Chapter 3 Project: U.S. Energy Flows

Name ___________________________ Name _______________________________

Background: The attached diagram shows energy production and end-use consumption data for all major sectors in the United States for the year 2001. The diagram was produced by Lawrence Livermore National Laboratory using data provided by the Energy Information Administration, a division of the U.S. Department of Energy.

Reading the chart: In the diagram, follow the flow of energy by moving left to right. On the far left are energy values given by basic energy source: Electricity Imports, Nuclear, Hydro, Biomass, Coal, etc. The 4 white boxes towards the right (residential/commercial, industrial, etc) are the 4 end-use sectors of energy consumption. Some of the basic source energy is first converted to electricity before it is transmitted to the 4 end-use sectors, as shown by the white box labeled "Electric Power Sector." On the far right the diagram indicates the amount of energy that is lost (shown in gray) and the amount that is used for its intended purpose (shown in yellow). The width of each energy flow (pipeline) is in direct proportion to the amount of energy in that flow. Ignore "Bal. no."

Units: All energy measurements on the diagram have units of quadrillion British thermal units (BTU). The header on the top of the chart states that Net Primary Resource Consumption is approximately 97 Quads—this is energy-speak for 97 quadrillion BTUs. One quadrillion is 10^{15}. One BTU is the quantity of heat needed to raise the temperature of 1 pound of water by 1°F at or near 39.2°F. Some approximate conversion factors are given below.

Fuel	**Energy content (BTU)**
1 ton of coal	21,400,000
1 barrel (42 gallons) of crude oil	5,800,000
1 cubic foot of natural gas	1,000
1 kilowatt-hour of electricity	3,400

Precision: In most cases, the numbers on the chart have been rounded to 1 decimal place (tenth of a Quad). Because of this rounding, the total Quads listed next to each production sector and end-use sector might not exactly equal the sum of the individual components.

Directions: Refer to the energy graph to answer the following questions. Show steps that you take to make your computations. Always show and label units whenever appropriate. You may use **Q** as an abbreviation for Quads.

ENERGY SOURCES

1. Sources/Production of U.S. Energy

Seven sources of energy and their quantities are shown on the diagram. Rank these energy sources from highest to lowest in Quads. Fill in the rest of the table.

Energy Source	Quads	% of total
1.		
2.		
3.		
4.		
5.		
6.		
7.		
Total		

2. Petroleum and NGPL

NGPL stands for Natural Gas Plant Liquids; these are hydrocarbon liquids obtained when natural gas is extracted from the ground. Because of their liquid state, NGPL are combined with petroleum (oil).

a) How many Quads of petroleum and NGPL energy were supplied by both domestic and foreign sources in 2001?

b) How many barrels of petroleum and NGPL is that amount? How many gallons? *Express in scientific notation.*

3. Natural gas

a) Like petroleum, natural gas is obtained by drilling into underground hydrocarbon reservoirs. Hydrocarbon liquids and undesirable gases are extracted; what's left is predominantly methane ("swamp gas"). What is the total energy amount contained in both domestic and imported natural gas supplies?

b) How many cubic feet of gas is that? Show work.

c) Complete the table with the amount of natural gas energy that flows directly to each sector. To compute percentages, use the total of 23.5 Quads. *(Individual sector values will not add to 23.5 because of rounding.)*

energy sector	amount of energy	percent of total
Electric power sector		
Residential/commercial		
Industrial		
Nonfuel		
Transportation		
Total	23.5 Quads	

4. Fossil Fuels and Renewable Energy

a) Which of the 7 sectors of energy production are based on “fossil fuels”?

b) Which of the 7 sectors represent “renewable energy” sources?

c) What percentage of the total energy produced is due to renewables?

ELECTRIC ENERGY

5. Analysis of the Electric Power Sector

Many sources of energy flow into the electric power sector, which then distributes electricity to the residential/commercial, industrial, and transportation sectors. Petroleum, coal, natural gas and biomass are burned in conventional power plants to produce heat to boil water. The steam from the boiling water spins turbines which then produce electricity. Nuclear fuels can be used to produce electricity in much the same way: nuclear reactions in power plants make the heat which boils the water which spins the turbines which produces the electricity. Both conventional-electric and nuclear-electric power plants are highly inefficient—a large amount of the fuel energy is lost in the process of making electricity and some is lost during transmission along electrical lines.

a) The diagram indicates that the electric power sector converted various energies to 37.5 Quads of electrical energy in 2001. What were the top two sources of energy for the electric power sector?

b) How many Quads of electricity were successfully distributed from power plants, and how many Quads were lost at the power plants?

c) The **efficiency** of an energy system is the percentage of the total energy used for the intended purpose. Determine the efficiency of the U.S. electric power sector, using your previous answers and ignoring losses after distribution.

d) Natural gas currently contributes 5.4 Quads of energy to the electric power sector. How many Quads of that contribution are immediately lost by the electric power sector?

e) Give 2 practical reasons why so little electricity is distributed to the transportation sector.

1.

2.

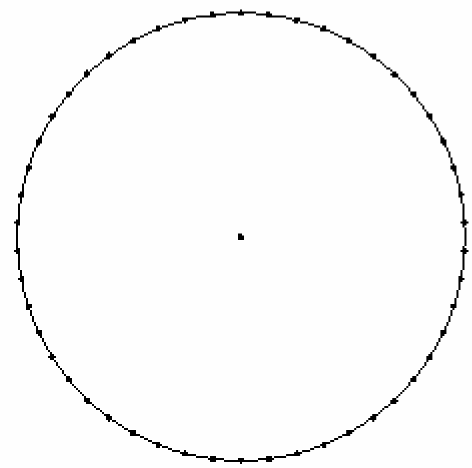
CONSUMPTION/END USE SECTORS

6. Residential/Commercial Sector

a) This sector includes residences, religious and non-profit organizations, and educational and governmental institutions. The residential and commercial sector consumes 19.3 Quads of energy in 5 forms, through 5 different pathways. Fill in the table below with these 5 energy forms, their individual energy amounts, and the amounts expressed as a percent of the total. Use the total of 19.3 Quads when computing the percentages. *(Individual sector values will not add to 19.3 because of rounding.)*

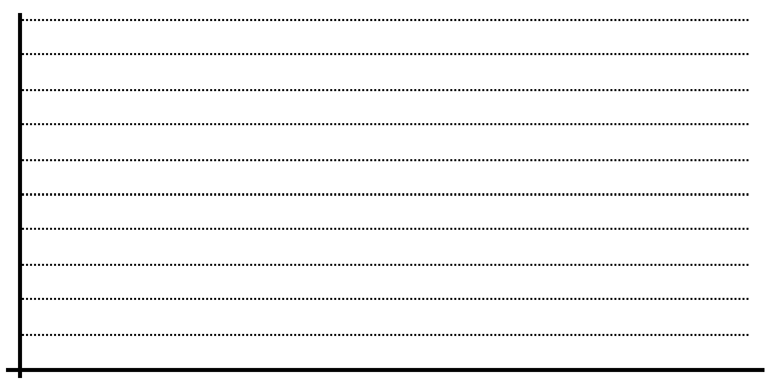
Energy forms/sources	**Quads**	**% of total**
Total	**19.3**	

b) Make a **pie chart** illustrating the 5 energy forms and their percentages of the total energy consumed by the residential/commercial sector. Use the circle below, which is divided into 50 arcs of the same length. Label on the pie chart the name and the percentage for each form of energy.



7. Industrial Sector

a) The industrial sector includes manufacturing industries, mining, construction, agriculture, fisheries and forestry. The industrial sector consumes 19.0 Quads through 6 forms of energy. Draw a **bar chart** to illustrate the number of Quads consumed for each form of energy. Label each bar with its energy name and amount.



b) Coal energy is *directly* consumed by the industrial sector through the burning of coal. The industrial sector also consumes coal energy *indirectly* by using distributed electricity. Compute the *total* Quads of coal energy consumed by the industrial sector. *Ignore energy losses.*

8. Oil and Transportation

a) The transportation sector is primarily fed by the energy derived from petroleum and NGPL. What percent of the total petroleum and NGPL energy is consumed by the transportation sector? *You can ignore the small amount of oil energy that is first converted to electricity.*

b) What percent of the energy consumed by the transportation sector was wasted in 2001? *Consider all forms of energy.*

c) Multiply the percentages found in the last 2 questions to find the percentage of all petroleum and NGPL energy that is wasted by the transportation sector. How many barrels of oil is that? How many gallons?

9. Heating your home

Most homes and apartments today are heated with electricity or natural gas. Electric heaters are 100% efficient because all of the energy that goes into the heaters is turned into heat (the intended purpose). Natural gas furnaces vary considerably in how efficiently they burn gas. The most efficient ones turn about 95% of the gas energy into heat (the intended purpose); the other 5% is wasted through the furnace exhaust.

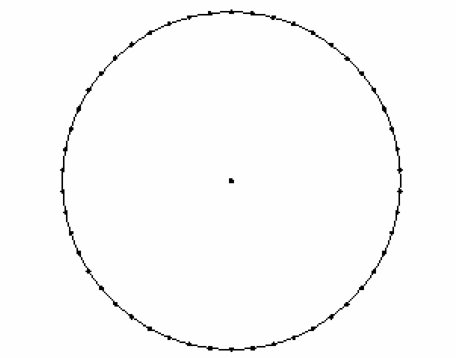
Comparing the numbers (100% versus 95%), one could argue that electric heaters are slightly better than even the most efficient gas furnaces. Explain what is wrong with this argument, using numbers to support your answer.

10. Electric Power Once Again

Some of the electricity generated by the electric power sector was successfully distributed to users, and much was lost in the system (see questions in section 5). Some of the electricity that is distributed to the residential/commercial, industrial, and transportation sectors is further wasted (i.e. lost). Compute the total amount of **electricity** that is wasted after it is transported to these 3 sectors.

Considering your answer to previous question, determine the amount of electric energy that is distributed and then used, and the total amount that is squandered, for the U.S. electric power system.

In a pie chart, illustrate the percent of electric energy used, and the percent wasted.



11. The End of the Road

a) What is the total energy lost in the U.S. each year? What is the total useful energy consumed each year in the U.S. (include the nonfuel sector)? What is the efficiency of the entire U.S. energy flow?

b) (no calculations) Name the two energy sources which waste/lose the greatest Quads of energy (most inefficient). Name the two energy sources which waste/lose the least amount of energy (most efficient).

c) Consider the top two "losers" from the previous question. For each loser, briefly describe 1 change to make that energy source more efficient. List a different change for each of the two "losers."

d) Wind and solar power, both renewable sources of energy, have many positive attributes. But they both have the same "Achilles heel," the same negative attribute. What is that?