Energy Facts

Gloria and John L. Blackburn Academic Symposium

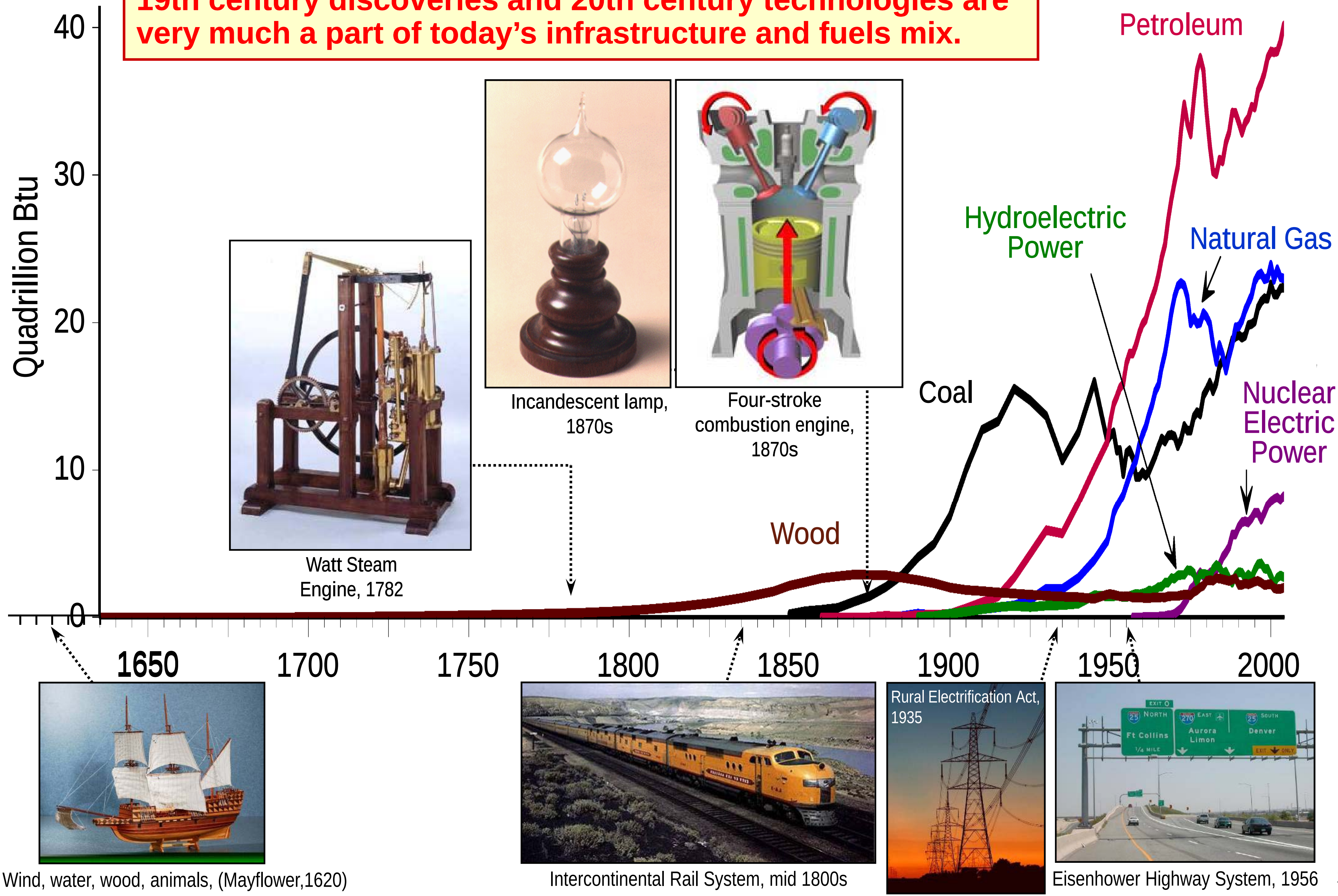
Tuscaloosa, AL

Friday, October 30, 2009

Linda G. Blevins, Ph.D.
Senior Technical Advisor
Office of the Deputy Director for Science Programs
Office of Science, U.S. Department of Energy

400 Years of Energy Use in the U.S.

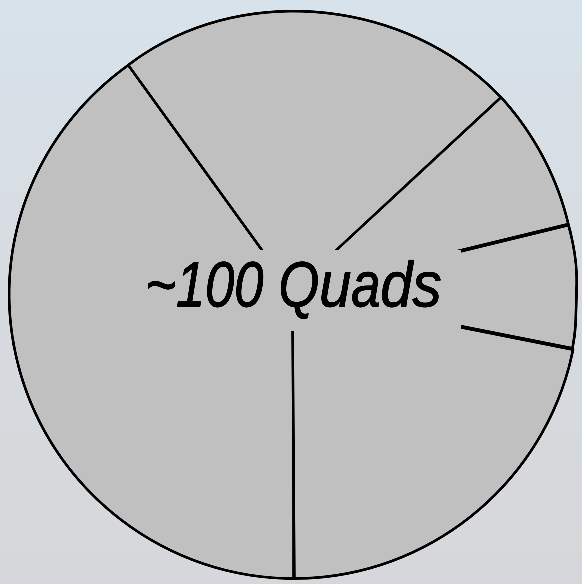
19th century discoveries and 20th century technologies are very much a part of today's infrastructure and fuels mix.



Energy Facts That We Should Know

- Energy consumption today
- Energy needs through the 21st century
- Energy sources and consumption sectors
- Fossil fuel reserves
- Nuclear and renewable energy
- Energy and the environment

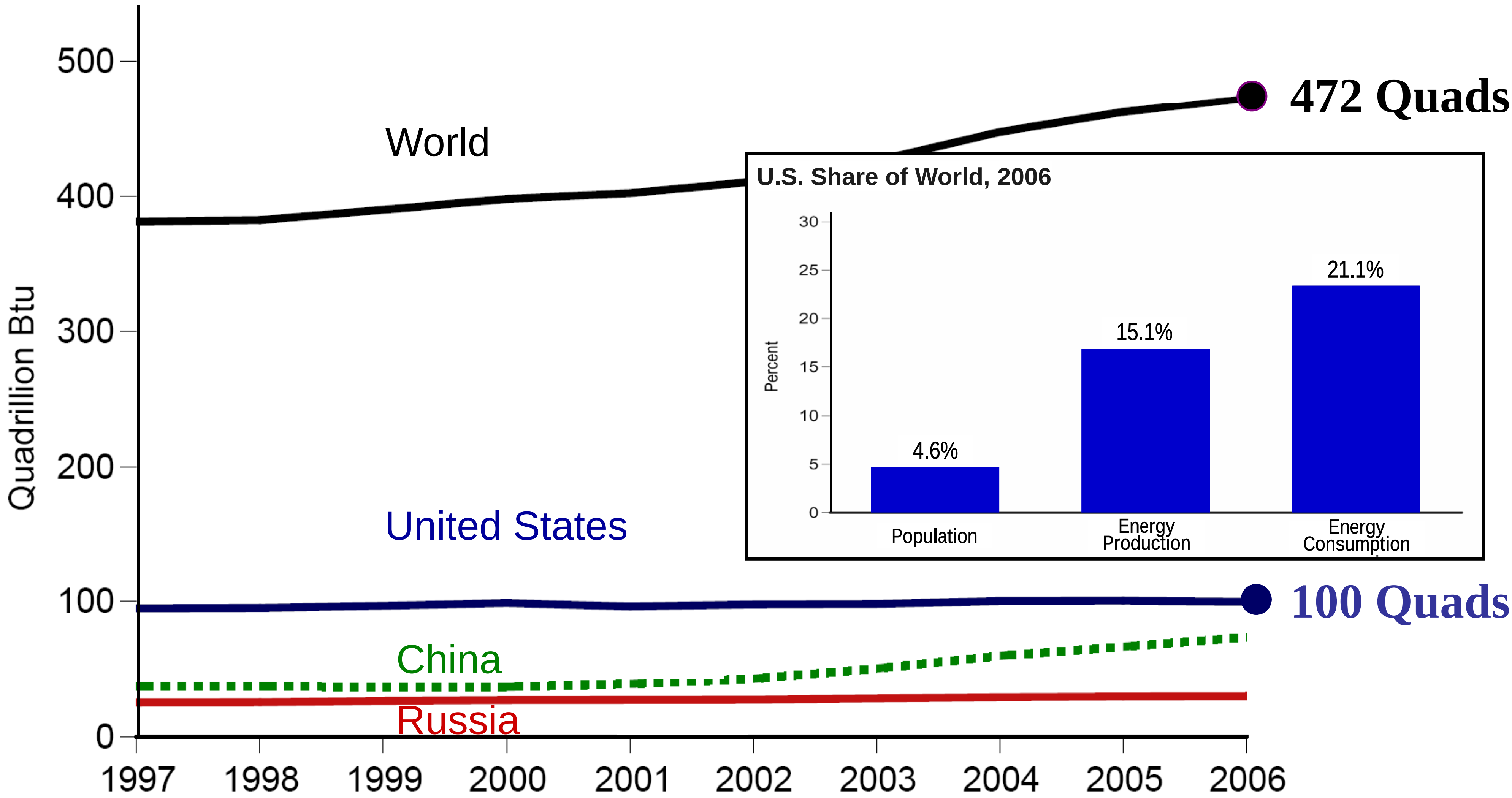
Energy consumption today

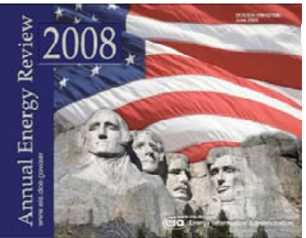


Quad = 10^{15} BTU

U.S. and World Energy Consumption Today

With <5% of the world's population, the U.S. consumes 21% of all primary energy



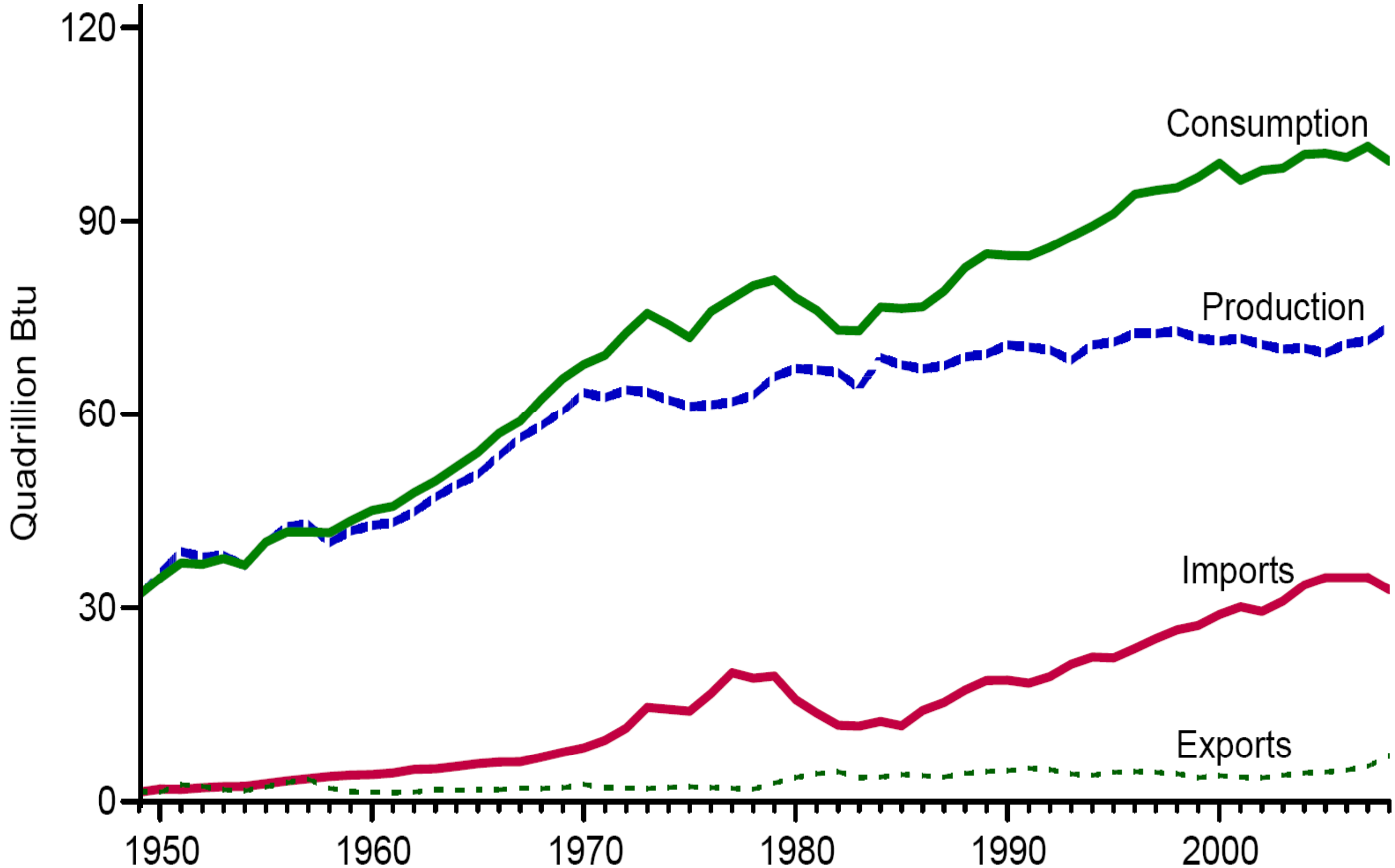


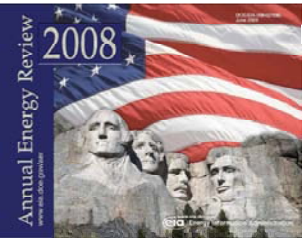
<u>Some equivalent ways of referring to the energy used by the U.S. in 1 year (approx. 100 Quads)</u>

100.0 quadrillion British Thermal Units (Quads)	U.S. & British unit of energy
105.5 exa Joules (EJ)	Metric unit of energy
3.346 terawatt-years (TW-yr)	Metric unit of power (energy/sec)x(#seconds in a year)

U.S. Energy Production & Consumption Since 1950

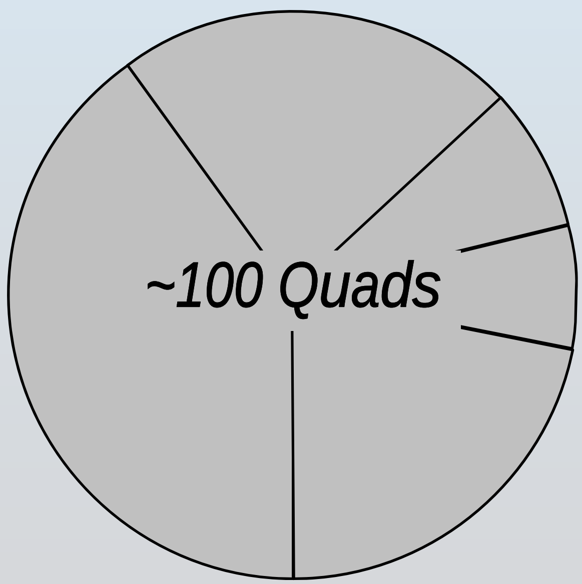
The U.S. was self sufficient in energy until the late 1950s





Energy needs in the 21st century

U.S.

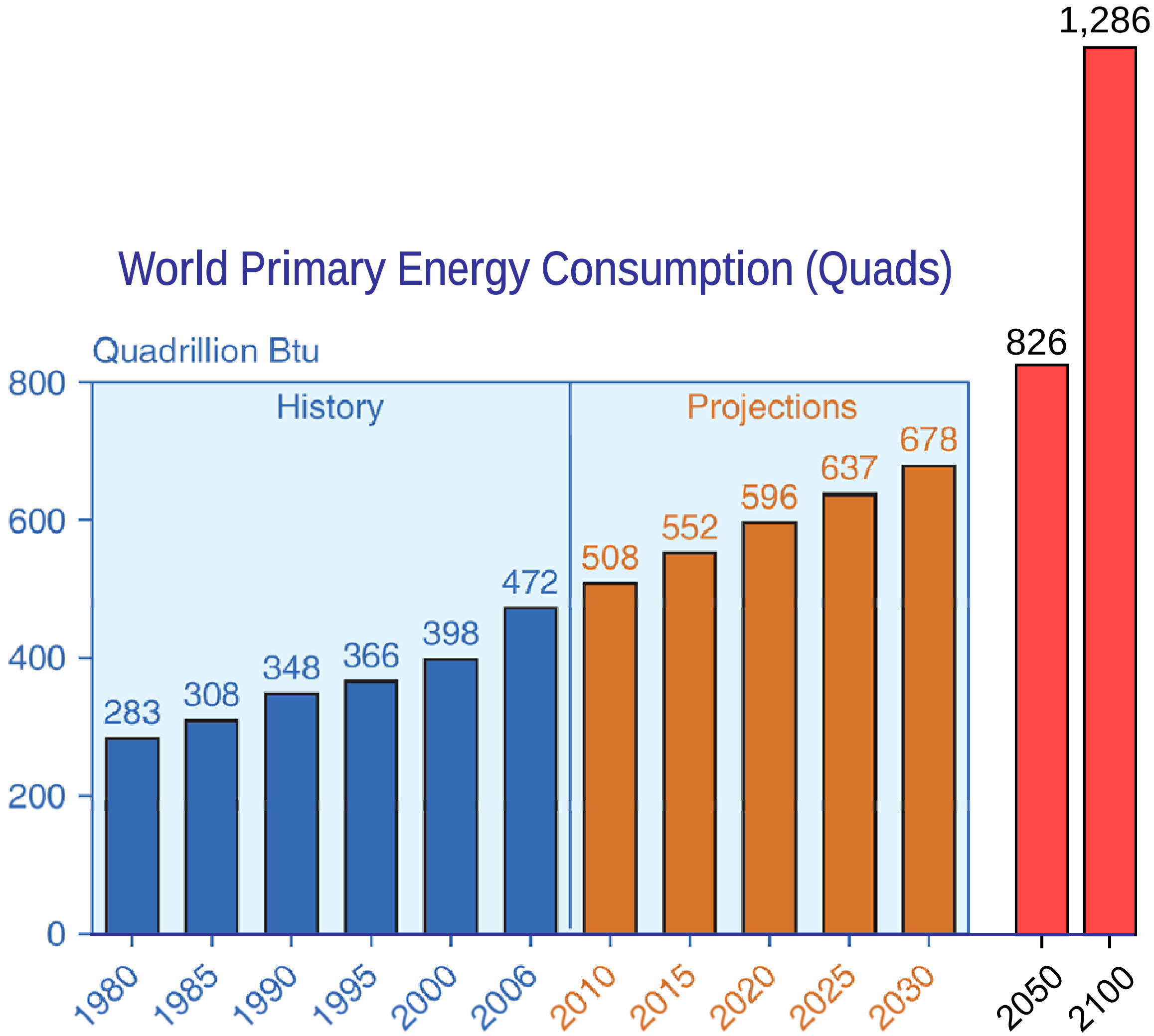


?

World *472 Quads* ?

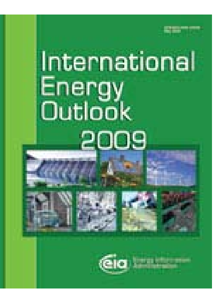
World Energy Needs will Grow in the 21st Century

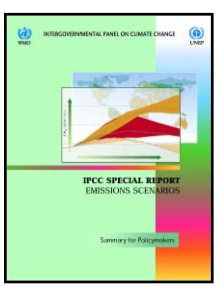
By the end of the century, world energy needs may triple

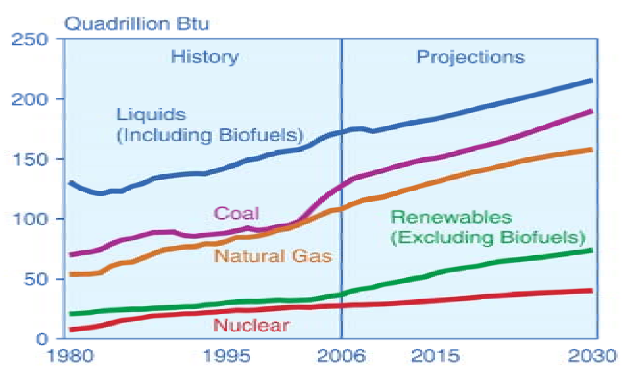


Projections to 2030 are from the Energy Information Administration, International Energy Outlook, 2009.

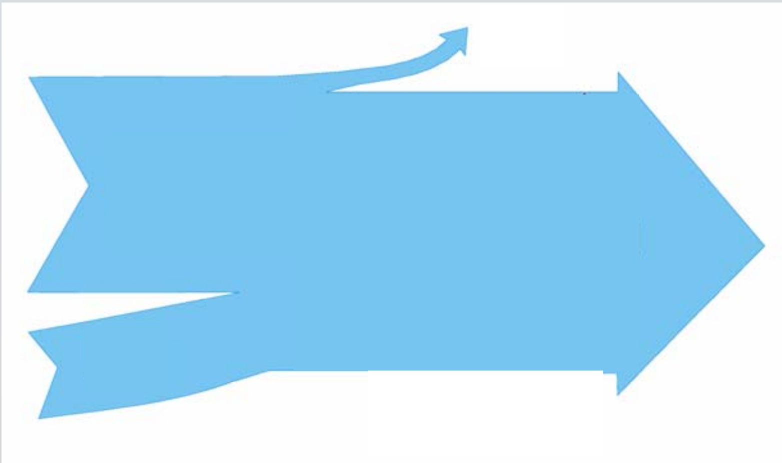
Projections for 2050 and 2100 are based on a scenario from the Intergovernmental Panel on Climate Change (IPCC), an organization jointly established in 1988 by the World Meteorological Organization and the United Nations Environment Programme. The IPCC provides comprehensive assessments of information relevant to human-induced climate change. The scenario chosen is based on "moderate" assumptions (Scenario B2) for population and economic growth and hence is neither overly conservative nor overly aggressive.





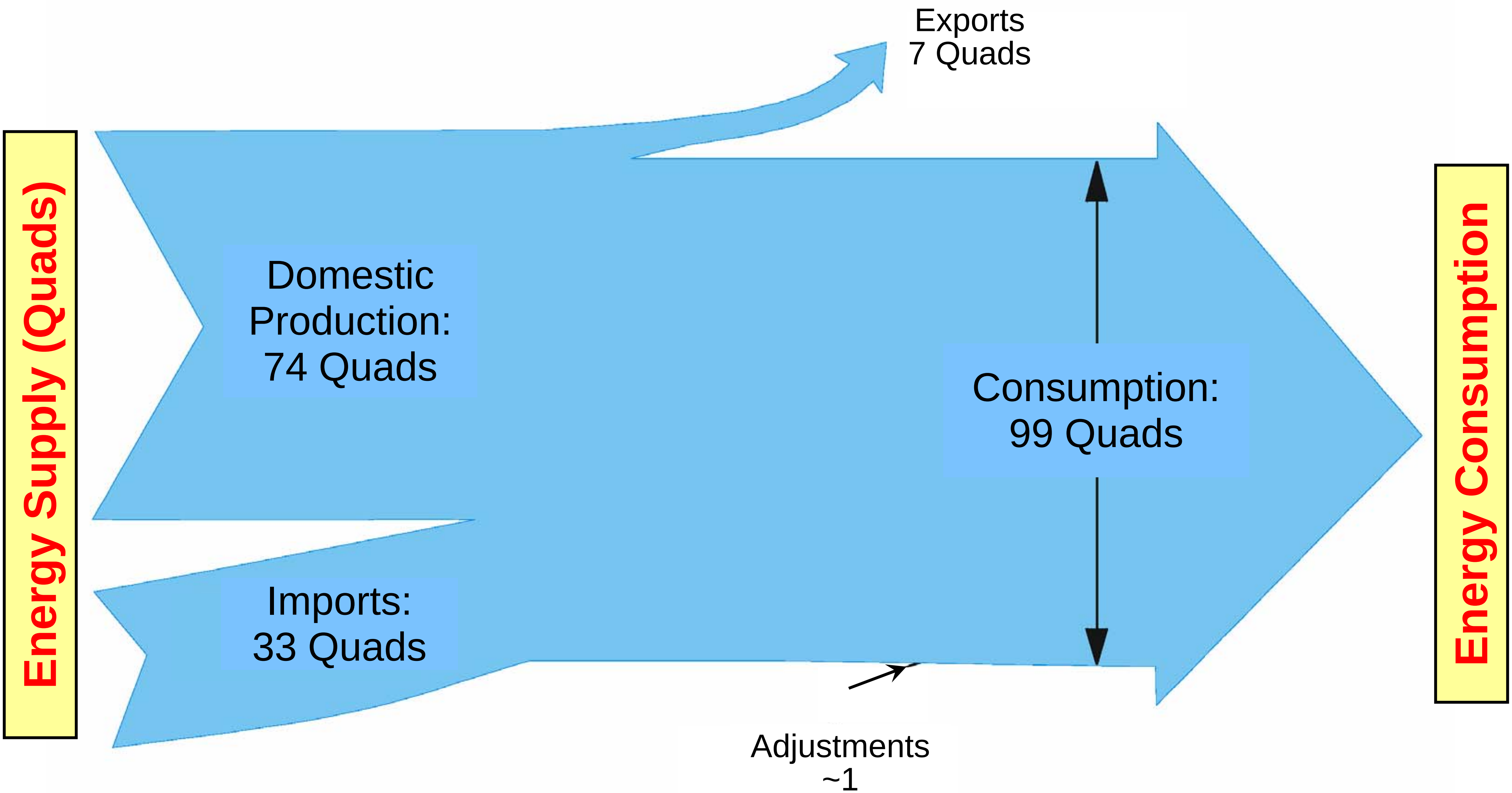


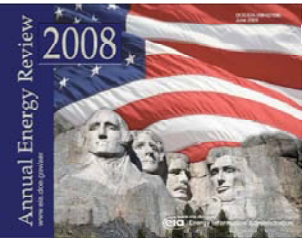
Energy sources and consumption sectors in the U.S.



U.S. Energy Flow, 2008

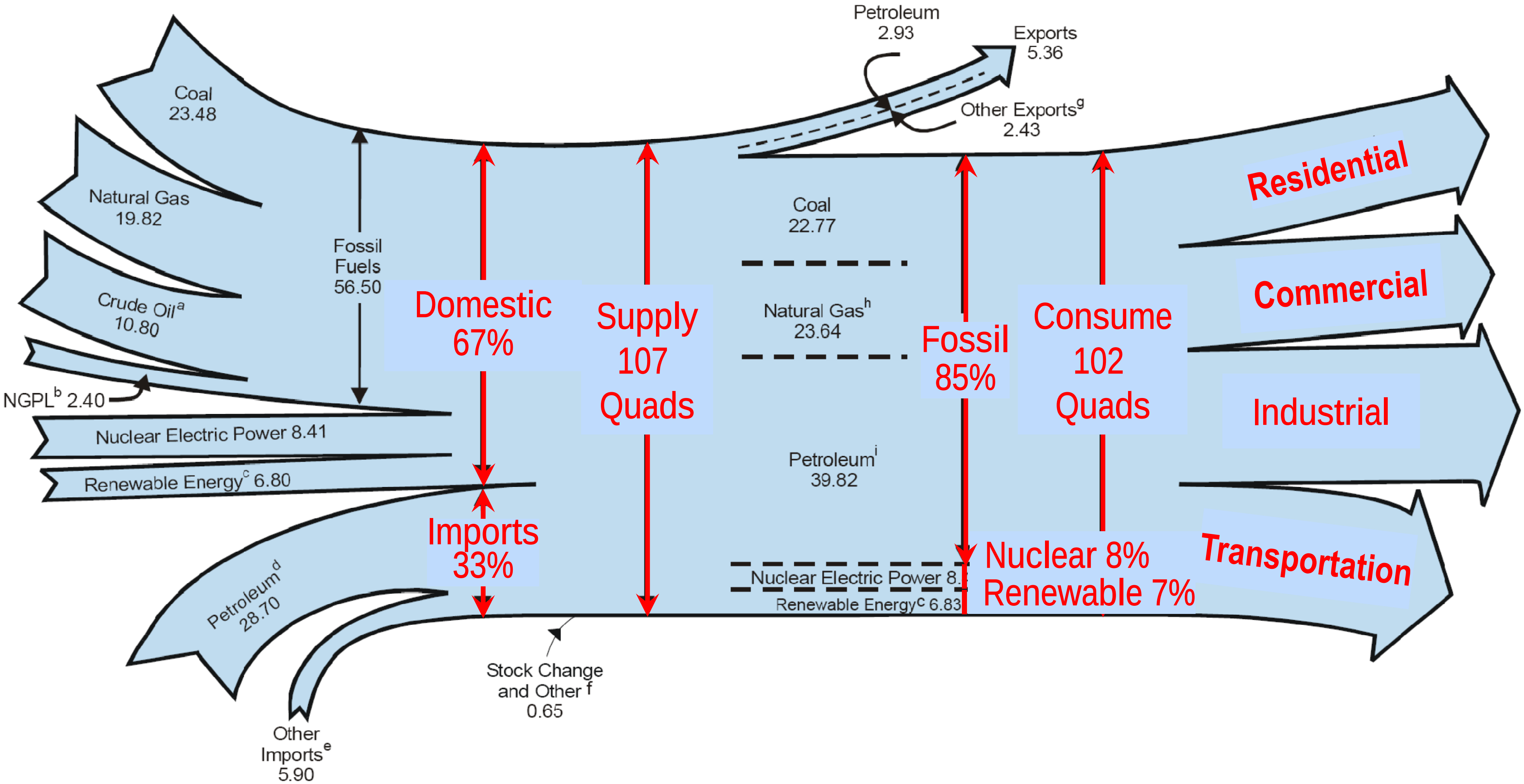
About 1/3 of U.S. primary energy is imported

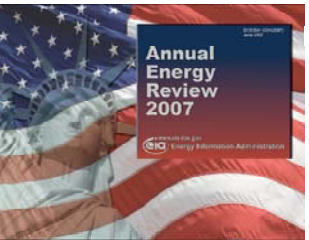




U.S. Energy Flow, 2007 (Quads)

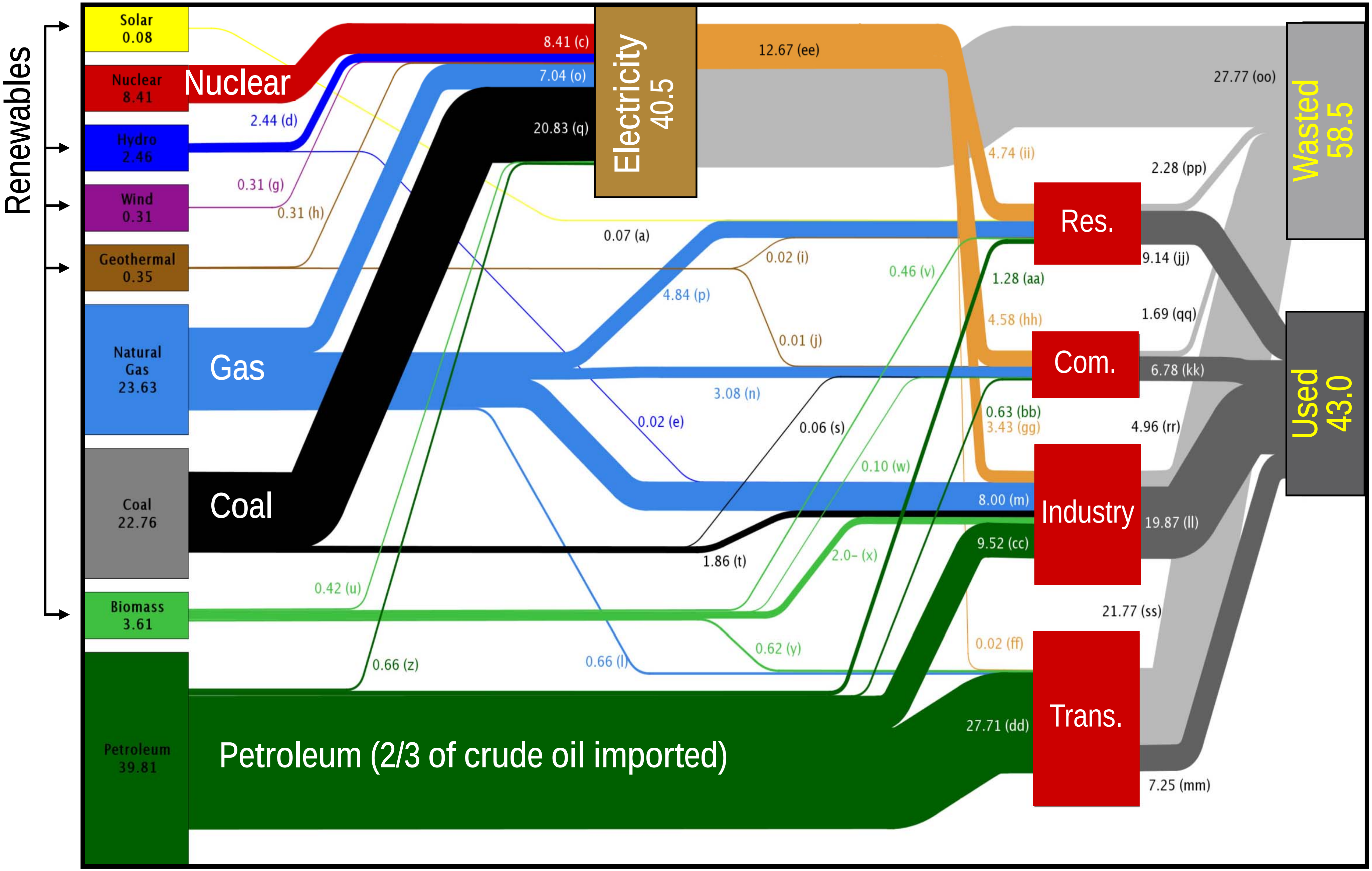
85% of primary energy is from fossil fuels





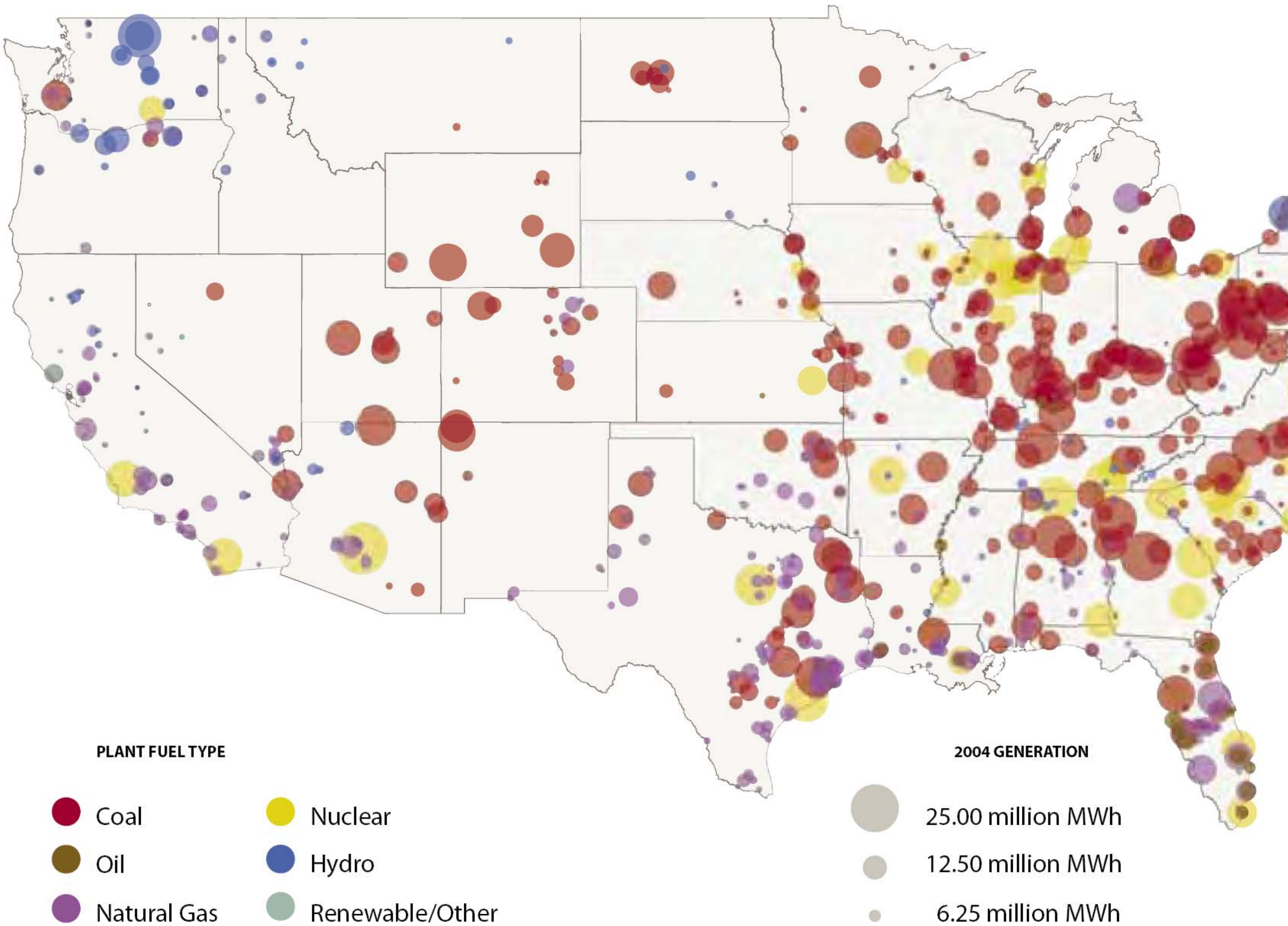
U.S. Energy Flow, 2007 (Quads)

58% of Primary Energy is Waste

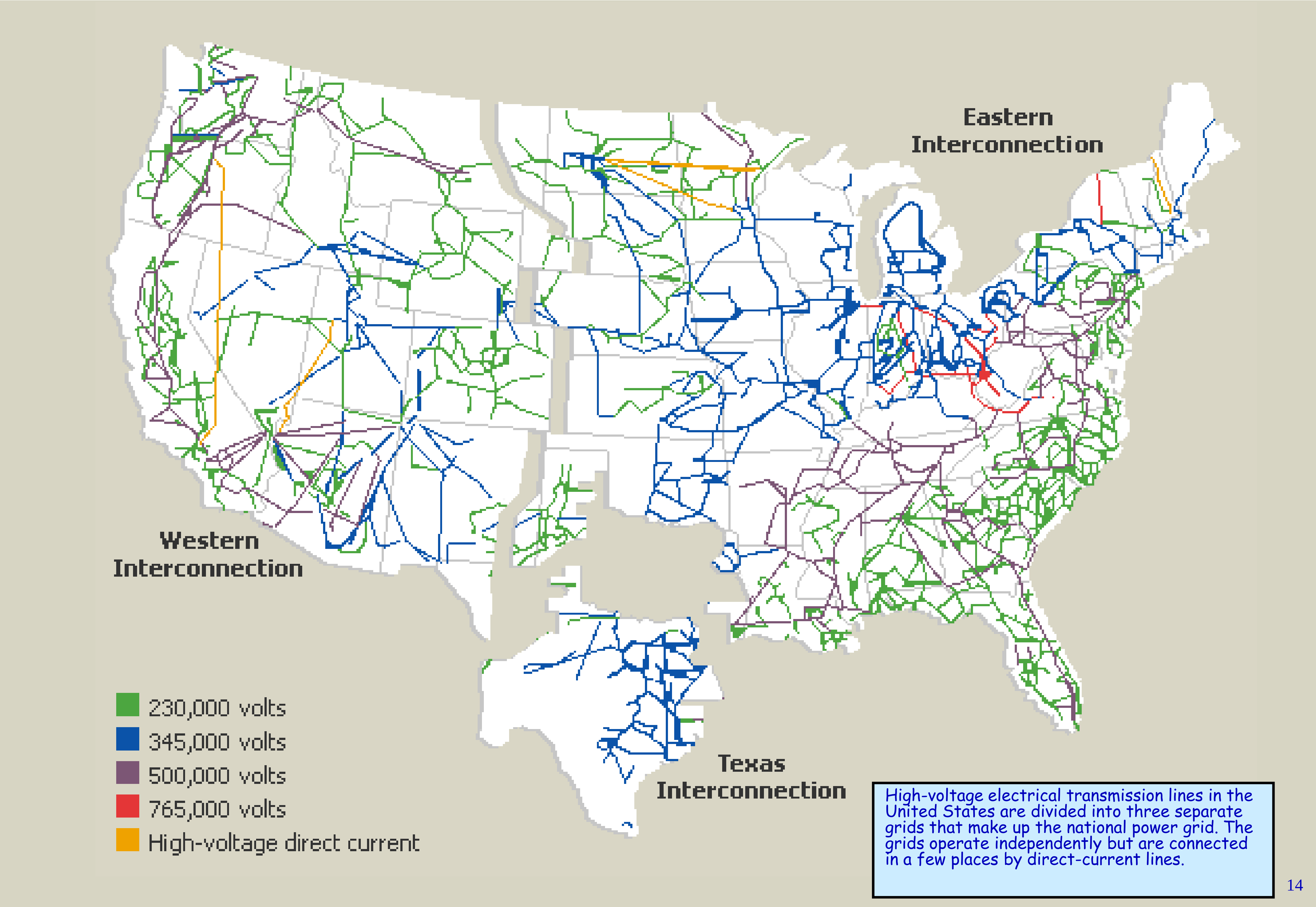


Source: LLNL 2008; data are based on DOE/EIA-0384(2006). Credit should be given to LLNL and DOE.

U.S. Power Plants are Predominately Fossil Fuel Fired; …



Three Largely Separate Grids Distribute the Power; ...



High-voltage electrical transmission lines in the United States are divided into three separate grids that make up the national power grid. The grids operate independently but are connected in a few places by direct-current lines.

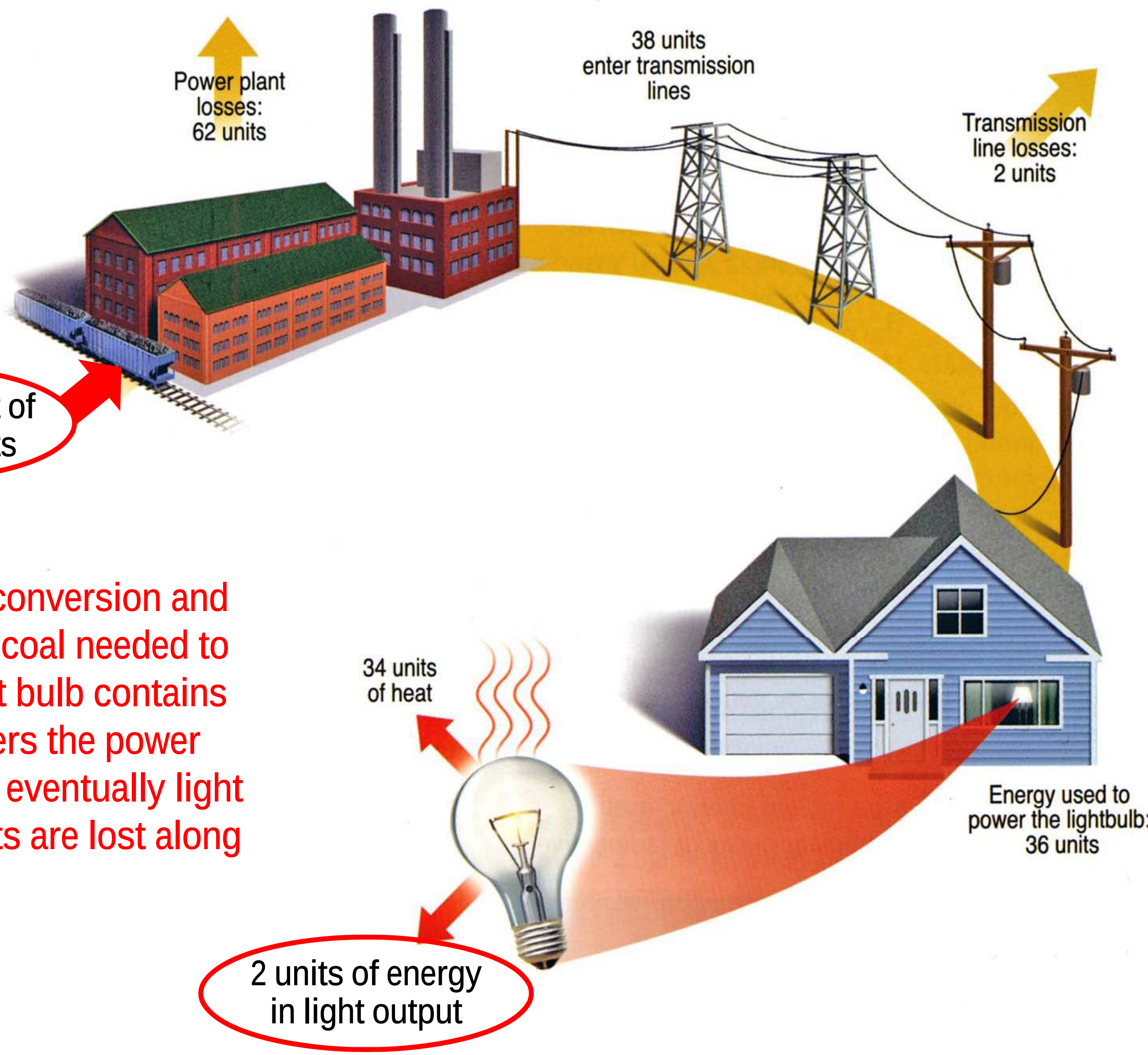
Allowing Illumination of the Night Sky

2/3 of the U.S population has lost naked-eye visibility of the Milky Way

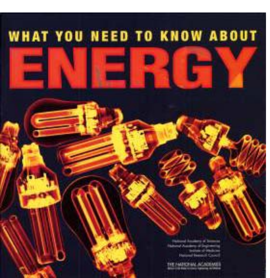
http://visibleearth.nasa.gov/view_rec.php?id=1438l

Overall Efficiency of an Incandescent Bulb ≅ 2%

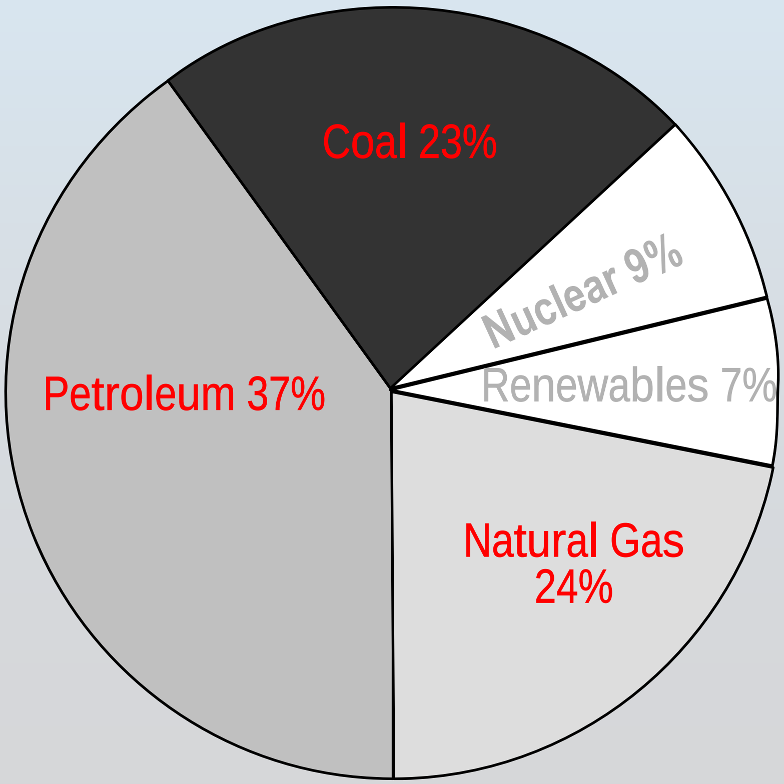
Lighting accounts for ≅22% of all electricity usage in the U.S.



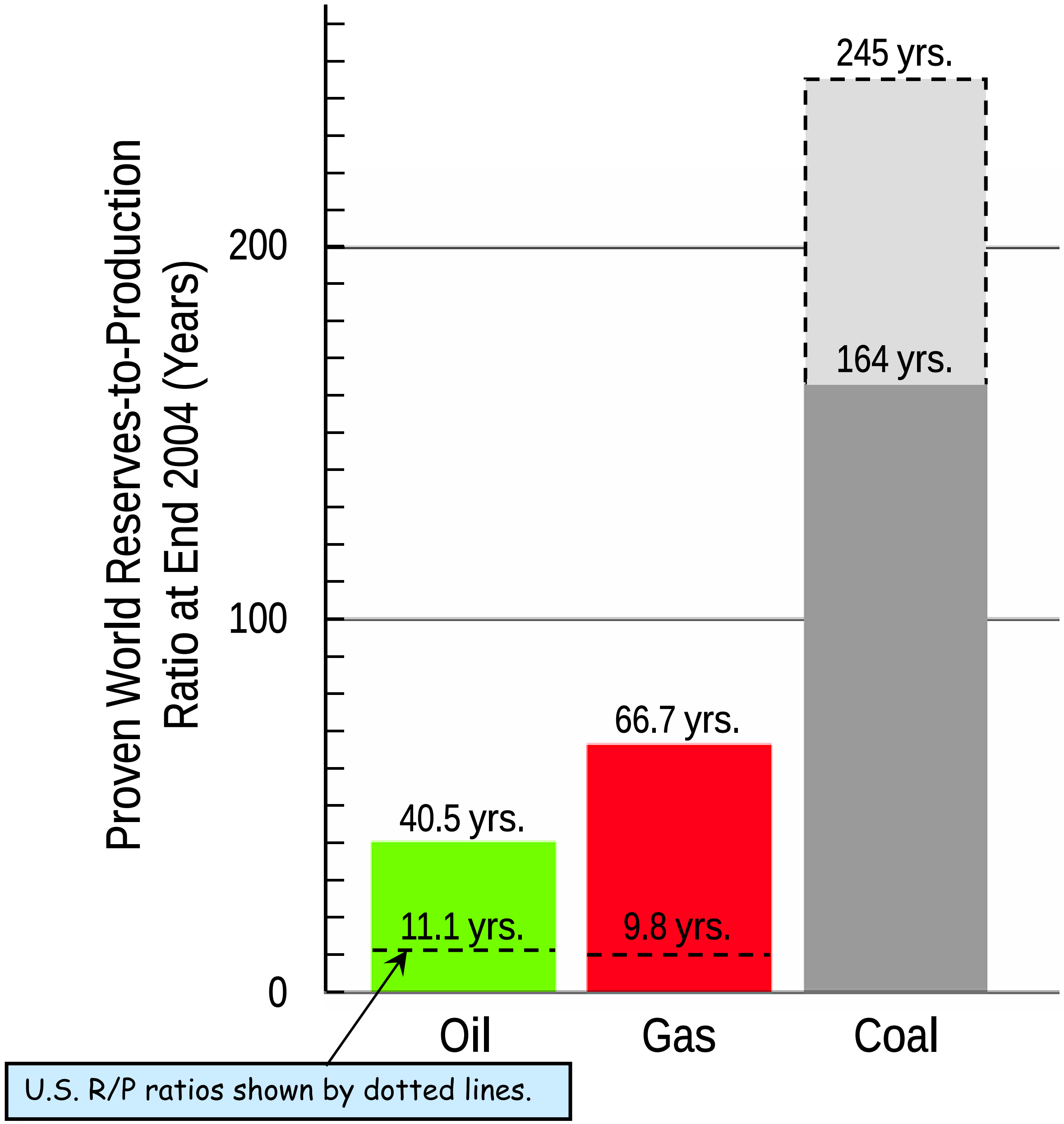
Example of energy lost during conversion and transmission. Imagine that the coal needed to illuminate an incandescent light bulb contains 100 units of energy when it enters the power plant. Only two units of energy eventually light the bulb. The remaining 98 units are lost along the way, primarily as heat.



Fossil fuel reserves



Fossil Fuel Supplies are Estimated using Reserves-to-Production (R/P) Ratios



- The R/P ratio is the number of years that proved reserves would last at current production rates.

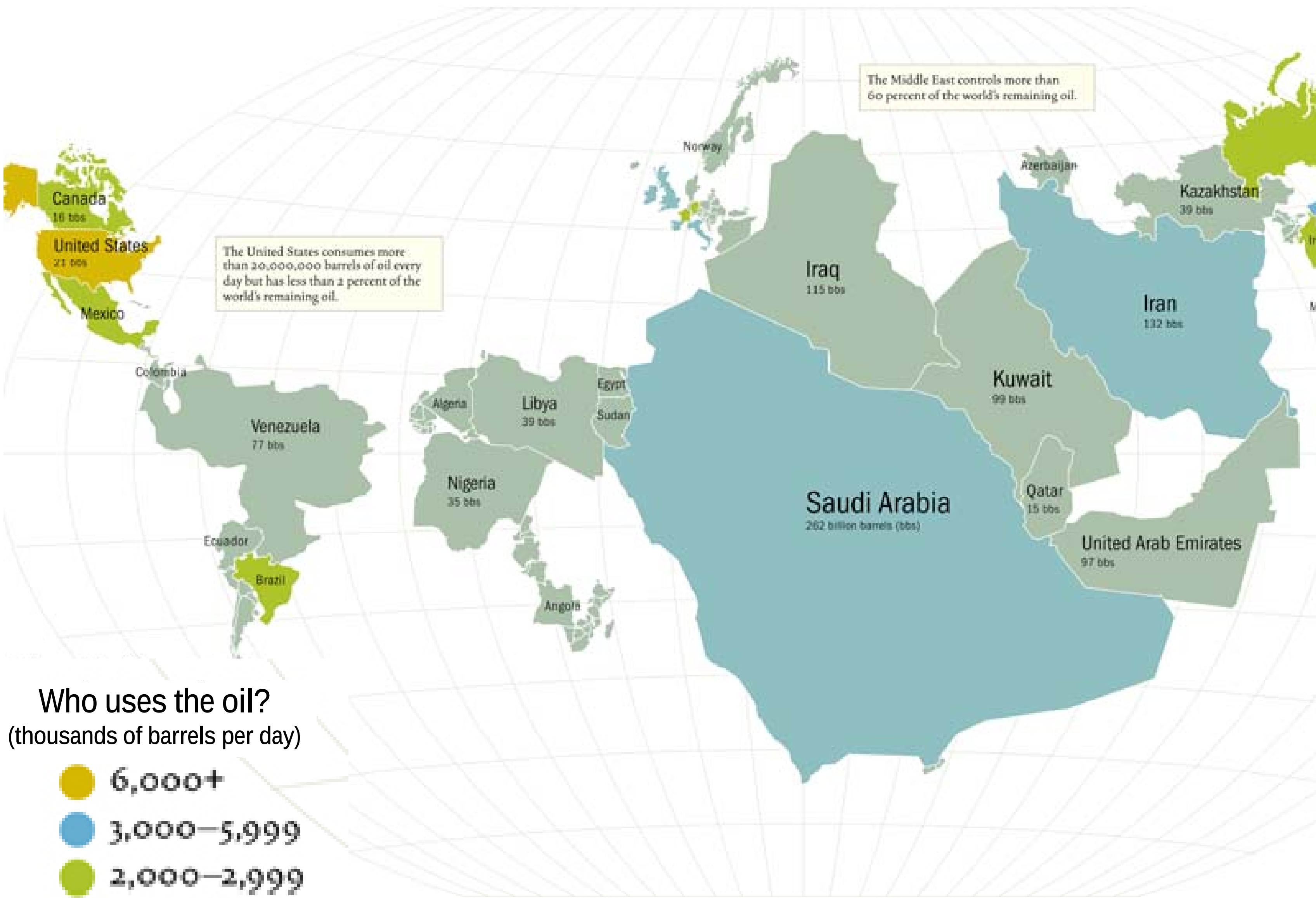
- World R/P ratios are:
  Oil = 40.5 years;
  Natural Gas = 66.7 years;
  Coal = 164 years

- U.S. R/P ratios are:
  Oil = 11.1 years;
  Natural Gas = 9.8 years;
  Coal = 245 years

BP Statistical Review of World Energy 2005

World Reserves of Oil

There is a significant dislocation between fossil fuel supply and demand



World Reserves of Oil

	Billions of Barrels	Percentage of World Reserves
Saudi Arabia	262.73	22.3%
Iran	132.46	11.2%
Iraq	115.00	9.7%
Kuwait	99.00	8.4%
United Arab Emirates	97.80	8.3%
Venezuela	77.22	6.5%
Russia	72.27	6.1%
Kazakhstan	39.62	3.4%
Libya	39.12	3.3%
Nigeria	35.25	3.0%
United States	21.37	1.8%
China	17.07	1.4%
Canada	16.80	1.4%
Qatar	15.20	1.3%

Who uses the oil?
(thousands of barrels per day)

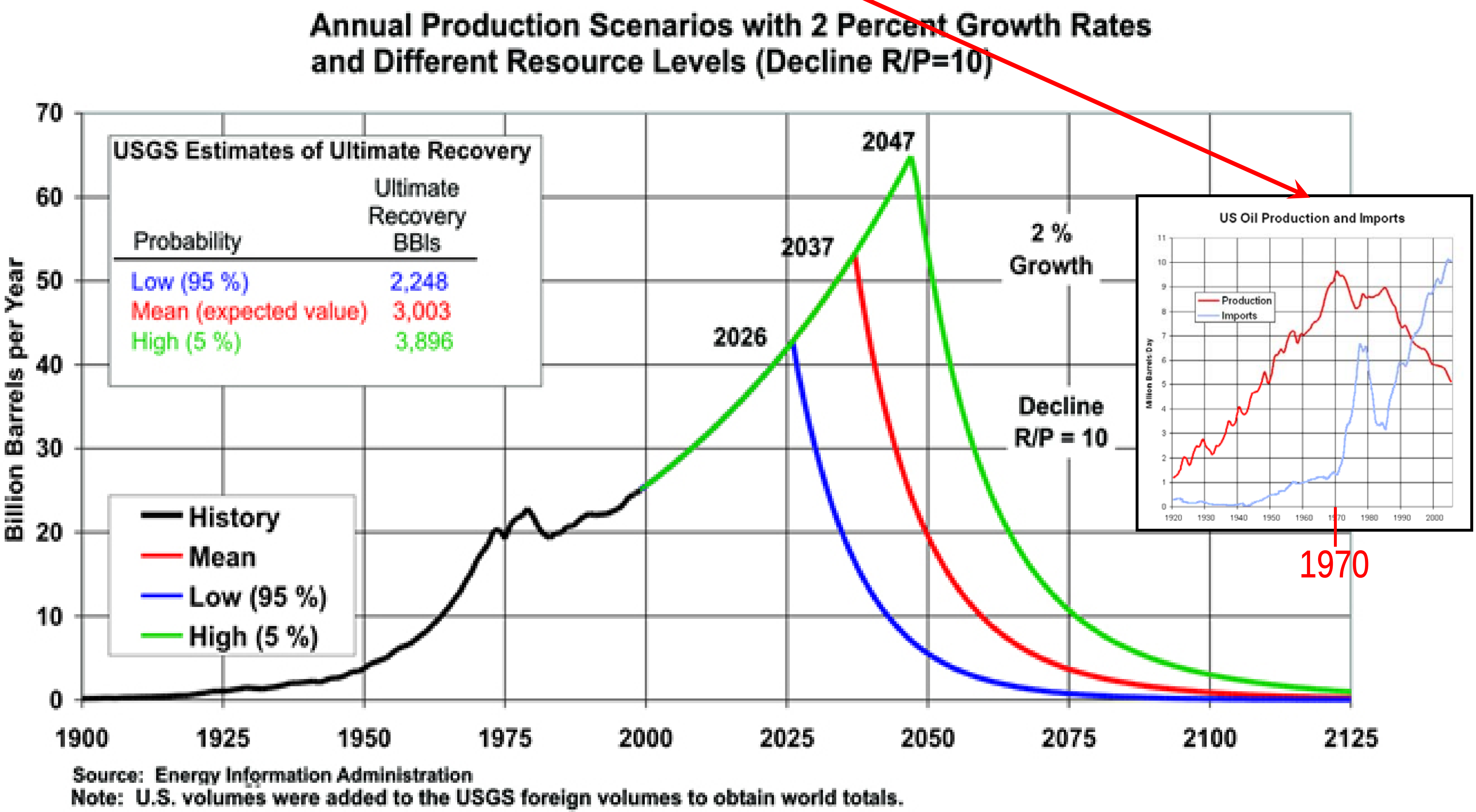
- 6,000+
- 3,000–5,999
- 2,000–2,999
- 1,000–1,999
- 0–999

Each country's size is proportional to the amount of oil it contains (oil reserves); Source: BP *Statistical Review* Year-End 2004 & Energy Information Administration

(http://www.energybulletin.net/37329.html)

“Peak Oil”

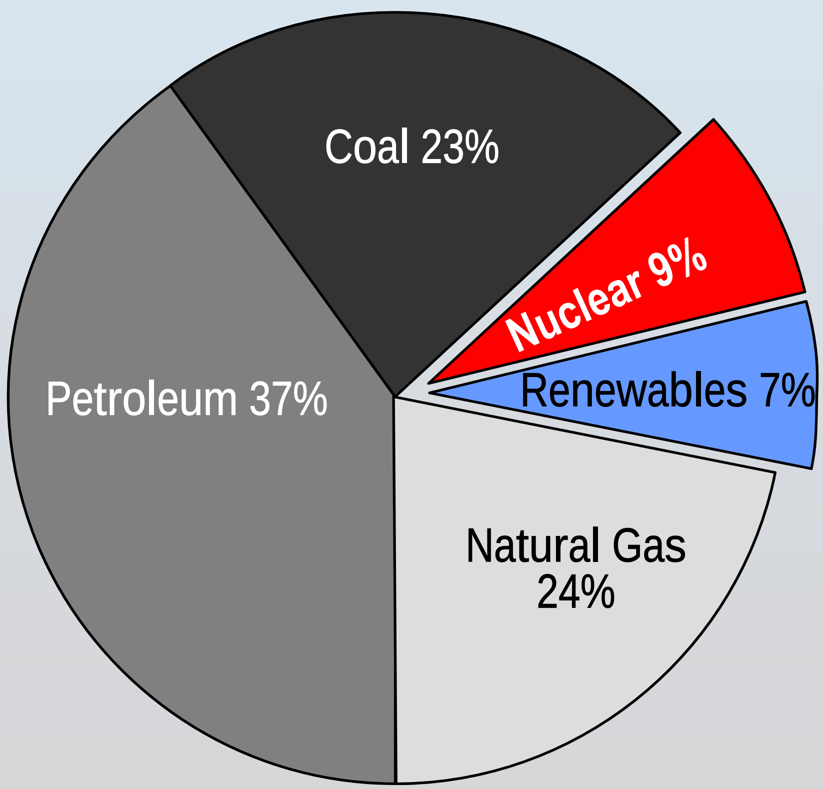
U.S. oil production peaked in 1970; world oil production will peak mid century



Long-Term World Oil Supply Scenarios: *The Future Is Neither as Bleak or Rosy as Some Assert*, John H. Wood, Gary R. Long, David F. Morehouse

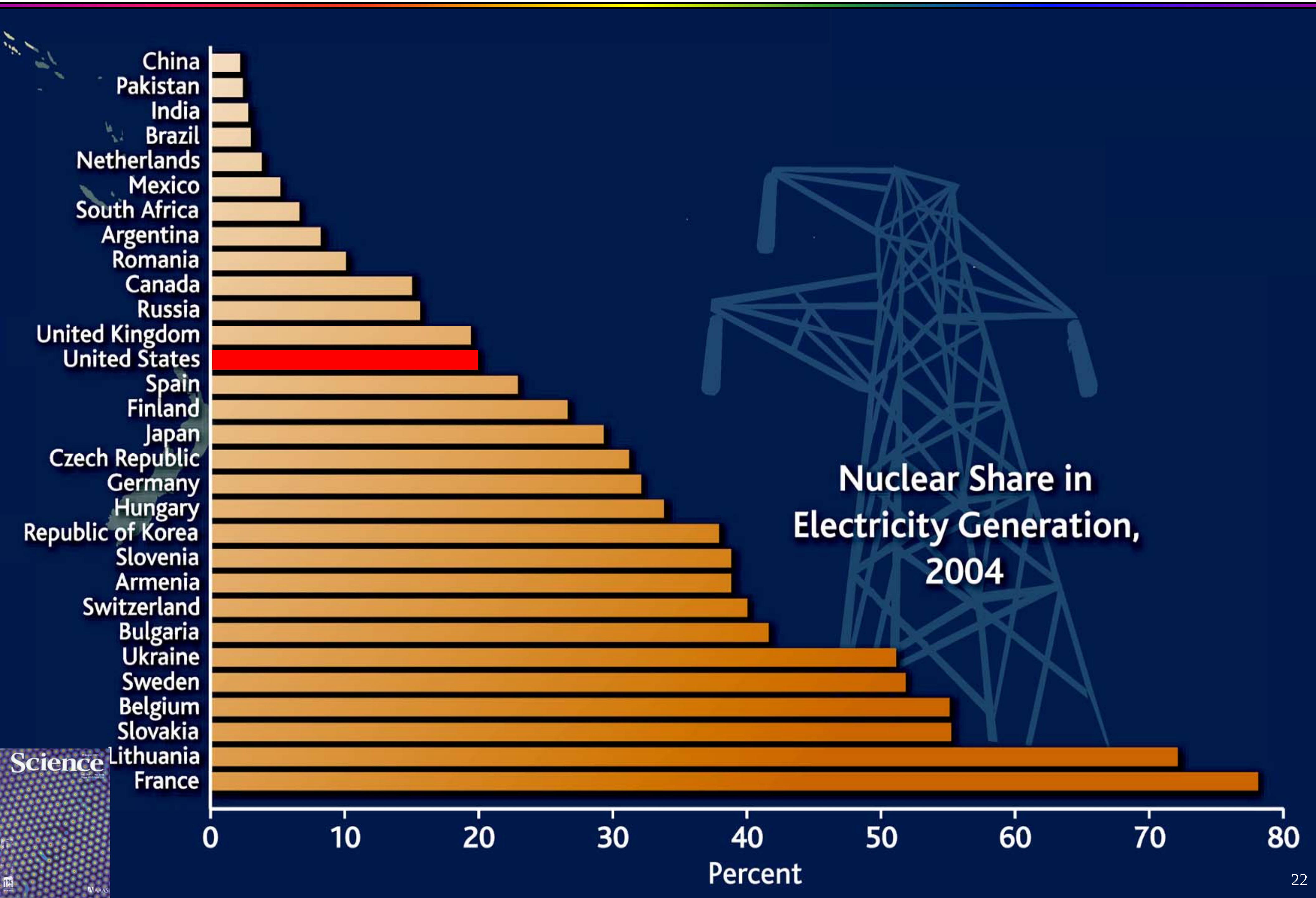
http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2004/worldoilsupply/oilsupply04.html

Nuclear and renewable energy



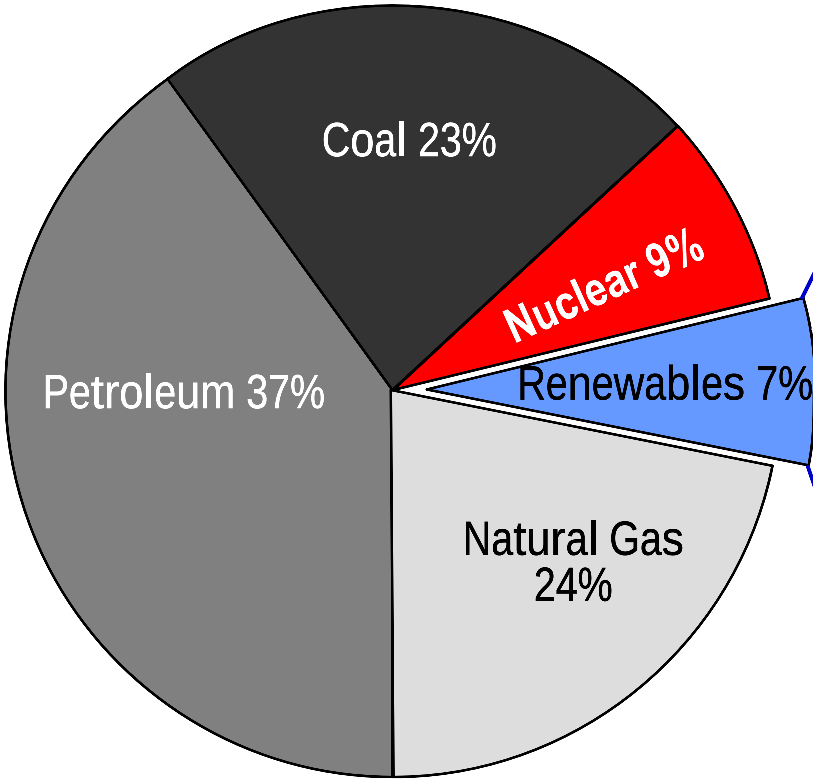
Nuclear Energy Provides 20% of U.S. Electricity

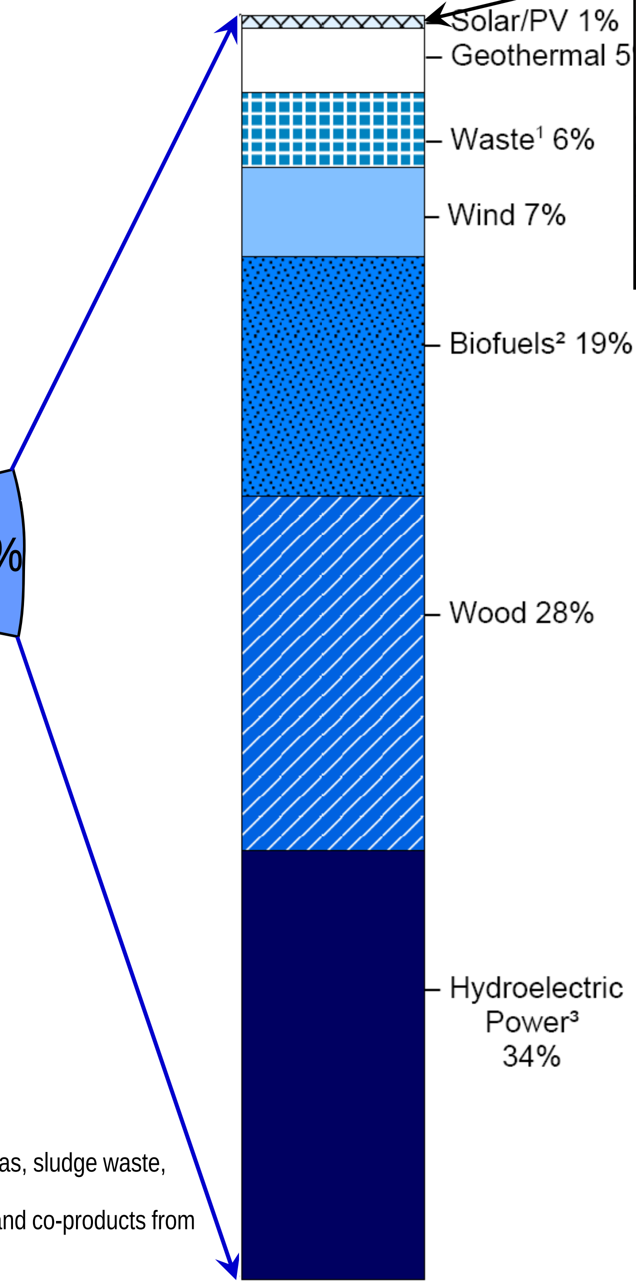
Europe and Japan rely much more heavily on nuclear energy for electricity generation

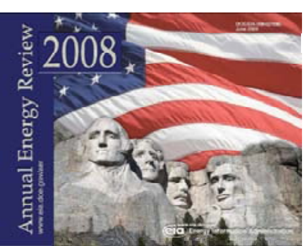


Nuclear and Renewable are ~15% of Energy Supply

Hydroelectric and wood still dominate the renewable energies







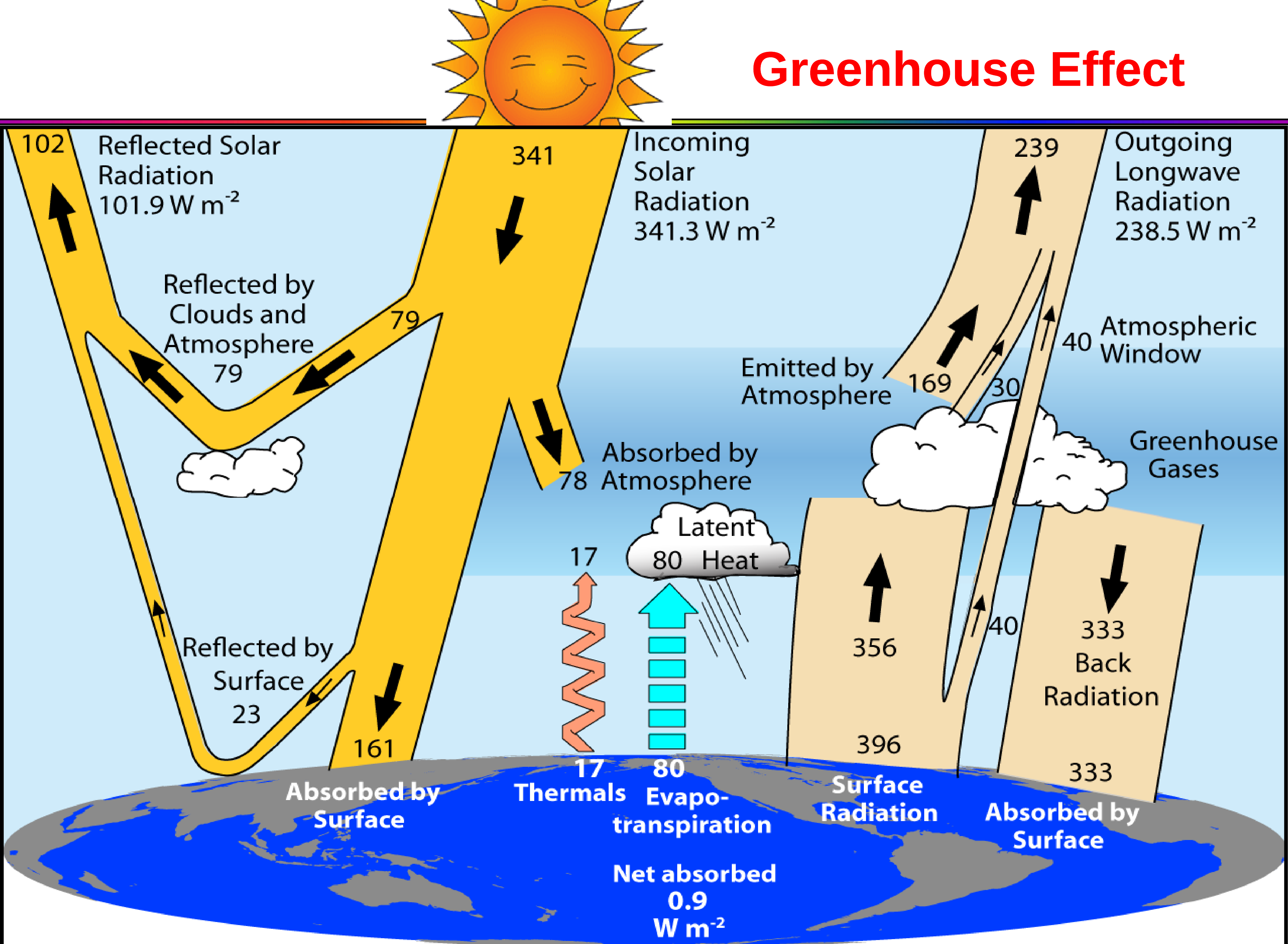
1 Municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural byproducts,and other biomass.

2 Fuel ethanol and biodiesel consumption, plus losses and co-products from the productionof fuel ethanol and biodisel.

3 Conventional Hydroelectric Power

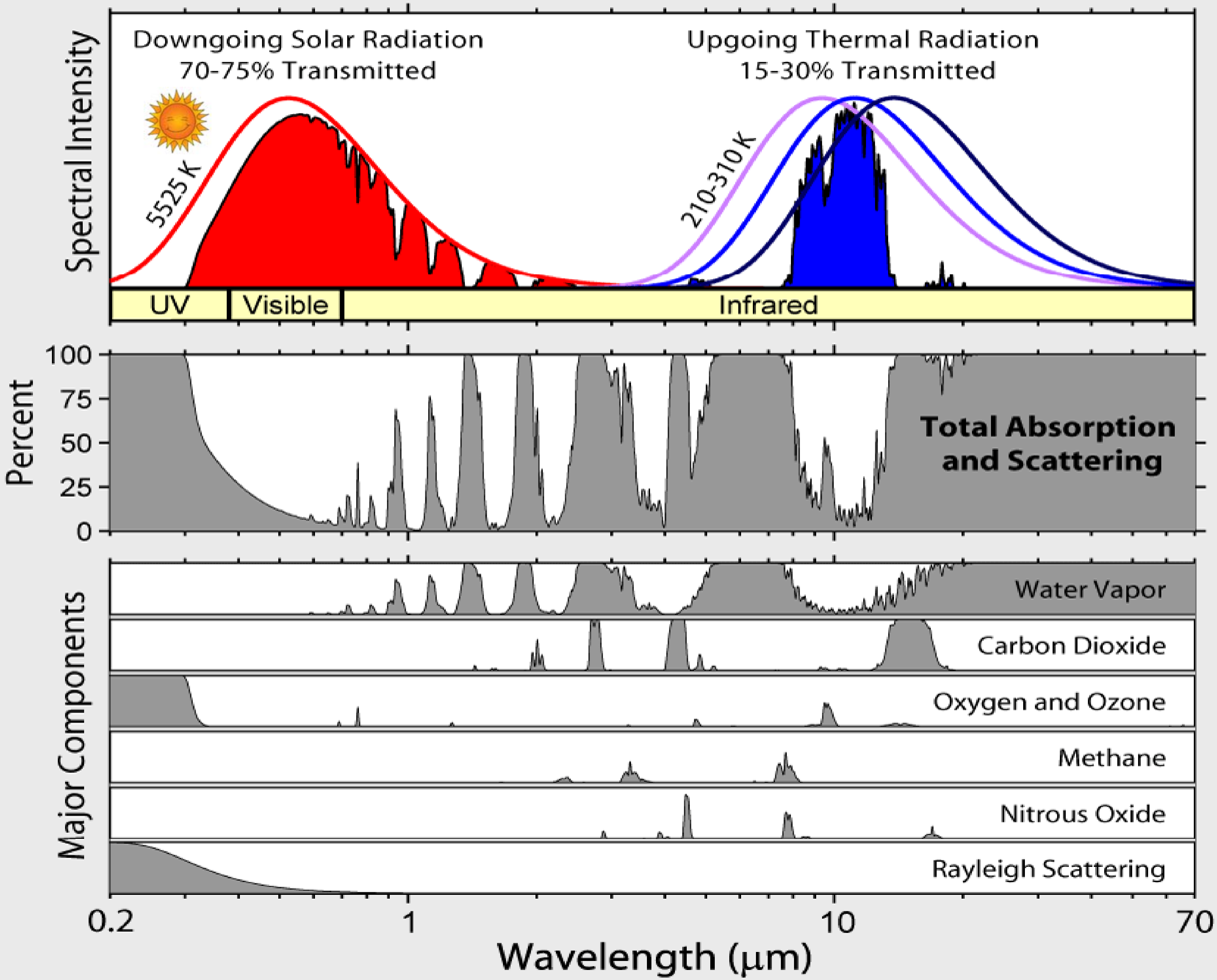
Energy and the environment

Greenhouse Effect



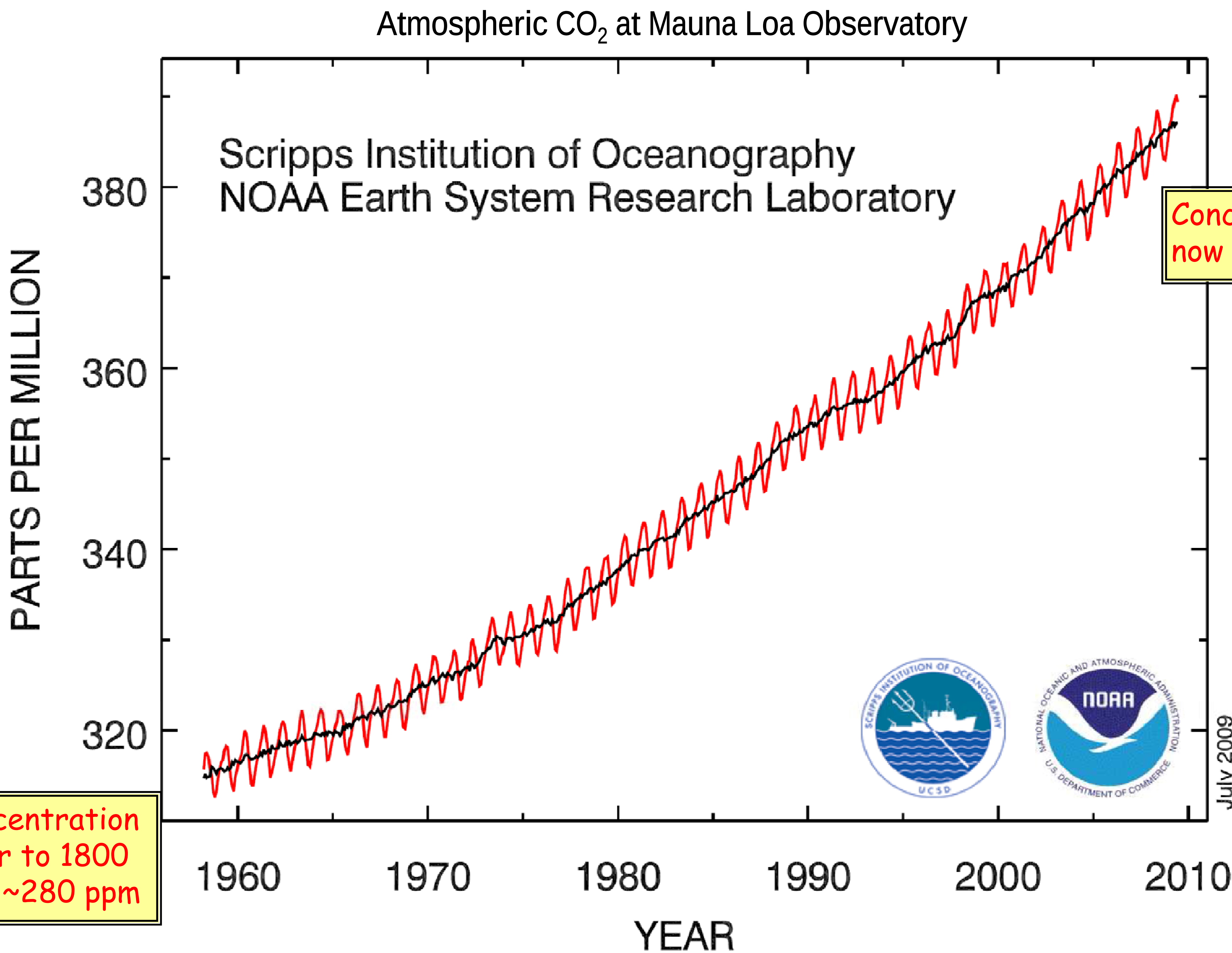
Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Greenhouse gases that are not naturally occurring include hydro-fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), which are generated in a variety of industrial processes.

Radiation Transmitted by the Atmosphere



Modern CO_2 Concentrations are Increasing

The current concentration is the highest in 800,000 years, as determined by ice core data



Concentration now ~388 ppm

Concentration prior to 1800 was ~280 ppm

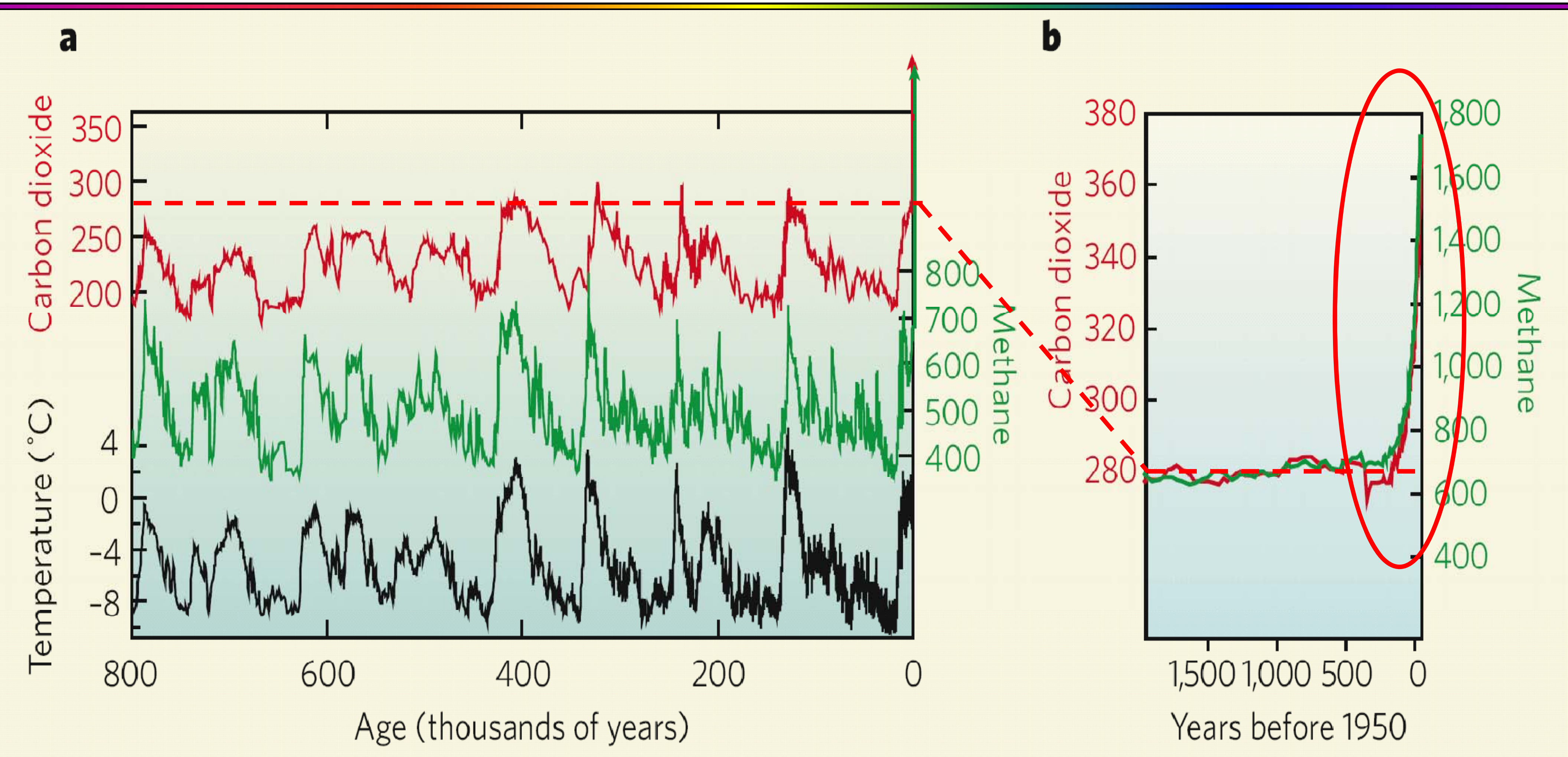
Bubbles – 800,000 Years of CO_2 Concentrations

Nature, 15 May 2008, Cover Image: The air bubbles trapped in the Antarctic Vostok and EPICA Dome C ice cores provide composite records of levels of atmospheric carbon dioxide and methane covering the past 650,000 years. Now the record of atmospheric carbon dioxide and methane concentrations has been extended by two more complete glacial cycles to 800,000 years ago. The new data are from the lowest 200 metres of the Dome C core. This ice core went down to just a few metres above bedrock at a depth of 3,270 metres.

The cover shows a strip of ice core from another ice core in Antarctica (Berkner Island) from a depth of 120 metres. Photo credit: Chris Gilbert, British Antarctic Survey.

CO_2 Concentrations and Temperature

The correlation extends throughout the 800,000-year time span of the ice core data

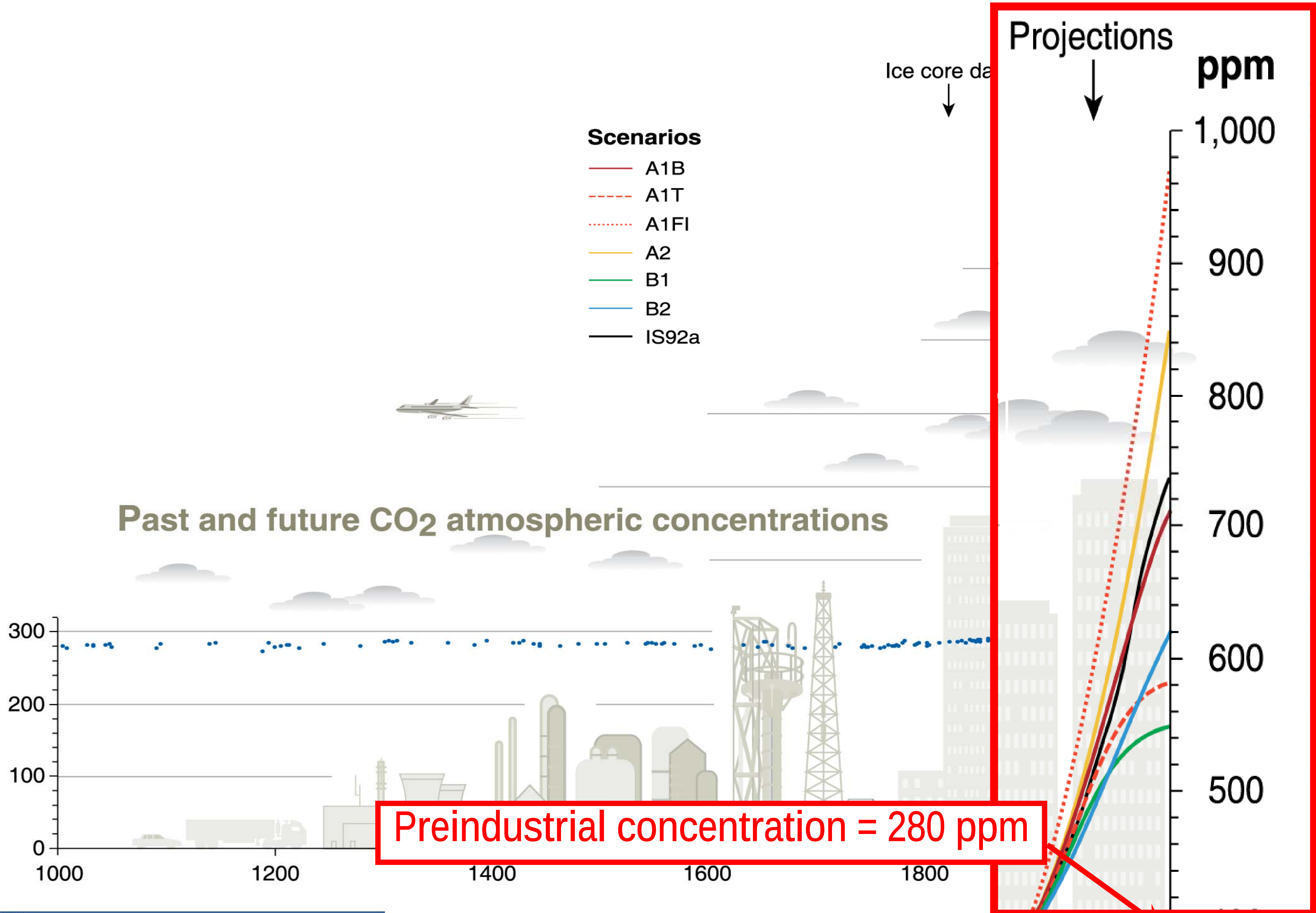


a The 800,000-year records of atmospheric carbon dioxide (red; parts per million, p.p.m.) and methane (green; parts per billion, p.p.b.) from the EPICA Dome C ice core together with a temperature reconstruction (relative to the average of the past millennium) based on the deuterium–hydrogen ratio of the ice, reinforce the tight coupling between greenhouse-gas concentrations and climate observed in previous, shorter records. The 100,000-year ‘sawtooth’ variability undergoes a change about 450,000 years ago, with the amplitude of variation, especially in the carbon dioxide and temperature records, greater since that point than it was before. Concentrations of greenhouse gases in the modern atmosphere are highly anomalous with respect to natural greenhouse-gas variations (present-day concentrations are around 380 p.p.m. for carbon dioxide and 1,800 p.p.b. for methane).
b The carbon dioxide and methane trends from the past 2,000 years.

Ed Brook, Nature **453**, 291 (2008).

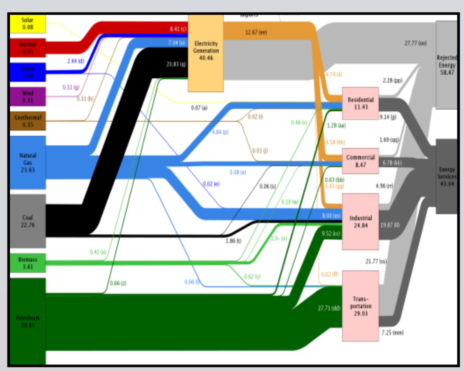
Past and Future CO_2 Concentrations

CO_2 concentrations are predicted to increase by a factor of two to three



Recap

and the components of energy strategies



Electric Energy Storage

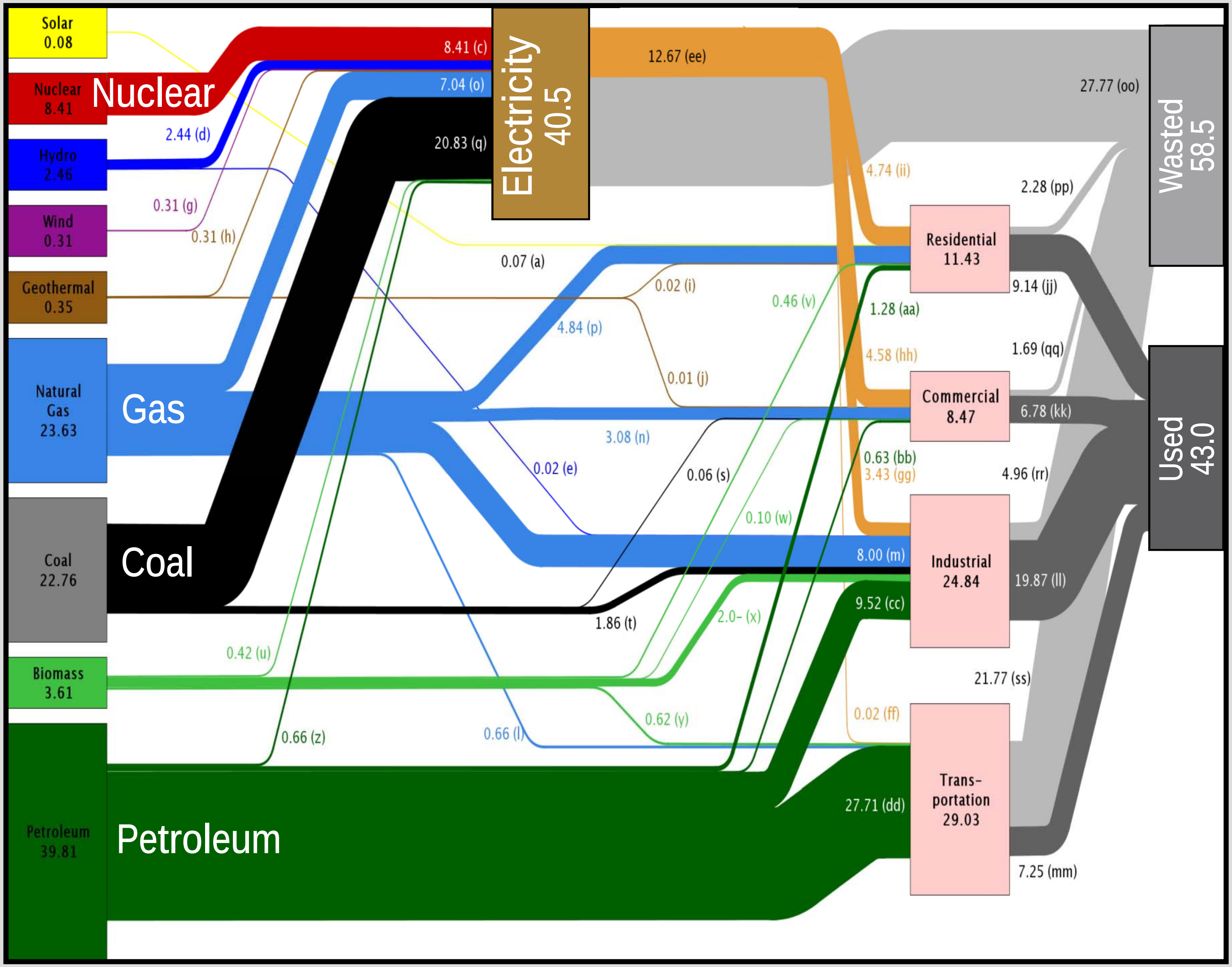
Transmission & Distribution

Zero-net-emissions Electricity Generation

Fuel Switching

CCS

Fuel Switching



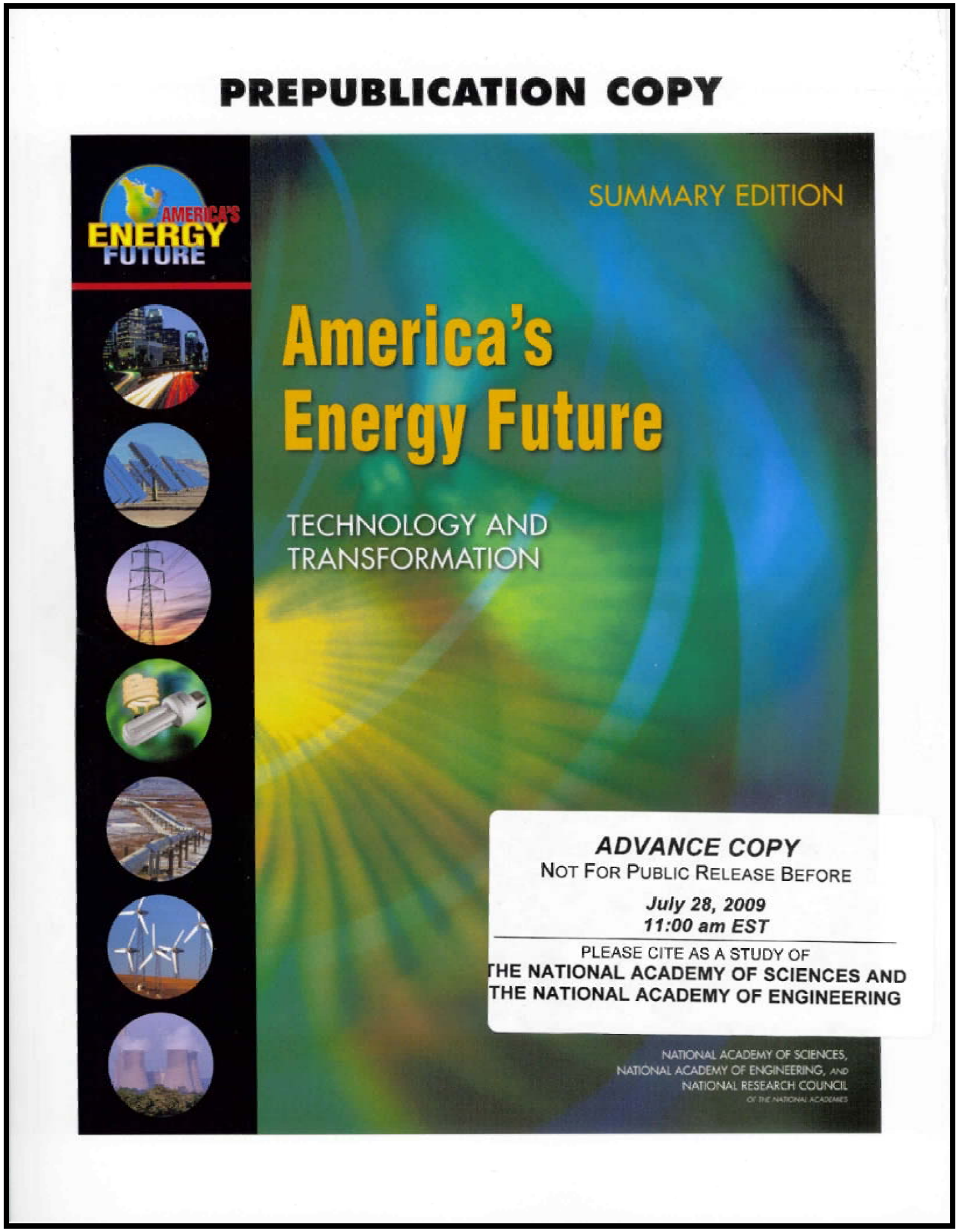
End-use Efficiency

Climate/Environment Science

Source: LLNL 2008; data are based on DOE/EIA-0384(2006). Credit should be given to LLNL and DOE.

NAS America's Energy Future

"One of the committee's conclusions is that there is no technological 'silver bullet' at present that could transform the U.S. energy system through a substantial new source of clean and reasonably priced domestic energy. Instead, the transformation will require a balanced portfolio of existing (although perhaps modified) technologies, multiple new energy technologies, and new energy-efficiency and energy-use patterns."



NAS America's Energy Future

"But a timely transformation of the energy system is unlikely to happen without finally adopting a strategic energy policy to guide developments over the next decades. ***Long-term problems require long-term solutions, and only significant, deliberate, stable, integrated, consistent, and sustained actions will move us to a more secure and sustainable energy future."***

Harold T. Shapiro, Chair
Preface
Committee on America's Energy Future

DEPARTMENT OF ENERGY

- **Office of the Secretary**
  Dr. Steven Chu, Secretary
  Daniel B. Poneman, Deputy Secretary*
  - Federal Energy Regulatory Commission (dashed-line relationship)
  - Chief of Staff
  - **Office of the Under Secretary For Nuclear Security/ Administrator for National Nuclear Security Administration**
    Thomas P. D'Agostino
    - Deputy Administrator for Defense Programs
    - Deputy Administrator for Defense Nuclear Nonproliferation
    - Deputy Administrator for Naval Reactors
    - Deputy Under Secretary for Counter-terrorism
    - Associate Administrator for Defense Nuclear Security
    - Associate Administrator for Emergency Operations
    - Associate Administrator for Infrastructure & Environment
    - Associate Administrator for Management & Administration
  - **Office of the Under Secretary**
    Dr. Kristina M. Johnson
    Under Secretary
    - Assistant Secretary for Energy Efficiency & Renewable Energy
    - Assistant Secretary for Environmental Management
    - Assistant Secretary for Fossil Energy
    - Assistant Secretary for Nuclear Energy
    - Assistant Secretary for Electricity Delivery & Energy Reliability
    - Civilian Radioactive Waste Management
    - Legacy Management
  - **Office of the Under Secretary for Science**
    Dr. Steven E. Koonin
    Under Secretary for Science
    - Office of Science
      - Advanced Scientific Computing Research
      - Basic Energy Sciences
      - Biological & Environmental Research
      - Fusion Energy Science
      - High Energy Physics
      - Nuclear Physics
      - Workforce Development for Teachers & Scientists
  - Energy Information Administration
  - Southeastern Power Administration
  - Bonneville Power Administration
  - Western Area Power Administration
  - Southwestern Power Administration
  - *Departmental Staff and Support Offices*
    - Advanced Research Projects Agency -Energy
    - General Counsel
    - Chief Financial Officer
    - Chief Information Officer
    - Chief Human Capital Officer
    - Management
    - Public Affairs
    - Assistant Secretary for Congressional & Intergovernmental Affairs
    - Assistant Secretary for Policy & International Affairs
    - Health, Safety & Security
    - Inspector General
    - Economic Impact & Diversity
    - Hearings & Appeals
    - Intelligence and Counterintelligence

* The Deputy Secretary also serves as the Chief Operating Officer

26 May 09

Addressing America's Energy Challenges

From a presentation by Steven E. Koonin

Under Secretary for Science

October, 2009

America's energy challenges (I)

- **Energy security**
  - Reliable and economic energy supply
  - Mostly about liquid hydrocarbons for transport
  - Imports are 60% of daily consumption
  - Geopolitical and financial urgency
    - 12 M bbl/day @ $70/bbl = $250B/yr
  - **Goal**: 3.5 M bbl/day reduction in crude use (~25% of daily transport use)

America's energy challenges (II)

- **Greenhouse gas emissions**
  - Mostly about CO_2 from stationary sources (power and heat)
  - 387 ppm now, BAU is 550 ppm by 2050
  - Urgency in leadership, infrastructure "lock-in"
  - **Goal**: ~20% reduction by 2020, 80% by 2050

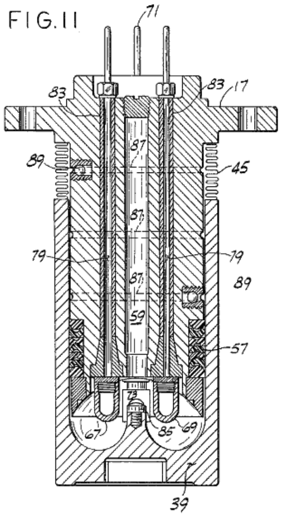
America's energy challenges (III)

- These goals require significant changes in energy sources and uses

Identify, develop, demonstrate, and deploy
cost-effective, material, and timely solutions
and
create jobs in the process

What can we do about transport?

- **Encourage vehicle efficiency and conservation**
  - CAFÉ standards
- **Encourage novel/alternative vehicle technologies at cost**
  - Improved internal combustion engines
    - HCCI, Exhaust Gas Recycling, Variable Valve Timing, selective cylinder deactivation, …
  - Gradual electrification paced by battery development
    - Hybrids, plug-in hybrids, battery vehicles
  - DOE AVT and battery loan programs



What can we do about transport?

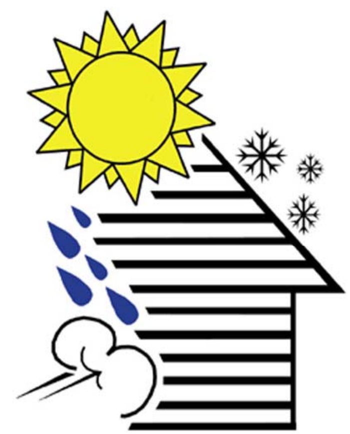
- Encourage vehicle efficiency and conservation
- Encourage novel/alternative vehicle technologies at cost
- **Encourage (with consistency) a diverse portfolio of unconventional fuels**
  - Biofuels
    - Lignocellulose, feedstocks, better molecules, algae?
  - What is the government doing?
    - Renewable fuel standards
    - Bioenergy centers, integrated biorefineries

What do we do about heat and power?

- **Conservation and efficiency**
  - Make the price of electricity evident
  - Efficiency standards (appliances…)
  - Regulatory incentives

    (pay utilities for conservation)
  - Buildings, city design

    (DOE weatherization programs)
  - Smart grid and storage enable renewables, encourage efficiency, enhance reliability



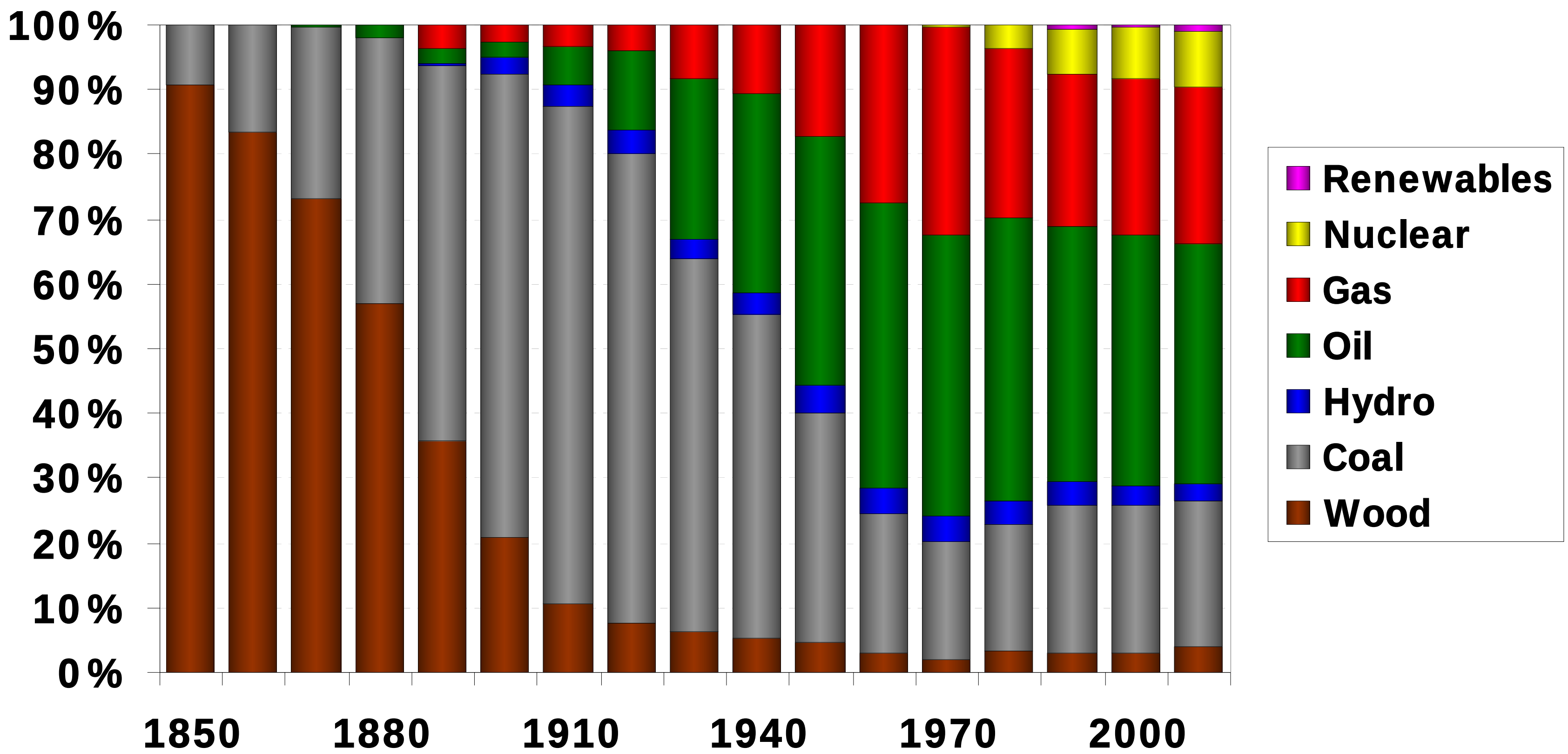
What do we do about heat and power?

- Conservation and efficiency
- **Set a price on carbon emissions**
  - Sources favored by technology and economics are:
    - Natural gas
    - On-shore wind
    - Small and medium hydropower
    - Nuclear fission
    - Carbon capture and storage (in demo soon)

- **Portfolio standards**
  - Renewable versus low-carbon

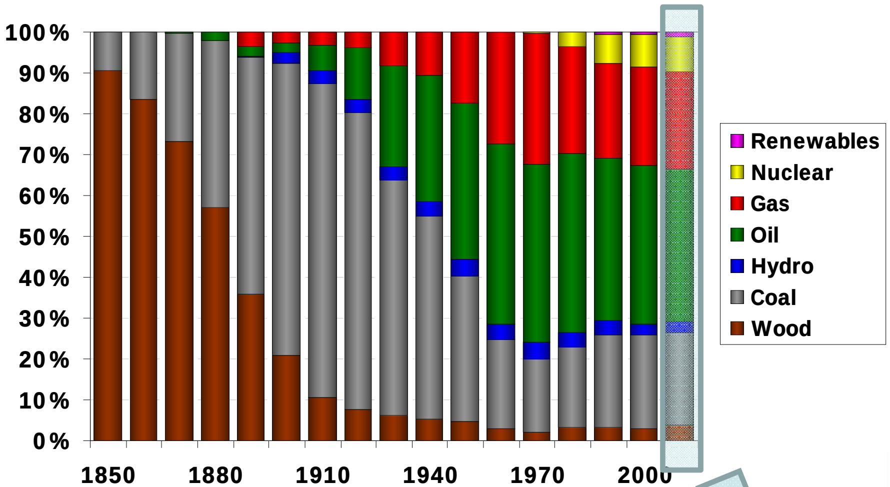
Energy technologies change slowly

US energy supply since 1850

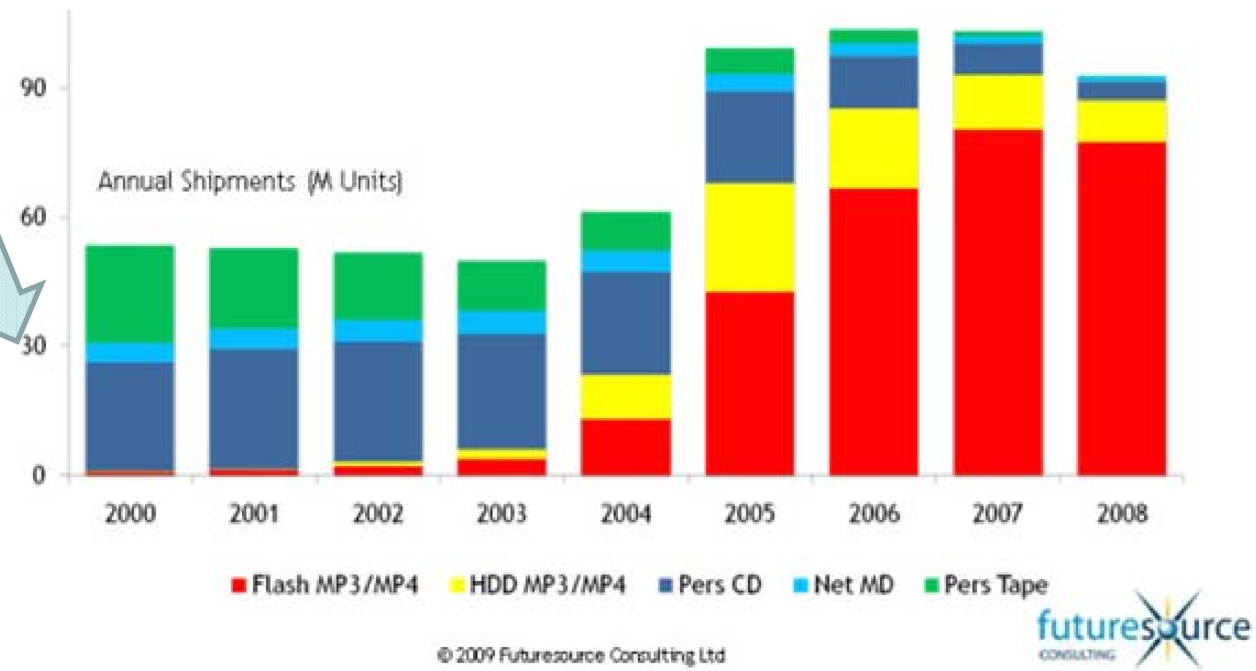


Source: EIA

IT technologies change rapidly

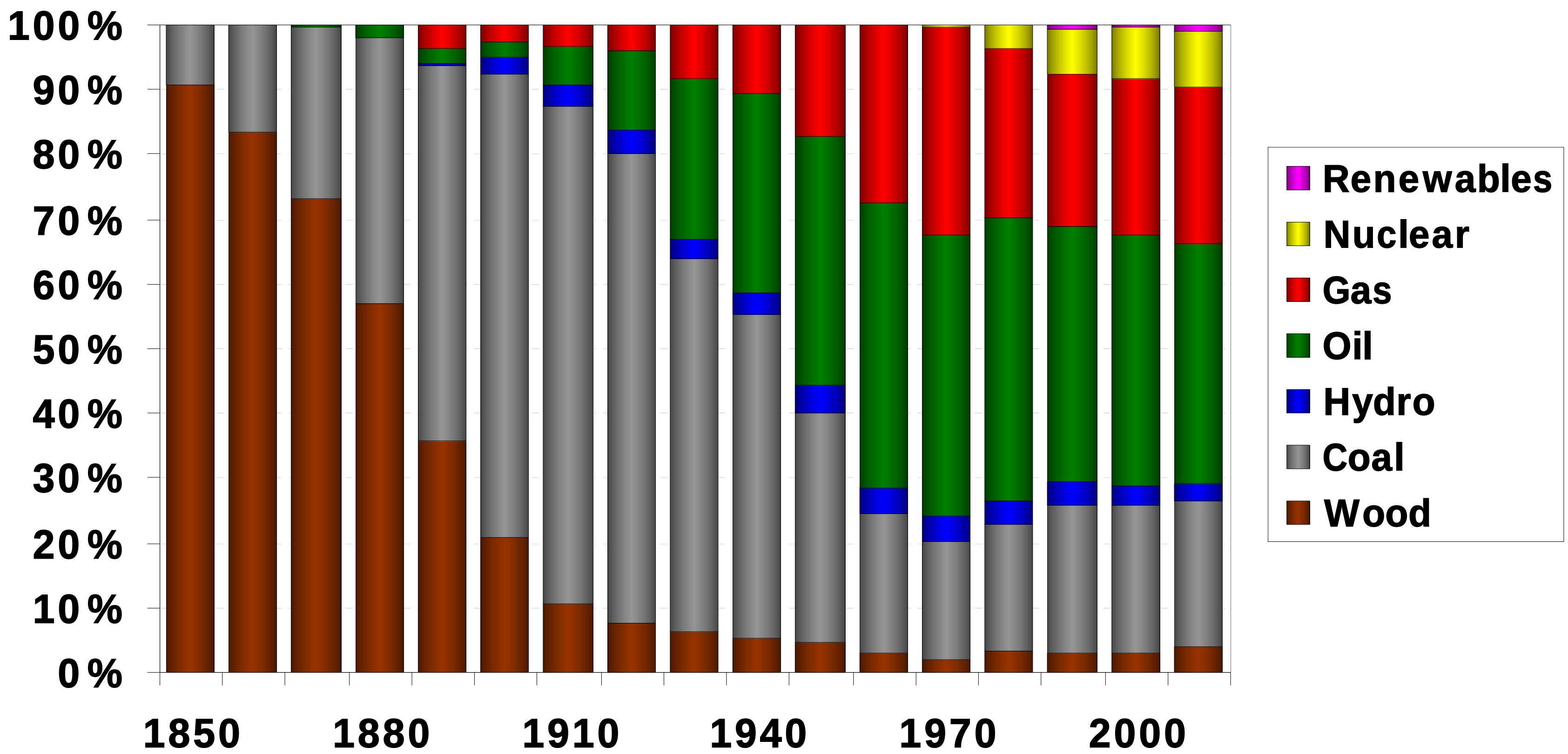


Sales of Personal Audio/Video since 2000



Energy technologies change slowly

US energy supply since 1850



Source: EIA

Because energy innovation is different

- **Energy Frontier Research Centers** — Underlying science
  - Find solutions to fundamental scientific roadblocks to clean energy and energy security
- **HUBS** proposal — Academia/government/industry partnerships
  - Create sustained, tightly focused research centers with contributors from academia and industry
- REgaining our ENERGY Science and Engineering Edge (**ReENERGYSE**) proposal — Workforce training
  - Energy scientists (technology and policy)
  - Clean energy workers
- **ARPA-E** — High risk, transformational research
  - Develop and deploy breakthrough energy technologies
- Coordination among many Federal/State agencies

Office of Science Early Career Research Program

The Department of Energy is now reviewing proposals for the first annual Office of Science Early Career Research Program to support the research of outstanding scientists early in their careers.

- Purpose: To support the development of individual research programs of outstanding scientists early in their careers and to stimulate research careers in the disciplines supported by the Office of Science.
- Principal investigators are within 10 years of receiving a Ph.D. and are either untenured academic assistant professors on the tenure track or full-time DOE national laboratory employees.
- At least 50 awards to be given in FY10 with $85M in Recovery Act funds. Future annual competitions will be supported through regular research appropriations.
- University grants are at least $150,000 per year for five years to cover summer salary and expenses; Lab awards are at least $500,000 per year for five years to cover full annual salary and expenses.
- Announcements posted 7/2/09; Letters of intent due 8/3/09; Full proposals due 9/1/09; Awards 3/10.
- Research will be competitively awarded based on peer review. Review and award management will take place in the six science programs.
- Eligibility criteria, review criteria, and program rules are common across the Office of Science.
- Frequently Asked Questions posted on http://www.science.doe.gov/SC-2/earlycareer

Office of Science Graduate Fellowship Program

The Department of Energy is now accepting applications for the first annual DOE Office of Science Graduate Fellowship Program.

- Purpose: To support outstanding students to pursue graduate training in basic research in areas of physics, biology, chemistry, mathematics, engineering, computational sciences, and environmental sciences relevant to the Office of Science and to encourage the development of the next generation scientific and technical talent in the U.S.
- To be eligible for the Fellowship, applicants must be U.S. citizens and currently a first or second year graduate student enrolled at a U.S. academic institution, or an undergraduate senior who will be enrolled as a first year graduate student by the fall of 2010.
- The Fellowship award provides partial tuition support, an annual stipend for living expenses, and a research stipend for full-time graduate study and thesis/dissertation research at a U.S. academic institution for three years.
- The Office of Science will award approximately 80 graduate fellowships to be funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act). These fellowships will begin in the fall of the 2010-2011 academic year.
- Fellowships will be competitively awarded based on peer review.
- Applications are due November 30, 2009. See http://www.scied.science.doe.gov/SCGF.html

EIA Alabama Profile – Quick Facts

Although it produces substantial amounts of coal, Alabama relies on deliveries from other States to meet roughly half of State demand.

Alabama produces natural gas largely from wells offshore in the Gulf of Mexico and from coalbed methane deposits, found primarily in the Black Warrior Basin and the Cahaba Coal Field.

With numerous dams along the Alabama and Coosa Rivers, Alabama is one of the largest hydroelectric power-producing States east of the Rocky Mountains.

Alabama's soil is well suited for growing switchgrass, making the State a potential site for the installation of bioenergy plants.

Alabama is a top producer of energy from wood resources and contains one of the world's largest solid biofuel plants, designed to produce 520,000 metric tons of wood pellets each year.

http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=AL

Thank You.

linda.blevins@science.doe.gov