DOCUMENT RESUME

ED 390 679 SE 057 311

TITLE Energy Math Challenge.
INSTITUTION National Energy Education Development Project, Reston, VA.
PUB DATE 94
NOTE 13p.
AVAILABLE FROM National Energy Education Development Project, P.O. Box 2518, Reston, VA 22090.
PUB TYPE Guides - Classrocm Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Educational Games; Elementary Secondary Education; *Energy; Lesson Plans; *Number Concepts; Physics; *Word Problems (Mathematics)

ABSTRACT

This booklet is a teacher's guide for a lesson, appropriate for grades 3-9, to strengthen students' mathematics skills while increasing their knowledge of energy. It consists of a game in which teams of students solve mathematics problems about energy units. The booklet contains 24 challenging mathematics word problems and 1 mega-question. (MKR)

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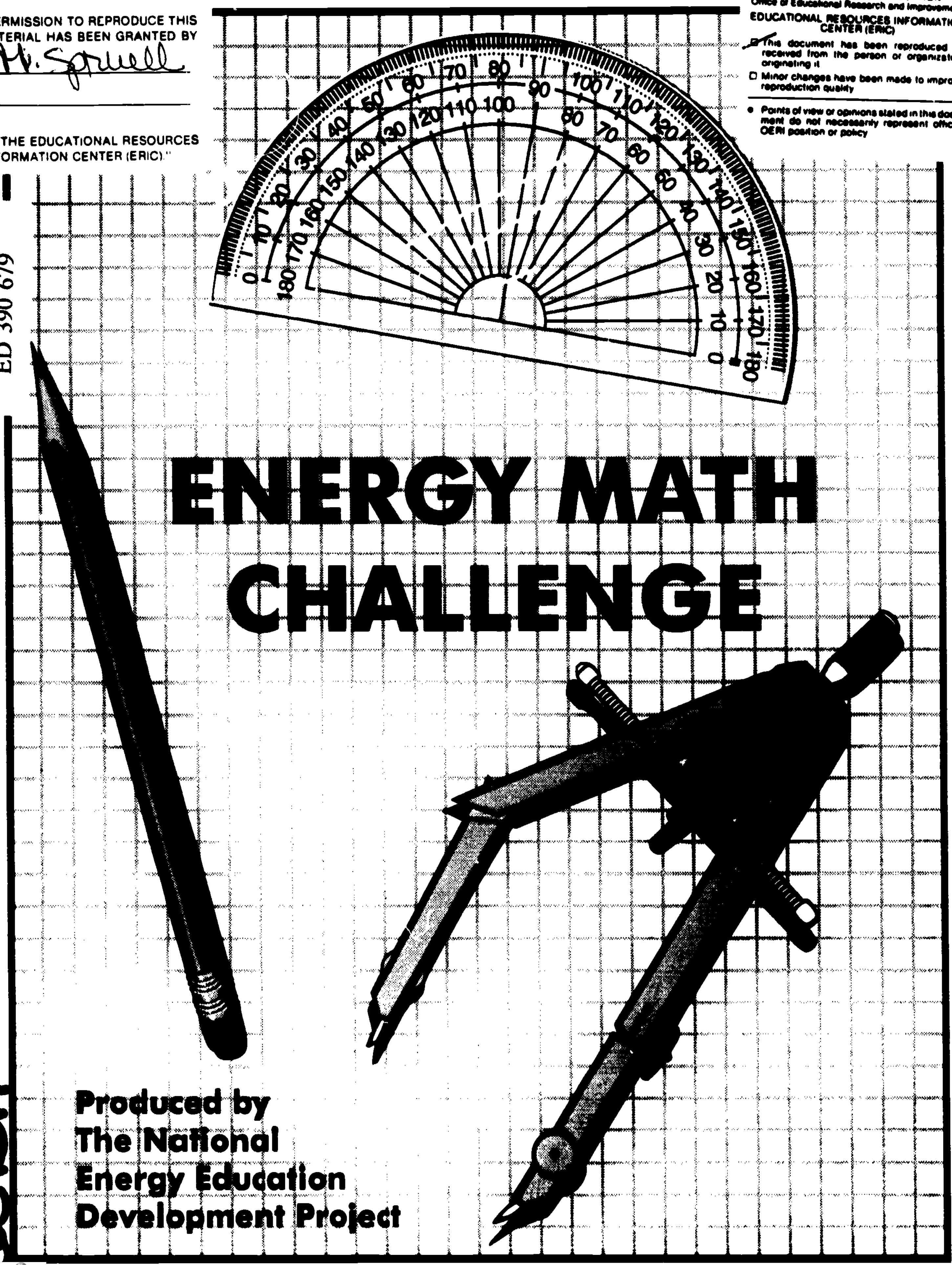

ENERGY MATH CHALLENGE

Produced by The National Energy Education Development Project

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Goal: To strengthen students' math skills while increasing their knowledge of energy.

Background: The Energy Math Challenge (EMC) is suitable for students in grades three through nine. When used in conjunction with other NEED/energy education activities, the EMC will encourage students to recognize the interrelationship of math, science, language arts, and social studies. The EMC is also ideal for older students to use if they adopt a younger class of students.

In the first round of the EMC, students solve four different math problems. These same types of problems are repeated in rounds two and three. In the fourth round, teams solve a Mega-Question that incorporates the four skills targeted in the first three rounds.

Time: The first three rounds of the EMC take approximately eight to ten minutes, and the fourth round takes approximately 15 to 20 minutes. If you want to play the game over a four day period, each round can be played independently of the others. After each round, the teacher should review the math problems with the students. Total class time for the EMC will range from 90 to 120 minutes, depending on the students' math skills and the amount of teacher review after each round.

Materials:

- One set of Round One and Round Two math problems for each team.
- One set of Round Three math problems for each student.
- One Mega-Question for each team.

Procedure:

Step One—Preparation

The EMC problems are organized into three grade levels. These levels are identified on the top of the EMC problem sheets. (Form E for elementary, Form M for middle, and Form J for junior high school.) The problems are numbered Round One through Round Three, and the fourth round is labeled the Mega-Question.

Divide the class into teams of three to four students. Each team should have at least one strong math student. Duplicate a set of Round One and Round Two math problems for each team. Duplicate a set of Round Three math problems for each student in the class. Each team will also need a single copy of the Mega-Question.

For Rounds One and Two, cut each sheet into quarters. Clip together each set of four math problems for Rounds One and Two. Provide scrap paper for each team. Decide if you want the students to write their answers on the math problems or on the scrap paper. Your school or personal policy regarding calculators will determine if the students can use calculators during any of the rounds.

Step Two—Play the Game

Once students are in their groups, give each team a set of the Round One problems. Begin the game by giving the teams the following instructions:

I have given each team four Energy Math Challenge problems for Round One. Each of the four problems will require your team to use a different problem solving skill. I will review the math problems with you after each of the four rounds.

Your team will receive 10 points for each problem it solves correctly during Round One. In Round Two, each problem will be worth 15 points, and in Round Three, each problem will be worth 20 points. Teams can receive 100 points in the final round.

Round One will last 10 minutes. Round Two will last eight minutes, and Round Three will last 10 minutes. Before we start the third round, I will give your team 10 minutes to review the problems from the first two rounds. During this study session, make sure everyone knows how to do all four types of problems correctly.

In the third round, every student must solve the four problems independently, with no help from his or her teammates. Therefore, it is important that your team works together during rounds one and two and during the study session. The team's average score in the third round will be added to the points earned in the previous two rounds.

In the fourth round, you will work as a team to solve a Mega-Question using the math skills you concentrated on in the first three rounds. Your team will have 15 to 20 minutes to solve the Mega-Question. Before we start, I will review some energy unit terms with you.

Btu—One *British thermal unit* is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit. A single Btu is quite small. A wooden kitchen match, if allowed to burn completely, would give off one Btu of energy. Every day, the average American uses approximately 889,000 Btu's.

MBtu—An *MBtu* is equal to one million (1,000,000) Btu's. The average American family consumes approximately 98 MBtu's of energy a year.

Quad—*Quads* are used to measure very large quantities of energy. A quad is equal to one quadrillion (1,000,000,000,000,000) Btu's. The United States uses about one quad of energy every 4.3 days.

KWh--A *kilowatt-hour* is how much electricity is used in one hour at a rate of 1,000 watts. Just as we buy gasoline in gallons or wood in cords, we buy electricity in kilowatt-hours. Utility companies charge their customers for the kilowatt-hours they use during a month.

BKWh—A *BKWh* is equal to one billion (1,000,000,000) kilowatt-hours. The U.S. consumes approximately 2,973 billion kilowatt-hours (BKWh) of electricity a year.

Junior High School Answers

Round One:	1. 55%	2. 48 million units	3. 840 units	4. 617 BKWh
Round Two:	1. 44%	2. 5.9 quads	3. 360 million	4. 3 quads
Round Three:	1. 36%	2. 56 MBTu	3. 0.47 BKWh	4. 2.2 quads

Mega-Question: The total for the 2010 list of sources is 111.5 quads. There are no right or wrong answers for the 2010 pie chart as long as the numbers add up to 100%.

Middle School Answers

Round One:	1. 55.2 MBtu	2. 4/21	3. 8.8 MBD	4. 21%
Round Two:	1. 15.5 quads	2. 1/42	3. 810 liters	4. 3.5%
Round Three:	1. 272.8 barrels	2. 1/60	3. 1 quad	4. 79%

Mega-Question: The totals for the 1994 list: Renewable—6.3 quads, Non-renewable—82.2 quads, and Total—88.5 quads. The total for the 2010 list is 111.5 quads. There are no right or wrong answers for the 2010 pie chart as long as the numbers add up to 111.5.

Energy Math Challenge — Round One

1. The United States consumed 2,973 billion kilowatt-hours (BKWh) of electricity in 1994. Coal fueled 1,635 BKWh of this electrical power generation. To the nearest percent, calculate the percentage of the nation's electricity that was generated by coal in 1994.

Answer: ______________________ percent

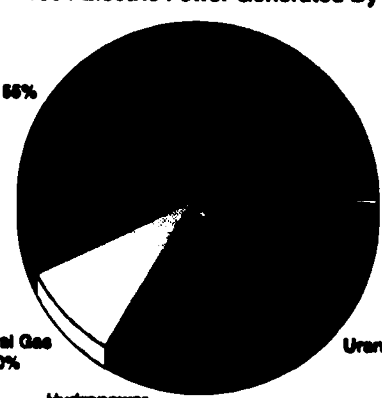
2. In 1994, approximately 51 percent of the nation's 95 million housing units were heated by natural gas. To the nearest million, how many housing units in the nation were heated by natural gas in 1994?

Answer: ______________________ units

3. Today's power plants convert about one-third of the energy stored in fuels into electrical energy. During these conversions, most of the energy is transformed into heat rather than electricity. A certain electric power plant consumes 360 units of energy every day. How many units of electrical energy would the plant actually generate in a week?

Answer: ______________________ units

4. In 1994, the U.S. consumed 2,973 billion kilowatt-hours (BKWh) of electricity. How many billion kilowatt-hours of electricity did uranium provide in 1994?



Answer: ______________________ BKWh

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Energy Math Challenge — Round Two

1. In 1994, the United States consumed a little over 17.6 million barrels of petroleum a day. Gasoline, the number one product produced by the refining of petroleum, consumed 7.7 million barrels of the petroleum. To the nearest full percent, calculate what percentage of petroleum is currently being refined into gasoline.

Answer: ______________________ percent

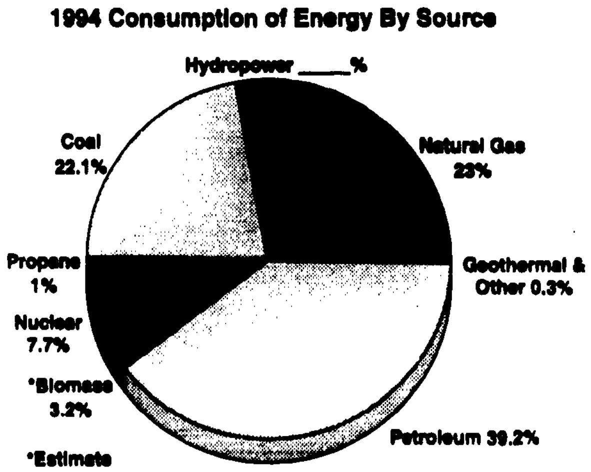
2. Hydroelectric, biomass, wind, and solar energy are all a result of the sun's rays striking the earth. Geothermal energy, which provides approximately six percent of the nation's renewable energy, is the only renewable source resulting from energy found below the earth's surface. In 1994, all five renewable sources of energy provided the nation with a total of 6.3 quads of energy. To the nearest tenth of a quad, how many quads of energy in 1994 were a result of the sun's rays striking the earth's surface?

Answer: ______________________ quads

3. A 42 gallon barrel of petroleum is refined into kerosene, jet fuel, heating oil, and gasoline (the number one product). About 18 of the 42 gallons of petroleum are refined into gasoline. A tanker containing 840 million barrels of petroleum has unloaded its cargo at the refinery. To the nearest whole million, how many barrels of petroleum from the tanker will be refined into gasoline?

Answer: ______________________ million

4. In 1994, the U.S. consumed 88.5 quads of energy. How many quads of energy did hydropower provide the United States in 1994?



Answer: ______________________ quads

1. To generate electrical energy, a fossil fuel power plant consumes 72 units of chemical energy stored in the fossil fuel. Only 26 units of electrical energy are actually produced and sent out over the transmission lines. This loss occurs because a large amount of the energy stored in a fossil fuel is changed into thermal (heat) energy during the generation of electrical power. To the nearest whole percent, calculate the efficiency of this power plant at converting chemical energy into electrical energy.

Answer: ____________________ percent

2. The average American family consumes approximately 98 Million Btu's (MBtu's) of energy a year. Heating and cooling rooms account for 57 percent of the total household energy use, appliances and lights account for 25 percent, and heating water accounts for the remaining 18 percent. To the nearest MBtu, how many MBtu's of energy are consumed by the average household for heating and cooling rooms.

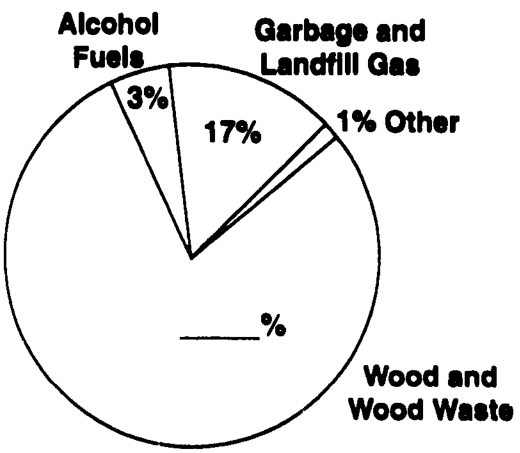
Answer: ____________________ MBtu

3. When uranium atoms are split they give off heat. This heat produces high pressure steam that turns a turbine in a nuclear power plant. In 1994, the nation's 109 nuclear power plants generated 610 BKWh of electricity—21 percent of the total U.S. production. In 1994, how many BKWh of electricity did the average U.S. nuclear power plant generate each month?

Answer: ____________________ BKWh

4. In 1994, biomass provided the nation with 2.8 quads of energy. How many quads of biomass energy were provided by wood and wood waste?

U.S. Consumption of Biomass

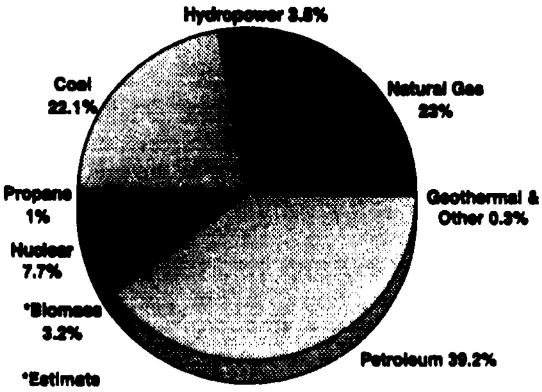


Answer: ____________________ quads

Energy experts predict the nation's total annual energy use will increase by **26 percent** by the year 2010. Which energy sources will provide that additional energy? Will all of them change at the same rate as consumption, or will some sources increase more, while others remain unchanged? Some source may even decline in consumption during the next 15 years.

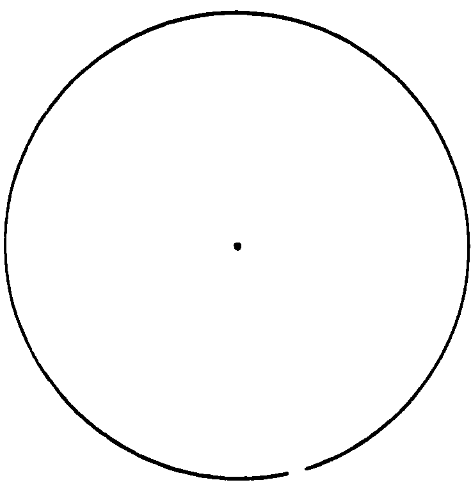
Below is a circle graph showing the contribution each of the energy sources provided the nation in 1994. As a team, discuss what role each of the sources will play over the next 15 years. After your discussion, complete the blank 2010 circle graph. To show you what 26 percent more looks like, the 2010 blank circle graph is 26 percent larger than the 1994 circle. Make sure you include your reasons for selecting the number of quads each source will provide in 2010.

1994 Consumption of Energy By Source



1.	Petroleum	34.7 quads
2.	Natural Gas	20.3 quads
3.	Coal	19.6 quads
4.	Nuclear	6.8 quads
5.	Hydropower	3.1 quads
6.	Biomass	2.8 quads
7.	Propane	0.8 quads
8.	Geothermal & Other	0.4 quads
	TOTAL	88.5 quads

2010
Consumption of Energy By Source



1.	Petroleum	quads
2.	Natural Gas	quads
3.	Coal	quads
4.	Nuclear	quads
5.	Hydropower	quads
6.	Biomass	quads
7.	Propane	quads
8.	Geothermal & Other	quads
	TOTAL	quads

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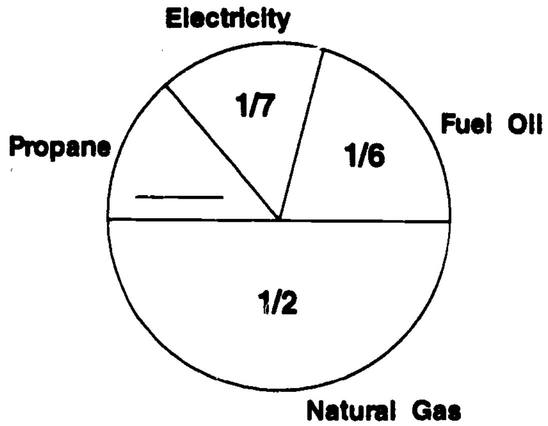
1. The average American household uses 57 percent of the total energy it consumes just for heating and cooling rooms. Each month, 4.6 MBtu's of energy are used for maintaining comfortable temperatures in our homes. How many MBtu's of energy does the average housing unit consume each year for heating and cooling rooms?

Answer: ______________________ MBtu

2. Natural gas is primarily used for heating buildings and homes. In fact, natural gas heats over one-half of the nation's housing units. Reduced to the lowest common denominator, what fraction of the housing units in 1994 were heated by propane (the fourth leading source of home heating energy)?



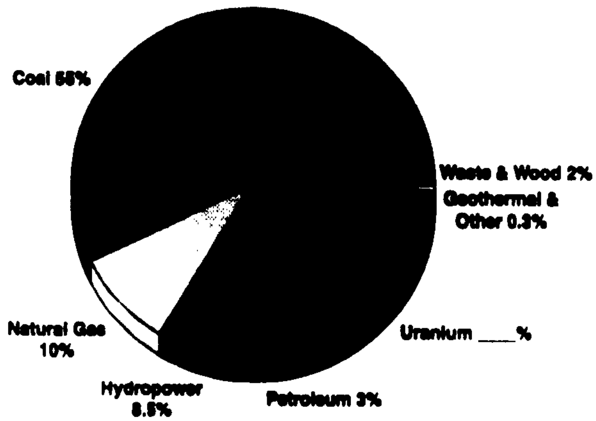
Answer: ______________________

3. The United States consumes more petroleum than it can produce. In 1994, the U.S. consumed 17.6 Million Barrels a Day (MBD) of petroleum—only half of the petroleum was supplied by domestic production. To the nearest tenth of an MBD, how many MBDs were imported from other nations to supply America's demand for petroleum in 1994?

Answer: ______________________ MBD

4. In 1994, what percentage of the nation's electric power was generated by uranium?

1994 Electric Power Generated By Source



Answer: ______________________ percent

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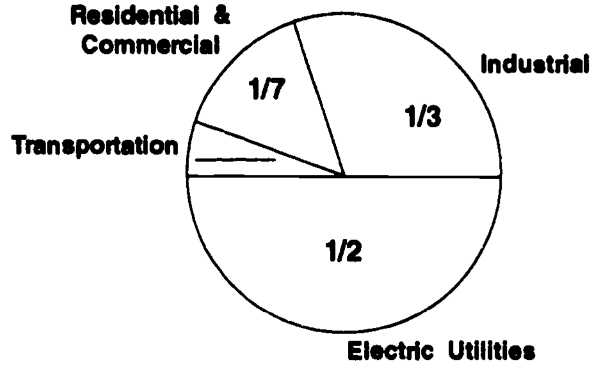
1. Hydroelectric power is the nation's top renewable source of energy. Hydroelectric power provided 3.1 of the 88.5 quads of energy the U.S. consumed in 1994. Energy experts predict hydroelectric power production will remain relatively constant during the next five years. How many quads of energy will hydroelectric power provide the nation during the next five years?

Answer: ____________________ quads

2. Renewable energy sources provided the nation with approximately seven of the 88.5 quads of energy the U.S. consumed in 1994. The use of renewable energy for the production of electricity accounted for almost half of the consumption of all renewable sources. Reduced to the lowest common denominator, what fraction of the nation's renewable sources were used for transportation?

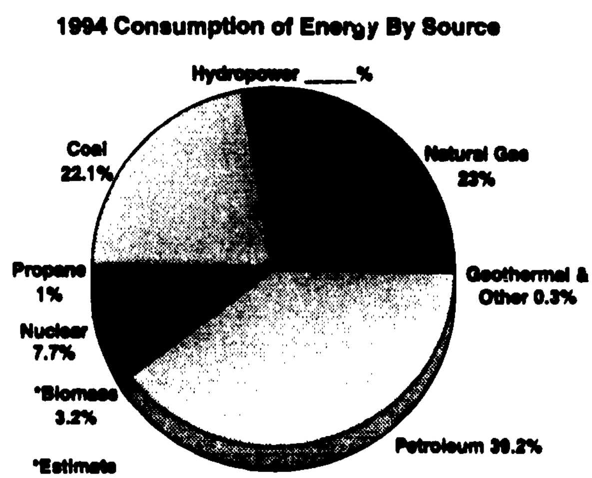


Answer: ____________________

3. Propane is 270 times more compact in its liquid state than it is as a gas. This makes propane a very portable source of heat energy. How many liters of propane gas would a three liter pressurized tank hold for your next camping trip?

Answer: ____________________ liters

4. In 1994, what percentage of the nation's total energy consumption was provided by hydropower?



Answer: ____________________ percent

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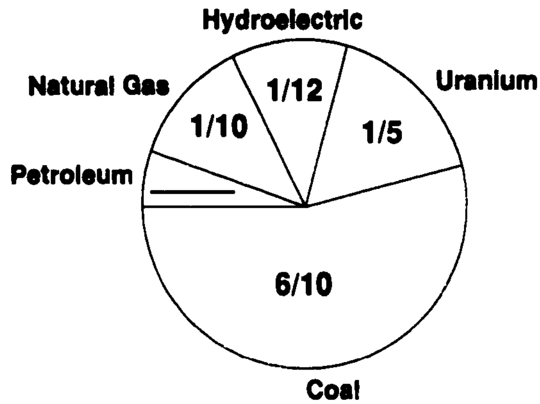
Energy Math Challenge Round Three

1. In 1994, the United States imported almost half of its petroleum from other countries. The average daily import was 8.8 million barrels. In 1994, how many barrels of petroleum did the nation import during the month of March?

Answer: ______________________ barrels

2. Coal, the nation's top source of energy for generating electricity, provides over half the nation's electric power. In fact, the major use of coal is the production of electricity. Reduced to the lowest common denominator, what fraction of the nation's electricity was provided by petroleum (the nation's fifth leading source of electricity)?



Answer: ______________________

3. Approximately 6/7 of the energy given off by the splitting of uranium atoms in a nuclear reactor is due to the heat energy produced by the motion of the splitting atoms. The other 1/7 of the heat energy is a result of the radiation released from the nucleus of the splitting atoms. If uranium provided the nation with 6.8 quads of energy in 1994, how many quads of energy were the result of the radiation released by the splitting of uranium atoms?

Answer: ______________________ quads

4. In 1994, what percentage of the nation's consumption of biomass energy was provided by wood and wood waste?

U.S. Consumption of Biomass

Answer: ______________________ percent

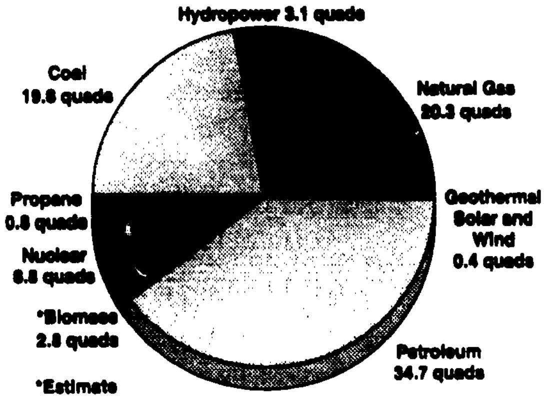
Energy Math Challenge Mega Question

In 1994, almost all the energy we used in the United States came from non-renewable energy sources. Using the 1994 circle graph below, figure out how many total quads of energy we used, and how many quads were renewable and non-renewable. Write your answers in the spaces below.

By 2010, experts predict that the United States will use 26 percent more energy than we do now. Figure out how many total quads of energy the United States will use and write it in the space below.

Will we use the same sources to provide that energy or will we use different sources? As a team, discuss how the energy picture will change by 2010. Fill in the blank circle graph using your team's predictions. The blank circle graph is 26 percent larger to show you what this increase looks like. How many quads of renewable energy do you think we will use? How many quads of non-renewable energy? Add up the figures on your graph and fill in the total amounts.

1994 Consumption of Energy By Source



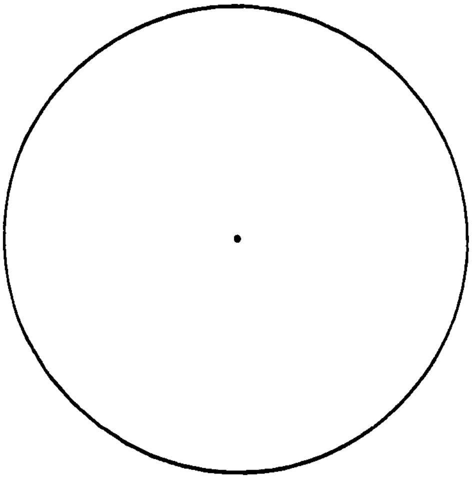
1994

Renewable:_______________quads

Non-renewable: ___________quads

Total energy use:___________quads

2010
Consumption of Energy By Source



2010

Renewable: _______________ quads

Non-renewable: ___________ quads

Total energy use: __________ quads

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