Peaking of World Oil Production:

The Mitigation Challenge

Robert L. Hirsch

Senior Energy Program Advisor, SAIC

National Research Council Workshop on Trends in Oil Supply and Demand and Potential for Peaking of Conventional Oil Production

October 21, 2005

Overview

- **Peaking of world conventional oil production is unavoidable, but the timing is uncertain.**
- **Mitigation technologies are available.**
- **Implementation will be the challenge.**
- **World oil consumption is enormous so mitigation will be a huge worldwide undertaking.**

There are no quick fixes.

Optimists:
Not to worry

- We've heard this before.
- Geological problems are distant.
- There's time enough for markets to work.
- We can muddle through.

Concernists:
Worry!

- We know much more now.
- Geological limits are likely in 0-15 years.
- Effective action will take decades.
- Inaction will be catastrophic.

Oil & Futures Markets:
Worry?

- Futures prices are very high.
- Something is different this time.

Wildcards:
Worry?

- Terrorism
- Political instability

This Presentation

- **Background Review**
- **Mitigation Options**
- **Three Scenarios**
- **Timing**

Much from Hirsch, Bezdek & Wendling. PEAKING OF WORLD OIL PRODUCTION: IMPACTS, MITIGATION, & RISK MANAGEMENT. DOE Report. February 2005

The Problem

At some point, world conventional oil production will no longer meet demand = OIL PEAKING

- **WHY?** Rapid depletion of a finite resource.
- **WHEN?** Uncertain - Soon? 10 years? Later?
- **WHY CAN'T THE PROBLEM BE FIXED QUICKLY?**

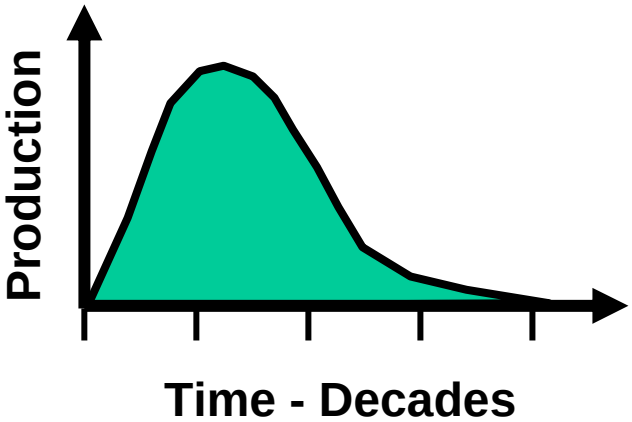
The scale of change is

ENORMOUS

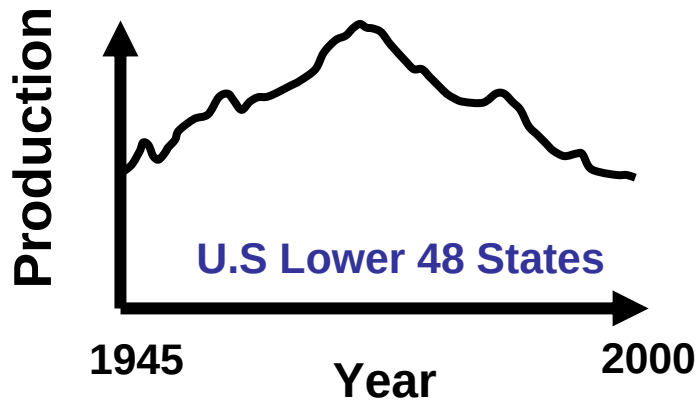
World oil consumption is over 3 million barrels per hour.

……. about 30 seconds to fill this room with oil…….

Why will conventional oil production peak?



Oil fields peak

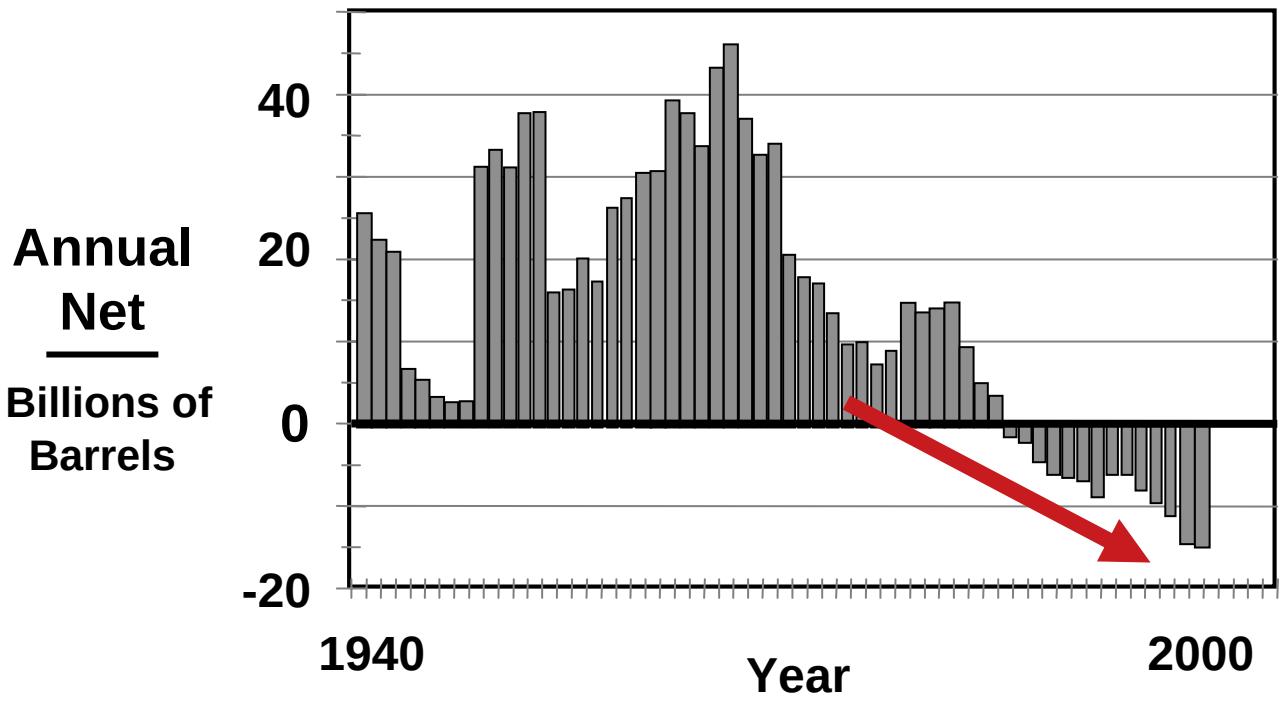


Regions peak (Many fields)

The world will peak.

(All regions)

We're finding much less than we're consuming.



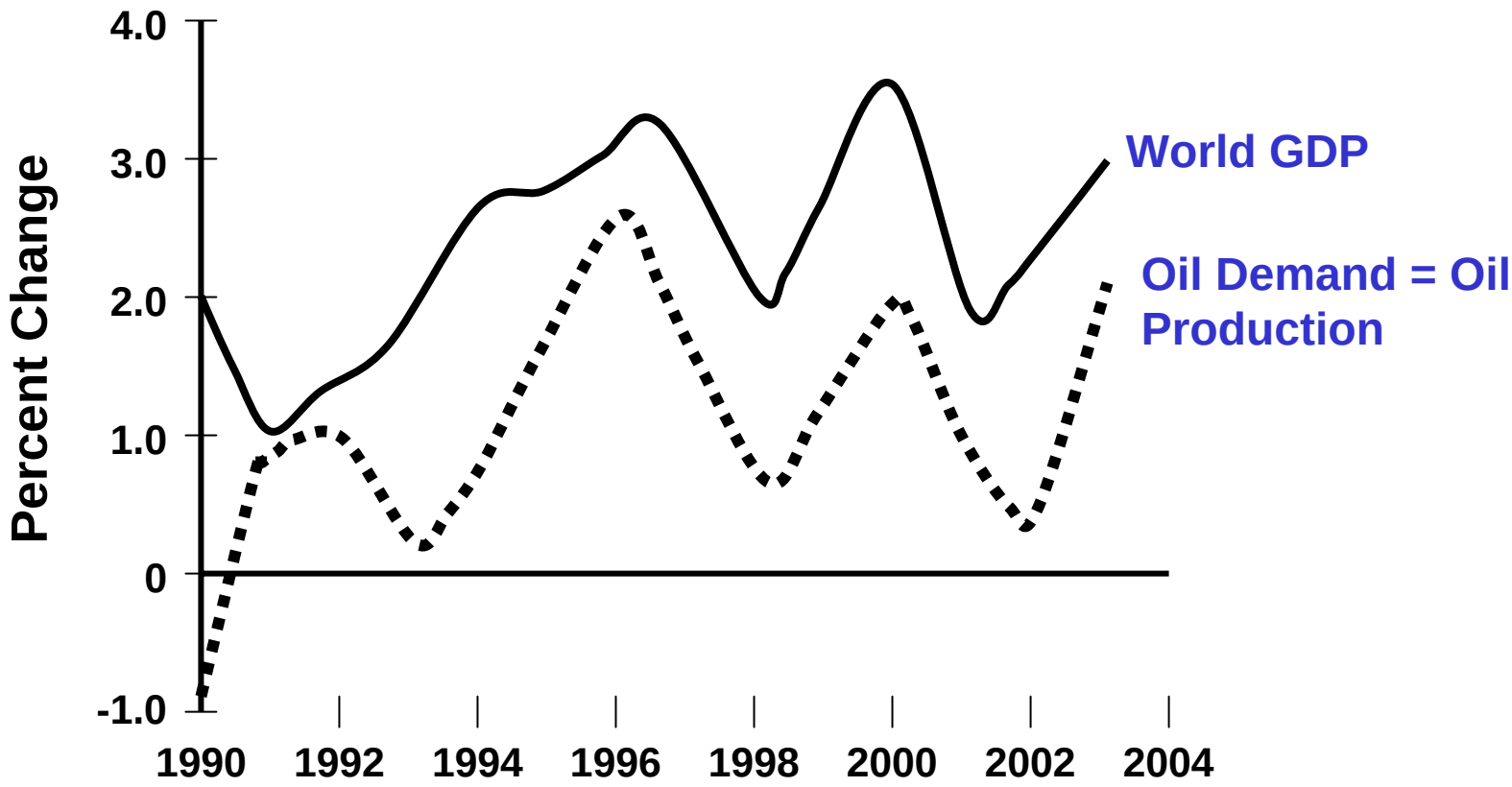
Trouble!

Fundamentals

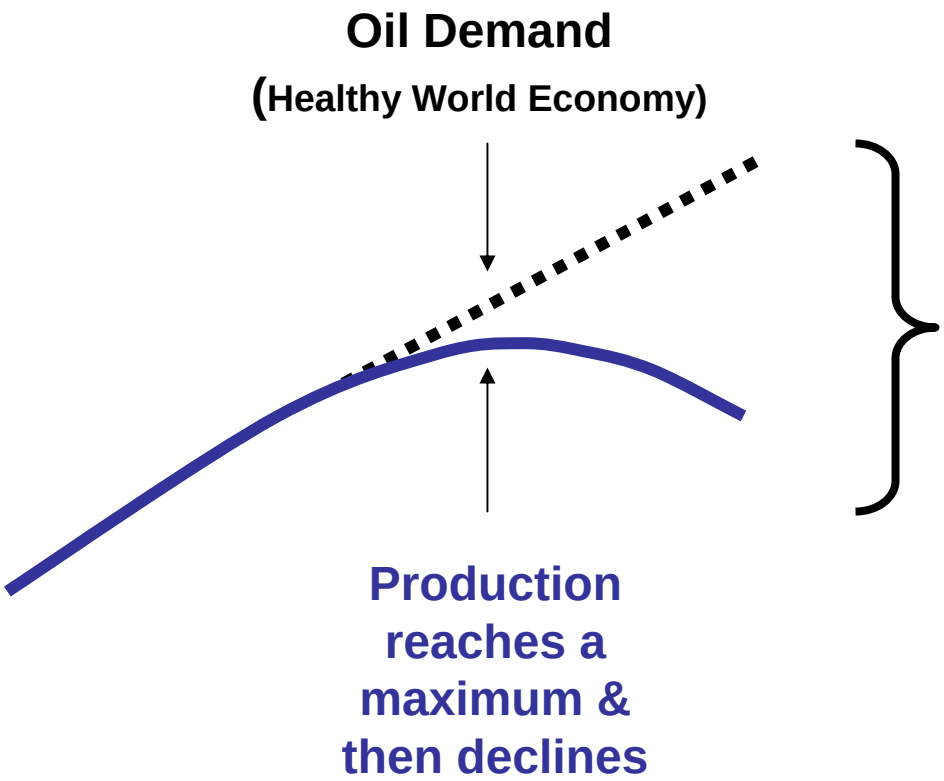
Peaking is maximum production, not running out.

It's a liquid fuels problem.

World Oil Consumption Follows & Fuels World Economic Growth



What's likely to happen at peaking?



Supply cannot meet demand

1) Prices escalate

2) Shortages develop

3) Economic trouble

Learning from Two Oil Major Interruptions

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

+ Inflation
+ Unemployment
+ Recession
+ High interest rates

- **Both events were relatively brief.**

- **World oil peaking impacts could last more than a decade.**
- **The world has never faced a problem like oil peaking - The first forced energy transition.**

When?

No one knows for certain

Forecast	Source
2006-2007	Bakhitari (Iran)
2007-2009	Simmons (U.S.)
After 2007	Skrebowski (U.K.)
2008	Campbell (Ireland)
Before 2009	Deffeyes (U.S.)
Before 2010	Goodstein (U.S.)
After 2010	World Energy Council
2012	Weng (China)
2016	Doug-Westwood (U.K.)
After 2020	CERA (U.S.)
2031 or later	EIA (U.S)

5 years

5-15 years

> 20 years

The North American Natural Gas Error

- **Experts overestimated North American natural gas reserves & future production as late as 2001.**
  - National Petroleum Council - 1999
  - **DOE EIA** - 1999
  - **Cambridge Energy Research Associates (CERA)** - 2001
- **Natural gas production is now flat / in decline.**

> • **Natural gas & oil geology have similarities.**
> • **What's the RISK on oil?**

Analysis of Three Mitigation Scenarios

Scenario I - No action until peaking occurs

Scenario II - Mitigation started 10 years before peaking

Scenario III - Mitigation started 20 years before peaking

Assumptions:

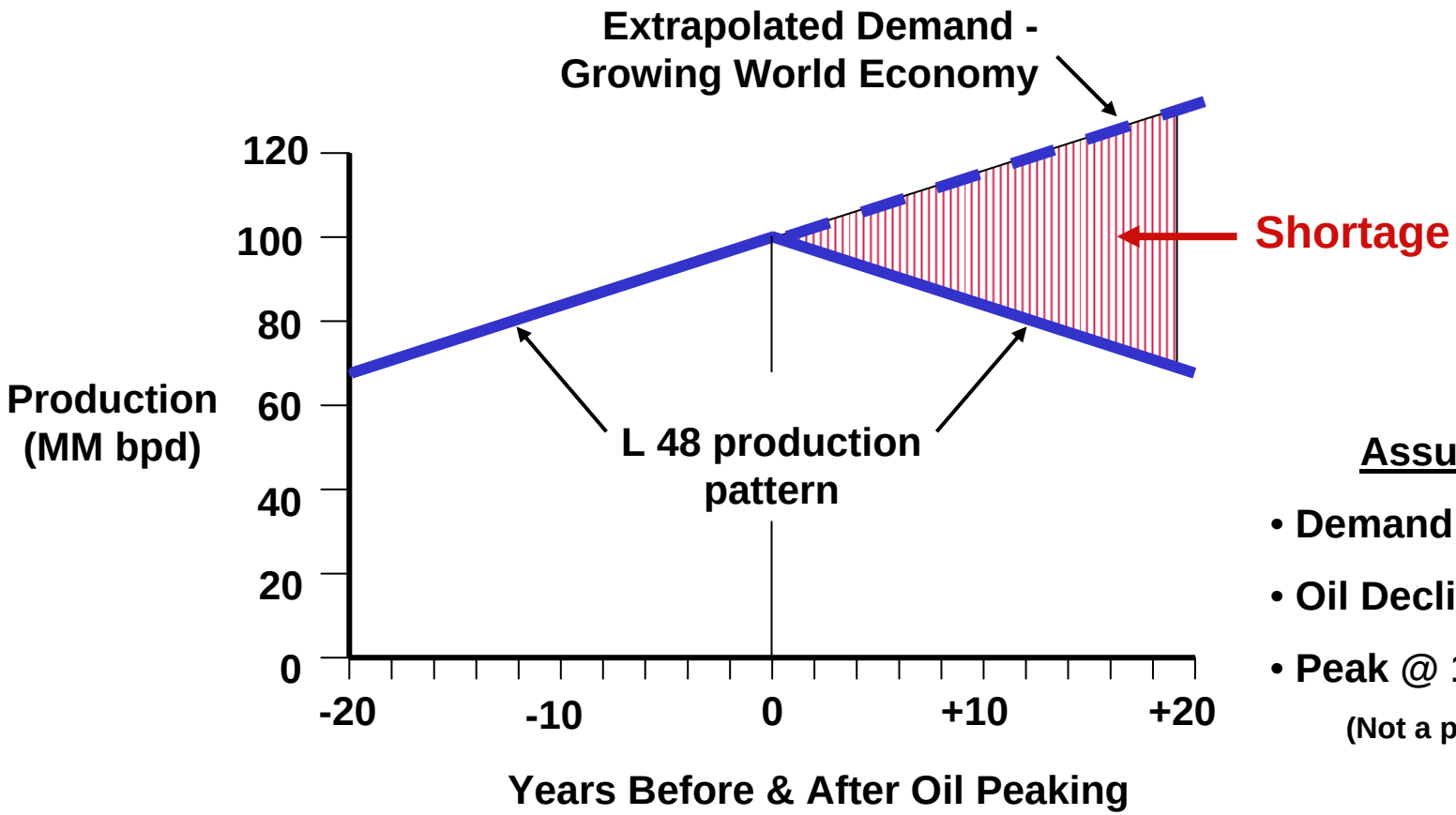
» **All mitigation initiated immediately**

» **Crash program implementation**

Optimistic limiting case

Modelling Requires a Pattern for World Oil Growth, Decline, & Demand

Leave the date for peaking open.



Assumed:

- **Demand @ 2%**
- **Oil Decline @ 2%**
- **Peak @ 100 MM bpd**

(Not a prediction)

Rapid Oil Production Declines After World Oil Peaking Are Conceivable

EIA (Hakes, J.) …….. ~ 8%

Saudi Aramco (Al-Husseini, S)…….. 3-5%

ExxonMobil…….. 4-6%

Schlumberger (Gould)……..8%

Our model assumes 2%.

Higher declines make the mitigation problem worse.

Mitigation Options We Considered

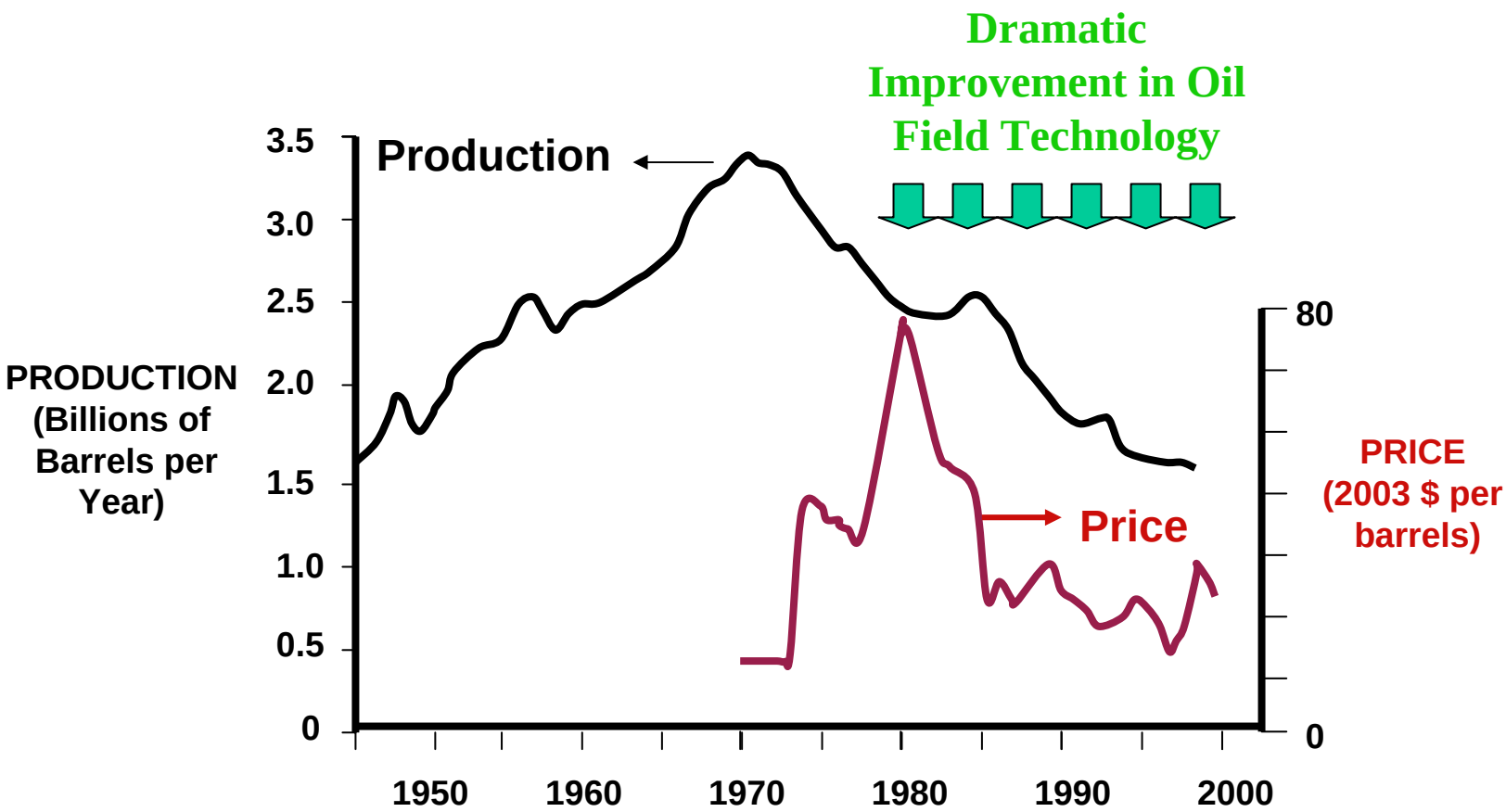
- Vehicle fuel Efficiency
- Heavy oil / oil sands
- Coal Liquefaction
- Gas-To-Liquids (GTL)
- Enhanced Oil Recovery (EOR)

Why these? There're ready for

Implementation

High Prices & Advanced Technology?

Experience: U. S. Lower 48 Oil Production



Help? - Yes

Reverse trends? - No

Options Not Included in Our Analysis

Option **Reasoning**

- **Nuclear**
- **Wind**
- **Solar**

…….. Electric / not LIQUID FUELS

- **Hydrogen……Neither ready nor economic**
- **Biomass…….. Not economic**
- **Shale Oil…….. Not commercial**

U.S. Transportation - 2003

	Autos	Light Trucks	Heavy Trucks	Airplanes
Share of transport fuel consumption	**39%**	**28%**	24%	9%
Fleet size - Millions	130	80	7	0.0085
New - Millions/Year	8.5	8.5	0.5	Small
Median life - Years	**17**	**16**	28	22

Biggest, fastest savings

VEHICLE FUEL EFFICIENCY

- Automobiles & light trucks (LDVs) are the largest liquid fuel consuming opportunity.
  - Diesel engines are up to 30% more efficient than gasoline engines.
  - Hybrids are 40% more efficient in small cars / 80% in medium cars.
  - Enhancements to existing technologies can also contribute.

Estimates based on 30%, then 50% improvements

GAS-TO-LIQUIDS

- Now commercial & could be significant
- Must compete with LNG
- Non-U.S. resource

Estimates based on 2x recent GTL projections

HEAVY OIL / OIL SANDS

- Canada + Venezuela: 3-4 trillion barrels
- ~600 billion barrels economic
- Only part clean fuels - Canada: 0.6 of 1.0 MM bpd
- Current plans - Canada: 3 MM bpd synthetic oil by 2030
- Large energy input required
- Oils harder to refine
- Significant environmental problems

Estimates based on 2-2.5x recent projections.

COAL-TO-LIQUIDS

- Now commercial / near-commercial.
- Cost: $30-35/bbl
- Huge coal resource in U.S., elsewhere
- Liquids don’t need refining

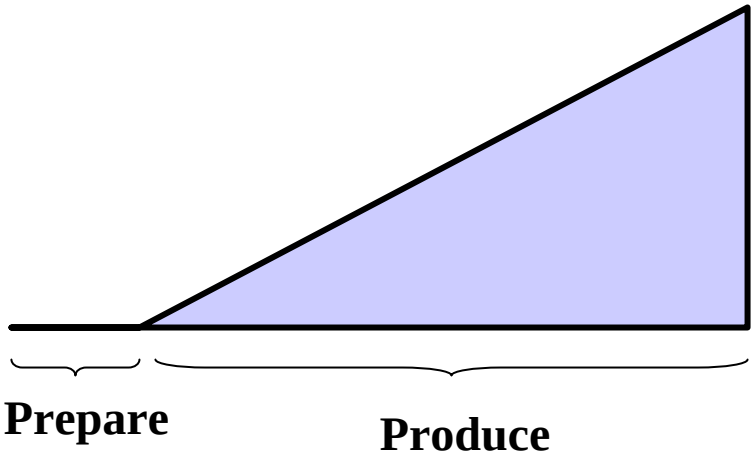
Assume five new 100,000 bpd production plants/year.

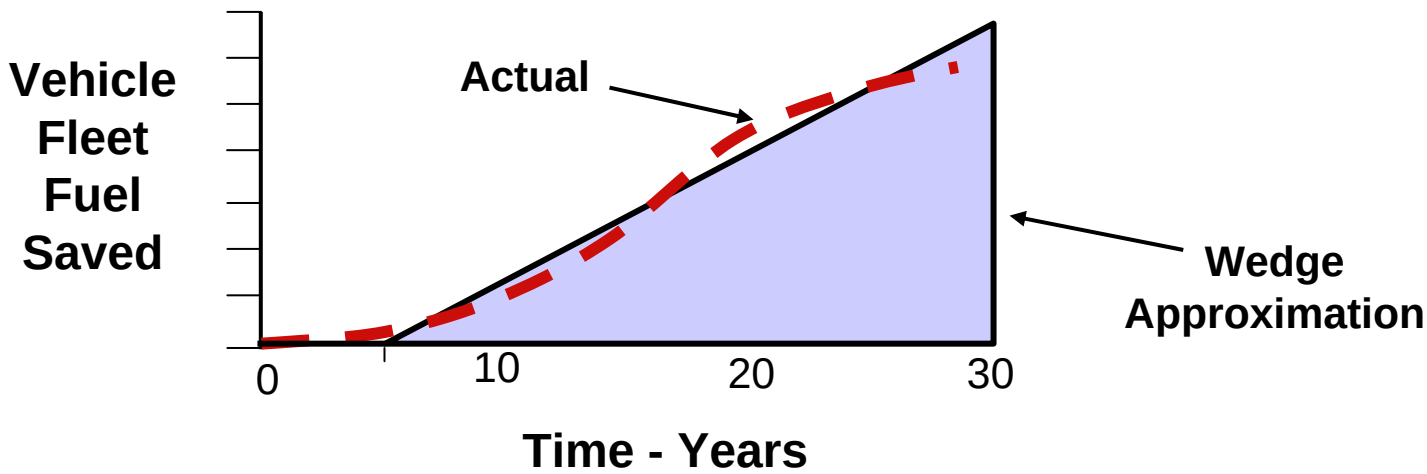
ENHANCED OIL RECOVERY

- EOR has been utilized for decades.
- It’s usually applied after primary and secondary recovery.
- It helps recover additional oil from reservoirs past peak production.

Production estimates paced by CO2 availability.

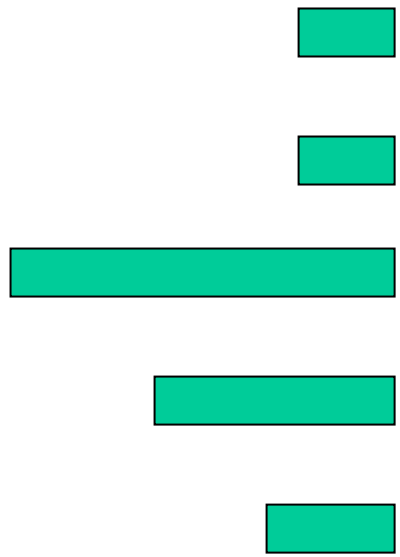
Wedges Used to Show Mitigation Effects



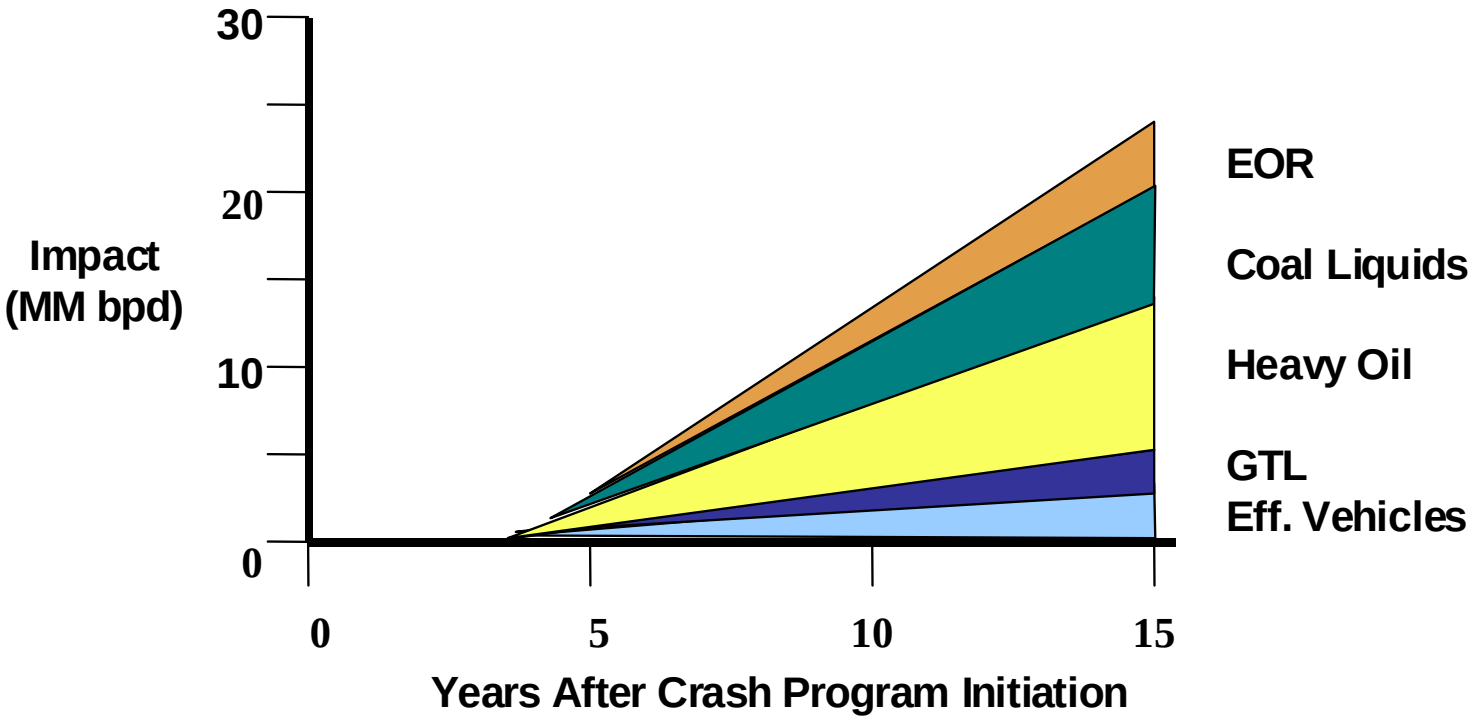


Wedge Estimates from Our Study

Mitigation Option	Preparation Delay (Years)	Impact 10 Years Later (MM bpd)
– **Vehicle Efficiency**	3	2
– **Gas-To-Liquids**	3	2
– **Heavy Oils / Oil Sands**	3	8
– **Coal Liquids**	4	5
– **Enhanced Oil Recovery**	5	3

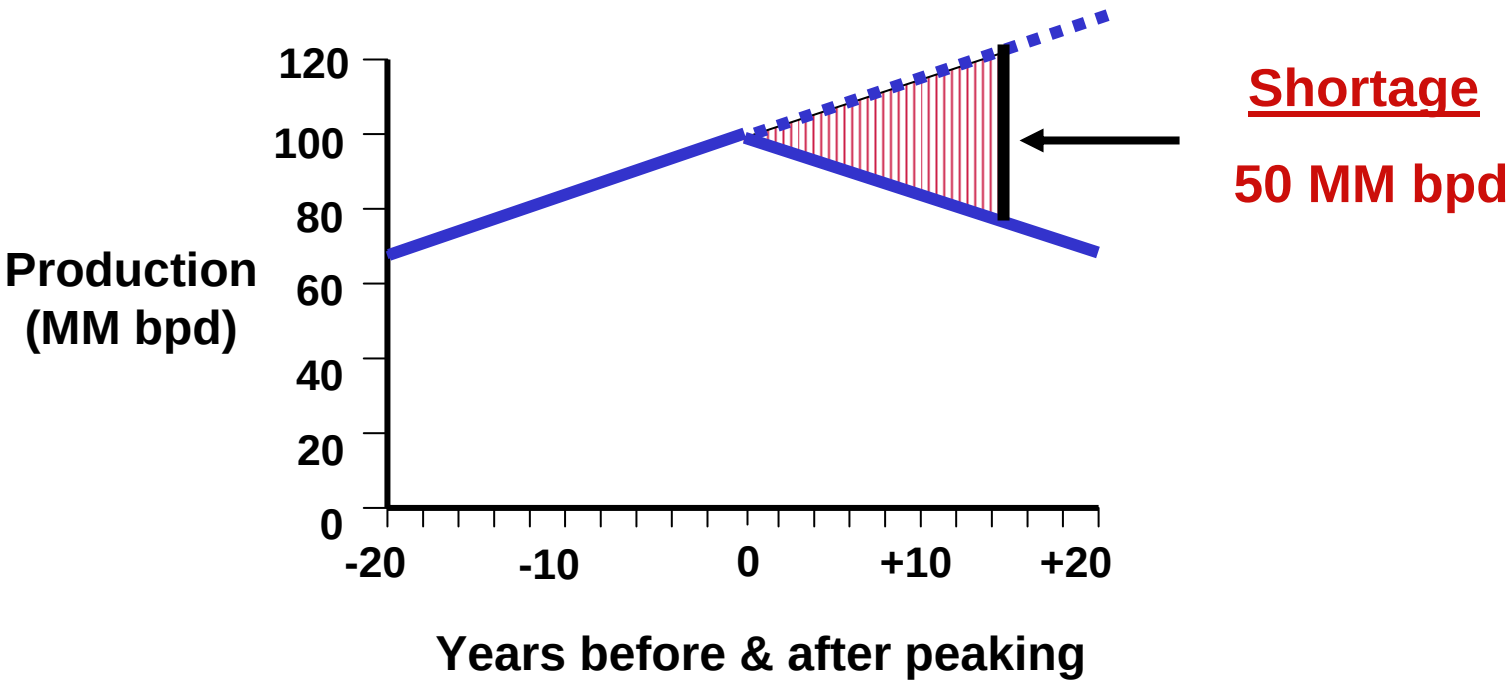


Sum of Wedges



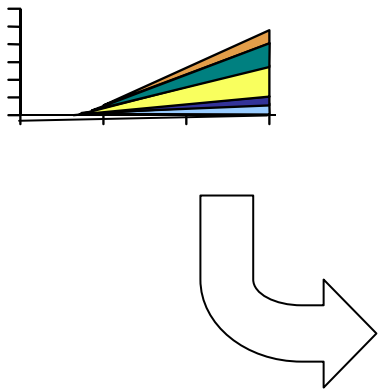
- Delay, then rapid growth.
- **Roughly 25 MM bpd after 15 years.**

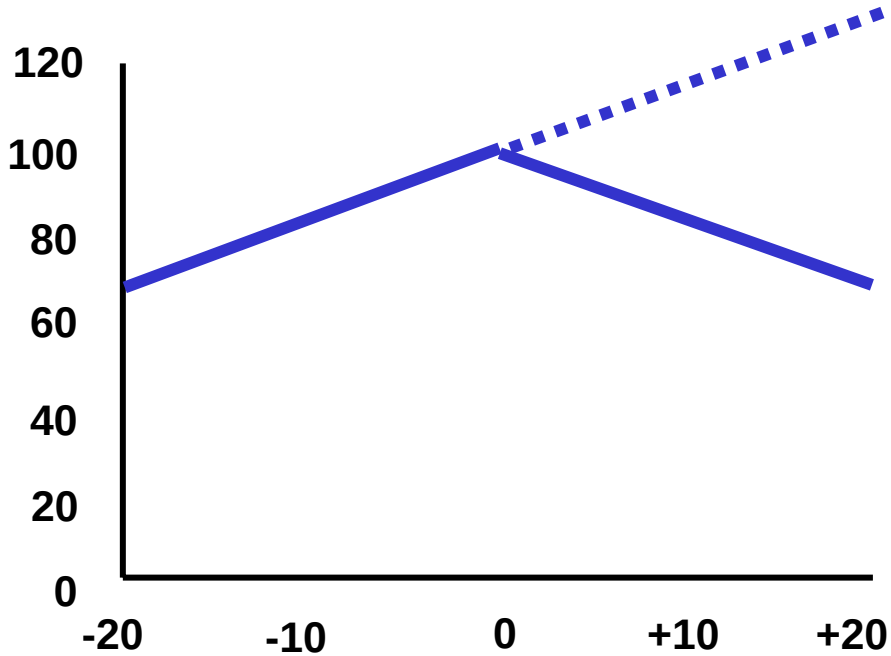
But In Our Model the World Shortage Would be 50 MM bpd, 15 years After Peaking



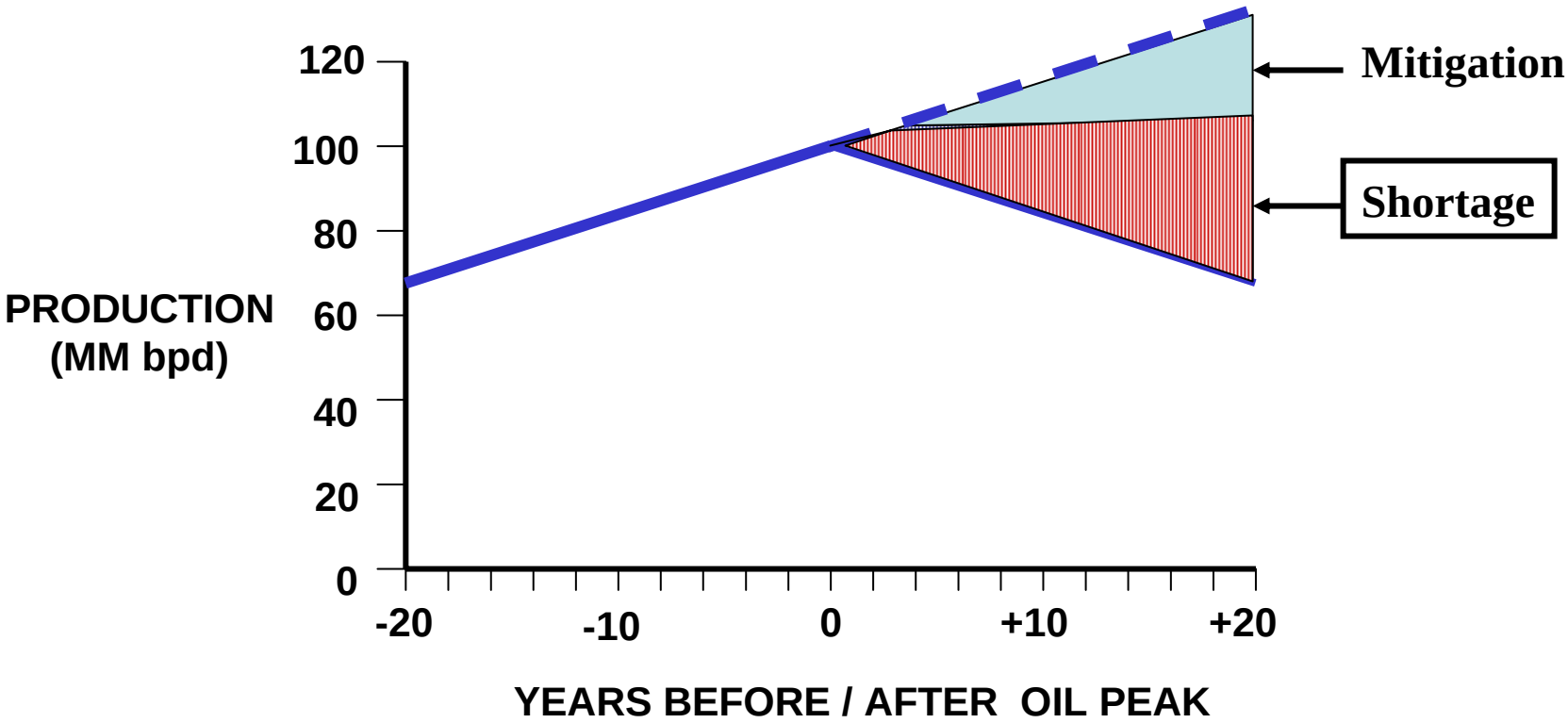
World modeled after the U.S. Lower 48 production pattern, 100 MM bpd at peak, & continuing demand associated with a growing world economy.

Apply the Wedges to World Demand & Production for the Three Scenarios

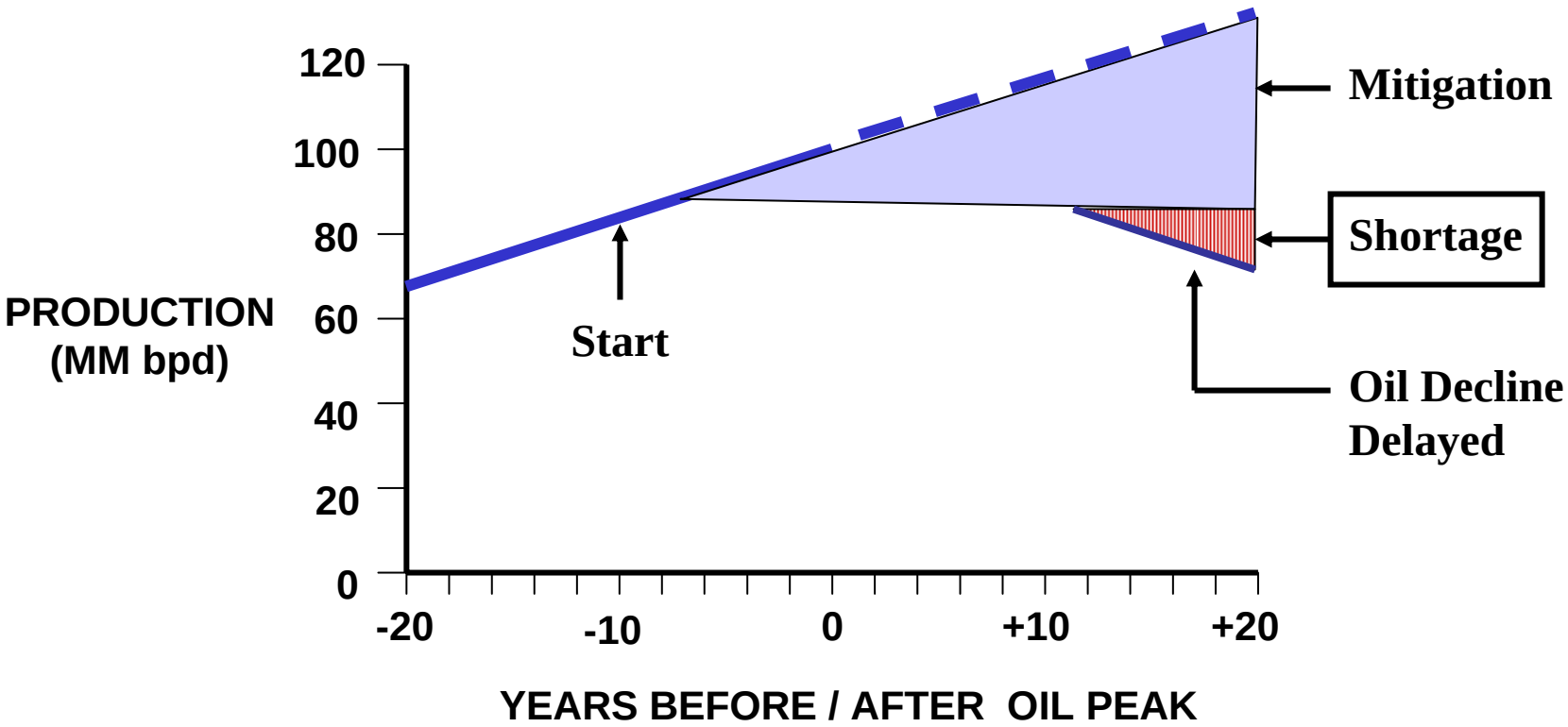




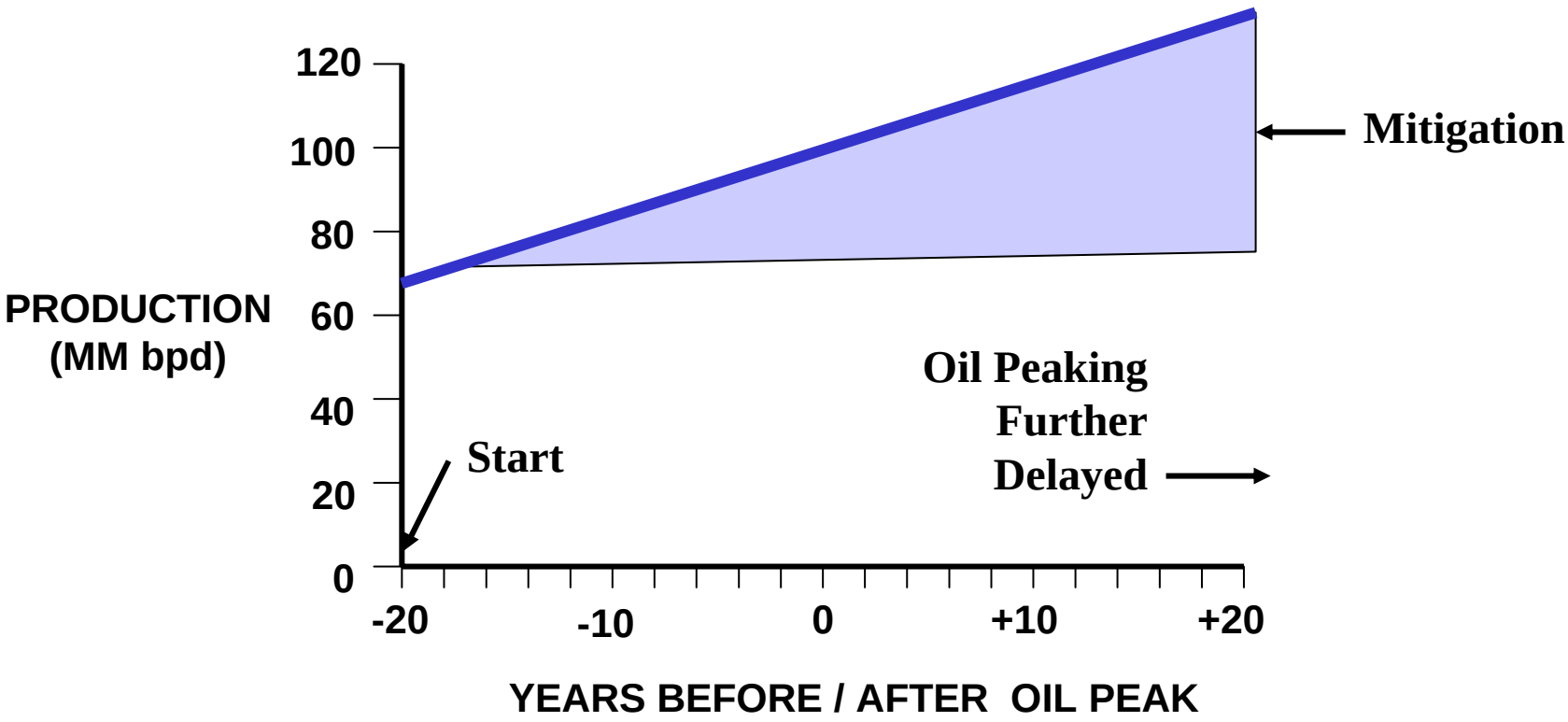
SCENARIO I: MITIGATION @ PEAKING



SCENARIO II: MITIGATION 10 YEARS BEFORE



SCENARIO II: MITIGATION 20 YEARS BEFORE



SCENARIOS ANALYSIS CONCLUSIONS

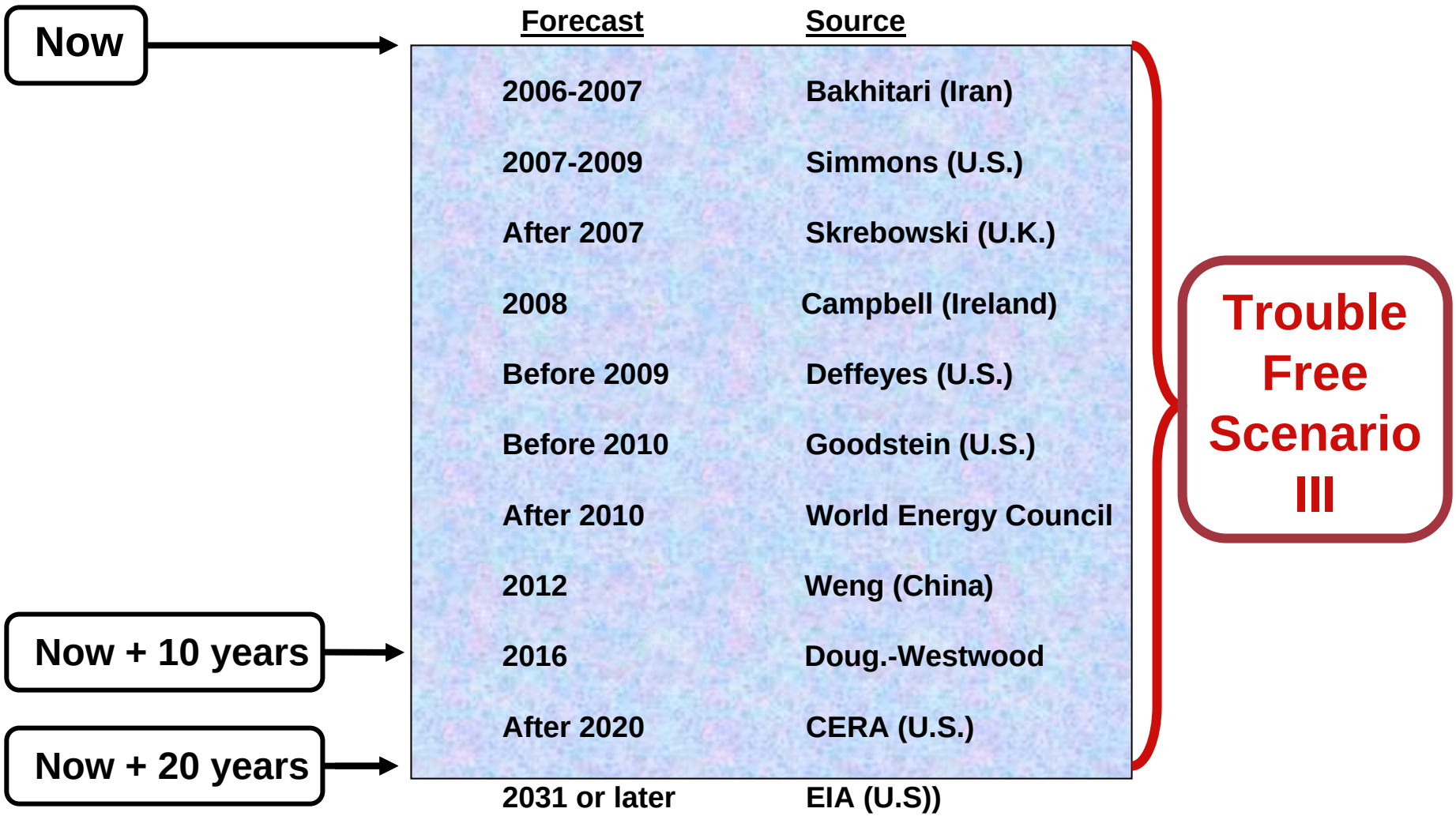
Basis: Immediate crash program mitigation

I. Wait for peaking → **Oil shortages largest, longest lasting**

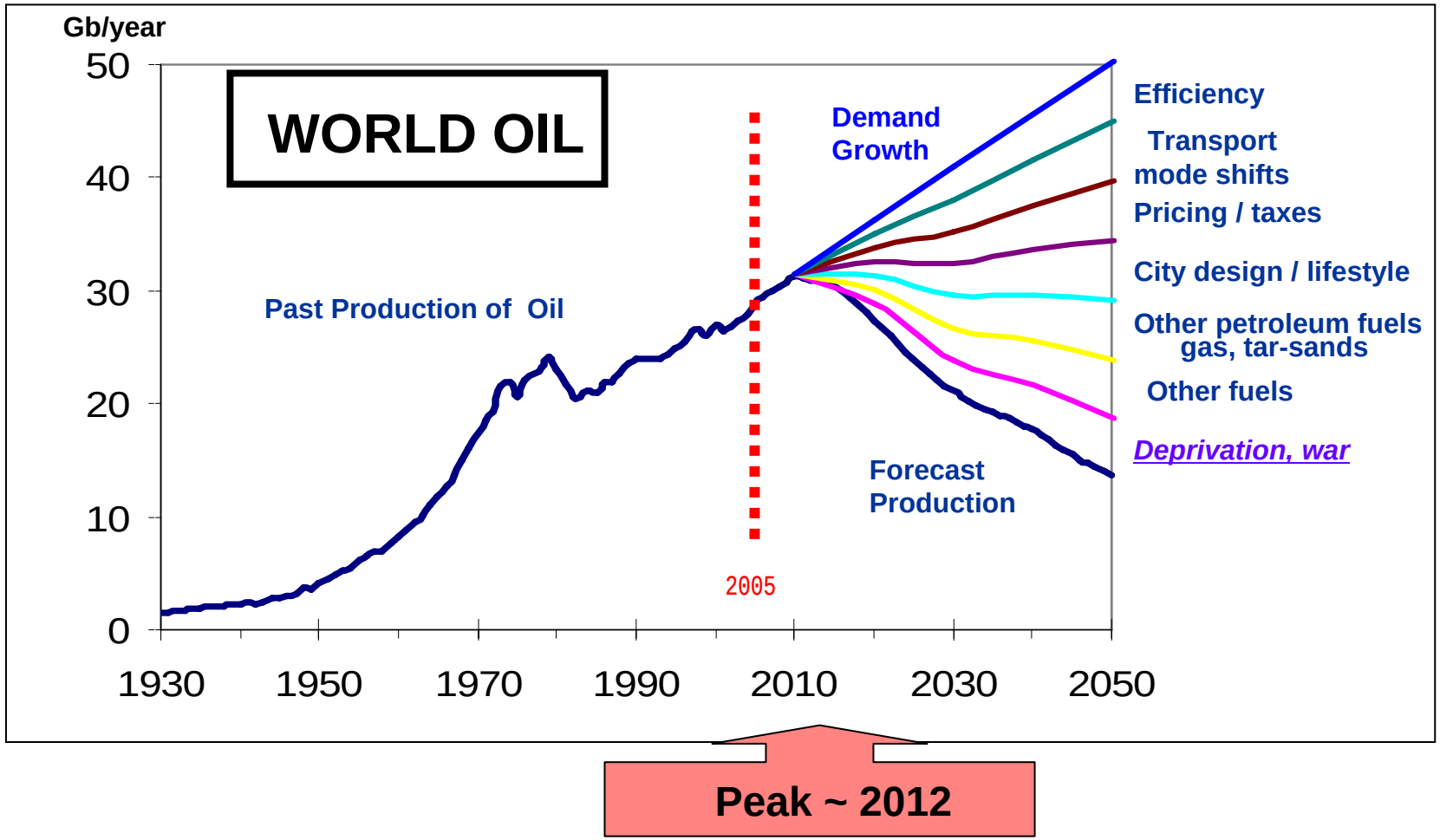
II. Start 10 years early → **Delays peaking; still shortages**

III. Start 20 years early → **Avoids the problem; smooth transition**

Forecasts of World Conventional Oil Production Peaking



A Chinese View on Peak Oil



- no single "Magic Bullet" solution
- probably no replacement ever for cheap plentiful oil
- Urgent preparation and adjustment are vital

"The Chinese government is well aware of peak oil."

Dealing with Uncertain Oil Reserves Estimates

Most Agree

World conventional oil reserves data are uncertain & often political. Truth will be known after the fact.

Optimistic View

Peaking is decades away & markets will manage.

Concernist View

Peaking may occur soon & result in long-lasting, large-scale economic damage.

My Concern

The downside of the optimists-being-wrong is dire, which heavily skews the

RISK

Summary & Conclusions

- Oil peaking timing is uncertain.
  - It may be soon.
  - "Soon" is less that 20 years according to our analysis.
- Peaking = World's first forced energy transition.
- It's a world liquid fuels problem.
- A number of mitigation technologies are ready.
- With timely mitigation, economic damage can be minimized.