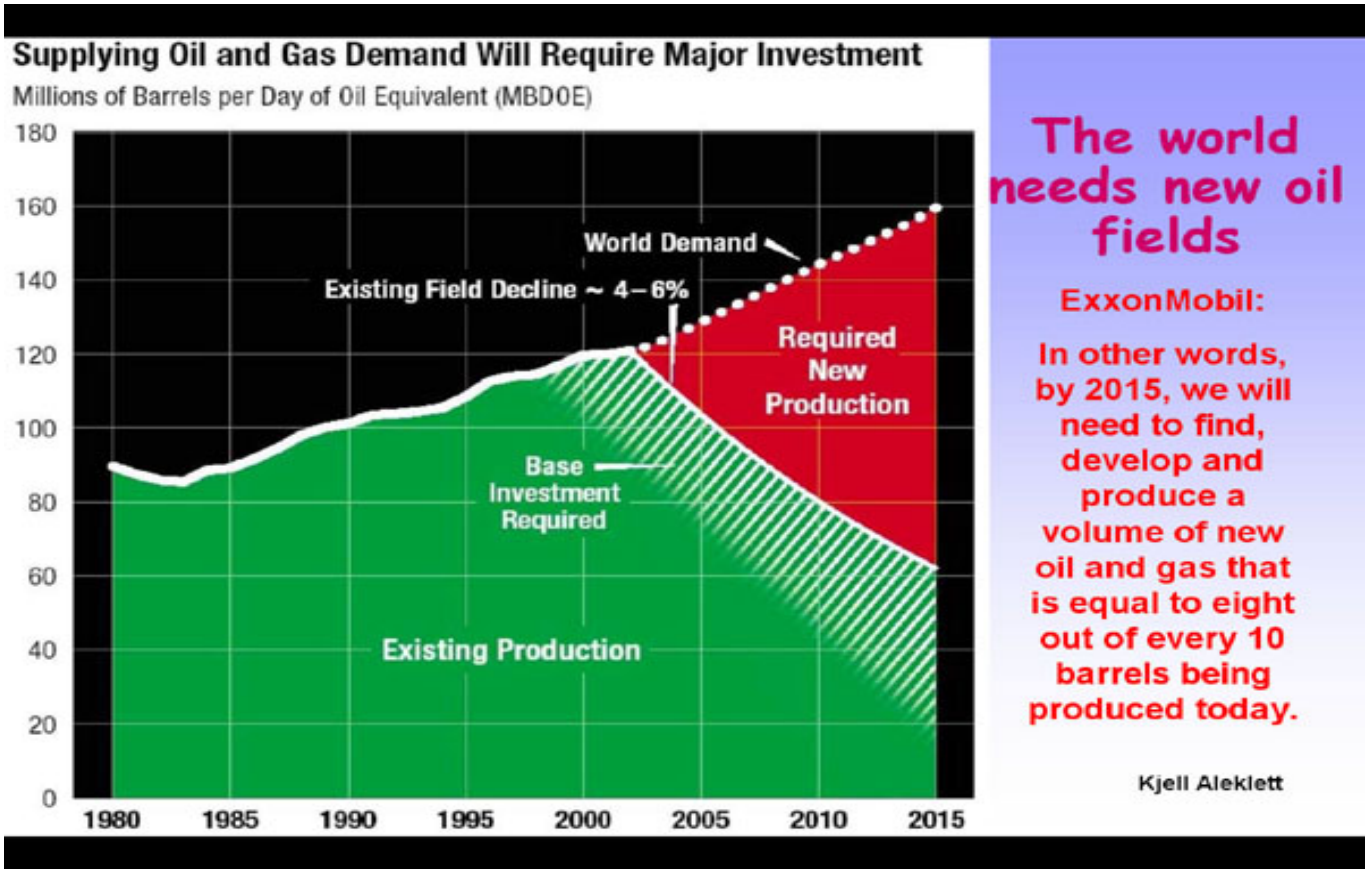
This Presentation

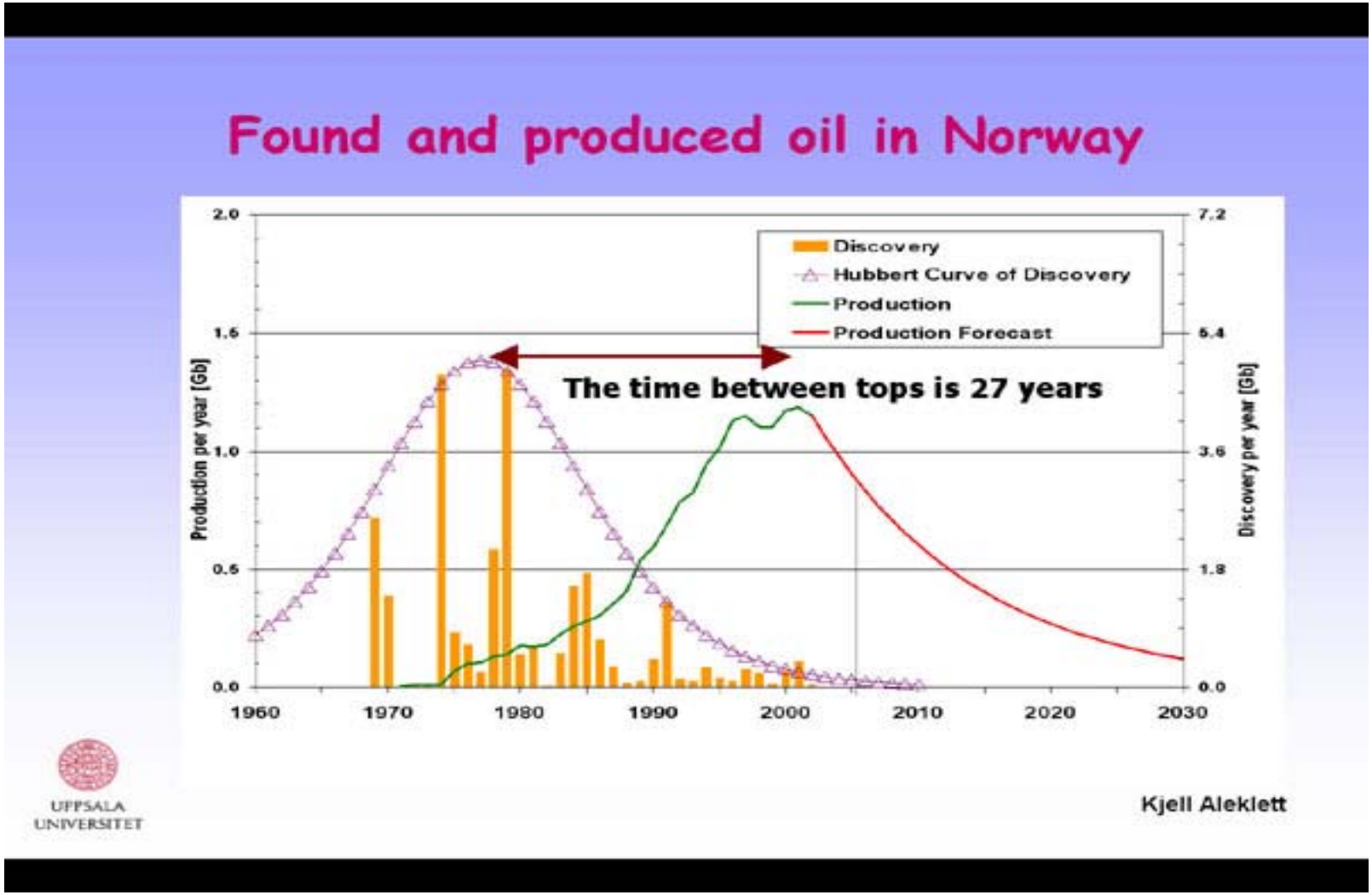
- **On the road to peaking**
- **Timing**
- **Why is it so complicated & contentious?**
- **One “simple” approach to forecasting**
- **Mitigation & risk**

The Task Ahead Is Daunting or Worse: Oil & Natural Gas Worldwide



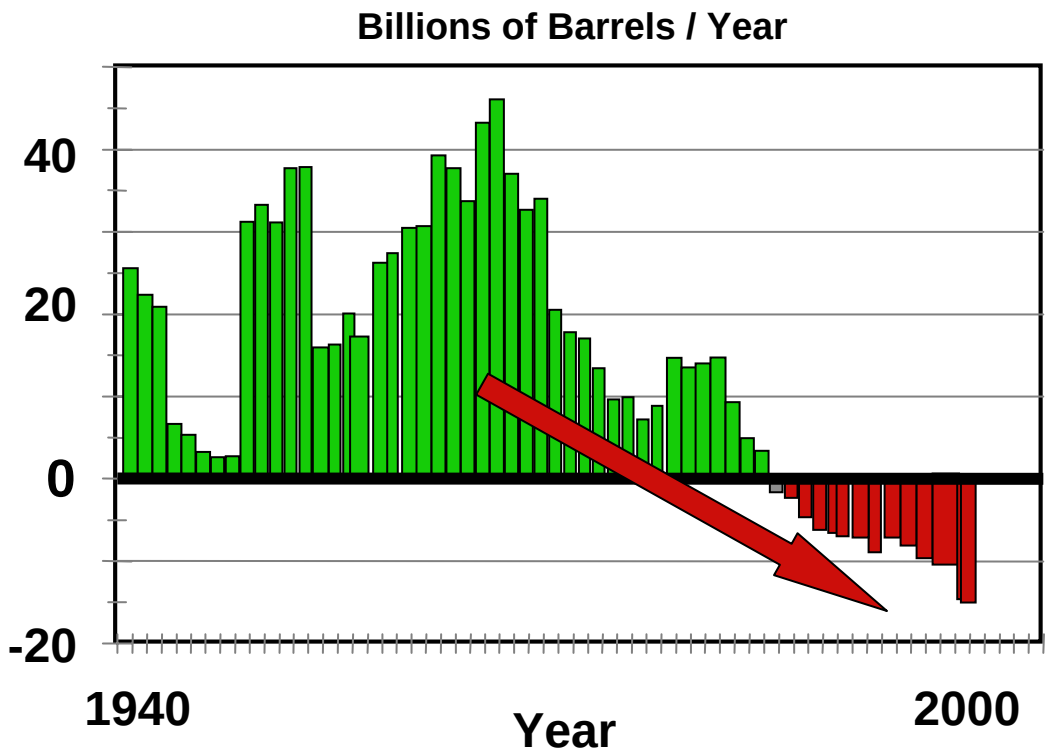
Produce 8 / 10 of current by 2015

Peaking Is Natural - When Discovery Declines, Production Declines Later



The World Has Been Consuming Much More Oil Than It Has Been Finding.

World Conventional Oil Reserves Annual Additions Minus Consumption



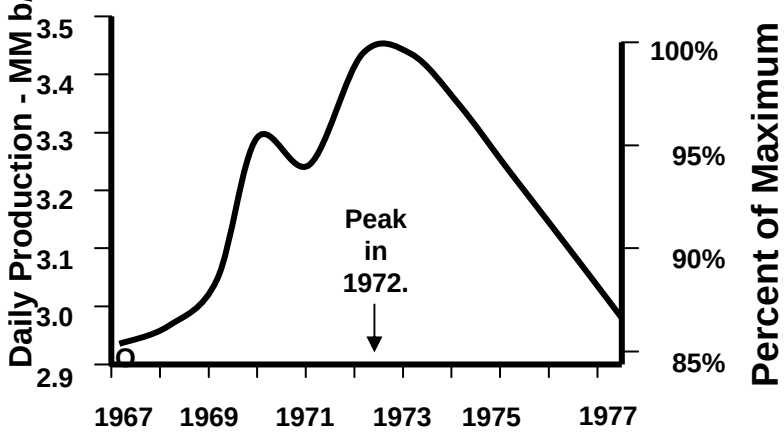
Peak production of conventional oil lies ahead.

Oil production is in decline [Past Peak] in 33 of the 48 largest oil producing countries....

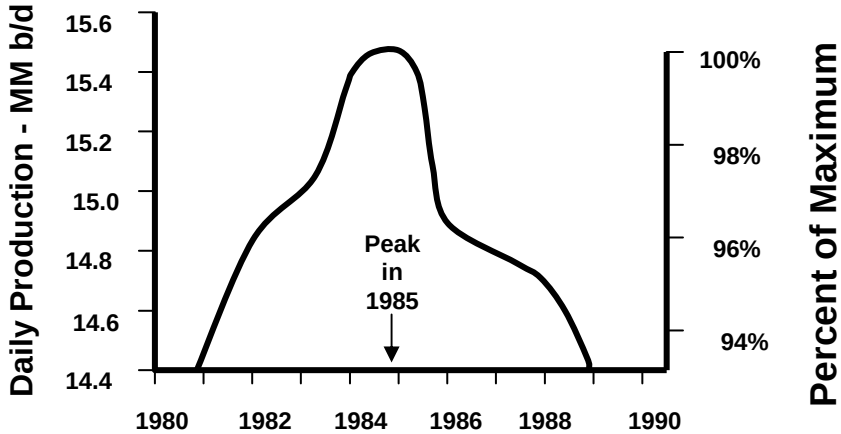
Chevron Corp. full page advertisements in major U.S. newspapers, July 25, 2005.

Peak Production Can Be Sudden & Sharp

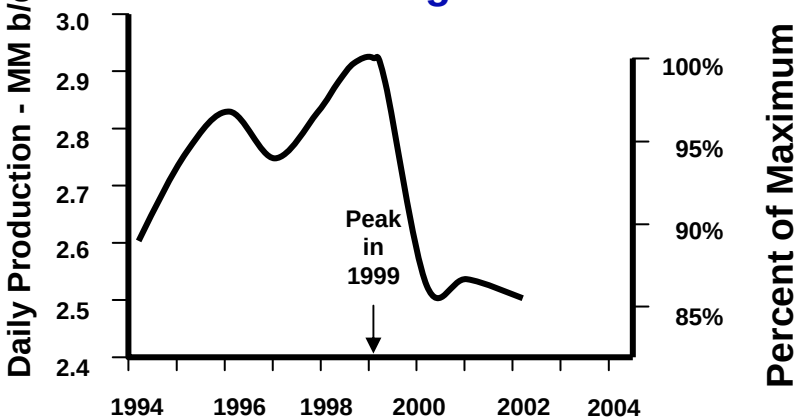
Texas



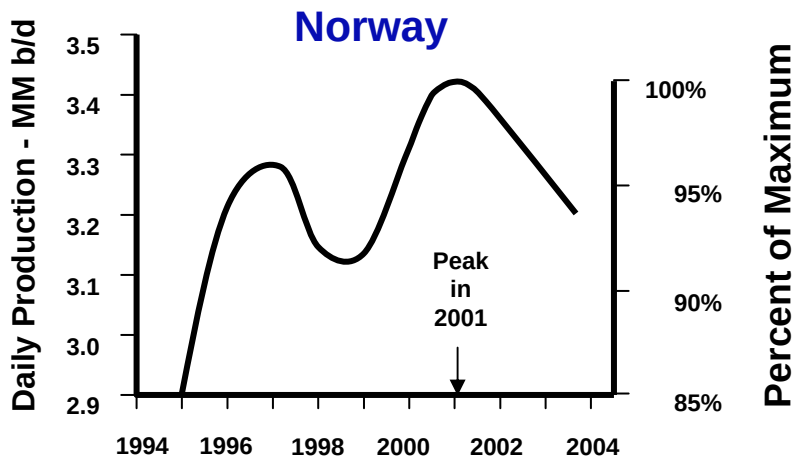
North America



United Kingdom



Norway



Will the world behave like this?

Some of What's Happening

For the third straight year, the industry failed to replace its oil reserves through the drill bit.

Upstream costs keeping pace with oil prices.. (John S. Herold Inc. & Harrison Lovegrove & Co. Ltd.) OGJ. Oct. 2, 2006.

Output from Cantarell (the world's second-largest oil complex) declined by … 10.3% in the first half of 2006…

Shields, D. Despite falling output, Mexican Politics Keep Foreign Operators Out. Offshore. September 2006.

EU crude oil production decreased 9% in 2005.

Leblond, D. EU energy production drop forces higher imports. OGJ. Sept. 22, 2006.

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Things Are Changing:

Notable Recent Statements Relating to the End of Easy and / or Cheap Oil.

- **David O'Reilly, Chairman,** Chevron
- **Samuel Bodman,** U.S. Secretary of Energy
- **Jeroen van der Veer,** Shell **Chief Executive**
- **Viktor Khristenko,** Russian **Energy Minister**
- **Guy Caruso, Administrator,** U.S.EIA

Recent Peak Oil Forecasts to 2011 (5 years)

- **Pickens, T. Boone** (Oil & gas investor)…… **2005**
- **Deffeyes, K.** (Retired Princeton professor & retired Shell geologist)……..**2005**
- **Westervelt, E.T. et al.** (US Army Corps of Engineers)……..**At hand**
- **Bakhtiari, S.** (Iranian National Oil Co. planner)……..**Now**
- **Herrera, R.** (Retired BP geologist)……..**Close or past**
- **Groppe, H.** (Oil / gas expert & businessman)……..**Very soon**

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- **Wrobel, S.** (Investment fund manager)……..**By 2010**
- **Bentley, R.** (University energy analyst)……..**Around 2010**
- **Campbell, C.** (Retired oil company geologist; Texaco & Amoco)……**2010**
- **Skrebowski, C.** (Editor of Petroleum Review)……..**2010 +/- a year**
- **Koppelaar, R.H.E.M.** (Dutch oil analyst)……..**Around 2012**
- **Meling, L.M.** (Statoil oil company geologist)……..**A challenge around 2011**

Important Recent Peak Oil Forecasts Ranging From 2011 - 2021 (5 - 15 years)

- **Volvo Trucks**……**Within a decade**
- **de Margerie, C.** (Oil company executive) ……....**Within a decade**
- **al Husseini, S.** (Retired Exec. VP of Saudi Aramco)……**2015**
- **Merrill Lynch** (Brokerage / Financial)……**Around 2015**
- **West, J.R., PFC Energy** (Consultants)……..**2015-2020**
- **Maxwell, C.T., Weeden & Co.** (Brokerage)..**Around 2020 or earlier**
- **Amarach Consutling** (Ireland)……**Within 15 years**
- **Wood Mackenzie** (Energy consultin……..…**Tight balance by 2020**
- **Total** (French oil company)……..**Around 2020**

Important Recent Peak Oil Forecasts Ranging Beyond 2021.

- **UBS** (Brokerage / Financial)……..**Mid to late 2020s**
- **CERA** (Energy consulting)……**Well after 2020**

“Peak oil theory is garbage”

- **ExxonMobil** (Oil company)……**No sign of peaking**
- **Browne, J.** (BP CEO)……...**Impossible to predict**
- **OPEC……Deny peak oil theory**

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Data?

“The oil industry is unusual in the degree to which its statistics are plagued by

- Errors,
- Exaggerations,
- Omissions and
- Just plain deceit.

As a result, current numbers are not very accurate, accurate numbers are not very current and there are conflicting versions of some important historical series. Worse yet,

- Few people know the true condition of reservoirs...
- Hardly any of these are talking and
- The penalty for ... espionage can be instant death.”

Smith, L.L. "Wild Cards in the Oil Deck." USAEE Dialogue. August 2006

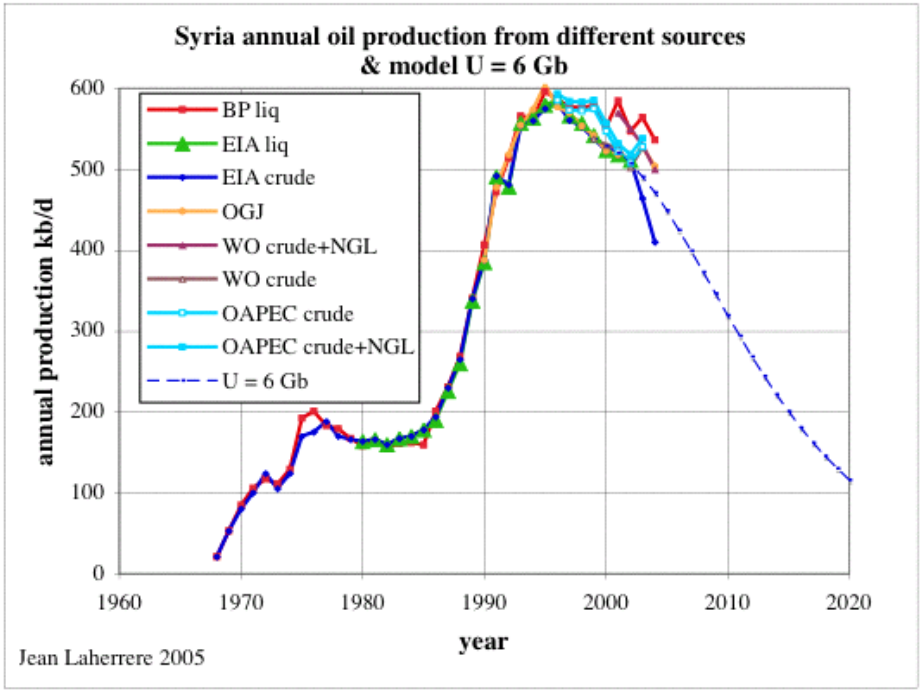
We Are Dealing With Approximations

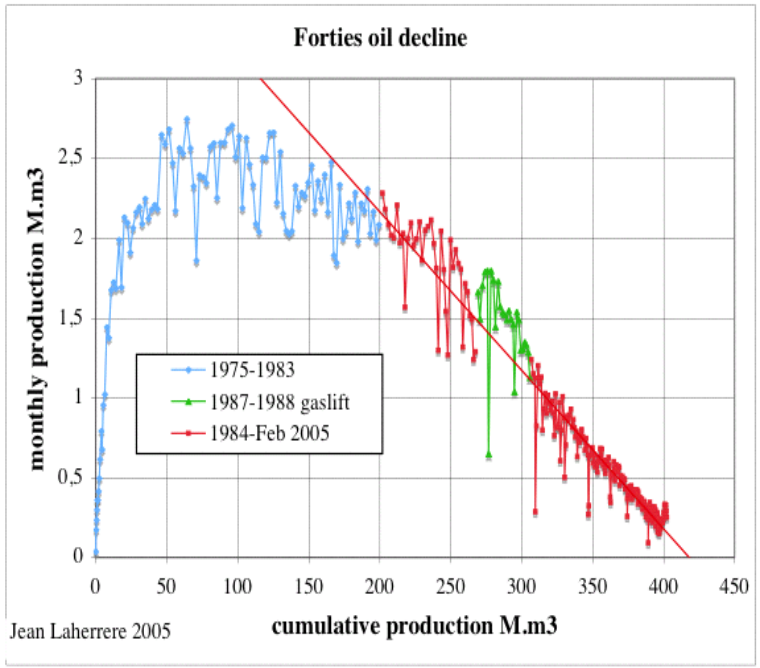
Nobody can measure oil and gas reserves. The numbers are estimates based on interpretation --- often quite a lot of interpretation --- of sparse data about indirect indicators like well and seismic information.

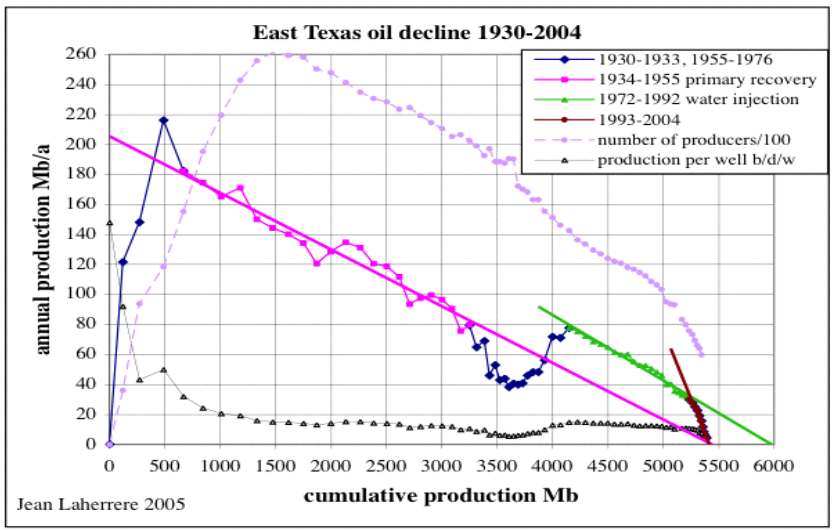
Yet people who don't know better see numbers and assume they represent measurements, as if from some geophysical dipstick. Reserves aren't measurable ….

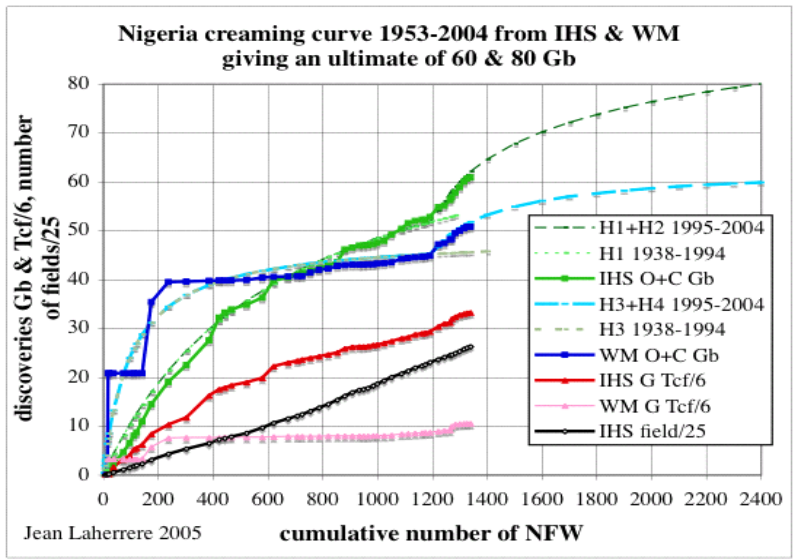
Tipee, B. Reserves numbers aren't oil's only market perplexity. OGJ. September 25, 2006.

It's Very Complicated



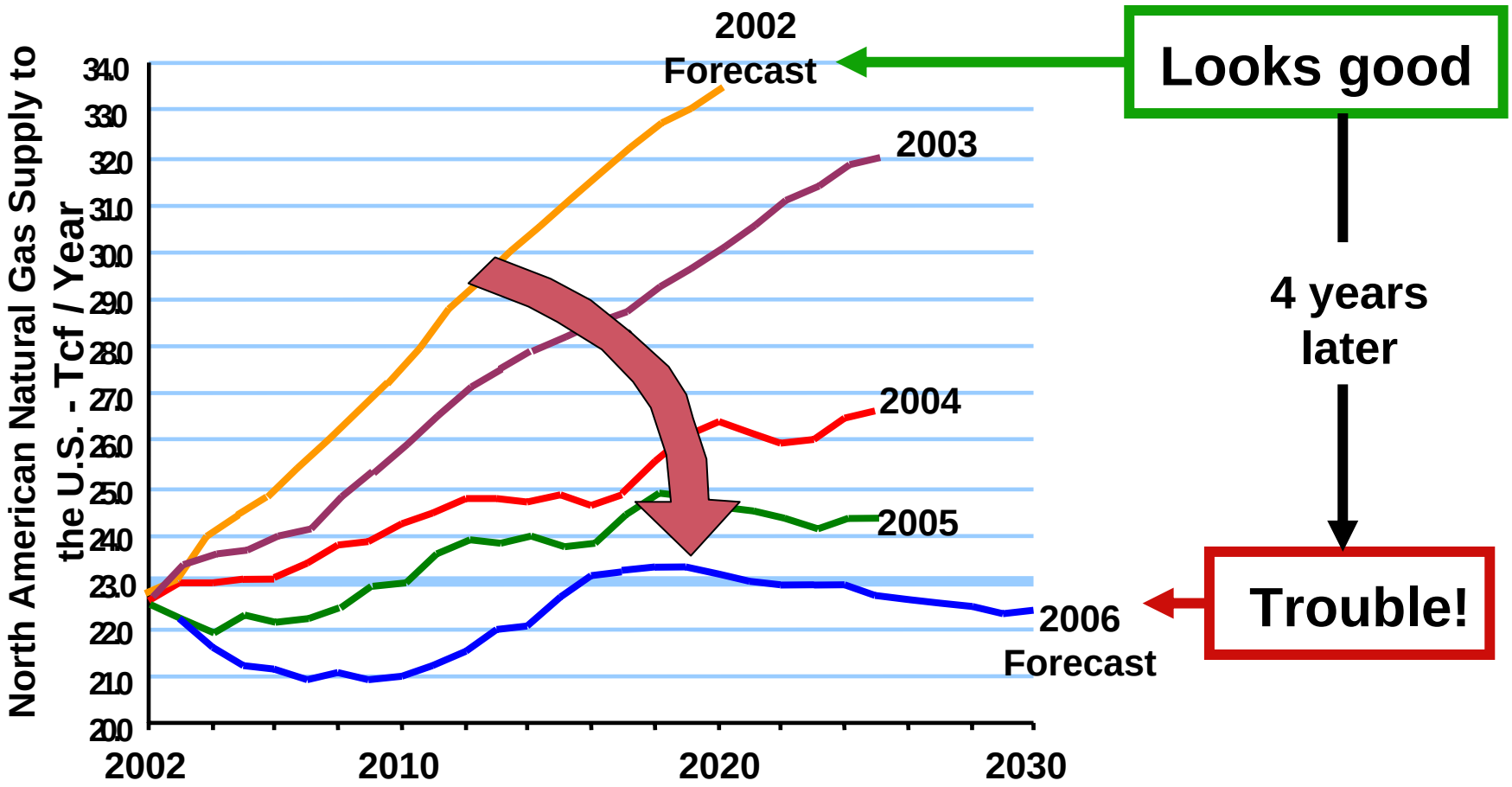






Forecasting Oil & Gas Supply Is Difficult.

DOE EIA Record on Natural Gas



What's the RISK with world oil?

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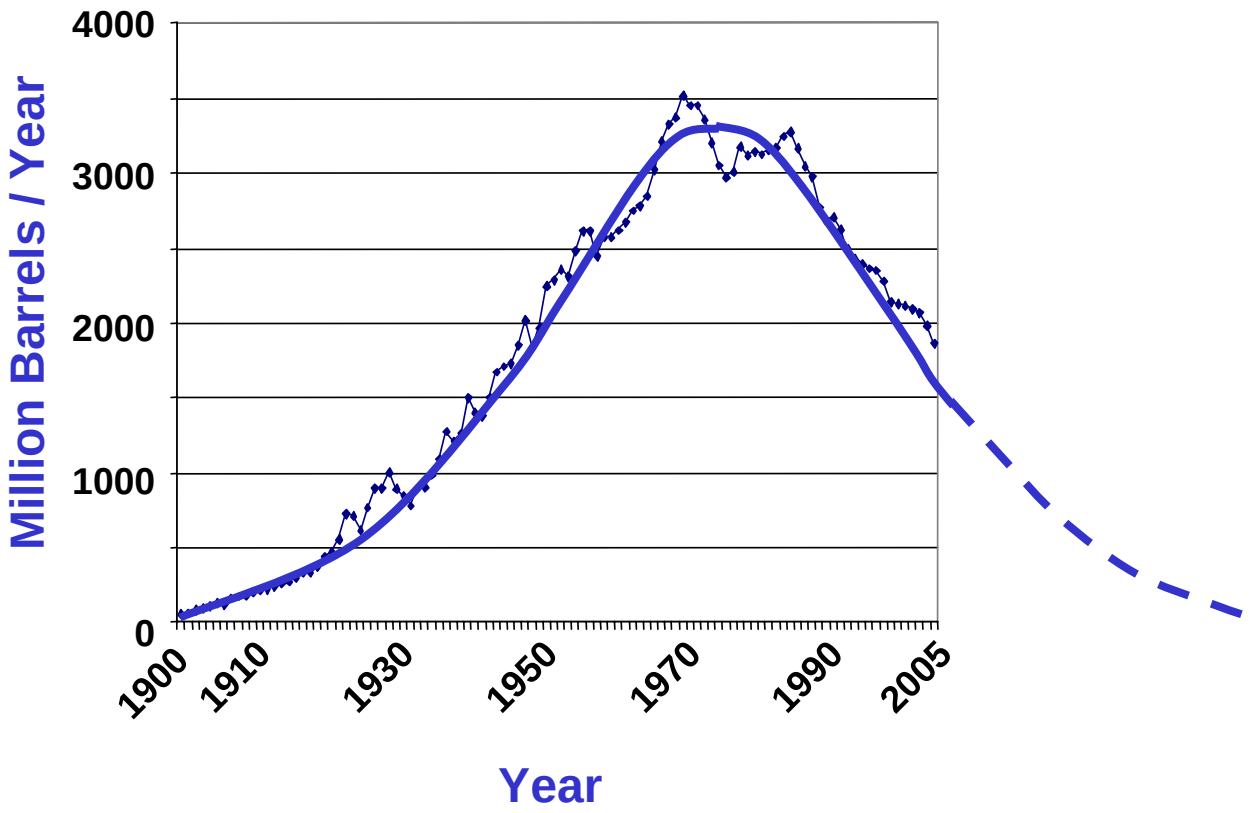
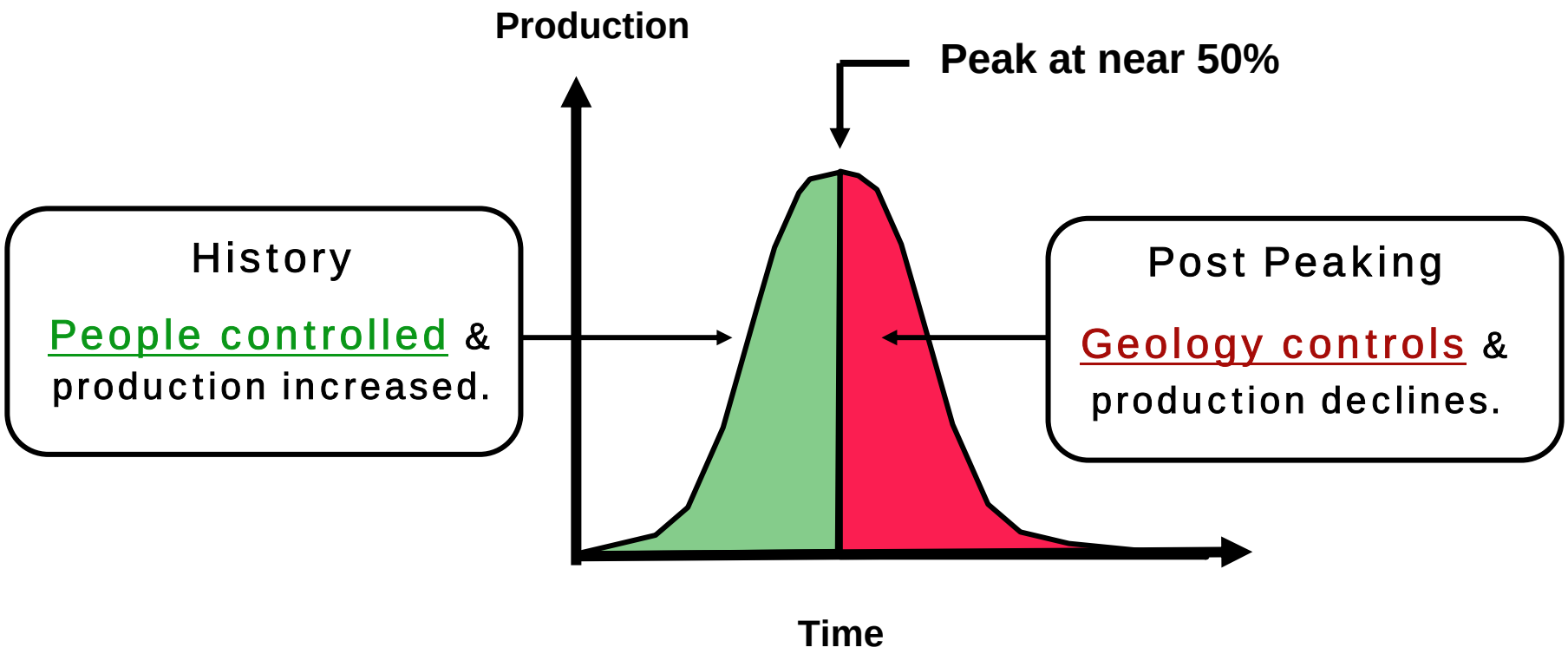
The U.S. Oil Production History Fits the Logistic (Bell Curve) Distribution Well Thus Far



Peaking of World Conventional Oil Production
Will Likely Occur Near 50%
of Ultimately Recoverable World Reserves

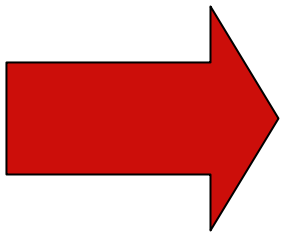


[The curve is smoothed]

Some Numbers

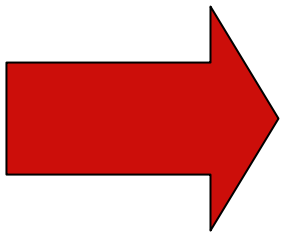
Already consumed worldwide: ~ One Trillion Barrels

Some estimates of remaining world reserves = One Trillion Barrels



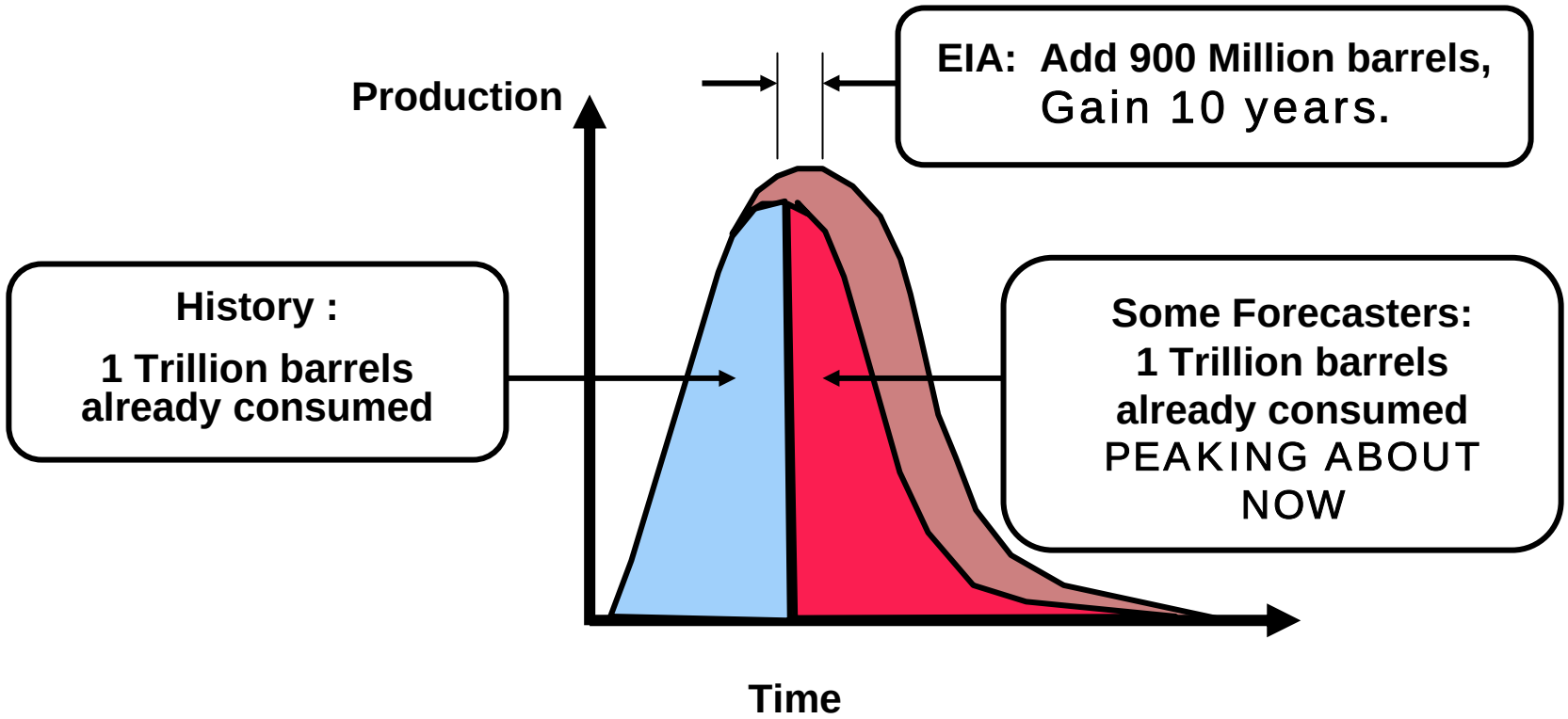
If so, world oil peaking is about now. **[50% of total]**

Others estimate remaining world reserves = Two Trillion Barrels



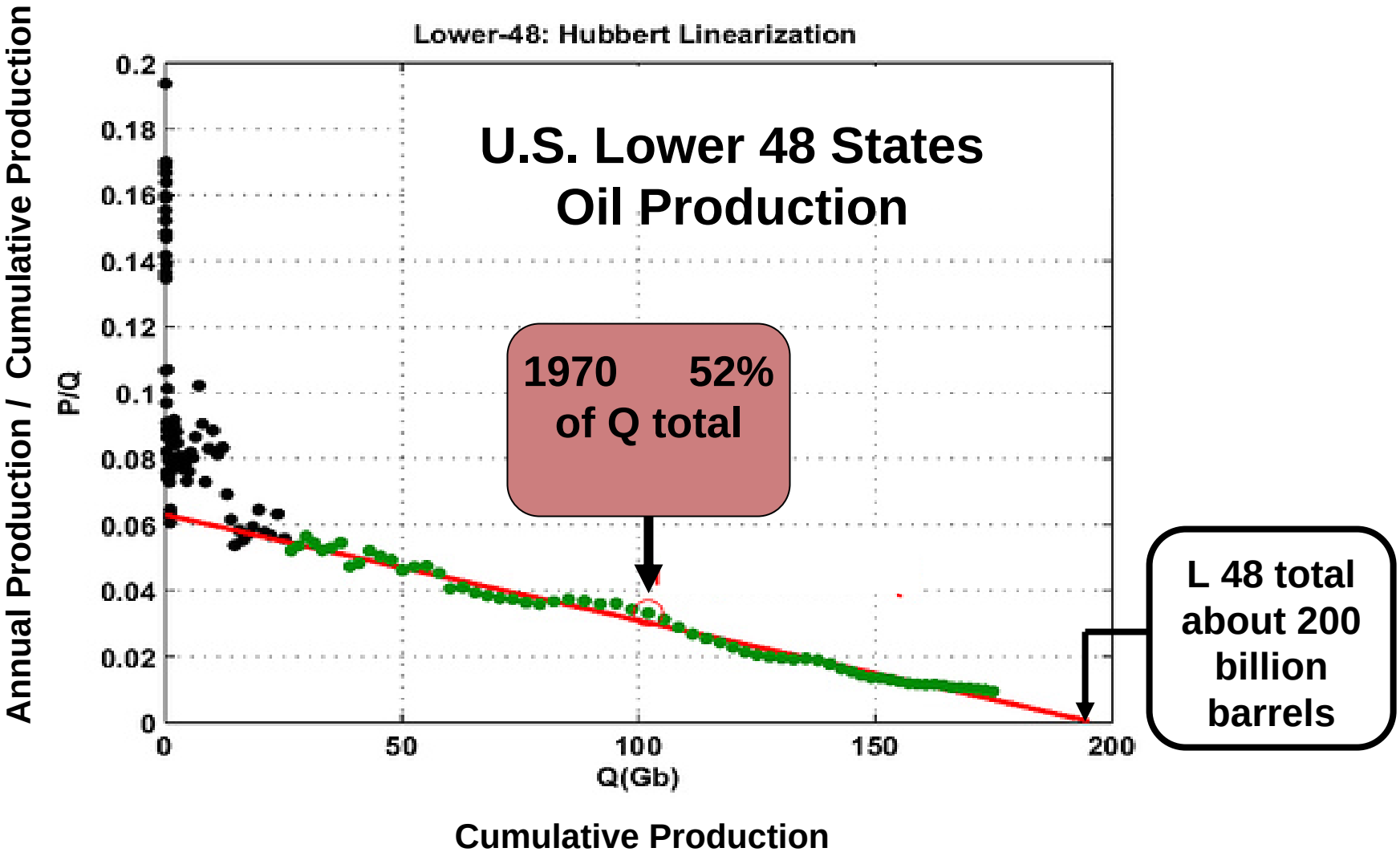
EIA: "(Our) results are remarkably insensitive to … alternative resource base estimates… adding 900 Bbbl more oil …**only delays the estimated production peak by** 10 years."

Peaking of World Conventional Oil Production Will Occur Near 50% of Ultimately Recoverable World Reserves



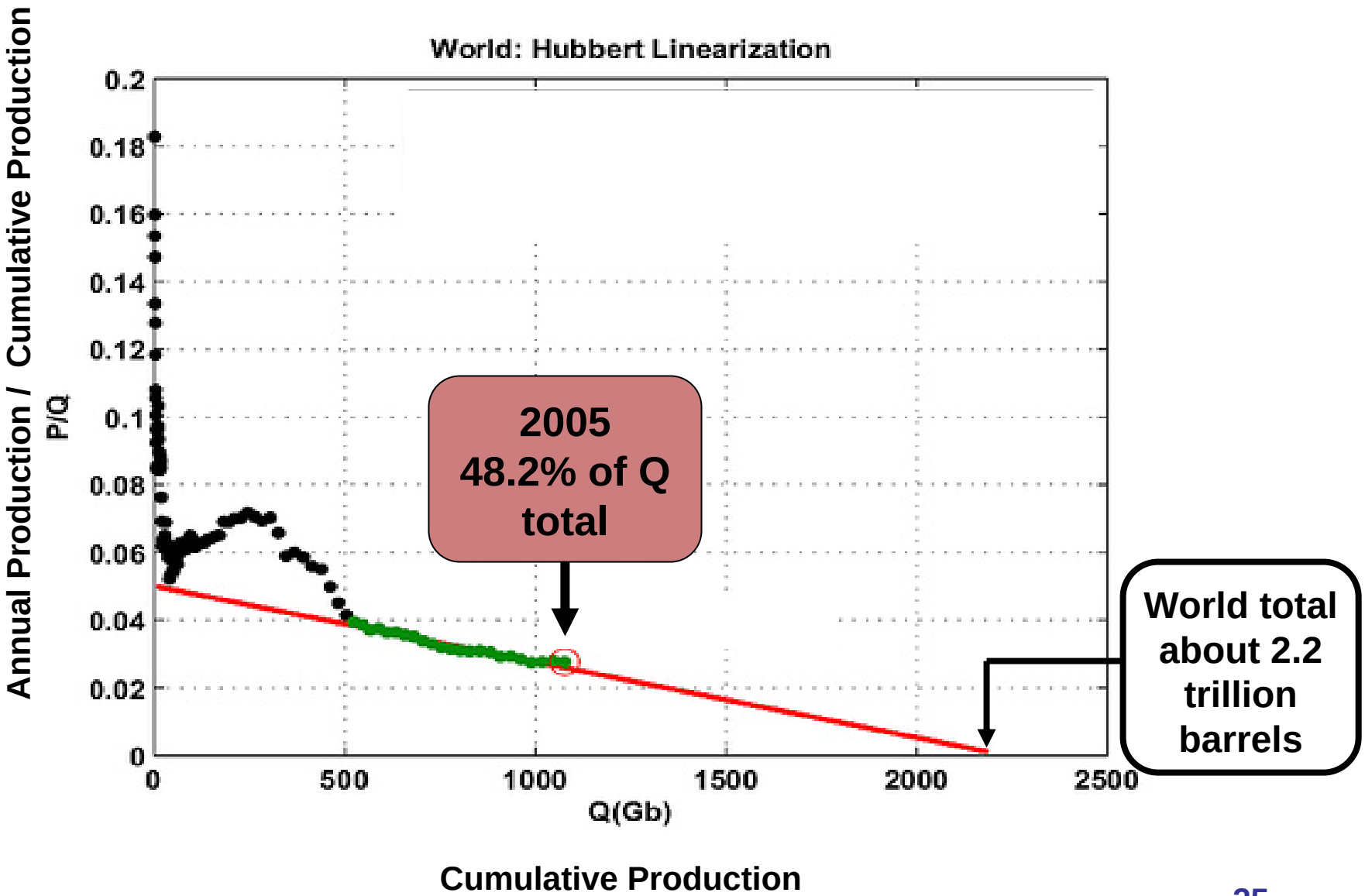
[The curve is smoothed]

One Model Has Shown That a Very Complex Situation Maps Into a Straight Line.



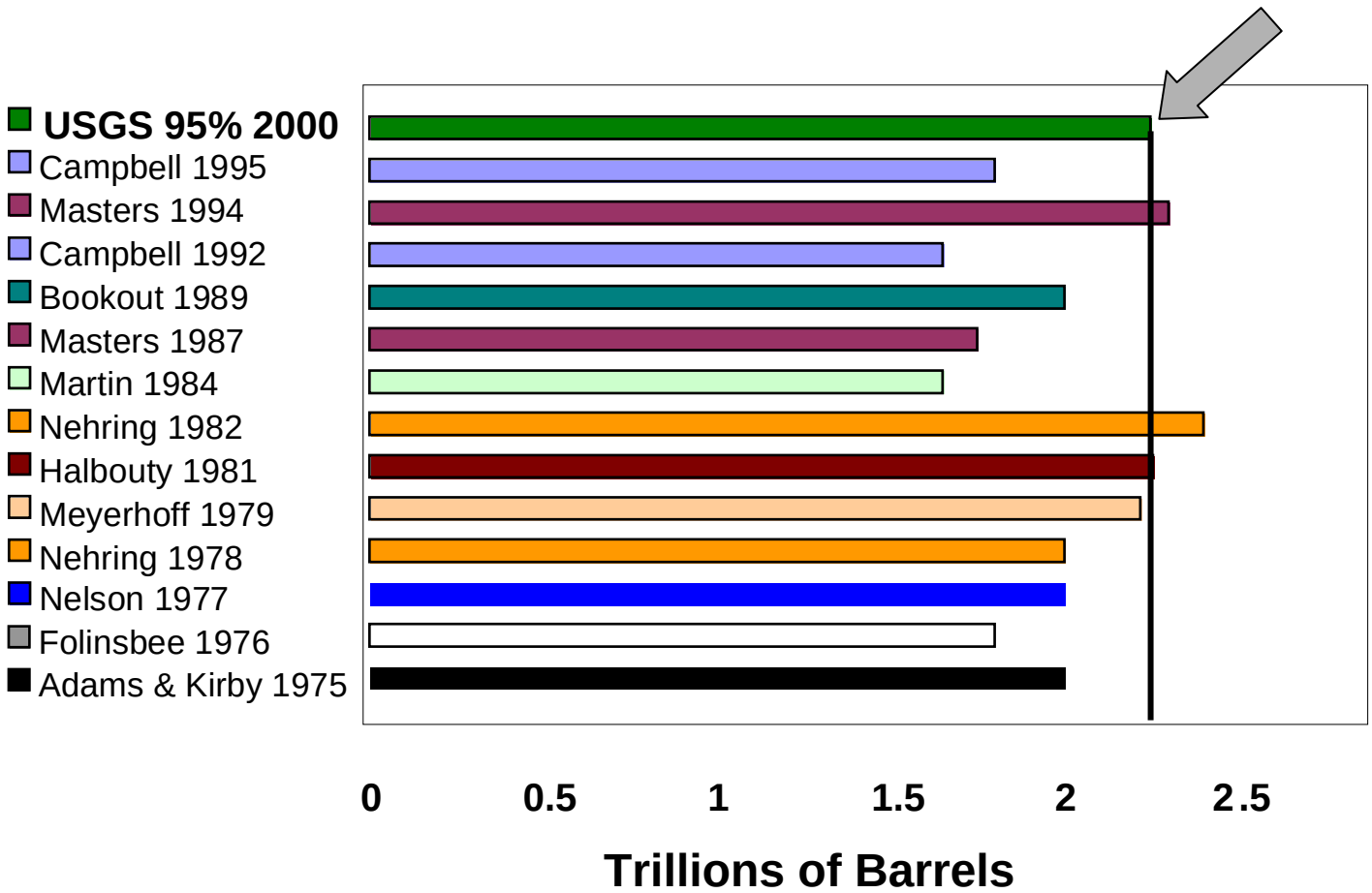
Ref: Deffeyes, others

The Model Indicates Early World Peaking

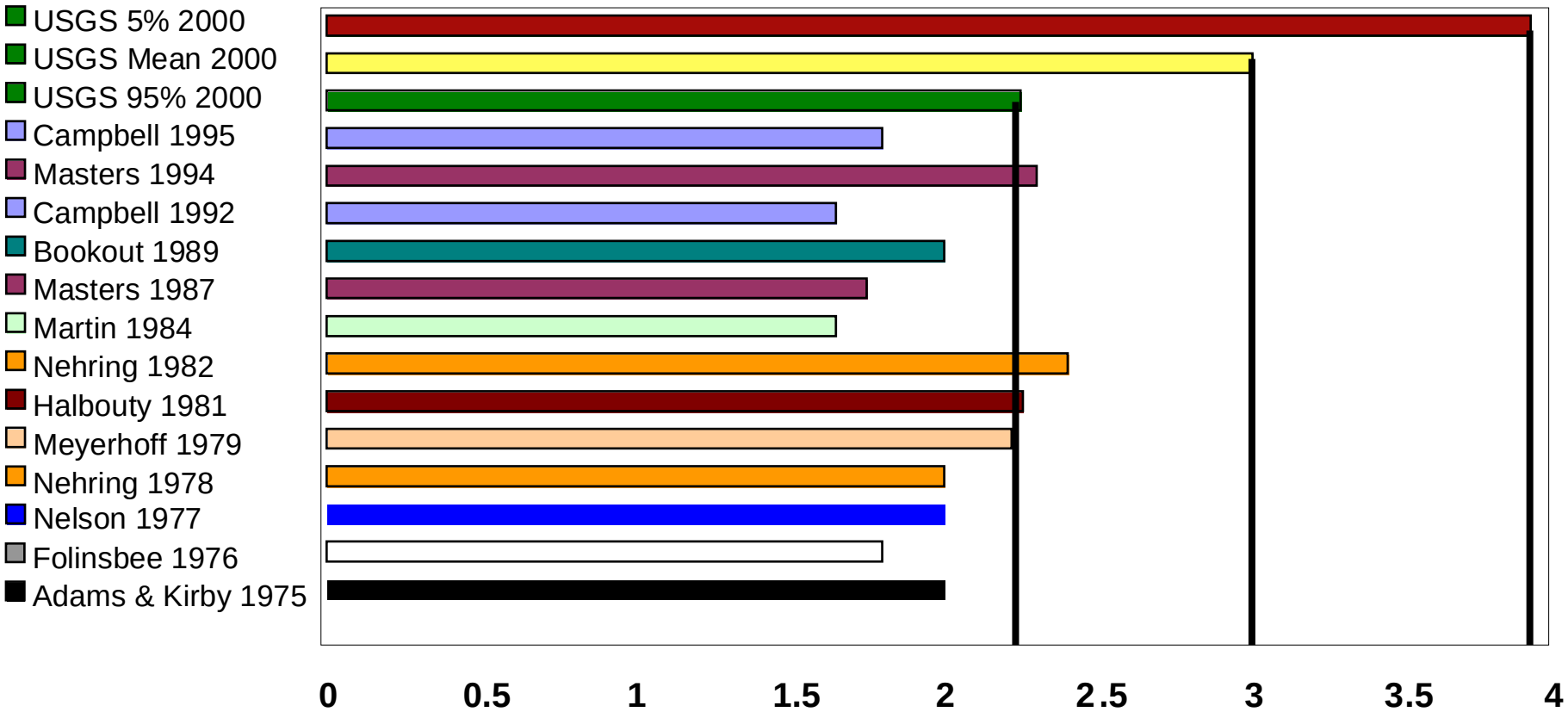


Ref: Deffeyes, others

PAST WORLD CONVENTIONAL OIL RESERVES ESTIMATES FIT ROUGHLY WITH THE HUBBERT EXTRAPOLATION & THE USGS 95% ESTIMATE.



But
Many Are Basing Their Forecasts on the USGS Mean Estimate



USGS Mean Case = Later Peak

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Mitigation Is a Bridge to Sustainability

- **We must mitigate because it will require <u>many, many decades</u> to massively modify or replace the world's end-use equipment.**
  - **Light, medium & heavy duty vehicles**
  - **Airplanes**
  - **Ships, Trains, Etc.**
- **<u>Sustainability requires choices</u>, which are still not made e.g., conservation, renewables, nuclear, ???**
- **Mitigation & moving to a sustainable future must <u>smoothly phase over time.</u>**

Mitigation Study

A 2005 analysis for the U.S. DOE

ASSUMED CRASH PROGRAM IMPLEMENTATION:
THE MOST OPTIMISTIC CASE

Scenario I - No action until peaking occurs

Scenario II - Mitigation starts 10 years before peaking

Scenario III - Mitigation starts 20 years before peaking

Transparent approximations provided robust insights.

Mitigation Options Considered

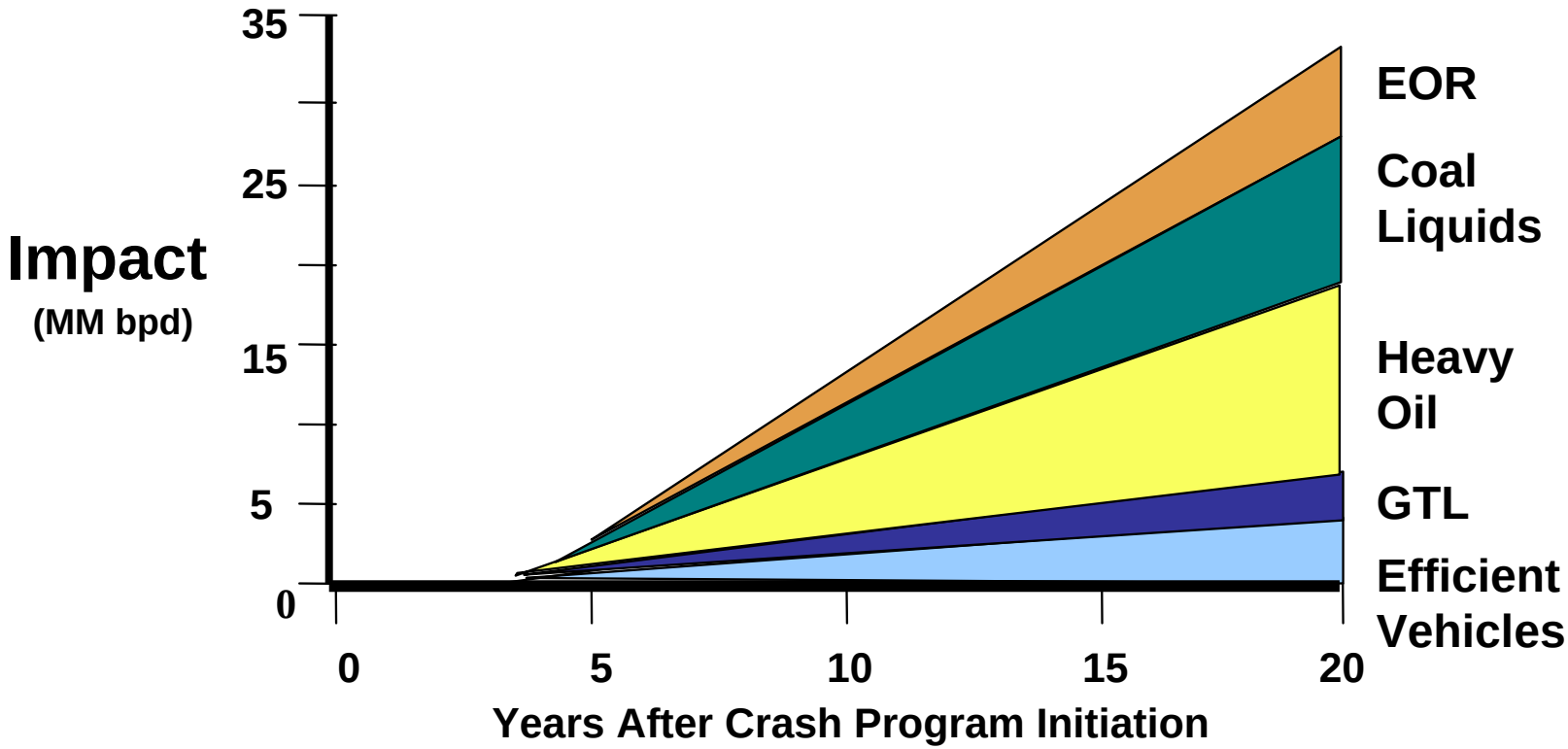
- **Vehicle Fuel Efficiency**
- **Heavy oil / oil sands**
- **Coal Liquefaction**
- **Gas-To-Liquids (GTL)**
- **Enhanced Oil Recovery (EOR)**

Why these? There're liquid fuels & ready for

Implementation

Electric power of little help in the short term

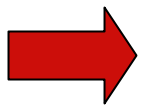
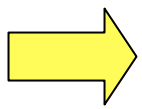
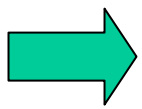
Worldwide Crash Program Mitigation of Conventional Oil Production Peaking



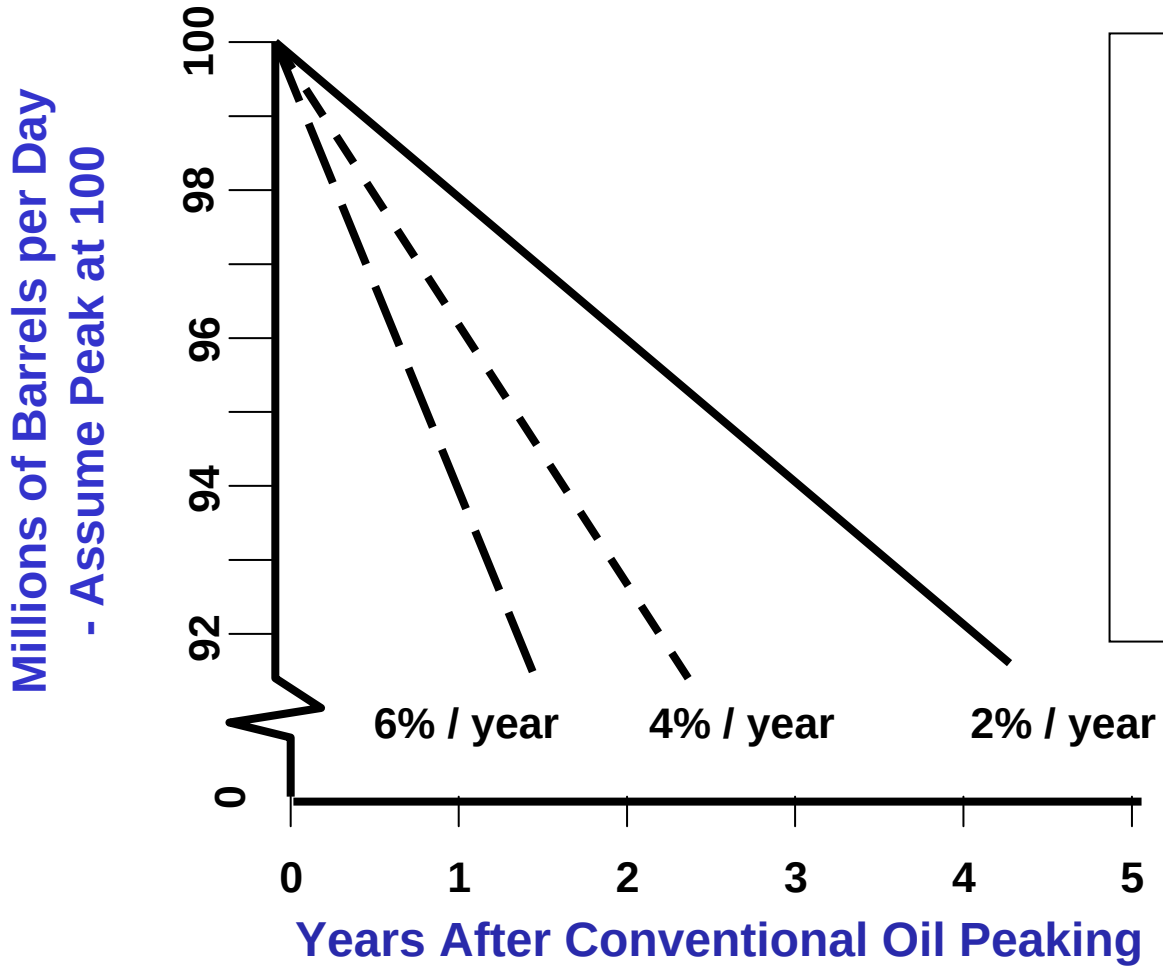
- Delay is followed by rapid growth.
- Can mitigation overtake oil decline?

Scenario Results For A Worldwide Mitigation Crash Program

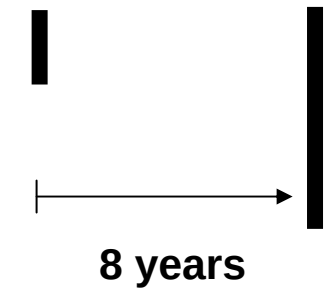
The Most Optimistic Case

I. Wait for peaking		Extremely Bad
II. Start <u>10 years</u> early		**SERIOUS TROUBLE**
III. Start <u>20 years</u> early		**NO PROBLEM?**

It's a Matter of Rate of Change - Will Decline Outrun Our Ability to Respond?



Question: How much can Canadian Oil Sands help?



RISK

What Impact Might World Oil Peaking Have on World GDP?

Over the last 30 years

World GDP grew @ 3% / Year

Oil demand grew @ 1.5% / Year

After peaking, oil production will decline, dragging world GDP with it.

At what rate?

RISK

How Will Post-Peak Oil Shortages Impact?

- **The 1973 & 1979 BRIEF oil interruptions caused….**

+ Inflation	+ Recession
+ Unemployment	+ High interest rates

- **World oil peaking impacts could last for DECADES.**
- **Without more than a decade of vigorous worldwide mitigation…**

The year of world conventional oil peaking will likely mark the start of world recession.

Problem

People are strongly influenced by current oil prices & fluctuations, which are short term.

Peaking is unlikely to influence the short term market until after there are obvious, continuing shortages.

RISK

We are now faced with -

1. **<u>Serious concerns</u> from many competent, unbiased professionals**
2. **<u>Optimism</u> from many of high repute**
3. **The option of trusting the <u>marketplace</u>**

THE RISKS ARE ASYMMETRIC:

- Premature mitigation **might misuse some resources.**
- Delayed mitigation **almost certainly means huge worldwide suffering for a long time.**

In Conclusion

- **Oil production is very complex / intuition fails.**
- **Oil peaking will happen; the timing is uncertain.**
- **It's liquid fuels, not energy.**
- **"Simple" theory fits the data; Implications are unpleasant.**
- **The risks are very large.**
- **Mitigation technologies are available:**

Implementation & timing are critical.