Peaking of World Oil Production -

What Are We Willing to Risk?

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The Messages

- **World petroleum production will peak.**

  + **Timing is uncertain.**
  + **Many worry it may be soon.**

- **Technology / high prices likely will NOT save the day.**

- **Skyrocketing oil prices & shortages = economic disaster.**

  + **Mitigation will require a decade or more.**
  + **We need to better understand timing & action options.**

It's world-class, risk-management problem.

Fundamentals

- Oil is the lifeblood of modern civilization (Cars, trucks, planes, etc).

- Oil is found in reservoirs of various sizes, characteristics, & depths in a limited number of places in the world.

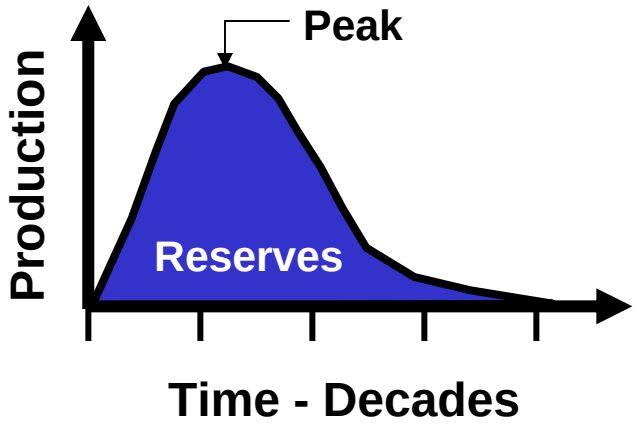
- Super-Giant fields are generally the easiest to find & least expensive to produce. The Middle East has many.

- Geologists agree: World old production will peak.

Peaking is not running out - It's maximum production

This is a **LIQUID FUELS PROBLEM**, not an "energy problem."

Oil Production & Reserves



In all oil fields, production increases to a peak & then declines.

- **The total producible oil in a field = reserves.**
- **Reserves are estimated & re-estimated over the life of a field.**

  + Reserve estimation is often influenced by politics.

- **Peak production occurs after roughly half is produced.**

Reserves do not tell you when oil peaking will occur.

Some Facts

- Oil is hard to find because it's normally buried deep & normally doesn't show at the surface.

- Large numbers of wells are required to achieve high production & enable a good estimate of reserves. [Reserves estimation is tough!]

  + U.S. reserves estimates are good.

  + Elsewhere it's poor & often political.

- Two oil classifications are "Conventional" & "Unconventional."

Most oil now produced is conventional.

Observations

- World petroleum demand is huge & growing. More and more reservoirs on the “upswing” are needed to offset those on the downside.

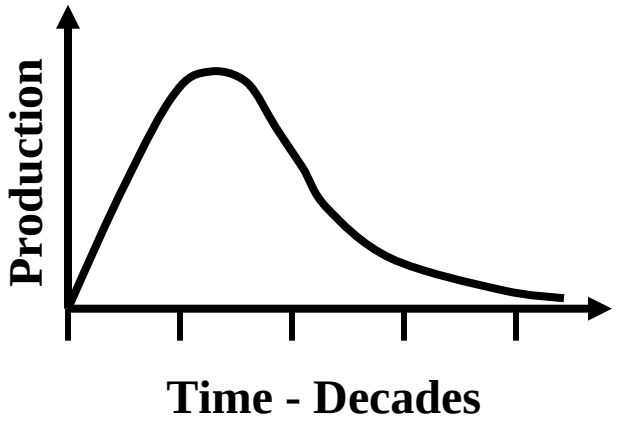
- Past peaking predictions: Wrong before doesn’t mean wrong always.

- What’s different today?
  - + Extensive drilling worldwide - Tested most of the best places.
  - + Modern geology & seismic technology are very advanced.
  - + Reserves / well have been dropping for ~ decade.
  - + More experts are pessimistic.
  - + World oil peaking could be economically disastrous.

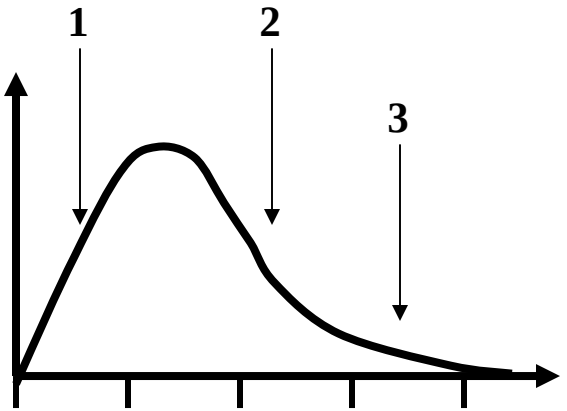
Thought Exercise:

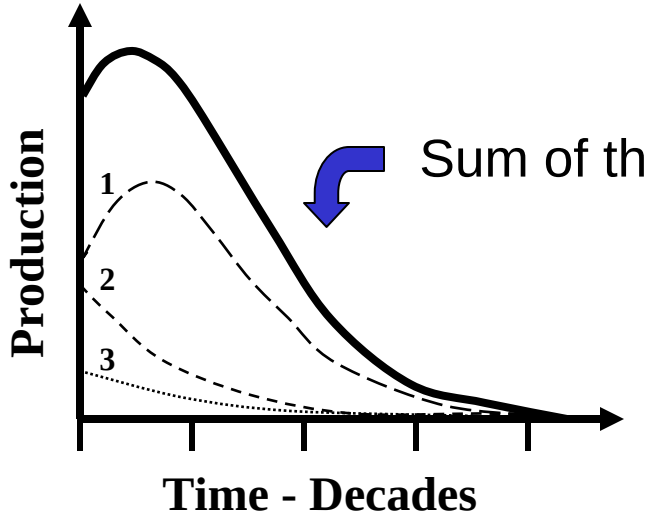
Sum Outputs from Three Similar Reservoirs at Different Stages of Production

Assume this individual reservoir profile



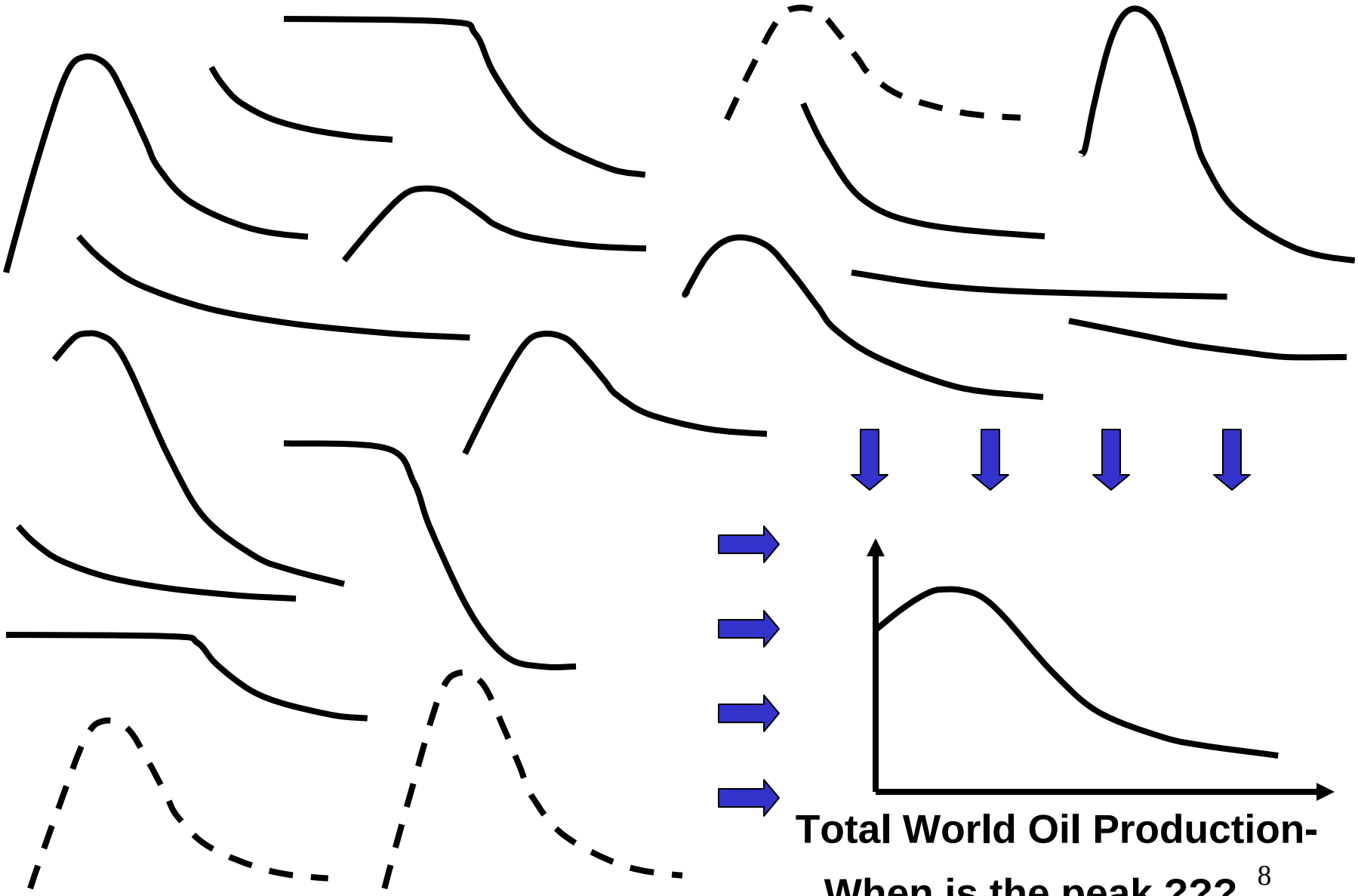
Assume These stages of production





Sum of three profiles

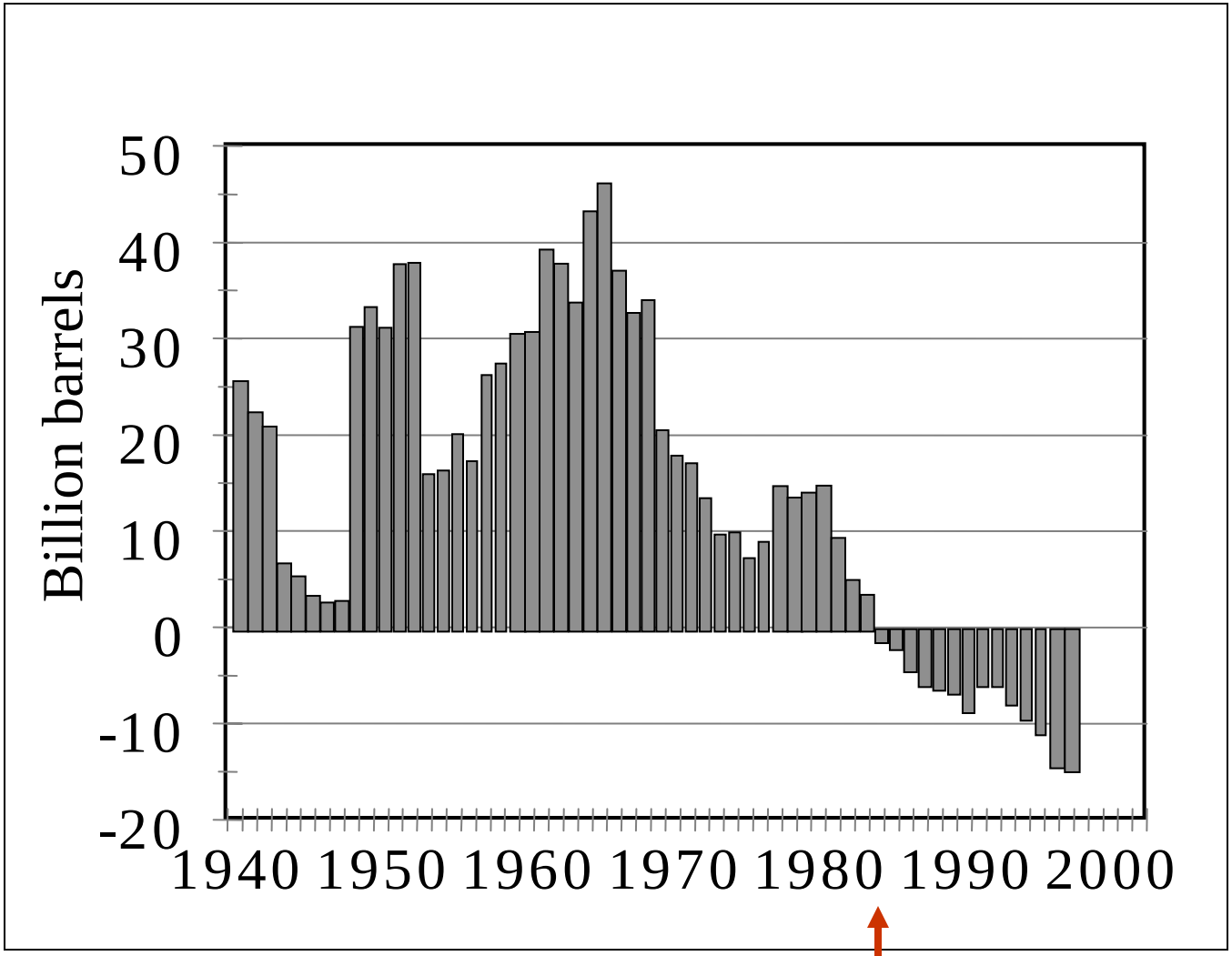
World Oil Production = Outputs of All Reservoirs



Total World Oil Production-

When is the peak ???

Annual World Oil Finding Minus Consumption



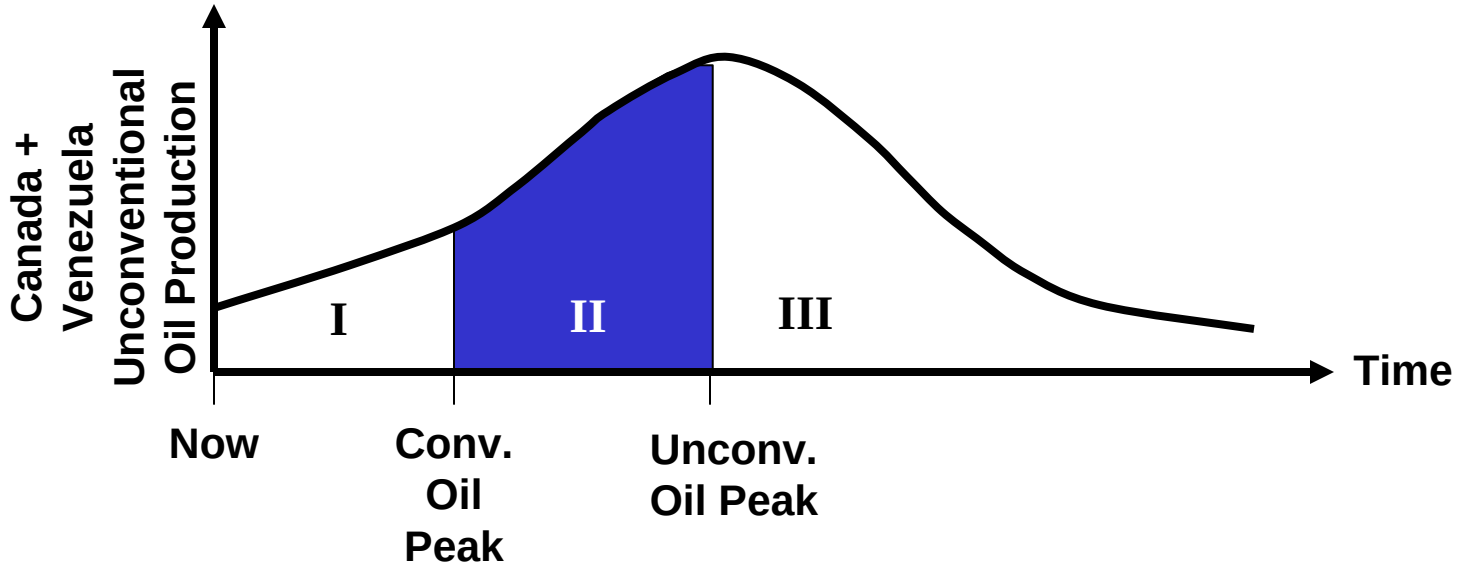
Started "eating our seed corn!"

Unconventional Oil - The Two Biggest

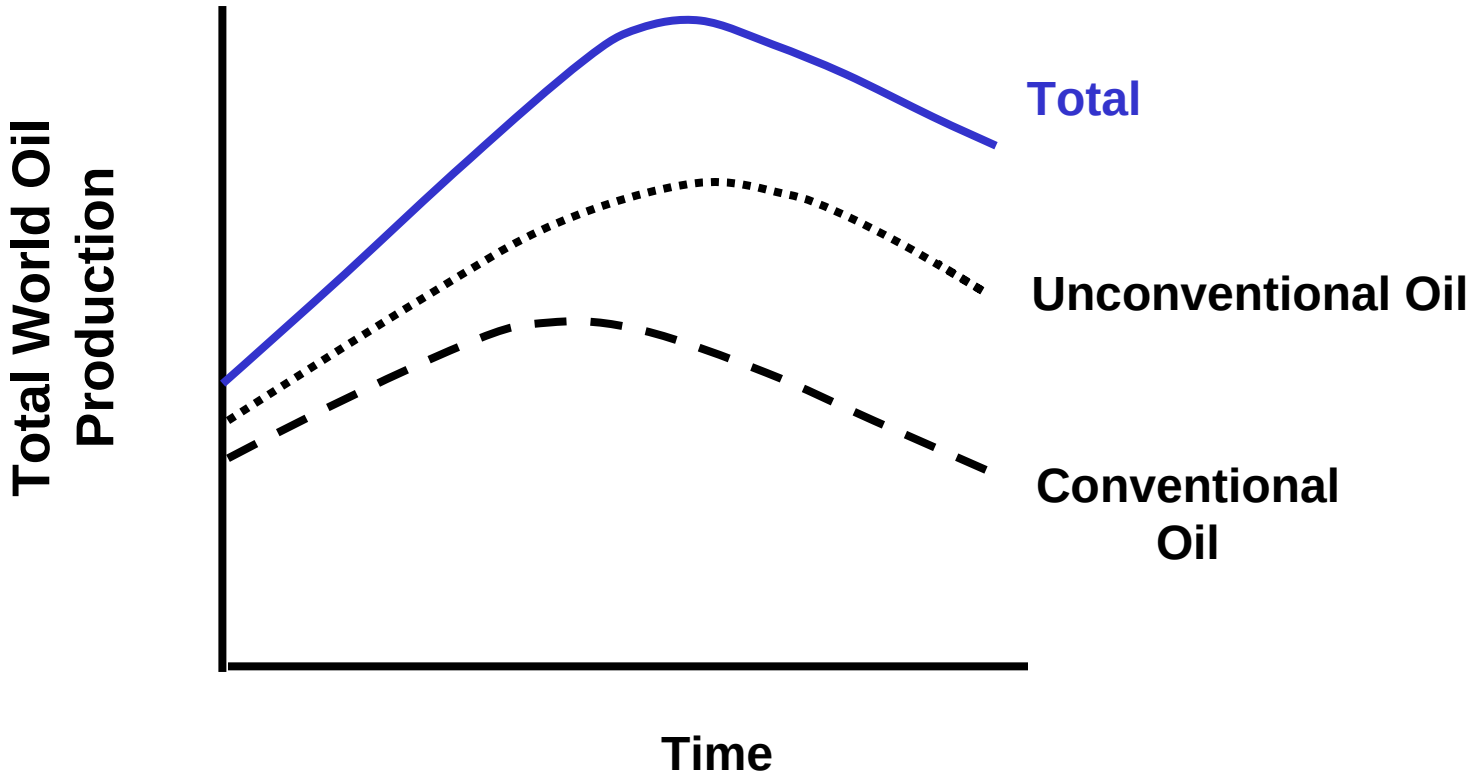
	Resource Size (Trillion Barrels)	Est. Recoverable (Billion Barrels)
Canadian Heavy Oil	1.7-2.5	315
Venezuela Tar	1.2	270
Totals	3-4	600

Total world demand @ 100+ MM bbls / day ➡ 40 billion bbls / year

How long will 300 billion bbls last?



Notional World Production of Conventional & Unconventional Oil



More Facts

- World's last Super Giant oil fields found in 1967 & 1968.
- All the great Middle East finds happened decades ago.
- From 1996-1999, >$400 billion only kept production flat.
- In mid 1980s, OPEC production quotas became partly based on "reserves."

    + From 1986 to 1990 "reserves" increased by ~300 Gb
    + Only ~10 Gb were actually discovered (Games!)

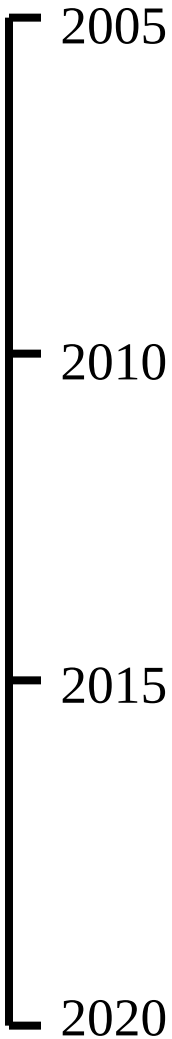
Various Predictions of World Oil Production Peaking

Simmons: 2007-2009
Goodstein: 2007-2009
Skrebowski: After 2007
Bakhtiari: Before 2010
Campbell: Around 2010

Laherrere: 2010-2020

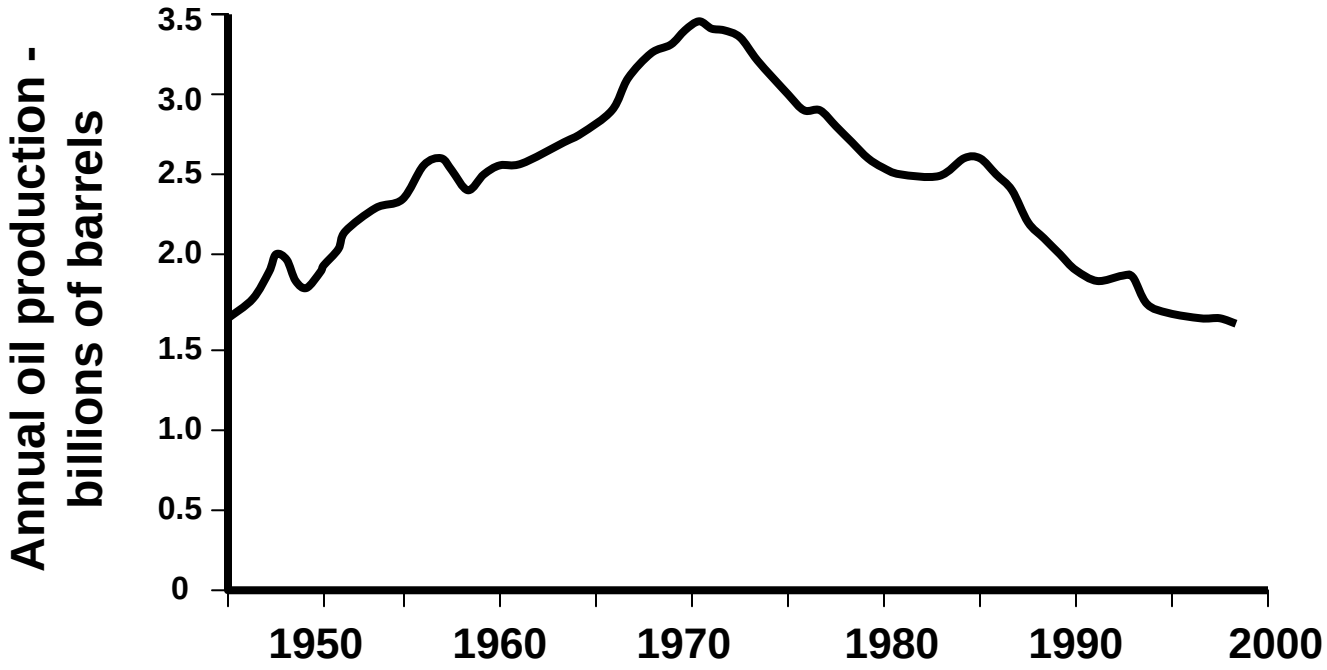
EIA (Nominal case): 2016
Douglas - Westwood: As early as 2016

CERA & Shell: After 2020 / 2025

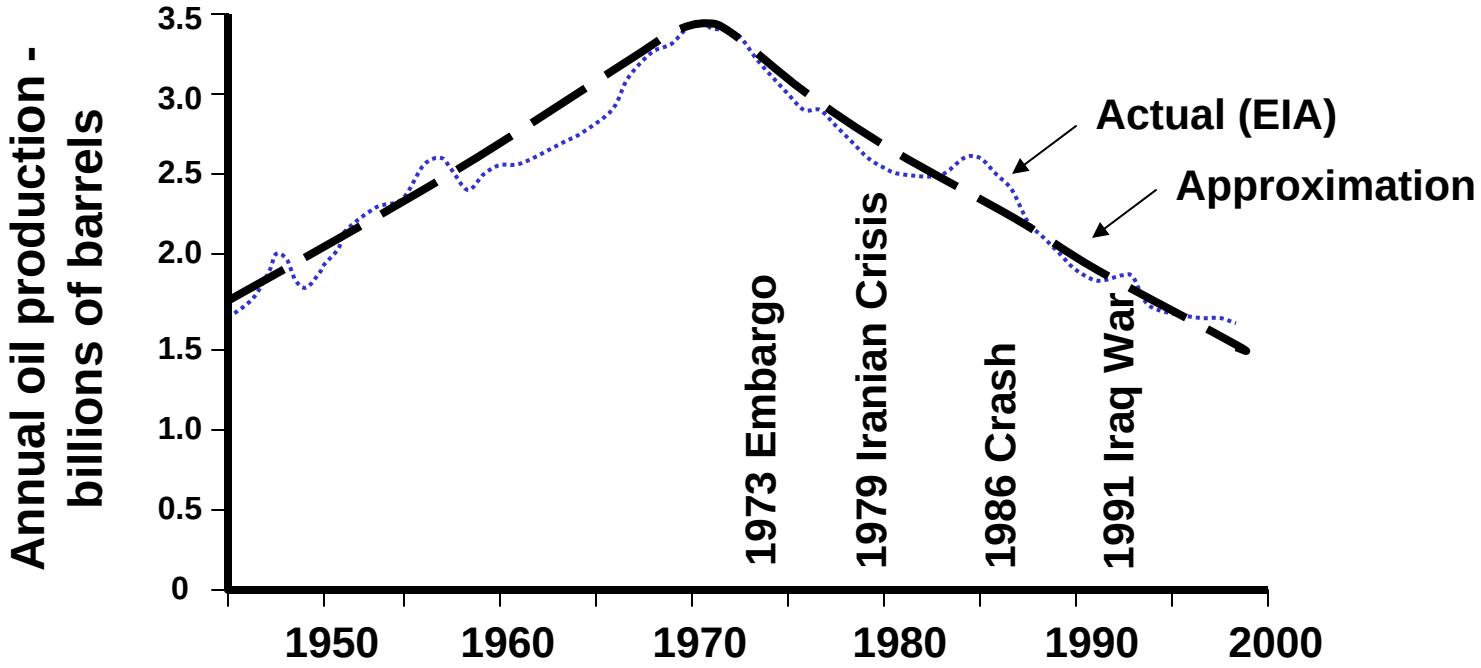


Can Prices & Technology Save Us?

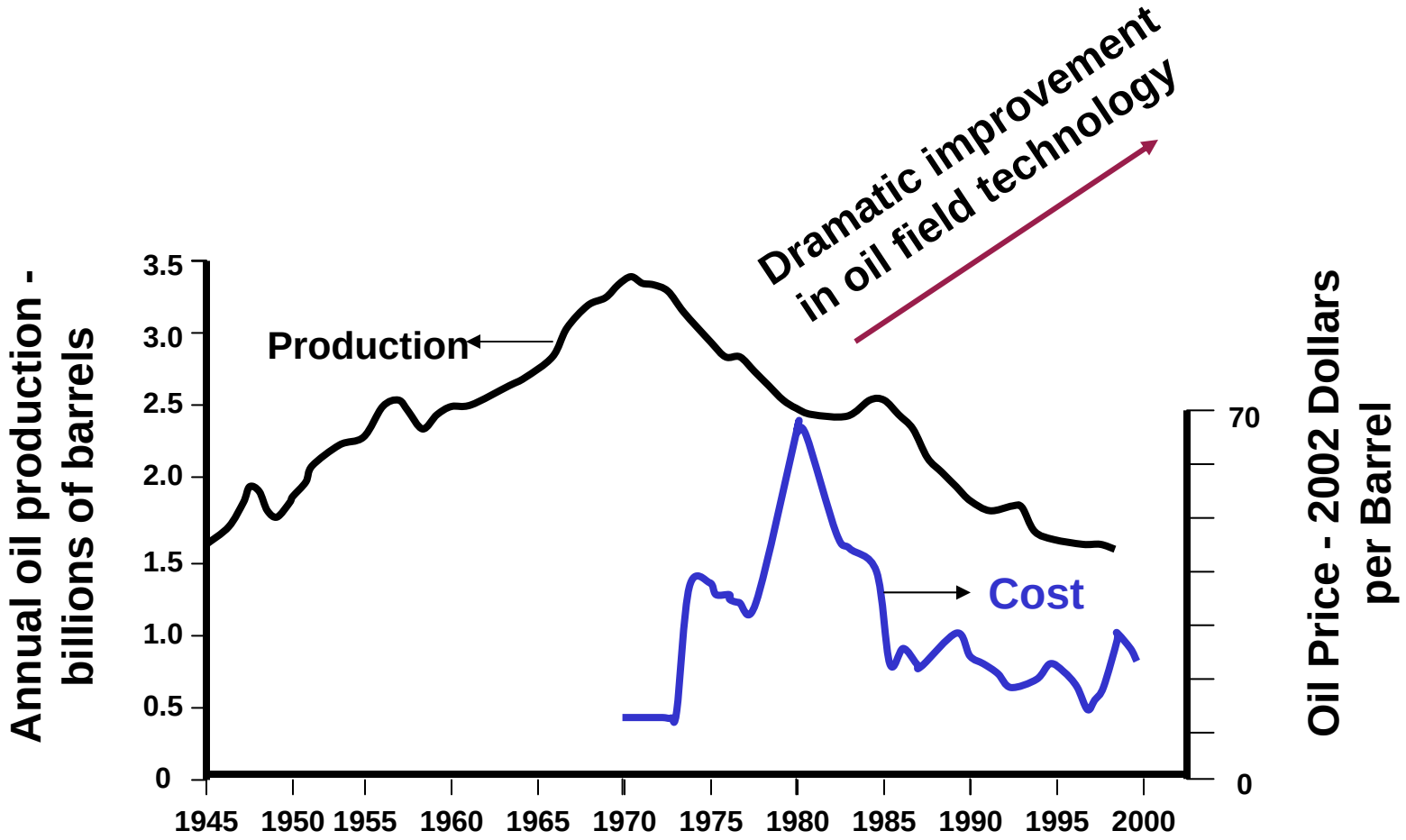
Consider Lower 48 Crude oil Production



Lower 48 Crude Oil Production

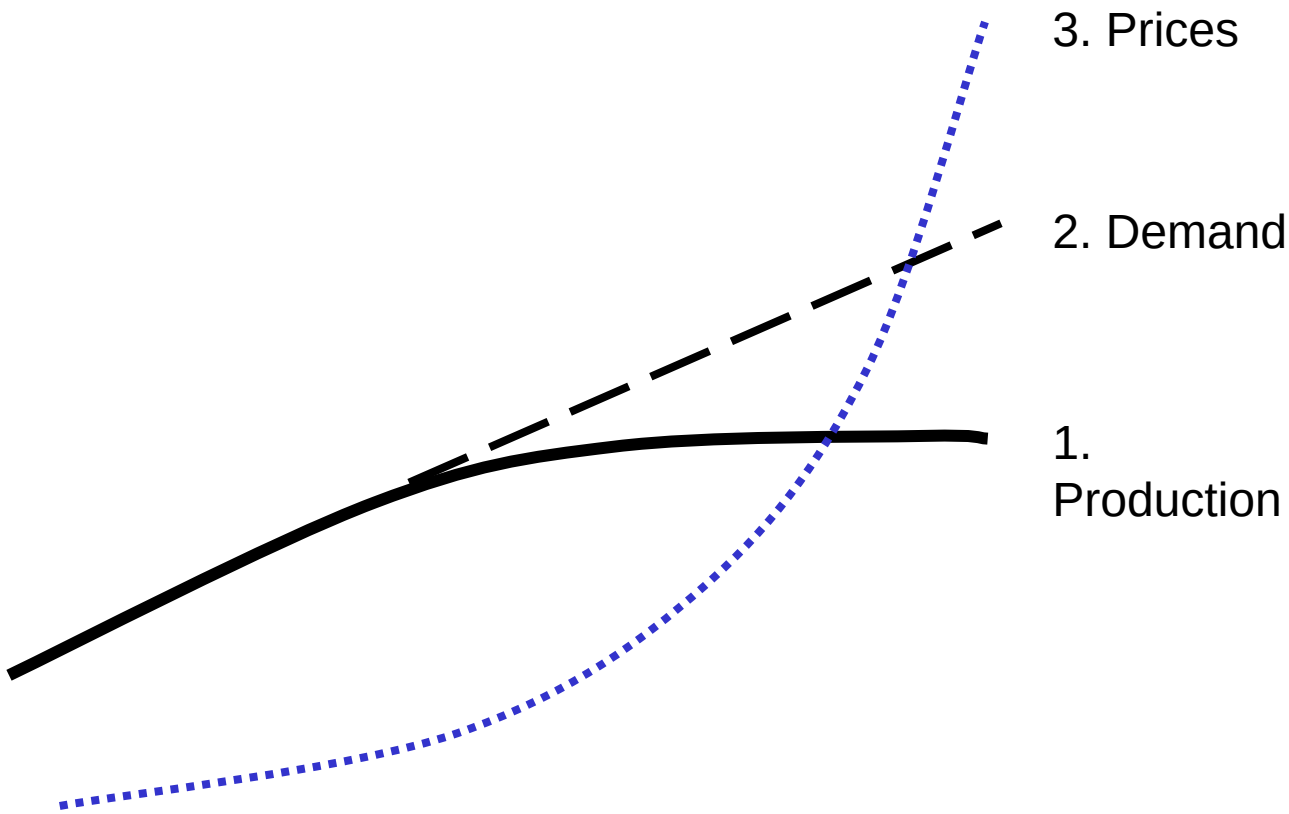


Lower 48 Crude oil Production & Oil Prices



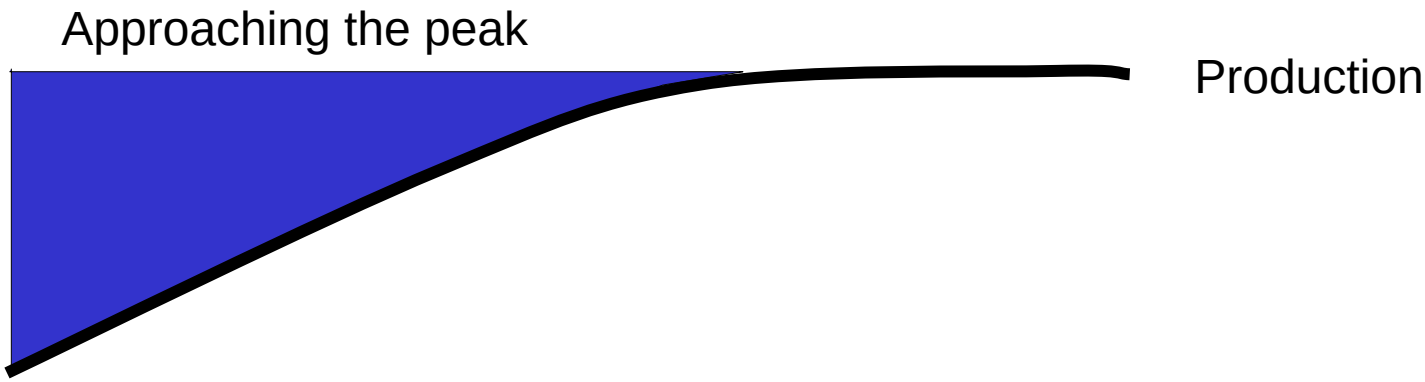
For the L 48, neither dramatic improvements in technology nor huge price increases had much impact after the peak.

Likely Trends Near the Peaking of World Oil Production



A LIQUID FUELS PROBLEM,
not the “usual energy problem.”

Possible Impacts & Actions Approaching Peak World Oil Production



Oil price escalation worldwide

Voluntary consumer reductions where possible

Inflation & recession in developed counties

Government rationing & allocations

Relaxation of drilling & environmental restrictions

Depression in undeveloped counties

Dramatic political upheavals / wars?

Nation-Scale Change in Energy Generation Require Decades

Single Projects

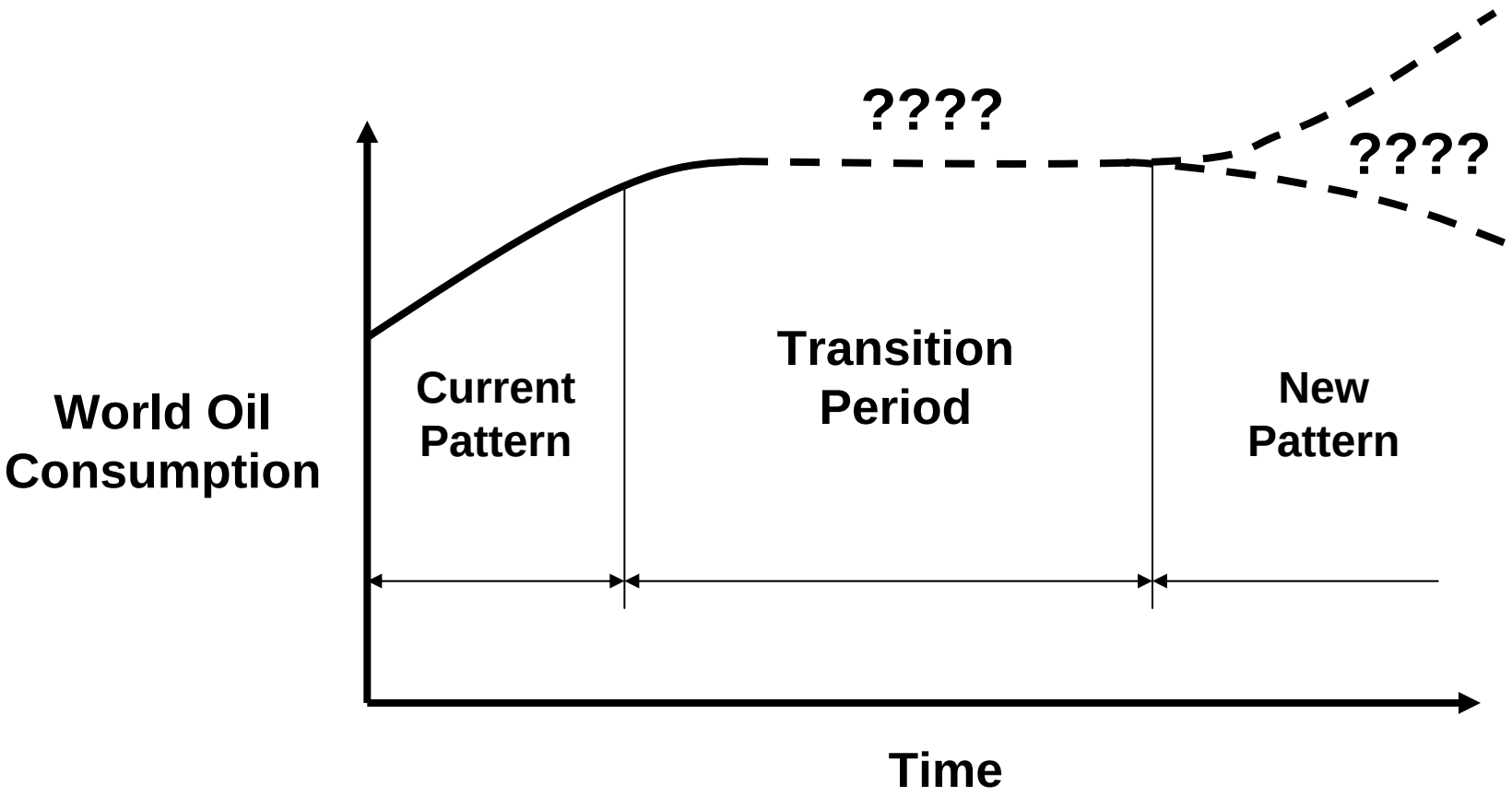
- **Gigawatt power plants - Decade-scale & billion $ class. Synfuels?**
- **Alaska Gas Pipeline: A decade / $10-20 billion.**
- **Major new electric transmission lines take 5 years - never.**
- **A GW of wind power requires 300 - 3.3 MW wind turbines.**
- **Refineries - None built for so long; time & costs unknown.**

Nation-Scale Energy Conservation Requires Decades

1970s CAFE - Roughly 15 years to maximum savings:

- **Automobile**: Median lifetime of **1990** model **cars** = 16.9 years. In 2007, one-half will still be on the road.
- **Heavy Trucks:** 50% of 1990 model year trucks will still be in use in 2018.
- **DOD Planned Turn-Over Rates**
  - Tanks - 15-30 years
  - Helicopters - 15-30
  - Fighters/tactical planes - 20-30 years
  - Bombers/tankers - 25-50 years

The World Liquid Fuels Future



How long & how bad the transition?

Closing Thoughts

- **World oil production will peak - no question.**

- **The pessimists have "cried wolf" before on oil peaking, but it hasn't happened yet.**
- **The optimists have cried "no-wolf" & have thus far been correct.**

- **Remember: In the late 1990s, the optimists said there's no problem with North American natural gas; now we require major imports & fast.**

What Are We Willing to Risk?

1973

This for a decade or more?