Energy and Our Future

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Conclusions

- We are living in a unique era, about half way through a 1900-2100 transition period; trend extrapolation has limits in these times
- The major factors in this transition are population growth and distribution, technology, resource availability and environmental impacts.
- The results of these changes on the U.S. and the world are unclear, but they will be dramatic and long term

Overview of Energy Sources and Uses

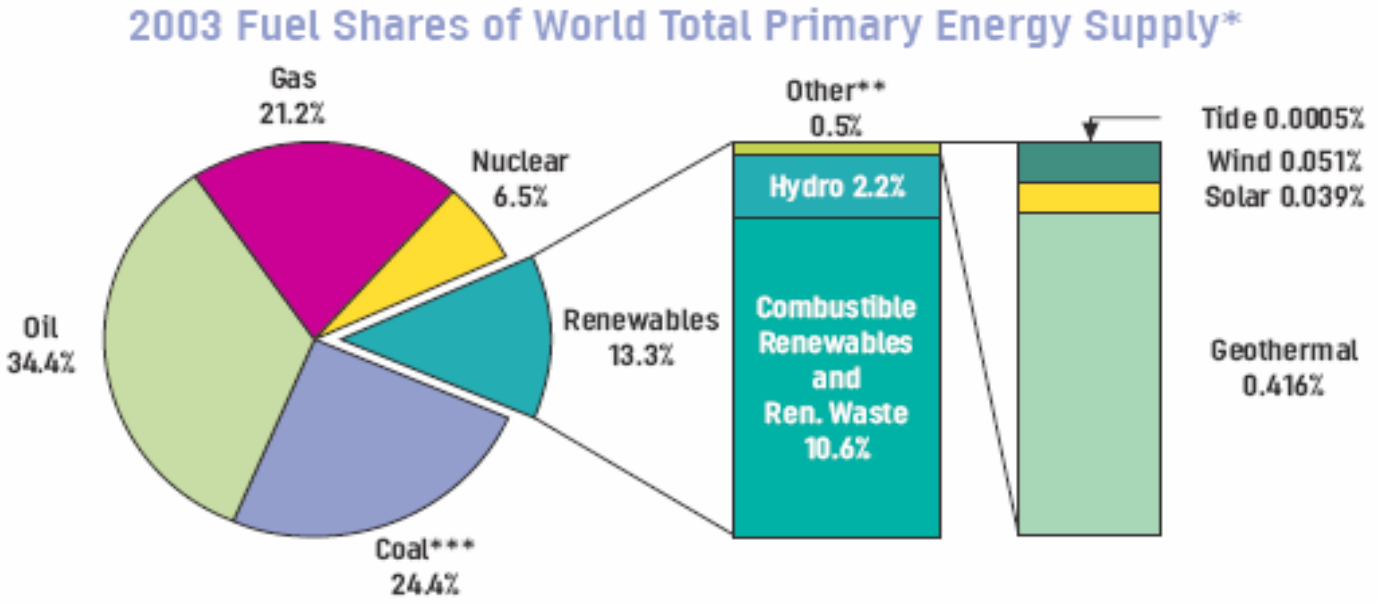
Background to a transition period –

From wood to coal to oil and soon to an efficiently used mix of many sources

Changes That Impact Energy Use

- Pre-1900
  - Lights and motors, home heating
  - Industrialization, steam engine, railroads
- Changes 1900 to WW II
  - Automobile, radio, refrigerators,, mechanization (including agriculture)
  - Oil era underway
- Changes WW II to 1970 or so
  - Air conditioning, containerized shipping, television
  - Major increase in oil use, increased travel of all types
- Changes 1970 to 2000 or so
  - High volume shipping, non-local manufacturing
  - Global interaction and interdependence
- Post-2000
  - New energy paradigm – multiple events cause changes in types and efficiencies of energy use, affecting costs and supplies

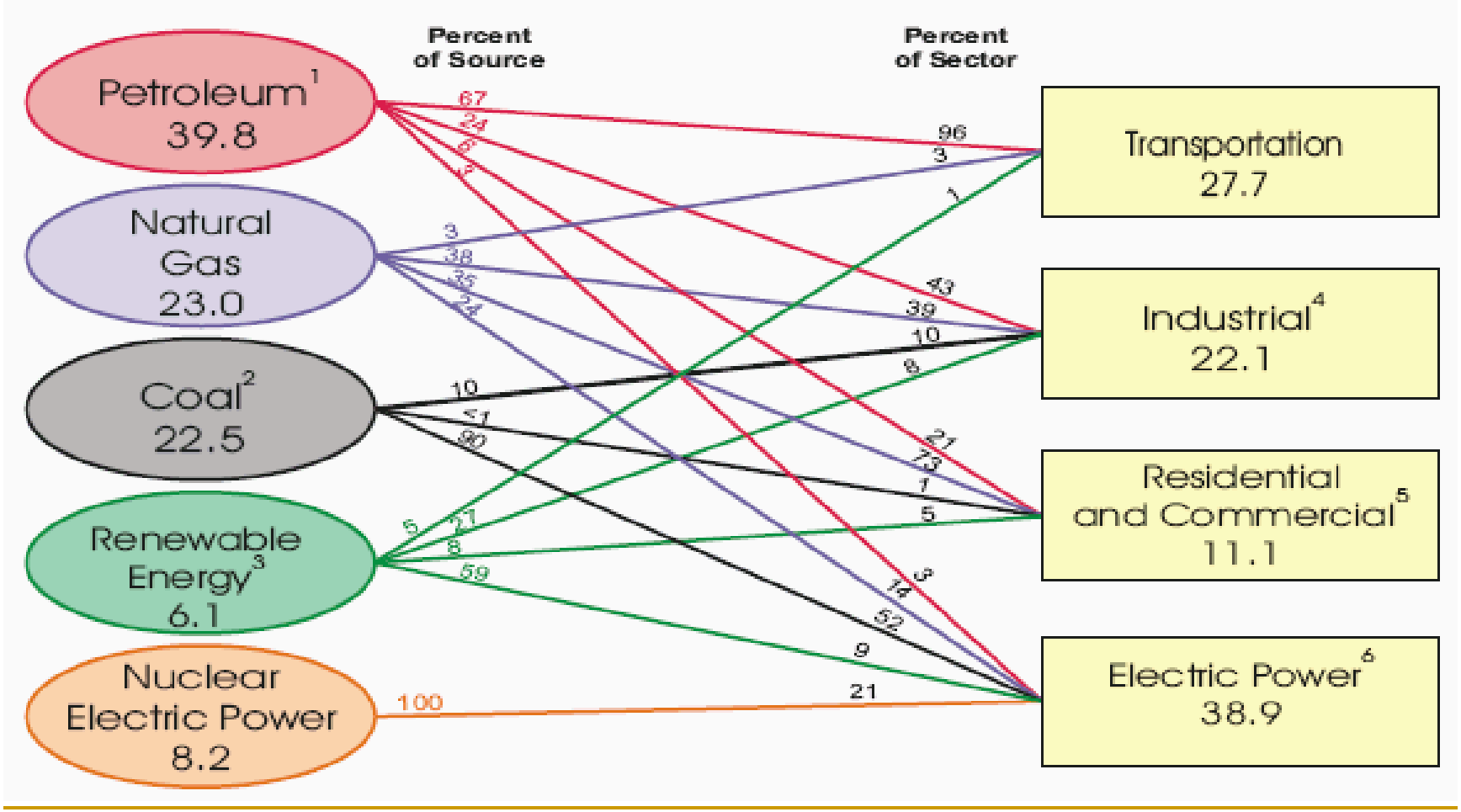
World Energy Consumption - 2003



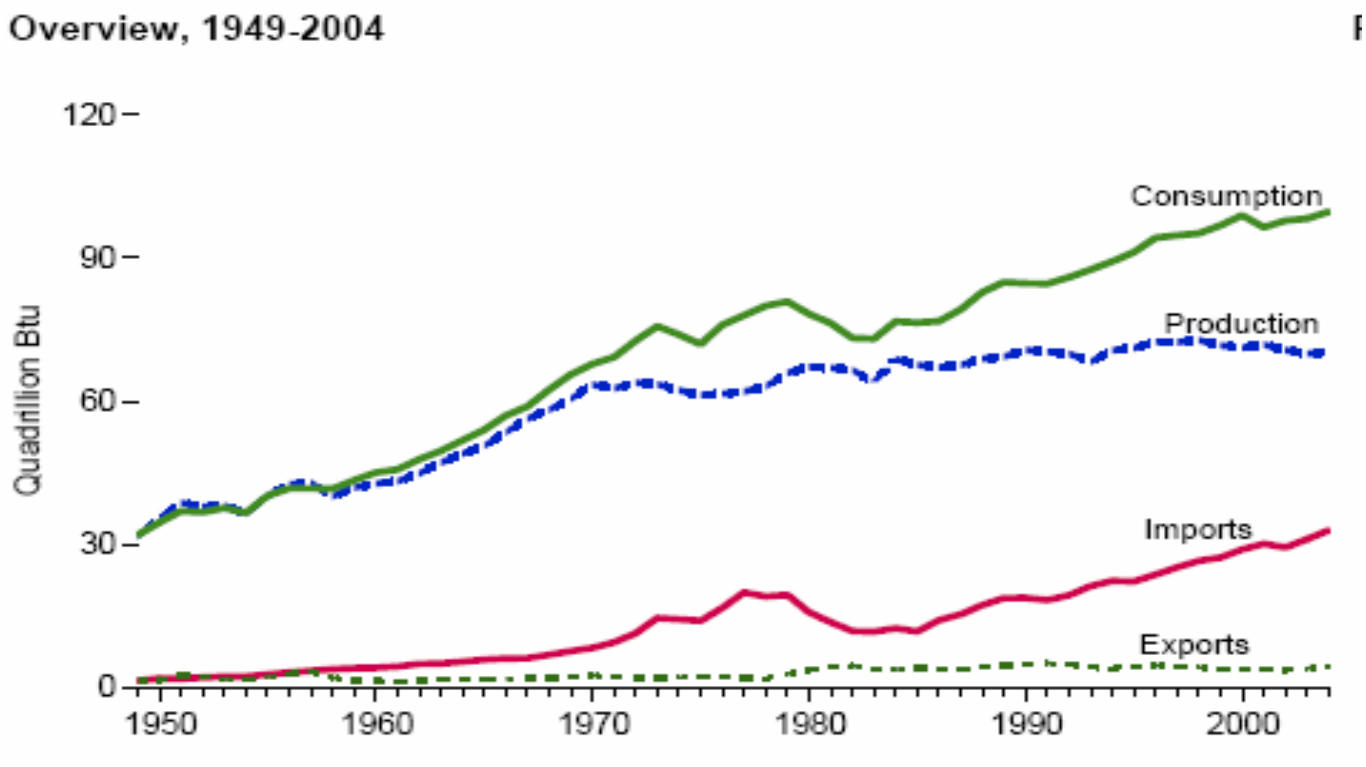
* TPES is calculated using the IEA conventions (physical energy content methodology). It includes international marine bunkers and excludes electricity/heat trade. The figures include both commercial and non-commercial energy.
** Geothermal, solar, wind, tide/wave/ocean.
*** Includes non-renewable waste.

Source: IEA Energy Statistics

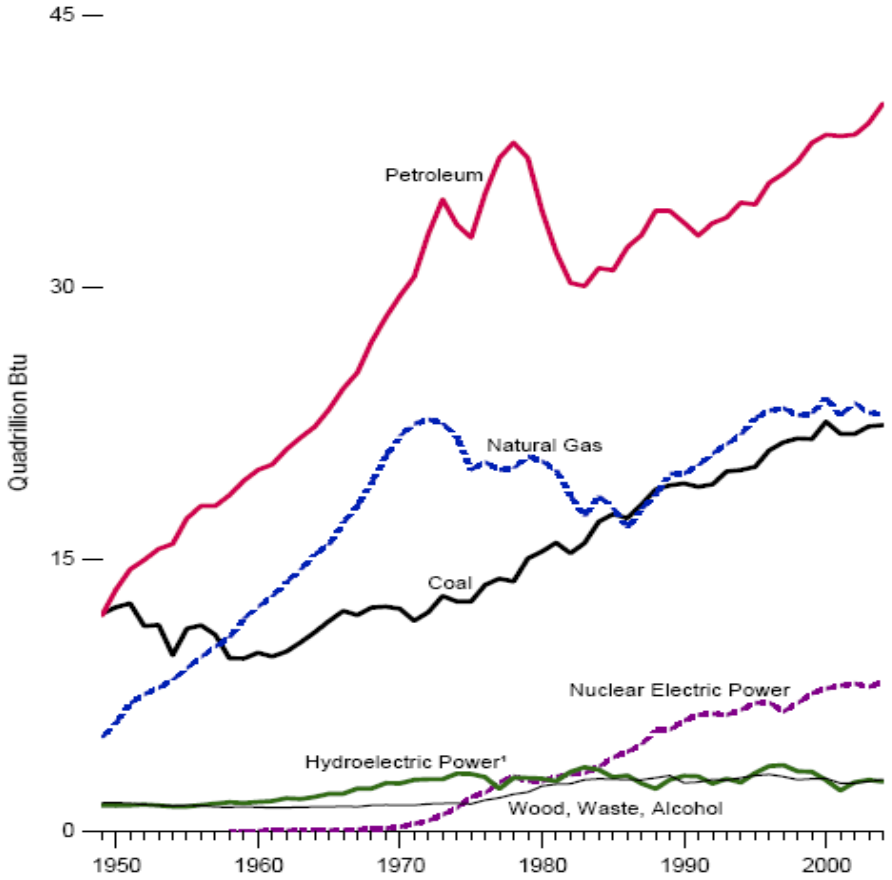
U.S. Energy Consumption - 2004 (Quads) - total = 99.6 (EIA)



US Energy: 1949-2004 - USDOE



US Energy Consumption: Impacts of 1973,1978 OPEC Oil Embargos

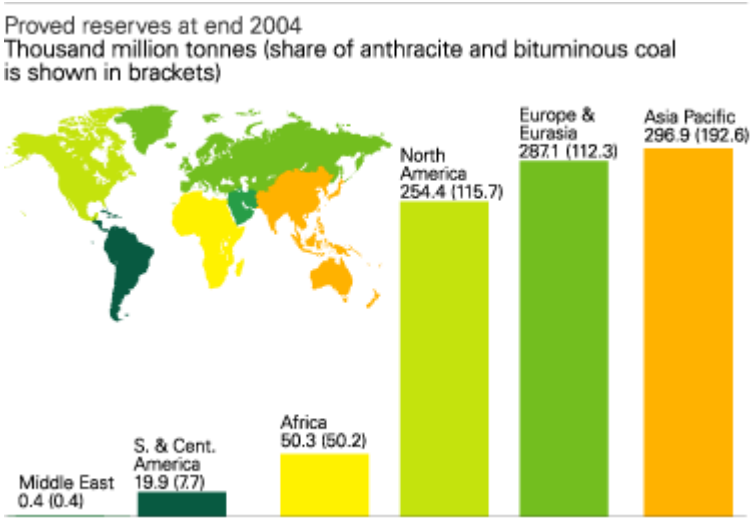


Traditional Energy Sources

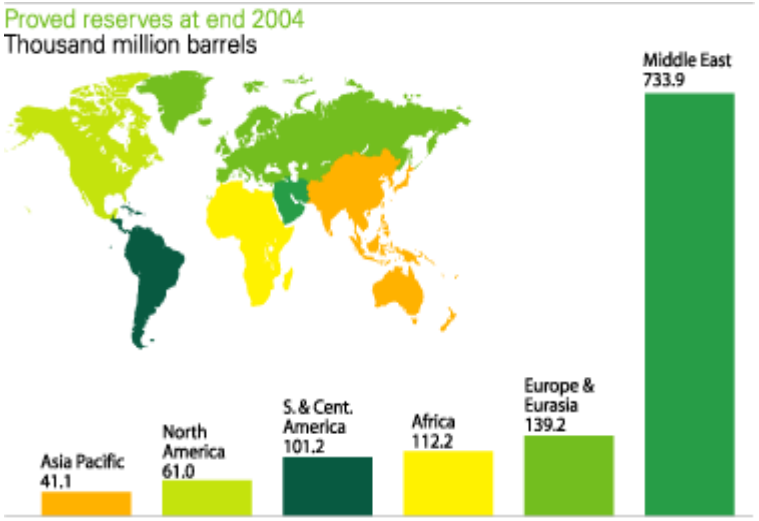
Coal, oil, natural gas, nuclear

World Coal and Oil Reserves (BP)

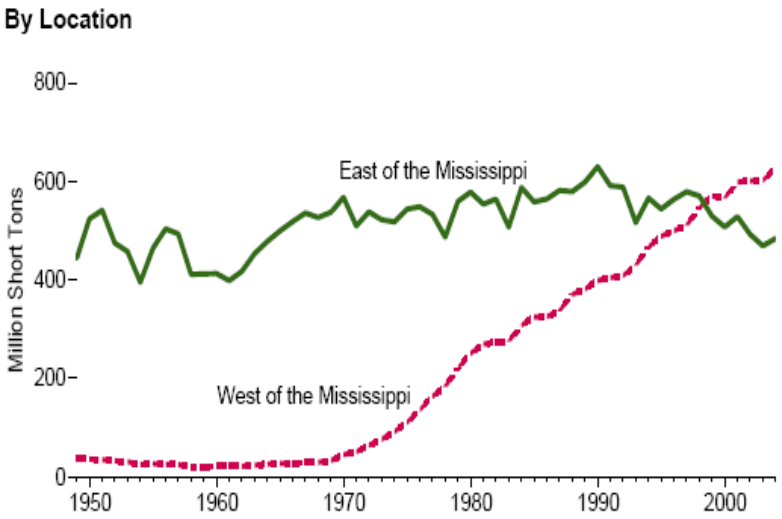
- Coal

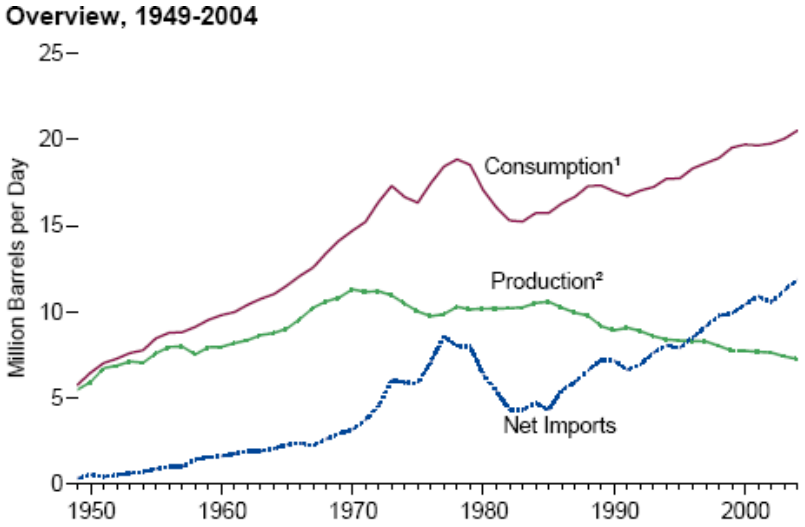


- Oil

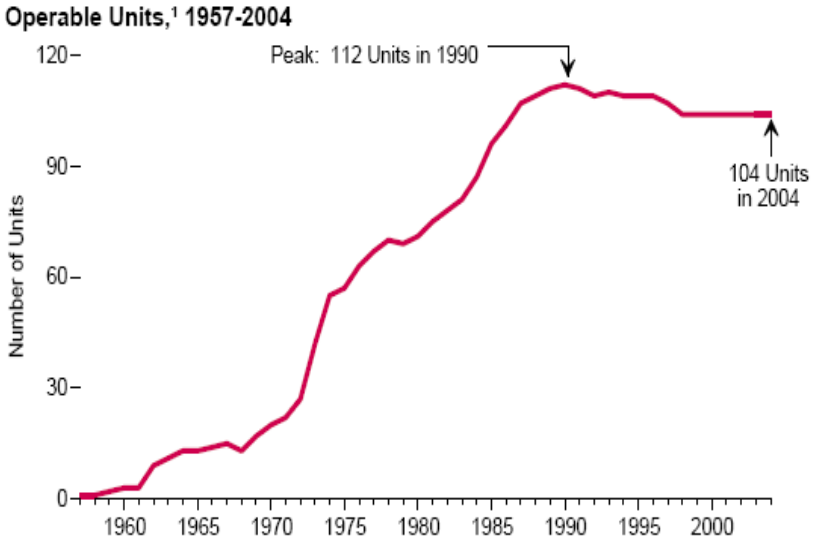


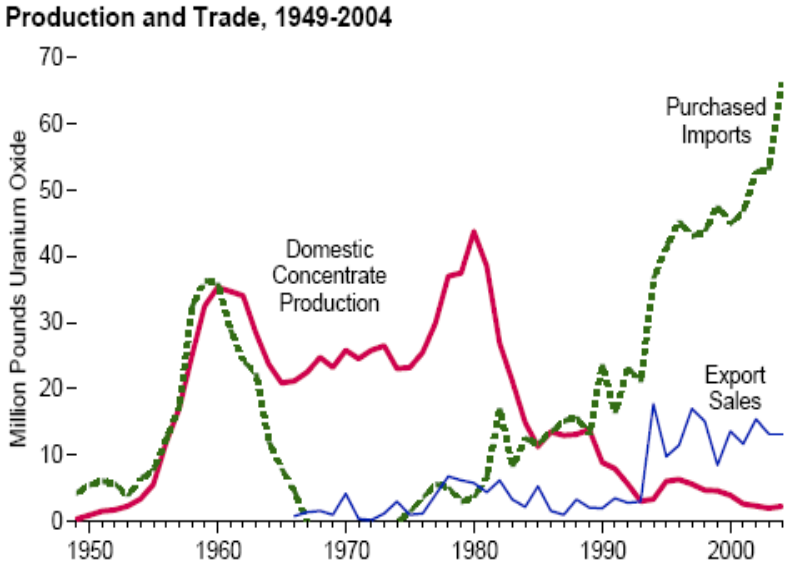
U.S. Coal and Oil Trends





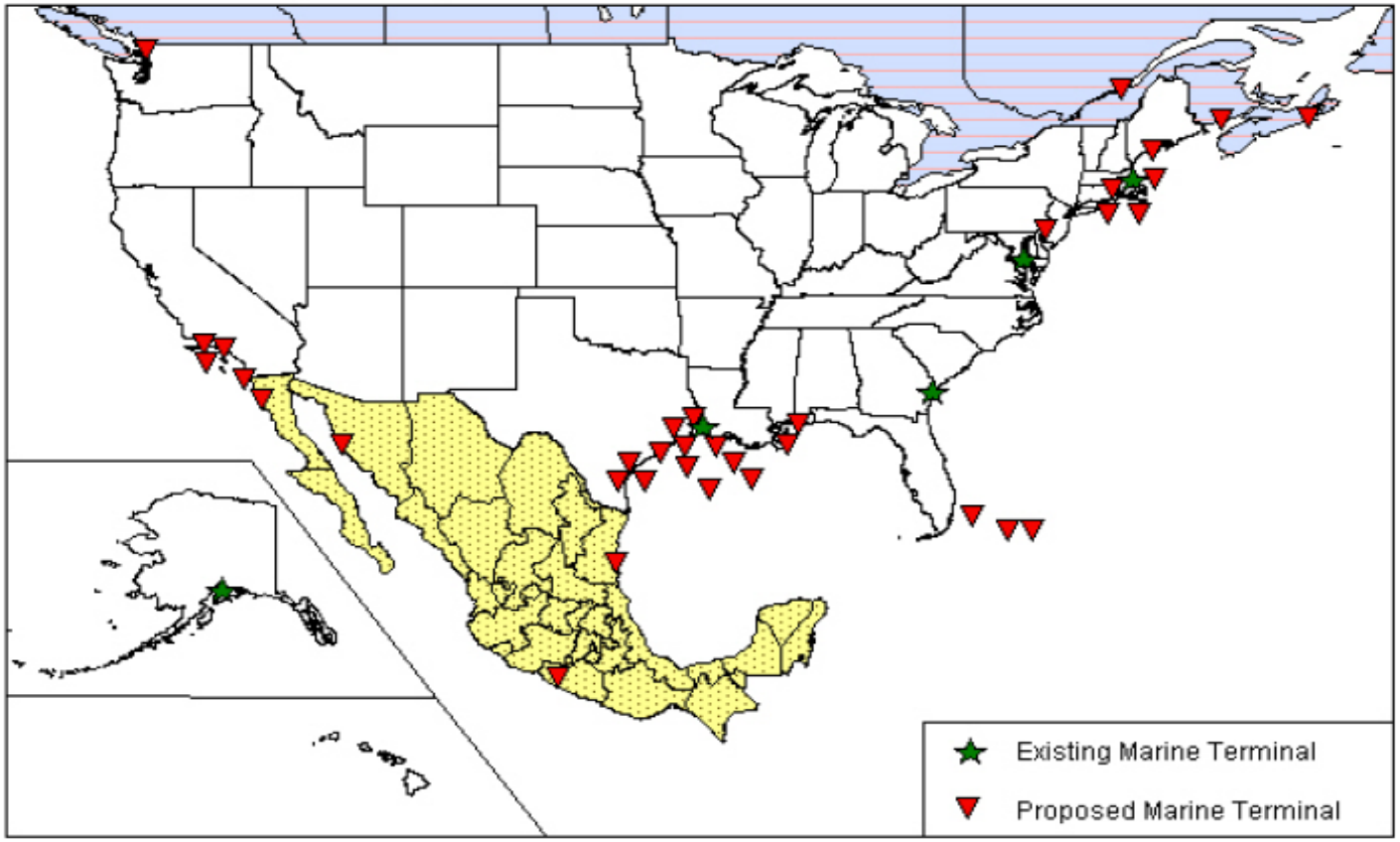
U.S. Nuclear Plants and Uranium Sources





LNG Terminals in U.S. and Mexico (5 existing, 34 proposed)

Figure A1. Existing and Proposed LNG Marine Terminals in North America as of June 2004



Traditional Source Issues

- Nuclear – safety, waste storage, security, new design, role in carbon dioxide, cost
- Oil – supplies from unstable areas, reserves
- Coal – safety, hauling, contaminants
- LNG – liquefied natural gas – risk, security, imports
- Natural gas – reserves
- All sources – new technologies extend reserves, new approaches bring in new reserves (e.g., shale, low producing wells, coal “walls” removed)

Mini-vote

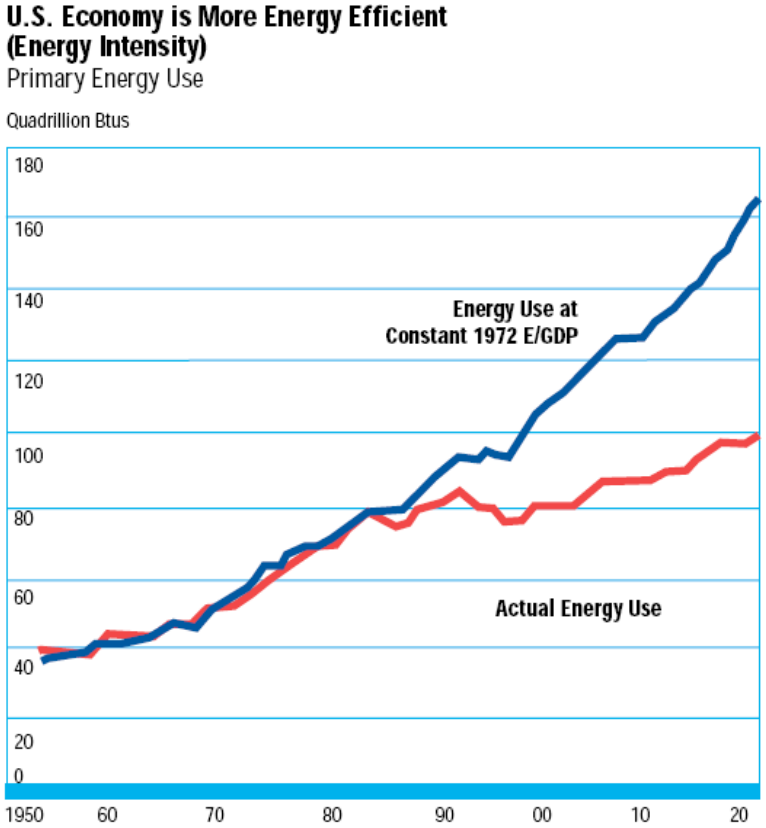
- Are current energy trends sustainable?
  - If no, then what should we do differently?

Energy Efficiency and Renewable Sources

While retaining traditional sources, efficiency will be the greatest source of “new energy”, followed by a mix of alternative sources

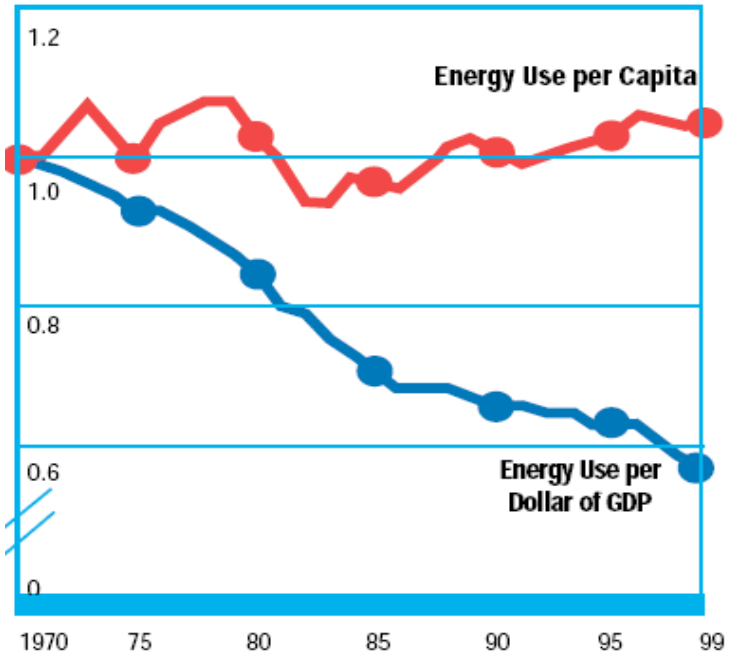
Energy Efficiency and GDP

U.S. Economy is More Energy Efficient (Energy Intensity)
Primary Energy Use



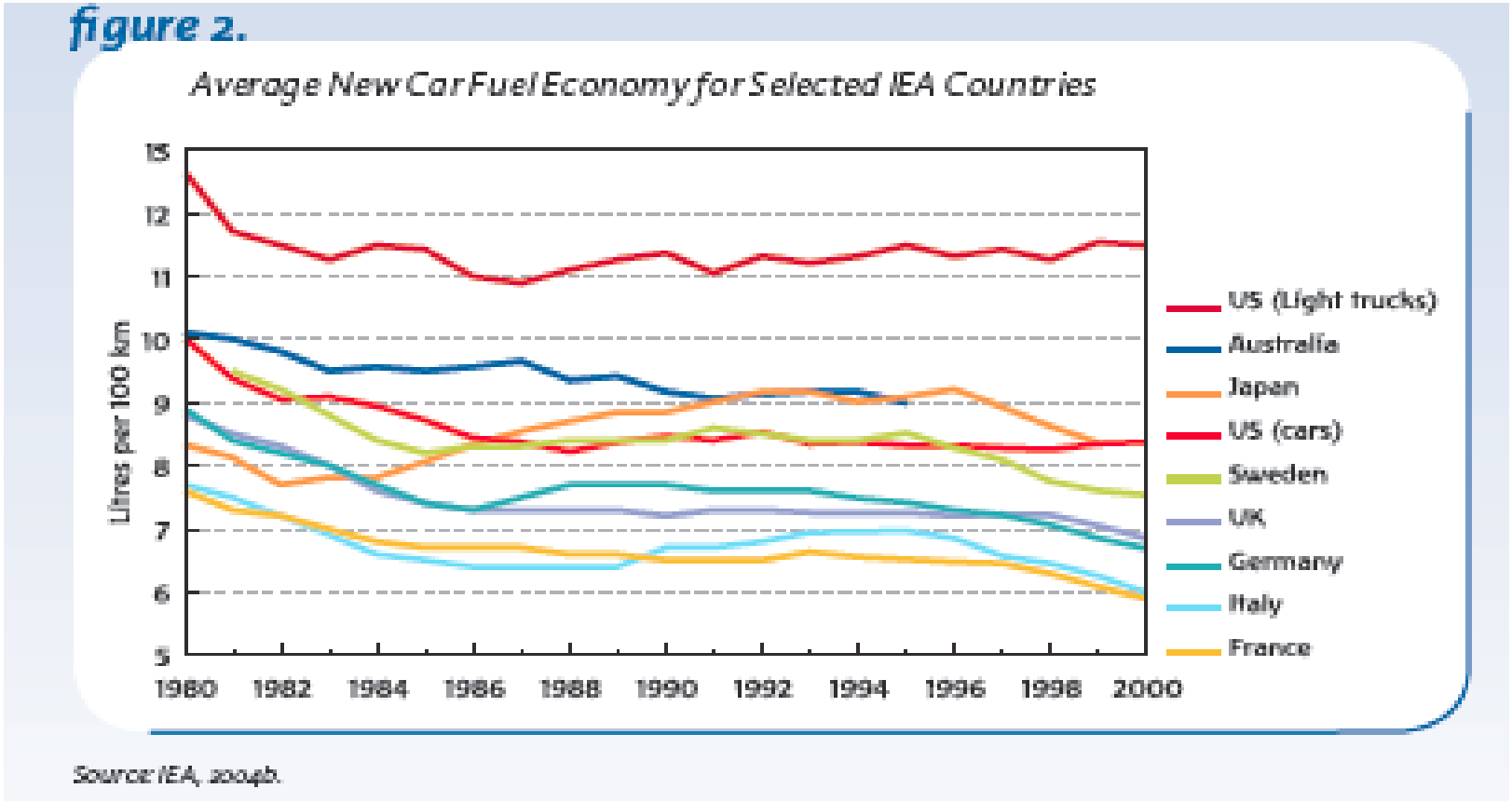
Improvements in energy efficiency since the 1970s have had a major impact in meeting national energy needs relative to new supply. If the intensity of U.S. energy use had remained constant since 1972, consumption would have been about 70 quadrillion Btus (74 percent) higher in 1999 than it actually was.

U.S. Energy Use per Capita and per Dollar of GDP: 1970–1999
(Index: 1970 = 1)

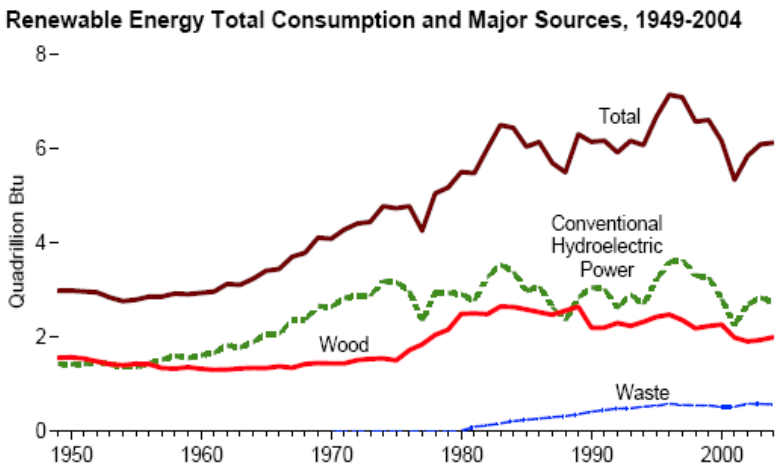


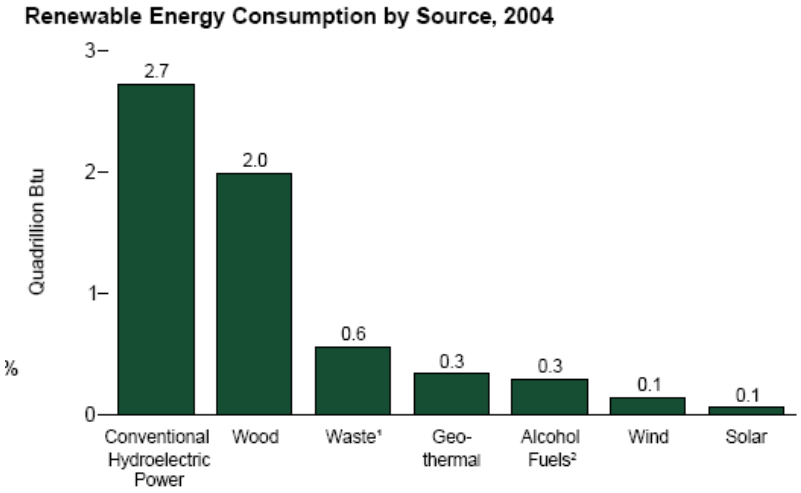
The energy intensity of the U.S. economy is measured by the amount of energy used to produce a dollar's worth of gross domestic product (GDP). By that yardstick, U.S. energy intensity declined significantly between 1970 and 1985, and has continued to decline, albeit at a slower rate.

Comparison of New Car Efficiencies (higher lines are less efficient)



U.S. Renewable Energy

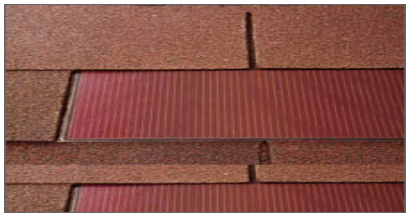




Examples of New Approaches

- Return to Distributed Energy Production
- Wind – vertical axis

- Organic / integrated silicon photovoltaic



- Solar Tower

Renewable Energy Issues

- Solar – passive and active could be significant in areas of high sunlight and low cloud cover
- Wind – fastest type of energy growth, lots of possibilities, noise and visual impacts are negatives
- Hydro – some low-head hydro possible but not expected as major growth area
- Biofuels – part of complex of shifting chemical feed stocks, drugs, and fuel to agriculture (but competes with food and requires energy and water)
- All sources – except for hydro, currently small quantities of energy are from these sources

Mini-vote

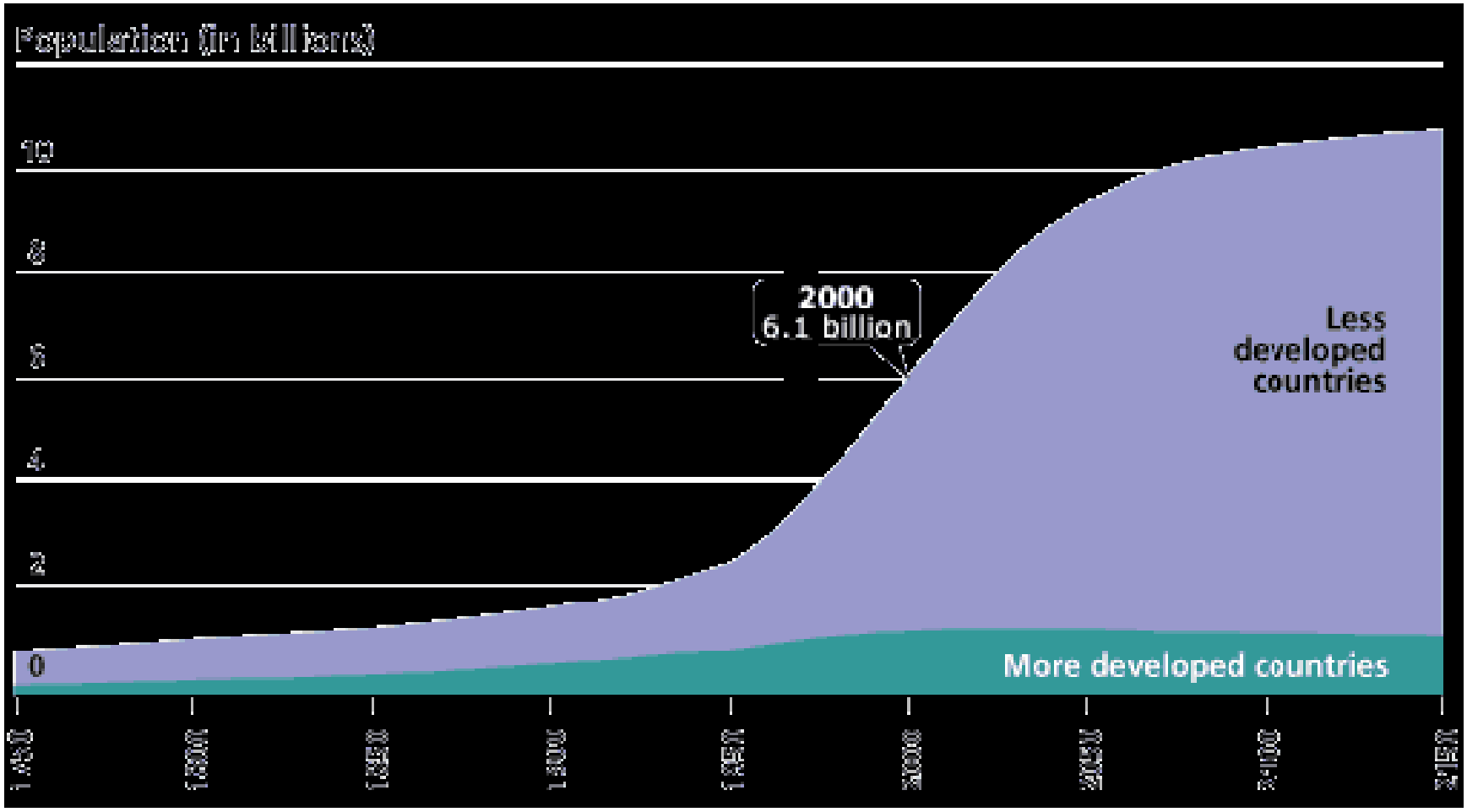
- Is energy efficiency the answer?
- Are renewable energy sources the answer?
- Is a mix of everything the answer?

Energy Sources Summary

- The problems:
  - Other countries are going to increase energy use – many are today's developing countries
  - World supplies are limited – either by quantity or in a practical sense by price when in short supply. Except for coal, US supplies are limited
  - Central role of energy in the economy and in war
- The solutions:
  - Efficiency is first choice – least expensive and most effective, think of it as an investment not a cost
  - New sources, new technologies, new approaches using traditional and new sources (including distributed production)
  - Incentives/disincentives will help or hurt, depending on the specific, but costs of energy are likely to remain high

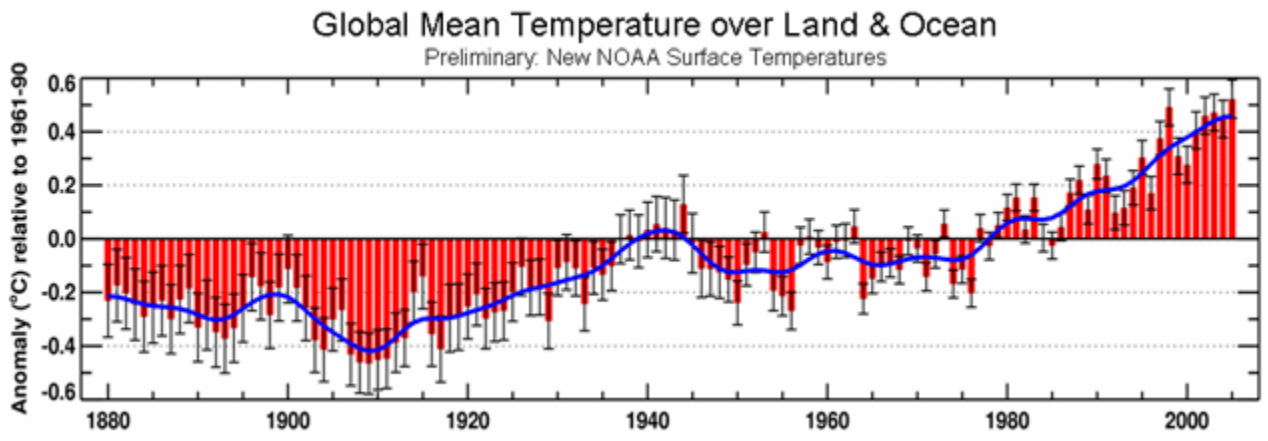
Key Factors Impacting Energy Use and Supply

World Population 1750-2150 (PRB)
Less Developed Percentage Growing

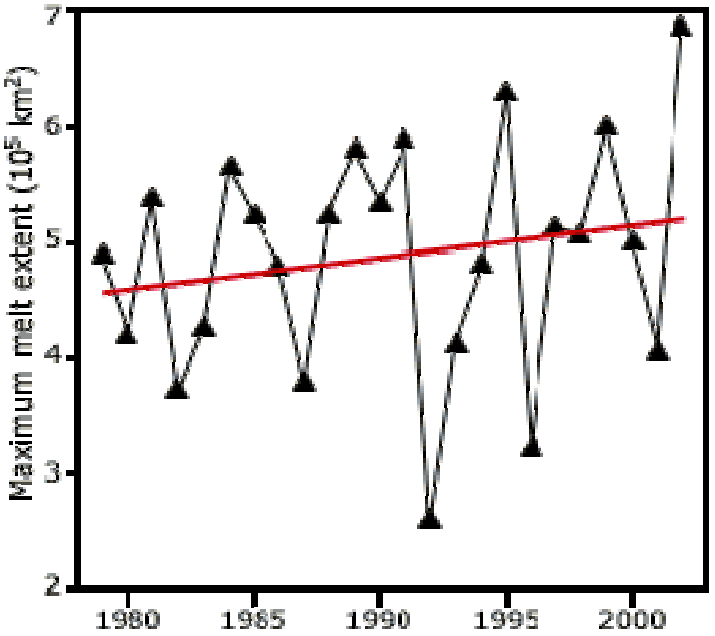


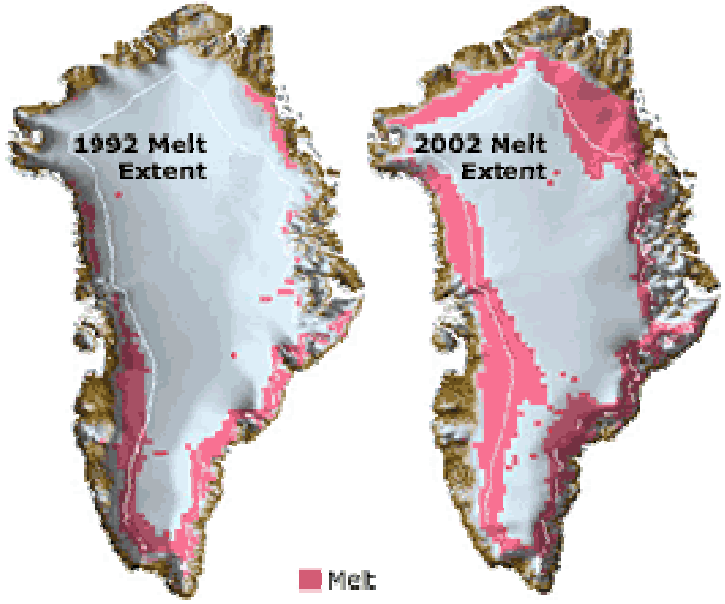
Global Temperature is Increasing

Blue line is temp relative to 1961-1990 average

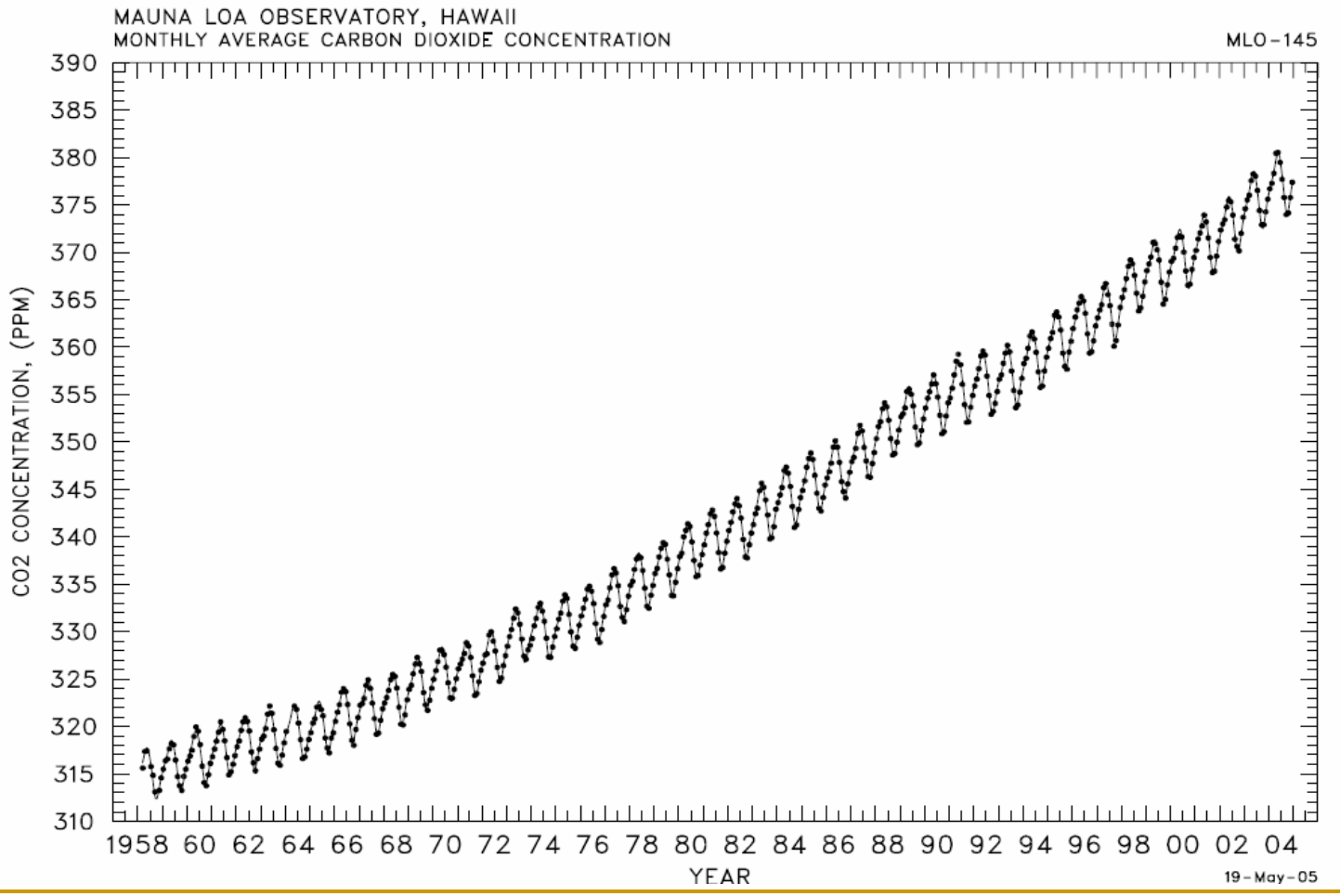


Greenland Ice Melting (NASA)





Carbon Dioxide Increasing 1958-2005



Population and Environment Summary

- World-wide population *growth rate* slowing but developing countries are growing as percent of world; increased per capita energy use will put new pressure on energy supplies
- Environmental effects are real, only the causes are unclear (global climate change, pollution, security)

Mini-vote

- Is global climatic change likely occurring?
- Will per capita consumption by developing countries increase?

Thinking About the Future

Should we anticipate the future (by using our radar) and make appropriate adjustments or just let the future (or an obstacle) hit us?

Why We Should Better Anticipate the Future

- The future is a continuation of the past – but often it cannot be simply extrapolated
- Where are we going? What bumps are in the road? Are we in a “unique” time (1900-2100)?
- What are the driving forces of change?
- What are possible changes in trends, and what are their implications to us and others?
- How should we use this information?

Three Different Energy Views

- US Department of Energy
  - Heavy on extrapolation of trends, results suffer because of periodic changing of policy directions
- Amory Lovins
  - Focuses on efficiency and alternative sources, with an emphasis on building design and distributed systems.
- Peter Huber/Mark Mills
  - Book title: “The Bottomless Well: The twilight of fuel, the virtue of waste, and whey we will never run out of energy” (due to new technologies, long term trends)

Remember the Past

We know more about energy options than we put to use

US Energy Forecasts: Summary of DOE studies (AnRev Energy/Environ)

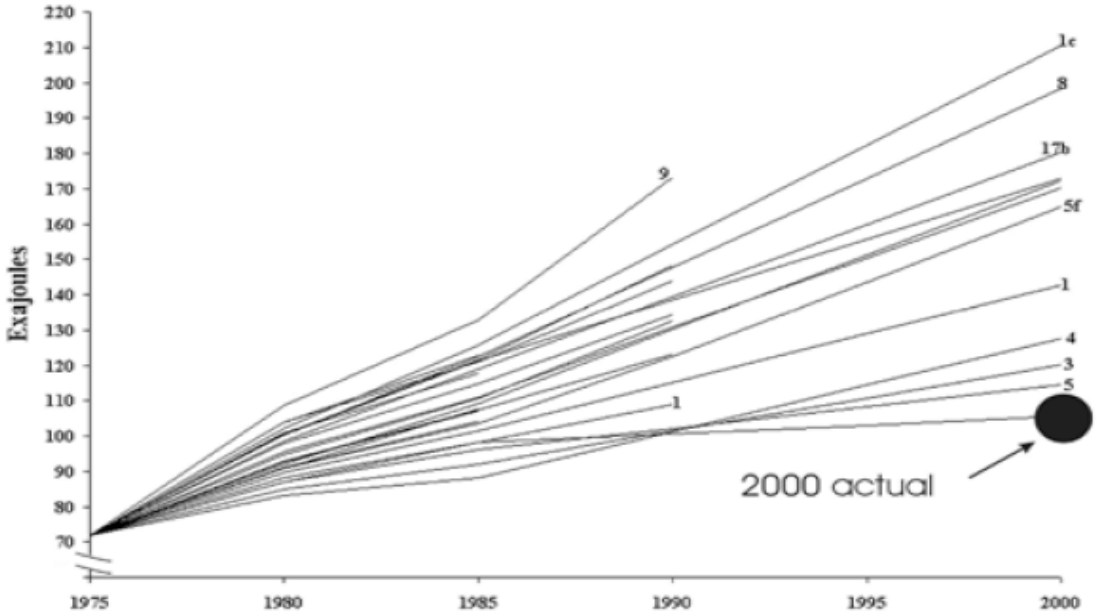


Figure 1 Projections of total U.S. primary energy use from the 1970s. The figure is redrawn from a Department of Energy report (3) and simplified from a summary of dozens of forecasts. Actual use at the end of the century [105 exajoules (4)] is indicated. Forecasters clearly did not anticipate the ability of the economy to limit growth of energy use. Note that the figure suppresses the zero baseline. Sources for the individual curves may be found in Reference 3.

Case History on Oil Transport: Torry Canyon tanker, March 1967

- First major oil spill, caused new laws
- Liberian flag, chartered from Union Oil to BP, experienced Italian crew
- Hit a known object while hauling from Persian Gulf to Wales, went off course while on autopilot, good visibility, in range of lightship, 3 lighthouses, and a radio beacon
- Problem: scaled up from regular tanker size, early warnings missed. In 1989 the Exxon Valdez in Alaska repeated much of this.

What Should We Do Now?

Context for Understanding the World We Live in and How to React

VUCA World

- Volatile
- Uncertain
- Complex
- Ambiguous

FAIR Response

- Flexible
- Agile
- Innovative
- Responsive

For energy we realize change is certain:

- Efficiency is the most cost efficient and effective
- There is no single magic bullet solution
- Uncertainties exist

Things to Ponder

- The U.S. is a combination first world and third world country, is currently a super power, and has a separate set of rules it plays by.
- China and India are growing rapidly, Asian use of energy will surpass that of U.S. and Europe about 2020. Oil supplies are finite.
- Energy is historically intimately tied up with tradition and culture, war, and the global economy.

Your Turn (talk about these points with your friends) …
but now – any questions?

- Select an important energy event or issue
- List some possible outcomes
- Think about some implications of those outcomes
- List a few of wildcards and uncertainties
- Decide what we could do differently and what would need to be changed to accomplish it

References for Energy

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  - http://www.oecd.org/department/0,2688,en_2649_33707_1_1_1_1_1,00.html
- Class on “Anticipating the Future”
  - http://cals.arizona.edu/futures