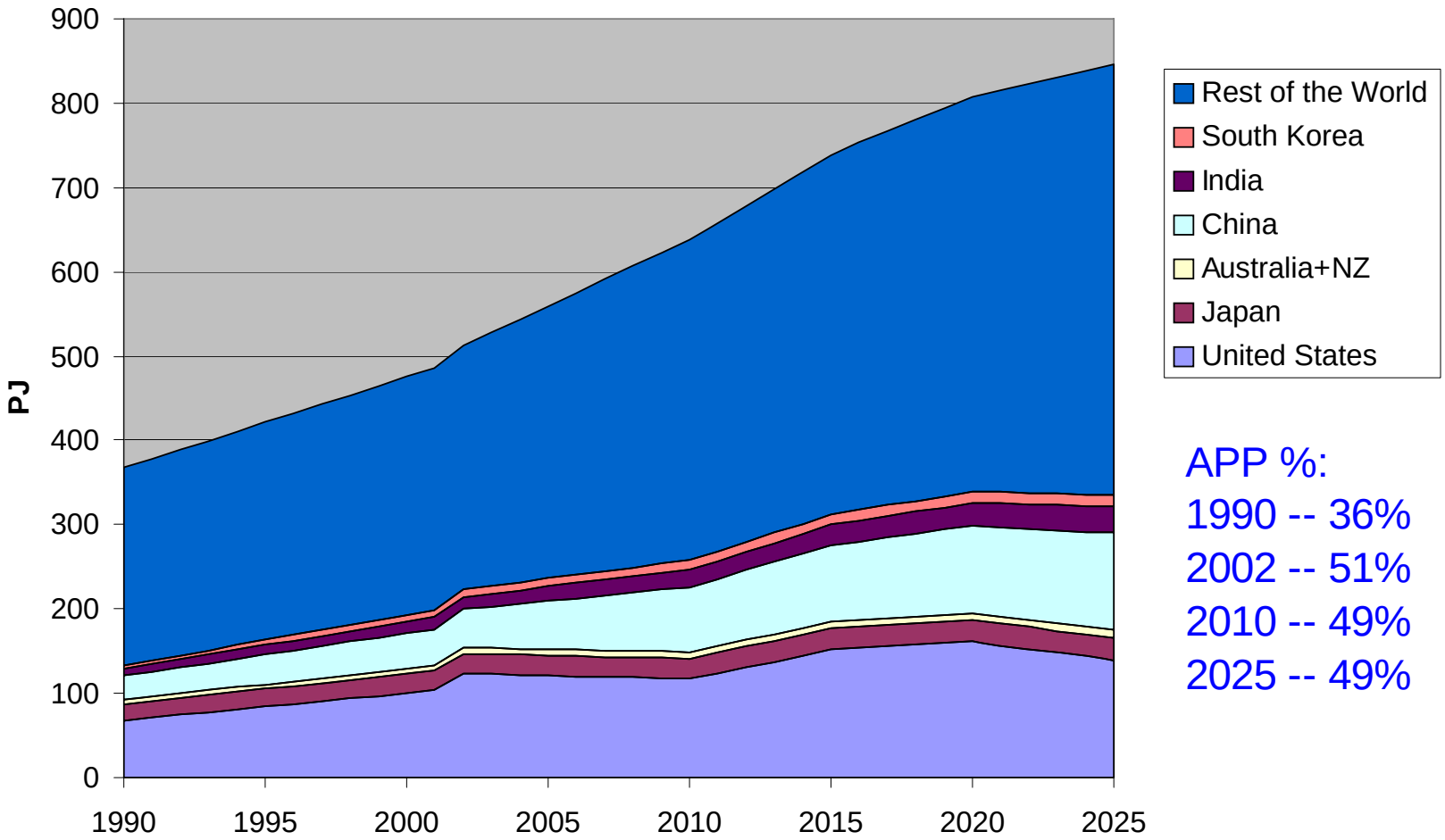
Solutions to the energy problem

ASIA PACIFIC PARTNERSHIP CONFERENCE

Claremont Hotel, Berkeley
19 April, 2006

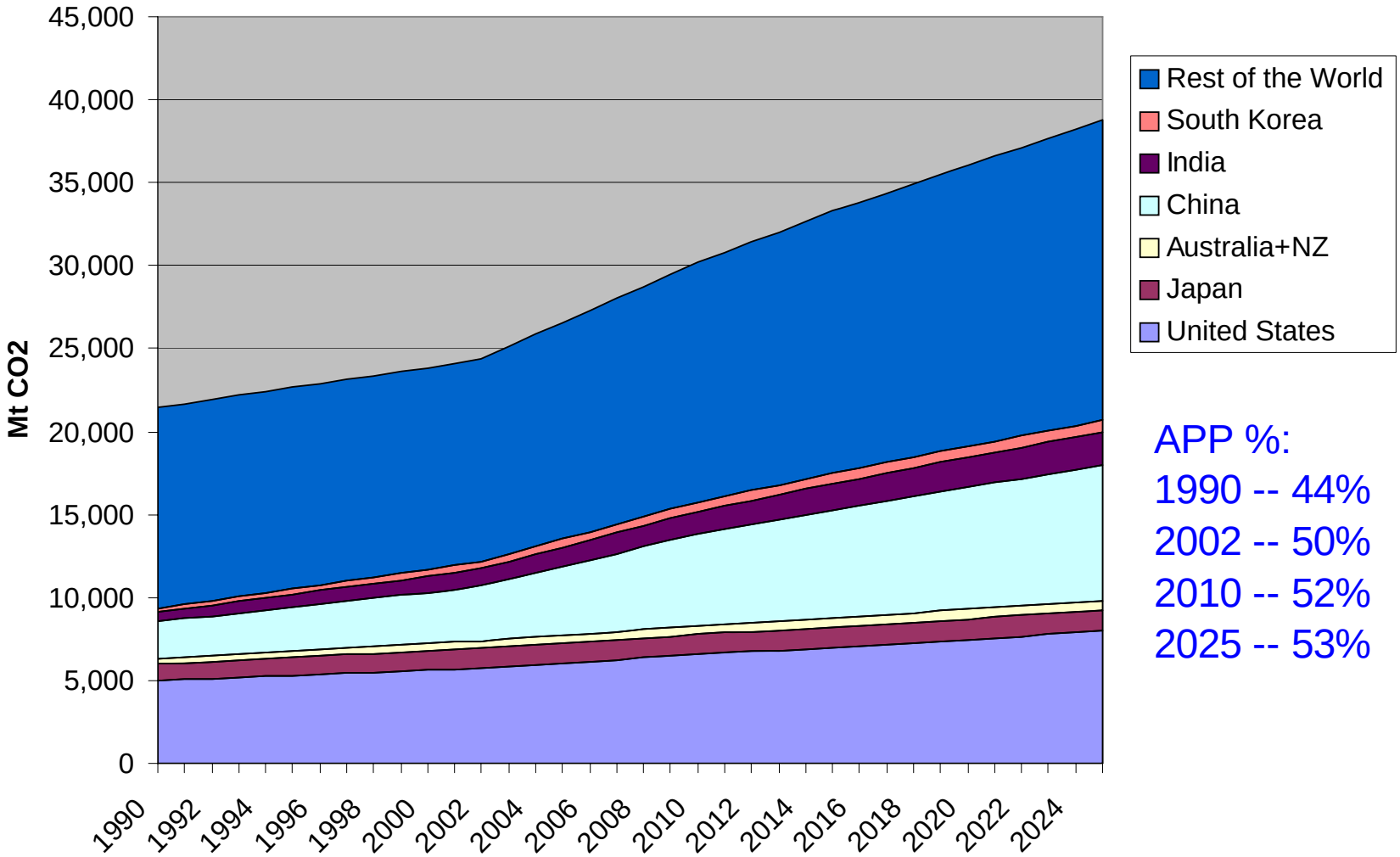
World Primary Energy Consumption by Region
(US DOE/EIA Reference Case)



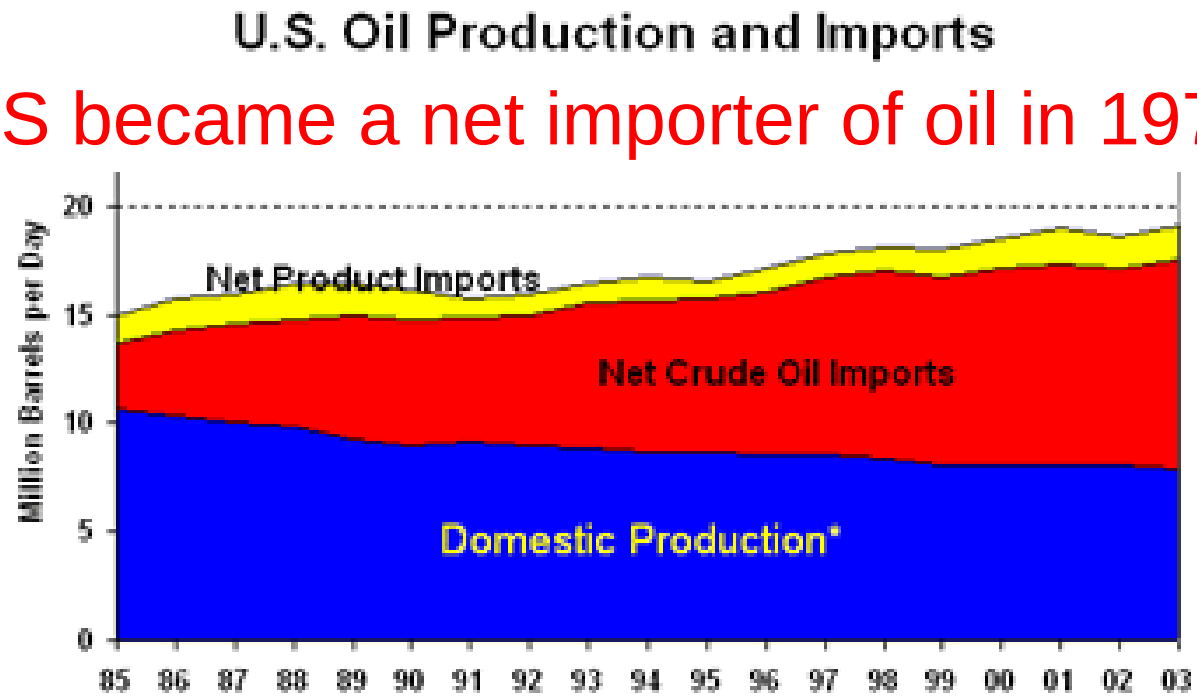
APP %:
1990 -- 36%
2002 -- 51%
2010 -- 49%
2025 -- 49%

Source: International Energy Outlook, EIA, 2005
Notes: India and China values exclude traditional biomass

World Carbon Dioxide Emissions
(USDOE/EIA Reference Case)

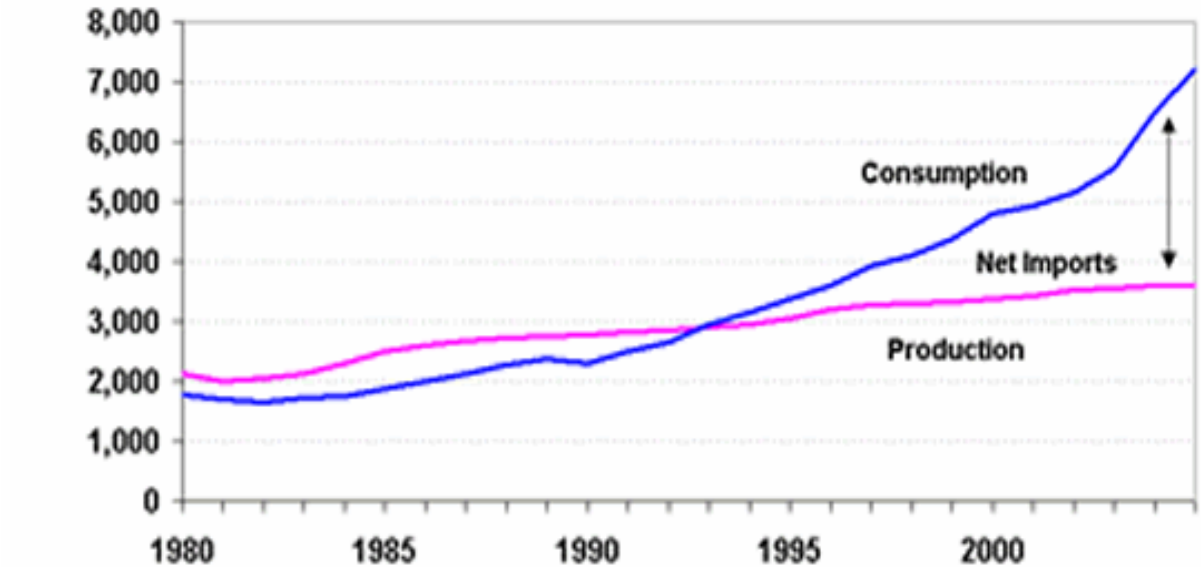


Source: International Energy Outlook, EIA, 2005

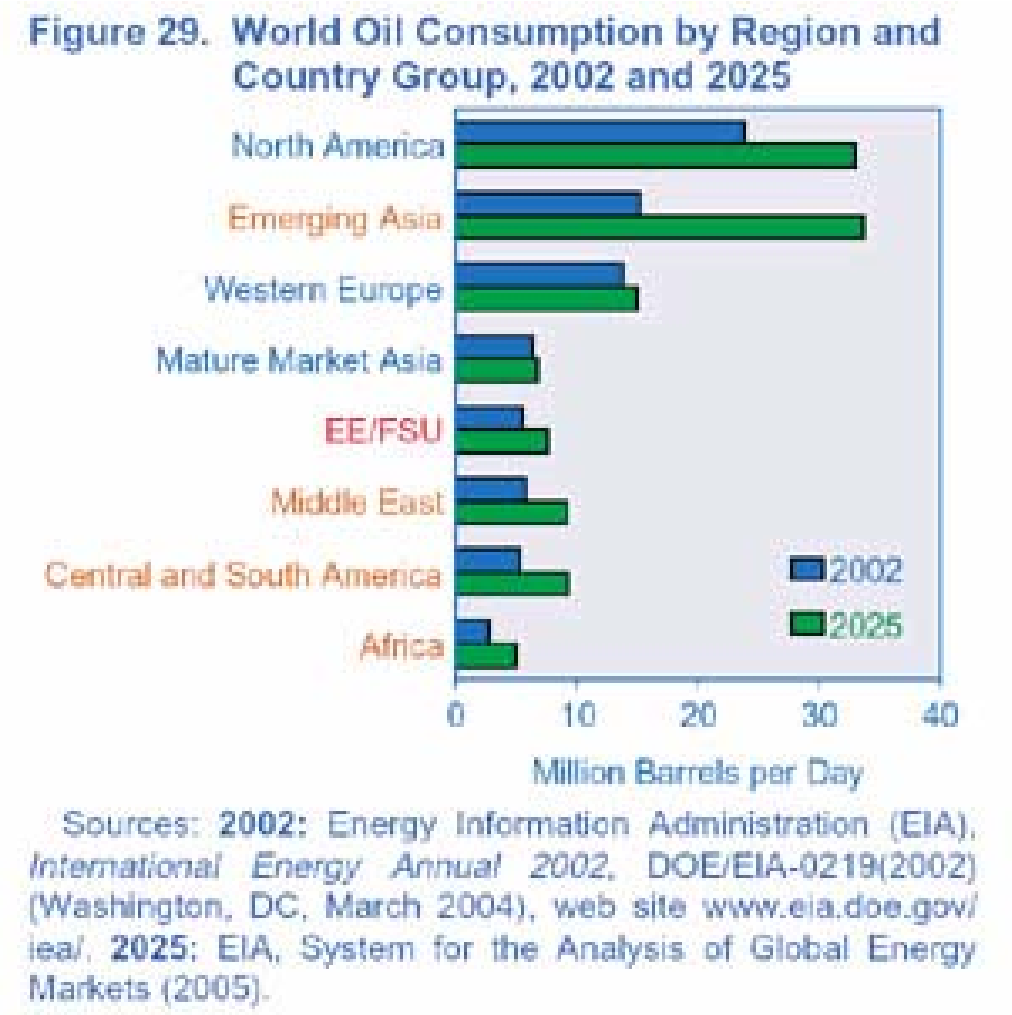


US became a net importer of oil in 1970

China oil consumption and production 1980 -2005



In 2025, China is projected to import 13 billions of barrels of oil per day.
World consumption is forecast to be 119 million barrels



A dual strategy is needed:

1) Conservation: maximize energy efficiency and minimize energy use, while insuring economic prosperity

2) Develop new sources of clean energy

Advantages and limitations of free-market economies

- Free-markets provide powerful incentives for innovation (Profit is a very strong motivator)
- They are more nimble than regulated economies

Question: How many free-market economists does it take to change a light bulb?

Answer: None. If it needed changing, free-market forces would have taken care of it.

Can the free market economic forces provide a ***complete solution*** to the energy problem?

The downsides of free-market economies

- Free markets do not always account for “externalities” (e.g. pollution, climate change.)
- Free market forces promote “local” optimization (e.g. Building contractors have no incentive to invest in operating efficiency.)
- “Survival of the fittest” does not always mean “survival of the best”. (e.g. unethical business practices.) Regulation and *transparent enforcement* is needed
- Free markets do not respond well to long term problems or international/global issues. (e.g. International fishing, international pollution)

The externalities related to energy

- Energy dependence costs
- Environmental costs

Polices that modify free-markets.

- Global incentives (carrots), dis-incentives (sticks), commands (regulation)
- Stimulating *present* investments in existing technology on the demand and supply side
- Stimulate *mid- and long term* research and development for demand and supply sides

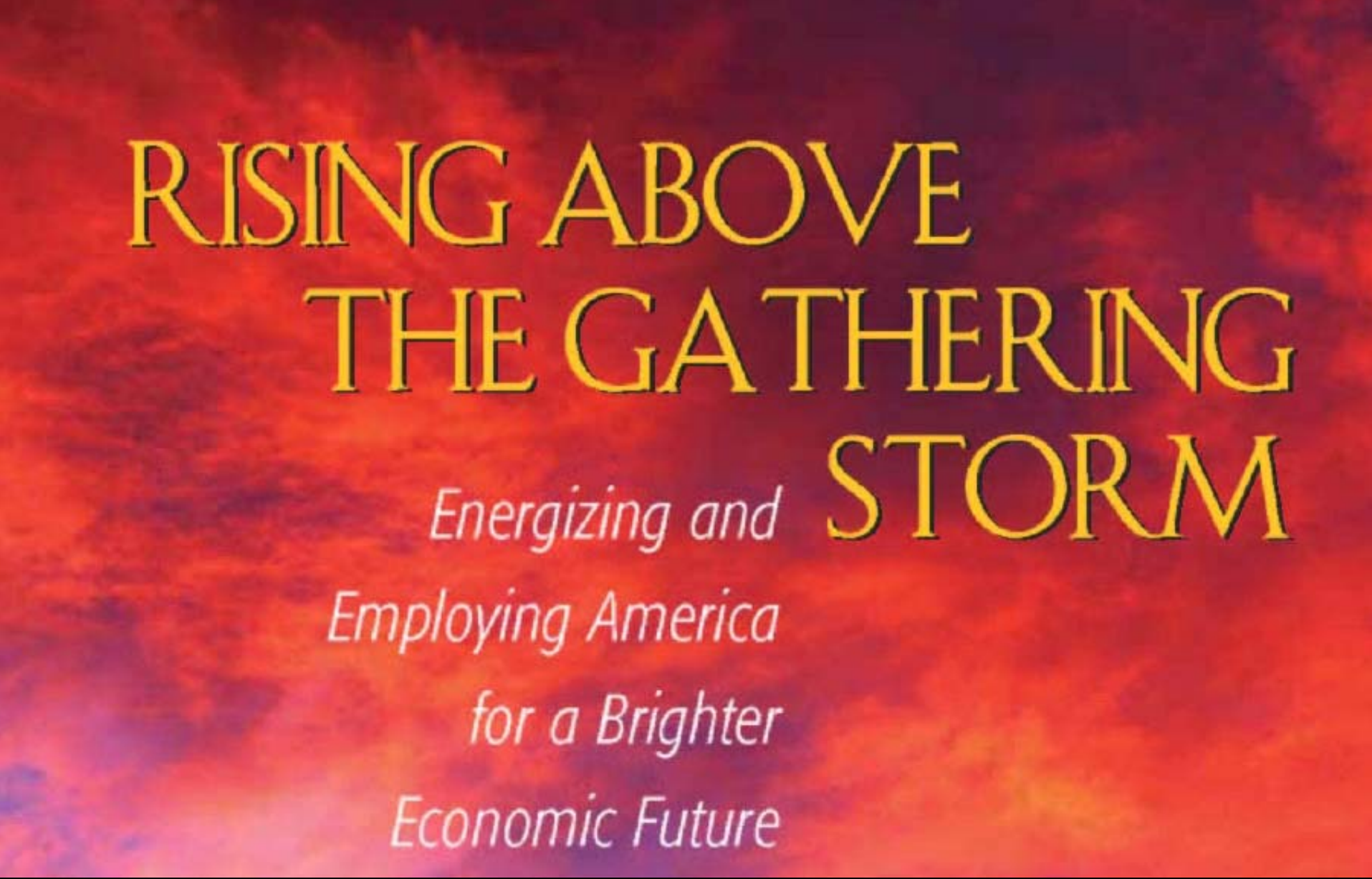
International Concerns

1) National security which is intimately tied to energy security

2) Economic prosperity

3) The environment

Sustainable, clean, CO_2 neutral energy



Chair: Norm Augustine, former Chairman and CEO of Lockheed-Martin

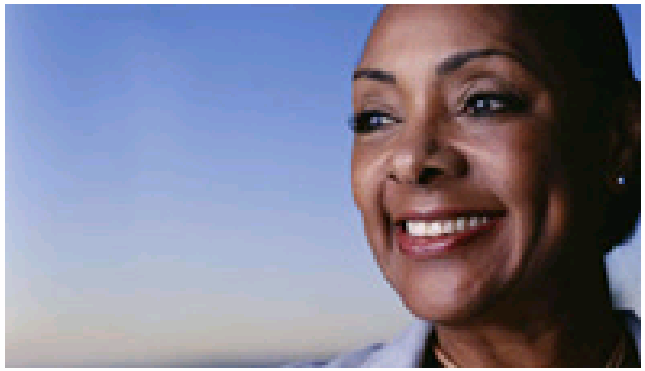
“Create an ‘Advanced Research Projects Agency—Energy’

(ARPA-E)

reporting to the Under Secretary for Science, charged with sponsoring specific research and development programs to meet the nation's long-term energy challenges.”

InterAcademy Council

About the IAC



Mobilizing the World's Best Science to Advise Decision-makers.

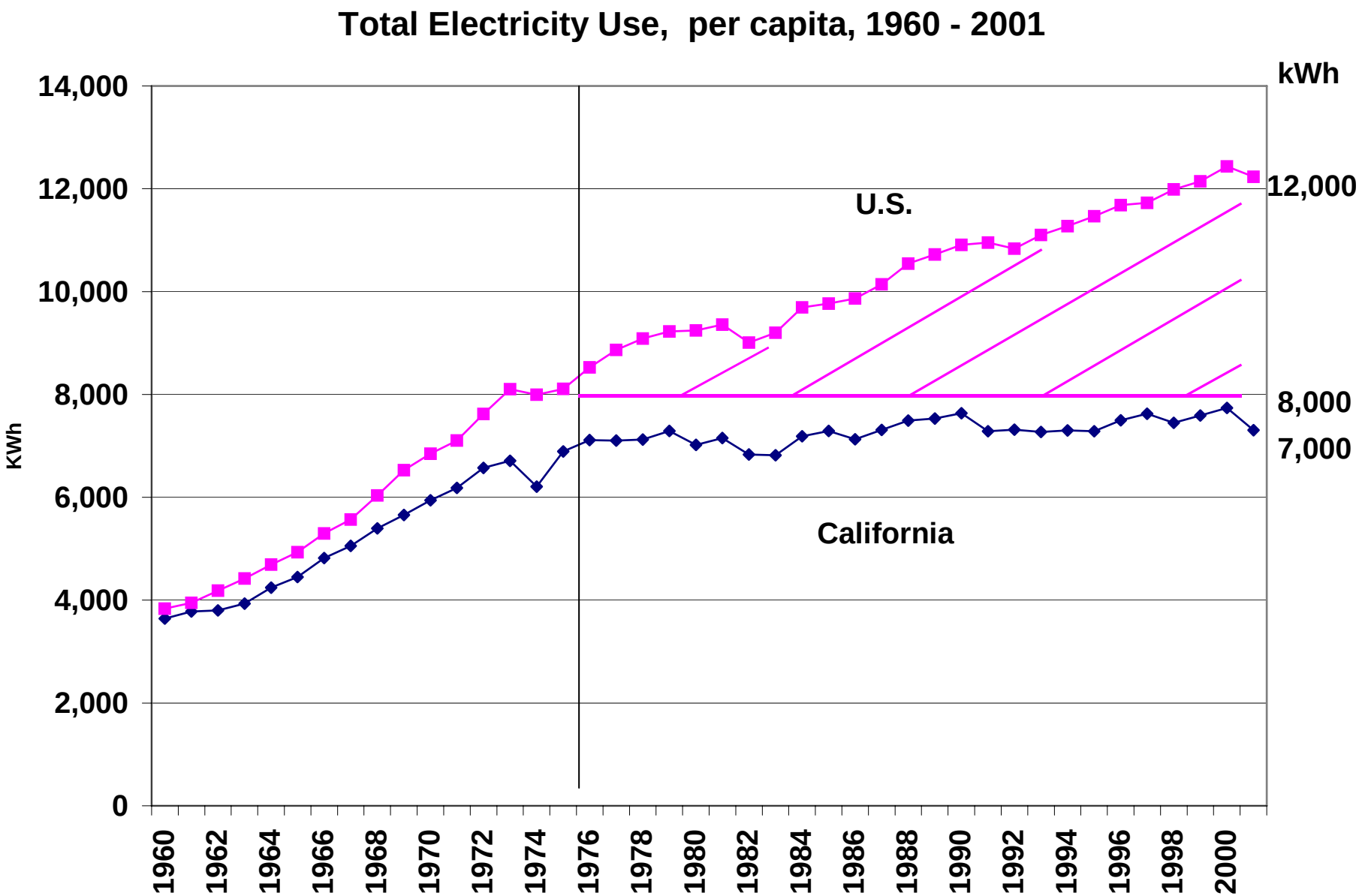
"Transitions to Sustainable Energy"

The world has a clear and major problem, with no global consensus on the way to proceed: how to achieve transitions to an adequately affordable, sustainable clean energy supply"

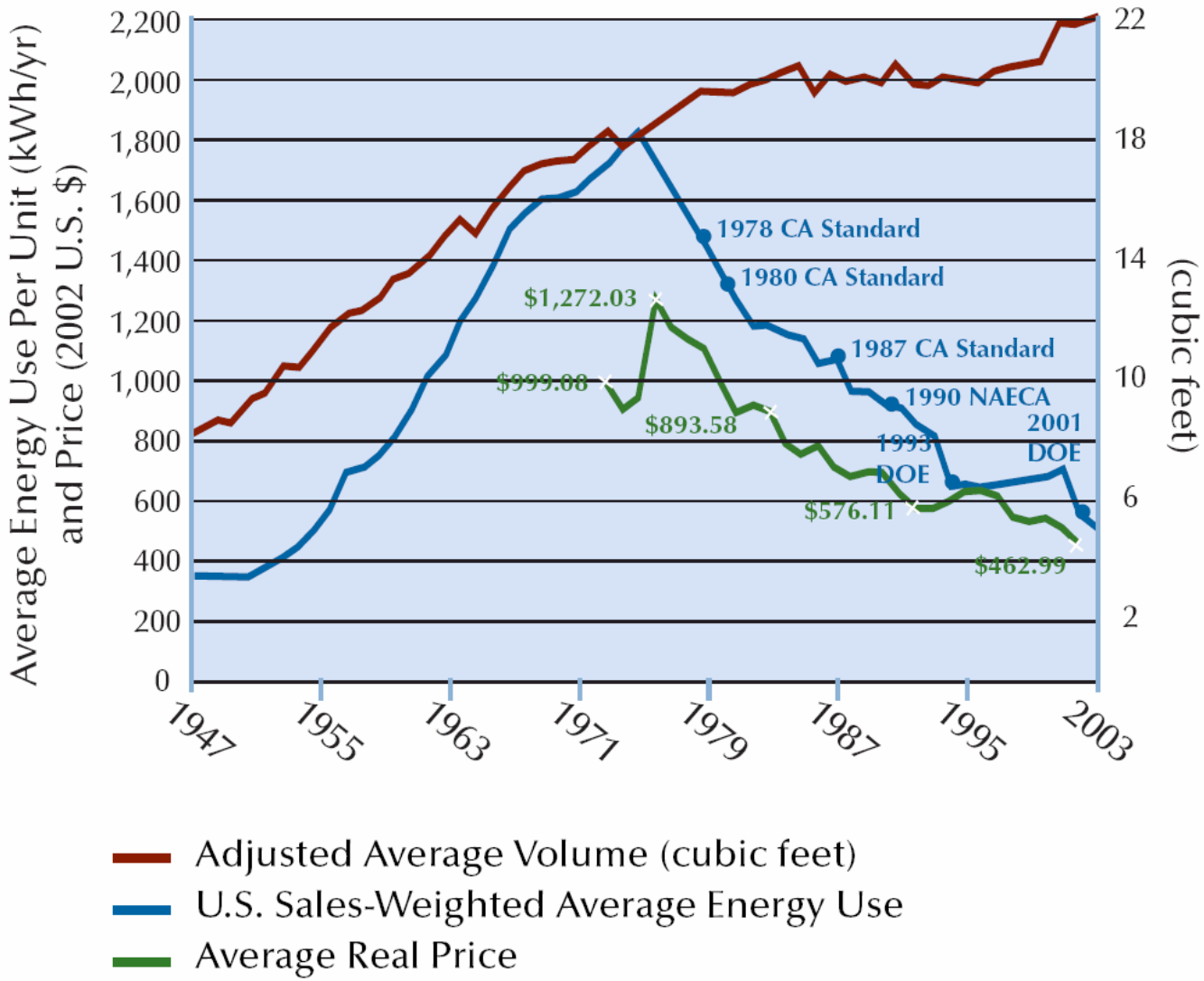
Co-chairs: Jose Goldemberg, Brazil
Steven Chu, USA

The Demand side of the Energy Solution

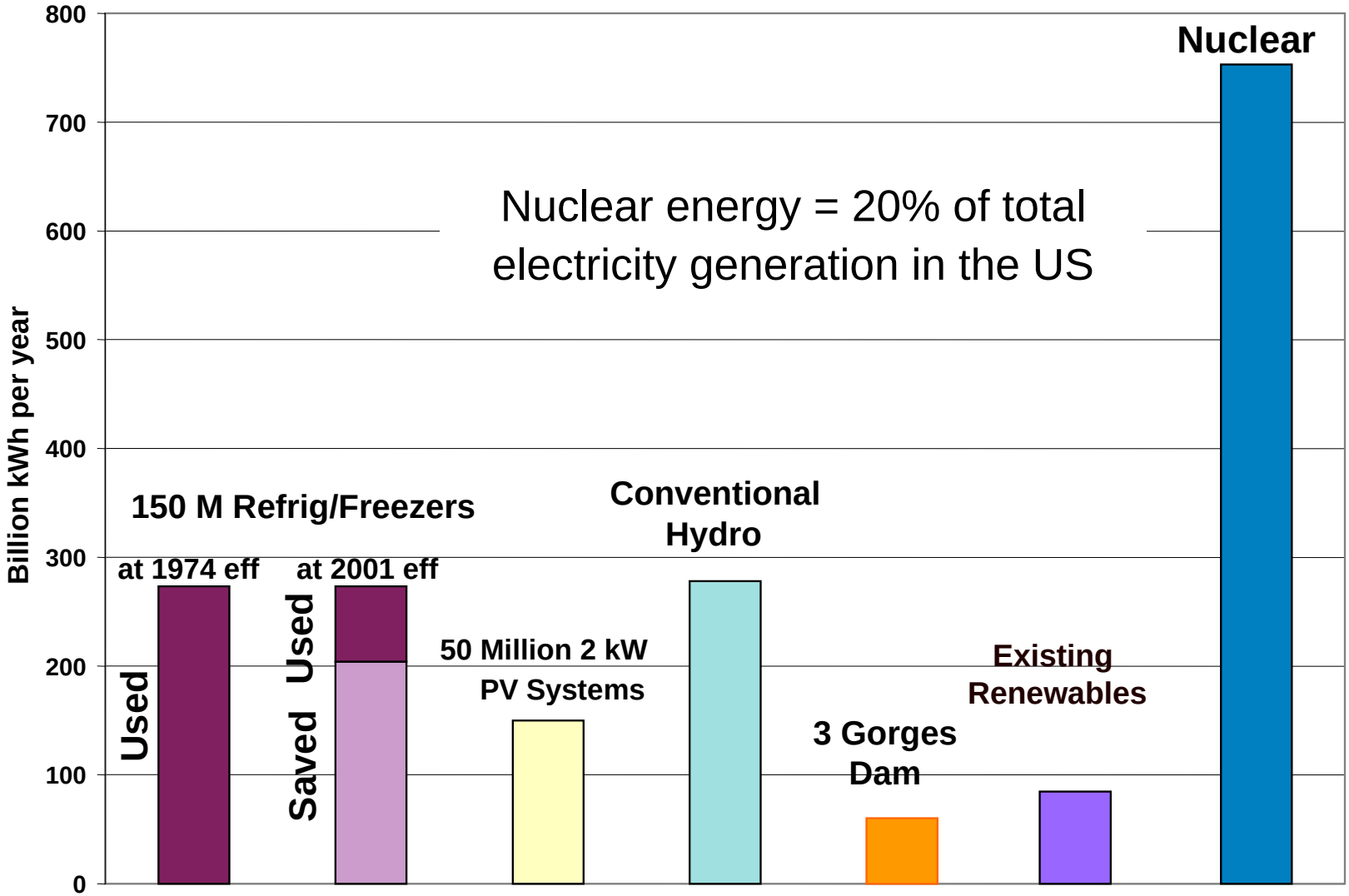
Regulations and fiscal policies can make a difference



Regulation stimulates technology: Refrigerator efficiency standards and performance. The *expectation* of efficiency standards also stimulated industry innovation

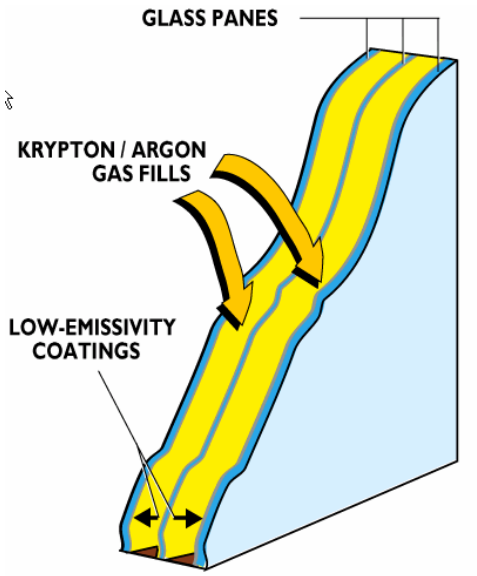


Electricity Use of Refrigerators and Freezers in the US compared to Generation from Nuclear, Hydro, Renewables, Three Gorges Dam and ANWR (Arctic National Wildlife Refuge)

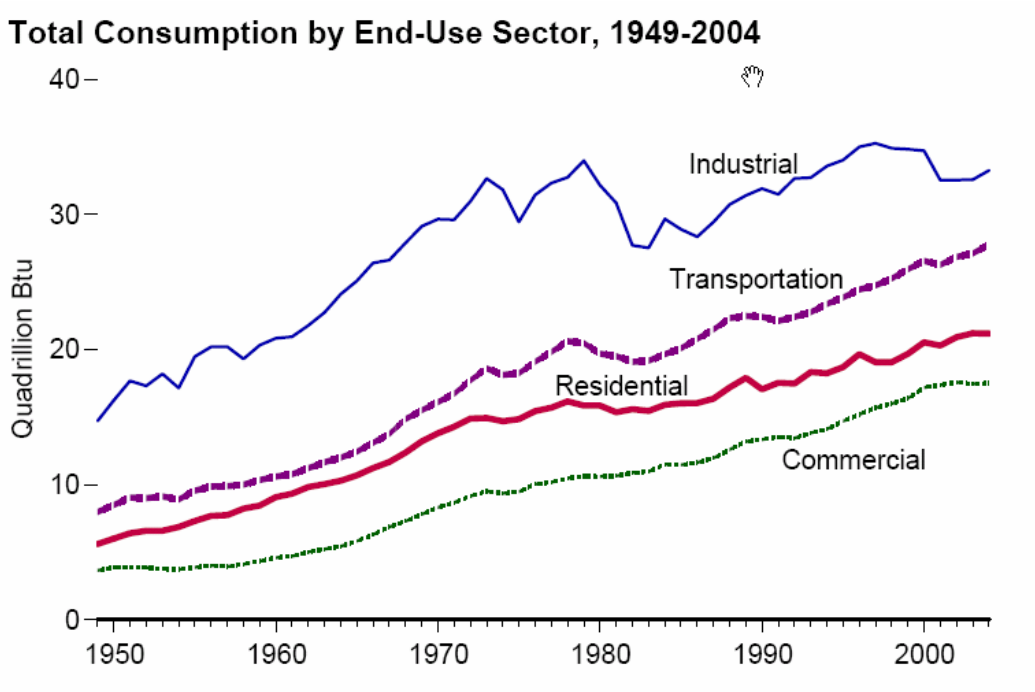


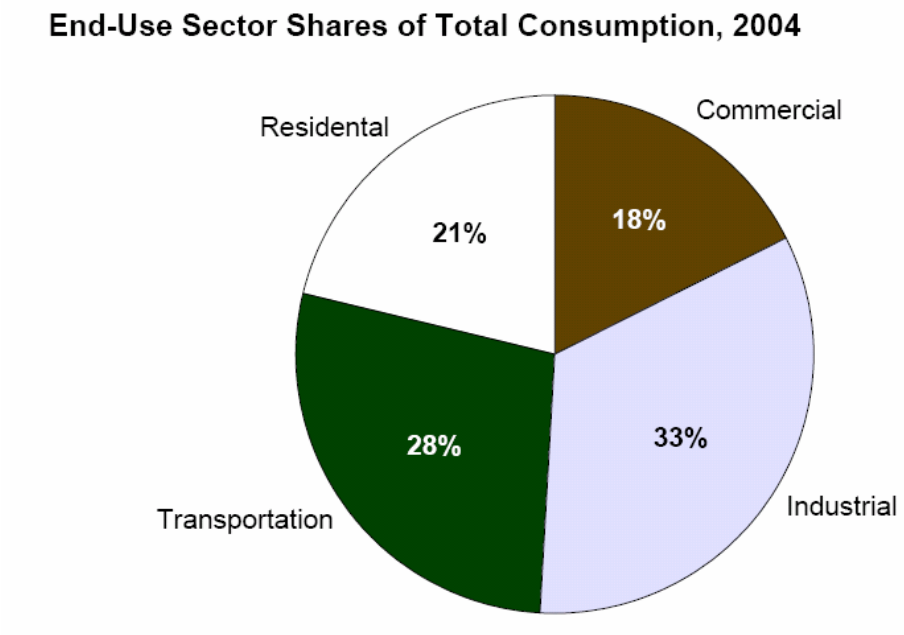
Efficiency

Energy for the Future



Cumulative U.S. energy savings for windows installed as of 1995 (National Academy study) was $2.1 billion.





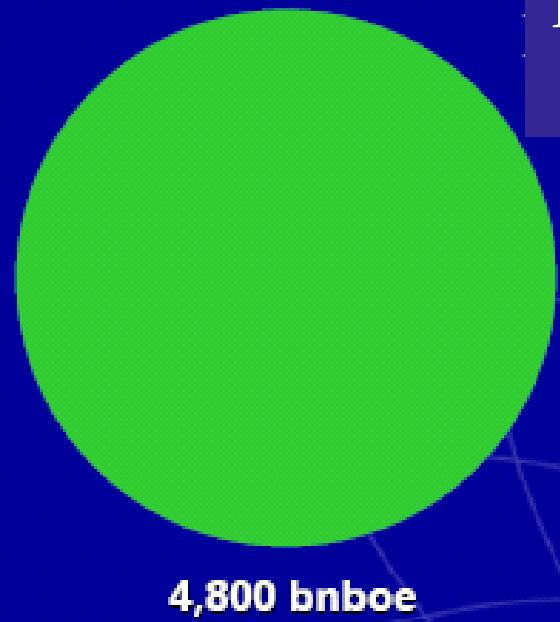
Potential supply-side solutions to the Energy Problem

- Oil, gas, coal, tar sands, shale oil …
- Fusion
- Fission
- Wind
- Solar photocells
- Bio-mass

substantial global fossil resources

R/P = 41 yrs

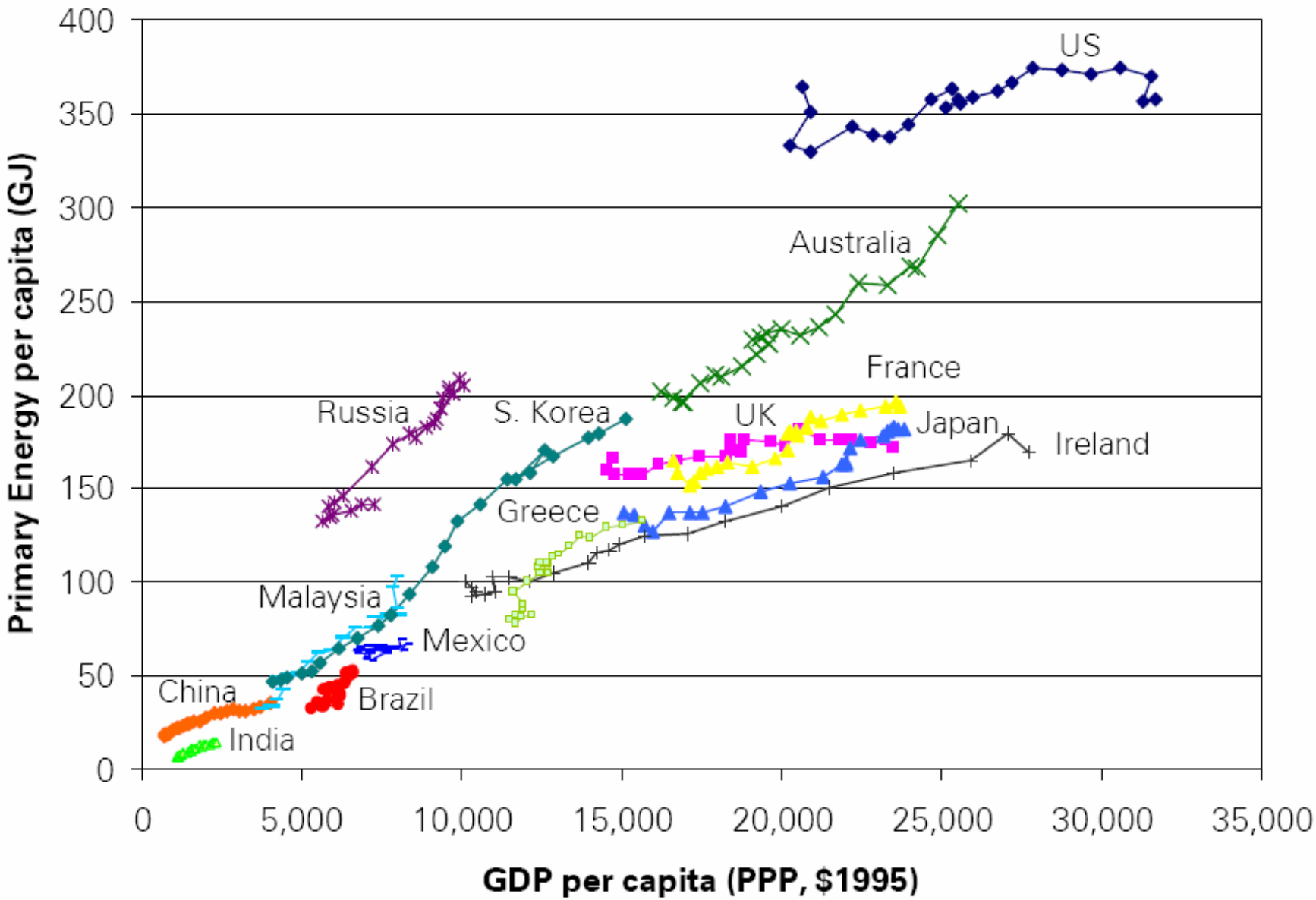
R/P = 67 yrs



R/P ~ 1000 years?

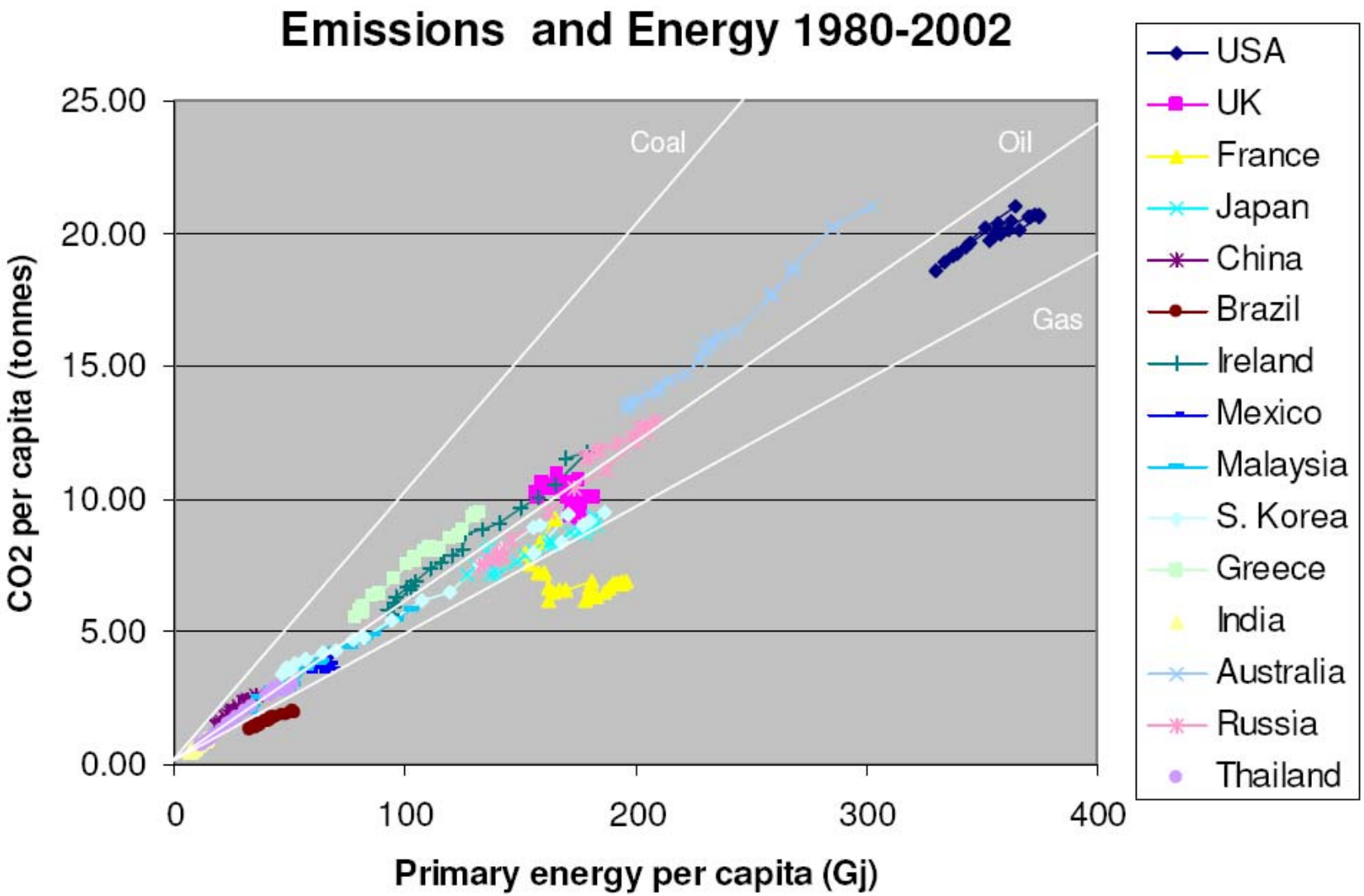
Courtesy Steve Koonin, Chief Scientist, BP

Energy demand vs. GDP per capita

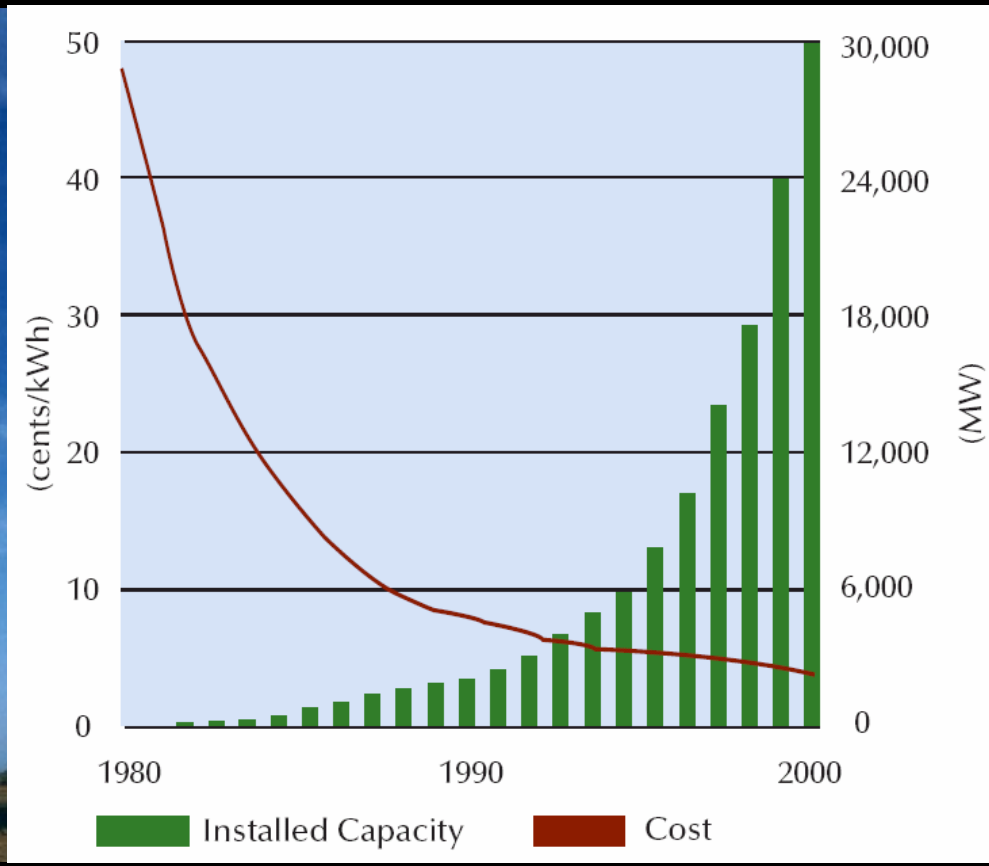


Source: UN and DOE EIA

CO_2 emissions depends on the energy source

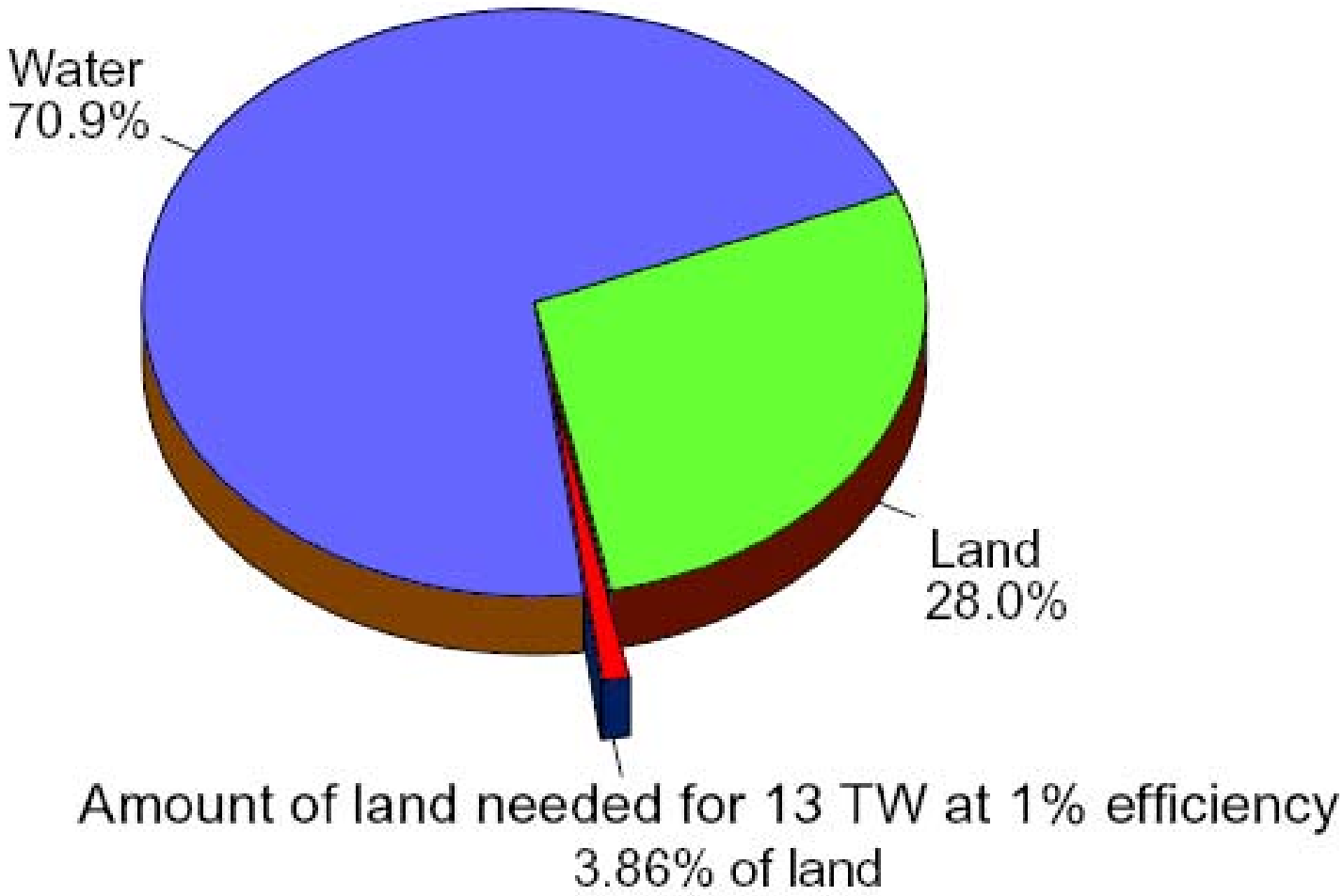


Incentives were essential to stimulate continued development of power generation from wind

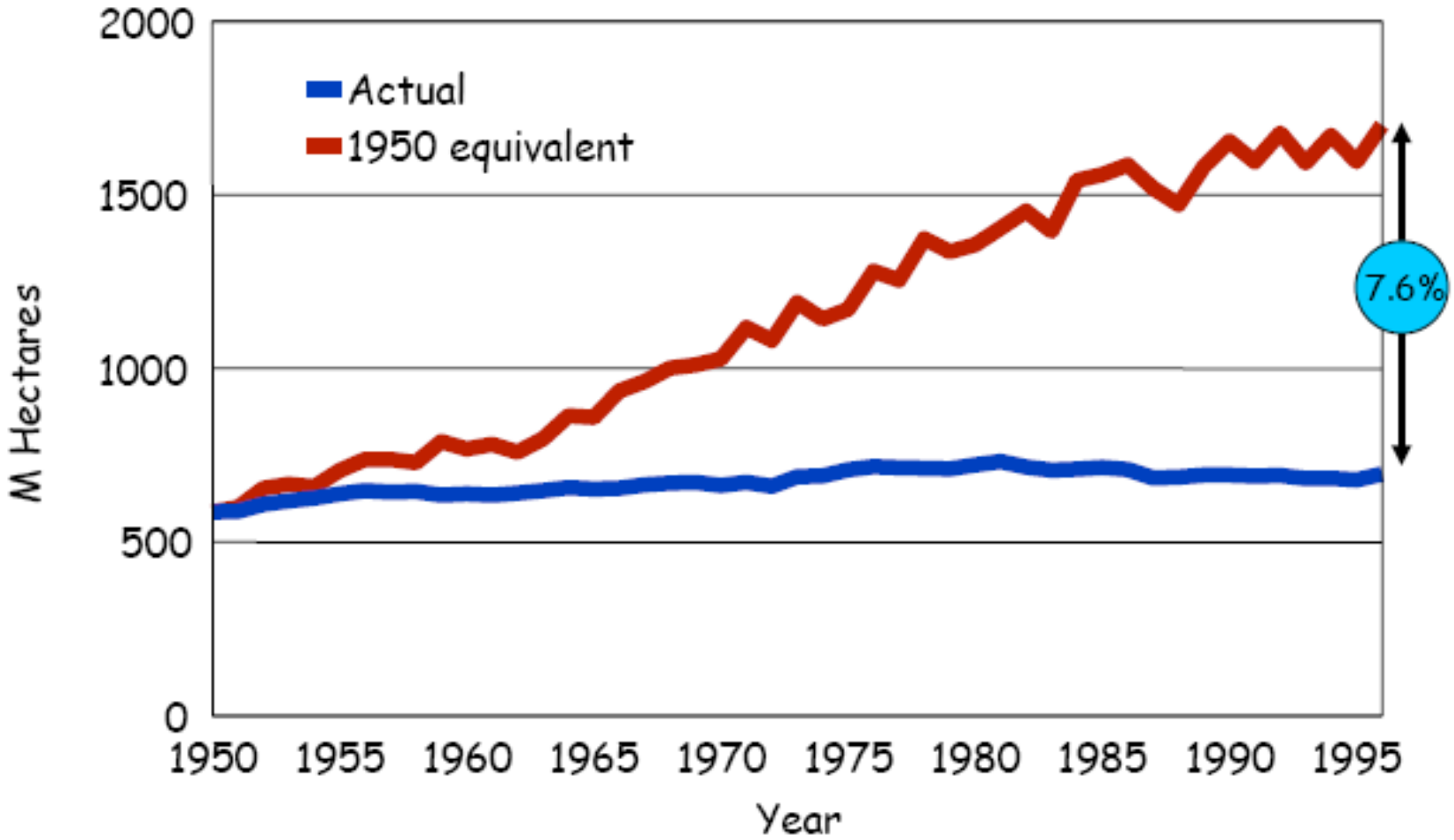


Is it possible to develop a new class of durable solar cells with high efficiency at 1/10th the cost of silicon?

~ 120,000 TW of solar energy received by the Earth



Hectares of Grain With and Without Yield Improvements



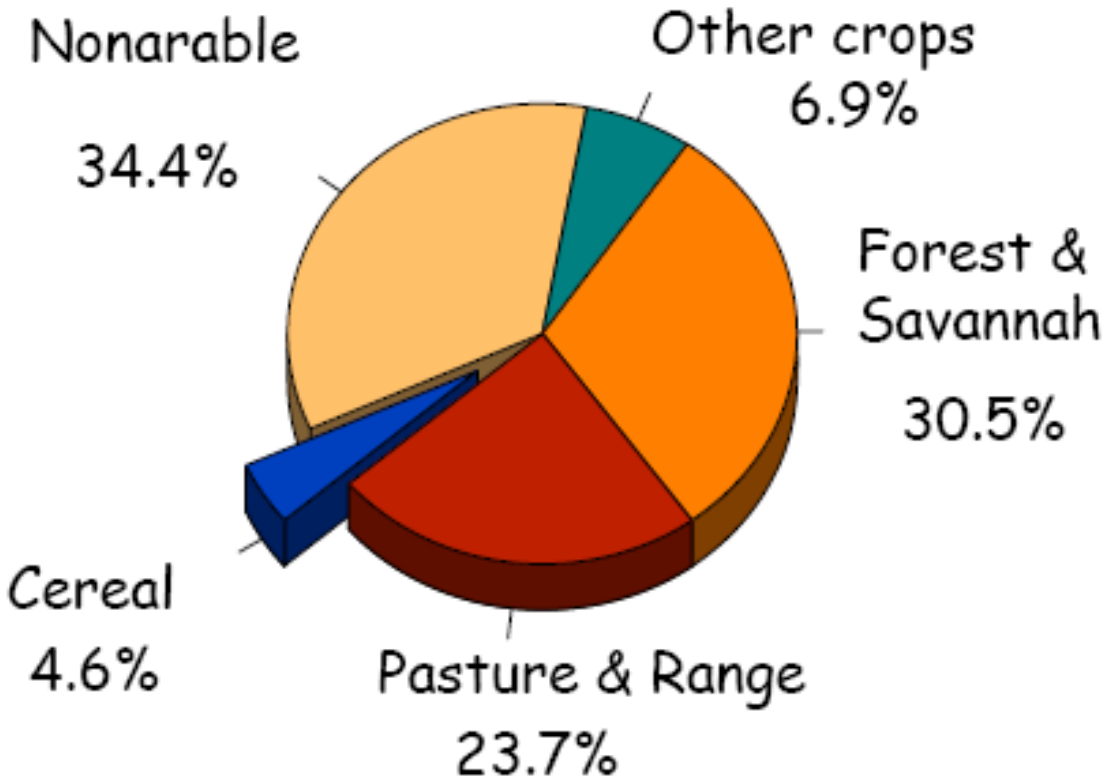
Data from Worldwatch database 1996, 1997

~13 B ha of land in the Earth

- 1.5 B ha for crops
- 3.5 B ha for pastureland
- 0.5 B ha are "built up"
- 7.5 B ha are forest land or "other"

~ 12% of the land is used for agriculture.

How much more land can be cultivated?



Land best suited for biomass generation (Latin America, Sub-Saharan Africa) is the least utilized

Table1 Land distribution

	Suitable for rain fed crops Billion ha	Arable land in use, 1997-1999, %
Latin America and Caribbean	1.07	19
Sub-Saharan Africa	1.03	22
Industrial Countries	0.87	44
Transition Countries	0.50	53
Asia	0.59	75
Near East and North Africa	0.10	86

- Potential arable land suitable for rain-fed crops:
  1.5 Billion ha $\Rightarrow$ 14 Billion ha
- With 1% efficiency in solar to biomass conversion, 1.5 Billion ha are needed to satisfy the existing Global energy supply of 14 TW.

The majority of a plant is structural material

Cellulose	40-60% Percent Dry Weight
Hemicellulose	20-40%
Lignin	10-25%

Sunlight

CO_2, H_2O,

Nutrients

→ Biomass →

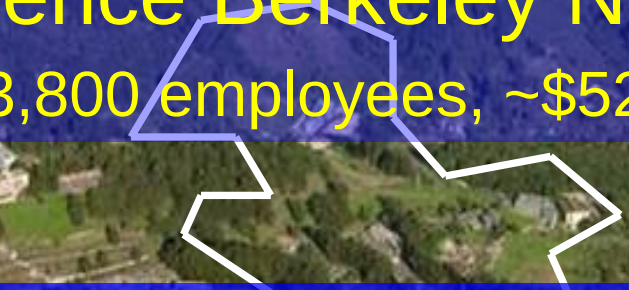
Chemical energy

Self-fertilizing, drought and pest resistant

Improved conversion of cellulose into chemical fuel

Lawrence Berkeley National Laboratory

3,800 employees, ~$520 M / year budget



10 Nobel Prize winners were/are employees of LBNL, and another “on the way”

Today:

57 employees in the National Academy of Sciences (~3% of the total membership),
18 in the National Academy of Engineering,
2 in the Institute of Medicine,

Helios Research Building