U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ENERGY EDUCATION AND WORKFORCE DEVELOPMENT

# Energy Analysis

Grades: 5-8, 9-12

Topic: Energy Basics

Owner: NEED

This educational material is brought to you by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

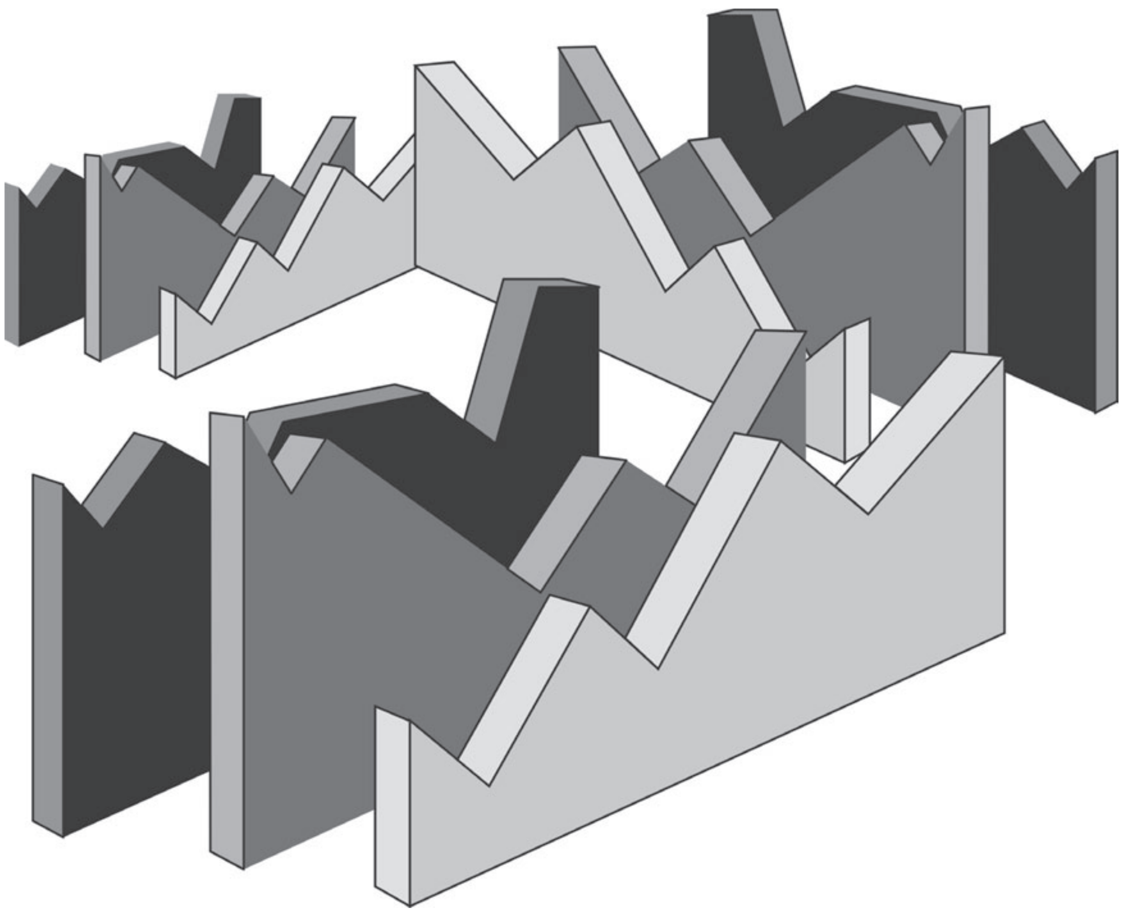
# ENERGY ANALYSIS

Students use graphs of historical data and research historical and societal events to determine and analyze trends in energy.

E

GRADE LEVEL
7–12

SUBJECT AREAS
Science
Social Studies
Math
Technology



NEED
2006-2007
Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

# Teacher Advisory Board



## NEED Mission Statement

*The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.*

## Teacher Advisory Board Vision Statement

*In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.*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*Energy data come from the Energy Information Administration (EIA) at **www.eia.doe.gov**.*
*Transportation and vehicle data come from EIA and the Bureau of Transportation Statistics at **www.bts.gov**.*
*Municipal solid waste data come from the Environmental Protection Agency at **www.epa.gov**.*

NEED
Putting Energy into Education

# Correlations to National Science Standards

## INTERMEDIATE (5-8) STANDARD–B: PHYSICAL SCIENCE

### 3. Transfer of Energy

a. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical.

b. Energy is transferred in many ways.

g. The sun is the major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths.

## INTERMEDIATE–D: EARTH AND SPACE SCIENCE

### 3. Earth in the Solar System

b. The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle.

## INTERMEDIATE–E: SCIENCE AND TECHNOLOGY

### 2. Understandings about Science and Technology

c. Technological solutions are temporary and have side effects. Technologies cost, carry risks, and have benefits.

## SECONDARY (9-12) STANDARD–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

### 3. Natural Resources

a. Human populations use resources in the environment to maintain and improve their existence.

b. The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and depletes those resources that cannot be renewed.

c. Humans use many natural systems as resources. Natural systems have the capacity to reuse waste but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

# Teacher Guide

## GOAL

**TO ENHANCE STUDENTS' CRITICAL THINKING SKILLS BY RESEARCHING AND ANALYZING HISTORICAL DATA AND EVENTS TO DETERMINE AND EXPLAIN ENERGY TRENDS.**

## BACKGROUND

Students practice graphing data, research historical events, and analyze the graphs in this guide and the Energy Information Administration's *Energy Perspectives* booklet to determine and explain energy trends in the United States during the last 50 years.

## TIME

Three to five 45-minute class periods plus outside research and homework.

## MATERIALS

- *Energy Perspectives* booklet (also online at www.eia.doe.gov/emeu/aer/contents.html)
- U.S. history textbook as a resource
- NEED's *Secondary Energy Infobook* (individual factsheets are available online at www.need.org)
- Overhead projector

## PROCEDURE

### Step One—Preparation

- Familiarize yourself with the activity, the **U.S. Energy Flow** diagram on page 14 (explanation on page 15), and with the graphs in this booklet and the *Energy Perspectives* booklet.
- Make copies of the **U.S. Energy Data** sheet and **U.S. Energy Timeline** for each student (pages 16-17).
- Make copies of the graphs you want the students to analyze from this booklet (pages 20-29) and the *Energy Perspectives* booklet. *(You can have all of the students use the same graphs and conduct classroom discussions or assign groups of students to different sets of graphs and have them make presentations to the class.)*
- Make copies of the pages you have chosen from NEED's *Secondary Energy Infobook* or obtain a class set of infobooks for the students to use by calling NEED at 1-800-875-5029. Individual factsheets are also available online at ***www.need.org/guides.htm***.
- Make transparencies of the **Energy Flow 2004** progressive diagram on pages 7-14 and the sample graphs on pages 18-19.

### Step Two—Introduction: Energy Yesterday, Today and Tomorrow

- Introduce the activity by discussing with the students how energy has been used throughout the history of the United States, the changing energy sources that have been used, the energy sources we use today and the purposes for which they are used, the major historical events that have had an effect on energy, and how the future energy picture might change.
- Use the **Energy Flow** transparencies and explanation to give an overview of energy consumption and production.

- Distribute the **U.S. Energy Timeline** and **U.S. Energy Data** sheets to the students.
- Discuss how the students can graphically compare aspects of the data to determine energy trends.
- Discuss the historical events listed that have significantly affected the energy trends in the U.S.

## Step Three—Graphing Data

- Have the students create graphs in class and as homework to answer the following questions:

  *How has per capita consumption of energy changed in the last 50 years?*

  *How has the percentage of energy we import from other countries changed in the last 50 years?*

  *How has the mix of energy sources changed in the last 50 years in production and consumption considering fossil fuels, uranium (nuclear) energy and renewable energy sources?*

- Check the students' graphs for accuracy and understanding. Use transparencies of the sample graphs and discuss the answers to the questions.

## Step Four—Analyzing Data and Determining Energy Trends (pages 20-29)

- Explain the assignment—the students will analyze the information in the graphs, determine the trends that are implied by the information, and research historical events that may have affected or may affect those trends.

### *Option One: All Students Analyzing the Same Graphs*

- If all of the students are assigned the same graphs, distribute the background information and sets of graphs you have chosen and have each student write an explanation of the graphs, the trends and the significant historical events. Allow them to begin the assignment in class and give them several days to complete the assignment as homework.
- Discuss the assignment upon completion to develop a consensus within the group.

### *Option Two: Groups of Students Analyzing Different Sets of Graphs*

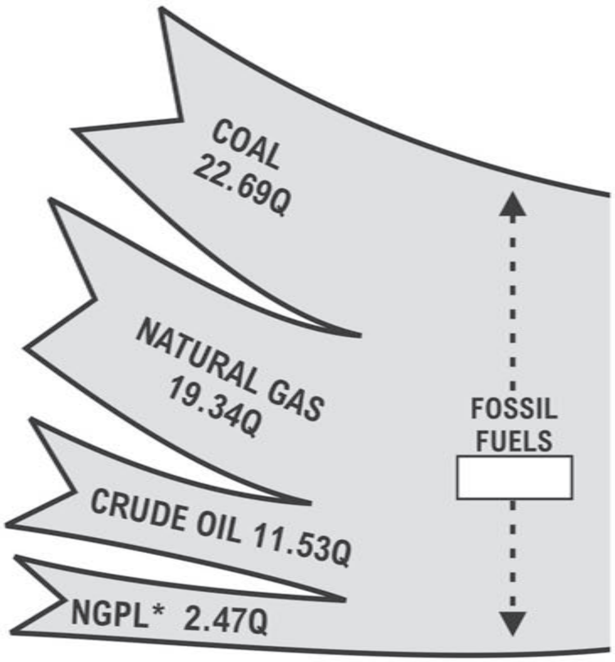
- If the students are working in groups to analyze different sets of graphs, divide the students into groups and distribute the background information and sets of graphs you have chosen for them to analyze. Explain that each group will prepare a five-minute presentation for the class to explain the graphs, the trends and the significant historical events. Allow the groups to begin the assignment in class and give them several days to complete the assignment, either as homework or as class work.
- Monitor group work.
- Have each group make its presentation.
- Discuss the assignment upon completion to develop an overall sense of what will happen in the energy sector in the near future and possible events that could have an effect that direction.

### *Technology Connection*

- Have the students conduct web-based research and prepare Power Point presentations on one aspect of energy and how its use has changed in the last fifty years.

## Step Five—Evaluation

- Evaluate individual and group work according to your own expectations.
- Evaluate the activity with the students using the Evaluation Form on page 31 and send to NEED.

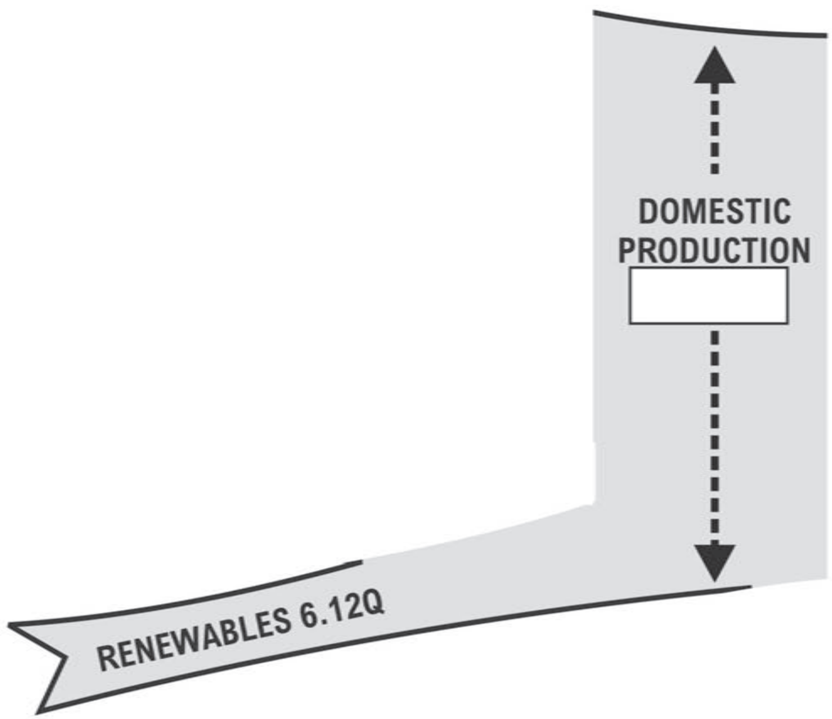


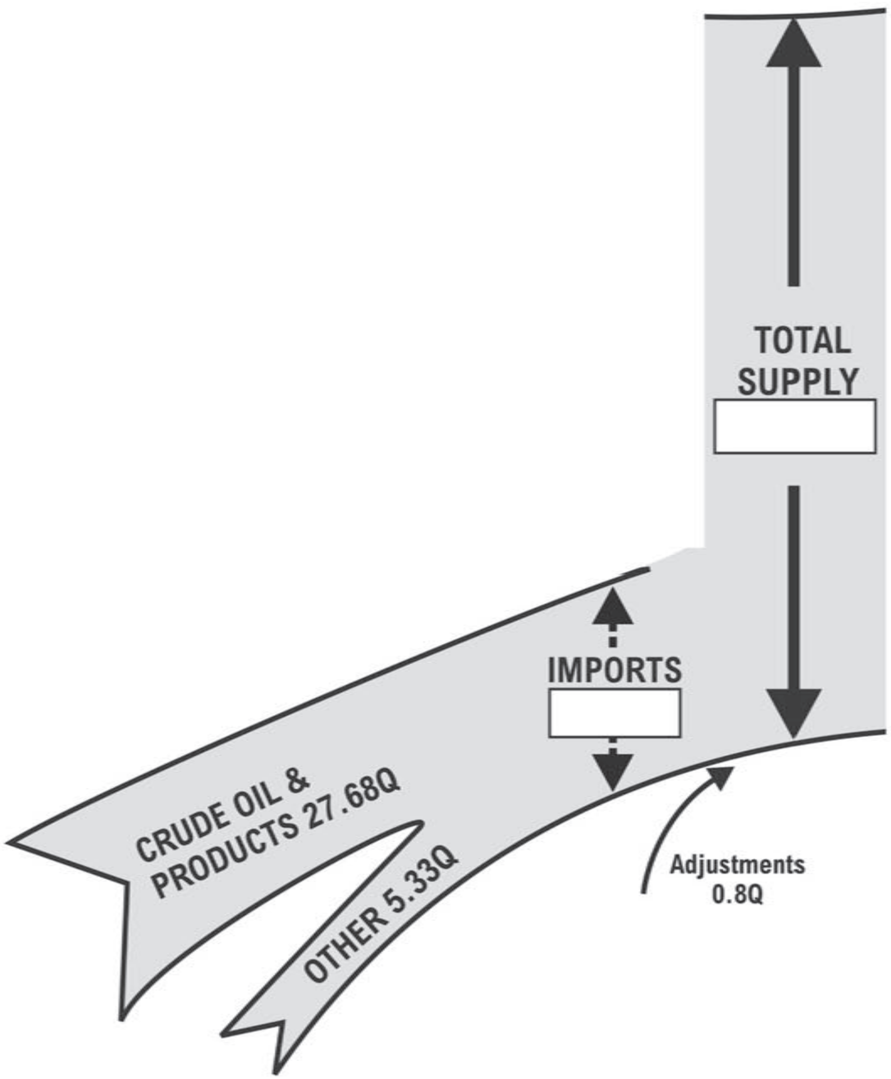

*Natural Gas Plant Liquids include petroleum & propane.

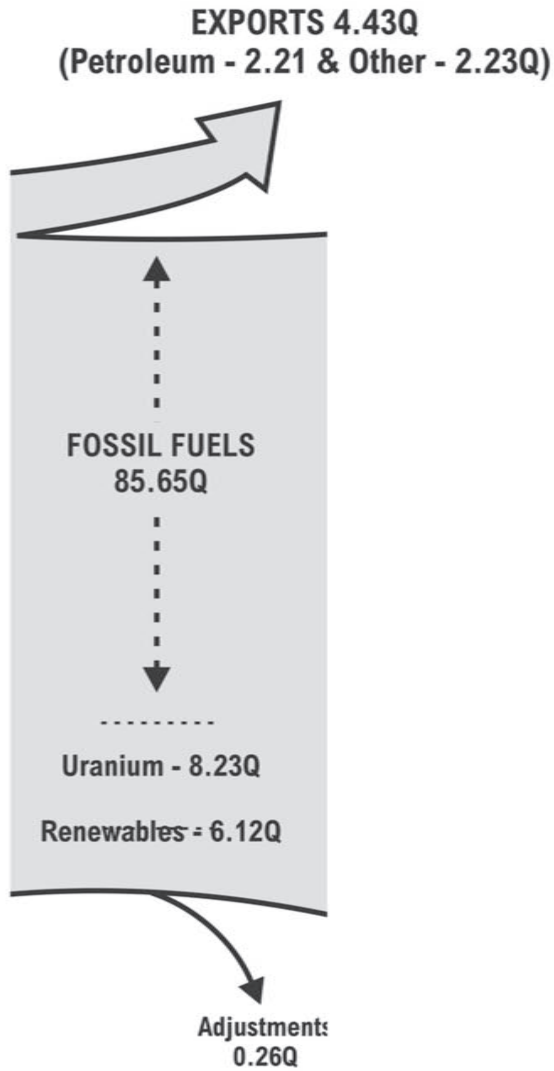
# U.S. ENERGY FLOW 2004

**PRODUCTION → CONSUMPTION**

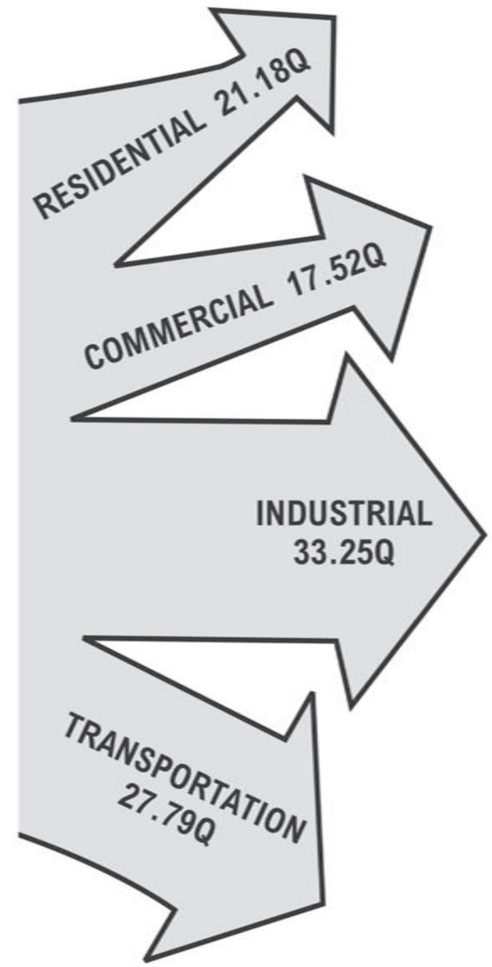

URANIUM 8.23Q

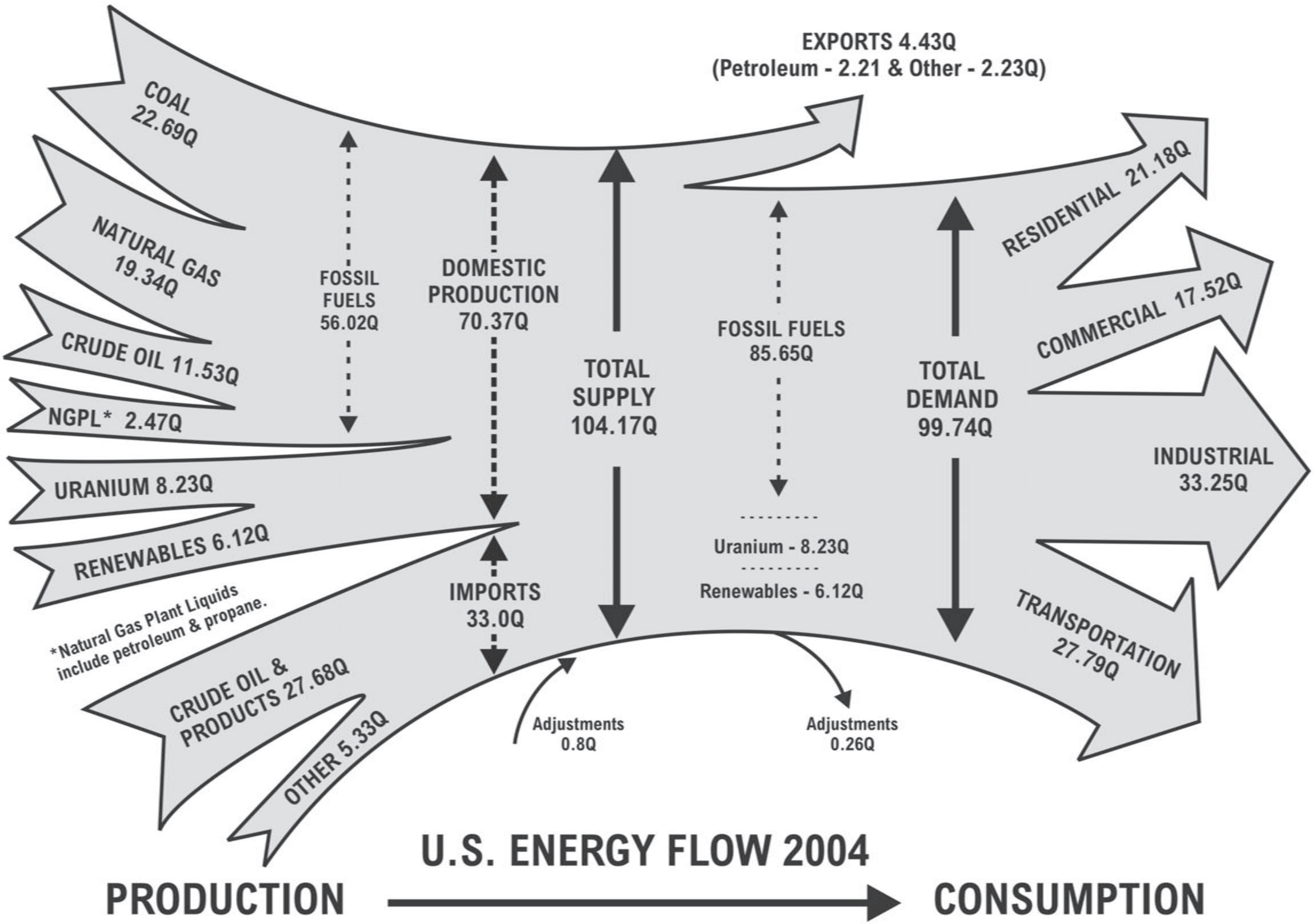

DOMESTIC
PRODUCTION
RENEWABLES 6.12Q


TOTAL
SUPPLY
IMPORTS
CRUDE OIL &
PRODUCTS 27.68Q
OTHER 5.33Q
Adjustments
0.8Q


EXPORTS 4.43Q
(Petroleum - 2.21 & Other - 2.23Q)
FOSSIL FUELS
85.65Q
Uranium - 8.23Q
Renewables - 6.12Q
Adjustments
0.26Q


TOTAL
DEMAND


RESIDENTIAL 21.18Q
COMMERCIAL 17.52Q
INDUSTRIAL
33.25Q
TRANSPORTATION
27.79Q




## U.S. ENERGY FLOW 2004

# ENERGY MEASUREMENTS

| | | |
|---|---|---|
| **1 cal** | **=** | **Calorie—a measure of heat energy—the amount of heat energy needed to raise the temperature of one gram of water by one degree Celsius.** |
| **1 cal** | **=** | **4.187 joules** |
| **1 Btu** | **=** | **British thermal unit—a measure of heat energy—–the amount of heat energy needed to raise the temperature of one pound of water by one degree Fahrenheit. One Btu is approximately the amount of energy released by the burning of one wooden kitchen match.** |
| **1 Btu** | **=** | **1,054 joules** |
| **1 Btu** | **=** | **252 calories** |
| **1 Q** | **=** | **Quad—1 quadrillion Btu. Quads are used to measure very large quantities of energy. The U.S. uses one quad of energy about every 3.7 days.** |
| **1 therm** | **=** | **100,000 Btu; approximately the amount of heat energy in one CCF of natural gas.** |
| **1 kWh** | **=** | **Kilowatt-hour—one kilowatt of electricity over one hour. One kilowatt-hour of electricity is the amount of energy it takes to burn a 100 watt light bulb for 10 hours. The average cost of one kilowatt-hour of electricity for residential customers in the U.S. is about nine cents.** |
| **1 kWh** | **=** | **3.6 million joules (3.6 Mj).** |
| **1 kWh** | **=** | **3,412 Btu** |
| **1 CF** | **=** | **Cubic foot—a measure of volume—one CF of natural gas contains about 1,020 Btu.** |
| **1 CCF** | **=** | **One hundred cubic feet—one CCF of natural gas contains about one therm of heat energy.** |
| **1 MCF** | **=** | **One thousand cubic feet—one MCF of natural gas costs $5–$10.** |

# ENERGY FLOW DIAGRAM EXPLANATION

**The left side of the diagram shows energy production (supply) figures for 2004 in the U.S. by source and imports:**

The top four on the list—coal, natural gas, crude oil, and NGPL—are fossil fuels that provided 56.02 quads of energy.

Uranium (nuclear) produced 8.23 quads of energy.

Renewables (solar, wind, hydropower, geothermal, and biomass) produced 6.1 quads of energy.

The bottom two show imports—mostly crude oil and petroleum products that produced 27.68 quads of energy, while all other imported energy produced 5.33 quads of energy.

The adjustment figure is a 'balancing' figure so that both sides of the graph are equal and includes uncounted inputs.

The diagram shows that most of 2004 U.S. energy supply came from fossil fuels and that the U.S. imported 31.68% of its total energy supply.

**The right side of the diagram shows energy consumption figures by energy source and sector of the economy:**

The U.S. exported 4.43 quads of energy in 2004.

The residential sector (homes) consumed 21.18 quads of energy or 21.24% of total energy consumption.

The commercial sector (businesses) consumed 17.52 quads of energy or 17.57% of total energy consumption.

The industrial sector (manufacturing) consumed 33.25 quads of energy or 33.34% of total energy consumption.

The transportation sector (vehicles) consumed 27.79 quads of energy or 27.86% of total energy consumption.

# U.S. ENERGY DATA

## BASIC ENERGY INFORMATION

| DATE | POPULATION | PRODUCTION *(in quads)* | CONSUMPTION *(in quads)* |
|---|---|---|---|
| 1950 | 151,326,000 | 35.6 | 34.6 |
| 1960 | 179,323,000 | 42.8 | 45.1 |
| 1970 | 203,302,000 | 63.5 | 67.8 |
| 1980 | 226,542,000 | 67.2 | 78.3 |
| 1990 | 248,422,000 | 70.7 | 84.6 |
| 2000 | 281,422,000 | 71.2 | 98.9 |

## ENERGY PRODUCTION BY SOURCE (in quads)

| DATE | COAL | NATURAL GAS | PROPANE | PETROLEUM | URANIUM (NUCLEAR) | RENEWABLES |
|---|---|---|---|---|---|---|
| 1950 | 14.1 | 6.2 | 0.4 | 11.9 | 0 | 3.0 |
| 1960 | 10.8 | 12.7 | 0.8 | 15.6 | 0 | 2.9 |
| 1970 | 14.6 | 21.7 | 1.2 | 21.7 | 0.2 | 4.1 |
| 1980 | 18.6 | 19.9 | 1.4 | 19.1 | 2.7 | 5.5 |
| 1990 | 22.5 | 18.3 | 1.2 | 16.5 | 6.1 | 6.1 |
| 2000 | 22.6 | 19.7 | 1.9 | 12.9 | 7.9 | 6.2 |

## ENERGY CONSUMPTION BY SOURCE (in quads)

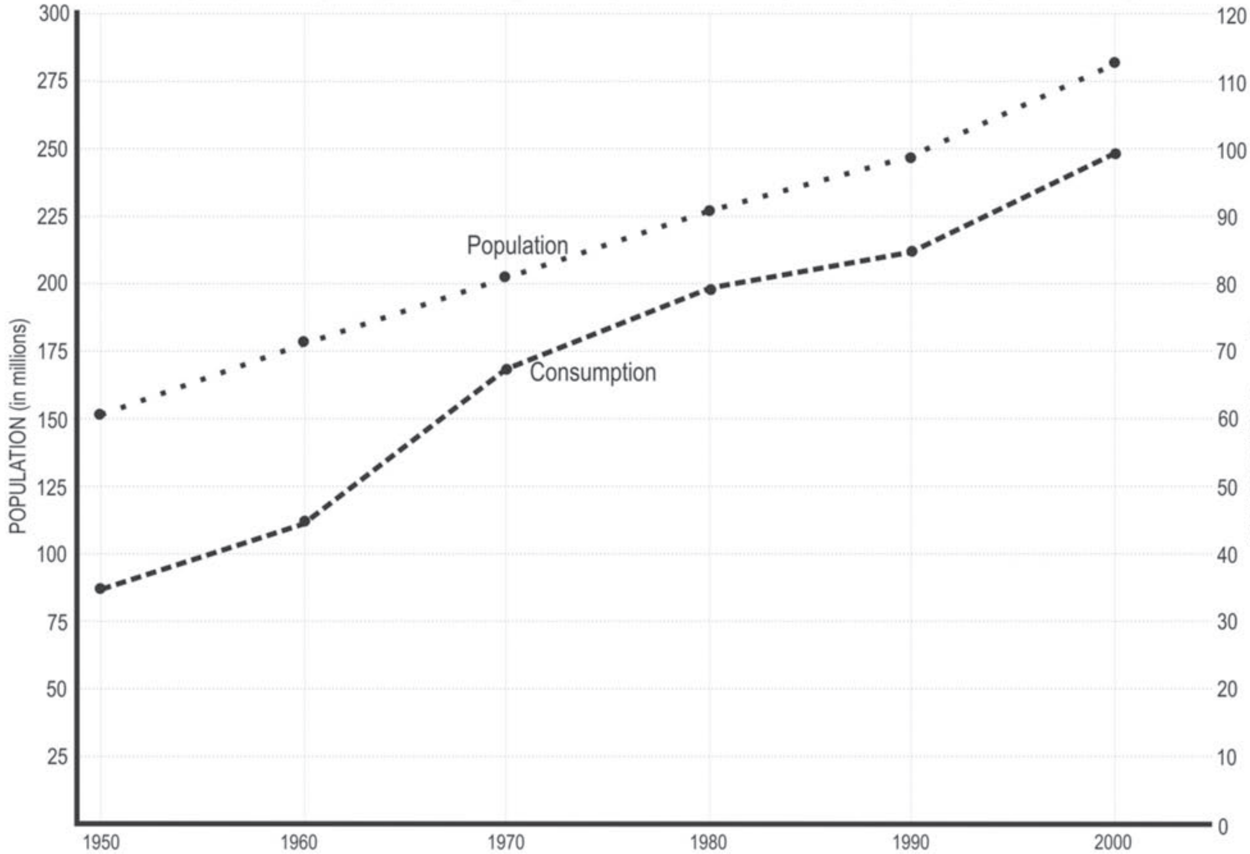
| DATE | COAL | NATURAL GAS | PROPANE | PETROLEUM | URANIUM (NUCLEAR) | RENEWABLES |
|---|---|---|---|---|---|---|
| 1950 | 12.3 | 6.0 | 0.3 | 13.0 | 0 | 3.0 |
| 1960 | 9.8 | 12.4 | 0.7 | 19.3 | 0 | 2.9 |
| 1970 | 12.3 | 21.8 | 1.1 | 28.3 | 0.2 | 4.1 |
| 1980 | 15.4 | 20.4 | 1.3 | 33.0 | 2.7 | 5.5 |
| 1990 | 19.2 | 19.7 | 1.1 | 32.4 | 6.1 | 6.1 |
| 2000 | 22.6 | 24.0 | 1.8 | 36.4 | 7.9 | 6.2 |

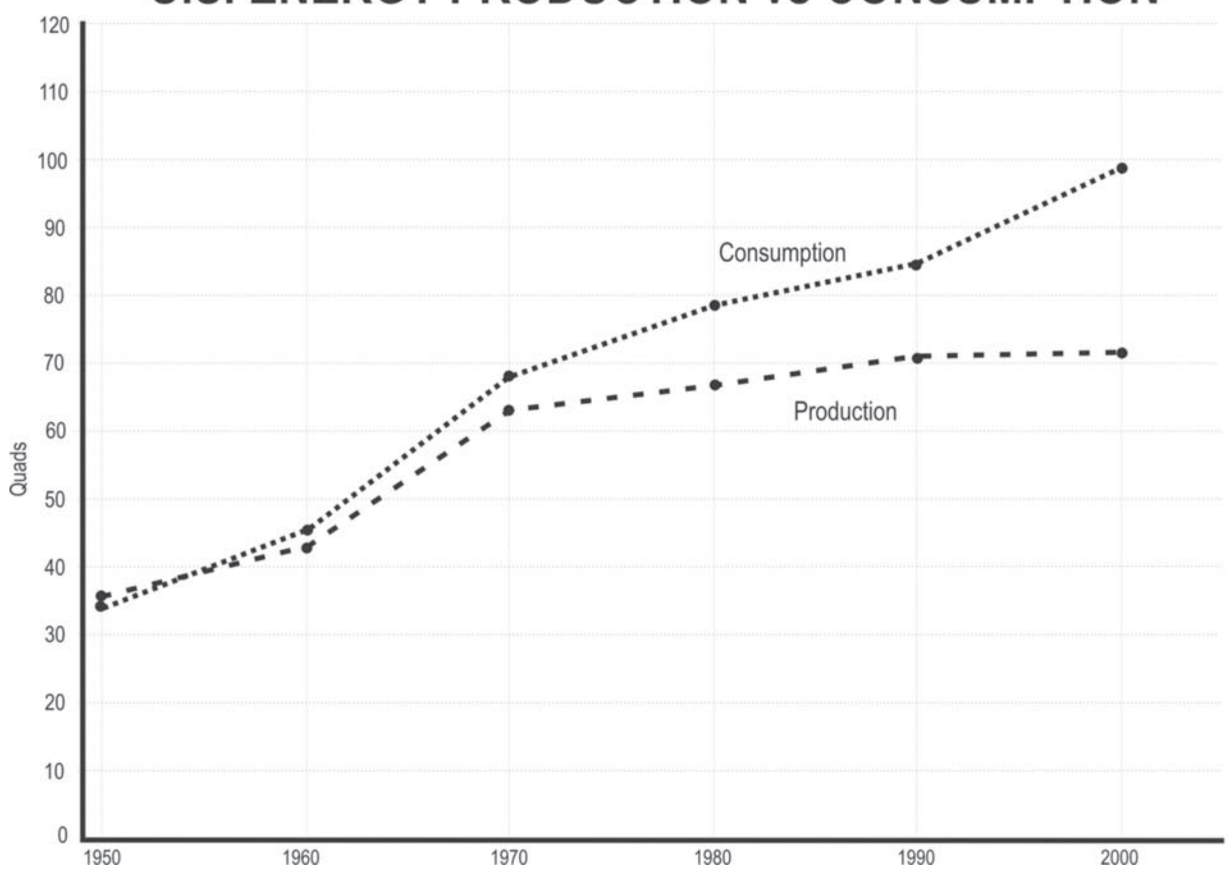
# U.S. ENERGY TIMELINE

| | |
|---|---|
| 1953 | First atomic reactor to produce power began operation in Idaho |
| 1954 | Demonstration of a solar cell by Bell Laboratory |
| 1954 | Atomic Energy Act enacted |
| 1956 | First coal pipeline constructed to move mixture of coal and water |
| 1957 | First nuclear power plant began operation in California |
| 1959 | First fuel cell designed to produce electricity from hydrogen and oxygen |
| 1960 | First commercial nuclear power plant opened in Massachusetts |
| 1960 | OPEC - Organization of Petroleum Exporting Countries - established to control oil production |
| 1960 | First geothermal power plant began operation in California |
| 1965 | Fuel cells were used in the space program |
| 1965 | Recycling program started for aluminum cans |
| 1967 | Short-lived Arab oil embargo to protest Six Day War |
| 1968 | Wild and Scenic Rivers Act enacted |
| 1969 | Oil discovered on Alaska's North Slope |
| 1970 | Environmental Protection Agency created |
| 1970 | First waste-to-energy plant began operation |
| 1973 | Arab oil embargo to protest Arab/Israeli War |
| 1973 | Gasoline rationing began |
| 1973 | Plastic bottles began to replace glass; plastic recycling began |
| 1974 | 55 mile per hour speed limits imposed |
| 1974 | Arab oil embargo lifted |
| 1976 | Electric Vehicle Act enacted |
| 1977 | Trans-Alaska oil pipeline opened |
| 1977 | Strategic Petroleum Reserve began |
| 1977 | Department of Energy created |
| 1978 | National Energy Act and PURPA (Public Utility Regulatory Policies Act) enacted |
| 1978 | Iranian Revolution shut down oil exports |
| 1979 | Nuclear accident occurred at Three Mile Island Nuclear Power Plant in Pennsylvania |
| 1979 | OPEC raised crude oil prices |
| 1979 | President Carter announced effort to reduce dependence on foreign oil |
| 1980 | First PV power plant opened in Utah |
| 1981 | Price controls ended on crude oil and petroleum products |
| 1982 | First solar-thermal power plant opened in California |
| 1983 | OPEC lowered price of crude oil for first time |
| 1988 | Vertical-blade turbine began producing electricity in Hawaii |
| 1989 | Exxon Valdez oil tanker spilled 240,000 barrels of crude oil in Alaska's Prince William Sound |
| 1989 | Shippingport Atomic Power Station decommissioned |
| 1989 | High efficiency PV cells developed |
| 1990 | Iraq invaded Kuwait causing crude oil price increase |
| 1998 | Electric utility deregulation began |
| 2003 | Invasion of Iraq disrupted crude oil supplies |
| 2003 | Major electricity blackout occurred in the Northeast |
| 2005 | Oil prices reach new high |

# U.S. POPULATION vs ENERGY CONSUMPTION

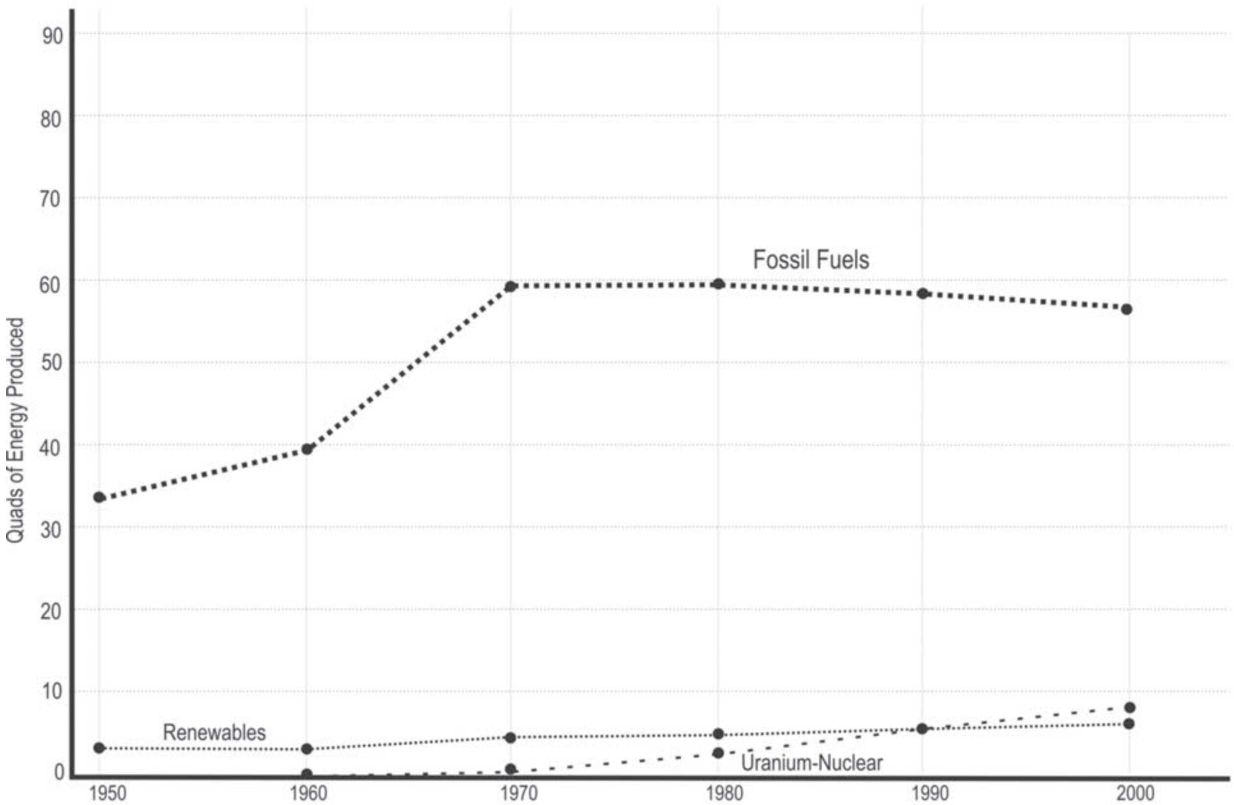



# U.S. ENERGY PRODUCTION vs CONSUMPTION

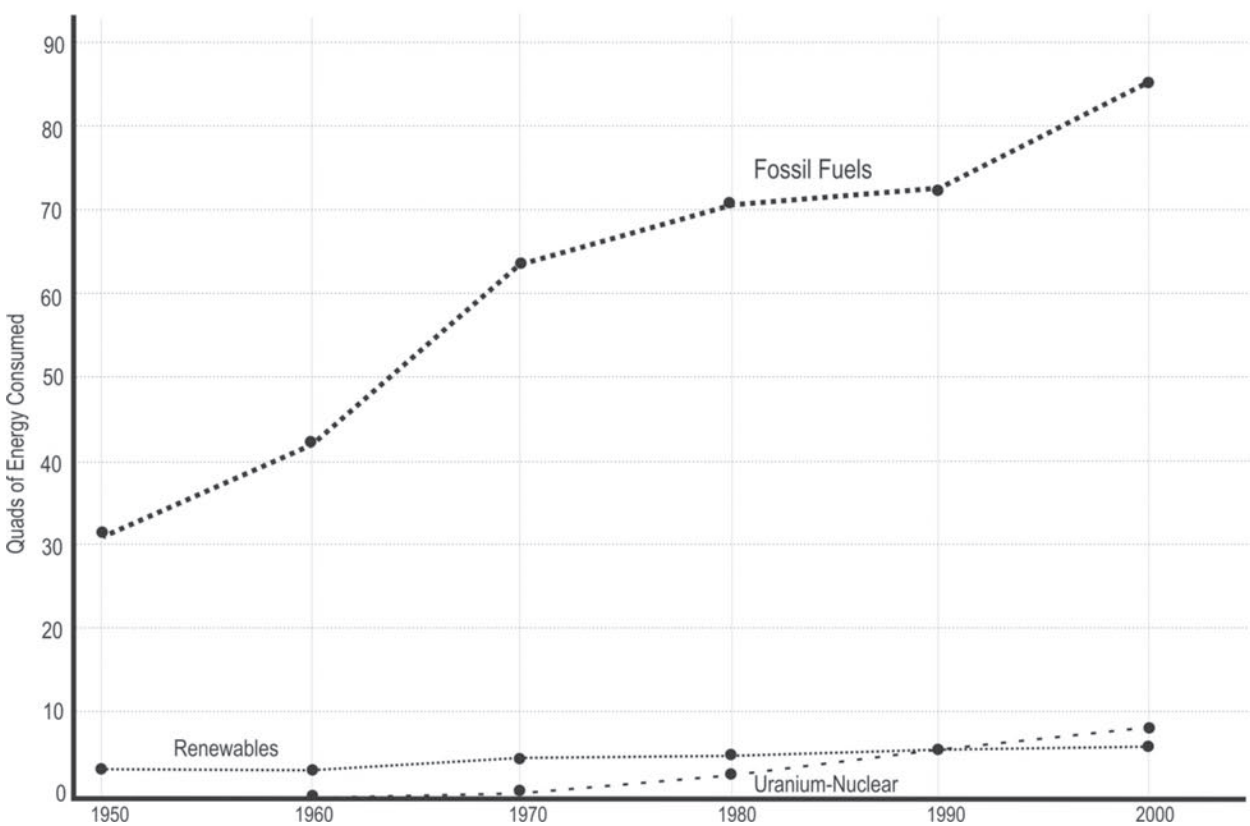


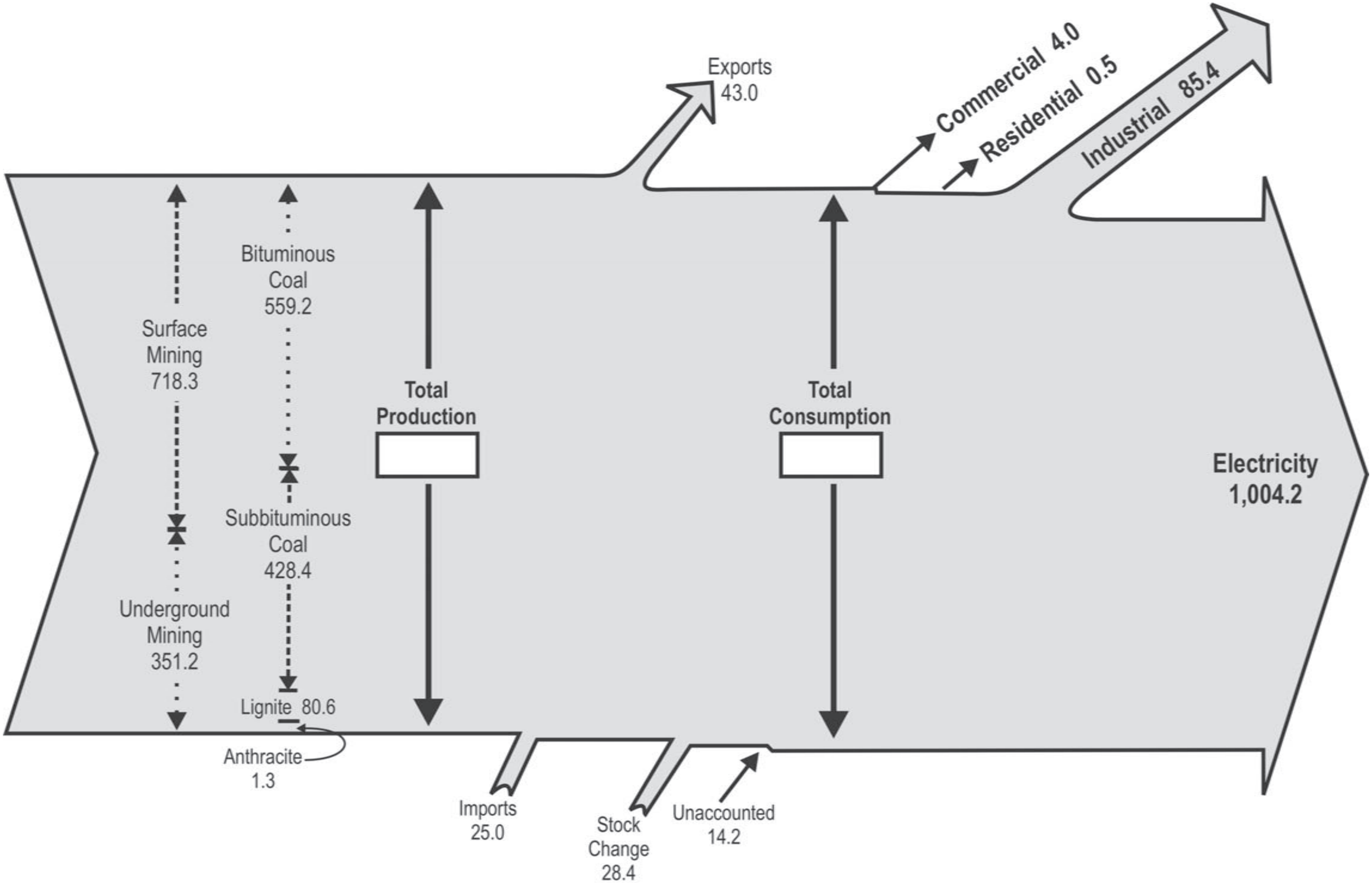

 

# U.S. PRODUCTION BY ENERGY SOURCE




# U.S. CONSUMPTION BY ENERGY SOURCE

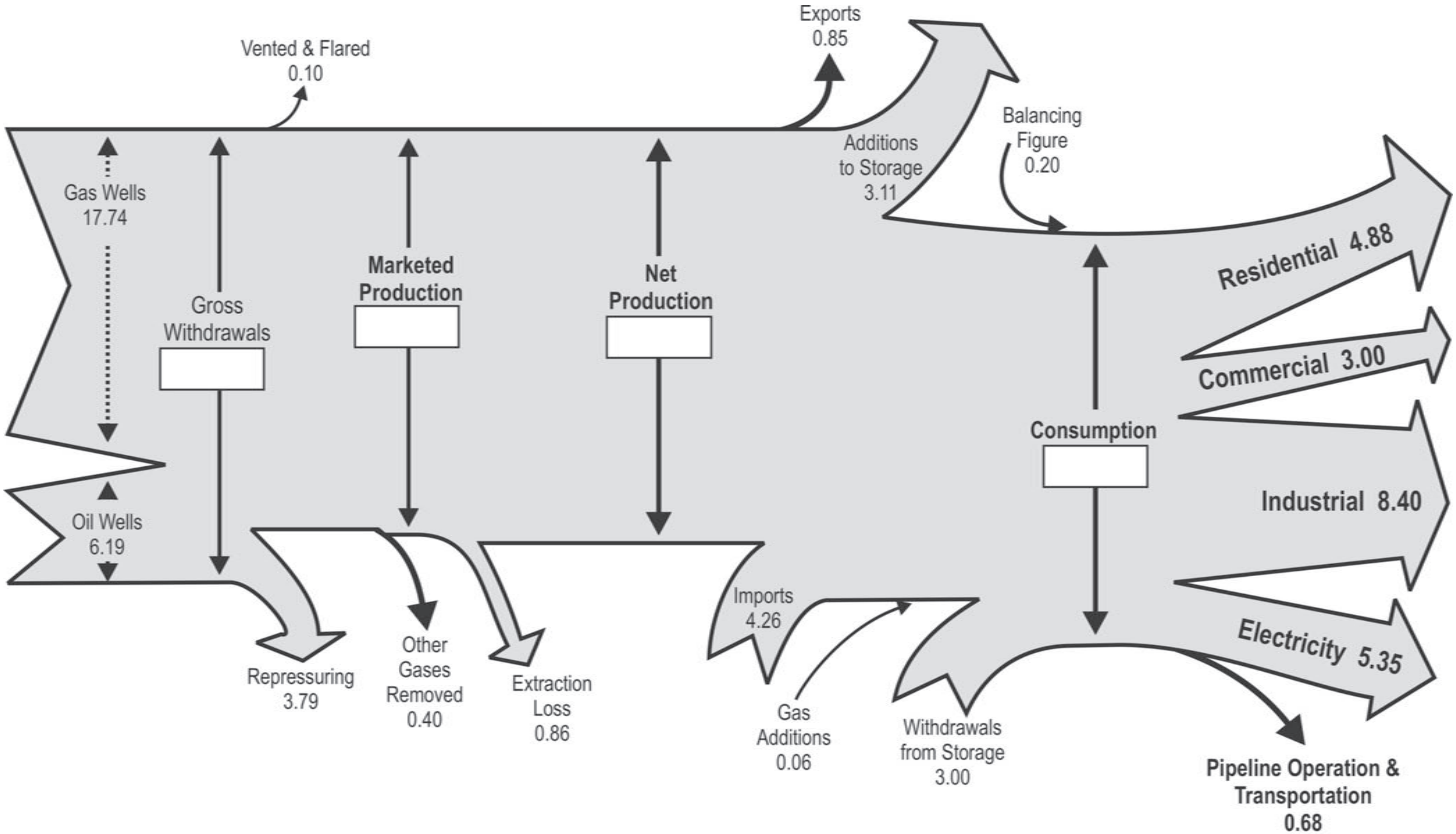





# U.S. COAL FLOW 2004

PRODUCTION → CONSUMPTION

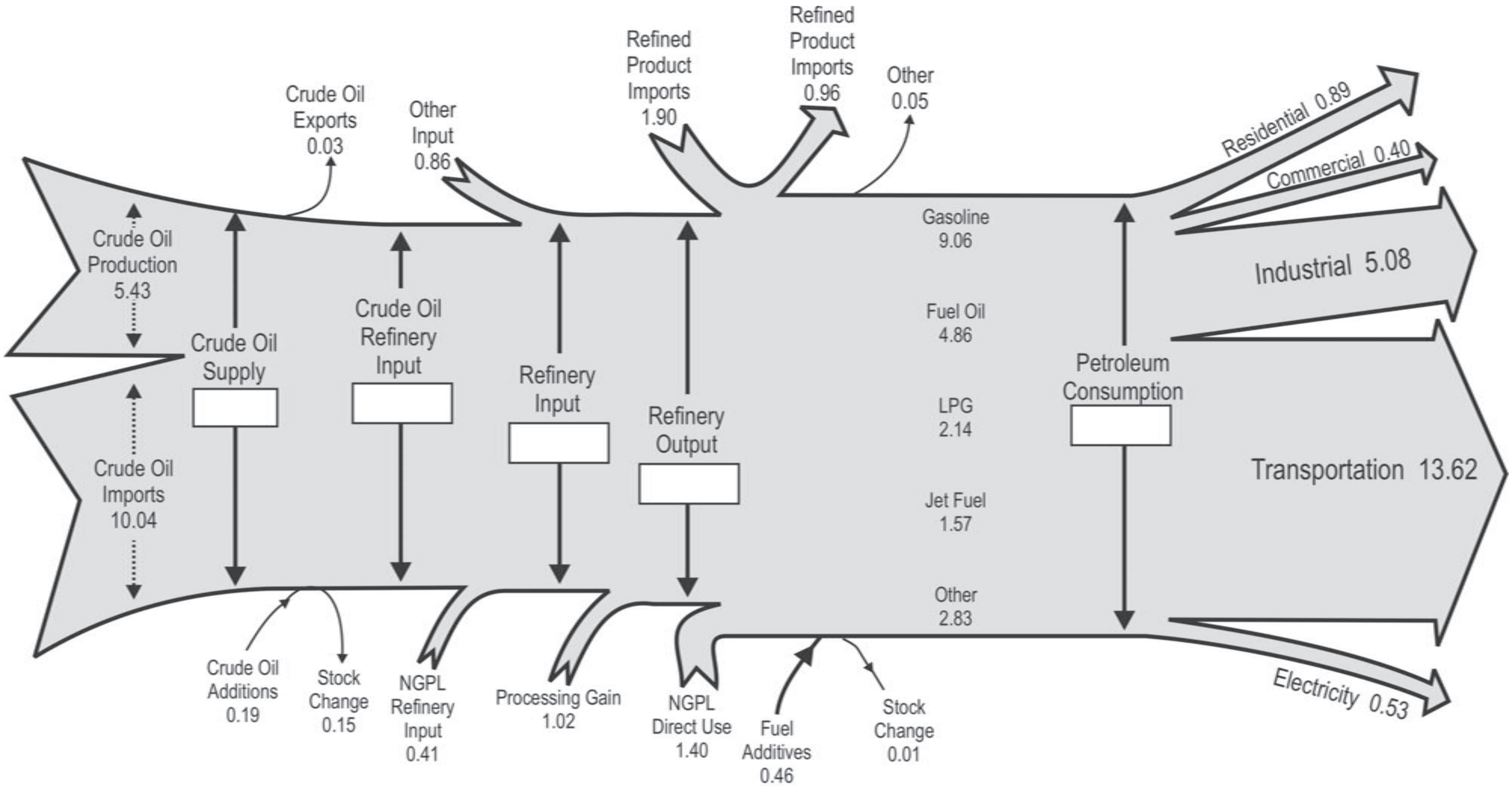
In million short tons




# U.S. NATURAL GAS FLOW 2004

PRODUCTION → CONSUMPTION

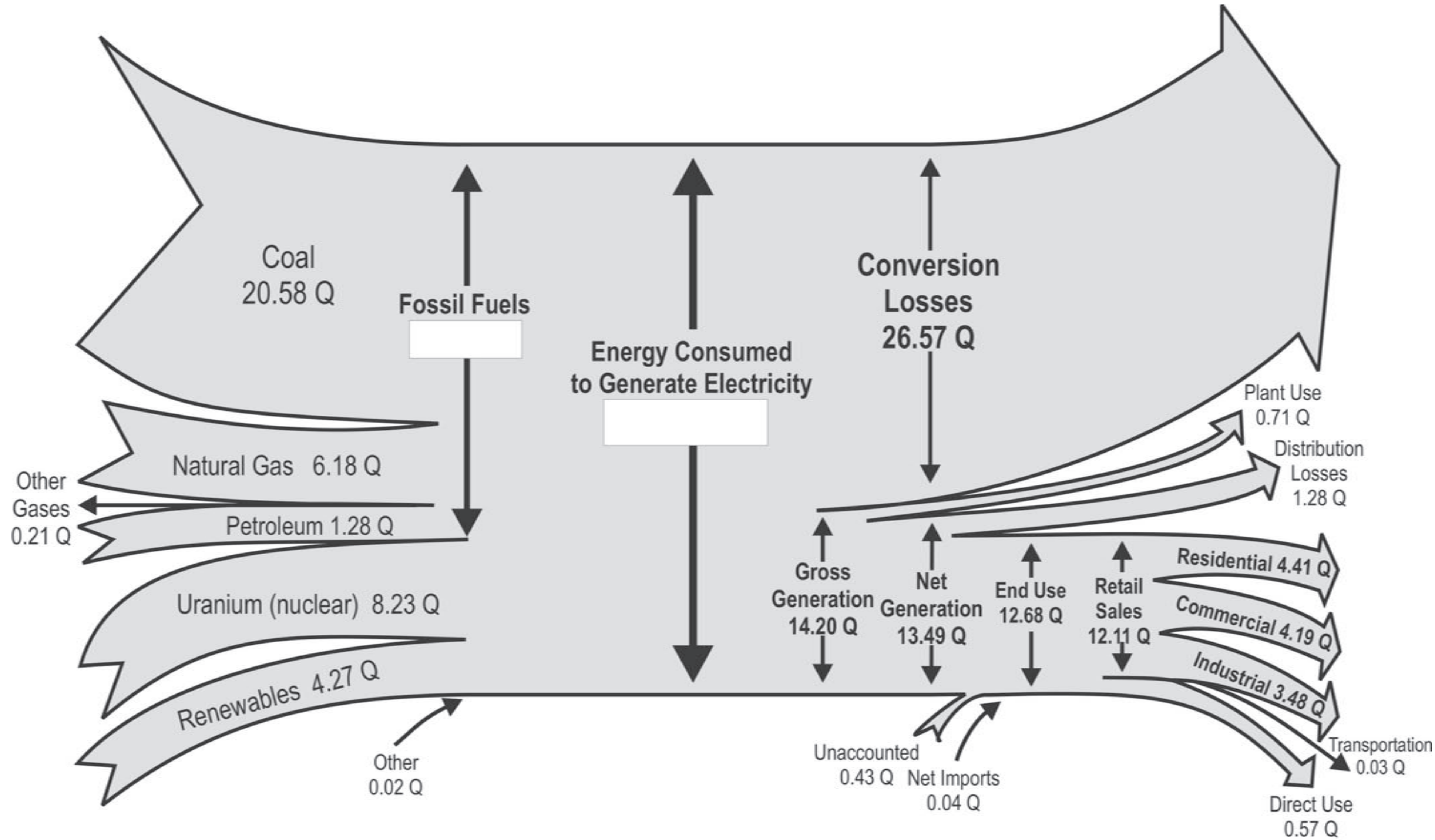
In trillion cubic feet




# U.S. PETROLEUM FLOW 2004

PRODUCTION → CONSUMPTION

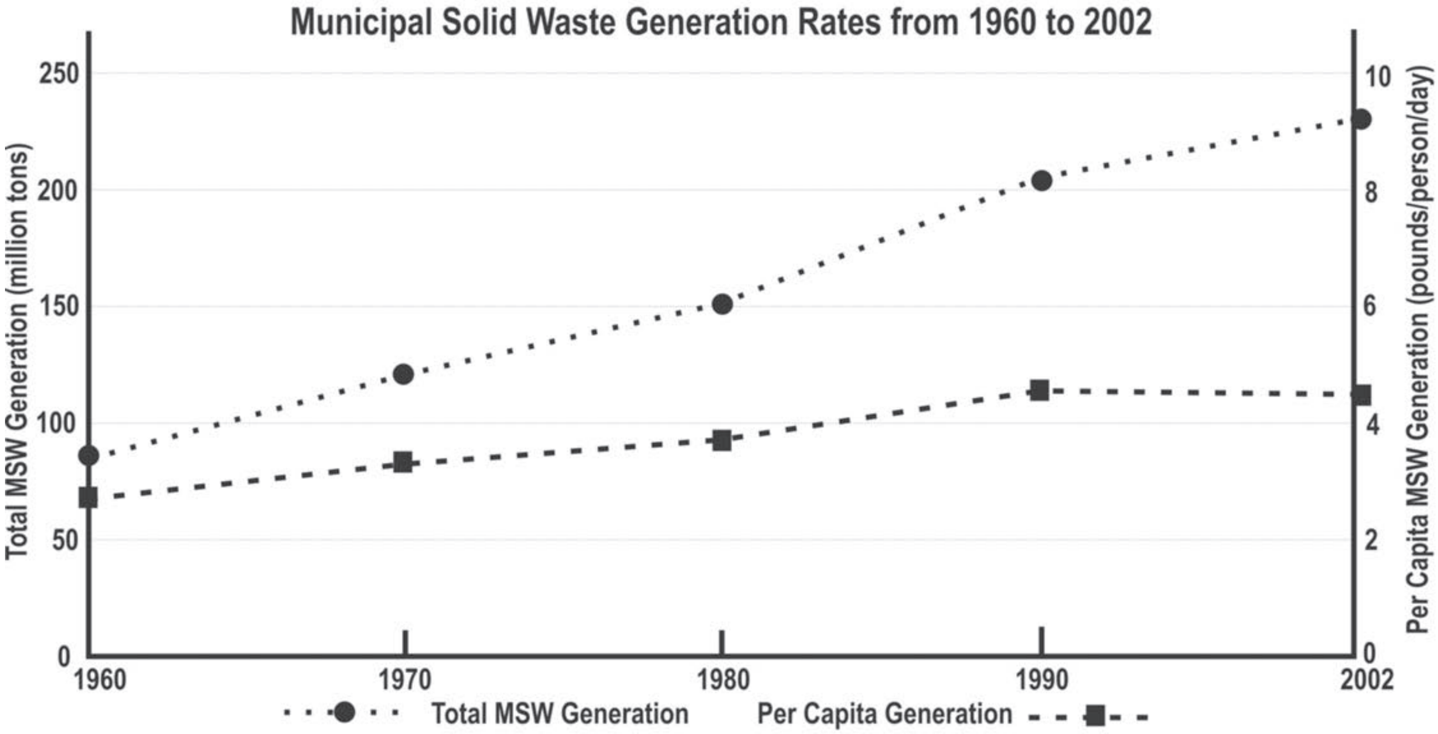
In million barrels per day

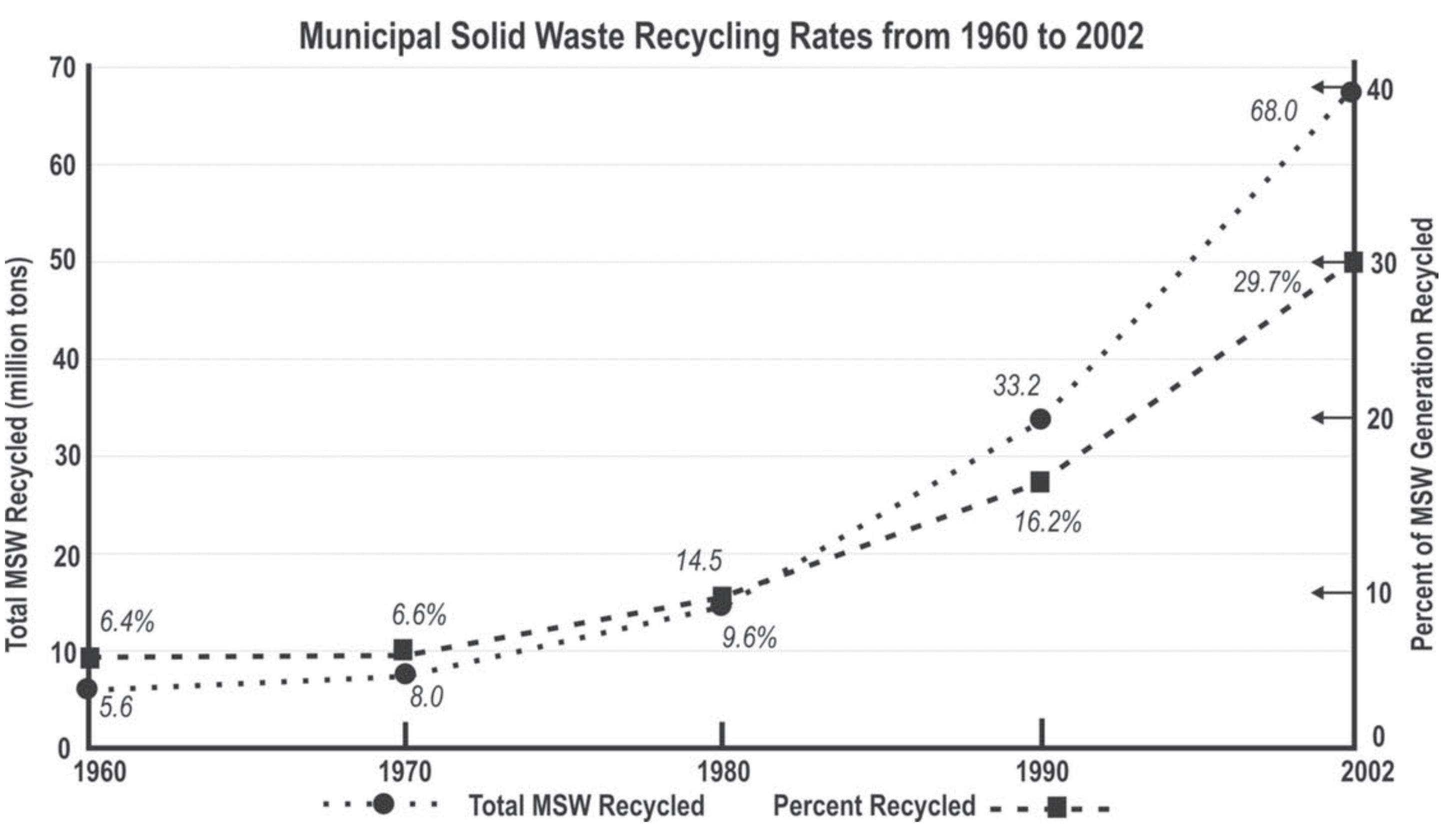



# U.S. ELECTRICITY FLOW 2004

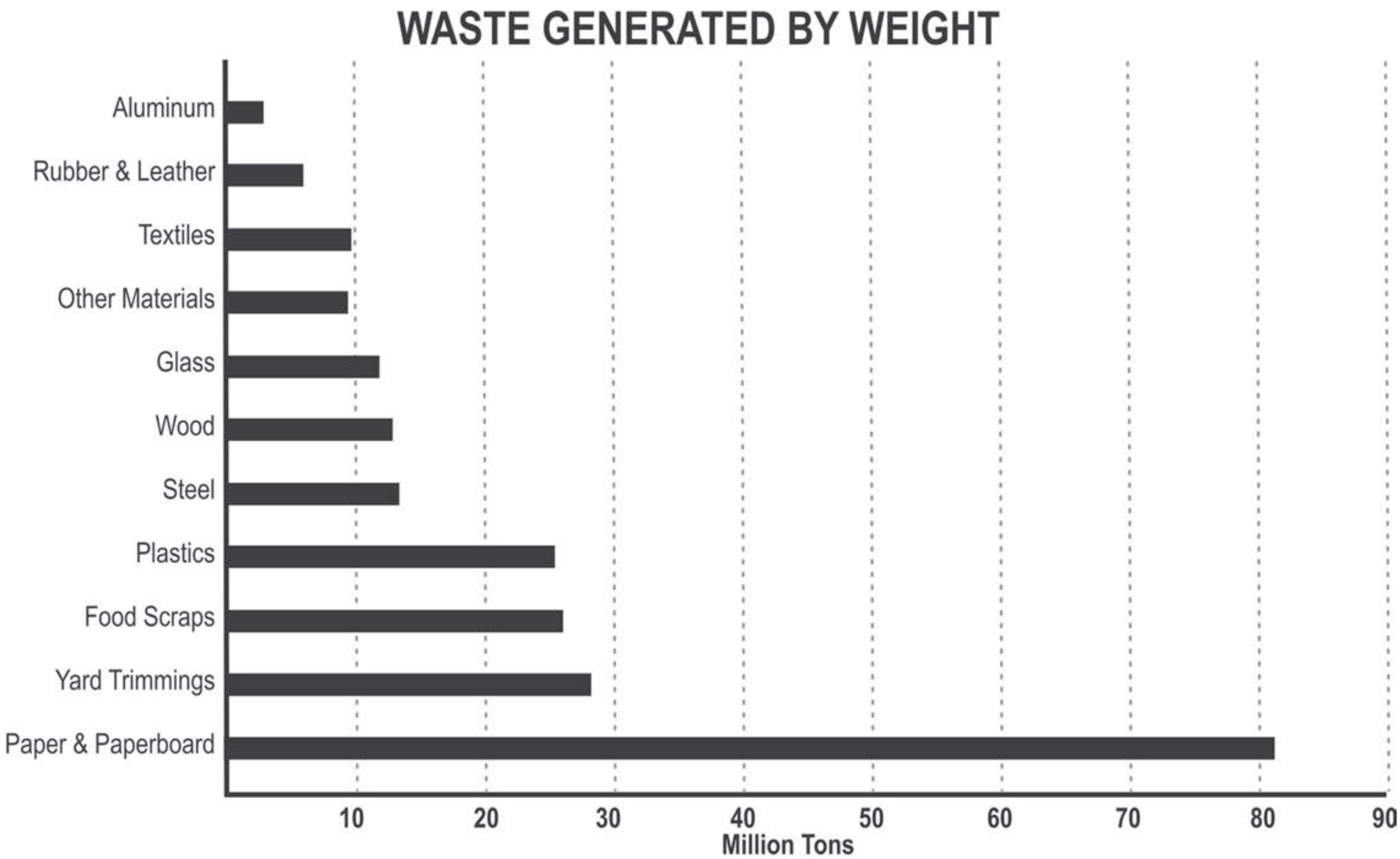
PRODUCTION ⟶ CONSUMPTION

# MUNICIPAL SOLID WASTE GENERATION & RECYCLING

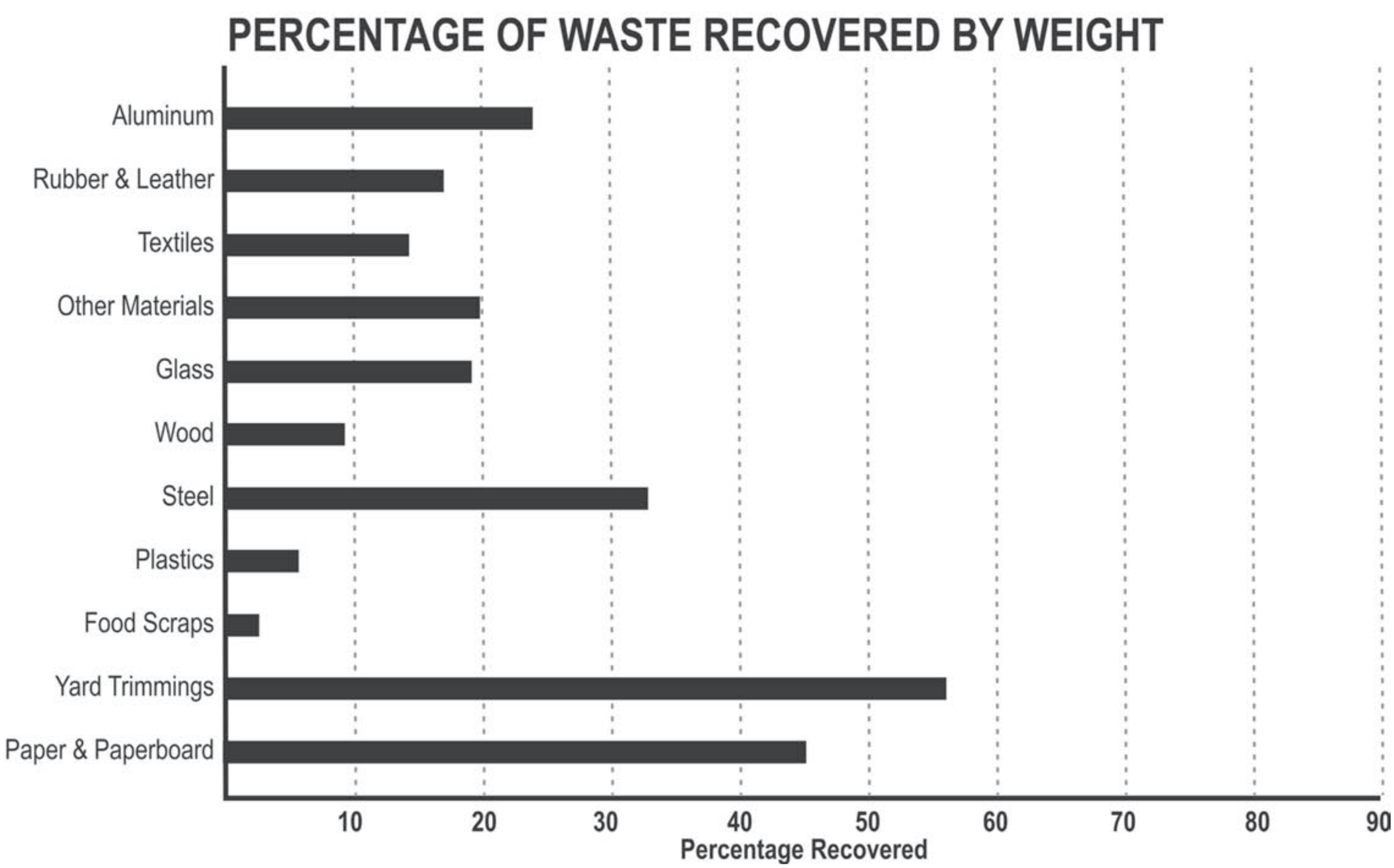


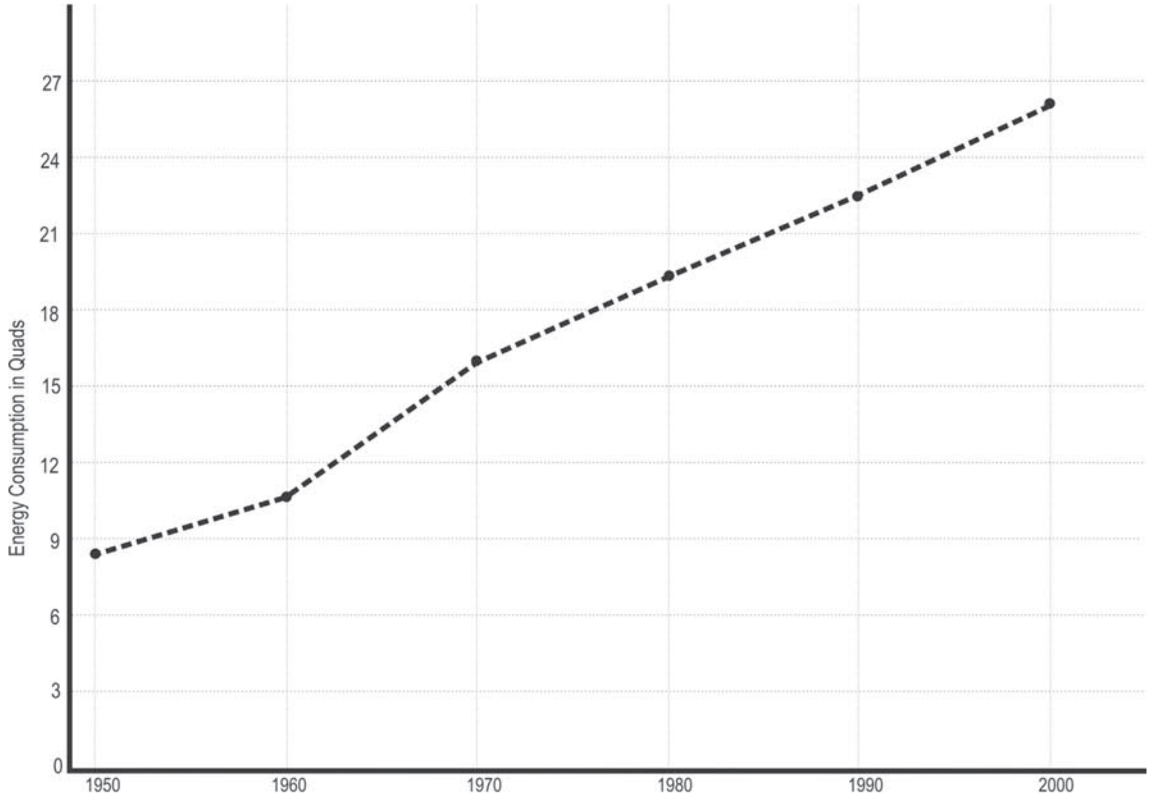


WASTE GENERATED BY WEIGHT
Aluminum
Rubber & Leather
Textiles
Other Materials
Glass
Wood
Steel
Plastics
Food Scraps
Yard Trimmings
Paper & Paperboard
10
20
30
40
50
60
70
80
90
Million Tons

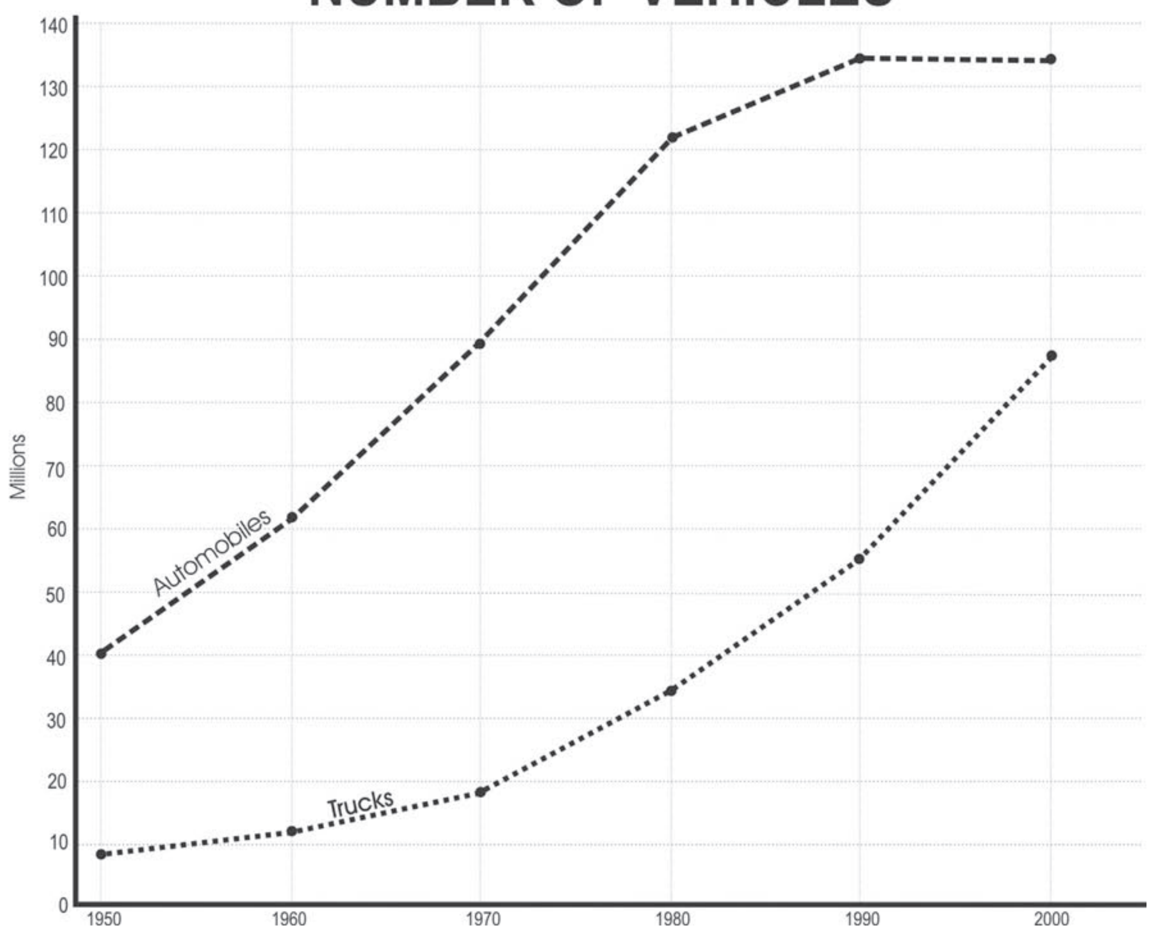



PERCENTAGE OF WASTE RECOVERED BY WEIGHT
Aluminum
Rubber & Leather
Textiles
Other Materials
Glass
Wood
Steel
Plastics
Food Scraps
Yard Trimmings
Paper & Paperboard
10
20
30
40
50
60
70
80
90
Percentage Recovered

# TRANSPORTATION SECTOR CONSUMPTION

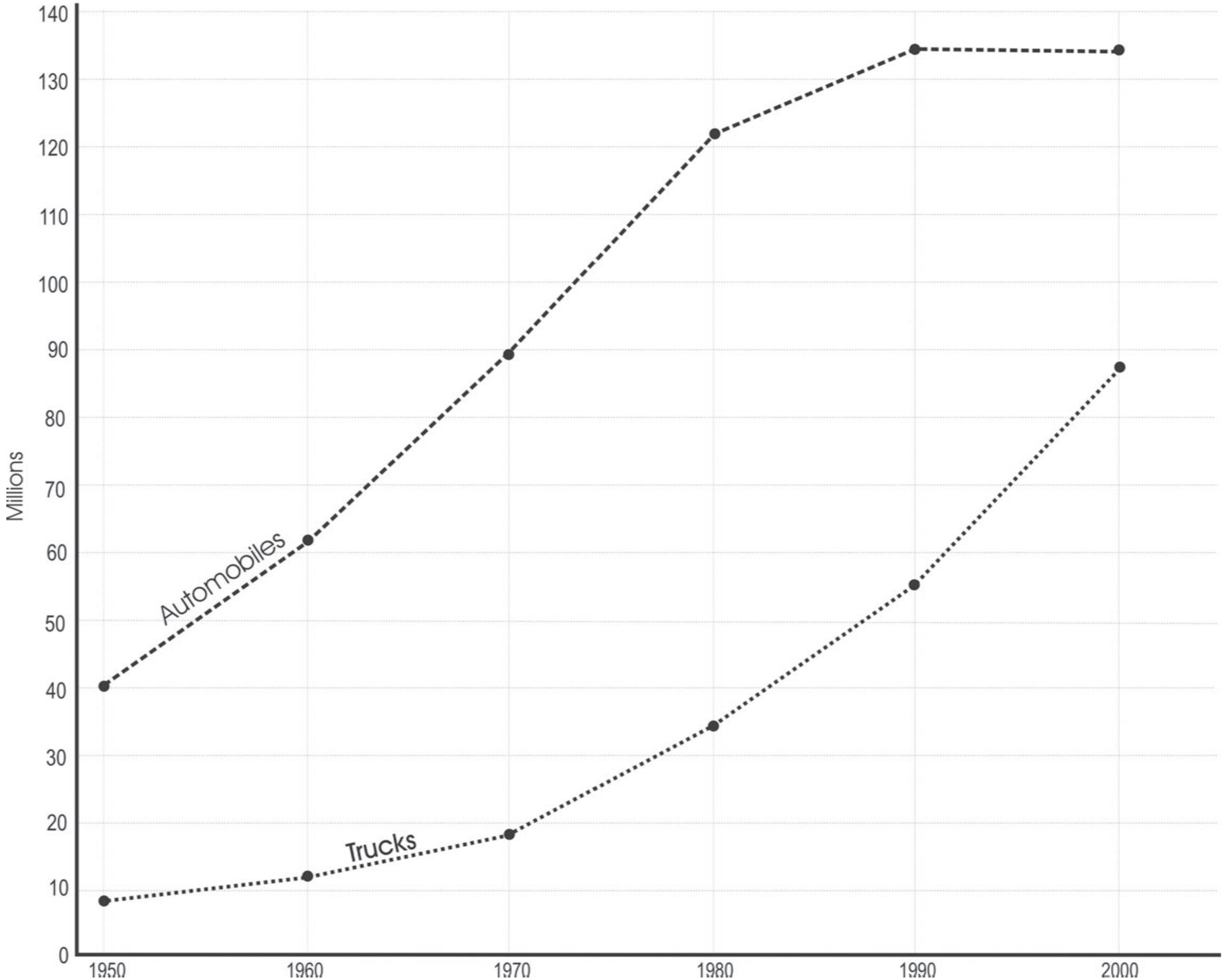



# NUMBER OF VEHICLES

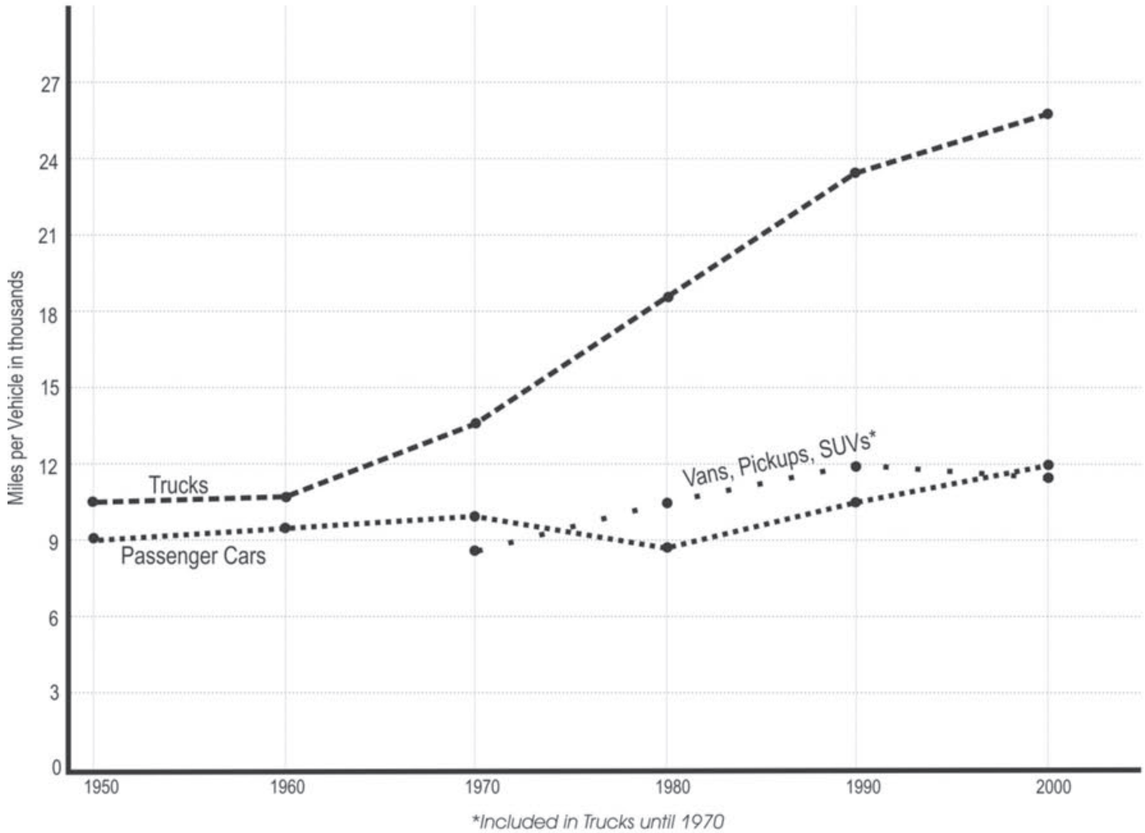


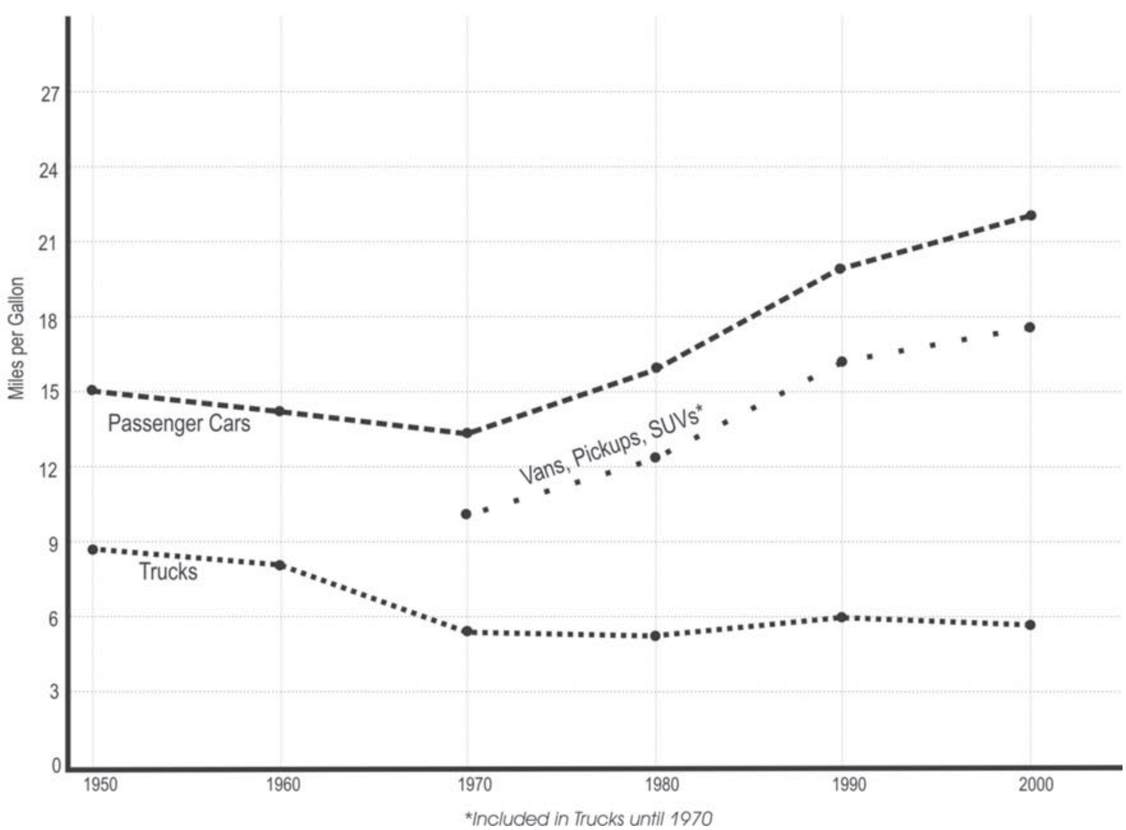
# NUMBER OF VEHICLES



# MOTOR VEHICLE MILEAGE

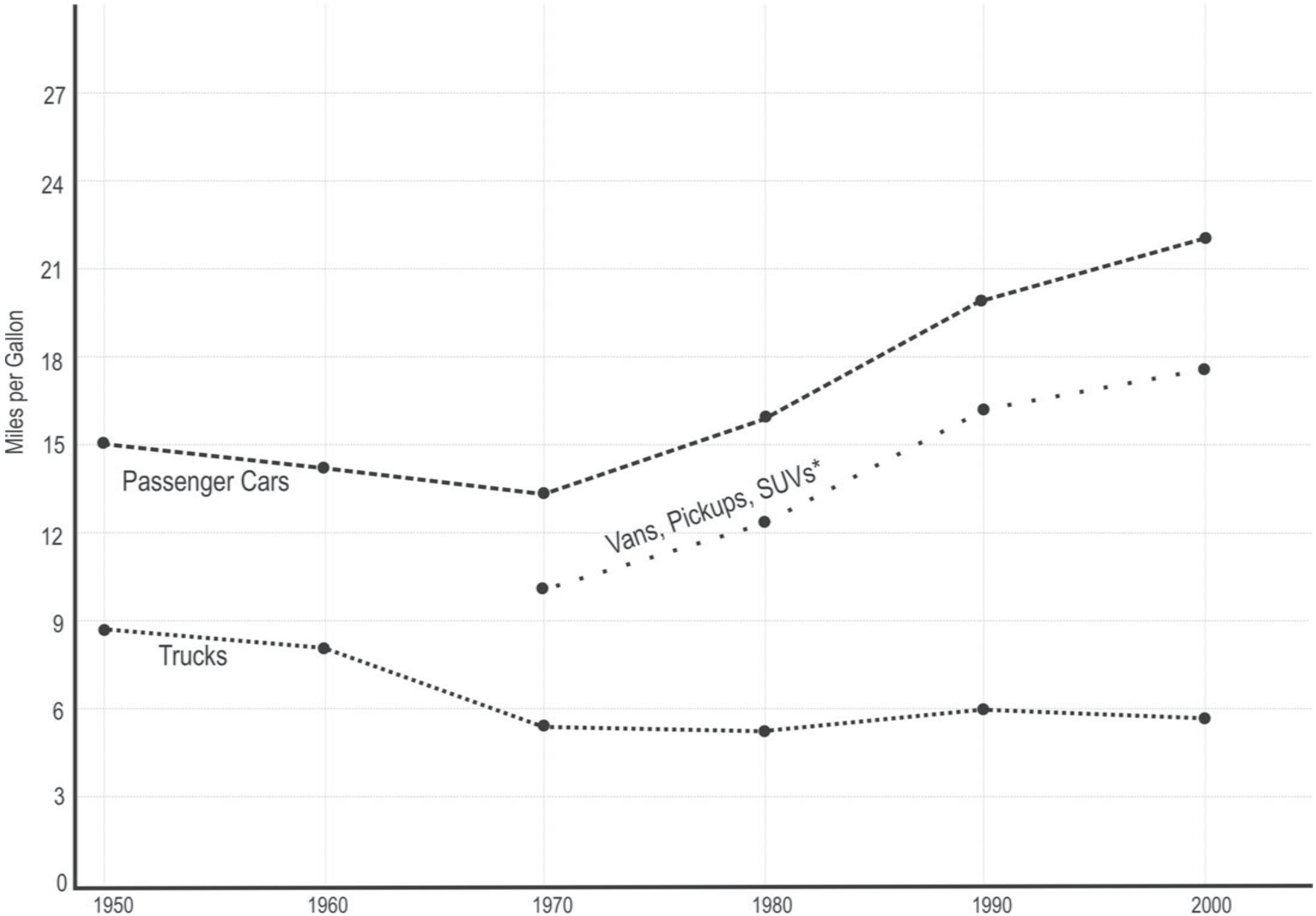



# MOTOR VEHICLE FUEL ECONOMY



# MOTOR VEHICLE FUEL ECONOMY




*Included in Trucks until 1970*

# ENERGY ANALYSIS
## Evaluation Form

**State: ___ _** **Grade Level: ___ _** **Number of Students: ___ _**

| | | |
|---|---|---|
| 1. Did you conduct the entire activity? | Yes | No |
| 2. Were the instructions clear and easy to follow? | Yes | No |
| 3. Did the activity meet your academic objectives? | Yes | No |
| 4. Was the activity age appropriate? | Yes | No |
| 5. Were the allotted times sufficient to conduct the activity? | Yes | No |
| 6. Was the activity easy to use? | Yes | No |
| 7. Was the preparation required acceptable for the activity? | Yes | No |
| 8. Were the students interested and motivated? | Yes | No |
| 9. Was the energy knowledge content age appropriate? | Yes | No |
| 10. Would you use the activity again? | Yes | No |

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

Please fax or mail to:

**NEED Project**
**PO Box 10101**
**Manassas, VA 20108**
**FAX: 1-800-847-1820**

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FMC Technologies
Fuel Cell Store
Gerald Harrington
GlobalSantaFe
Governors' Ethanol Coalition
Guam Energy Office
Halliburton Foundation
Hydril
Illinois Clean Energy Community Foundation
Illinois Department of Commerce and Economic Opportunity
Independent Petroleum Association of NM
Indiana Community Action Association
Indiana Office of Energy and Defense Development
Indianapolis Power and Light
Interstate Renewable Energy Council
Iowa Energy Center
Johnson Controls
Kentucky Clean Fuels Coalition
Kentucky Office of Energy Policy
Kentucky Oil and Gas Association
Kentucky Propane Education & Research Council
Kentucky River Properties LLC
Kentucky Soybean Board
Lee Matherne Family Foundation
Llano Land and Exploration
Maine Energy Education Project
Maine Public Service Company
Marathon Oil Company
Marianas Islands Energy Office
Massachusetts Division of Energy Resources
Michigan Energy Office
Michigan Oil and Gas Producers Education Foundation
Minerals Management Service – U.S. Department of the Interior
Mississippi Development Authority – Energy Division
Narragansett Electric – A National Grid Company
National Association of State Energy Officials
National Association of State Universities and Land Grant Colleges
National Biodiesel Board
National Fuel
National Hydrogen Association
National Ocean Industries Association
New Jersey Department of Environmental Protection
North Carolina Department of Administration State Energy Office
Nebraska Public Power District
New Mexico Oil Corp.
New Mexico Landman's Association
New York State Energy Research and Development Authority
Noble Energy
Offshore Energy Center/Ocean Star/OEC Society
Ohio Energy Project
Oil & Gas Rental Services
Pacific Gas and Electric Company
Permian Basin Petroleum Association
Petroleum Equipment Suppliers Association
Premiere
Puerto Rico Energy Affairs Administration
Renewable Fuels Association
Roanoke Gas
Robert Gorham
Rogers Training and Consulting
Roswell Desk and Derrick Club
Roswell Geological Society
Rhode Island State Energy Office
Saudi Aramco
Schlumberger
Sentech, Inc.
Shell Exploration and Production
Society of Petroleum Engineers
Southwest Gas
Spring Branch Independent School District – Texas
Strategic Energy Innovations
Tennessee Department of Economic and Community Development
Texas Education Service Center – Region III
Texas Independent Producers & Royalty Owners Association
TransOptions, Inc.
University of Nevada – Las Vegas
Urban Options
U.S. Environmental Protection Agency
U.S. Department of Agriculture – Biodiesel Education Program
U.S. Department of Energy
U.S. Fuel Cell Council
Vectren
Virgin Islands Energy Office
Wake County Public Schools – North Carolina
W. Plack Carr Company
Xcel Energy
Yates Petroleum