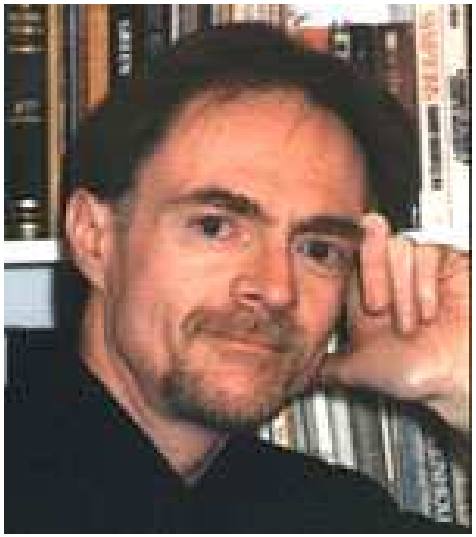
An Introduction of Richard Heinberg



New College of California, Santa Rosa, CA, USA

Seminar: Ecological Sustainability: Its relationship to Culture, Economy, and Society

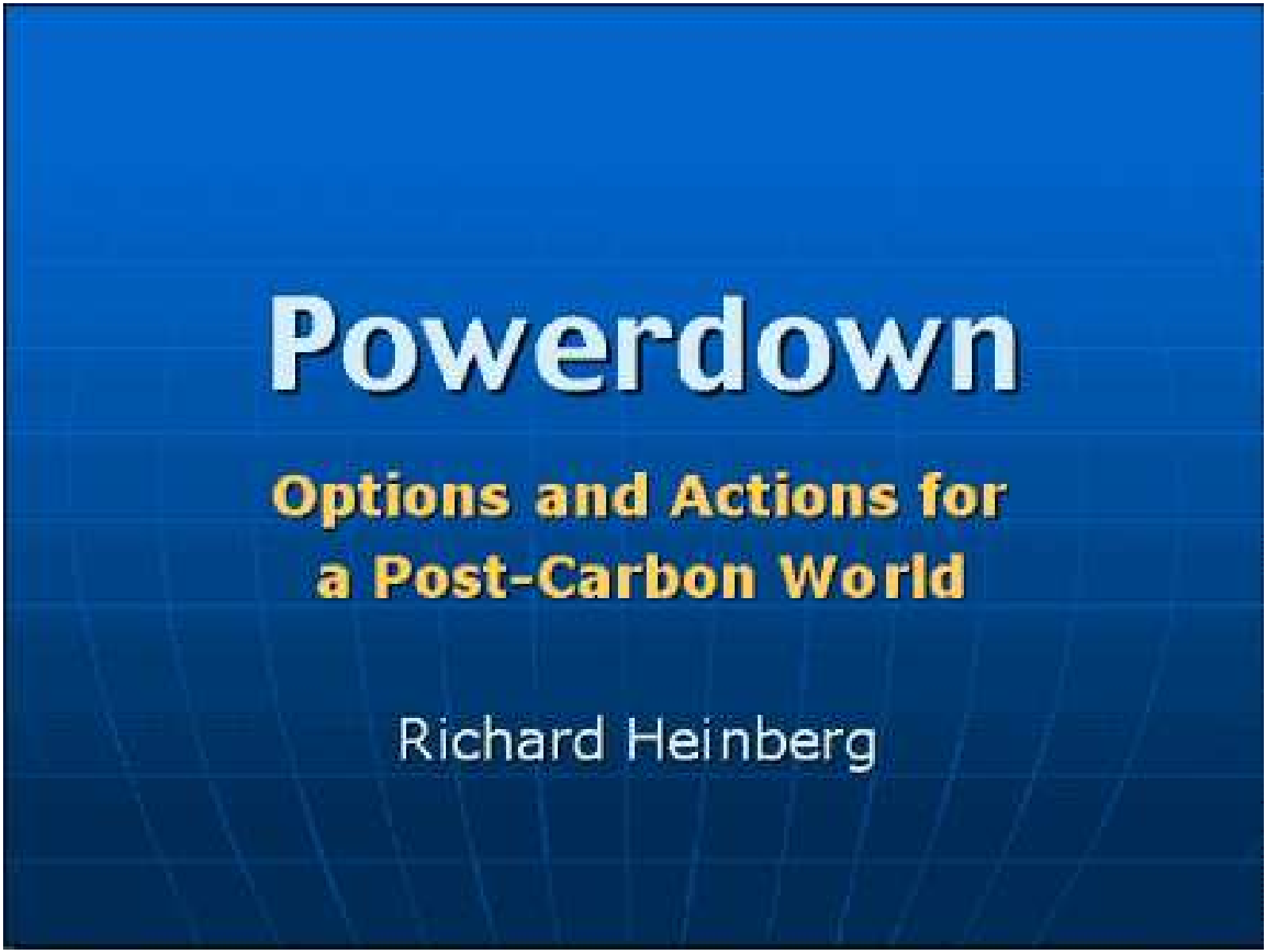
Utne's annual list of Best Alternative Newsletters

`http://www.museletter.com/`

Author of:

The Party's Over: Energy Resources and the Fate of Industrial Societies

Powerdown: options and actions for a post-carbon world.



- news can be unsettling
- seeking accurate map
- makes proposals

The Approaching "Perfect Storm"

- Global oil production peak
- Continuing population growth
- Declining per-capita food production
- Climate change, pollution, habitat destruction, loss of biodiversity
- Unsustainable levels of U.S. debt

- 1999: 6 billion population
- + North America since
- debt different, but:
- investment for alternative energy and agriculture?
- collapse of $?

- films:
  - End of Suburbia
  - We Feed the World
  - Day After Tomorrow (Documentary)
  - Walmart: The High Price of Low Prices

America in 1950

- World's foremost oil producer
- World's foremost oil exporter
- World's largest exporter of machine tools and manufactured goods
- World's foremost creditor nation
- Self-sufficient in nearly all resources

- much has changed since 1950

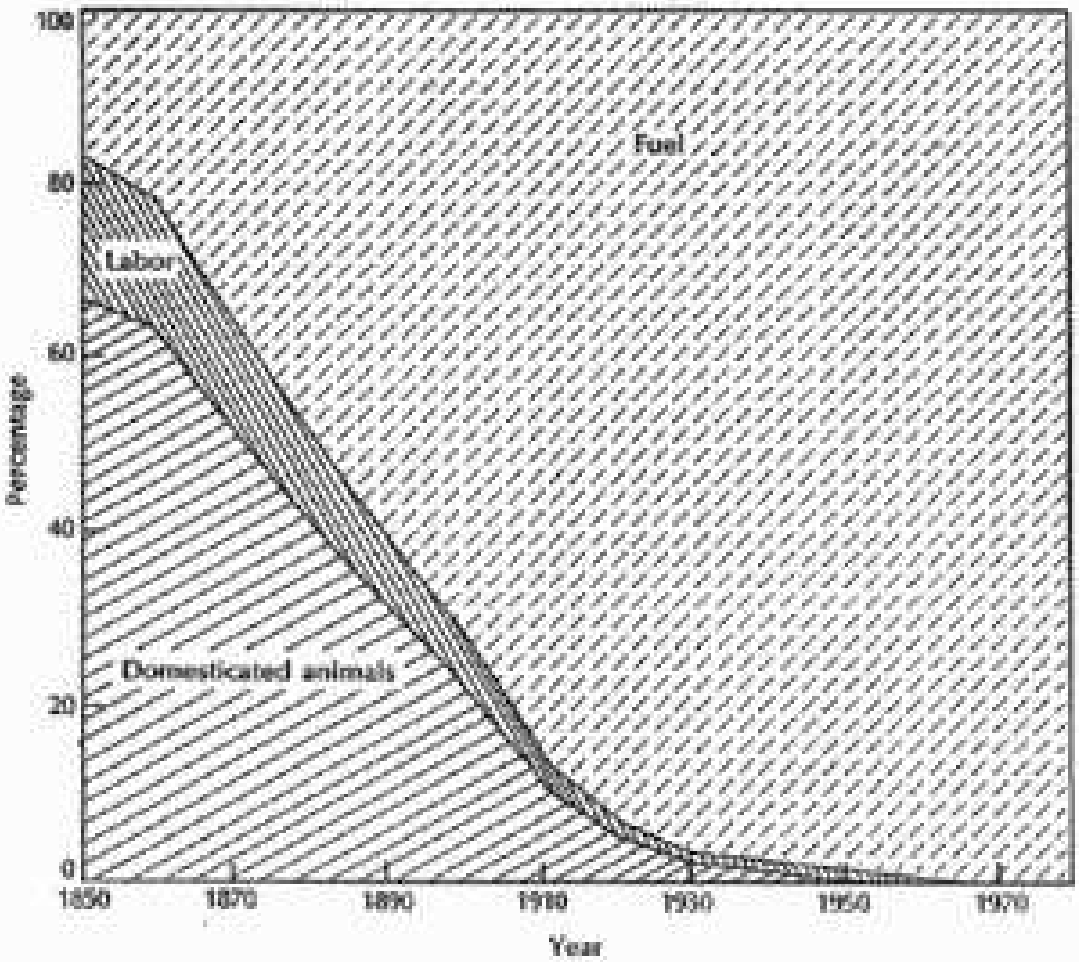
America in 2004

- World's foremost oil importer
- World's foremost debtor nation
- World's foremost importer of manufactured goods and non-petroleum resources
- Manufacturing jobs fleeing to other countries

- not just bad management
- largely due to depletion of energy resources

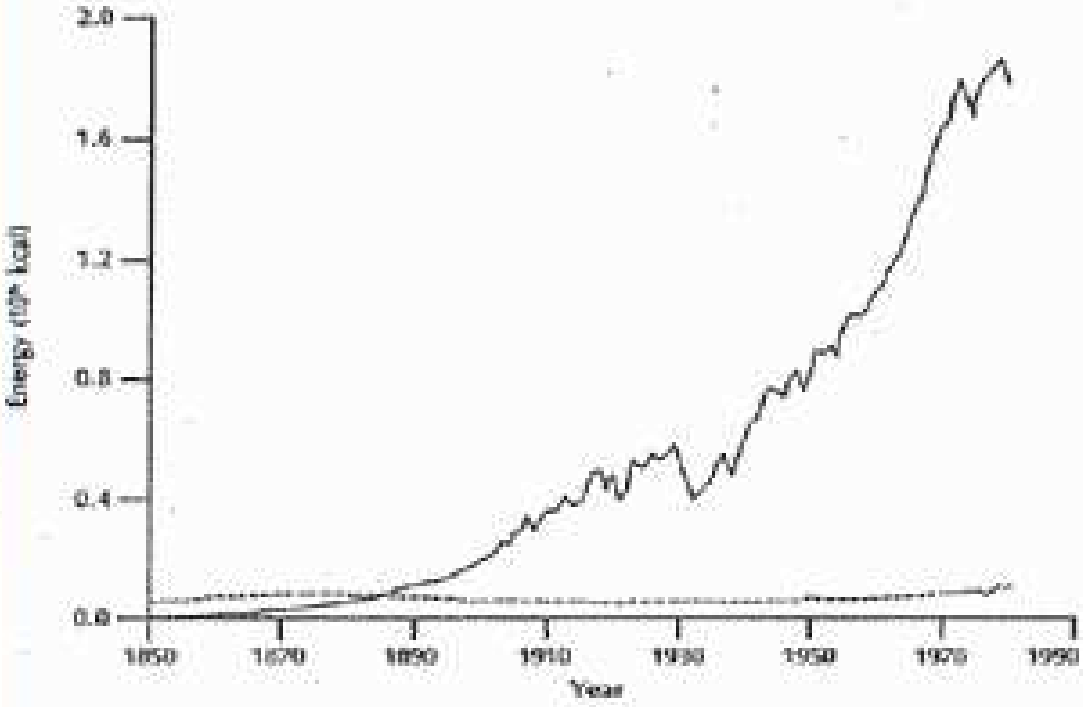
- oil industry in 1859
- Rockefellers, Standard Oil
- Rockefeller Foundation has funded pet projects:
  - molecular biology
  - alternative energy
- oil and money $\leftrightarrow$ American history since 1850

Figure 3–1. Stacked Representation of Work Done over Time in the United States by Humans, Domesticated Animals, and Machines, as a Percentage of the Total Horsepower in the Economy



- work done by:
  - domesticated animals
  - humans (slaves)
  - machines
- 1960: all fuel-fed machines

Figure 2–1a. Quantity of Energy Supplied by Nonrenewable Fuels Such as Oil, Gas, Coal, and Nuclear Electricity and the Amount of Energy Supplied by Renewable Sources Such as Wood, Wind, and Hydroelectricity and Food Consumed by the U.S. Population



Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C.: USGPO, 1975); U.S. Department of Energy, *Monthly Energy Review* (Washington, D.C.: DOE, various years); U.S. Department of Energy, Energy Information Administration, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981* (Washington, D.C.: USGPO, 1982).

Note: Dotted line is renewable fuels; solid line is nonrenewable fuels.

- nonrenewable grows
- renewable relative constant
- renewable-2004 $=$ 2 $\times$ renewable-1850
- US economy grown with nonrenewable energy

Energy Slaves

- Every year, each U.S. citizen uses, on average:
  - 8,000 pounds of oil
  - 5,150 pounds of coal
  - 4,700 pounds of natural gas
  - 1/10th pound of uranium
- If one "person-power" is 0.25 hp or 635 Btu/hr, this is the equivalent of 300 persons working around the clock for each of us. (from Youngquist)

- tank up with 1 liter
- drive until empty
- push the car back
- cost still 1 euro

Why is Oil Important?

- 97% of U.S. transport energy
- Critical for industrial agriculture, chemicals, pharmaceuticals, and clothing
- Many consumer products require oil feedstocks:

Ink • Dishwashing liquids • Paint brushes • Telephones • Unbreakable dishes • Insecticides • Antiseptics • Fishing lures • Deodorant • Tires • Motorcycle helmets • Linoleum • Clothing • Tents • Refrigerator linings • Paint rollers • Floor wax Shoes • Electricians tape • Plastic wood • Glue • Roller-skate wheels • Trash bags • Skis • Hand lotion • Clothesline • Dyes • Soft contact lenses • Shampoo • Panty hose • Cameras • Food preservatives • Fishing rods • Golf balls • Transparent tape • Anesthetics • Upholstery • disposable diapers • Cassettes • Maps • House paint • Electric blankets • Awnings • Ammonia • Car battery cases • Safety glass • Hair curlers • Synthetic rubber • Eye glasses • Vitamin capsules • Movie film • Candles • Rubbing alcohol • Loudspeakers • Credit cards • Fertilizers • Crayons • Insect repellent • Water pipes • Toilet seats • Caulking • Roofing shingles • Balloons • Shower curtains • Garden hose • Golf balls • Umbrellas • Detergents • Milk jugs • Faucet washers • Cold cream • Bandages • Antihistamines • Hair coloring • Nail polish • Guitar strings • False teeth • Yarn • Toothpaste • Golf bags • Tennis rackets • Toothbrushes • Perfume Luggage • Wire insulation • Shoe polish • Ballpoint pens •

Why exactly does a Society or an Economy depend upon Energy?

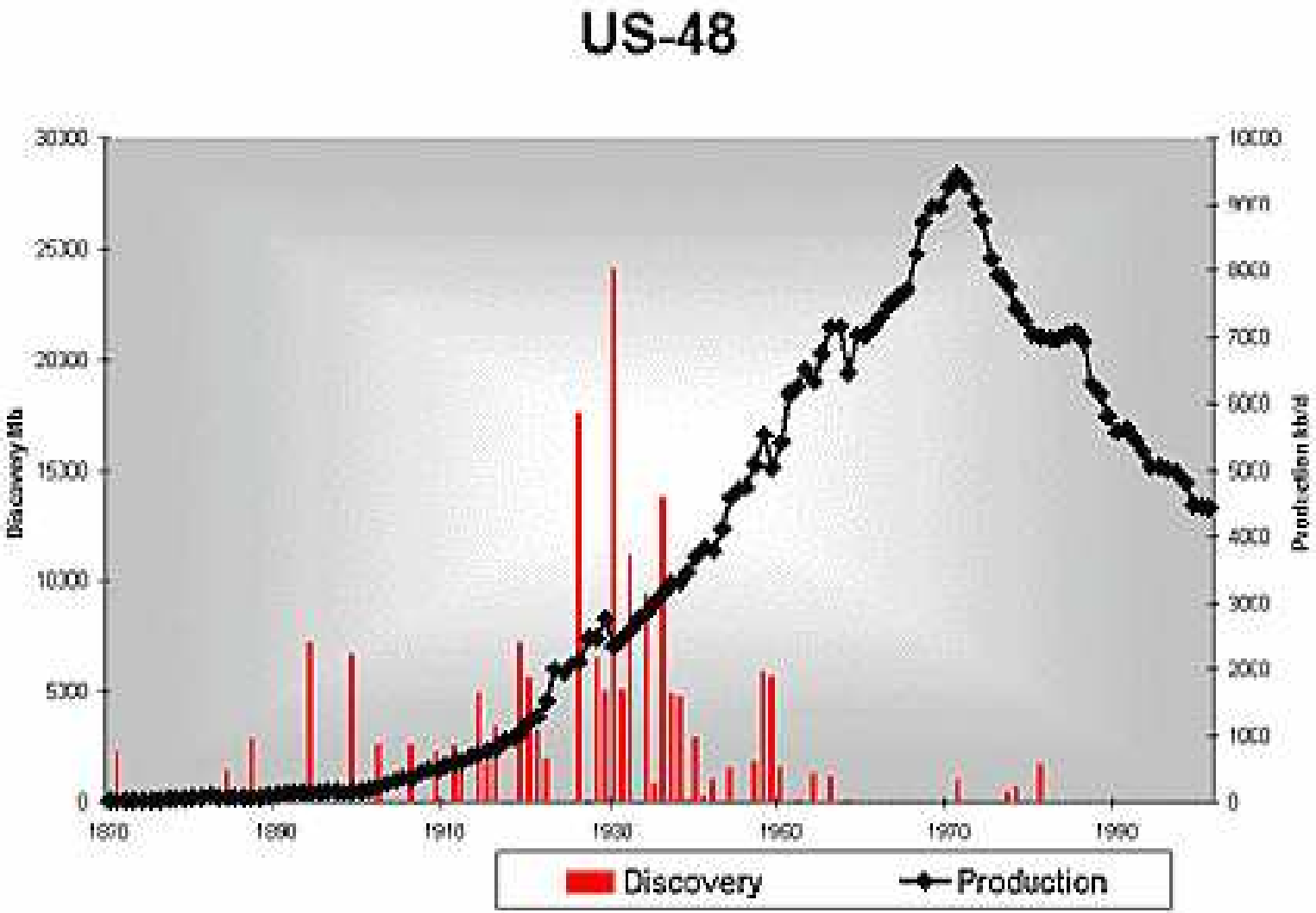
Thermodynamics

- Energy: capacity to move or change matter.
- First Law: energy forms can be converted, but energy is always conserved.
- Entropy: measure of disorder or dissipated energy no longer convertable into work.
- Second Law: entropy never decreases in energy conversions of isolated systems.
- Work is required to create and maintain order, e.g., clean house, repaired car.
- Humans and societies create and maintain order naturally.
- There are no violations of thermodynamics...
- Humans and societies are open systems: energy and matter flow through them.

Order and complexity always have an energy cost.

Net Energy Compared by Energy Profit Ratio (EPR)

Process	EPR	Process	EPR
Nonrenewable		**Renewable**	
Oil and gas		Ethanol (sugarcane)	0.8–1.7
1940s	>100	Ethanol (corn)	1.3
today	10	Ethanol (corn residues)	0.7–1.8
Coal		Methanol (wood)	2.6
1950s	80	Solar space heat (fossil backup)	
today	8	Flat-plate collector	1.9
Coal liquefaction	0.5–8.2	Concentrating collector	1.6
Geopressured gas	1–5		
Electricity Production			
Coal		Solar	
US Average	9	Power satellite	2
Western surface coal		Power tower	4.2
No scrubbers	6	Photovoltaics	1.7–10
Scrubbers	2.5	Geothermal	
Hydropower	11.2	Liquid Dominated	4
Nuclear (light-water reactor)	4	Hot dry rock	1.9–13



In the US,

- discovery peaked in 1930
- 40 years later...
- production peaked in 1970
- despite intense efforts...
- plateau at best in 1980s
- US is the template

- after US peak in 1970...
- change of lifestyle? no...
- import more oil
- use military
- gas lines of 1973 Arab oil embargo, and
- price hikes of 1979 fall of Shah of Iran
- reveal: dependency and vulnerability

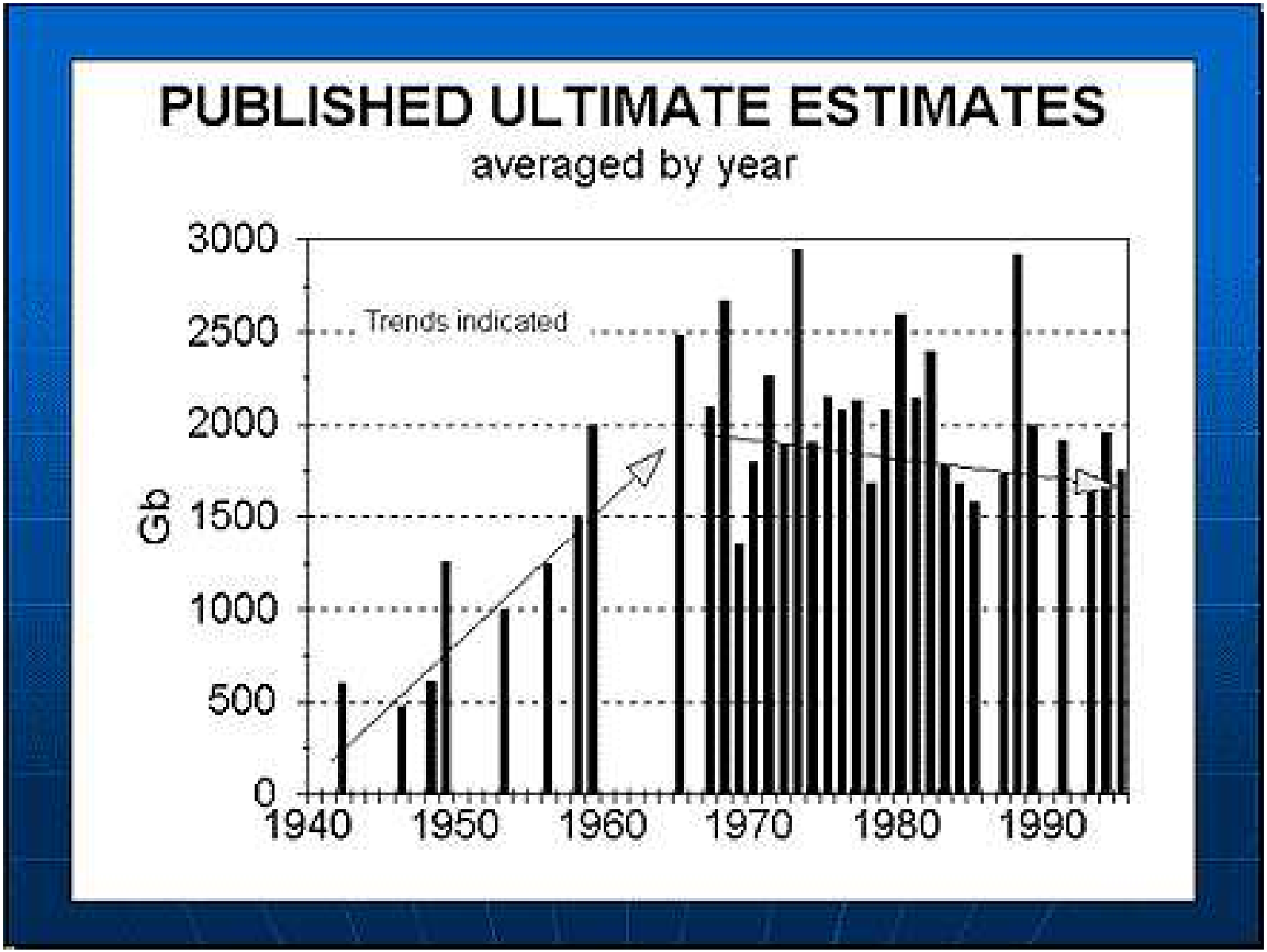
Following its national oil production peak, the US was able to compensate by importing more oil from other nations. Following the *global* oil production peak, we will not be able to compensate by importing more oil from other planets.

- significance no longer local

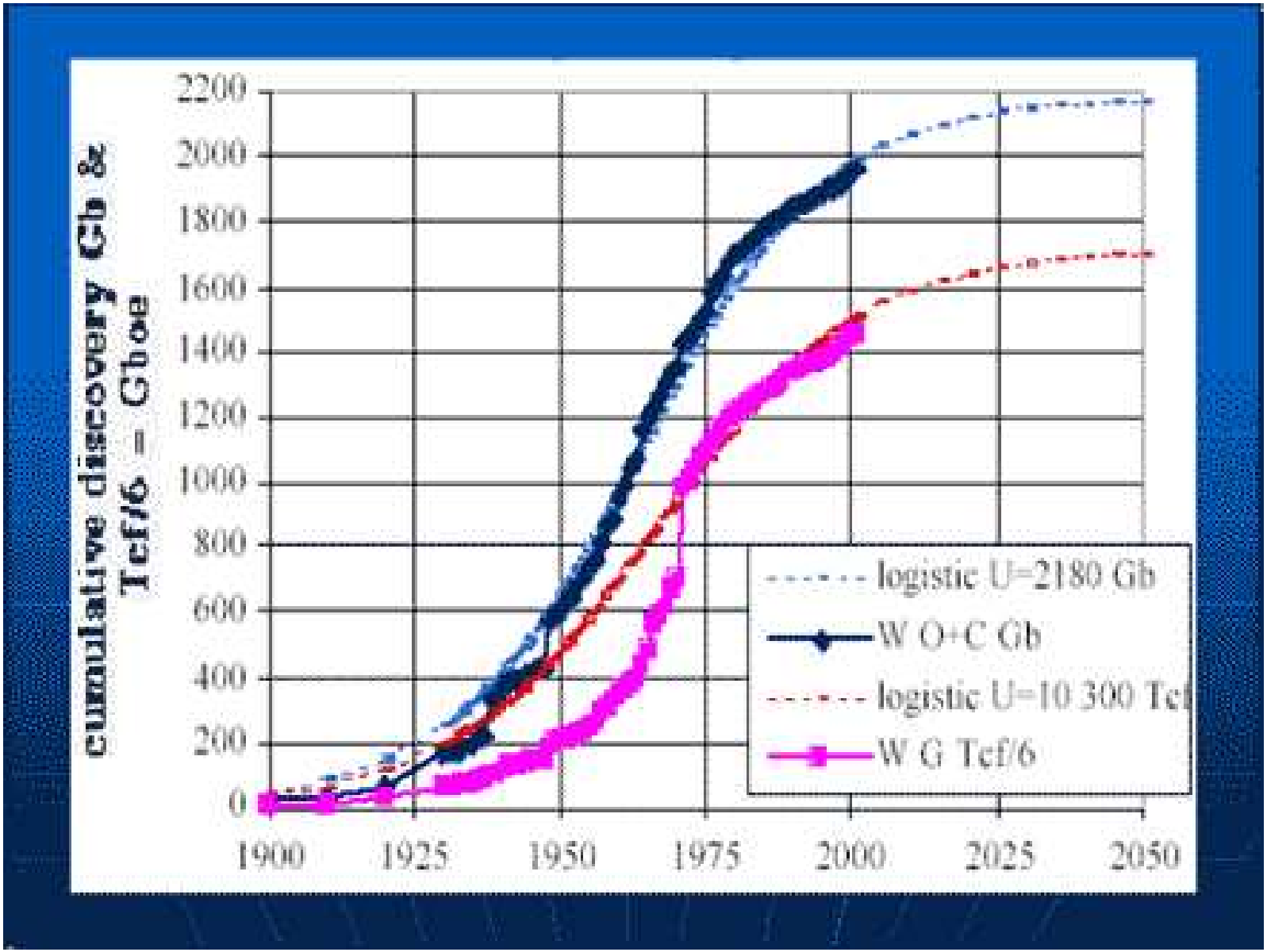
Four Ways to Predict Peak

1. Calculate the half-way point of extraction, based upon estimates of the ultimately recoverable resource, or URR (Hubbert, Campbell)

- global production peak...
- all agree it will happen...
- but when?
- estimates:
  - Deffeyes, Princeton: Thanksgiving 2005
  - official agencies: 2035
- half way in...
- bell-shaped distribution
- 30–60% never produced
- how much is recoverable?



- estimates converge on 2 trillion barrels
- $\approx |\text{Graz}-\text{Vienna}|^3$
- 1 trillion barrels already extracted!

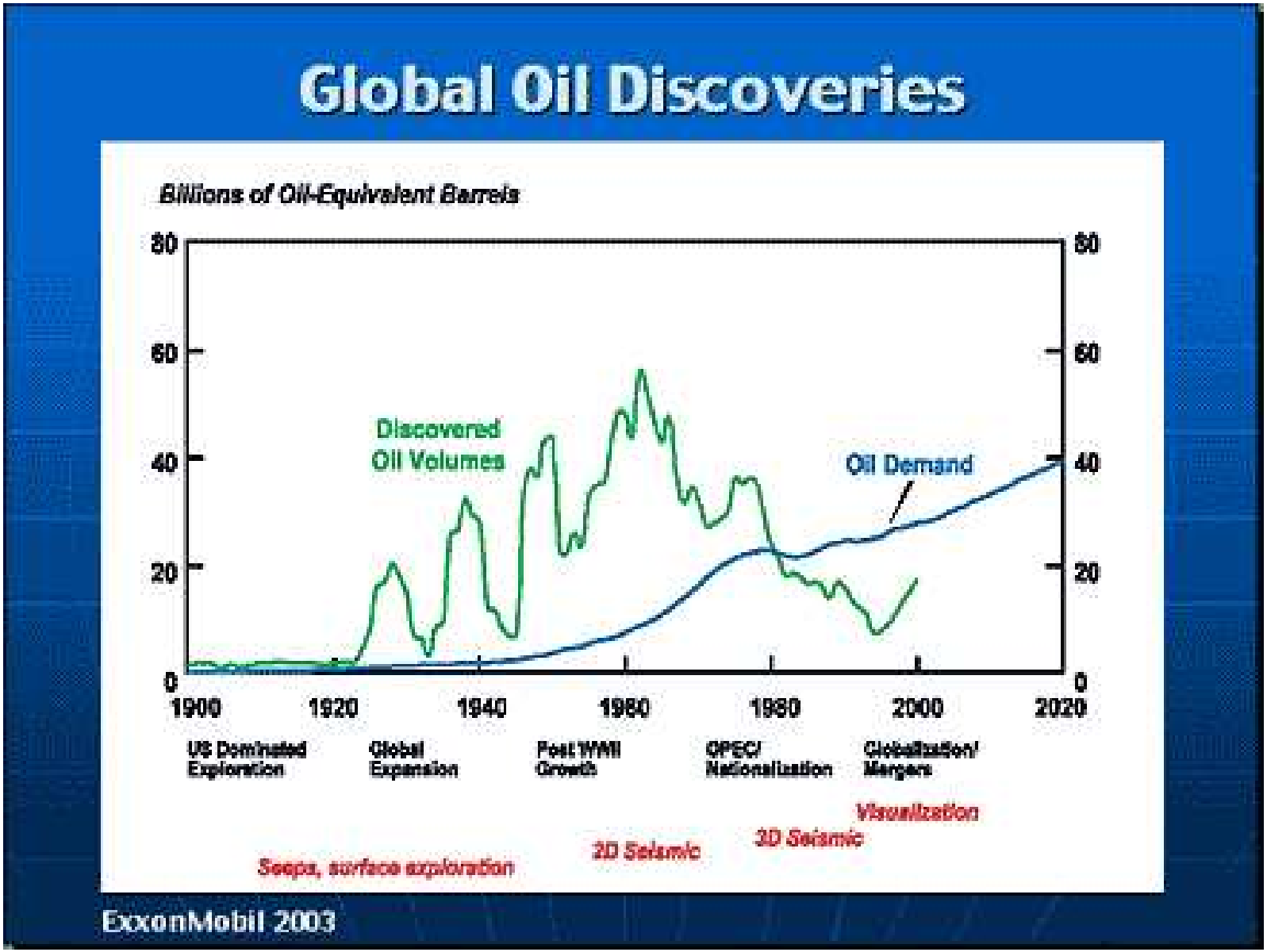


- creaming curves:
- cumulative discovery
- point to asymptote
- logistic curves point to roughly 2 trillion barrels

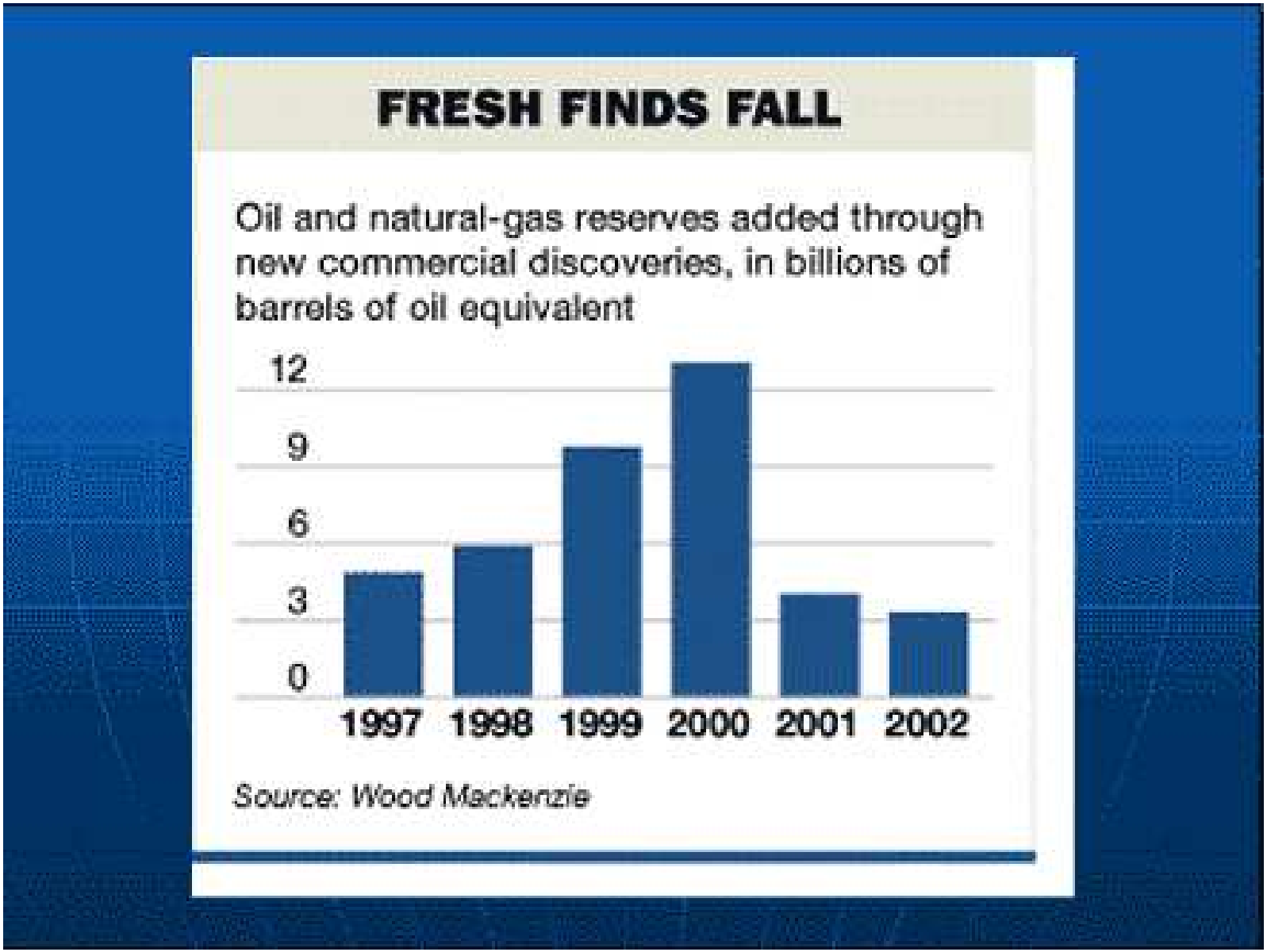
Four Ways to Predict Peak

2. Count the number of years from peak of discovery to peak of extraction (Campbell)

- on average difference is 40 years
  - North Sea: 30 years
  - Iraq: 50 years (sanctions)
- global discovery peaked in 1963...



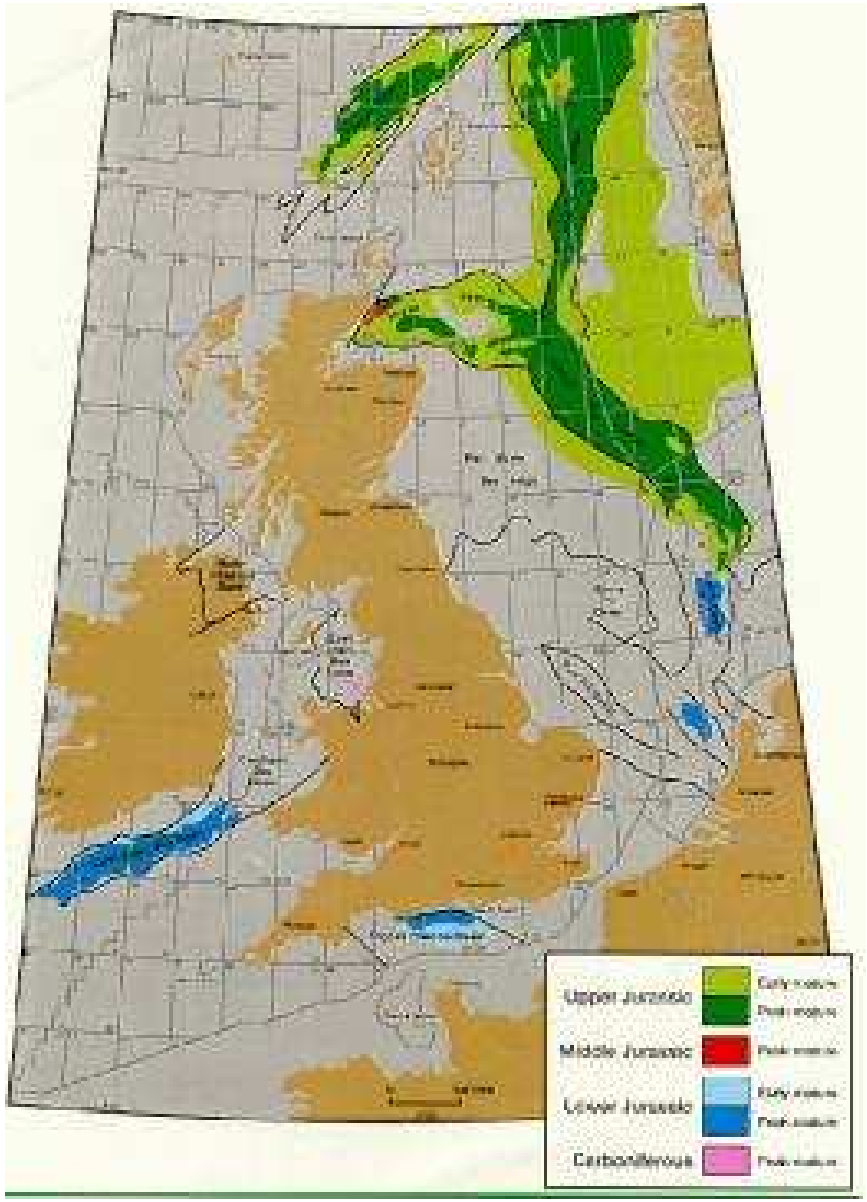
- from ExxonMobil:
- global discovery peaked in 1963
- discoveries going down since 40 years
- demand going up
- detail of latest discovery upturn...



- 1999 and 2000 very good discovery years
- discoveries made in Kazakhstan
- since then trend resumed

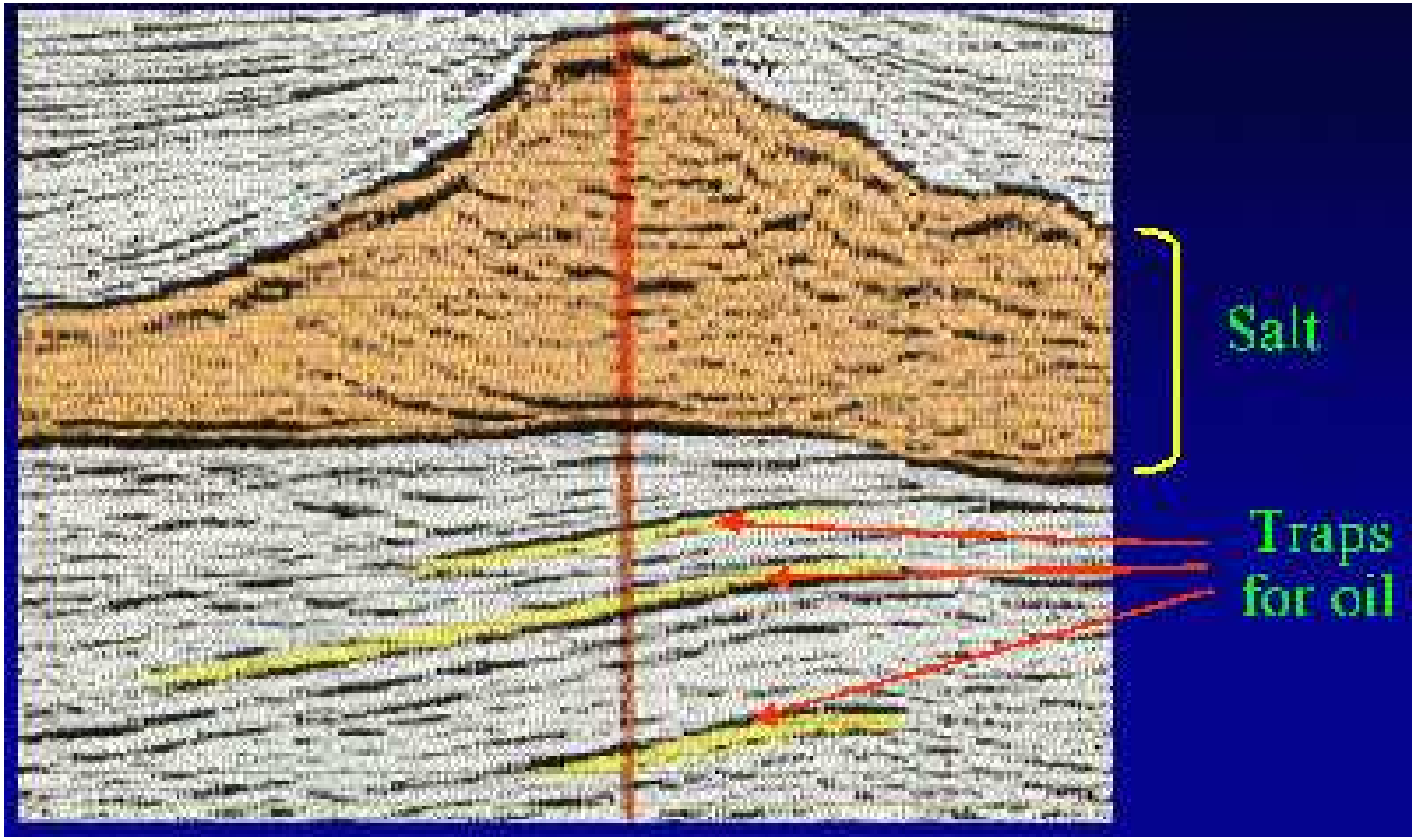
It appears that 2003 may be the first year since the dawn of the modern oil industry to have recorded no large oil discoveries at all, according to a recently published review by consultants IHS Energy. "One of the most significant concerns was that 2003 didn't produce large, unpredicted finds," said Ken White, Senior Editor of the IHS report, Discoveries and Highlights 2003. Chris Skrebowski, Editor of Petroleum Review, described the year's exploration results as "little short of horrifying" in a recent editorial, noting that "We would probably have to go back to the early 1920s to find a year when fewer large oil discoveries were made."

- 2003 was even worse
- global oil discoveries declining rapidly



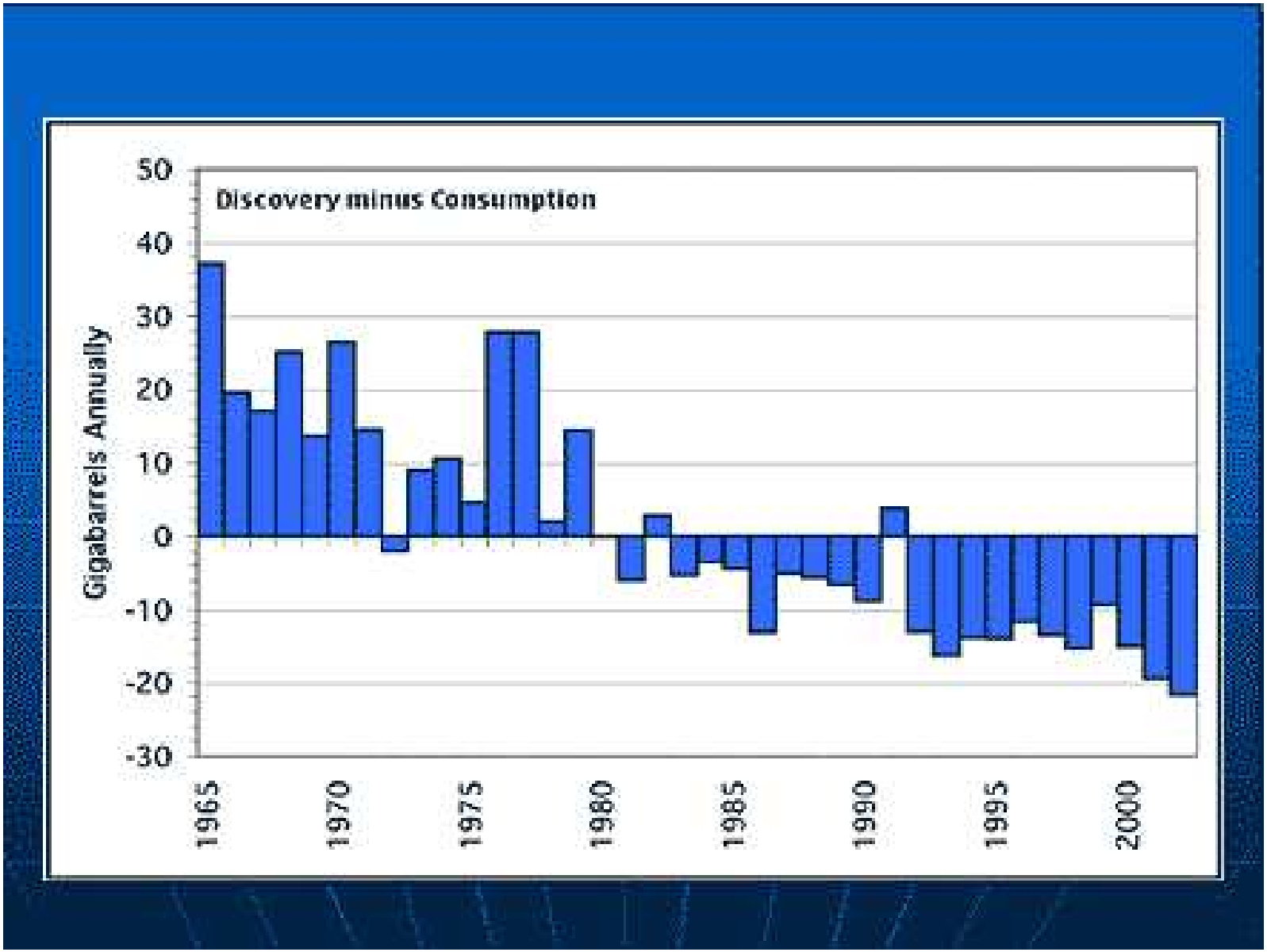
Campbell:

- geochemical breakthrough in 1980s made it possible to identify and map the generating belts.
- shown is the generating belt for the North Sea.
- the generating belts are known.

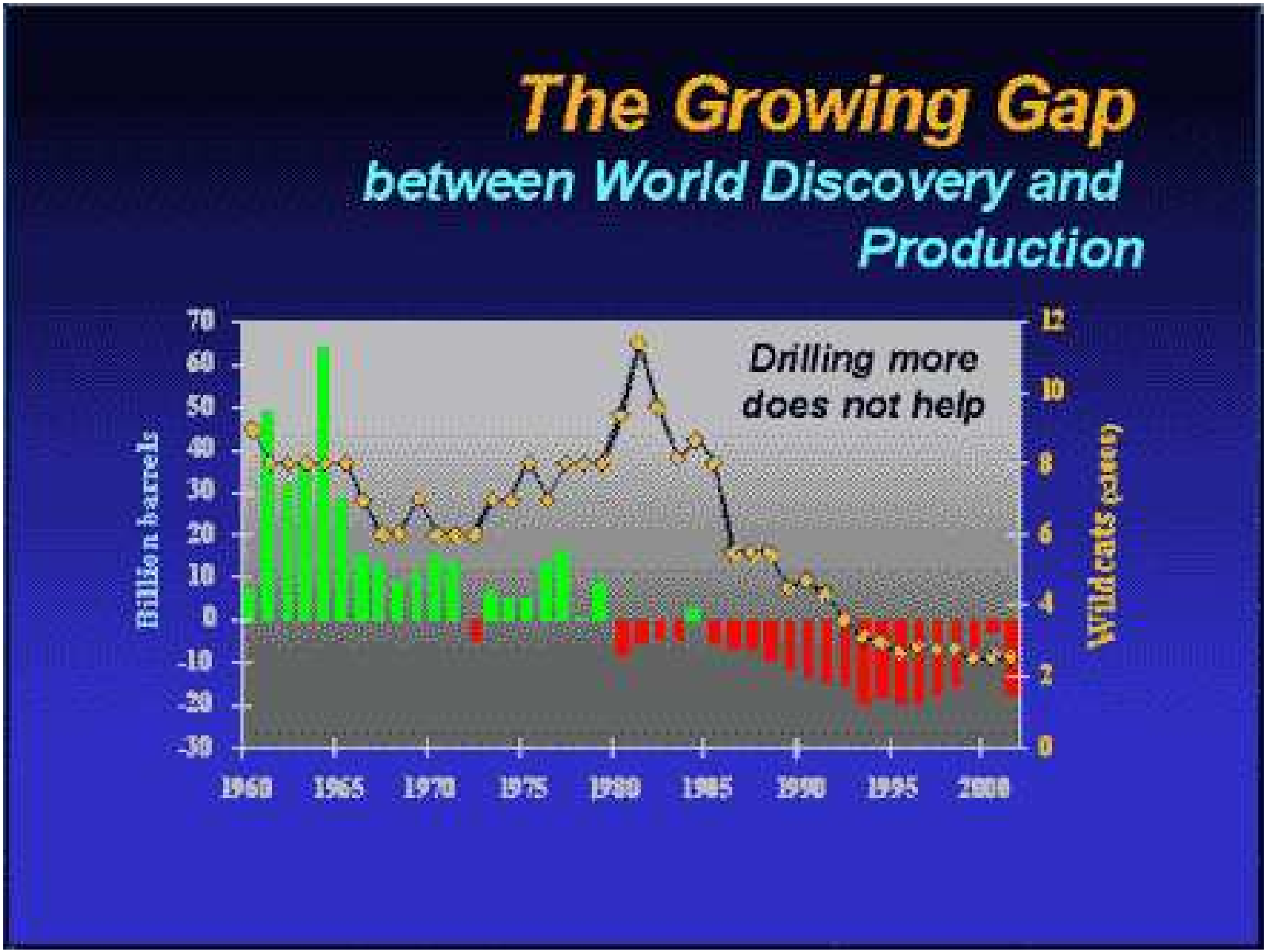


Campbell:

- seismic technology identifies the smallest traps
- ...but not necessary to find giant fields
- shows absence of large prospects



- 1960s:
  discover > extraction
- 1980: turning point
- today: extract 4 barrels for every 1 barrel discovered

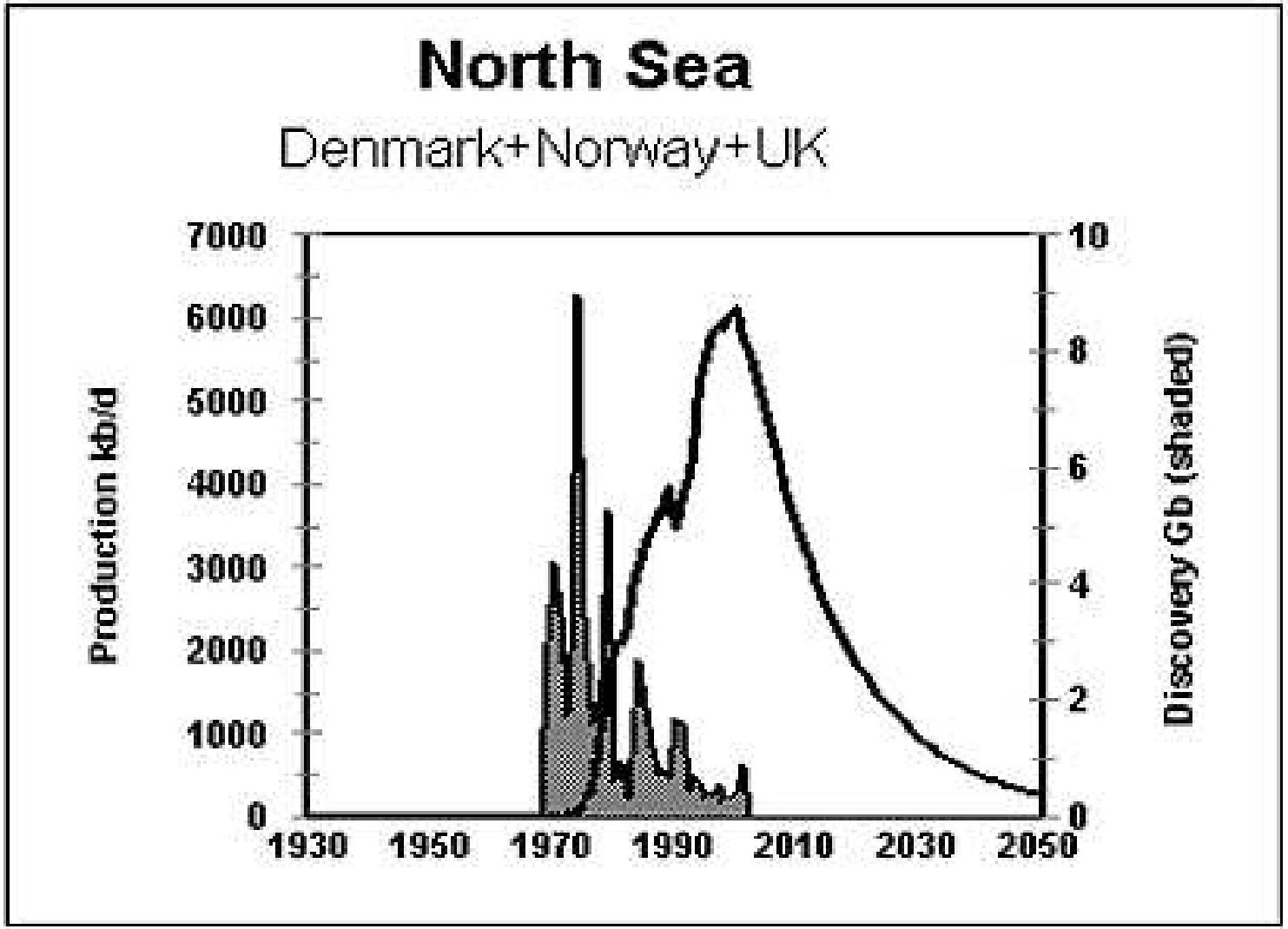


- superimposed is number of exploratory wells
- 1980s: heavy investment
- ...did not pay off
- 2003: 8 billion $ invested in exploration, and only 4 billion $ worth of oil found.

Four Ways to Predict Peak

3. Add up nation-by-nation peaks to arrive at the date for global peak (Richard Duncan)

- 44–45 significant oil producing countries
- 25 now past their peaks

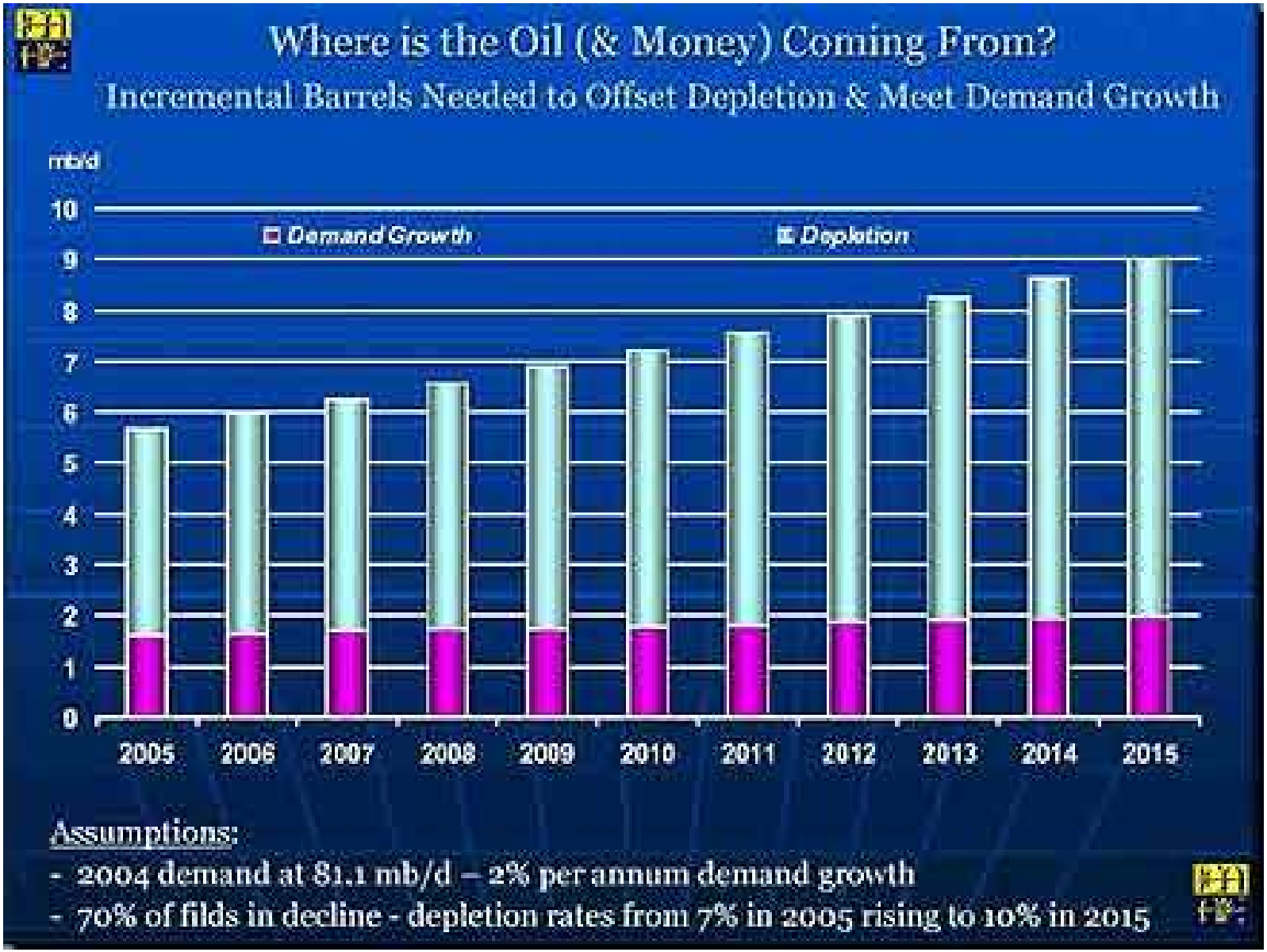


- after oil shocks...
- new source of friendly oil
- huge economic boost for Great Britain
- 2004: first year since 1970s for Great Britain to be net importer
- Duncan, Institute for Energy and Man: global peak in 2007

Four Ways to Predict Peak

4. Compare new production capacity needed in the next few years with the production capacity now in development (Chris Skrebowski)

- production capacity needed to stay even...



Internation Energy Agency (notoriously optimistic):

- 2004: 82 million barrels produced per day
- 2005: +1.5 million needed to meet new demand
- 2005: +4 million needed to offset decline in production
- 2006: even more, and so on
- requirements are cummulative...
- growing exponentially
- "Oil Field Megaprojects" (110kB/day at peak, 6 years discovery to production) after 2006: none

Jon Thompson, President of ExxonMobil Exploration Company, 2003:

"[W]e estimate that world oil and gas production from existing fields is declining at an average rate of about 4 to 6 percent a year. To meet projected demand in 2015, the industry will have to add about 100 million oil-equivalent barrels a day of new production. That's equal to about 80 percent of today's production level. In other words, by 2015, we will need to find, develop and produce a volume of new oil and gas that is equal to eight out of every 10 barrels being produced today. In addition, the cost associated with providing this additional oil and gas is expected to be considerably more than what industry is now spending."

- ExxonMobil says the same:
- ...need increase by 2015 of 80% of today's production...
- where does it come from?

Where Does New Production Capacity Come From?

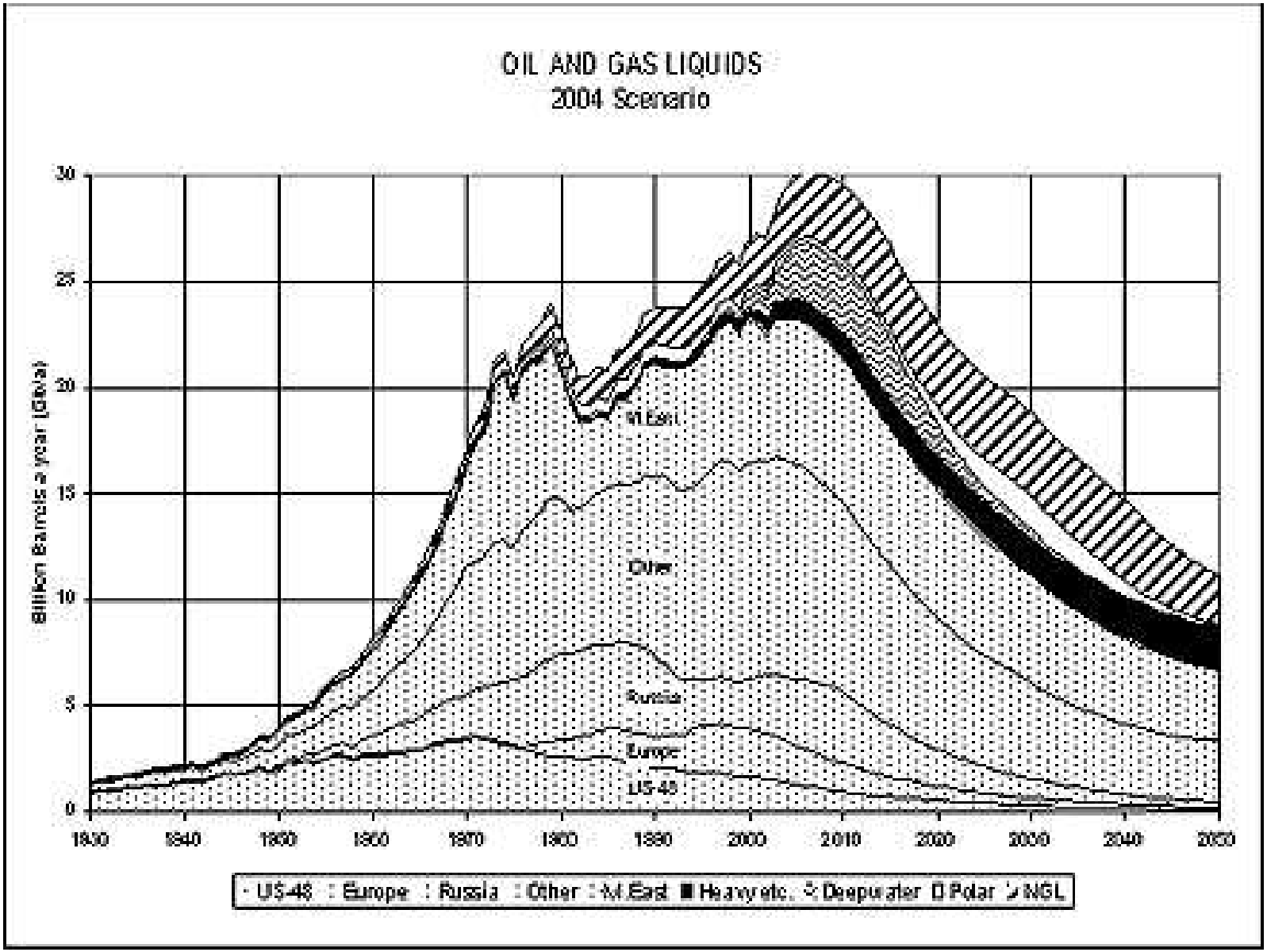
- New discoveries
- Development of unconventional resources
- Reserve growth
  - Underestimates of existing reserves
  - New recovery technologies

- new discoveries are declining rapidly
- unconventional:
  - deep water oil
  - natural gas liquids
  - tar sands from Alberta
  - shale oil from Colorado
  - polar or heavy oil from Veneuzuela
- extremely expensive
- reported reserves "grow"
- legitimate: more recovery
- manipulative: taxes and ability to satisfy stockholders
- no real reserve growth in new fields: already processed with new technology

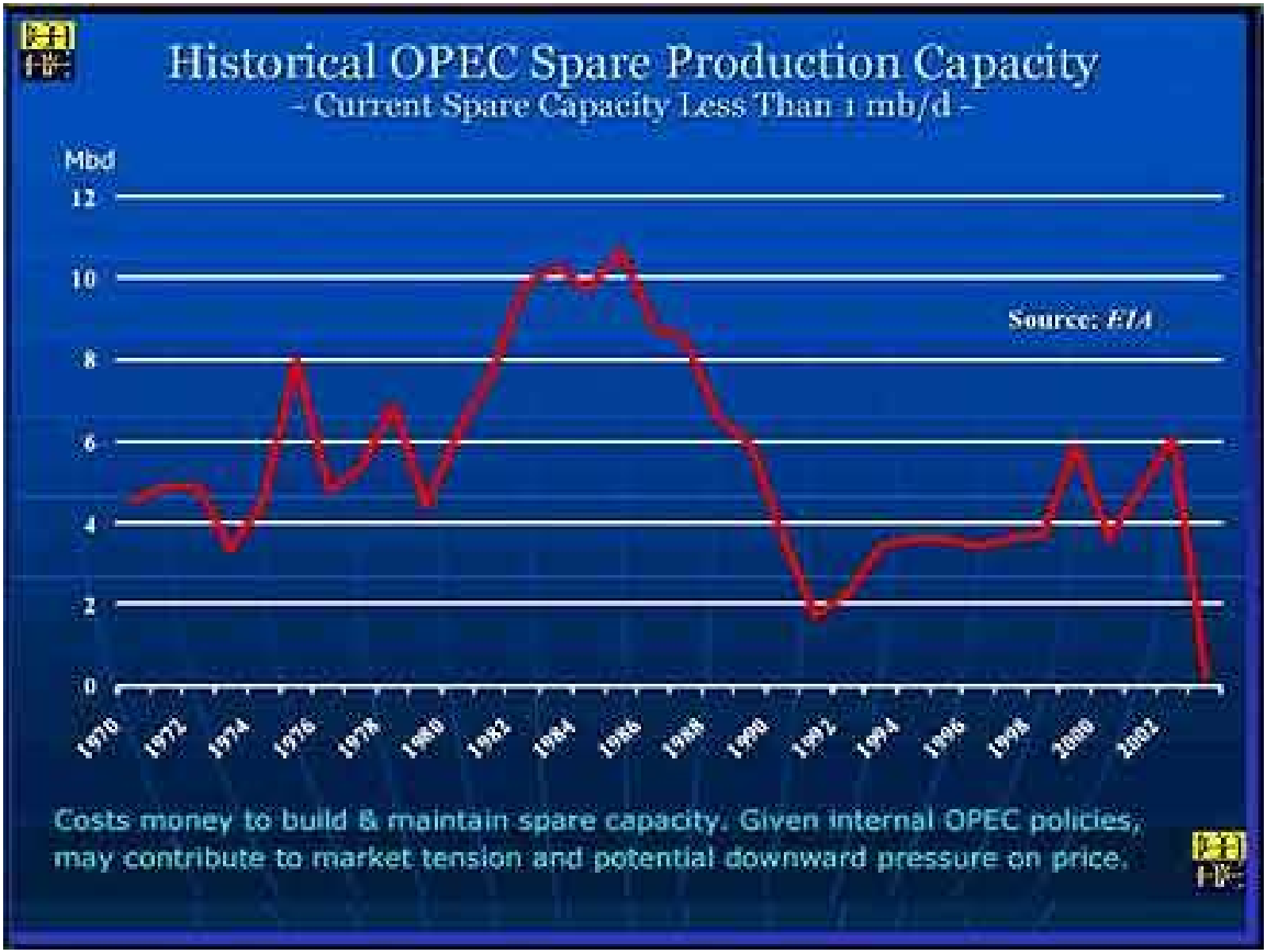
Where Does New Production Capacity Come From?

- New discoveries
- Development of unconventional resources
- Reserve growth
  - Underestimates of existing reserves
  - New recovery technologies

- newest fields (coming on line within 5 years):
  - coast of Nigeria
  - coast of Brazil
  - Gulf of Mexico
  - ...deep water projects (demand is high enough)
- Sum of new projects: 7–8 million barrels per day
- IEA: need 5.5 million new barrels per day in 2005, +6=11.5 for 2006, +6.5=18 for 2007, etc.



- conventional oil production has peaked
- unconventional:
  - deep water oil
  - natural gas liquids
  - tar sands from Alberta
  - shale oil from Colorado
  - polar or heavy oil from Veneuzuela



Internation Energy Agency (notoriously optimistic):

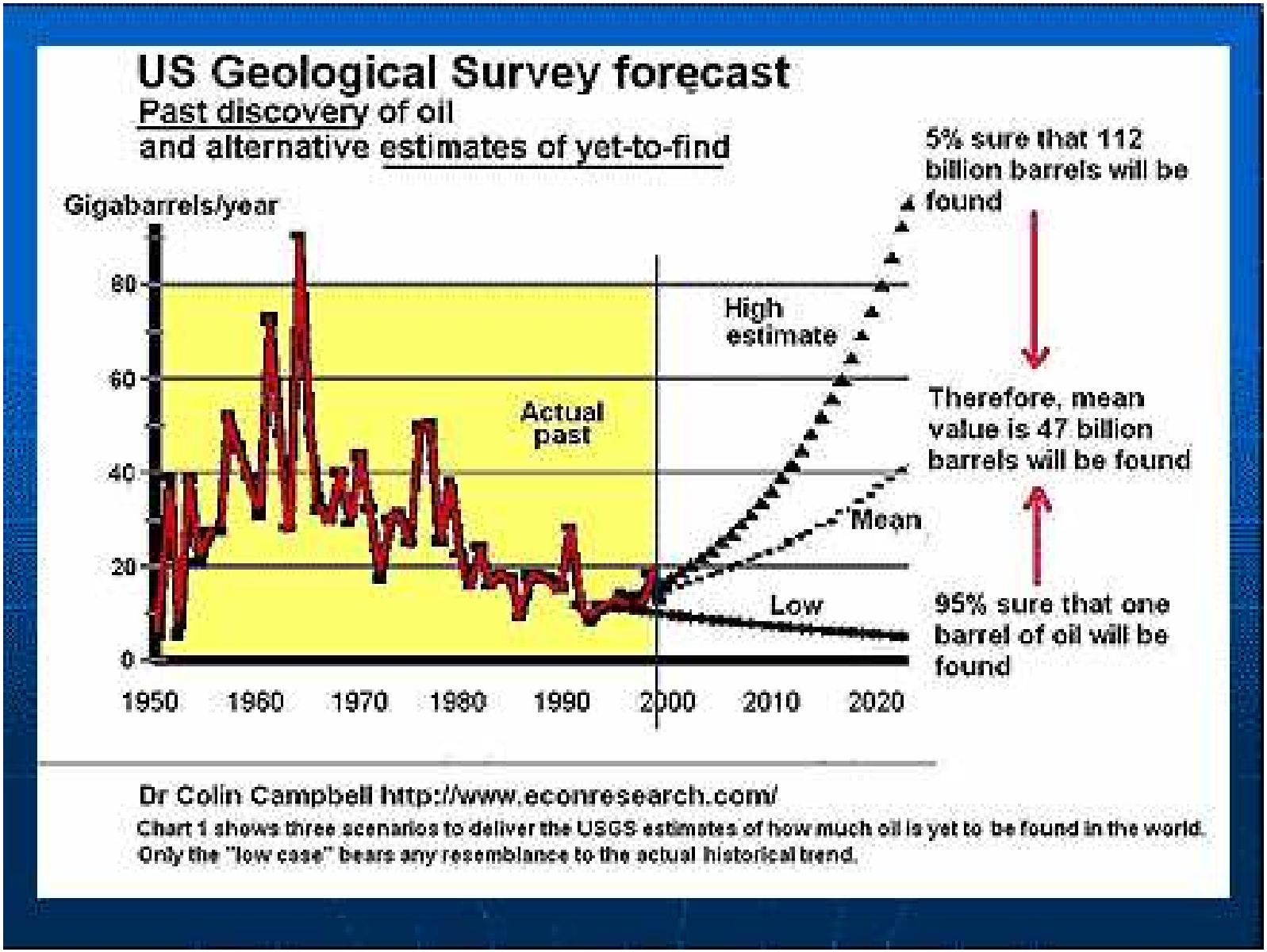
- industry wants 4–10 million barrels per day of spare production capacity.
- 2004: none remaining

Supply Crunch – The Coming "Oil Shock"?

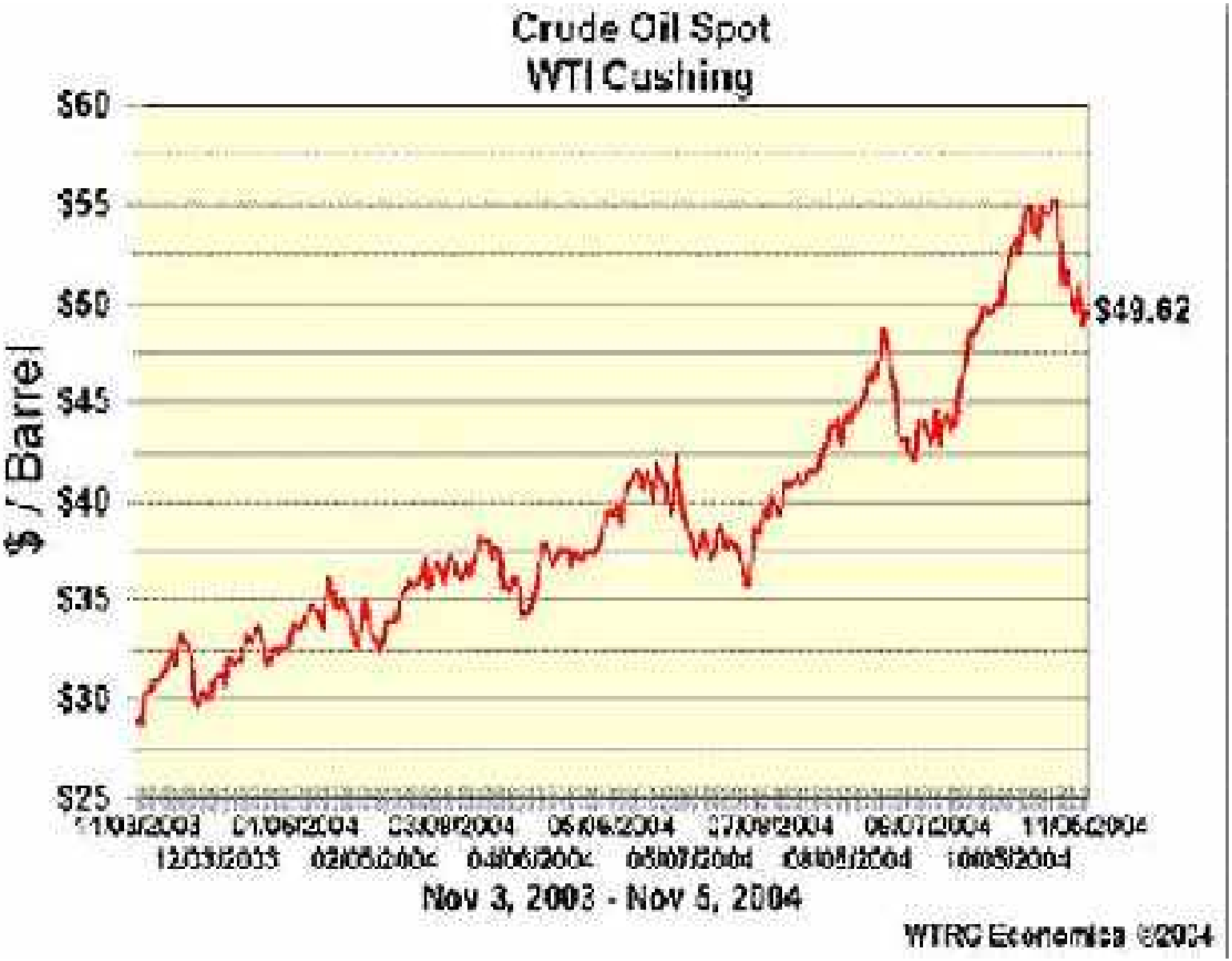
- While political oil embargo less likely some argue global economy faced with supply crunch ("peak oil") with similar devastating results
- Critical issue is on of reserves and depletion rates
  - Older fields are mature, declining
  - New discoveries smaller fields
  - Industry forced to produce-out more quickly
  - Global reserves over-stated for political reasons
  - Shift to more expensive, risky non-conventional areas
  - Have to run harder just to tread water (offset depletion)
- Resource constraints – already captured low-hanging fruit
- Supply constraints will push up price, limit demand growth, negatively impact & curtail economic growth

Internation Energy Agency (notoriously optimistic):

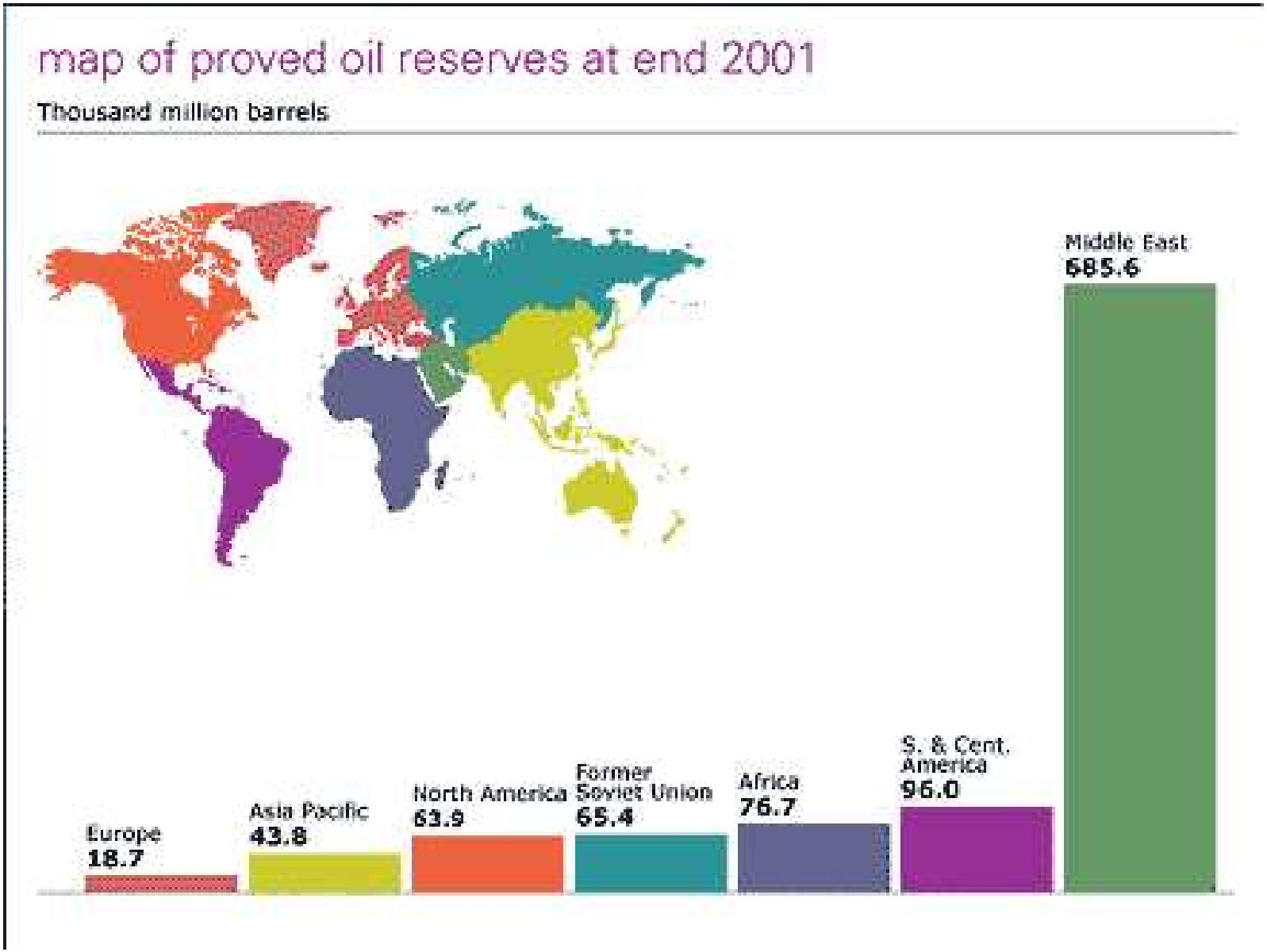
- admits: OPEC countries manipulate reserves which determine production quotas
- limits: Shell Oil had to downgrade its reserves
- "spreading" to other oil companies
- why aren't governments warning citizens?
- optimistic forecasting...



- optimistic forecasting?



- market senses the trend

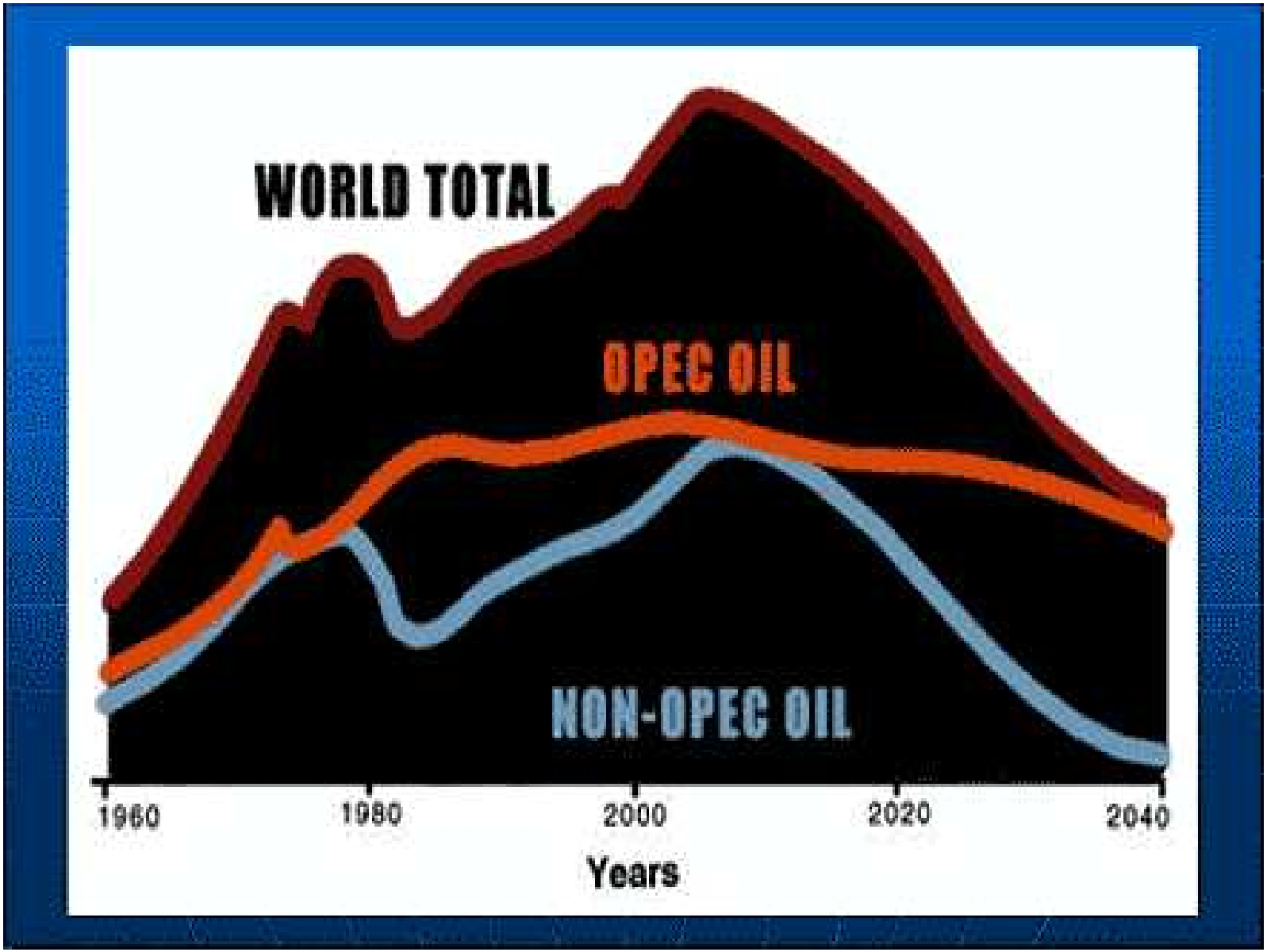


- green bar is overestimated
- should be about one-third shorter
- still mostly in the middle east (swing share)

Oil Endowment Horseshoe

MAP OF THE MIDDLE EAST SCHEMATICALLY SHOWING PETROLEUM ENDOWMENT HORSESHOE.

- most of the oil located in the horseshoe shaped region
- possibly *under*estimated?
- Matt Simmons:
  - energy investment banker
  - author: Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy



- non-OPEC production has peaked
- Middle East production has extreme strategic importance
- so what is the plan?...

- can cooperation be part of the plan?

- this name was changed

What Dick Cheney knew in 1999

In a speech to the International Petroleum Institute in London (late 1999), Dick Cheney, then chairman of the world's largest oil services company, Halliburton, presented the picture of world oil supply and demand to industry insiders. "By some estimates," Cheney stated, "there will be an average of two percent annual growth in global oil demand over the years ahead, along with, conservatively, a three percent natural decline in production from existing reserves."

Cheney ended on an alarming note: "That means by 2010 we will need on the order of an additional fifty million barrels a day."

This is more than six times Saudi Arabia's current output.

- Cheney's awareness of oil is known
- where will 6 times the output of Saudi Arabia come from?

Likely Forms of Resource Wars

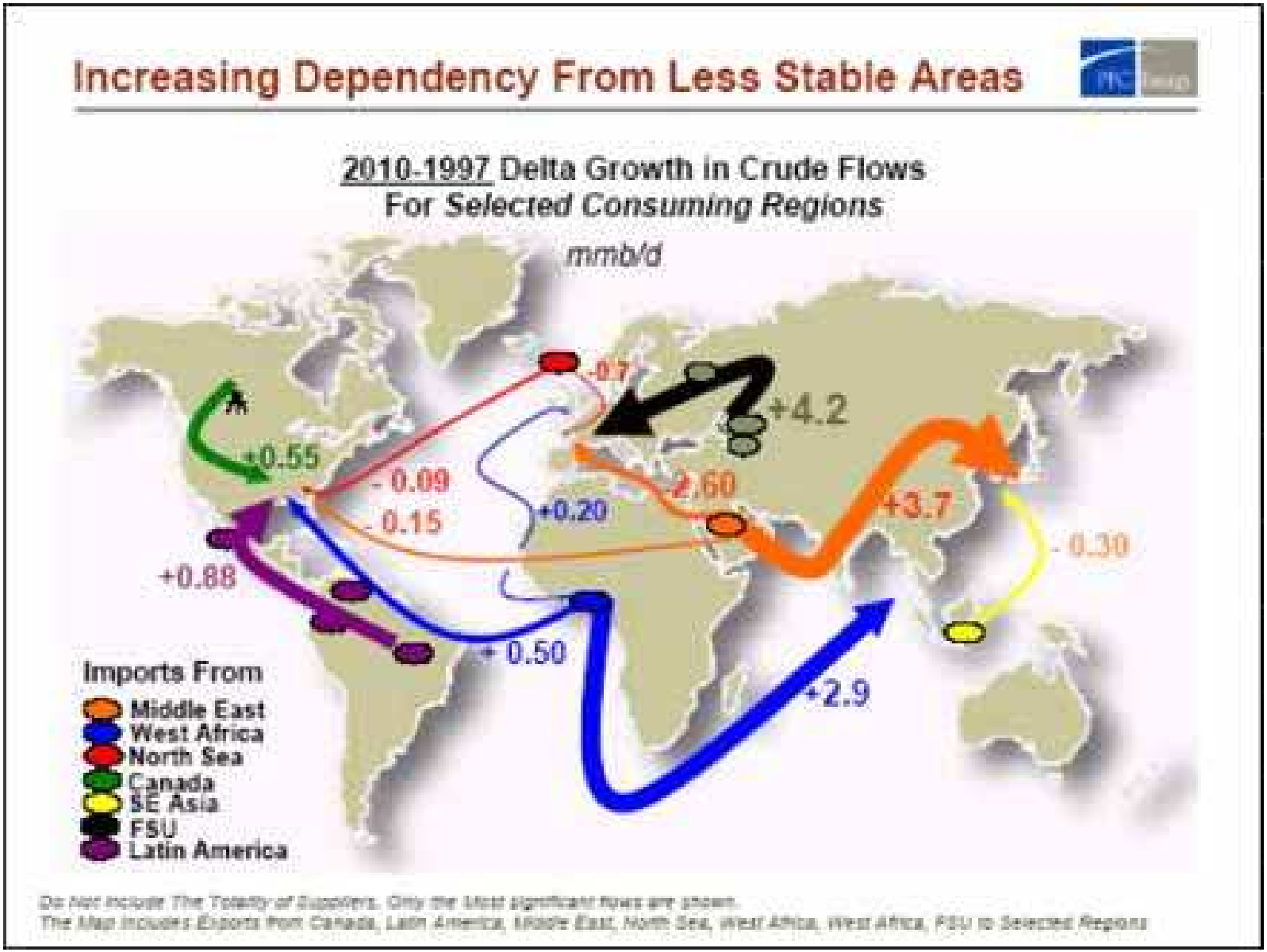
- Between rich consuming nations and poorer producing nations
- Between consuming nations
- Civil wars within producing nations for control of resources
- Asymmetrical warfare between rich consuming nations and non-state entities in producing nations

- Cheney: "...expect war for the remainder of our lifetimes..."
- poorer countries:
  - Venezuela
  - Columbia
  - West African nations
- consuming nations maneuvering economically:
  - western nations and China
  - latest Saudi contracts with China

Likely Forms of Resource Wars

- Between rich consuming nations and poorer producing nations
- Between consuming nations
- Civil wars within producing nations for control of resources
- Asymmetrical warfare between rich consuming nations and non-state entities in producing nations

- US and China locked in embrace:
  - US buys cheap goods from China
  - China buys American food
  - China buys (tremendous) US debt. `debt_clock`: $8 trillion total, $3–4 billion per day!
  - China seeks American companies
- China stops buying American debt: dollar collapses
- asymmetrical warfare: terrorism

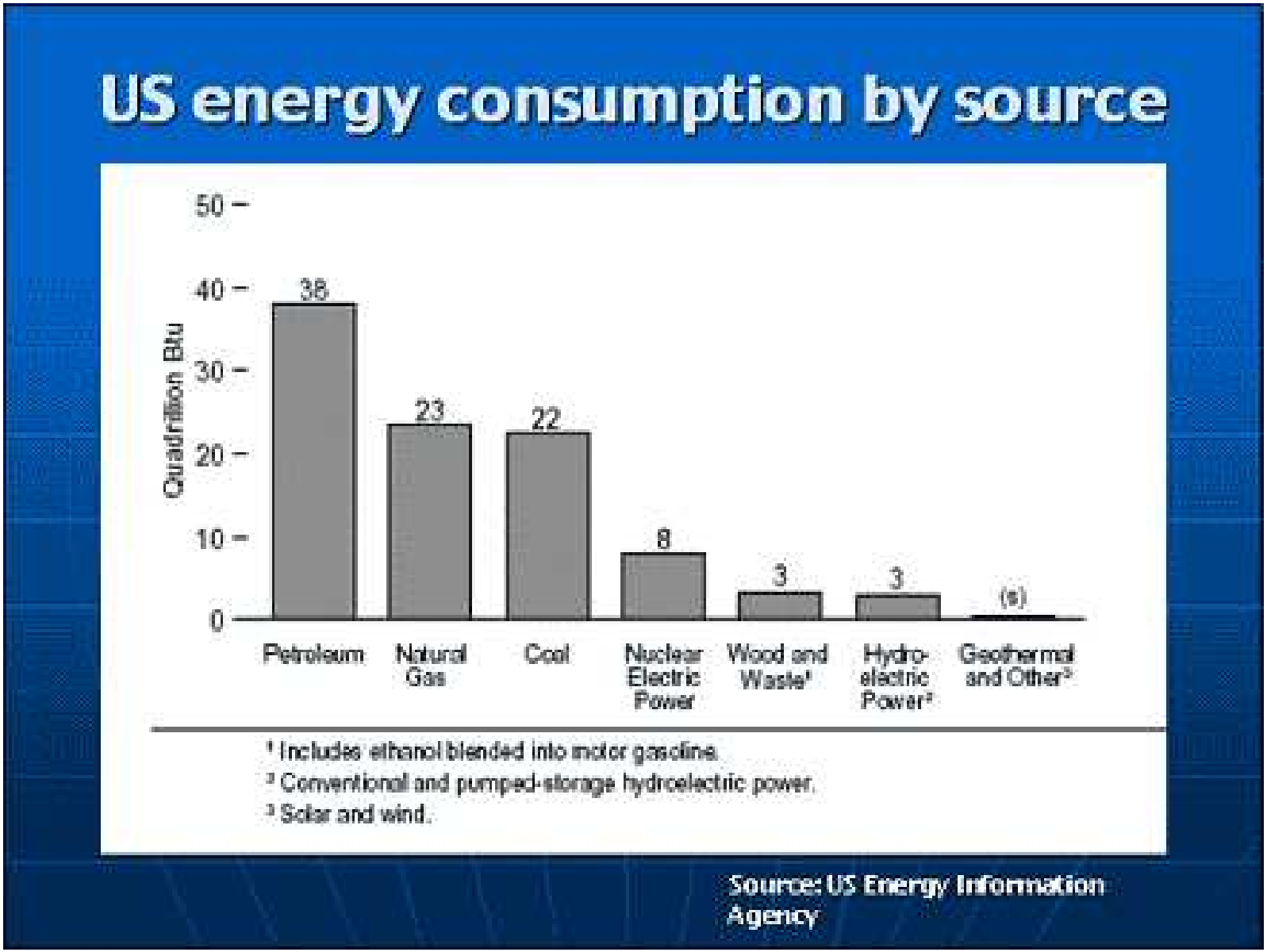


- shows increasing dependence on less stable areas of the world

Sites of Coming Oil Wars?

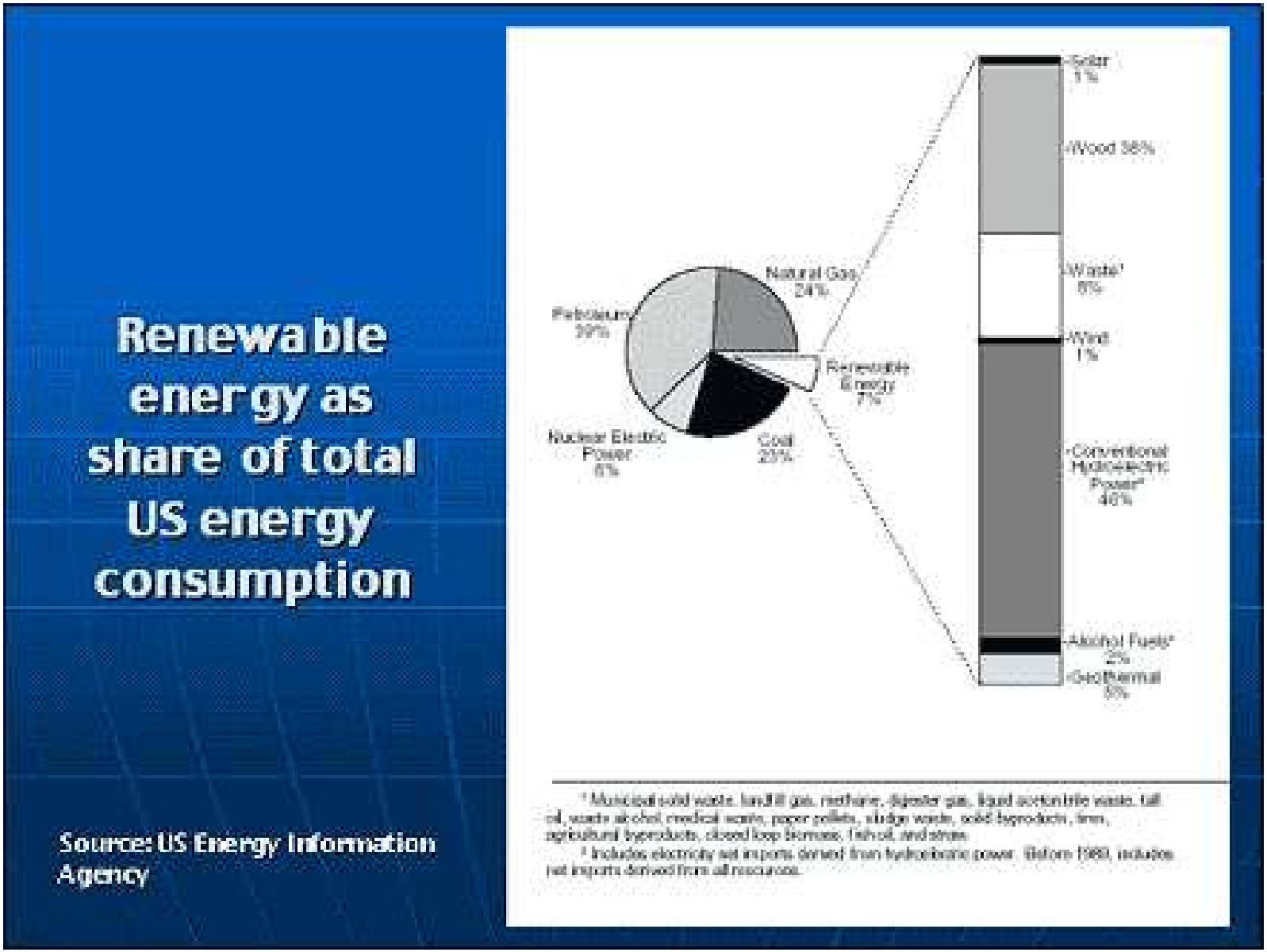
- Middle East
- West Africa
- South America
- Central Asia

- considerable discussion about the need for pipelines through Central Asia
- Central Asian reserves found to be dramatically less than expected



To avoid resource wars:

- find other energy sources
- now mainly: first three
- next prospects: next three
- other: solar and wind.



- renewables: 7%
  - hydroelectric: 40%
  - wood: 38%
  - waste: 15%
  - geothermal: 3%
  - alcohol: 2%
  - solar: 1%
  - wind: 1%
- solar+wind=0.14% of total
  - could grow
  - 20 years development
  - double twice (hard): <1% of total
- official agencies:
  - 100s of billions of $ inventment required
  - stated goal: more fossil fuels
- transition to renewables becomes ever more difficult, ever more precipitous

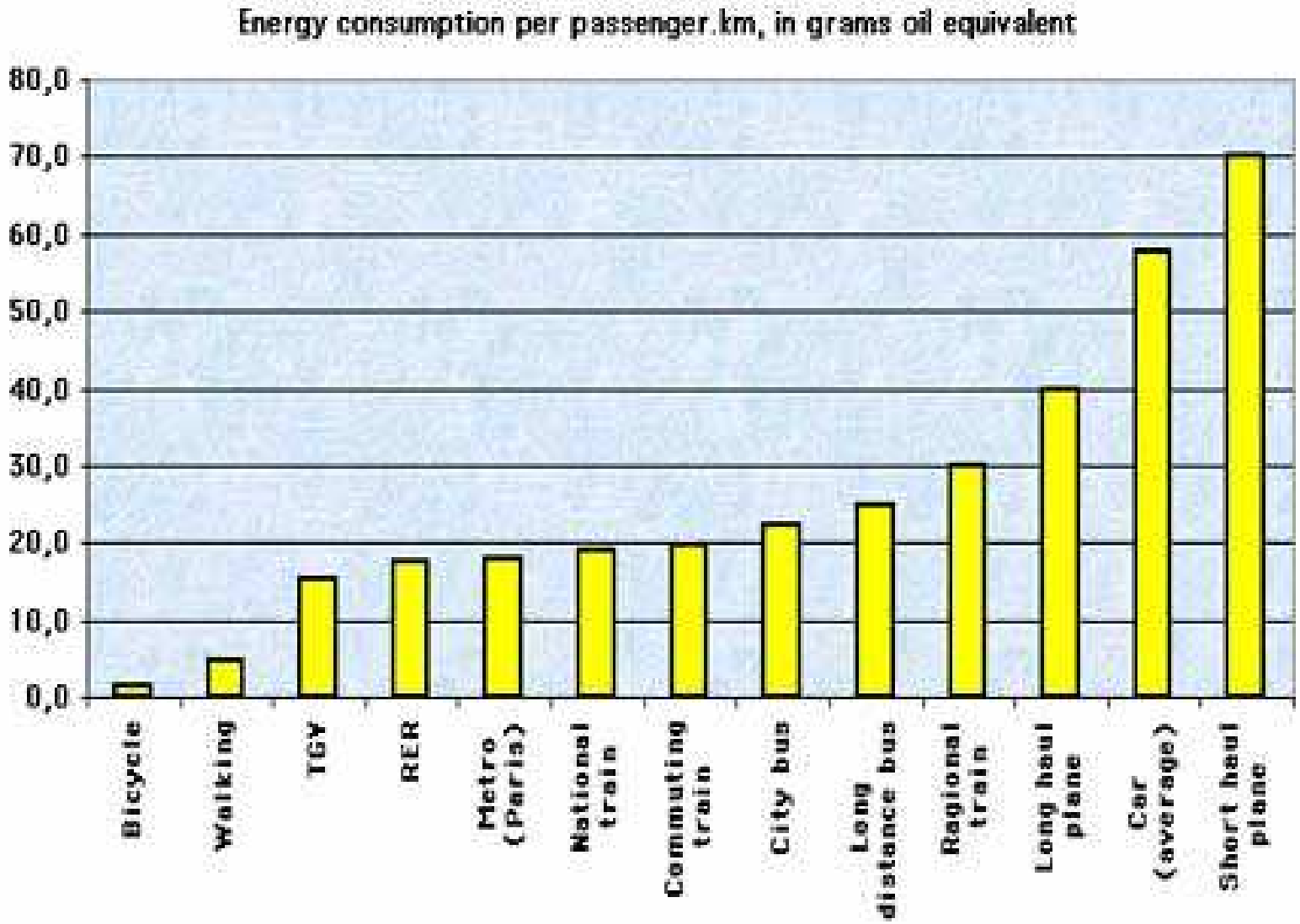
Is Hydrogen the Answer?

- Hydrogen is not an energy *source.*
- Most hydrogen is now made from fossil fuels.
- Making hydrogen from water using electrolysis will require immense quantities of electricity; this is why the coal and nuclear industries support the idea of a "hydrogen economy."
- There are significant storage problems.

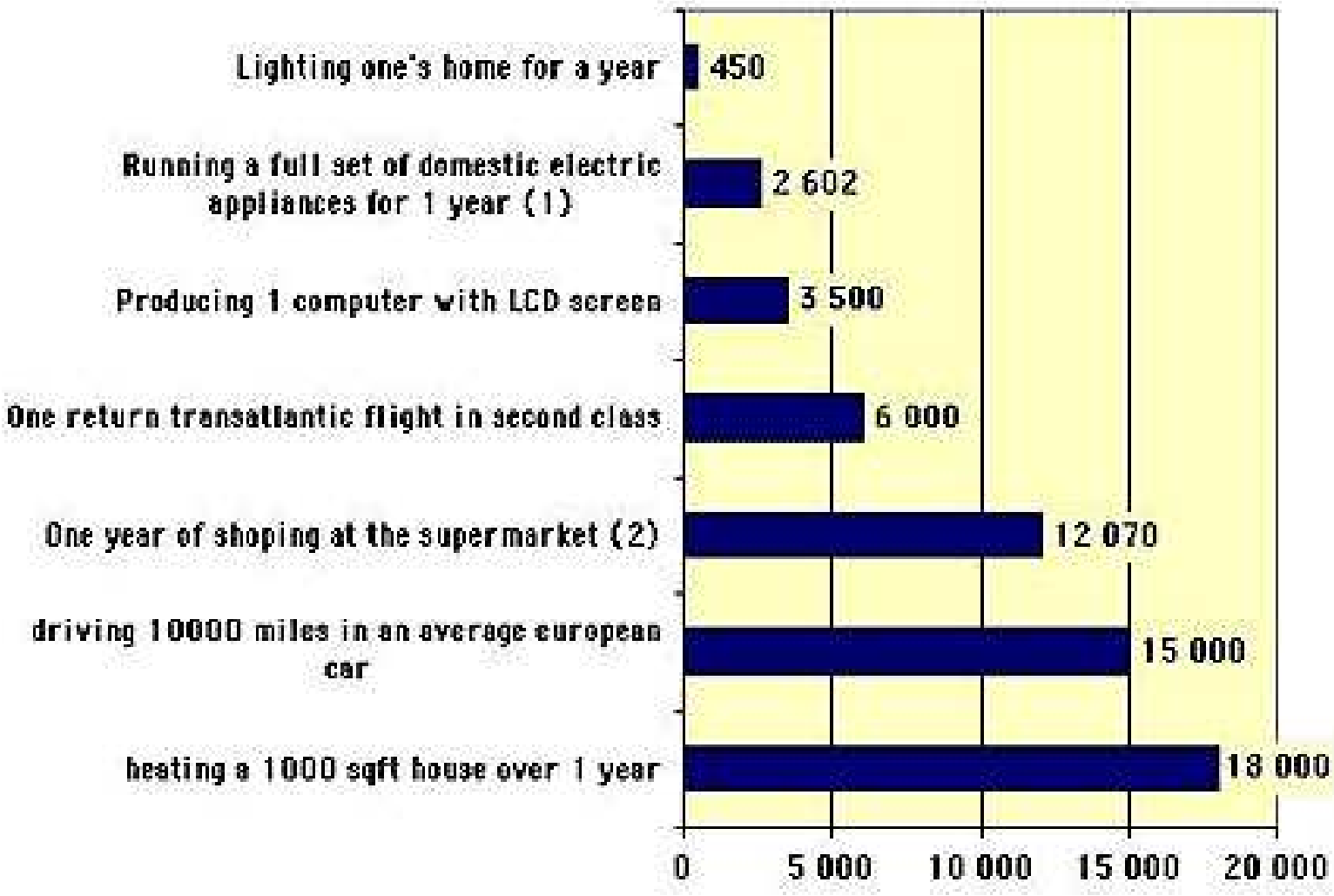
- considerable promotion of "hydrogen economy"
- motivates addressing hydrogen

- Fuel cells are efficient, but the inefficiencies of hydrogen production and storage would more than offset the efficiency gains from fuel cells.
- Spending money on hydrogen research takes investment capital away from the development of renewable energy sources.

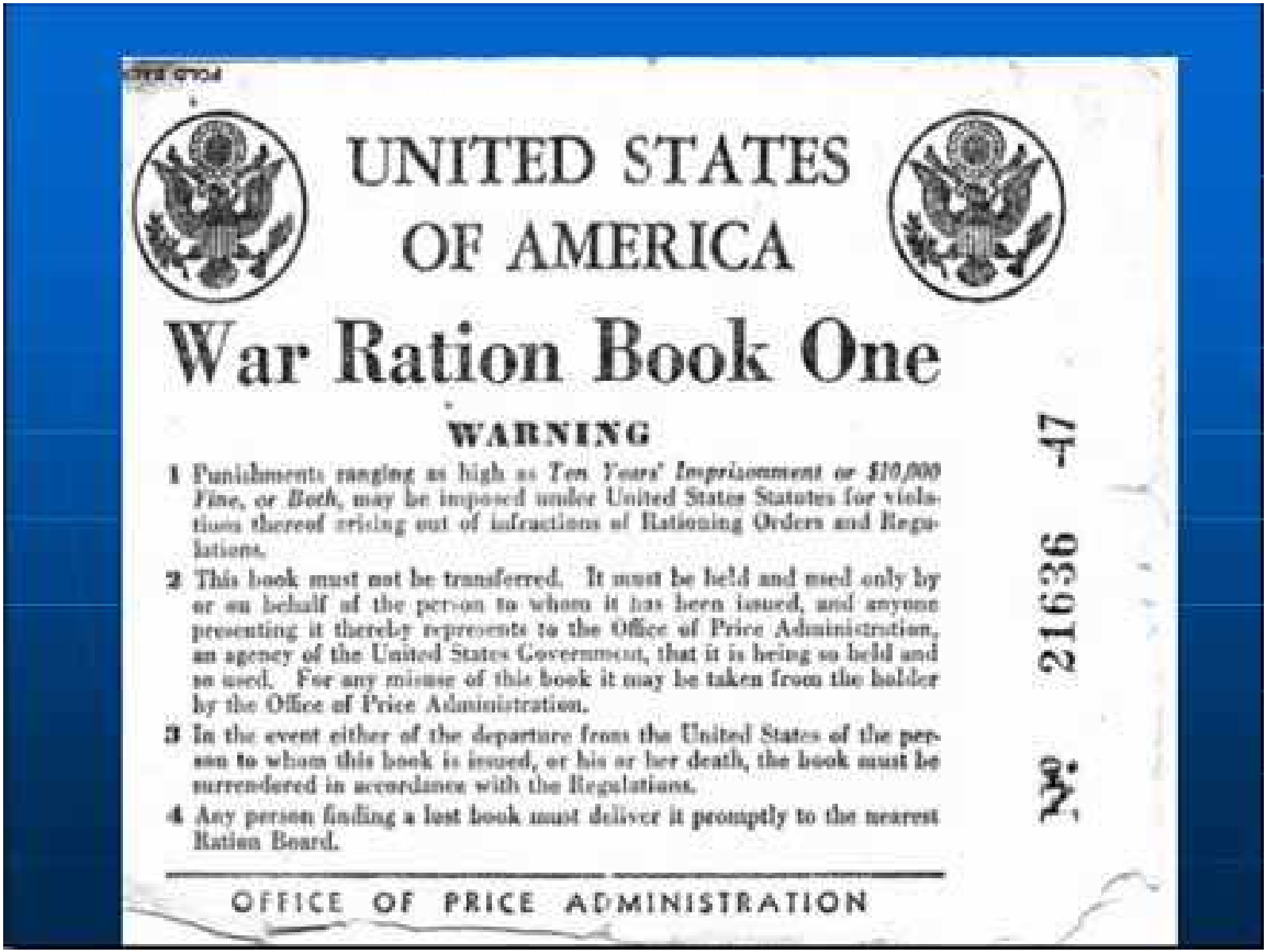
- hypothetical transition has considerable inertia
- analysis of alternatives to oil and natural gas shows they cannot be replaced, no matter how much is invested
- example: nuclear, just for transportation:
  - 103 plants now
  - needed: 1000
  - cost overruns from existing plants have nearly bankrupted utility industries
  - utility companies have been rescued by government (taxpayers)
- instead of supply side approach, demand side approach...



- where are we spending energy?
- consider just transportation (most oil used)
- (data from France)
- biggest contribution: give up auto
- bicycle is most efficient



- replacing incandescent bulbs is trivial contribution
- big three: home heating, driving and eating
- major contribution: home insulation
- major contribution: growing gardens
  - 10 calories of fossil fuel for 1 calorie eaten
  - Cuba has seen its peak oil and has transitioned to distributed agriculture and gardens even in cities
- 3000-mile Caesar salad?
- bananas in December?



UNITED STATES OF AMERICA

War Ration Book One

WARNING

1 Punishments ranging as high as *Ten Years' Imprisonment or $10,000 Fine, or Both*, may be imposed under United States Statutes for violations thereof arising out of infractions of Rationing Orders and Regulations.

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OFFICE OF PRICE ADMINISTRATION

No. 21636 -47

- proposal: grass-roots cooperation
- rationing has been accepted
- ...once the reason is clear
- home gardens have flourished in such times, etc

What shall we do?

- Fight for the last drop

What shall we do?

- Fight for the last drop
- Wait for a techno-fix


DON'T WORRY. TECHNOLOGY WILL SAVE YOU.
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What shall we do?

- Fight for the last drop
- Wait for a techno-fix
- Address the underlying ecological dilemma

The Universal Ecological Dilemma

- Resource depletion
- Habitat destruction
- Population pressure

- only about 24 civilizations in human history
- most have collapsed when unable to meet these challenges

- limited possible responses
- supply side or
- demand side
- civilizations eventually forced to adopt demand side approach
- Heinberg: technicians are eager with supply side solutions
- Kunstler: technicians understand thermodynamics
- carrying capacity:
  - population before oil age (industrial revolution): roughly 1 billion
  - population now: 6.4 billion
  - propably 5 billion people alive now because of fossil fuels.

The Uppsala Protocol

1. No country shall produce oil at above its current Depletion Rate, such being defined as annual production as a percentage of the estimated amount left to produce;
2. Each importing country shall reduce its imports to match the current World Depletion Rate.

Proposed by Uppsala Hydrocarbon Depletion Study Group, Uppsala University, Sweden

- cooperation necessary
- example: most of the world has signed Kyoto Protocol
- major oil consuming nations have to be willing

There is no single "magic elixir."

However, there are possible strategies:

- Aim for maximum efficiency
- Localize and decentralize
- Use alternatives *now*
- Use less
- Raise awareness: talk about the issue!

- "consumerism" is a very strong message in US
- need to use less for sustainability
- starting to gain traction even in government
- hard winter expected after effects of hurricanes
- winter shock may raise awareness

Priorities

- Ensure local food security
- Ensure local water security
- Reduce your need for transportation
- Support your local economy
- Foster local manufacturing of essential goods
- Plan for long-term emergency services

- critique the usual assumptions
- when it is too expensive for food to be produced, processed and shipped as usual, then what?
- it takes energy to process water
- chain stores have eroded local economic infrastructure
- but goods from China will eventually cost too much
- where are shoes and clothing made locally?
- what are the local skills?

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Questions Concerned with the Analysis of Graz

- What are the main items transported into Graz or produced in Graz?
- How would this flow be affected by an ever climbing oil price and oil scarcity?
- Which industries in Graz would be most immediately affected?
- Which industries are most crucial to equilibrium in Graz?
- What crucial items are most difficult to produce locally in Graz?
- How much electrical energy is produced in Graz by which sources?
- Which of these electrical energy sources is most or least reliable?
- What would be the effect if many commuters could no longer afford to drive into Graz?
- How would Graz strenthen the public transport system and provide fuel for it?
- At what level of costs for oil and natural gas do alternative home heating methods pay off?
- When that level of cost is met, can the transition to then cost effective alternatives be made smoothly or must that transition be promoted beforehand?
- How can Graz prepare itself for any of these possible effects?