2013

CPH601 Chapter 9 Health and Energy Use

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Health & Energy Use

CPH 601:Occupational & Environmental Health I

Learning Objectives

- Human Energy Needs
- Biomass Fuels
- Fossil Fuels
- Hydropower
- Nuclear Power
- Alternative Energy Sources
  - Wind Power
  - Geothermal
  - Solar thermal
  - Photovoltaic
- Priorities for Action
- Energy Costs

Human Energy Needs

- Basic human needs
- Agriculture
- Urbanization
- Transportation
- Industrial production

Human Energy Needs: Natural Energy Flows

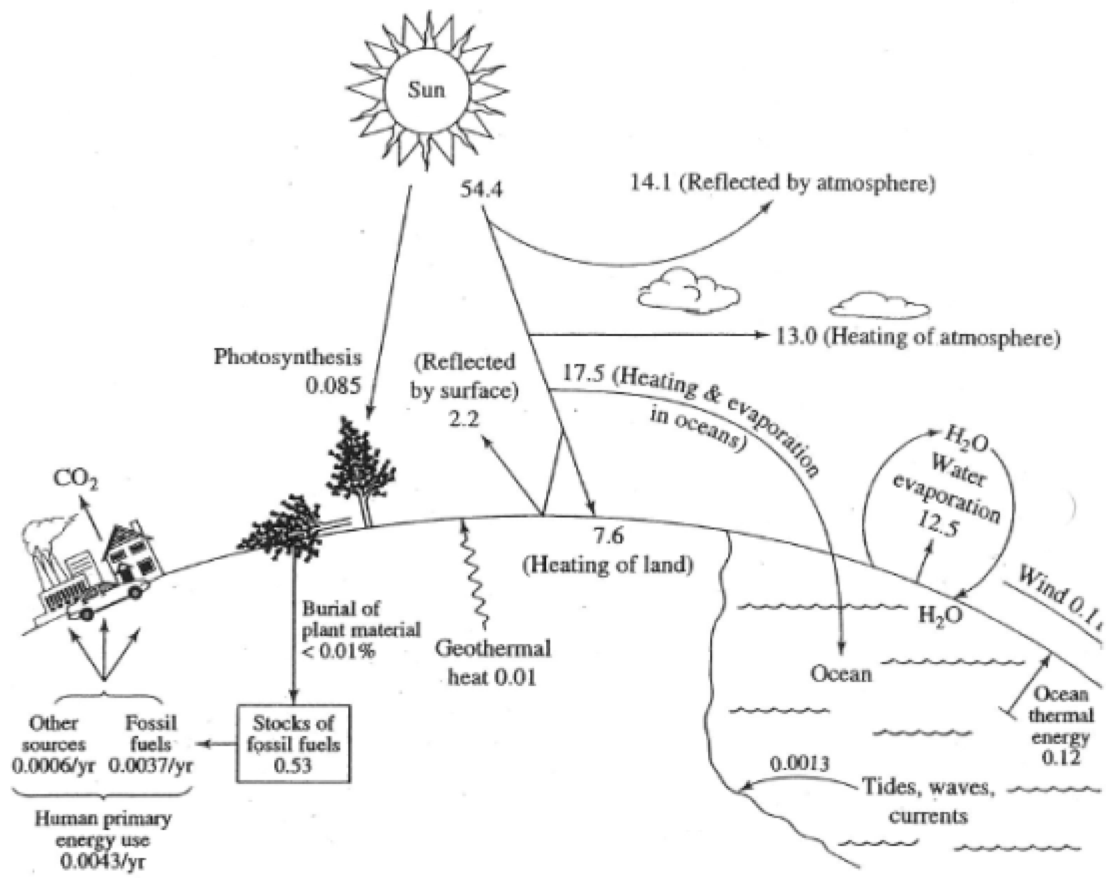


Figure 1.1 Annual energy fluxes on Earth (in 10^{20} kilojoules).

Human Energy Needs: Energy Consumption & Trends

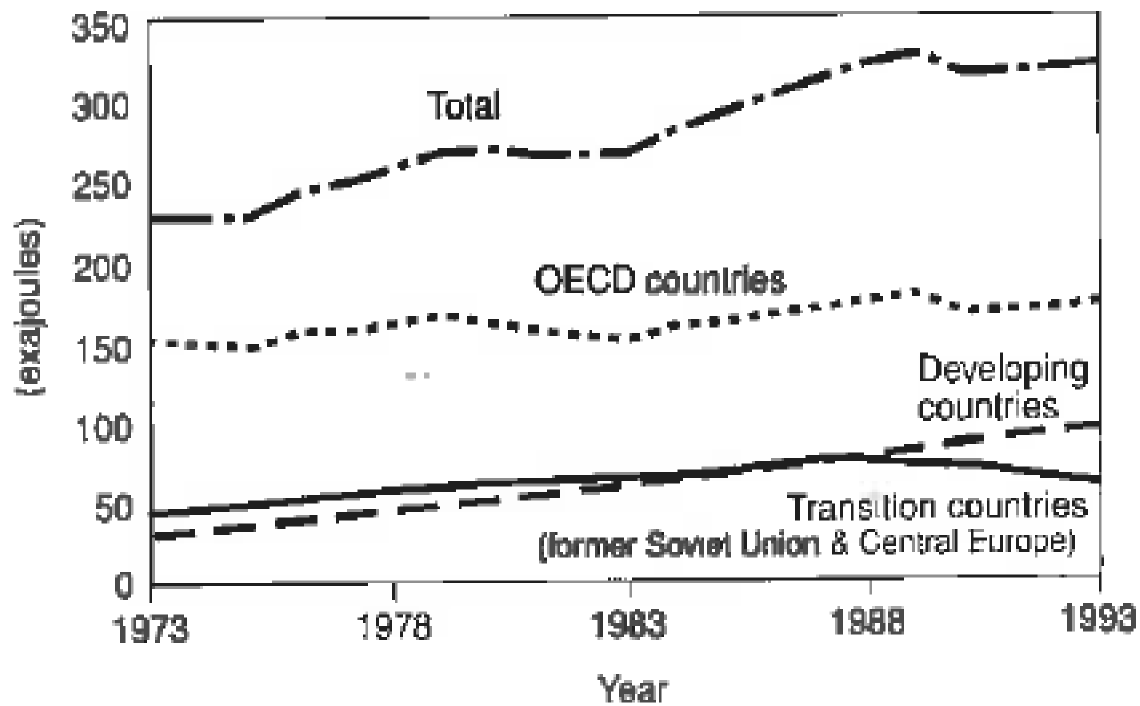


Figure 9.1 Trends in energy consumption, 1973–1993. From WRI, 1996, with permission.

Human Energy Needs: Energy Consumption (Developing World)

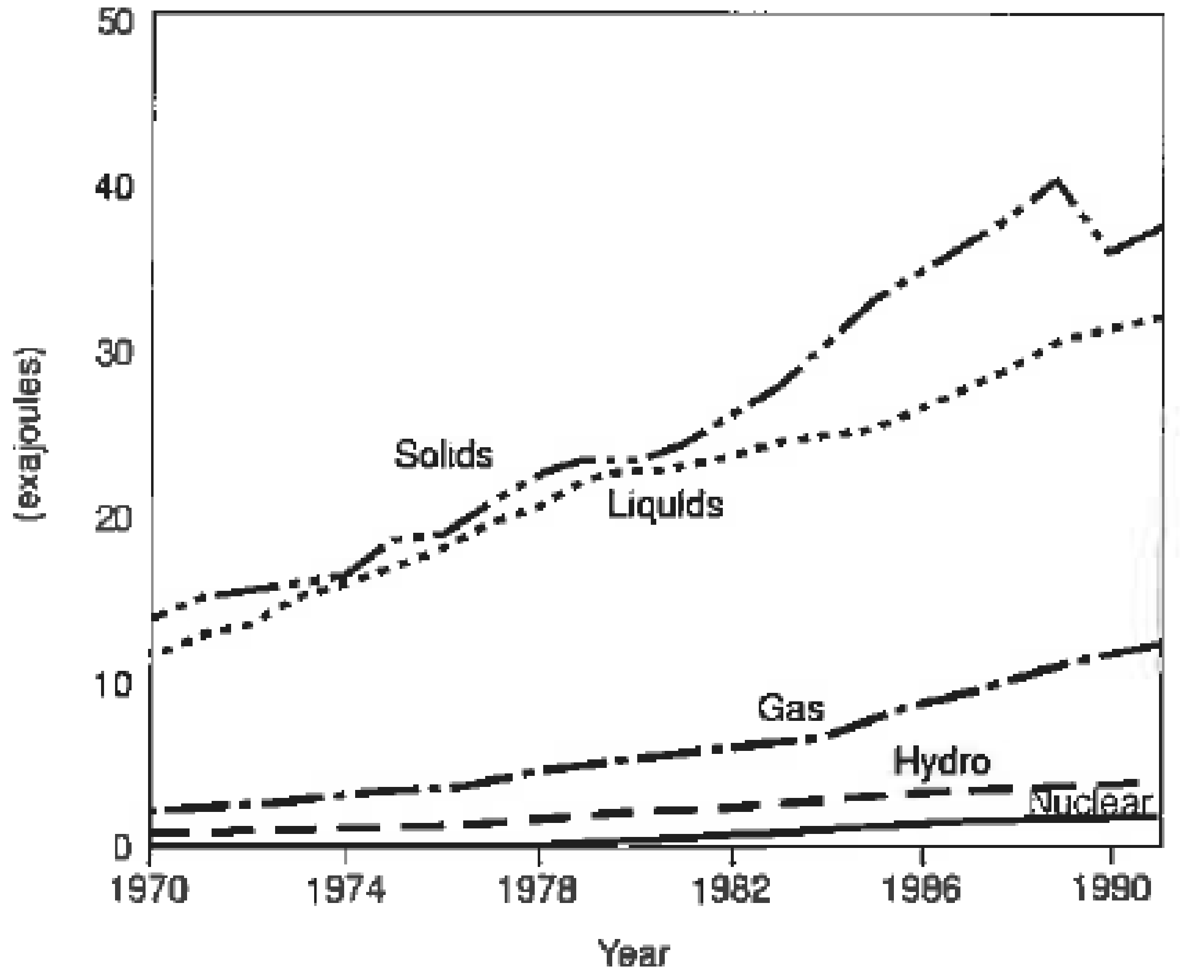


Figure 9.3 Commercial energy consumption by source, developing countries, 1971–91. From WRI, 1994, with permission.

Human Energy Needs: Energy Consumption (Developed World)

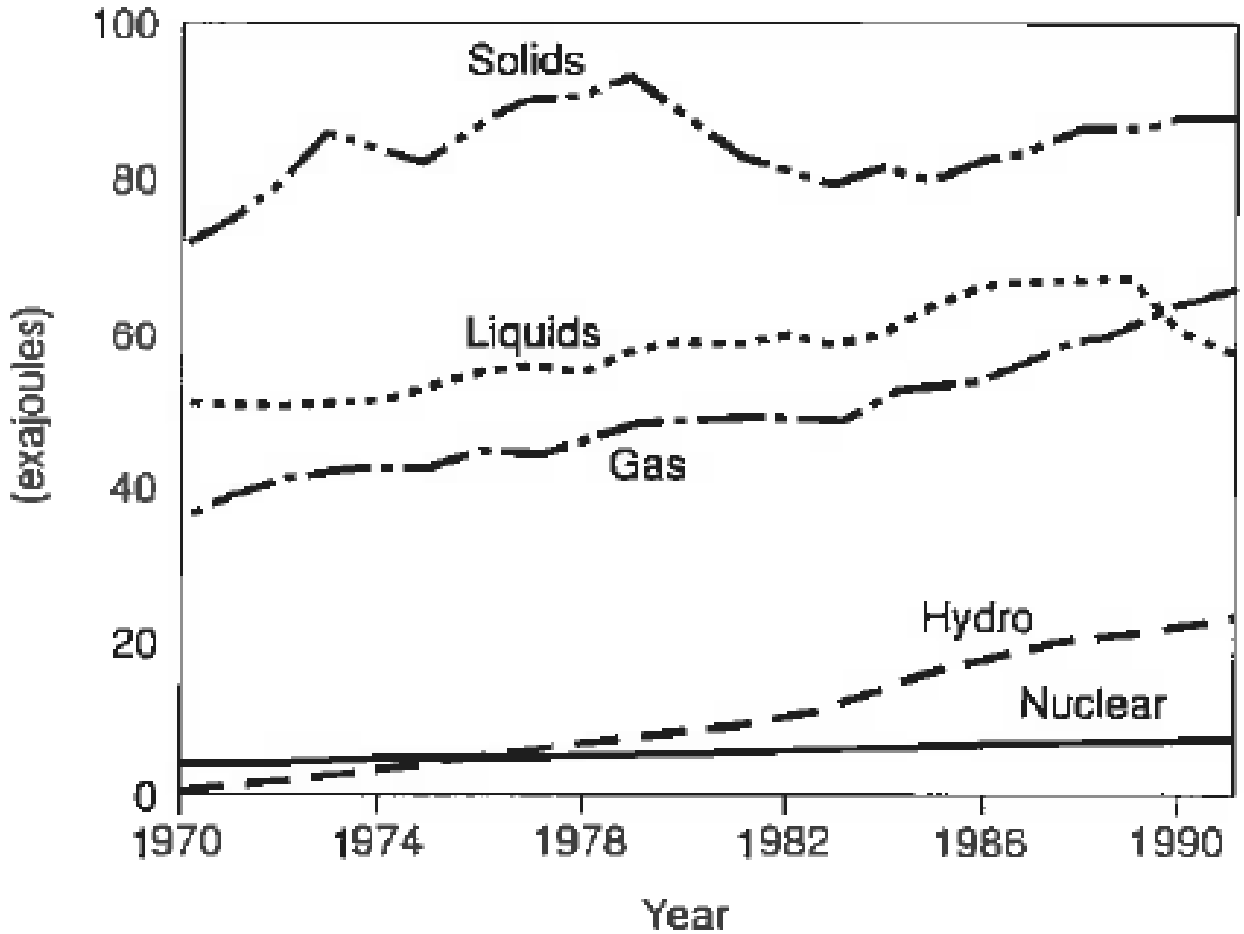


Figure 9.2 Commercial energy consumption by source, industrialized countries, 1971–91. From WRI, 1994, with permission.

Human Energy Needs: Energy Consumption & Trends

TABLE 1.2 ENERGY TRENDS IN TEN MOST POPULOUS COUNTRIES

Country	Population (millions) (2000)	Energy use (EJ) (1998)	Rate of increase (%) (1987–1998)	Doubling time (yrs)
China	1,277.6	36.0	+3.5	19.8
India	1,013.7	13.3	+6.3	11.0
United States	278.4	100.5	+1.5	46.2
Indonesia	212.1	3.8	+7.3	9.5
Brazil	170.1	8.6	+3.8	18.2
Pakistan	156.5	1.8	+5.2	13.3
Russian Federation	146.9	27.5	−4.6	—
Bangladesh	129.2	0.4	+5.9	11.7
Japan	126.7	22.6	+2.6	26.7
Nigeria	111.5	1.0	+3.5	19.8
Totals (1998)	3,622.7	215.5	+1.3	53.3

Country	Population (millions) (2020)	Energy use (EJ) (2020)	Rate of increase (%) (1998–2020)	Doubling time (yrs)
Totals (2020)	4,333.8	380.9*†	+2.6	26.7

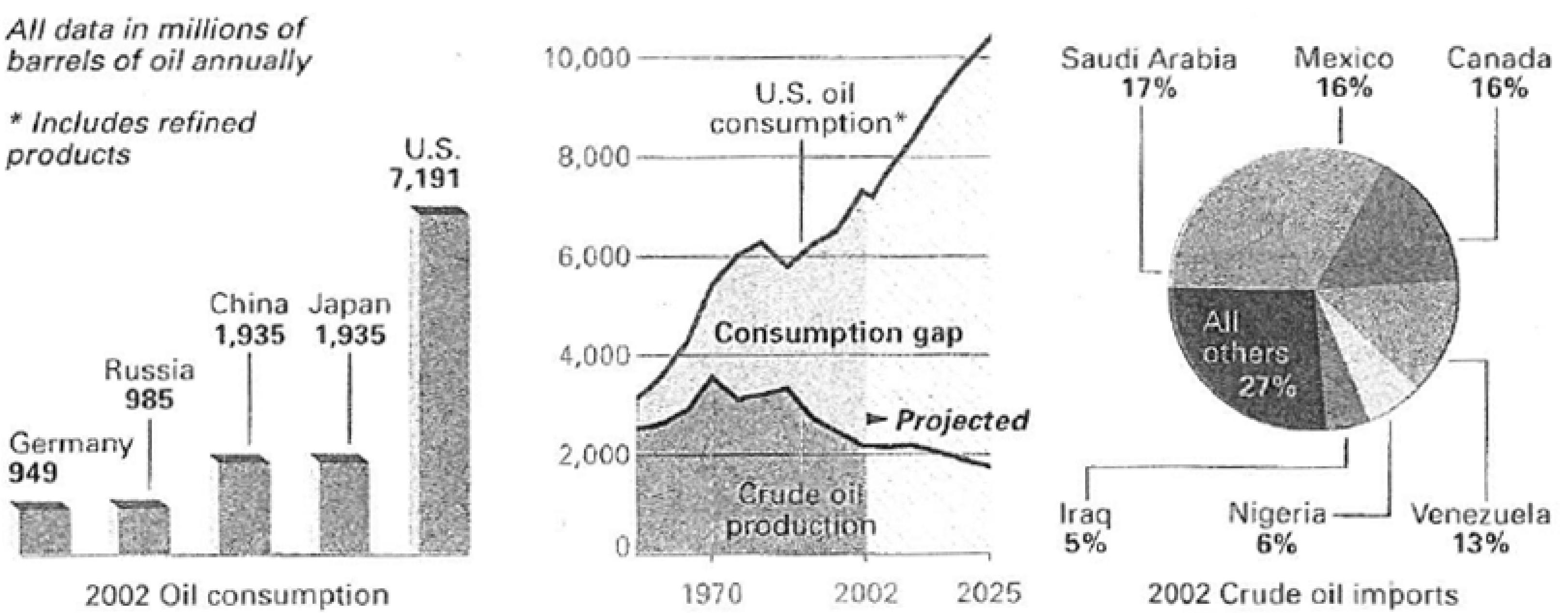
*For individual countries, assumes rates of increase during the period 1998–2020 are the same as they were in 1987–1998.

†Assumes Russian Federation consumption is fixed at 27.5 EJ throughout the time period 1998–2020.

Source: Energy Information Agency, U.S. Department of Energy (1999). International tables for population and energy consumption trends, Washington, DC. (http://www.eia.doe.gov/emeu/international/contents.html)

Human Energy Needs: Energy Consumption & Trends

THE U.S. USES MORE, PRODUCES LESS, AND RELIES ON IMPORTS



The gap in the U.S. between the production of crude oil and the consumption of all the products made from it has been widening steadily since the 1970s. As a result the U.S. imports crude from dozens of countries, Saudi Arabia first among them. The U.S. will likely become more dependent on Middle East supplies in the future.

CHARTS BY 5W INFOGRAPHICS. SOURCE: ENERGY INFORMATION ADMINISTRATION

National geographic, 2004

Human Energy Needs

- Total risk of an energy source includes evaluation of:

- Energy Cycle
  - Material acquisition and construction
  - Emissions from material acquisition and energy production
  - Operation & maintenance
  - Energy back-up systems
  - Energy storage systems
  - Transportation
  - Waste management

Biomass Fuel

- Used for domestic use
  - Cooking
  - Heating
- Often the only energy source available in poor, rural areas
- Due to incomplete combustion- biomass smoke often exceeds WHO's guidelines for
  - Respirable particles
  - Carbon monoxide
  - Nitrogen oxides
  - Formaldehyde
  - Complex organic compounds
    - Polycyclic aromatic hydrocarbons

Biomass Fuel

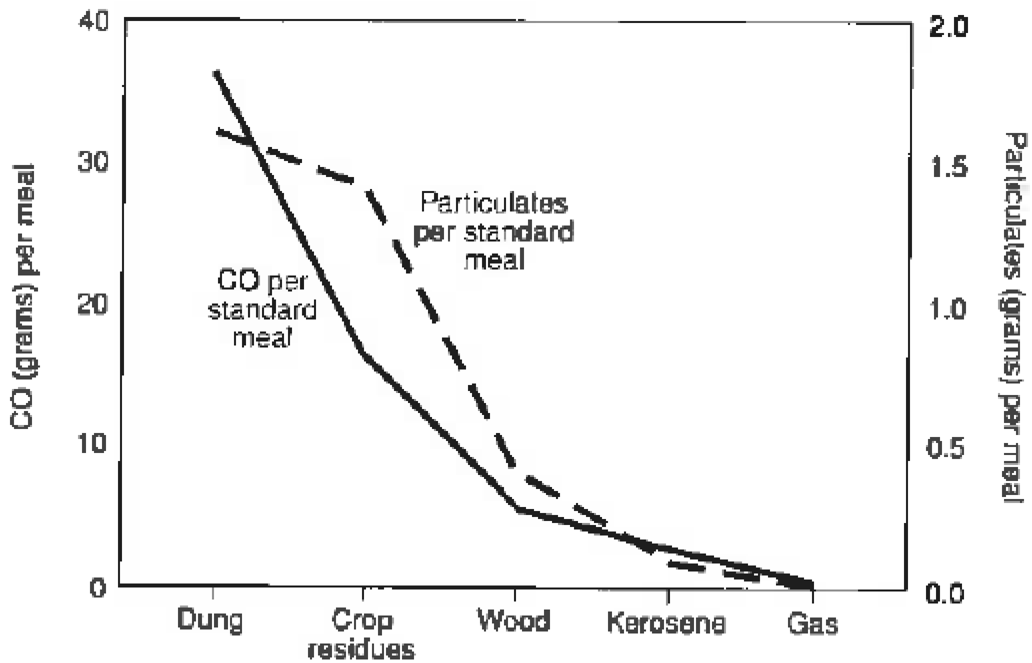


Figure 9.4 Amount of indoor air pollution for each meal cooked. From Smith, 1991, with permission.

WHO Executive Summary

- About 2.7 billion people still dependent on the use of rudimentary, traditional biomass and coal stoves
- Cause about 2 million deaths annually, including over 1 million deaths from chronic obstructive pulmonary disease and almost another million deaths from pneumonia in children under the age of 5
- Scenario modeling estimates that 11% of all chronic lung disease burden in Latin America and Sub-Saharan African among adults over 30 could be averted in less than a decade by the introduction of more advanced biomass or biogas stoves, in pace with UN targets for universal energy access
- About 36,000 lung cancer deaths every year are also due to indoor air pollution from coal stoves, and these, too, are also largely avoidable with cleaner stoves
- More than one-third of the annual deaths from chronic lung disease worldwide and nearly 3% of lung cancer deaths are due to indoor air pollution from biomass and coal stoves, and most of this burden is borne by poor women in developing countries

http://www.who.int/hia/hgebrief_henergy.pdf

Biomass Fuel

TABLE 9.2

ADVERSE EFFECTS OF BIOMASS FUEL PRODUCTION AND COLLECTION ON HUMAN HEALTH

Function	*Possible Health Effects*
Processing/preparing dung cakes	Fecal/oral/enteric infection
	Skin infection
Charcoal production	CO/smoke poisoning
	Burns/trauma
	Cataracts
Gathering fuel	Trauma
	Reduction in infant/child care
	Bites from venomous snakes, spiders, leeches, insects
	Allergic reactions
	Fungus infections
	Severe fatigue

ADVERSE EFFECTS OF BIOMASS COMBUSTION ON HUMAN HEALTH

Effects of smoke (acute and subacute)	Conjunctivitis, blepharoconjunctivitis
	Upper respiratory irritation, inflammation
	Acute respiratory infection
Effects of toxic gases (e.g., CO)	Acute poisoning (from CO)
	Cardiovascular diseases
Effects of smoke (chronic)	Chronic obstructive pulmonary disease
	Chronic bronchitis
	Adverse reproductive outcomes
	Cancer (lung)
Acute effects of heat	Burns
Chronic effects of heat	Cataracts
Ergonomic effects of crouching over stove/fire	Arthritis

Source: WHO, 1991b.

Biomass Fuel

- Indirect Health Effects
  - Unless vegetation materials are re-planted at the same rate as consumed
    - Deforestation
    - Greenhouse Effect
- Can decrease problems with biomass by:
    - More efficient stoves
    - Cutting amount of fuel required for domestic tasks
      - Lessen rate of deforestation
    - Increase ventilation
      - Installation of chimneys and hoods on stoves
      - Rearrange the stove or fire in a position where more of the emissions can flow outside

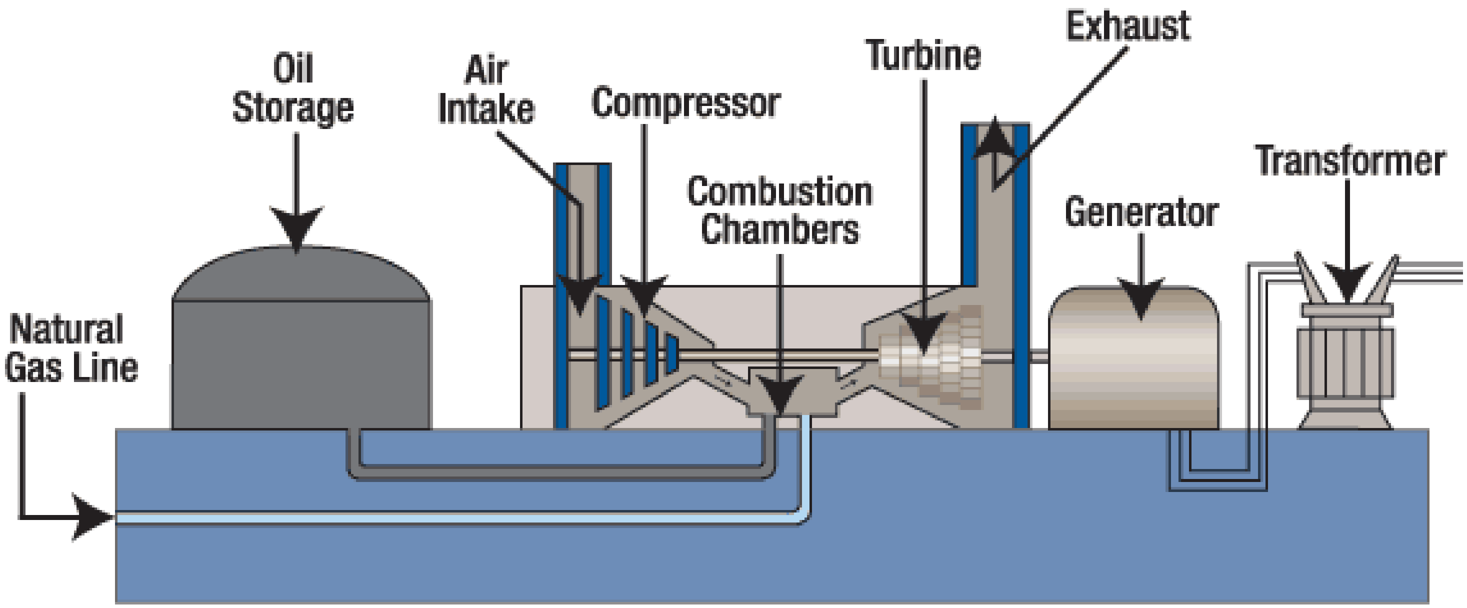
Fossil Fuels

- Derived from solar energy trapped in the form of fossilized plants
  - Were created over millions of years
  - Provides 90% of the worlds commercial energy
  - In 12 months the world consumes an amount of fossil fuels that took 1 million years to create

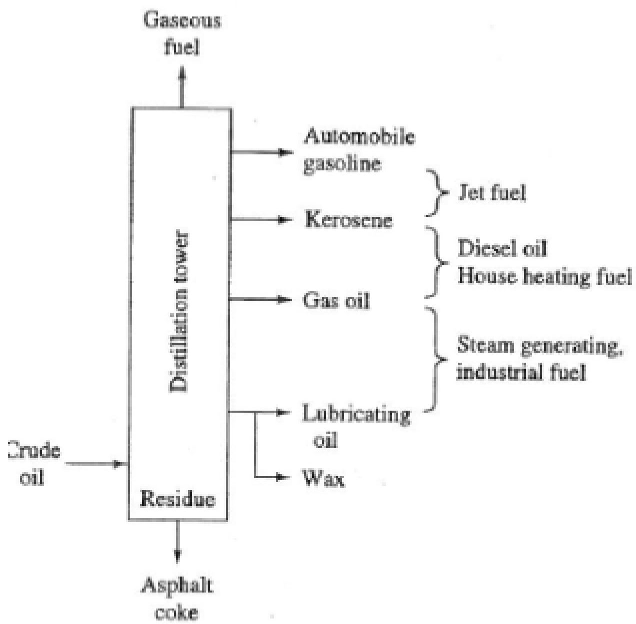
- Oil
  - Supplies 38% of world's energy needs
- Coal
  - Supplies 30% of world's energy needs
- Natural Gas
  - Supplies 20% of world's energy needs

Fossil Fuels

Combustion Turbine Power Plant



Fossil Fuels



Fraction	Chemical Composition		Boiling range, °C
	Carbon atoms	Molecular weight	
Gaseous	1–4	16–58	−126–0
Gasoline	5–12	72–170	0–204
Kerosene	10–16	156–226	180–274
Gas oil	15–22	212–294	260–371
Lube oil	19–35	268–492	338–468
Residue	36–90	492–1262	468+

Figure 2.5 Crude oil refining.

- Distillation process for dividing petroleum into various fractions
  - Separated on the basis of boiling points
  - Complex mixture of hydrocarbons and molecules
    - Metallic elements are present
    - Sulfur and metal-containing products are in residue
- Ease of transport & high level of efficiency & integration of fossil fuels creates challenge for alternative energy

Fossil Fuels - Oil

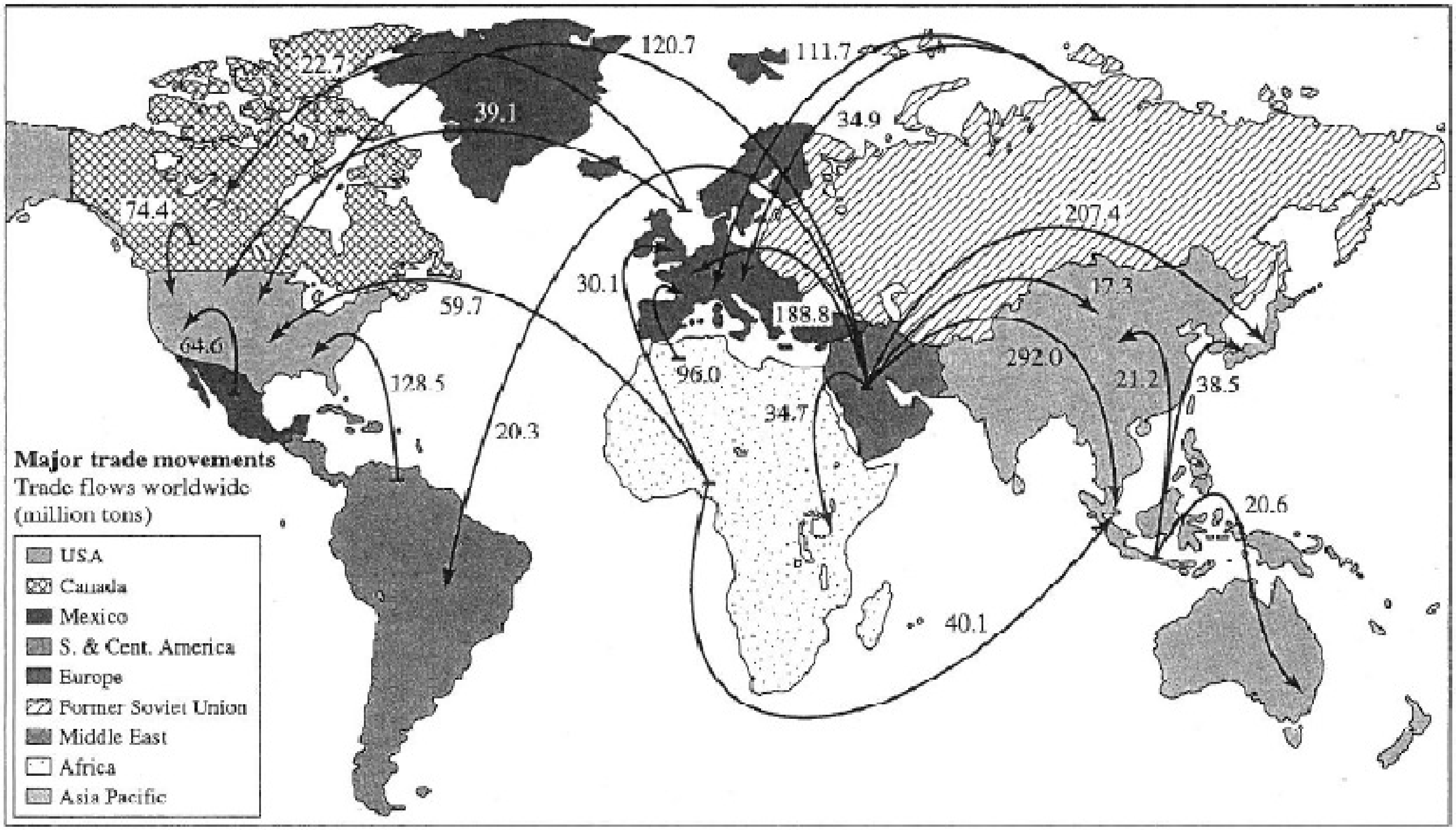
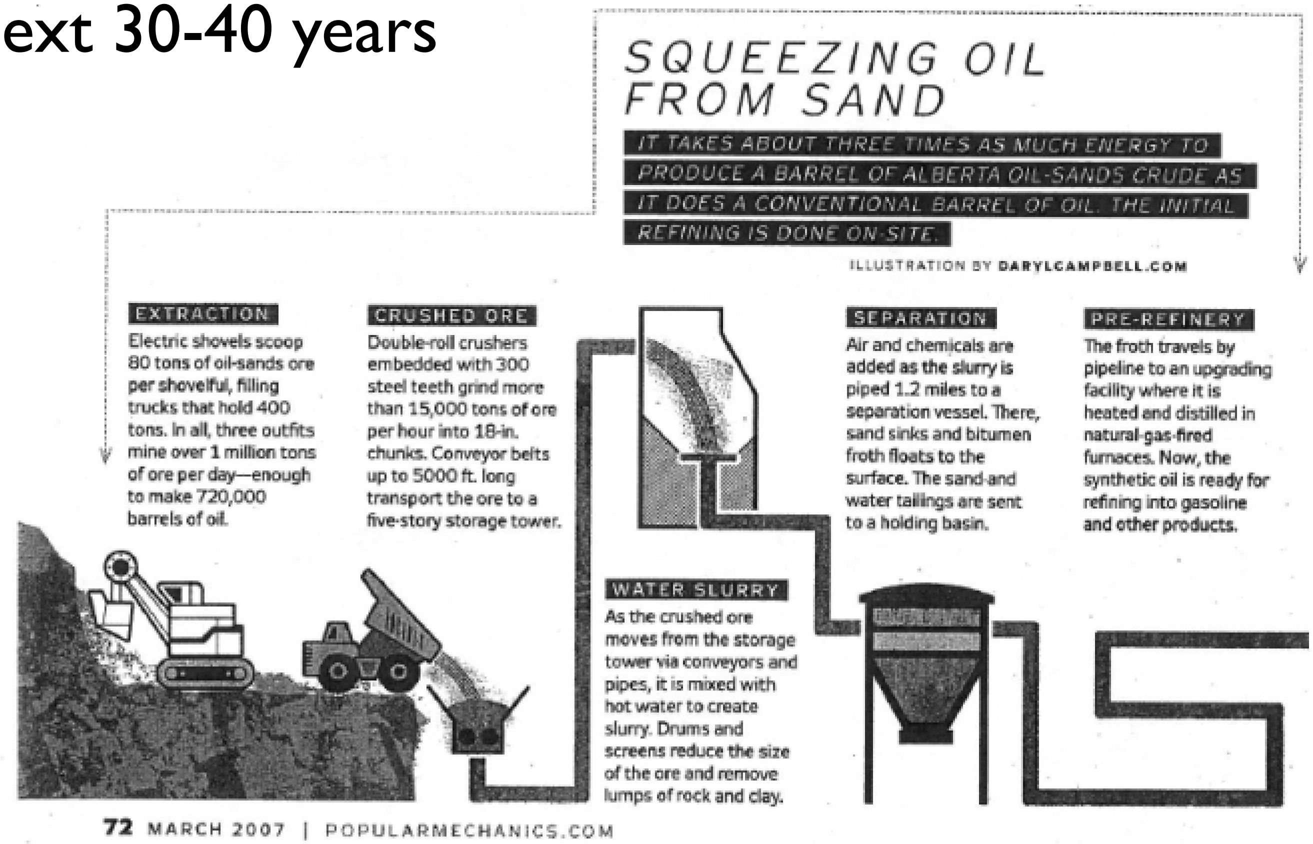


Figure 2.6 Routes of international oil trade. *Source:* BP Amoco, *Statistical Review of World Energy 2000.* (http://www.bp.com/centres/energy/world_stat_rev/oil/trade.asp)

Fossil Fuels

- Known reserves of oil and natural gas may be consumed in the next 30-40 years



Fossil Fuels

- Coal reserves may last 200 years
  - Remaining coal is lower in quality than what is used now
    - Combustion will produce less energy
  - Different coals have different amounts of minerals
  - When coal is burned inorganic and organically bound sulfur is oxidized to SO_2
    - SO_2 & NO_2 from burning coal is the major source of acid rain

Fossil Fuels - Coal

Average Sulfur Content of Coal by Rank		
Rank	% of total coal reserves	% with sulfur content > 1%
Anthracite	0.9	2.9
Bituminous	46.0	70.2
Sub-bituminous	24.7	0.4
Lignite	28.4	9.3
Total, all ranks	100.0	35.0

Figure 2.11 Coal distribution in the United States and average sulfur content of coal. *Source:* P. Averitt (1960). U.S. Geological Survey, *Bulletin 1136* (Washington, DC: U.S. Department of Interior).

Fossil Fuels

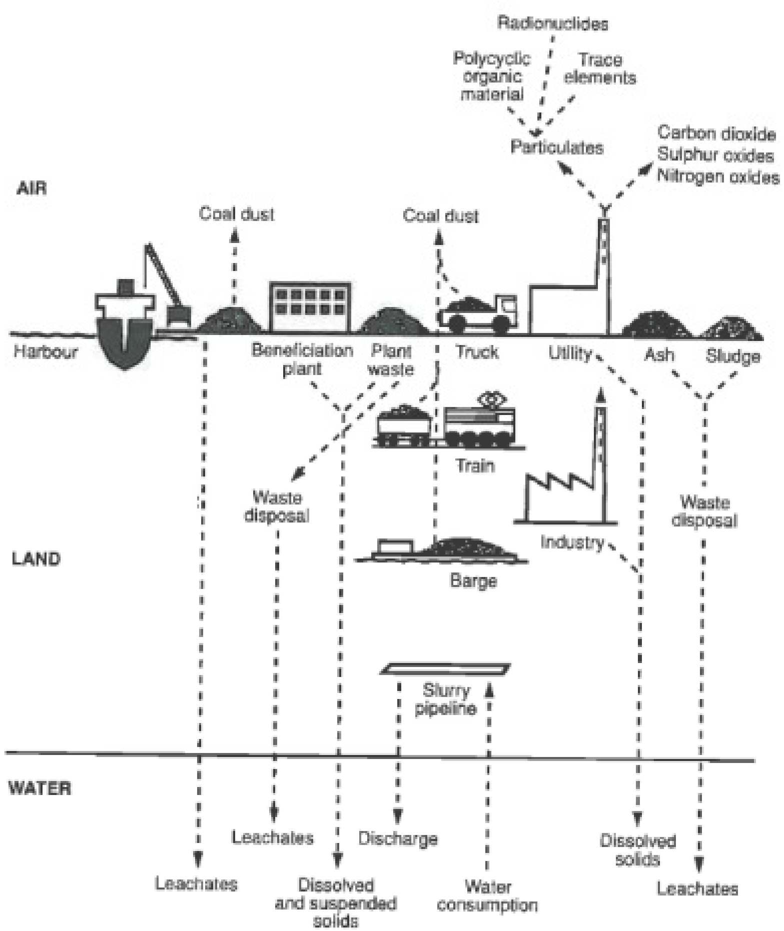
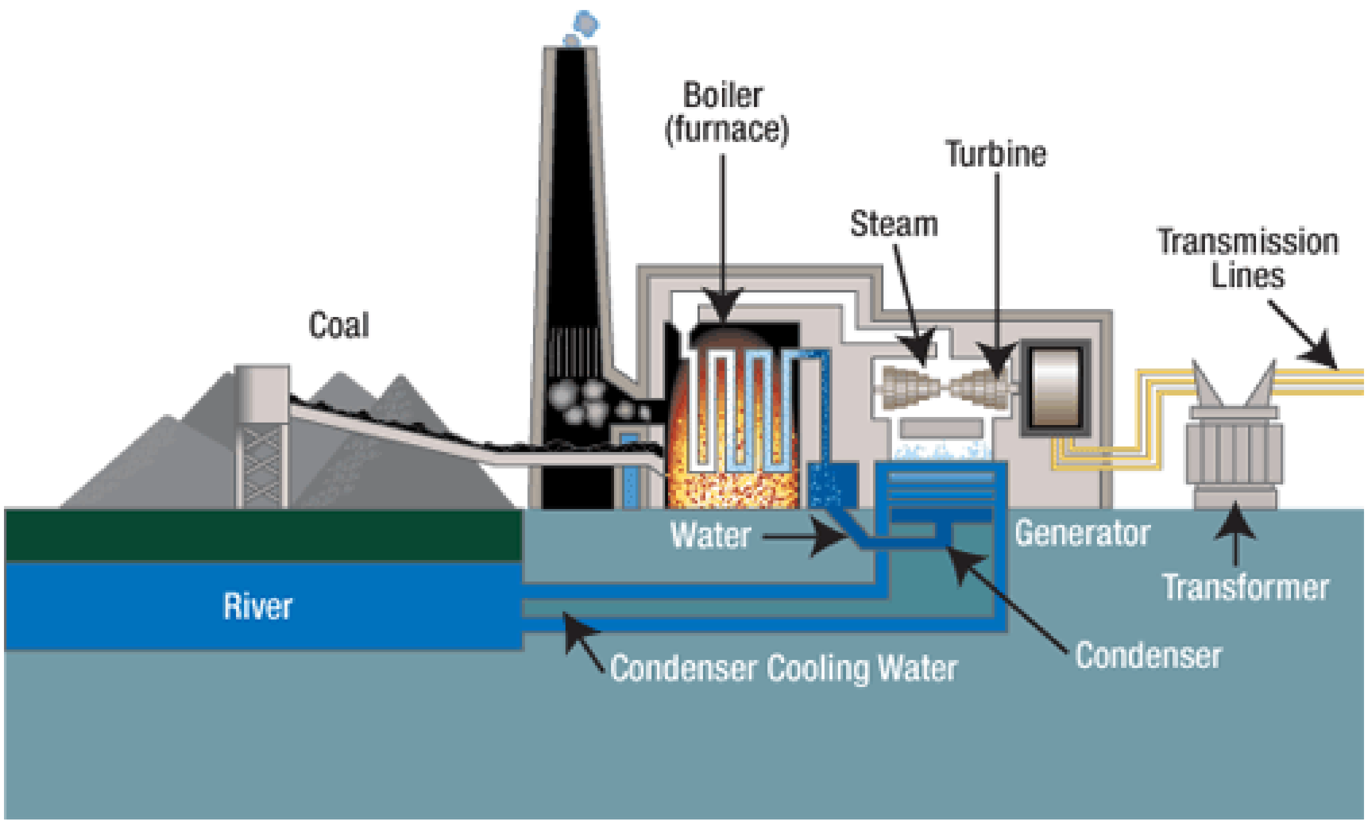


Figure 9.5 Various stages in the handling of coal in Sweden and the environmental disturbances that can occur. From SCHEP, 1983, with permission.

- Swedish Coal-Health-Environment Project
  - Using modern & effective techniques in burning coal, adverse effects can be reduced
  - Risk of increased levels of methyl mercury in fish
  - Fly ash is too high in radioactivity to use in building materials for residence
    - Drinking water wells should not be located in vicinity of dumps

Fossil Fuels

Coal-fired Power Plant



Fossil Fuels

TABLE 9.4

HAZARDS ASSOCIATED WITH FOSSIL FUEL EXTRACTION AND PROCESSING

Fuel	*Location*	*Hazards and Effects*
Coal	Underground mines	Coal workers' pneumoconiosis (CWP) or "black lung," silicosis, fires/explosions, injuries
	Open-pit mines	Industrial bronchitis, chronic cough, accidents (mining, transport)
Oil	Off-shore developments	Accidents caused by weather, explosions
	Land oil fields	Dermatitis (from long-term exposure to crude oil), accidents/explosions
	Refineries	Exposure to hydrocarbons (known carcinogens)
Natural gas	Deposits	Hydrogen sulfide exposure, accidents/explosions
	Refineries	Exposure to hydrocarbons (known carcinogens), accidents/explosions

TABLE 9.5

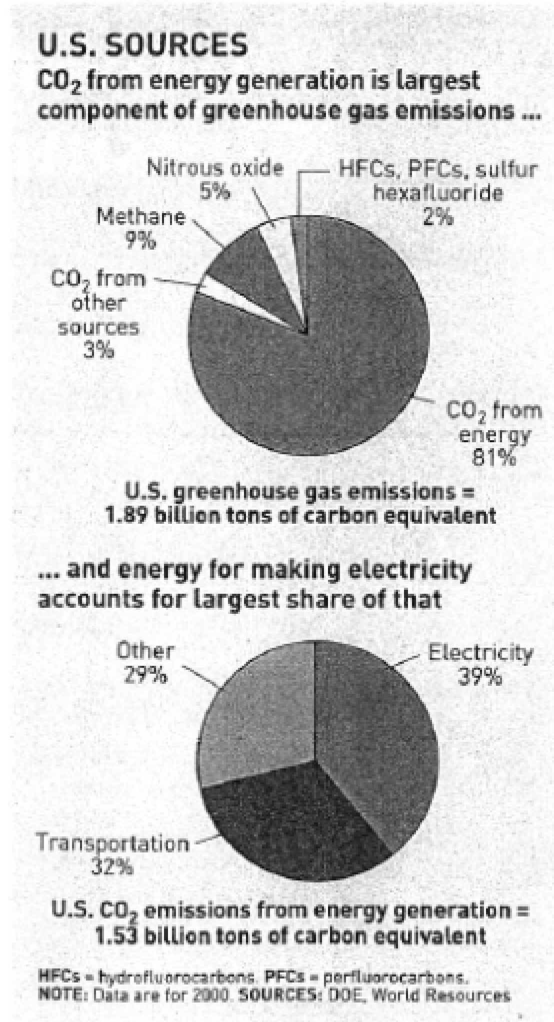
HEALTH HAZARDS ASSOCIATED WITH FOSSIL FUEL COMBUSTION

Fuel	*Method of Combustion*	*Associated Hazards and Effects*[a]
Coal	Domestic fires (i.e., using raw coal)	Acute respiratory infections, chronic lung diseases, lung cancer
	Industrial consumption	Accident/fire, air pollution effects
Oil	Industrial consumption	Accident/fire, air pollution effects
	Vehicles	Motor vehicle accidents, air pollution effects
	Domestic consumption (e.g., kerosene stoves)	Indoor air pollution effects
Natural gas	Industrial consumption	Air pollutants
	Domestic use (cooking/heating)	Air pollutants, asphyxiation, explosions

[a]The different types of air pollution are discussed in Chapter 5.

Fossil Fuels

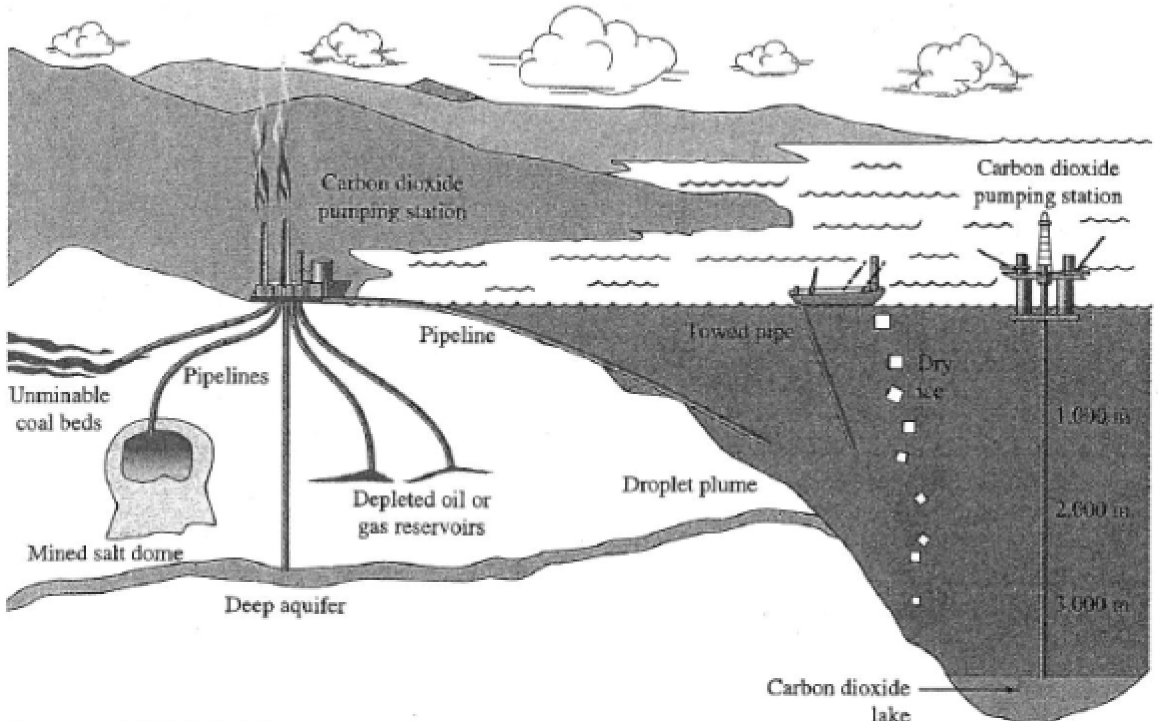
- Indirect Health Effects
  - Transboundary pollution
    - Urban centers located along country borders
  - Global warming
  - Acid Rain



Fossil Fuels

- Pollution Prevention
  - Mitigation technologies
    - Scrubbers- reduce SO_2 emissions up to 95%
    - Electrostatic precipitators & bag filters trap large amounts of particulates
- New technologies
  - Decarbonization
    - Separation
      - Separate CO2 from exhaust gasses after fuel combustion
    - Long-Term Storage
      - Deep oceans
        - CO2 could react with the water and harm marine life
      - Geoligic formations
        - Store in reservoirs where petroleum and gas were extracted
        - Enhances recovery of oil

Fossil Fuels



Storage underground	Advantages	Disadvantages	Storage in oceans	Advantages	Disadvantages
Coal beds	Potentially low costs	Immature technology	Droplet plume	Minimal environmental effects	Some leakage
Mined salt domes	Custom designs	High costs	Towed pipe	Minimal environmental effects	Some leakage
Deep saline aquifers	Large capacity	Unknown storage integrity	Dry ice	Simple technology	High costs
Depleted oil or gas reservoirs	Proven storage integrity	Limited capacity	Carbon dioxide lake	Carbon will remain in ocean for thousands of years	Immature technology

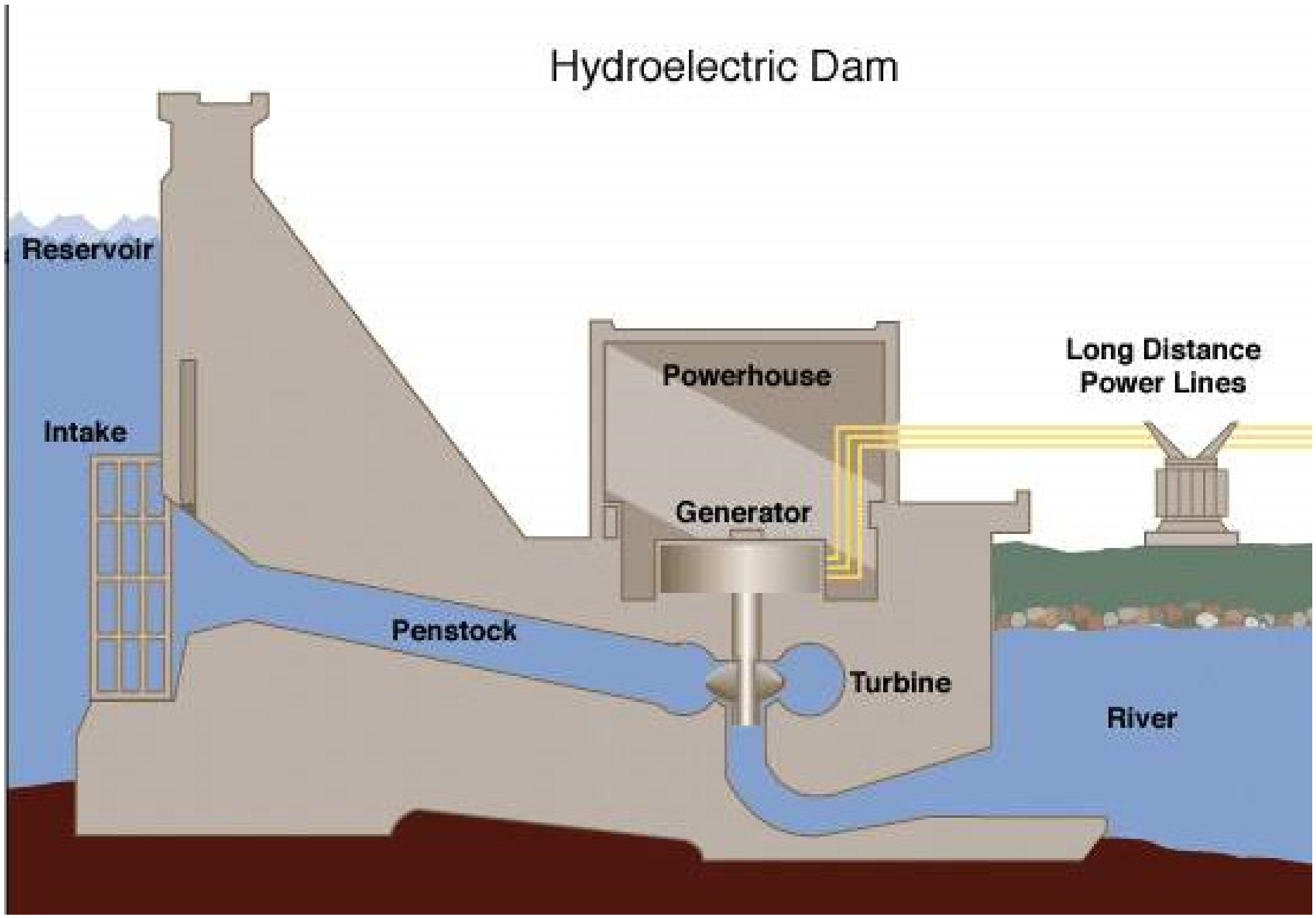
Figure 2.12 Potential storage sites for carbon dioxide in the ground and deep sea. *Source:* H. Herzog et al. (2000). Capturing greenhouse gases. *Scientific American* 282(February):72–79. Reprinted with permission from D. Fierstein.

Hydropower

- Renewable & Clean Energy

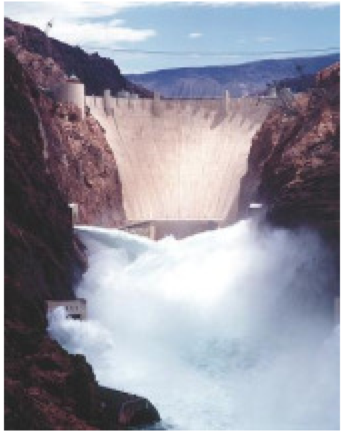
- Accounts for ¼ of world's electricity output
  - Potential uses of hydropower
    - Europe: 36%
    - North America: 59%
    - Asia: 9%
    - Latin America: 8%
    - Africa: 5%

Hydropower


Hydroelectric Dam
Reservoir
Intake
Powerhouse
Long Distance
Power Lines
Generator
Penstock
Turbine
River

Hydropower

- Construction of dams are expensive
  - Dams may only last decades
    - Buildup of silt behind the dam



- Creation of dam may cause:
  - Displacement of persons
  - Disruption of food supply
  - Large dams have been suspected of causing earthquakes
  - Ecosystems may be damaged or disappear

- Failure of a dam can cause:
  - Flooding
  - Loss of life

Hydropower

- Direct Health Effects
  - Over 10,000 skilled & unskilled workers will be employed to construct the dam
  - After the dam is constructed, hydroelectricity is relatively cheap
  - Dammed water can be used for irrigation
  - Fish can be bred in dam to provide food source for population

- Indirect Health Effects
  - After the dam is constructed, hydroelectricity is relatively cheap
  - Dam can change biological local environment
    - May contribute to spread of disease
      - Schistosomiasis
      - Malaria

Hydropower

- Mitigation by Environmental Management
  - Environmental Impact Statement (EIS) should be done on any new project
  - Predict negative effects of dam construction
  - To reduce negative effects, planners should:
    - Diminish peoples contact with vectors
    - Plan for the provision of water and sanitation
    - Health education and the promotion of public health participation to reduce hazards

Nuclear Power

- 95% of total generating capacity of nuclear power is in:
  - North America
  - Europe
  - Japan

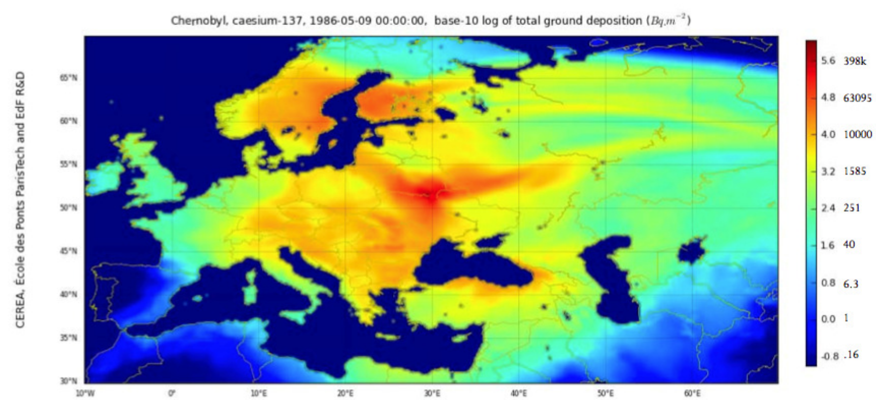
- Only known incidents to cause off-site releases
  - 3 Mile Island
  - Chernobyl
  - Fukishima

- Normal operation of plants produce less pollution than other forms of power

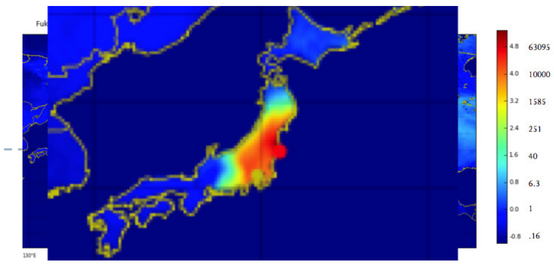
Nuclear Power

- 3- Mile Island
  - Core heated & melted
  - Pressure vessel & containment structure remained intact

- Chernobyl
  - Reactor was obsolete design
  - Not operated properly
    - Surge in reactor power
    - Rapid rise in temperature
    - Explosion of core
    - Intense fire
  - 31 deaths & approximately 1,000 thyroid cancer in children
  - Permanently evacuated 100,000 people
  - Several million people still living in contaminated areas



Nuclear Power



- Fukushima
  - Tōhoku earthquake and tsunami
    - equipment failures (reactors shut down, but back-up generators flooded);
    - nuclear meltdowns because no cooling water were circulated; and
    - explosions & releases of radioactive materials
  - The second disaster (along with Chernobyl) to measure Level 7 on the International Nuclear Event Scale
    - Radiation release from all the reactors taken together as equivalent to a "sixth"(17%) that of Chernobyl
  - 0 death due to direct radiation exposure
    - WHO estimated 70% increased risk of thyroid cancer among girls exposed as infants in the most affected area
  - 12 mi-radius (~100,000 persons) evacuation around the plant

Nuclear Power

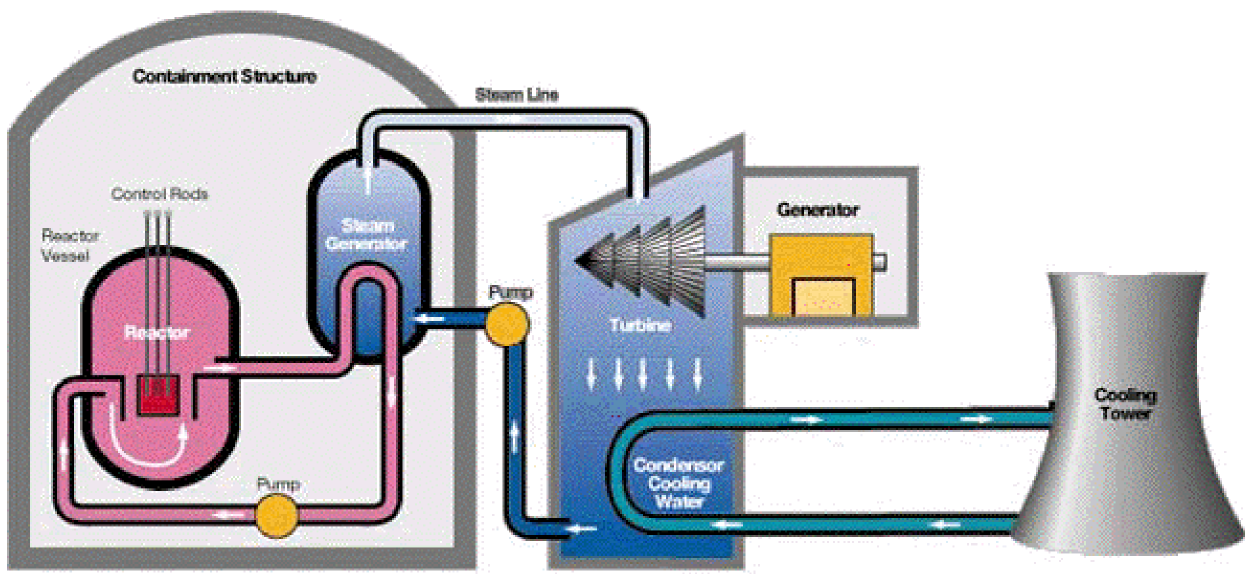
- Nuclear resources for reactors is uranium and thorium
  - Power is based on process of fission
    - Splitting of uranium atoms
  - Alternative nuclear technology
    - Fusion
      - Strong pressures force 2 hydrogen atoms to release energy
      - If successful, could produce cheap energy from sea water
      - Under development in engineering programs in the US, Japan, & Europe
      - Distant possibility

Nuclear Power

- Health Effects
  - Stochastic (non-threshold) effects
    - Cancer
      - Conflicting studies on increase in childhood leukemia
    - Heredity Effects
  - Deterministic (Threshold) effects
    - Acute exposure
    - Include:
      - Skin burns
      - Damage to bone marrow
      - Sterility

Nuclear Power

- Safety Approaches
  - Built-in-safety factors on new reactors
  - Retro-fit older reactors to achieve current safety standards
  - Management of nuclear waste



Nuclear Power

- Where to store waste?
  - Geologic formations
  - Yucca Mountain proposed site

- Types of Waste Disposal
  - Low & Intermediate-Level Waste Disposal
    - Effective barriers
      - Prevent significant transfer
    - Shallow ground disposal with or without concrete liner

  - High-Level Waste Disposal
    - Liquid waste stored for 1 year or more in water tanks to cool down
    - Deep underground & stable rock formations with multiple engineered barriers

Alternative Energy Sources

- Priorities for action on energy-related issues
  - Exposure to noxious agents in the course of domestic utilization of biomass and coal
  - Exposure resulting from urban air pollution in numerous large cities of the world
  - Energy-related climate change
  - Serious energy-related accidents with environmental impact

- Alternative to fossil fuel & biomass
  - Most promising alternatives:
    - Hydropower
    - Wind
    - Solar
    - Geothermal
  - Other alternatives
    - Tidal

Alternative Energy Sources

TABLE 9.6

SUMMARY OF SIGNIFICANT HEALTH EFFECTS OF TECHNOLOGIES FOR GENERATING ELECTRICITY

Technology	*Occupational Health Effects*	*Public Health Effects*
Geothermal	Exposure to toxic gases, routine and accidental Stress from noise Trauma from drilling accidents	Disease from exposure to toxic brines and hydrogen sulfide Cancer from exposure to radon Arsenic poisoning from contaminated water Mercury poisoning via fish in this water
Hydropower	Trauma from dam failures Trauma from construction accidents Disease from exposure to pathogens Health effects from lifestyle disruption associated with forced relocation	Mercury poisoning through mercury contamination of water and fish Malaria spread to new areas Schistosomiasis
Photovoltaics	Exposure to toxic materials during fabrication, routine and accidental	Exposure to toxic materials during fabrication and disposal, routine and accidental
Wind	Trauma from accidents during construction and operation	Noise disturbance
Solar thermal	Trauma from accidents during fabrication Exposure to toxic chemicals during operation	

Geothermal

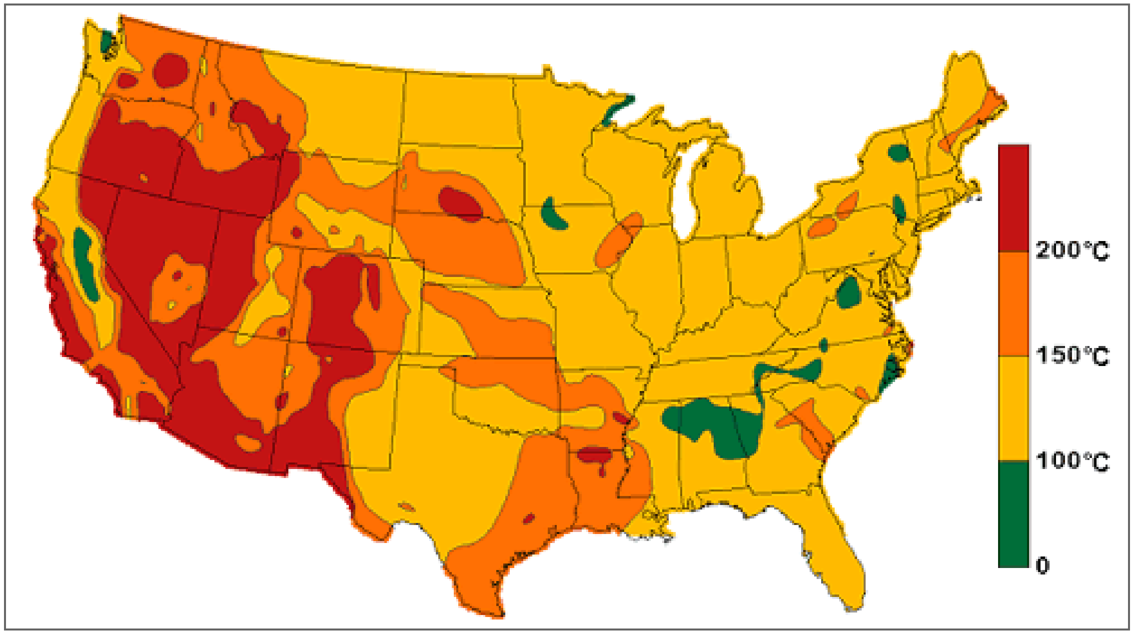
- Geothermal is Renewable
  - There is almost unlimited amount of heat generated by the Earth's core
  - Geothermal is Clean energy
  - Can be extracted without burning fossil fuel
  - Geothermal fuels only produce 1/6 CO_2 of relatively clean natural gas fueled power plants

- Shallow temperatures are relatively constant in the US
- Geothermal heat pumps can be used almost anywhere
- Characteristics of land determine type of heat pump
  - Geology
  - Hydrology
  - Land Availability

Geothermal Energy

- Good Site for Development for Geothermal Power Plant
  - Hot geothermal fluid with low mineral and gas content
  - Shallow aquifers for producing and re-injecting fluid
  - Availability of make up water for evaporative cooling
  - Geothermal fluid temperature should be at least 300°F
    - Plants operate on fluid temperatures as low as 210°F
- Need pollution control measures for release of hot, mineral-laden underground water
- Effects of heated water on ecosystems

Geothermal



- Resources are classified by temperature
- The highest temperature resources are used for electric power generation
- Low Temperature
  - Less than 90°C (194°F)
- Moderate Temperature
  - 90C-150°C (or 194F-302°F)
- High Temperature
  - Greater than 150°C (302°F)

Further Information about Geothermal:
http://www.sciencedirect.com/science/article/pii/S1364032101000028

Photovoltaic

- Renewable source of energy

- Photovoltaic cell (PV cell)
  - PV materials are semiconductors, solids with electrical properties between metals & insulators

  - Solar energy cannot be converted at 100% efficiency
    - ½ of photons cannot be utilized

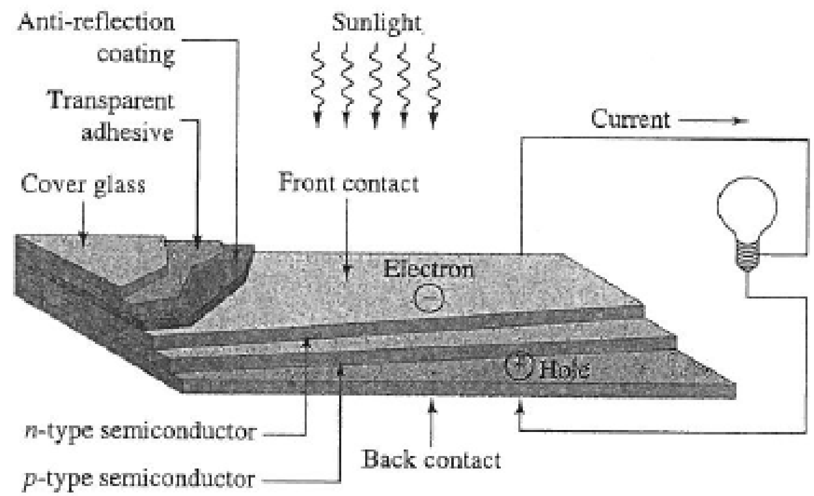


Figure 4.8 Schematic diagram of a photovoltaic cell. *Source:* C. L. Stanitski et al. (2000) *Chemistry in Context, Applying Chemistry to Society* (third edition) (New York: McGraw-Hill). Copyright © 2000 by The McGraw-Hill Companies. Reprinted with permission.

Photovoltaic

- Solar cells are portable
- In locations remote from power grids, PV electricity is cheaper than building grid extensions
- Solar cells can provide small amounts of power required for basic human needs:
  - Pumping water to villages, livestock, & irrigation
  - Refrigeration to preserve vaccines, blood, & other healthcare perishables
  - Lighting & appliances for homes &community buildings
  - Recharging batteries for flashlights & portable appliances

Solar Thermal

- Clean Energy
- Generate high temperatures by using mirrors to concentrate sun’s rays up to 5,000 x’s
- It would take an area of 10,000 sq miles in the Nevada desert to supply total electricity needs of the US

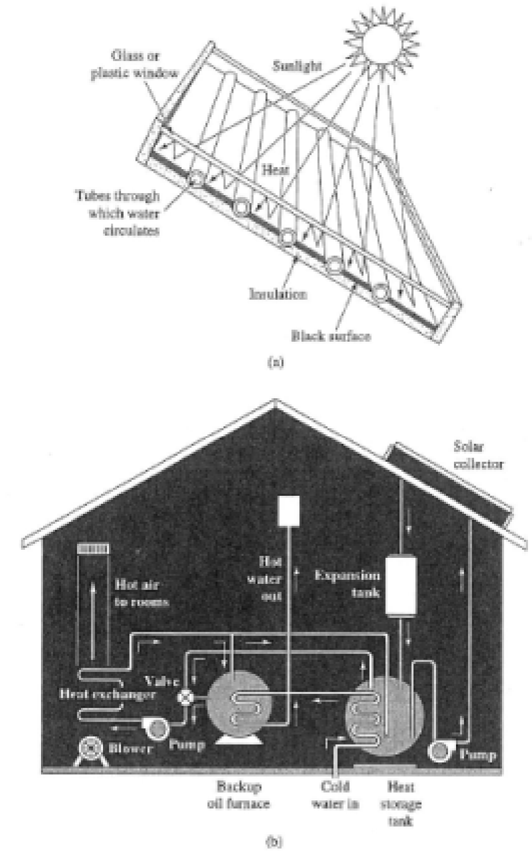


Figure 4.2 a) Solar collector on roof of active solar-heated house; b) Pumping system in active solar-heated house for provision of space heating and hot water. *Sources:* a) B. J. Nebel (1993). *Environmental Science: The Way the World Works* (Upper Saddle River, New Jersey: Prentice Hall). Copyright © 1993 by Pearson Education. Reprinted with permission; b) B. Anderson and M. Riordan (1976). *The Solar Home Book: Heating, Cooling and Designing with the Sun* (Harrisville, New Hampshire: Brick House Publishing). Copyright © 1976 by Brick House Publishers. Reprinted with permission.

Solar Thermal

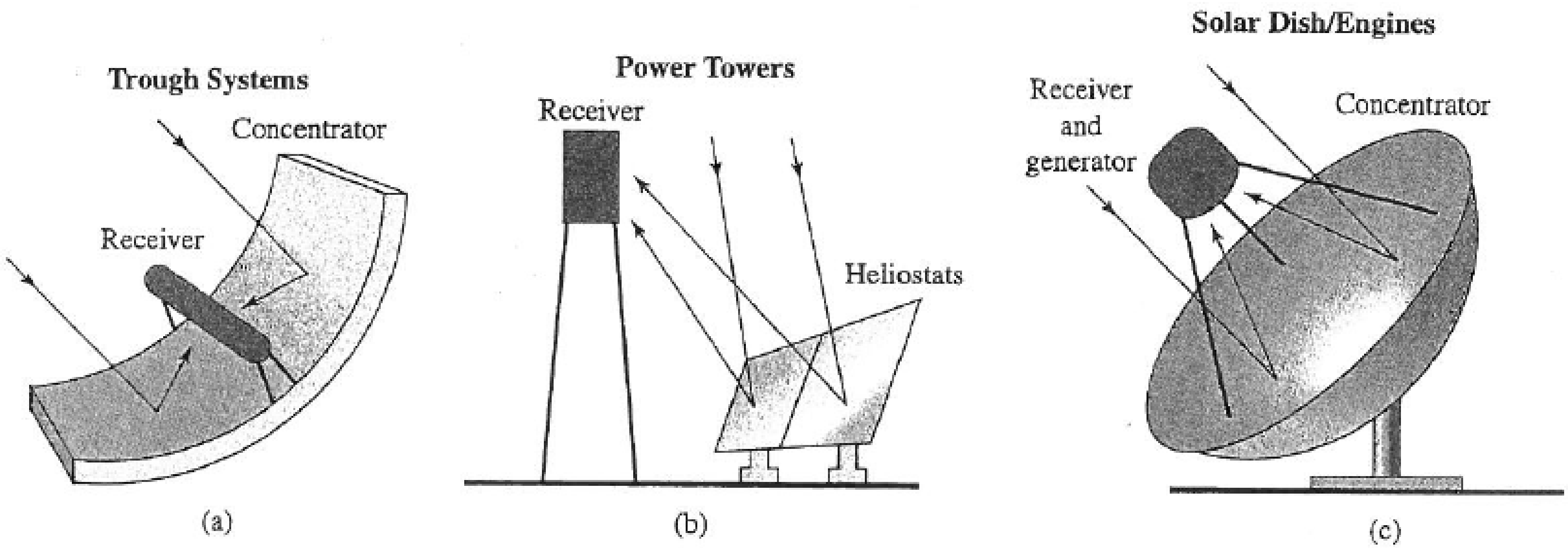
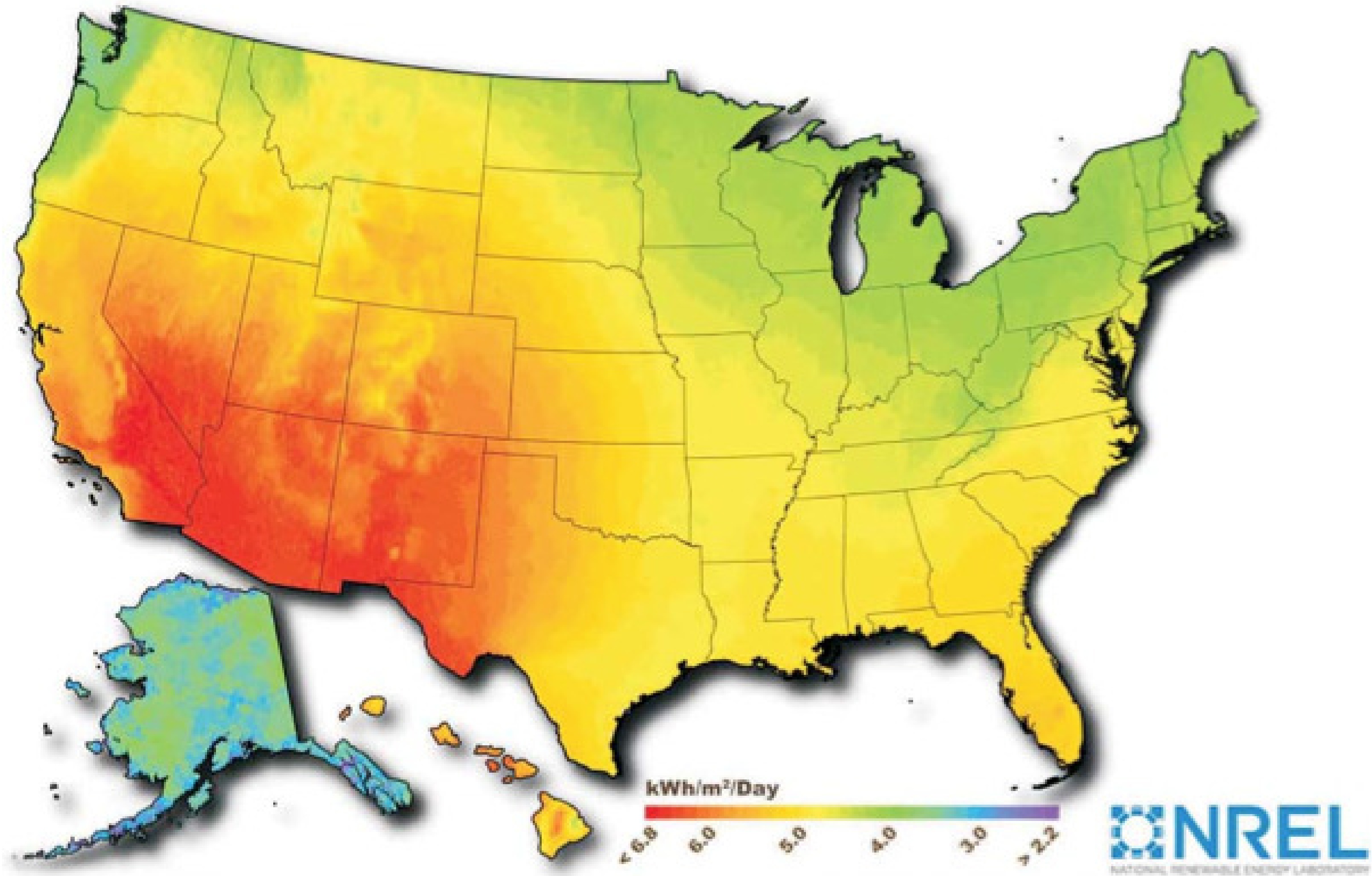


Figure 4.3 Electricity from solar thermal energy. a) Trough system; b) Power tower; c) Solar dish/engines. *Source:* Sun Lab Snapshot (1998). *Concentrating Solar Power Program, Overview.* U.S. Department of Energy. (http://www.nrel.gov/docs/fy99osti/24649.pdf)

Figure 4.12 Photovoltaic Solar Resources



Notes: • Annual average solar resource data are shown for a tilt=latitude collector. • kWh/m²/Day = kilowatthours per square meter per day.
Web Page: For related information, see http://www.nrel.gov/gis/maps.html.

Sources: This map was created by the National Renewable Energy Laboratory for the Department of Energy (October 20, 2008). The data for Hawaii and the 48 contiguous States are a 10-kilometer (km) satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005. The data for Alaska are a 40-km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

Wind Power

- Renewable source of energy
- Lowest-cost alternative o electricity from fossil fuel & nuclear plants
- The total wind resource in the Great Plains is nearly 3 x's as large as US electricity generation in 1999

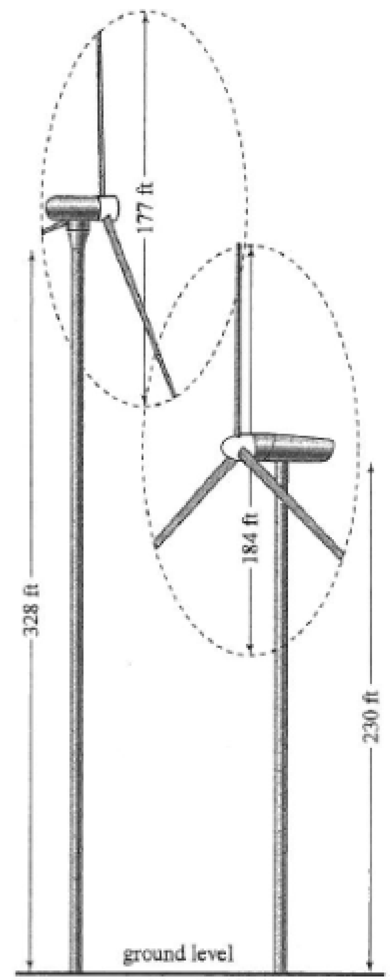
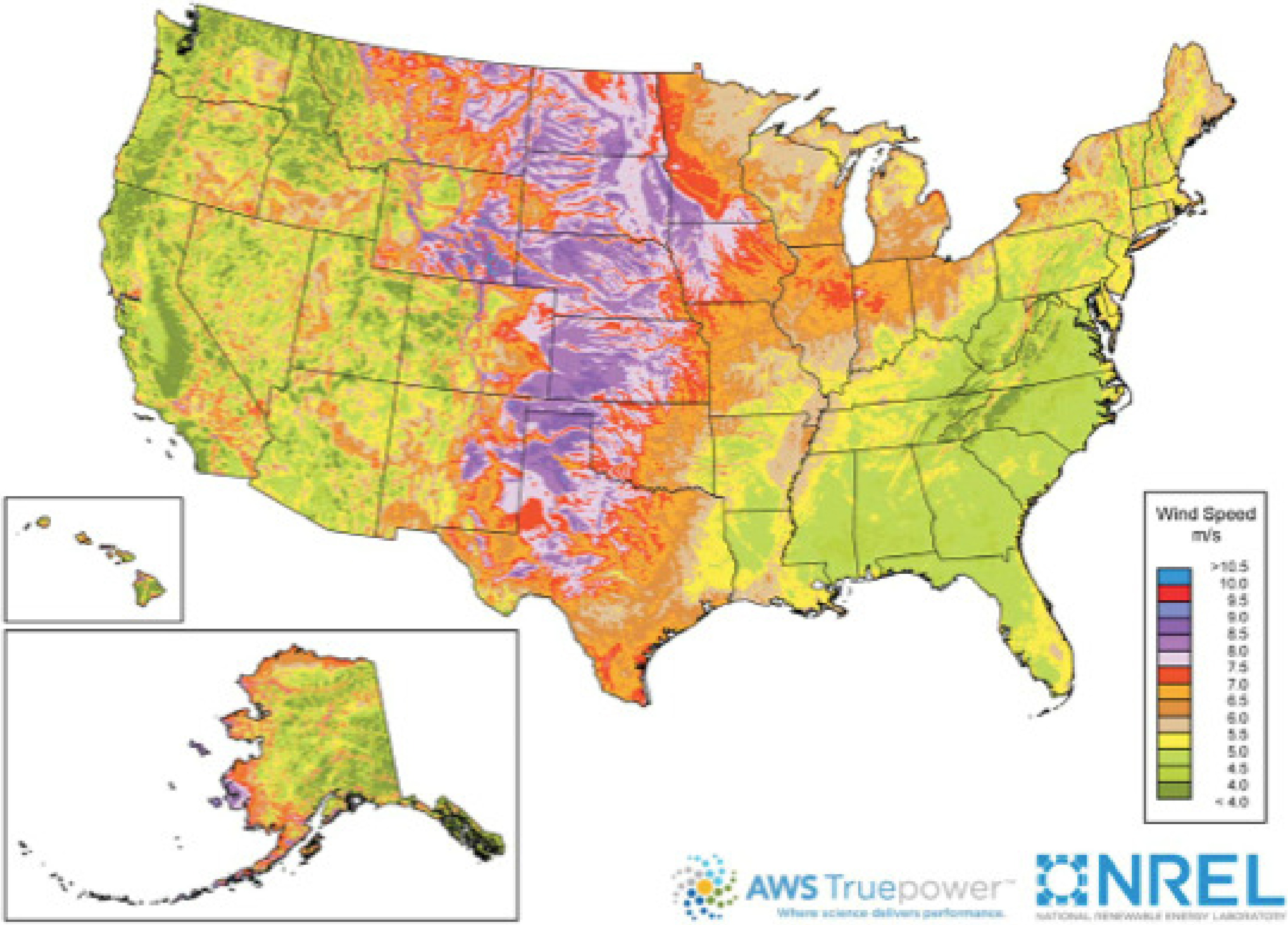


Figure 4.14 State-of-the-art wind turbines with high hub heights and large rotor diameters. *Source:* U.S. Department of Energy, Wind Energy Program. (http://www.eren.doe.gov/wind/large.html)

Figure 4.13 Onshore Wind Resources



Notes: • Data are annual average wind speed at 80 meters. • m/s = meters per second.
Web Page: For related information, see http://www.nrel.gov/gis/maps.html.
Sources: This map was created by the National Renewable Energy Laboratory for the Department of Energy (April 1, 2011). Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. See http://www.windnavigator.com and http://www.awstruepower.com. Spatial resolution of wind resource data: 2.5 kilometers. Projection: Albers Equal Area WGS84.

Wind Power

TABLE 4.2 TEN COUNTRIES WITH LARGEST WIND ENERGY PRODUCTION (2000)

Country	Installed wind capacity (MW)	Wind energy production (million MWh)	Total electricity production (million MWh)	Total provided by wind (percent)
Germany	6,113	11.50	495.2	2.3
United States	2,554	5.10	3,235.9	0.2
Spain	2,250	4.50	189.6	2.4
Denmark	2,140	4.28	32.9	13.0
India	1,167	2.33	424.0	0.6
Netherlands	449	0.90	97.8	0.9
Italy	420	0.84	272.4	0.3
United Kingdom	400	0.80	333.0	0.2
China	265	0.53	1,084.1	<0.1
Sweden	226	0.45	128.8	0.4
Total	**15,984**	**31.2**	**6,294**	**0.5**

Source: American Wind Energy Association, news release (February 9, 2001).

Energy Use

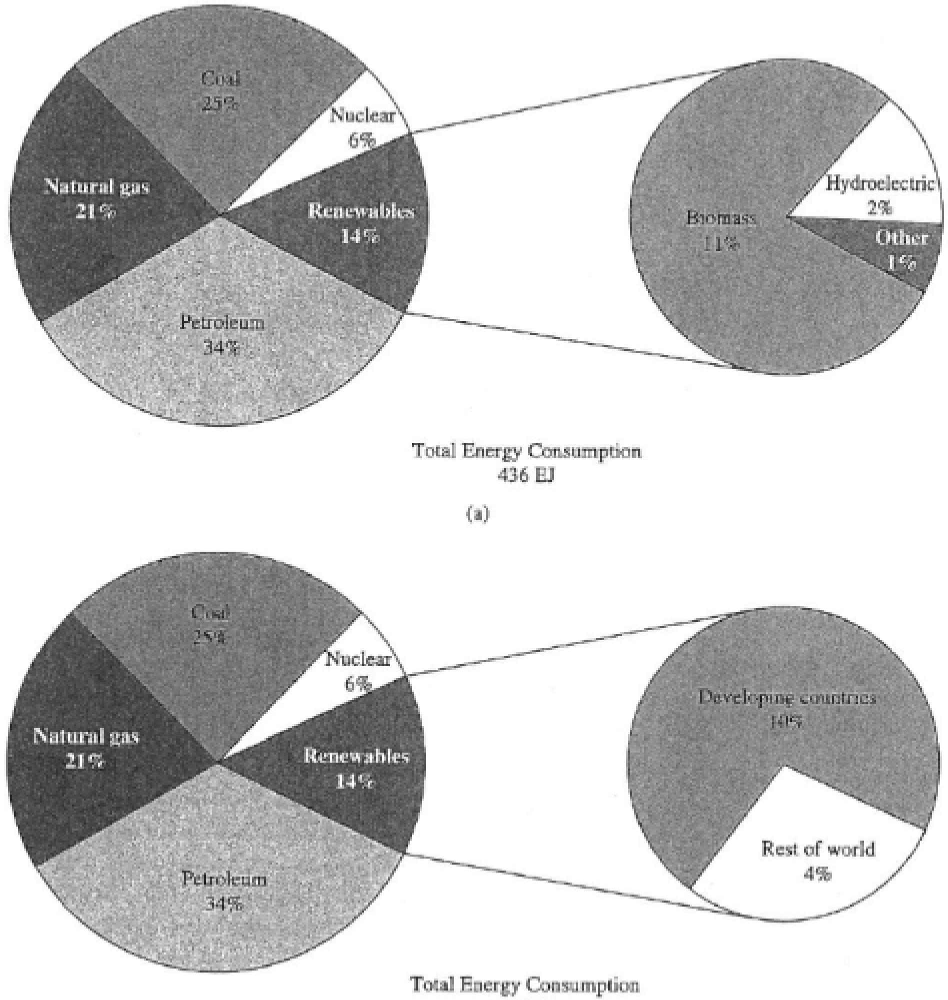


Figure 4.1 a) Distribution of fuels in world primary energy use including share of renewable energy contribution (2000); b) Distribution of renewable fuels in developing countries and rest of world. *Source:* Energy Information Agency, U.S. Department of Energy, *Outlook 1998 with Projections through 2020*, Washington, DC.

Energy Costs

- As demand for renewable energy goes up, the price is expected to decrease
- Solar power is becoming more cost-effective
- Wind & Geothermal are now at lower cost than traditional fossil fuels after initial instillation

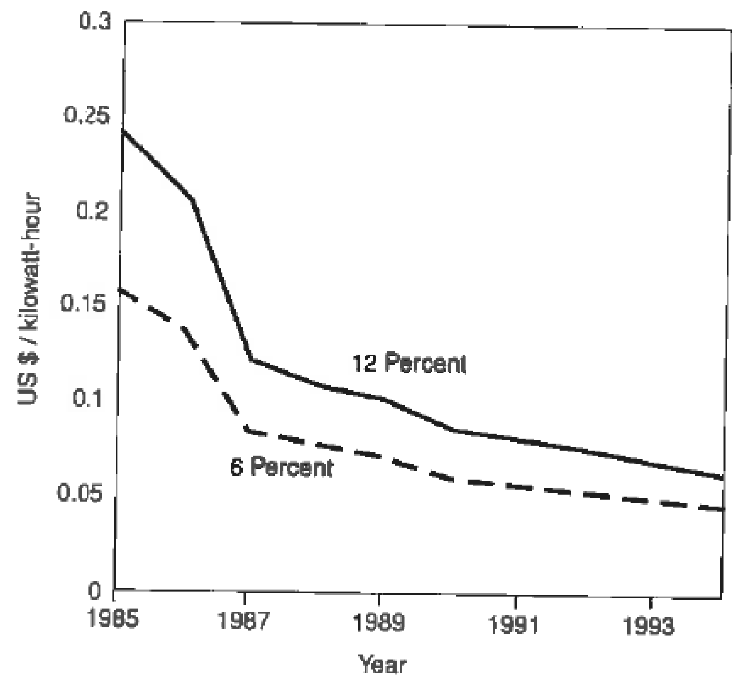
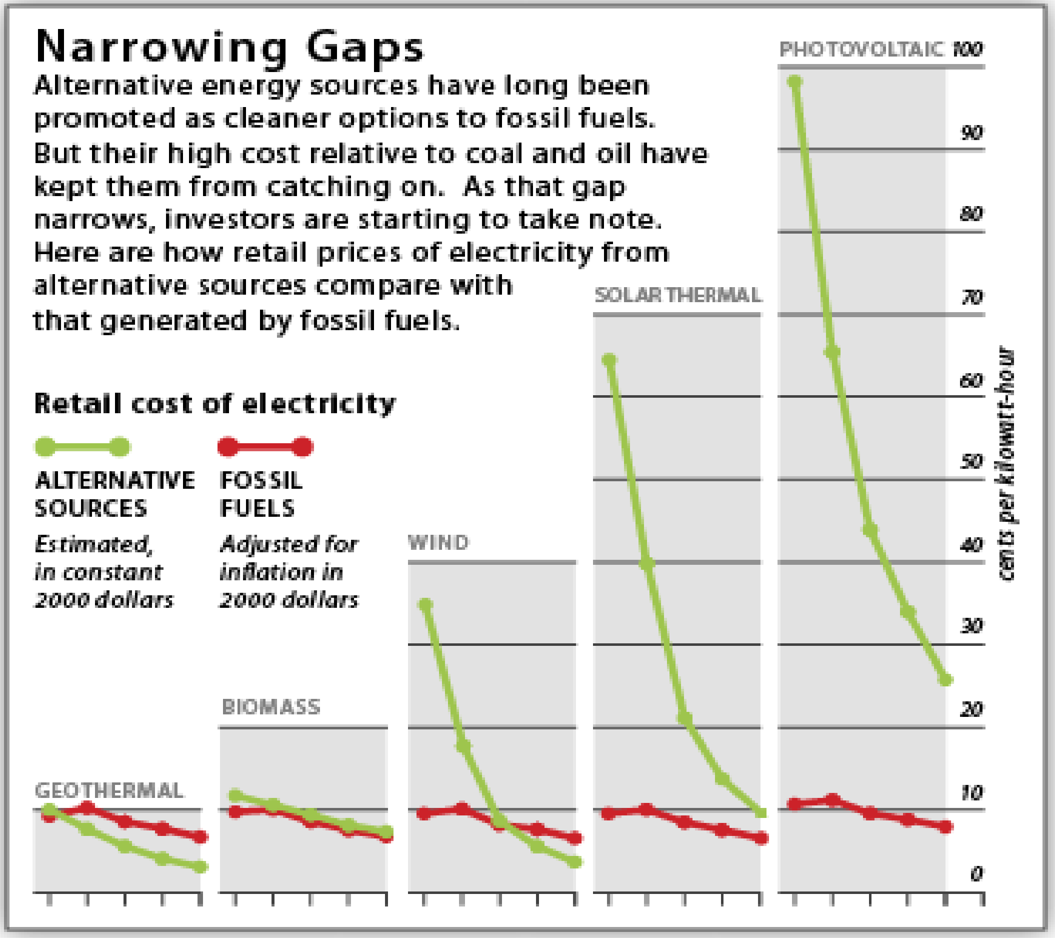


Figure 9.6 Cost of electricity from wind energy at two interest rates, 1985–94. From WRI, 1994, with permission.

Energy Costs



http://www.magma-power.com/pages/magma_power.html

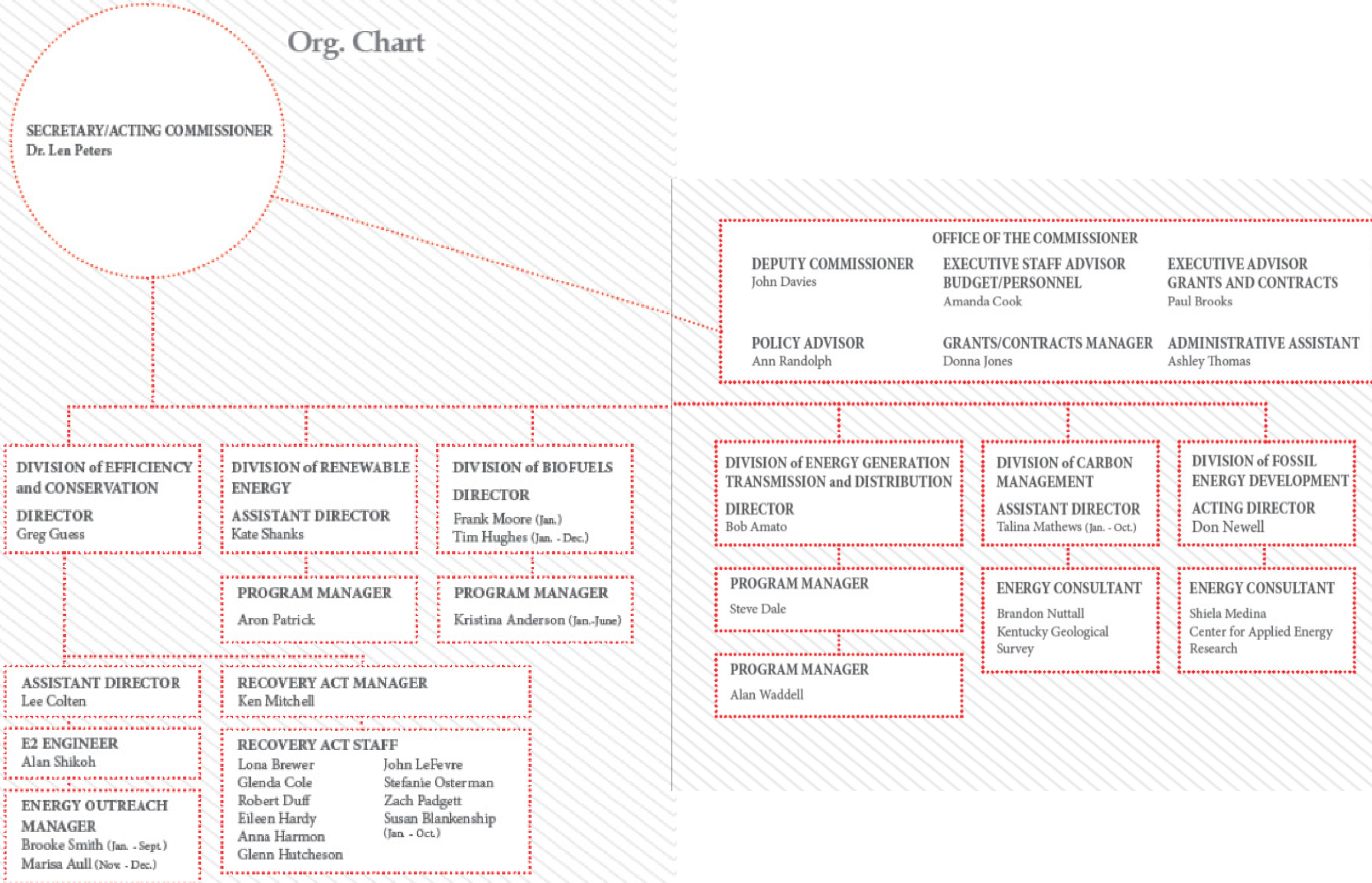
Kentucky Data

2011 Annual Summary

Kentucky Department for Energy Development & Independence

Kentucky Energy & Environment Cabinet

Org. Chart



SECRETARY/ACTING COMMISSIONER
Dr. Len Peters
OFFICE OF THE COMMISSIONER
DEPUTY COMMISSIONER
John Davies
EXECUTIVE STAFF ADVISOR BUDGET/PERSONNEL
Amanda Cook
EXECUTIVE ADVISOR GRANTS AND CONTRACTS
Paul Brooks
POLICY ADVISOR
Ann Randolph
GRANTS/CONTRACTS MANAGER
Donna Jones
ADMINISTRATIVE ASSISTANT
Ashley Thomas
DIVISION of EFFICIENCY and CONSERVATION
DIRECTOR
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DIVISION of RENEWABLE ENERGY
ASSISTANT DIRECTOR
Kate Shanks
DIVISION of BIOFUELS
DIRECTOR
Frank Moore (Jan.)
Tim Hughes (Jan. - Dec.)
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Aron Patrick
PROGRAM MANAGER
Kristina Anderson (Jan.-June)
ASSISTANT DIRECTOR
Lee Colten
E2 ENGINEER
Alan Shikoh
ENERGY OUTREACH MANAGER
Brooke Smith (Jan. - Sept.)
Marisa Aull (Nov. - Dec.)
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Ken Mitchell
RECOVERY ACT STAFF
Lona Brewer
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Robert Duff
Eileen Hardy
Anna Harmon
Glenn Hutcheson
John LeFevre
Stefanie Osterman
Zach Padgett
Susan Blankenship (Jan. - Oct.)
DIVISION of ENERGY GENERATION TRANSMISSION and DISTRIBUTION
DIRECTOR
Bob Amato
PROGRAM MANAGER
Steve Dale
PROGRAM MANAGER
Alan Waddell
DIVISION of CARBON MANAGEMENET
ASSISTANT DIRECTOR
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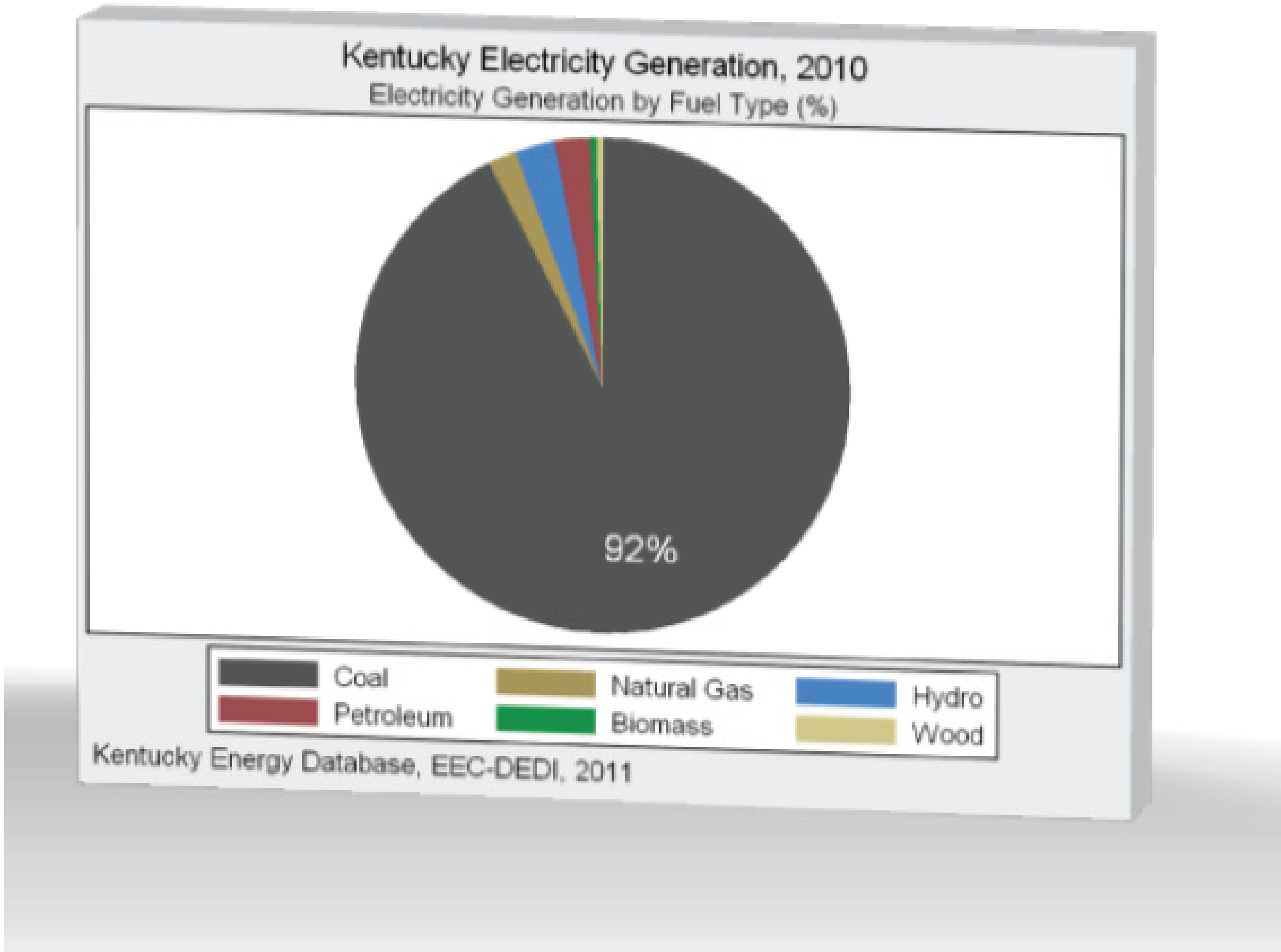
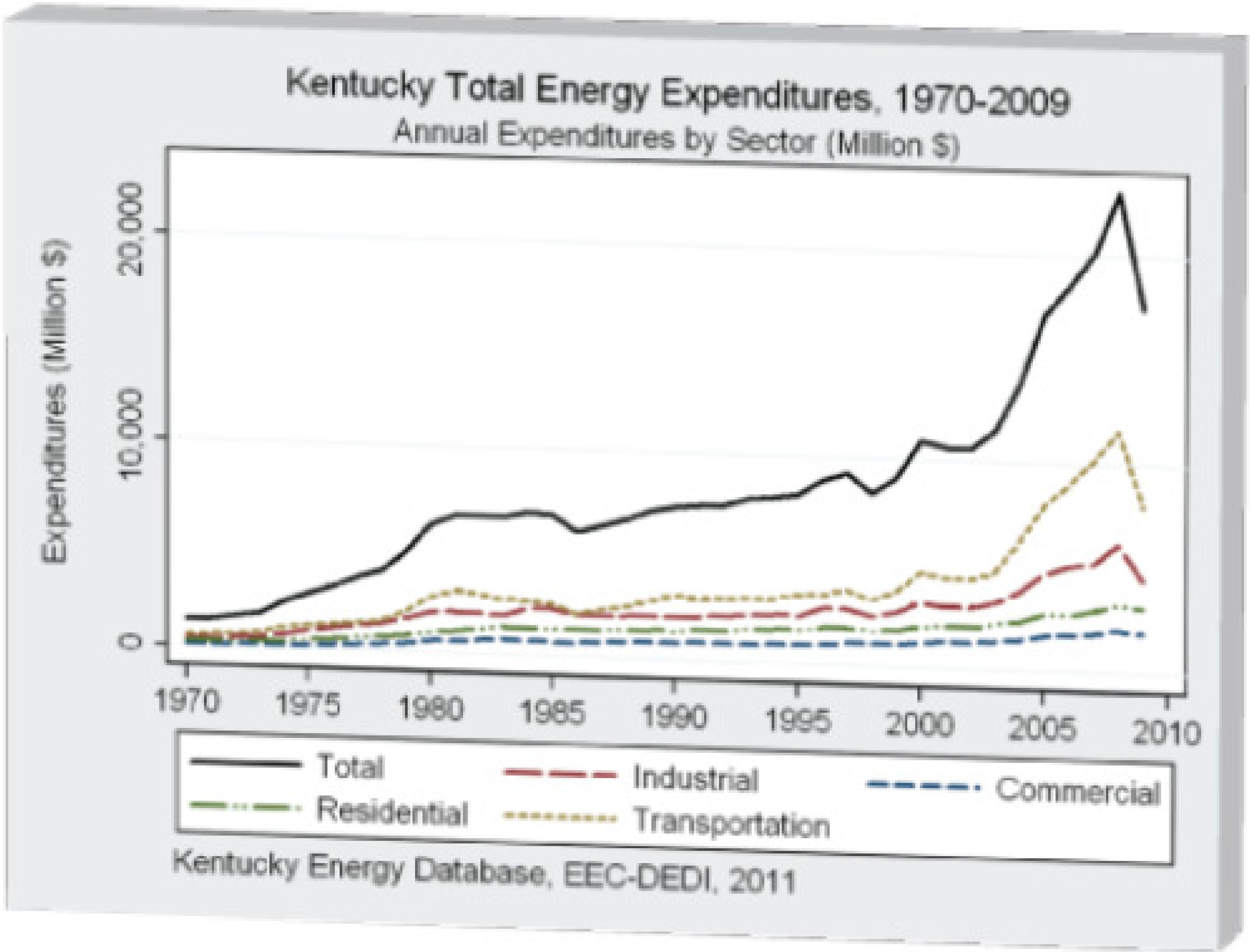
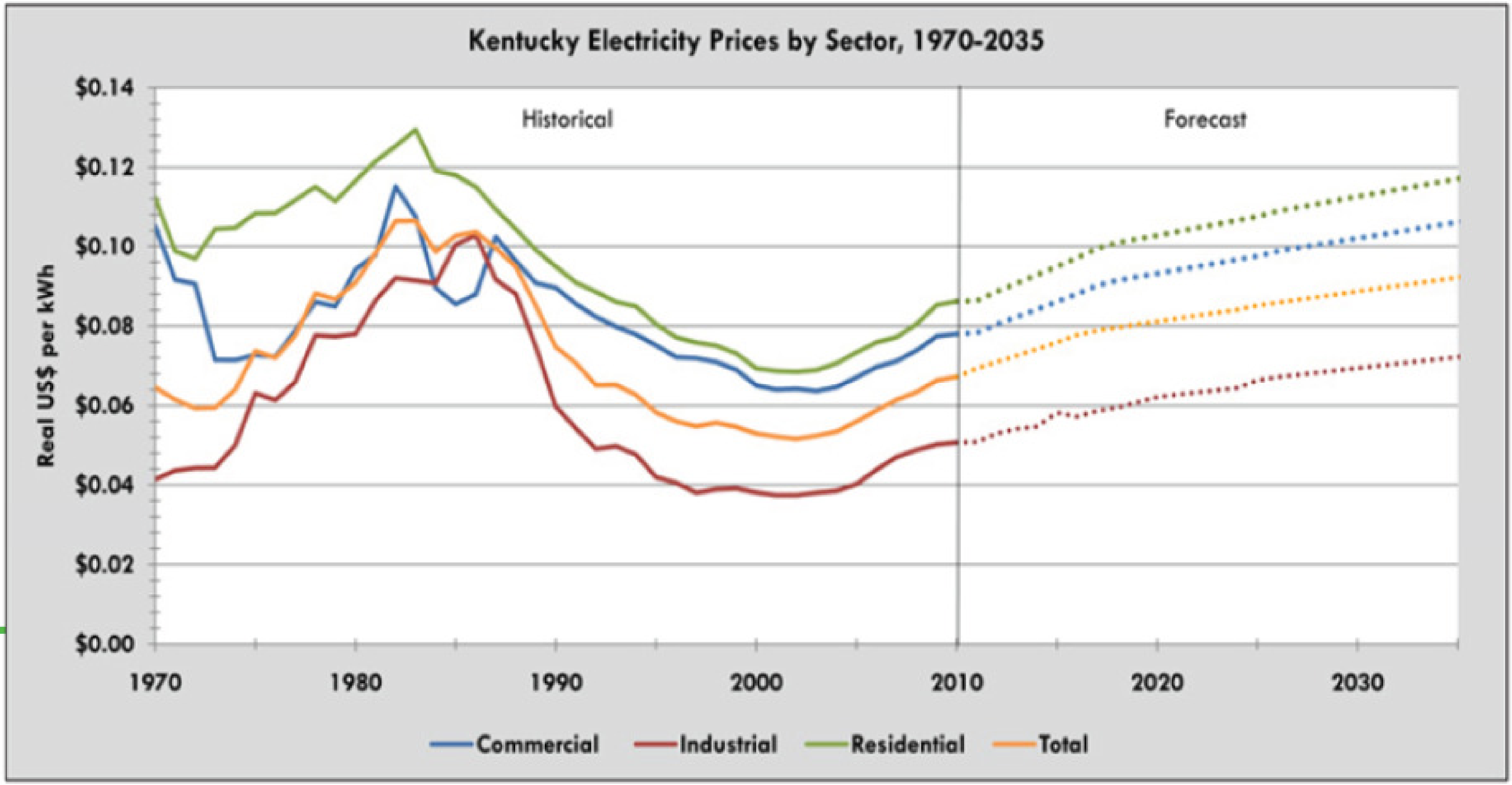
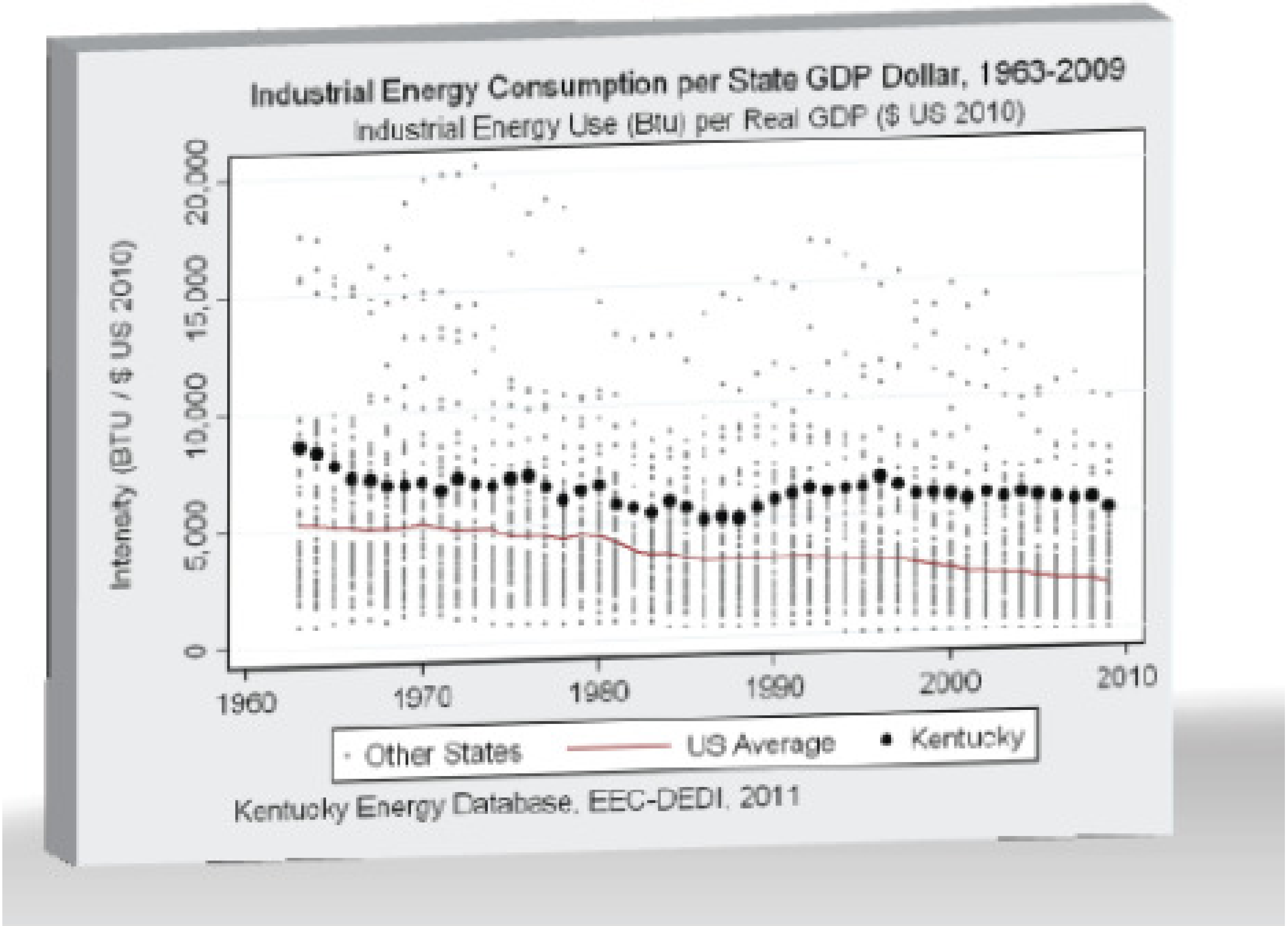
ENERGY CONSULTANT
Brandon Nuttall
Kentucky Geological Survey
DIVISION of FOSSIL ENERGY DEVELOPMENT
ACTING DIRECTOR
Don Newell
ENERGY CONSULTANT
Shiela Medina
Center for Applied Energy Research


Kentucky Electricity Generation, 2010
Electricity Generation by Fuel Type (%)
92%
Coal
Petroleum
Natural Gas
Biomass
Hydro
Wood
Kentucky Energy Database, EEC-DEDI, 2011

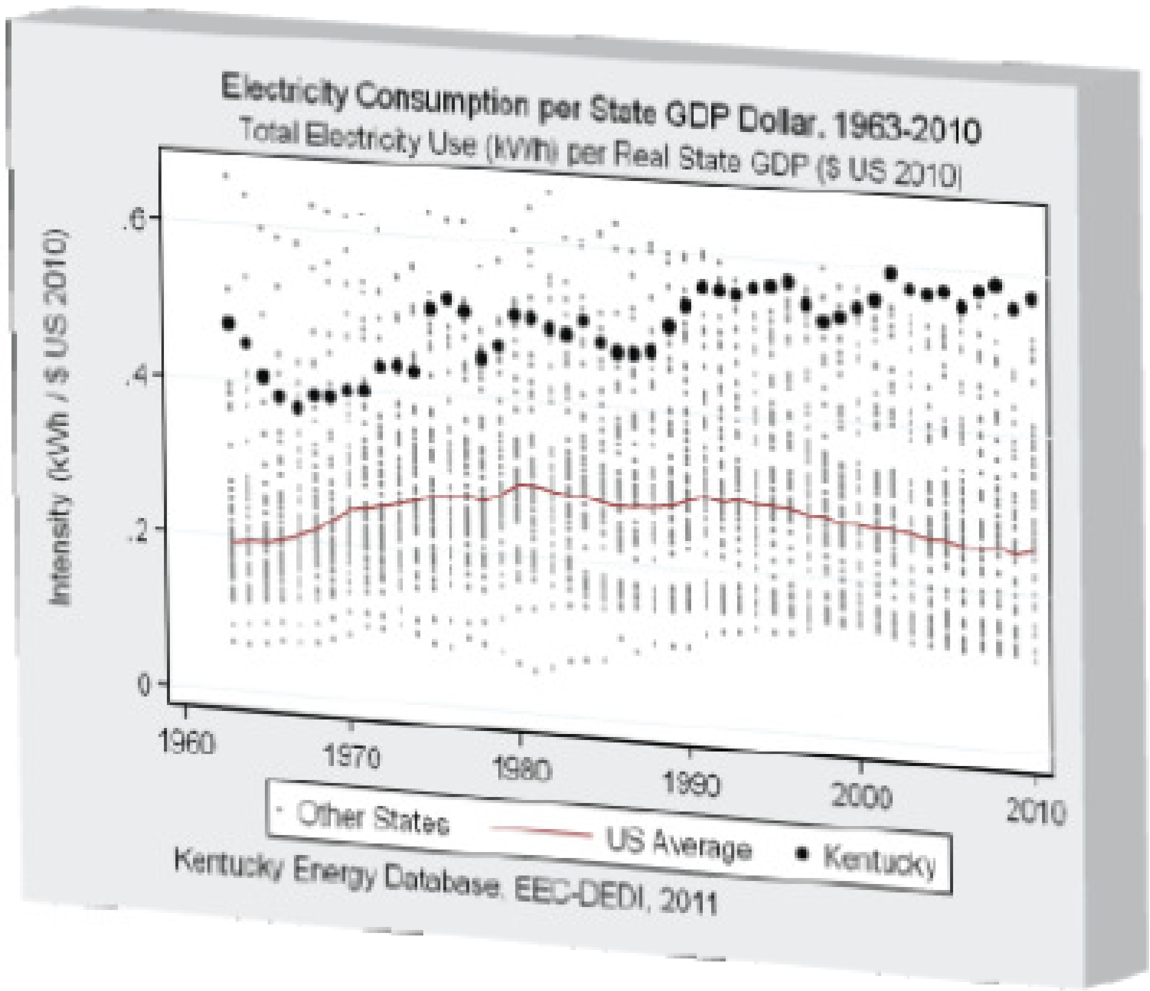

Kentucky Total Energy Expenditures, 1970-2009
Annual Expenditures by Sector (Million $)
Expenditures (Million $)
0
10,000
20,000
1970
1975
1980
1985
1990
1995
2000
2005
2010
Total
Industrial
Commercial
Residential
Transportation
Kentucky Energy Database, EEC-DEDI, 2011

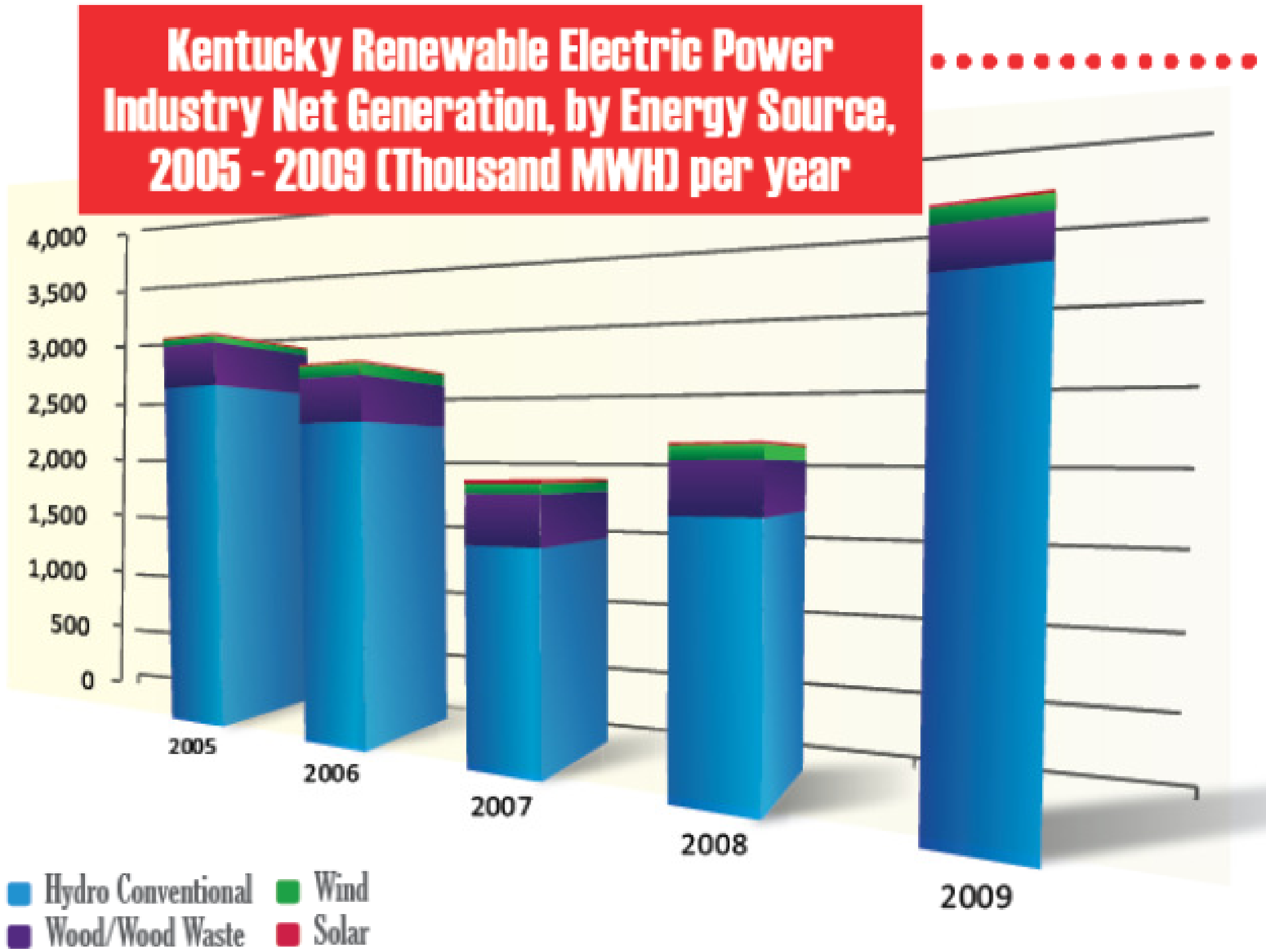


Source: EIA.gov

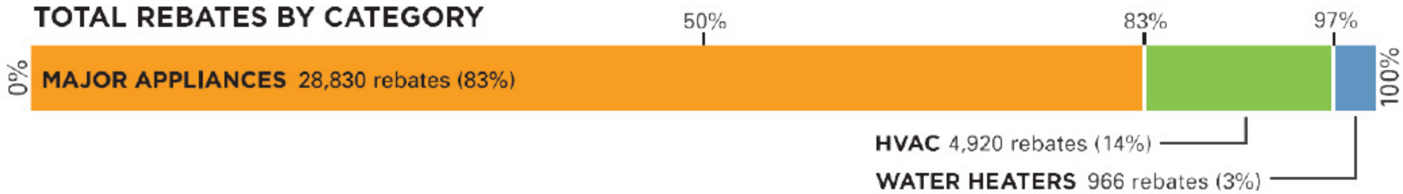


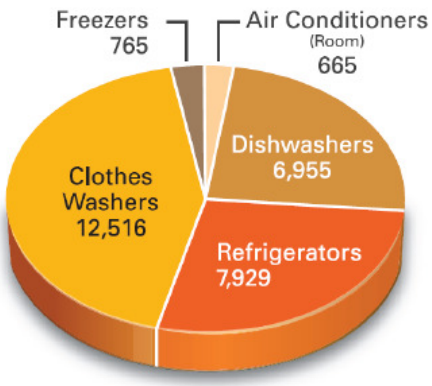
Industrial Energy Consumption per State GDP Dollar, 1963-2009
Industrial Energy Use (Btu) per Real GDP ($ US 2010)
Intensity (BTU / $ US 2010)
0
5,000
10,000
15,000
20,000
1960
1970
1980
1990
2000
2010
Other States
US Average
Kentucky
Kentucky Energy Database, EEC-DEDI, 2011


Electricity Consumption per State GDP Dollar, 1963-2010
Total Electricity Use (kWh) per Real State GDP ($ US 2010)
Intensity (KWh / $ US 2010)
.6
.4
.2
0
1960
1970
1980
1990
2000
2010
Other States
US Average
Kentucky
Kentucky Energy Database, EEC-DEDI, 2011

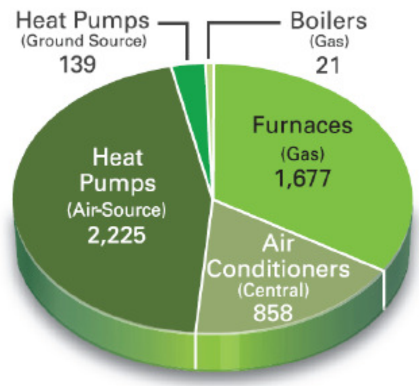


Source: EIA.gov

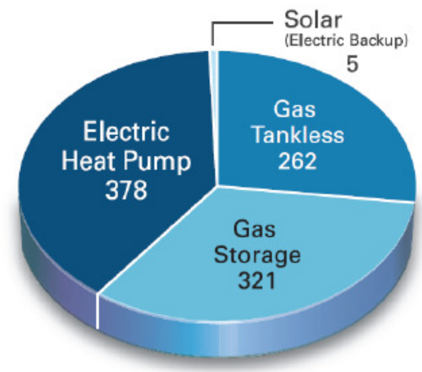




MAJOR APPLIANCES



HVAC



WATER HEATERS

	Major Appliances	HVAC	Water Heaters	All Products
Rebate Payments to Customers (Thousands)	$2,061	$1,539	$248	$3,848
Consumer Spending (Thousands) and Leveraging Ratio	$20,962 (10.2:1)	$28,958 (18.8:1)	$1,189 (4.8:1)	$51,108 (13.3:1)
Sales Tax Leveraged* (Thousands) and Leveraging Ratio	$1,258 (0.6:1)	$1,737 (1.1:1)	$71 (0.3:1)	$3,067 (0.8:1)
Annual Cost Savings* (Thousands)	$967	$433	$119	$1,519
Annual Energy Savings* (Billions of Btu)	14	25	6	45

* Estimated

Note: Due to rounding, the sum of the first three columns may not equal the "All Products" total.

http://kyenergydashboard.ky.gov

- A public website is available where visitors can learn about each of the buildings involved in the pilot and view the energy unit and dollar savings in real time.