

Elements of the World's Energy Future

**2050 should be good but getting there
will be a challenge.**

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Clean Technology 2008 Conference

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Outline

- **An Energy Vision for 2050**
- **Oil Fundamentals**
- **World Oil Decline Timing**
- **Mitigation of Oil Shortages**
- **Impact of Oil Shortages**
- **Conclusions**

World Energy in 2050

Vision

- **Major changes, higher prices, & more sustainability**
- **Most vehicles: Plug-in hybrids, electric, & hydrogen**
- **Liquid fuel consumption declining**
- **Electric power largely from nuclear & renewables**
- **Energy efficiency in all sectors**

Resource Situation

- **Conventional oil production will be roughly 50% of 2008 level.**
- **Natural gas production will be roughly 50% of 2030 level.**

The 2008 - 2050 Transition

Extremely Challenging

World Liquid Fuels in 2050

<ul style="list-style-type: none">• Structural energy efficiency	Save
---------------------------------------------------------------------------------------	-------------

- **Remaining oil production**

- **Coal-to-Liquids**

- **Enhanced Oil Recovery**

- **Oil Sands / Heavy oil**

- **Shale oil**

- **Gas-to-Liquids**

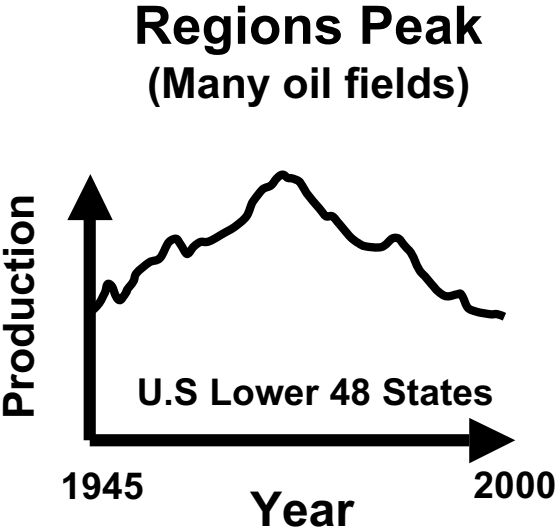
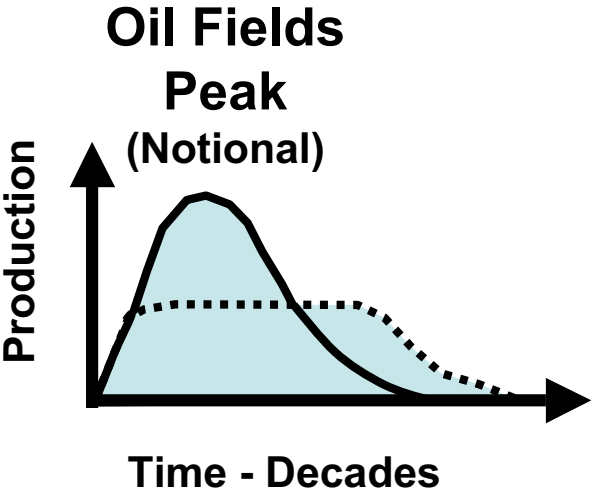
- **Cellulose**

**Sources of
liquid fuels**

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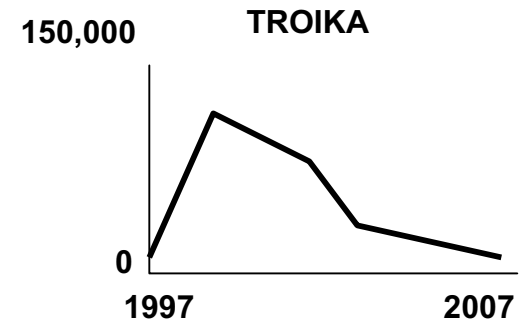
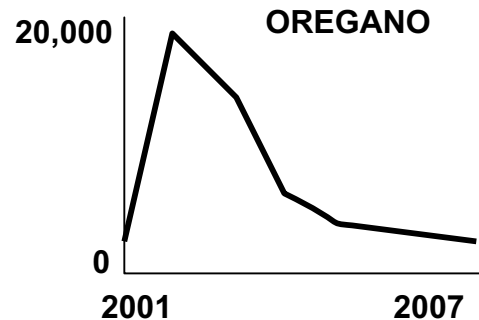
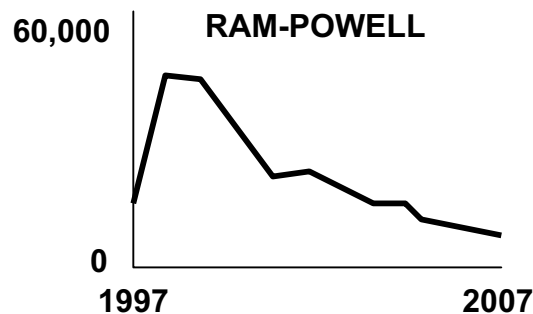
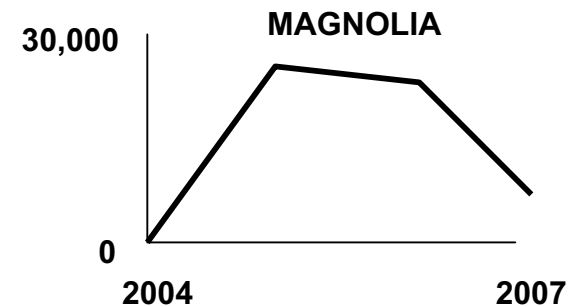
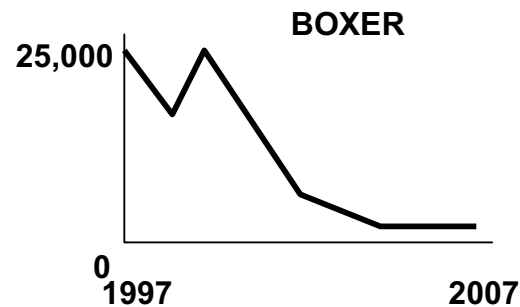
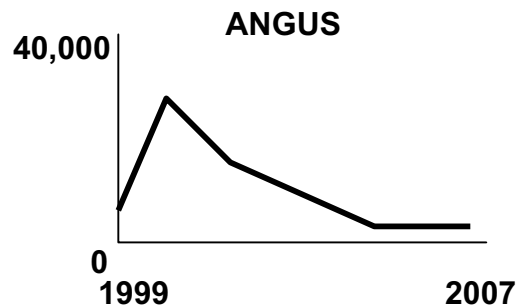
Oil peaking is unavoidable.



The world peaks
(All regions)

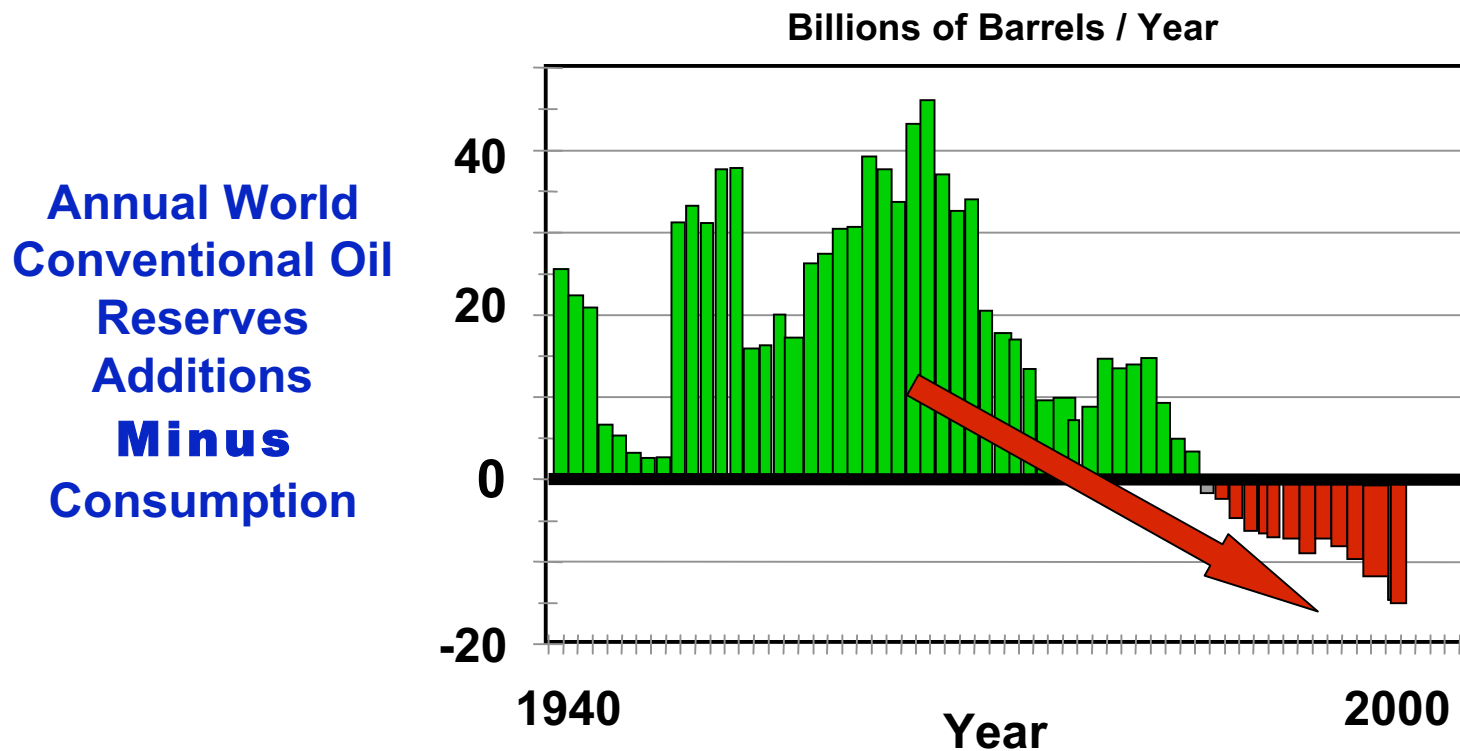
Some Oil Field Production Profiles

(GOM Deepwater Fields)



**All peak one way or another, then go into long decline.
It's fundamental.**

The world is consuming more oil than it has been finding.

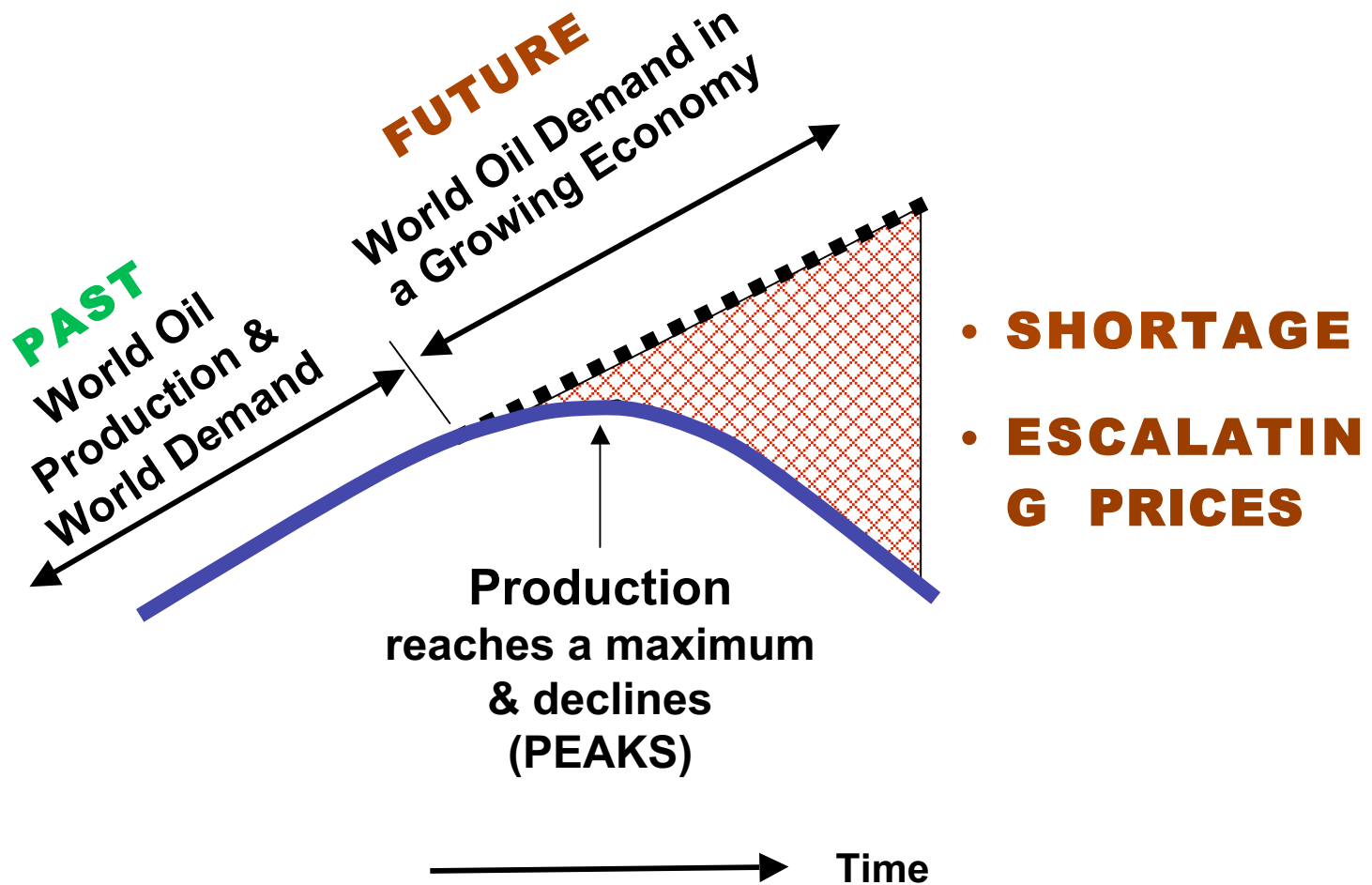


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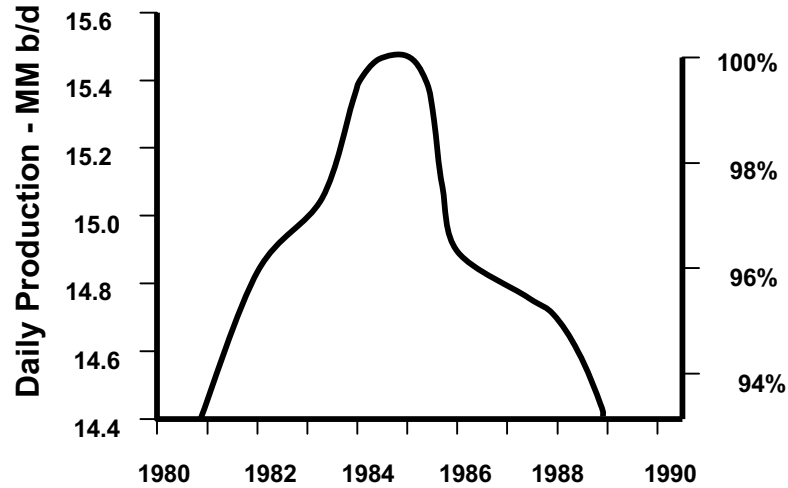
Sharp Peaking of World Oil

Production Notional

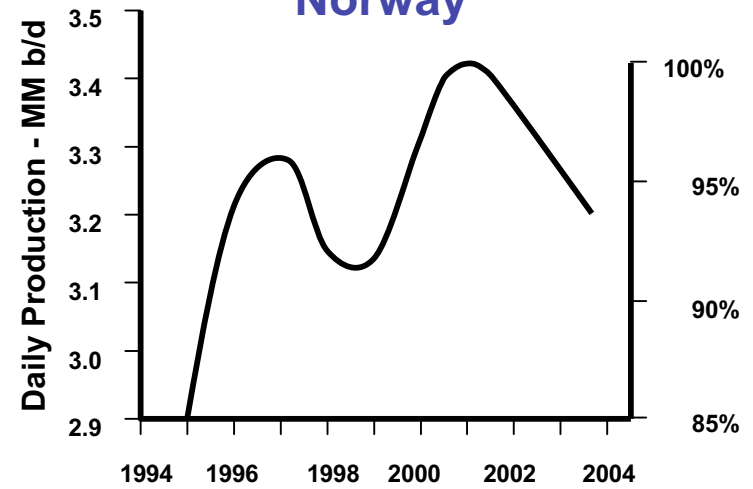


Examples of Sharp Oil Peaking

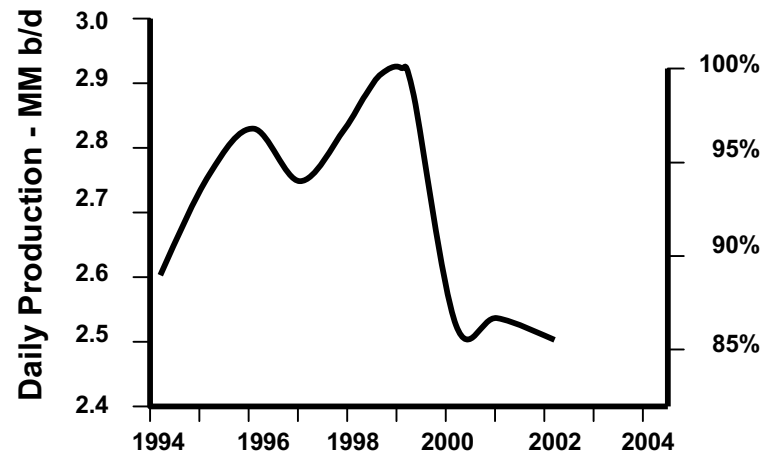
North America



Norway

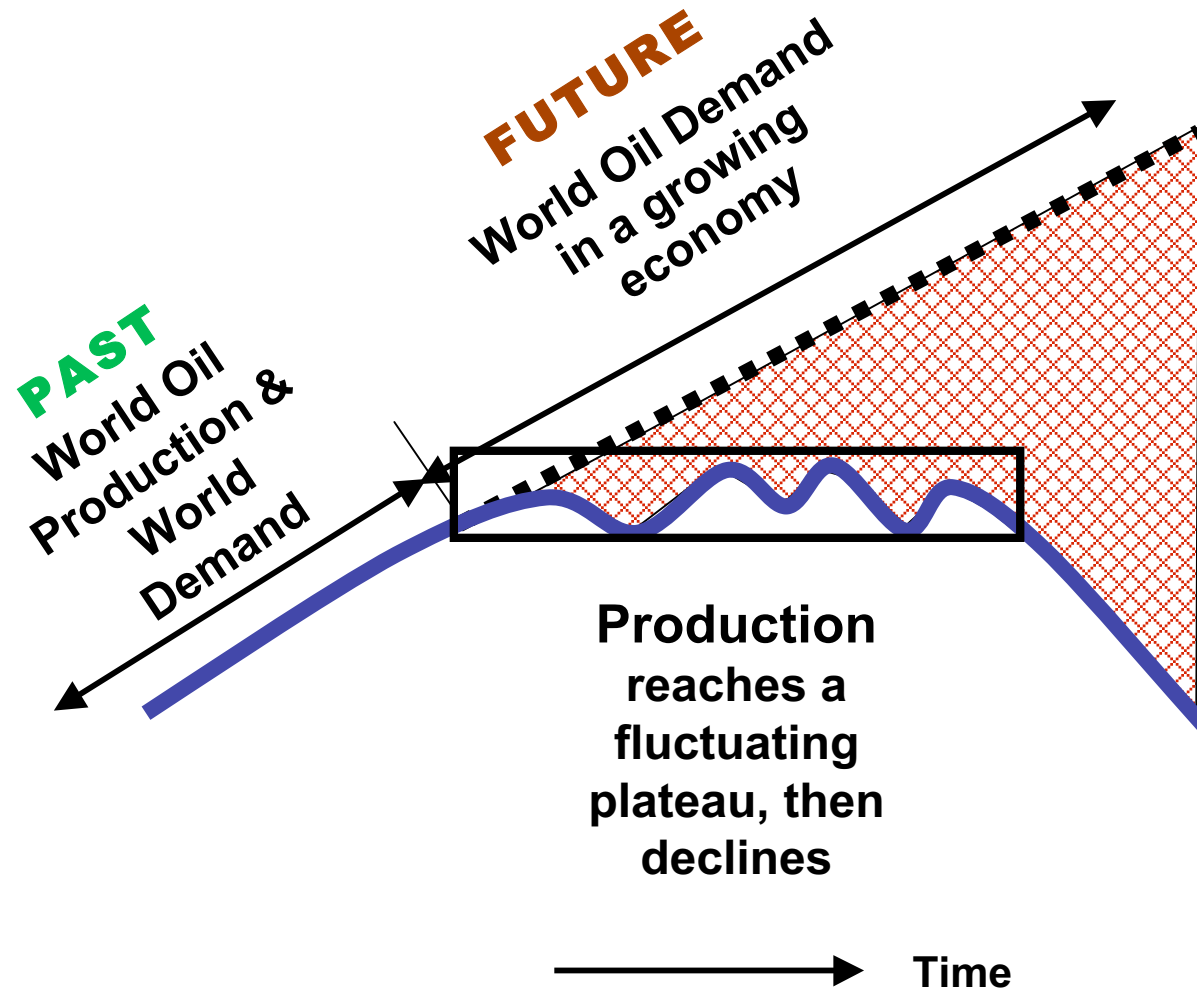


United Kingdom



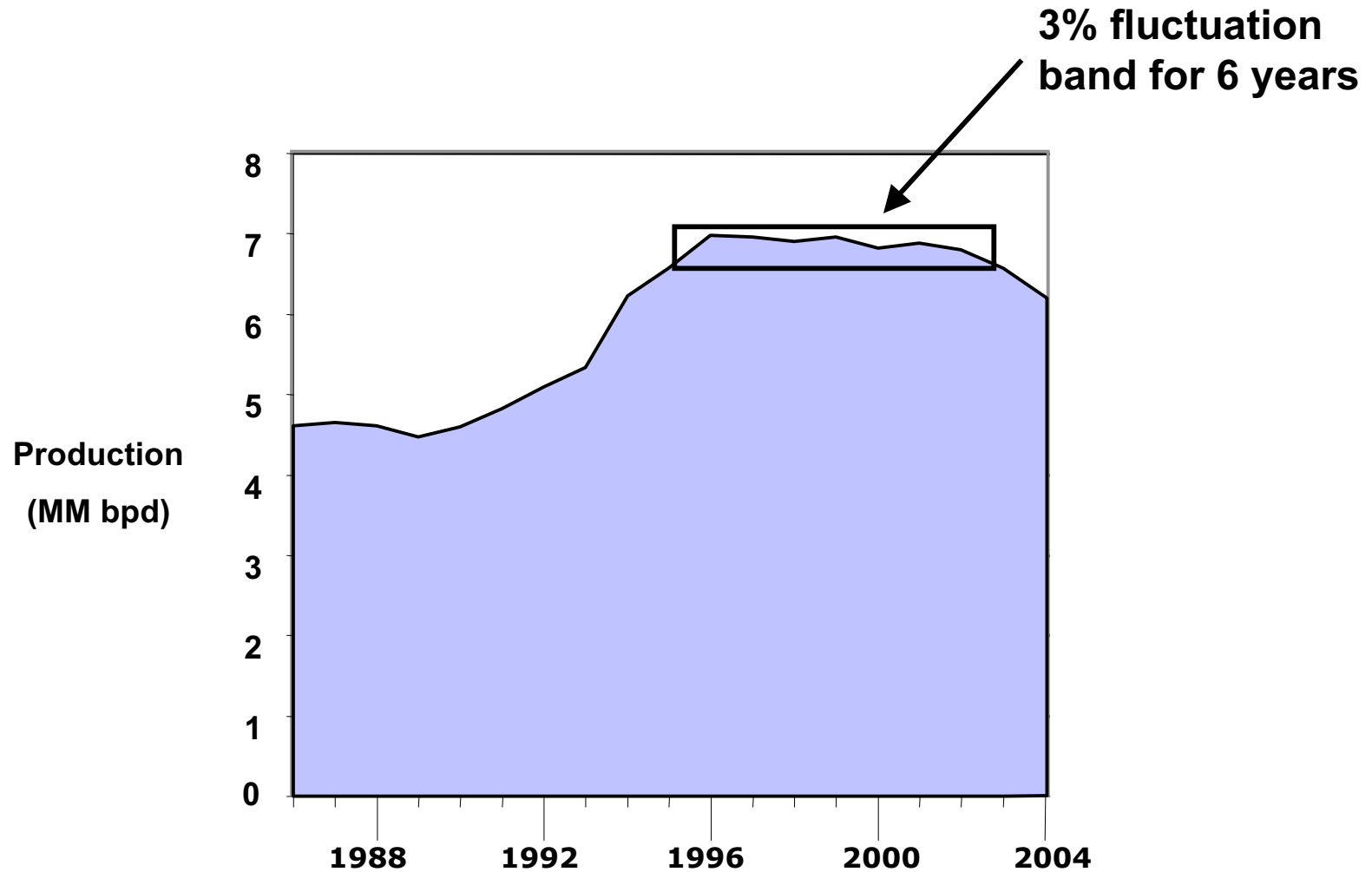
A production plateau is possible.

Notional

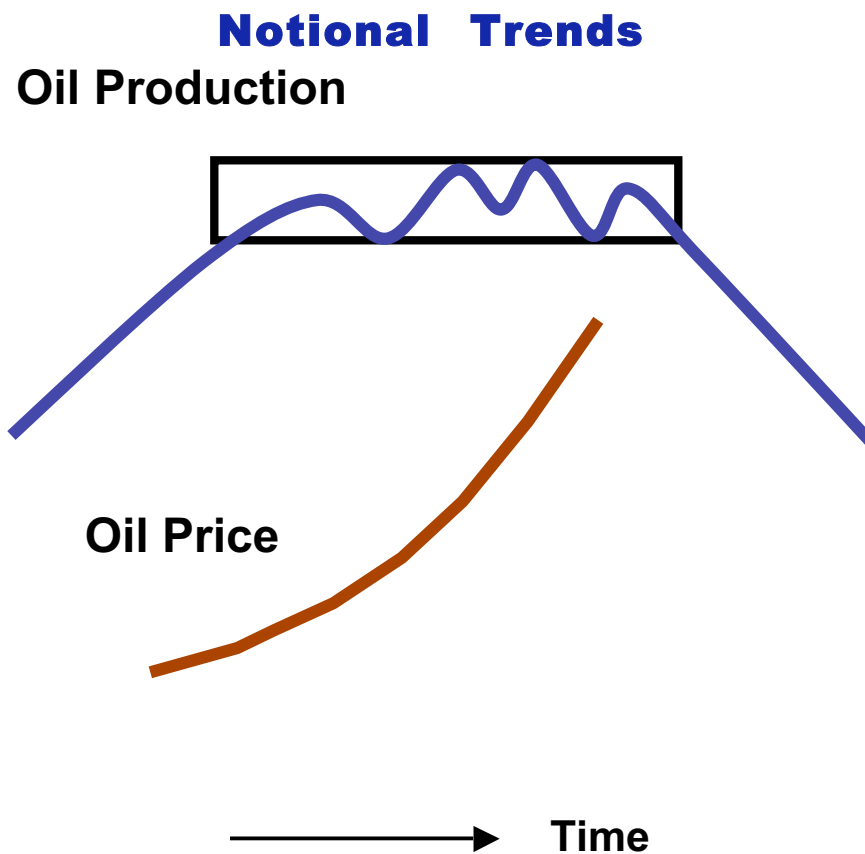


- **SHORTAGE**
- **ESCALATING PRICES**

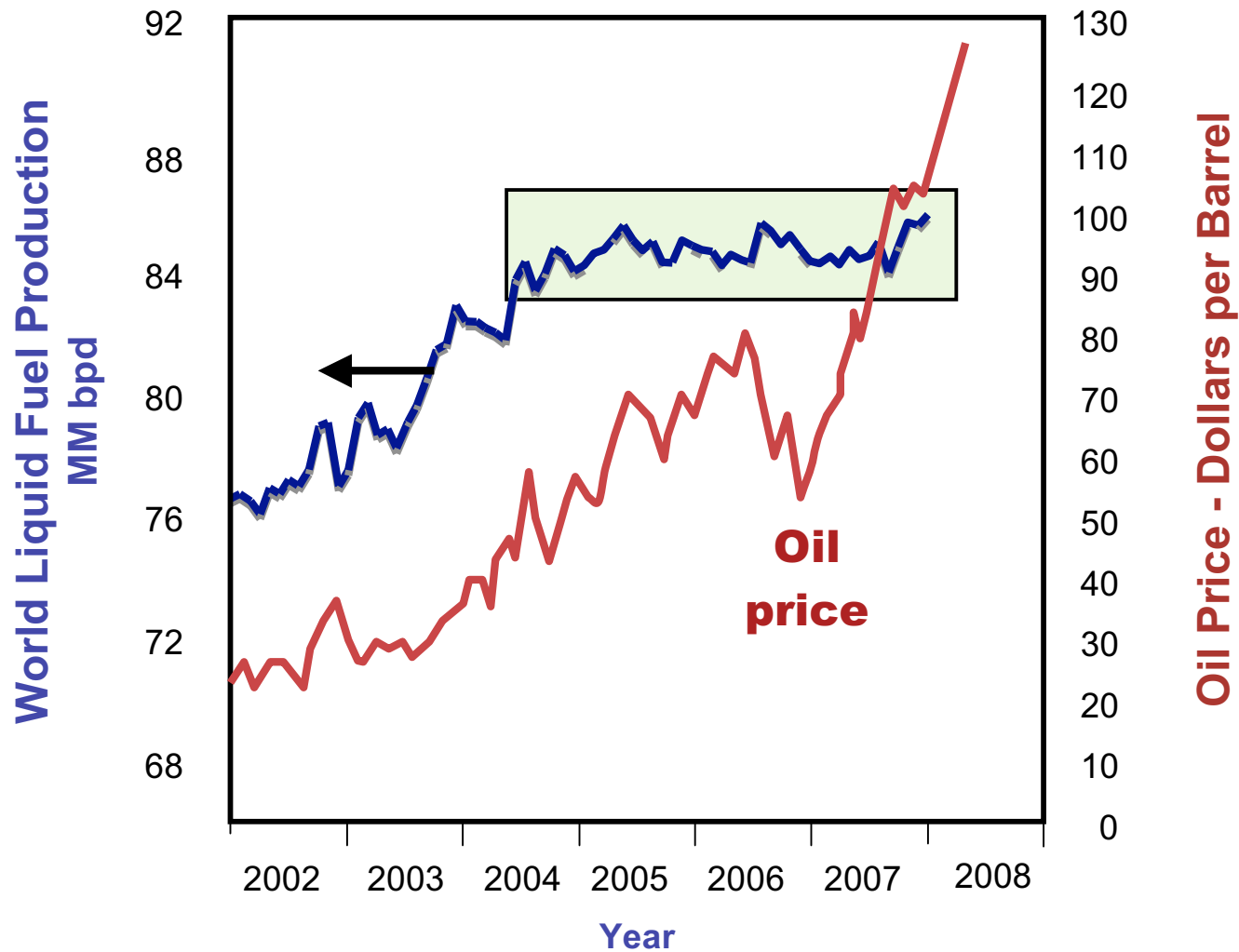
European oil production plateaued, then declined.



If world production were to plateau, oil prices would rapidly increase.



World oil production has been on a plateau since 2004, & prices have escalated.



The Royal Swedish Academy of Sciences

October 2005

54 of the 65

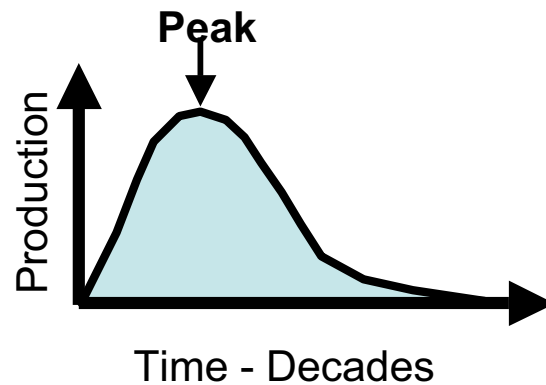
“... most important oil-producing countries have declining production (past peak)...”

“(The worldwide) rate of discoveries of new reserves is less than a third of the present rate of consumption.”

Critically Important

Oil shortages are a **Liquids Supply problem**, not “energy.”

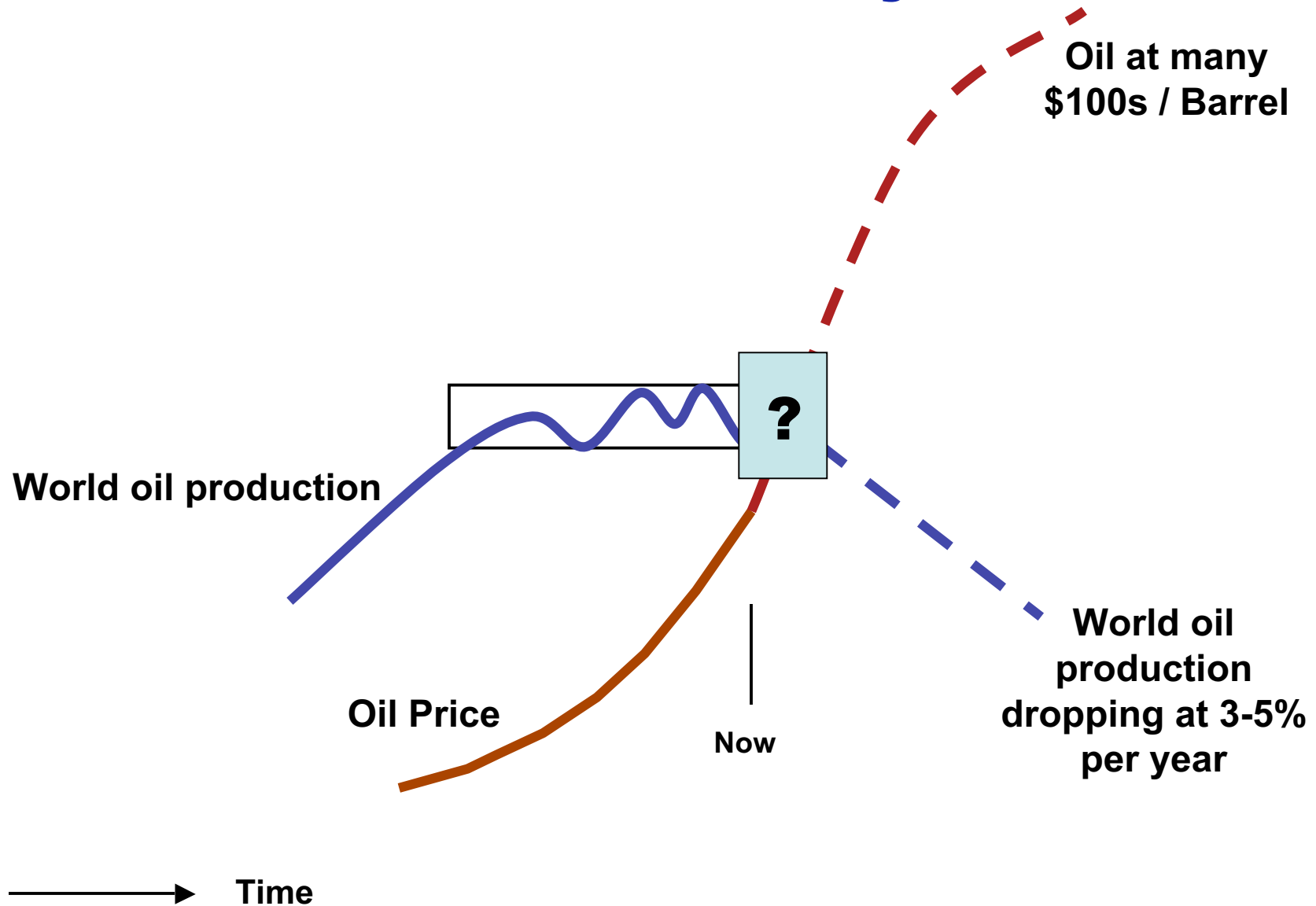
Peaking is **maximum production**.
It's not running out soon.



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Where We're Likely Headed



Peak Oil Forecasts

“SOON”

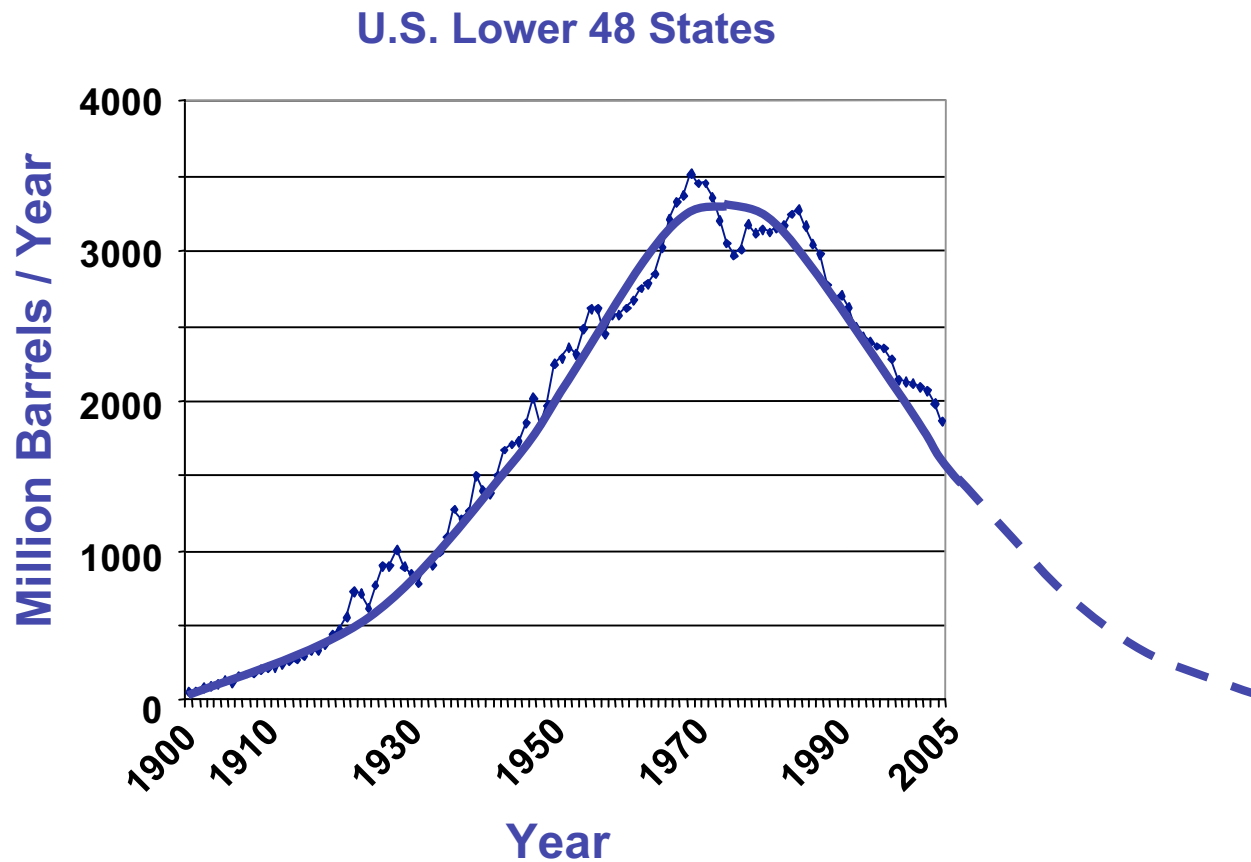
- IEA
- Chevron
- Shell
- Total Oil
- Chinese P.I.
- Statoil
- Hess Oil
- Volvo Trucks
- Jim Schlesinger
- Boone Pickens
- Matt Simmons
- Corps of Engineers
- CIBC (Canada)
- Retired oil geologists
- Many others

Not imminent problem:

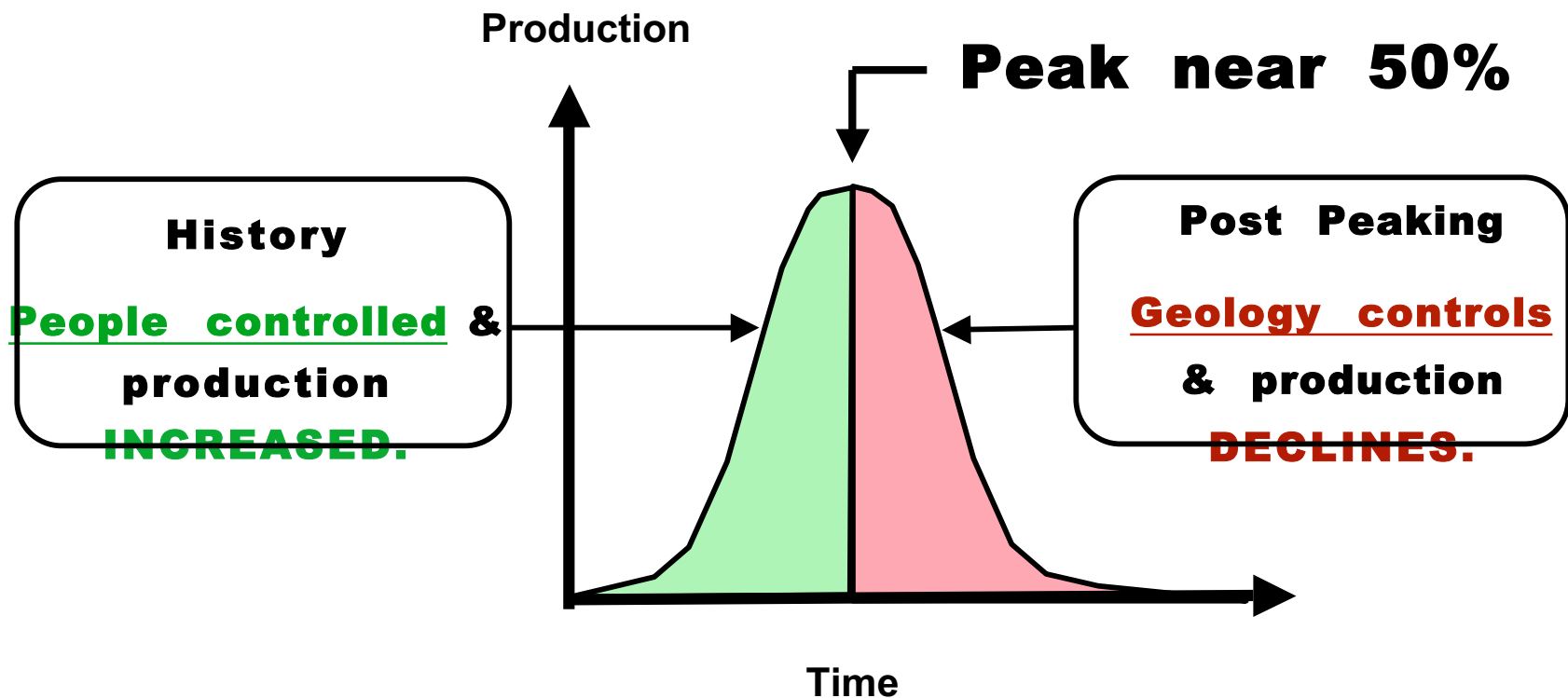
- OPEC
- EIA
- CERA
- ExxonMobil
- Fewer & fewer others

Logistic Modeling

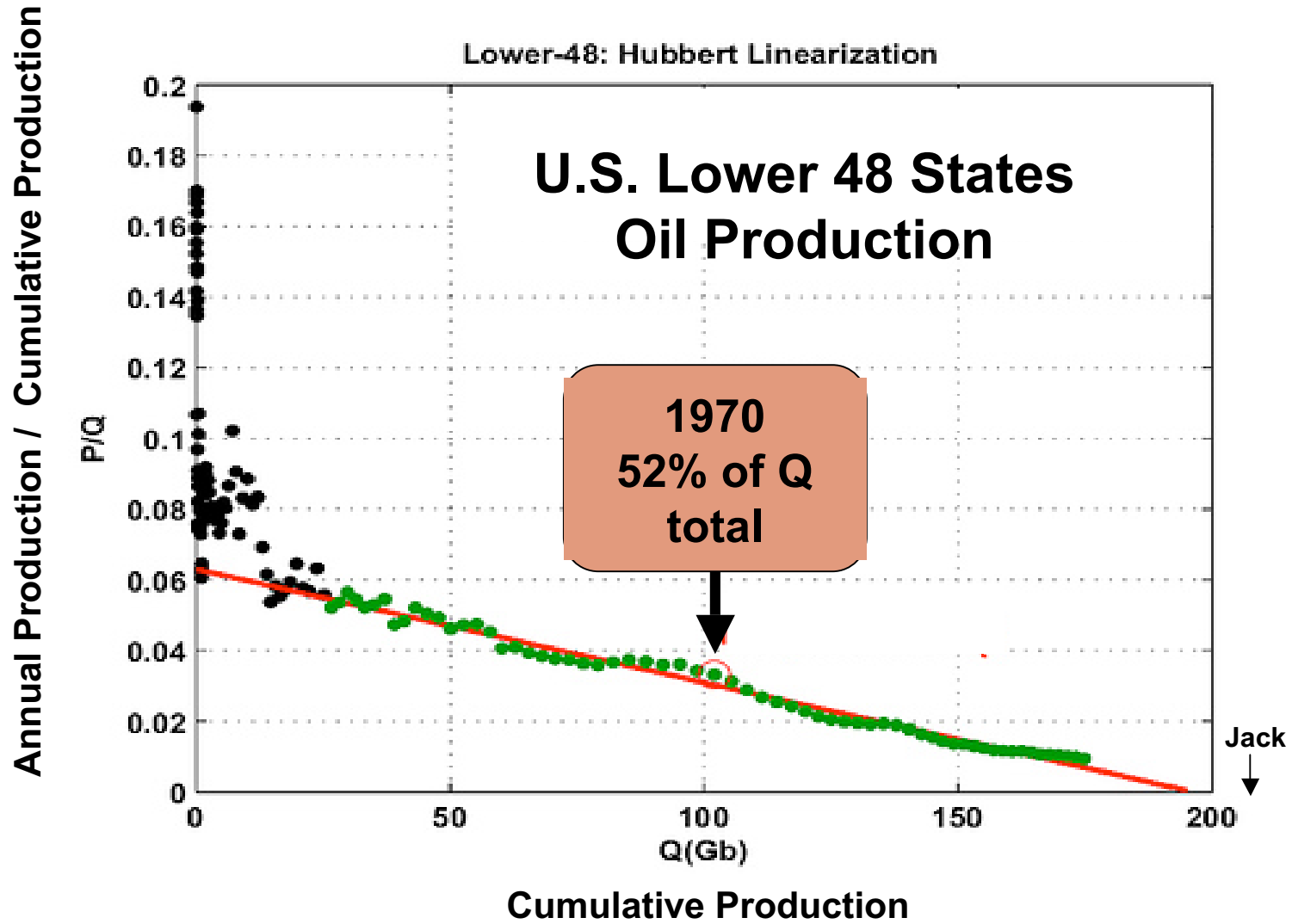
One of a number oil forecasting approaches



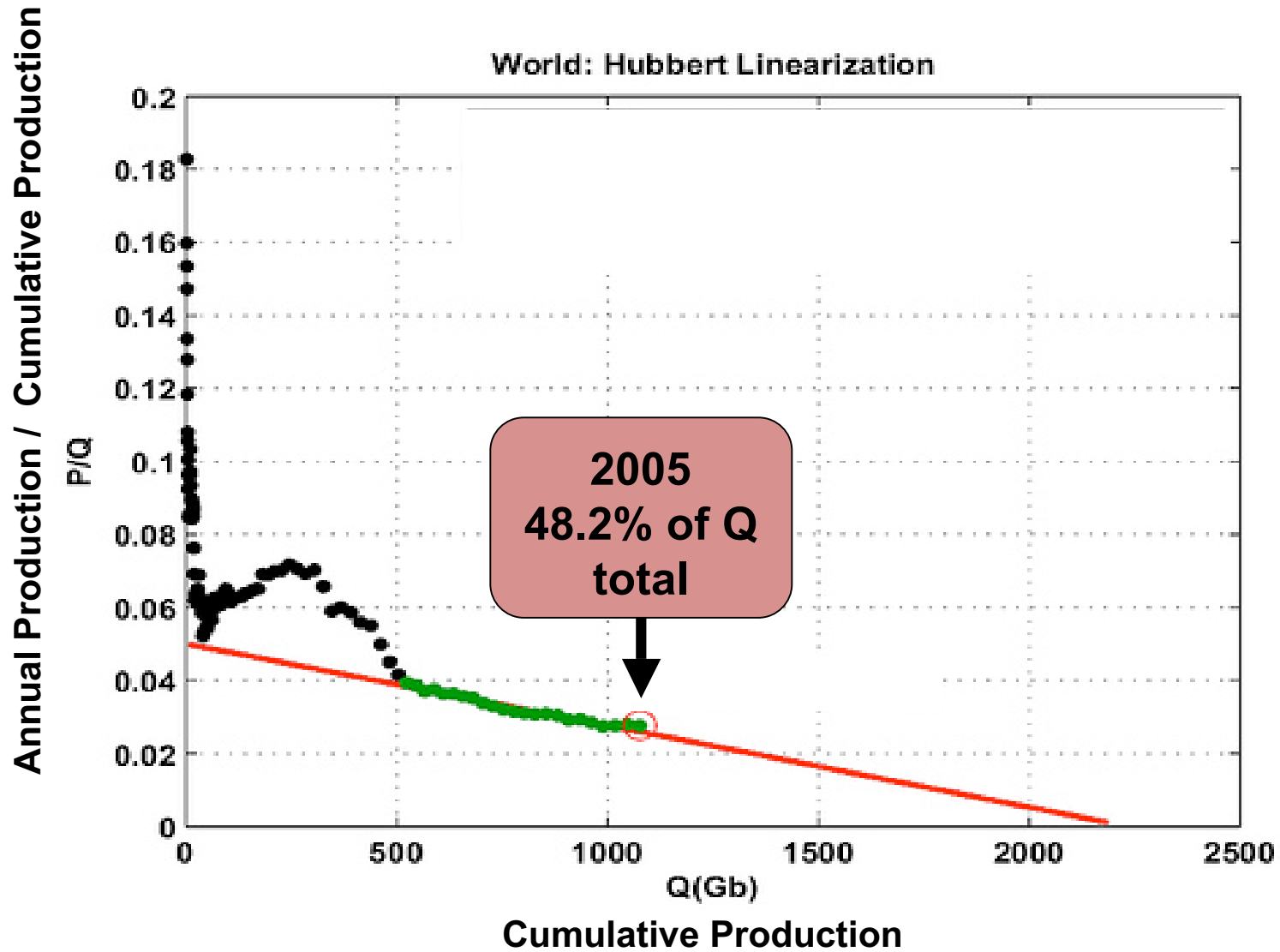
The Logistic Model For World Conventional Oil Production



The Logistic Model Maps Well for the U.S.



Logistic Model for the World

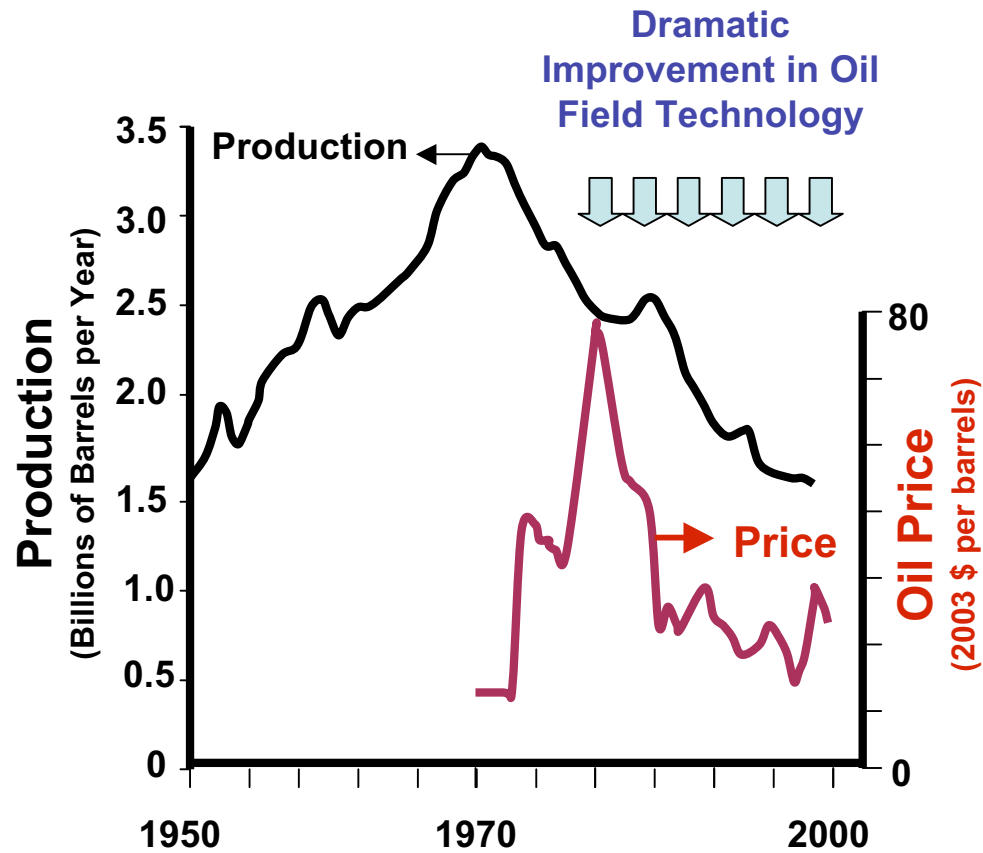


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Technology & price will not save us.

U. S. Lower 48 Oil Production

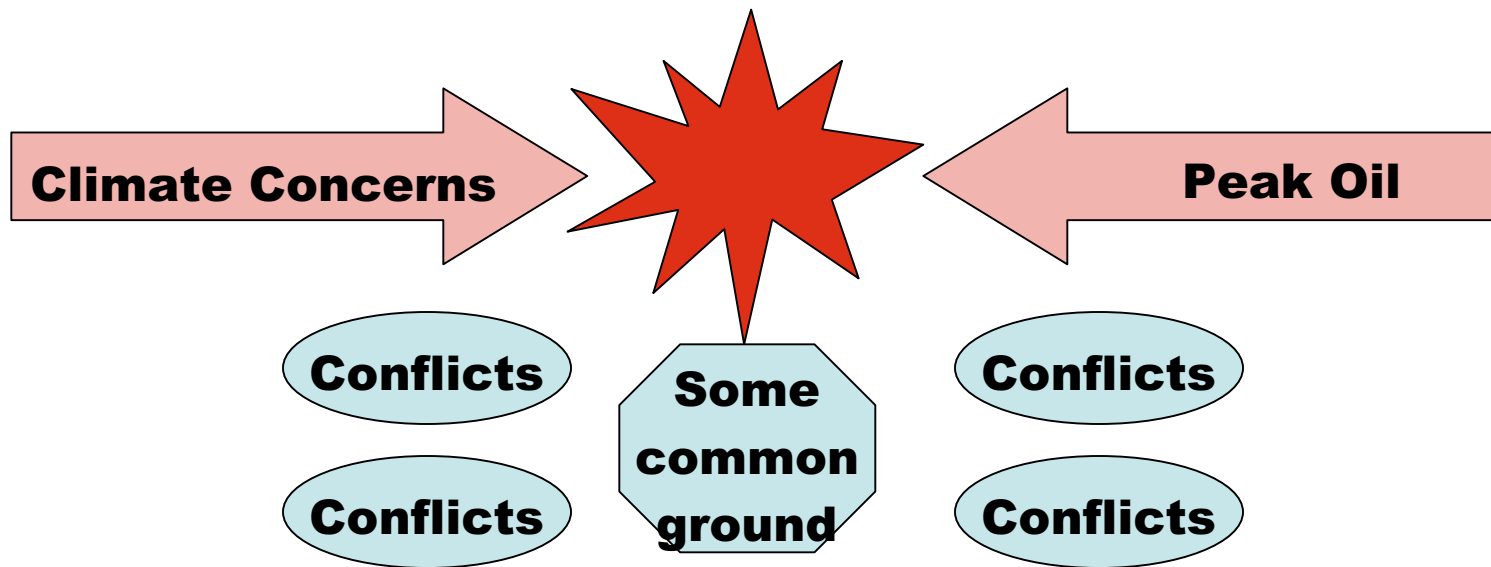


Decline not reversed.

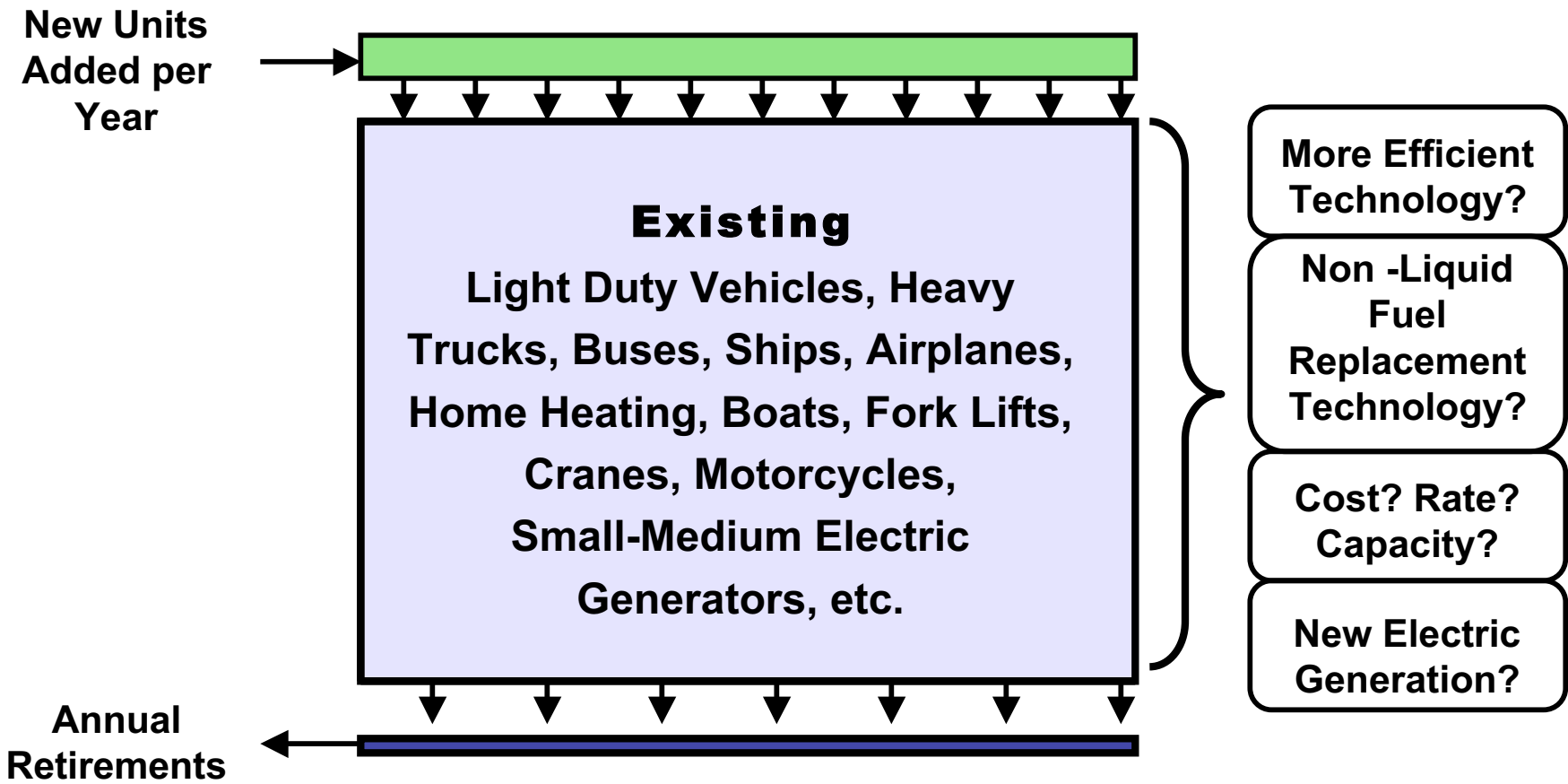
Mitigation is essential.

- It will require decades to massively modify or replace the world's end-use equipment. Otherwise economies will degrade dramatically.
- Mitigation & movement to a sustainable future must coexist for quite some time.

Will the coming clash be a train wreck?



It takes a long time & huge investment to replace massively deployed end-use equipment.



Administrative Mitigation Options

- **Lower highway speed limits**
- **Carpooling**
- **Four day workweek**
- **Telecommuting**
- **Rationing**
- **Open ANWR, other areas**
- **Etc.**

Physical Mitigation Options

- **Vehicle Fuel Efficiency**

- **Heavy oil / oil sands**

- **Coal Liquefaction (CTL)**

- **Gas-To-Liquids (GTL)**

~~- **Enhanced Oil Recovery (EOR)**~~

Why these? There're liquid fuels & ready for



Deployment

Options of Little Near Term Value

<u>Option</u>	<u>Reasoning</u>
– Nuclear Electric / Not Liquid
– Wind Fuels	
– Solar	
– Hydrogen.....	Neither ready nor economic yet
– Biomass.....	Not economic
– Shale Oil.....	Not commercial

Mitigation Study

A 2005 analysis for the U.S. DOE

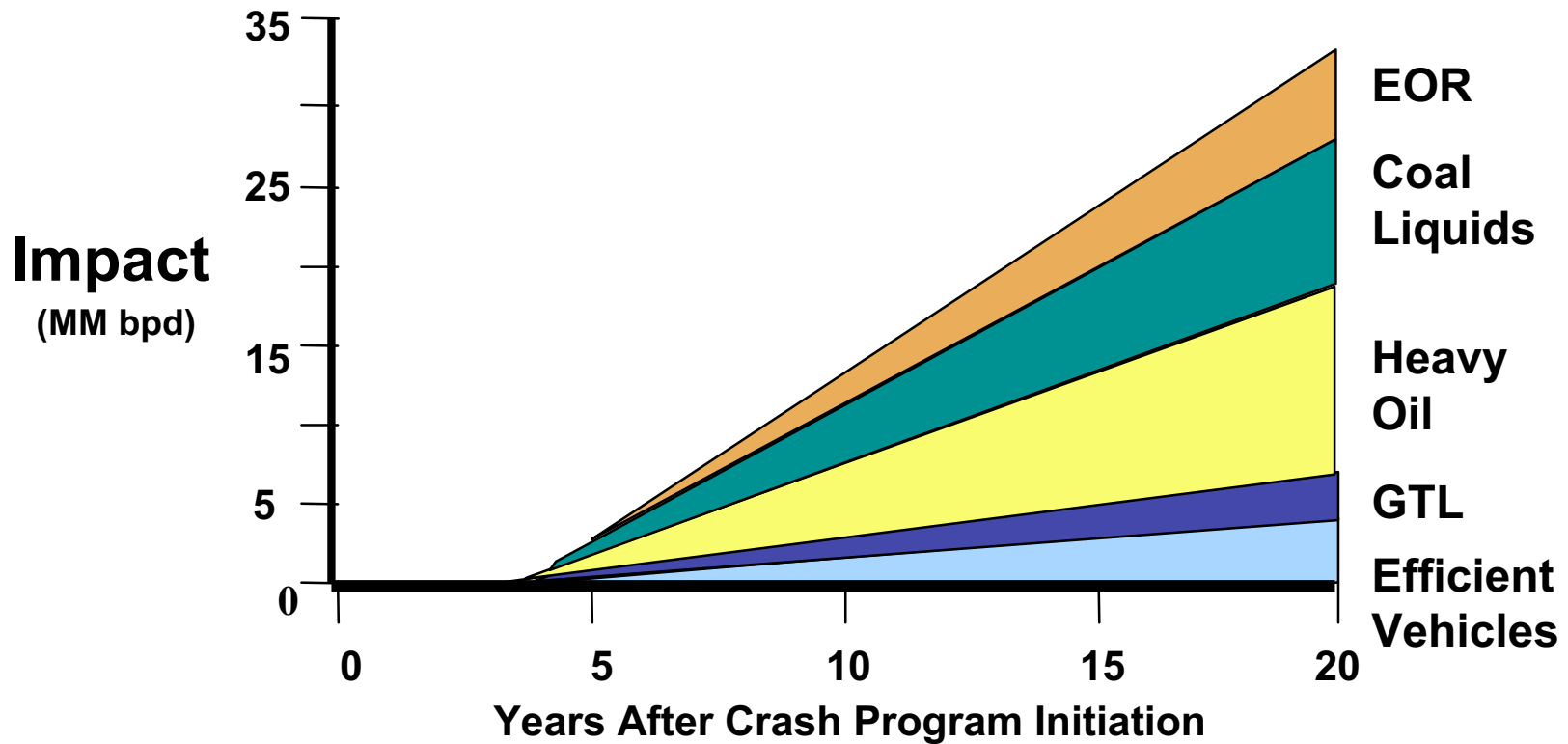
**ASSUMED CRASH PROGRAM
IMPLEMENTATION:
THE MOST OPTIMISTIC
CASE**

Scenario I - No action until peaking occurs

**Scenario II - Mitigation starts 10 years before
peaking**

**Scenario III - Mitigation starts 20 years before
peaking**

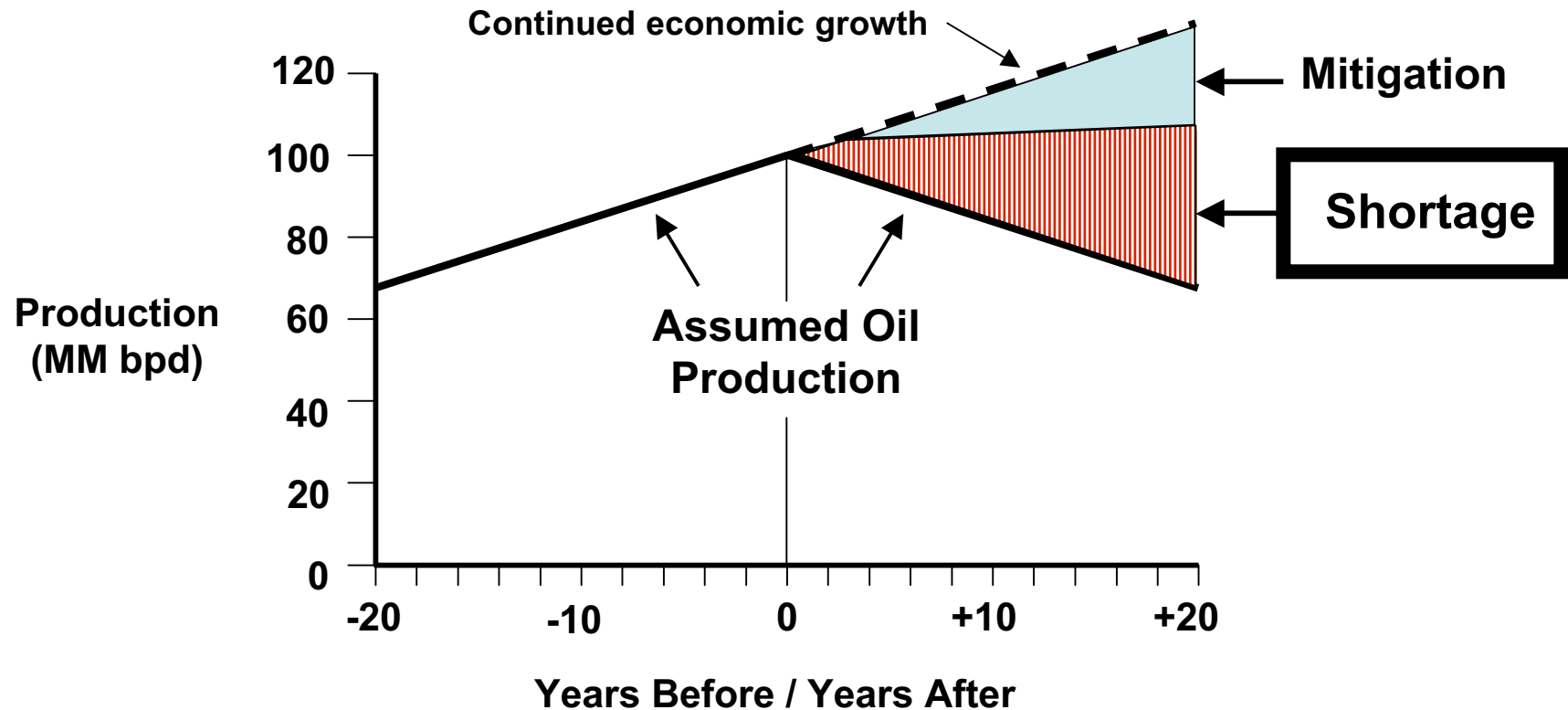
Worldwide Crash Program Mitigation of Conventional Oil Production Peaking



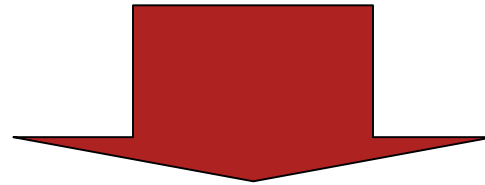
**Delay, then rapid
growth**

Crash Program Mitigation Started at Peaking - No Date Assumed

Center on the unknown date for peaking, assume 100 MM bpd at peak, & assume continued world economic growth. Adopt the Lower 48 production pattern.



Conclusion For A Worldwide Mitigation Crash Program Started At Peak



**Growing world liquid fuels shortages for
more than two decades**

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Past Oil Shortages - 1973 & 1979

BRIEF interruptions caused....

+ Recession

+ Inflation

+ Unemployment

+ High interest rates

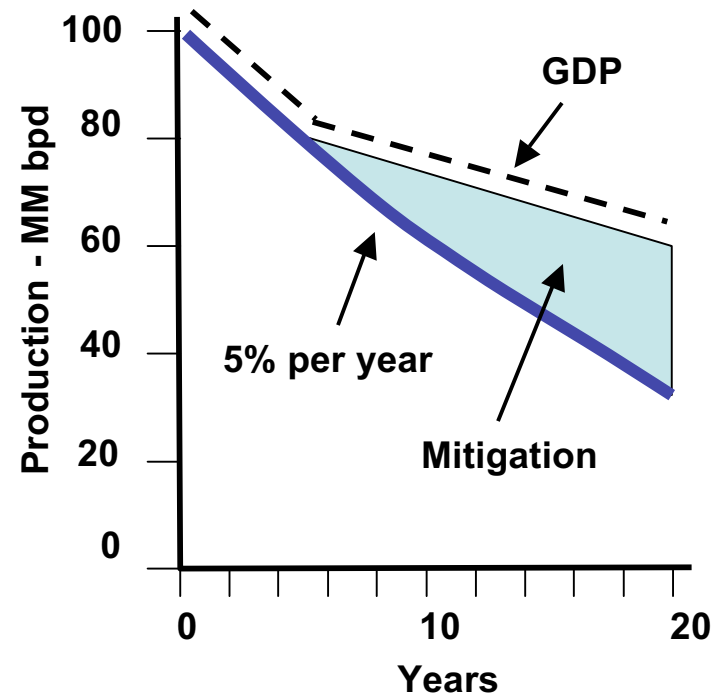
**World oil peaking won't be
BRIEF.**

Relationship Between World Oil Shortage & World GDP

- Only experience: **1973 & 1979.**
- Precision is impossible.
- From 1973 & 1979 + various studies:

$$\frac{\% \text{ Decline in GDP}}{\% \text{ Decline in Oil Supply}} \sim 1$$

Potential Impacts On World GDP

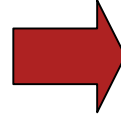


- What will the world oil decline rate be?
- How closely will GDP decline follow oil shortages?
- When will the world initiate a mitigation crash program?

The situation will soon change.

- **The peak oil issue is percolating up**
 - + Growing numbers of items in the media
 - + Recognized by both political parties
 - + Growing interest on Wall Street
 - + Google Peak Oil -- 4 million items

**When world oil decline
breaks into active public
consciousness**



**Psychological
Shock!**

- **I expect 1973 & 1979 reactions:**
 - + **Public panic & disorientation**
 - + **Hoarding & instant shortages**
 - + **Major negative reactions on Wall Street**
 - + **Recession, unemployment, inflation, etc.**

Conclusions

- Energy in 2050 looks very promising.
- Considering oil supply only, the world will have to work through dire economic circumstances.
- Mitigation will require:
 - **Massive deployment**
 - **Compromises**
 - **Speed**
- We have available options for near-term mitigation & other options are certain for 2050+.

We'll manage but it will be a huge challenge!