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ABSTRACT

This is one of a series of 14 instructional components of a semester-long, environmental earth science course developed for undergraduate students. The course includes lectures, discussion sessions, and individualized learning carrel lessons. Presented are the study guides and script for a learning carrel lesson on energy, energy policies, and energy resources. The slides, audio-cassette tape, and other materials necessary to the lesson are not included. (BT)

SCIENCE EDUCATION CENTER

STUDY GUIDE AND SCRIPT

SECTION II: ENERGY

LESSON 6.6: FUTURE PROJECTIONS

ENVIRONMENTAL STUDIES

A Cooperative Project of The Department of Geological Sciences and the Science Education Center

The University of Texas at Austin

ENVIRONMENTAL EARTH SCIENCE

"Environmental Earth Science" is a new course developed at The University of Texas at Austin by the Department of Geological Sciences and the Science Education Center. It is offered at The University of Texas at Austin as Geology 361K and has been tried out during the spring semesters of 1972, 1973, 1974, and 1975. Revisions have been made as necessary after each tryout. The project within which the course has been developed has been supported by the National Science Foundation.

The course includes lectures, discussion sessions, and individualized Learning Carrel Lessons. Extensive use has been made of multi-media technology in the presentation of the course. Learning Carrels for individualized instruction have been especially designed for this program. The lectures introduce specific topics, suggest problems or questions, and provide background information. The discussion sessions provide the student an opportunity to ask questions and clarify ideas. The discussion sessions also provide input and feedback to the instructor.

The Learning Carrel Lessons have been written by faculty and graduate students in the geological sciences and in science education. Writers and resource contributors include Dr. Robert Boyer, Dr. Rolland Bartholomew, Dr. Keith Young, Dr. Samuel Ellison, Dr. James Underwood, Dr. David Butts, Dr. Addison E. Lee, David Keller, Melanie Lewis, Wayne Schade, Ann Lee, and William McLoda. Technicians involved in production of scripts, sound, and photography were Stan Prescott, Lee West, Charles Geffen, and William McLoda. Artists were Jesus Rivas, Alice Canestaro, Aly Knox, and Javier Flores.

Each Learning Carrel Lesson consists of a set of 2 x 2 slides, an audio cassette tape, a study guide, a script, and other materials necessary to the lesson. The study guide and script are in this booklet. Students may set their own time schedule within an announced period when slides and tapes are made available.

The student should note the list of Learning Carrel Lesson topics to place in proper content the lesson in this booklet, and then read carefully the introduction, rationale, prerequisites, and lesson objectives in the study guide. The student should follow the instructions in the study guide for the entire lesson. In some instances, these instructions are also repeated on the audio cassette tape. The slides and tapes have been synchronized to automatically advance the slides appropriate to the audiotape. However, there is a tone signal given before the change of each slide so that the lesson can be used outside of the carrel if automatic facilities are not available. When the student is ready to start the lesson, the "on" switch should be pushed. If the slides and tape are operated manually, both will need to be turned "on." The first slide is always a title slide or a blank solid colored slide. If the slides and tape are manually operated, this title or blank slide should be on view before the tape is started. For automatic operation, the slides and tapes will be set up by the Instructor or Proctor before the lesson and between each use. It is most important to start each lesson according to these instructions in order to provide synchronization of the slides and tape. Remember that slides placed in the tray to be used with a rear view screen are reversed from those to be used with a front view screen.

The student will be instructed by the study guide and/or the tape to stop at various places to carry out certain activities. Usually the audio-tape will say, "Please stop the tape now and restart only when you have finished this exercise." Therefore, the student should wait a few seconds to finish hearing the instruction after the word "Stop." However, one should not wait long enough for the tone signal or automatic change to the next slide. This signal should be heard after you restart the tape. If the lesson is moving too rapidly, the student may stop the tape and slides at any time to consult the study guide or script, but it is NOT POSSIBLE to back up and re-examine a given slide without completing the entire cycle of the lesson.

It is particularly important for the student to carry out the instructions for activities given in the study guide. In order that a record may be maintained of these activities, each student should pick up a copy of the STUDENT RESPONSE SHEET which include questions to be answered and the other activities requiring responses. These should be completed and turned in to the instructor as required for grading, feedback for the instructor, and to provide a basis for student interaction in the discussion group.

Each Learning Carrel Lesson is independent within the context of the course. Some of them provide direct information on a given topic, but in an individualized mode requiring some activities and thought on the part of the student. Others place the student in a role-playing situation where some position must be taken on provocative questions or issues. Others deal primarily with applications of environmental information. In all the lessons, the student is expected to receive basic information that is coordinated with the lectures, the small group discussions, and the readings.

ENVIRONMENTAL EARTH SCIENCE

LEARNING CARREL LESSONS

STUDY GUIDE FOR LEARNING CARREL LESSON

6.6

FUTURE PROJECTIONS

ENVIRONMENTAL STUDIES

A Cooperative Project of the Department of Geological Sciences and the Science Education Center

THE UNIVERSITY OF TEXAS AT AUSTIN

TO THE STUDENT:

This booklet contains two sections: (1) the Student Study Guide for this lesson, and (2) the Script or printed copy of the discussion recorded on the audio cassette tape.

You are expected to begin with the printed instructions in the Study Guide and follow them continuously as you study the lesson. In many instances the same or similar instructions may also be heard on the audio cassette tape. Refer to the script only if you need to refresh your memory as to something that was said. The script is provided because you cannot back up the tape if you need to review something already said on the tape.

Specific instructions will be given in the Study Guide as to when to start and stop the tape. Do not restart the tape until instructed to do so in the Study Guide.

Questions requiring written answers should be completed on the STUDENT RESPONSE SHEETS provided by the Instructor.

This lesson is in two parts and is somewhat long. You may choose to do Parts I and II at separate times.

INSTRUCTIONS:

1. Read the Introduction, Rationale and Objectives for this lesson that follows. If you have questions, check with the Instructor or Proctor.

INTRODUCTION:

Return for a moment to your own elementary school days and recall a once popular riddle, "Where was Noah when the lights went out?". Of course, the answer was, "He was in the dark." Exchange places with Noah for a moment and imagine your predicament if every one of the lights in our country suddenly flickered and died. Nowhere would you be able to find a bulb or breaker to correct the damage created by a sudden shortage of electrical energy. Even as the temperature of your own previously air-conditioned environment began to rise, you would find nearly every household appliance you own useless. You would find it impossible to transmit or receive communication, avail yourself of commercial services, or transact your everyday affairs. Your ease of travel would be limited to the extent of the fuel presently in your car. The list of complications created by a shortage of energy is endless and unfortunately closer to realization than is commonly thought.

Each year our energy industries fall further behind in their ability to supply power on demand to a nation rapidly depleting its natural energy resources. Without even knowing it, we have already stepped into "A Crisis in Energy." This lesson investigates the nature and extent of our national energy situation.

Part I of this lesson explores facts and opinions currently under discussion among experts engaged in redirecting our national energy policies. Following the format of a TV program, it is a real interview with real experts in the energy field who have presented their views specifically for this lesson. The experts were Dr. Wilson Laird, Director of the American Petroleum Institute, Washington, D.C.; Dr. Samuel Ellison, Professor of Geological Sciences and Dean of the College of Natural Sciences (currently Alexander Deussen Professor in Energy Resources) at The University of Texas at Austin; and Dr. Herbert Woodson, Chairman, Department of Electrical Engineering at The University of Texas at Austin. These experts discuss significant trends in the production and consumption of our principle energy resources.

Part II of this lesson provides you with basic information concerning our energy resources. Much of it is in the form of graphs for you to read and interpret. In other instances, specific numbers or other data are given and you will be asked to translate these data into various forms of graphs. The purpose of these exercises is to reinforce your knowledge of the subject and emphasize the importance of various means of communication to learning.

RATIONALE:

"Self-evident as it may seem, in most situations we can help individuals adapt better if we simply provide them with advance information about what lies ahead." (Alvin Toffler in Future Shock)

OBJECTIVES OF THIS LESSON:

The objectives of this lesson are listed below. As you proceed through the program, place a checkmark in the column(s) which indicates in what part of the lesson each objective was discussed. (USE STUDENT RESPONSE SHEETS)

Upon completion of all the exercises associated with this lesson you should be able to:

Part I	Part II	Objectives
		1. state length of time undiscovered gas and oil will last in the United States
		2. state the lead time in discovering oil
		3. state 2 difficulties involved in importing hydrocarbons
		4. state 4 methods of mining coal
		5. explain the fluctuation in the utilization of coal from 1900 to 1980
		6. state the years in which hydrocarbons and coal are expected to reach peak production in the United States
		7. identify 2 fuels which can be used in a nuclear electric installation
		8. describe the process involved in converting Uranium-238 into Plutonium-235
		9. define lead time as used in this lesson
		10. state length of time known recoverable reserves of gas and oil in the United States will last
		11. state 4 reasons for the current and expected continuance of the energy crisis in the United States
		12. evaluate ramifications of a decrease in available energy in the United States in terms of the gross national product, unemployment, and per capita income
		13. identify trends in energy consumption by fuel type during the next 10 years

During the next 15 minutes you will listen to the interview that is Part I of your lesson. An edited transcript of the interview is prepared for you at the back of this Study Guide if you care to refer to it for review.

INSTRUCTIONS:

2. Start the audio cassette tape and slides (for manually operated slide carousels, be sure the slide on the screen is the title slide or the blank colored slide in slot number one. Otherwise, the slides and tape will not be synchronized). Listen to the tape and view the slides until the interview is completed at the end of Part I, then STOP THE TAPE AND SLIDES.

Preview your lesson objectives and identify those objectives that relate to specific concepts in the interview. Check the objectives on your STUDENT RESPONSE SHEET.

INSTRUCTIONS:

3. Restart the audio cassette tape. Listen to the tape and view the slides until you are told to name a few trends that you think might influence our rate of petroleum production, then STOP THE TAPE AND SLIDES as instructed. List these trends under Frame 1 of your STUDENT RESPONSE SHEET.

Frame 1

List trends that you think might have influenced the rise in the rate of petroleum production in the United States. (USE STUDENT RESPONSE SHEET)

INSTRUCTIONS:

4. Restart the audio cassette tape. Listen to the tape and view the slides until you are told to stop the tape. Then STOP THE TAPE AND SLIDES. You will need to continue viewing the slide with the graph "Complete Cycle of Natural Gas Production in the United States and Adjacent Continental Shelves, Exclusive of Alaska," since the questions below will require reading this graph. Answer the questions under Frame 2 on your STUDENT RESPONSE SHEET.

Frame 2

1. The projection for the production of natural gas between 1966 and 1980 is how many cubic feet?

2. What is our total capacity for the production of natural gas during the 160 years plotted on the graph?

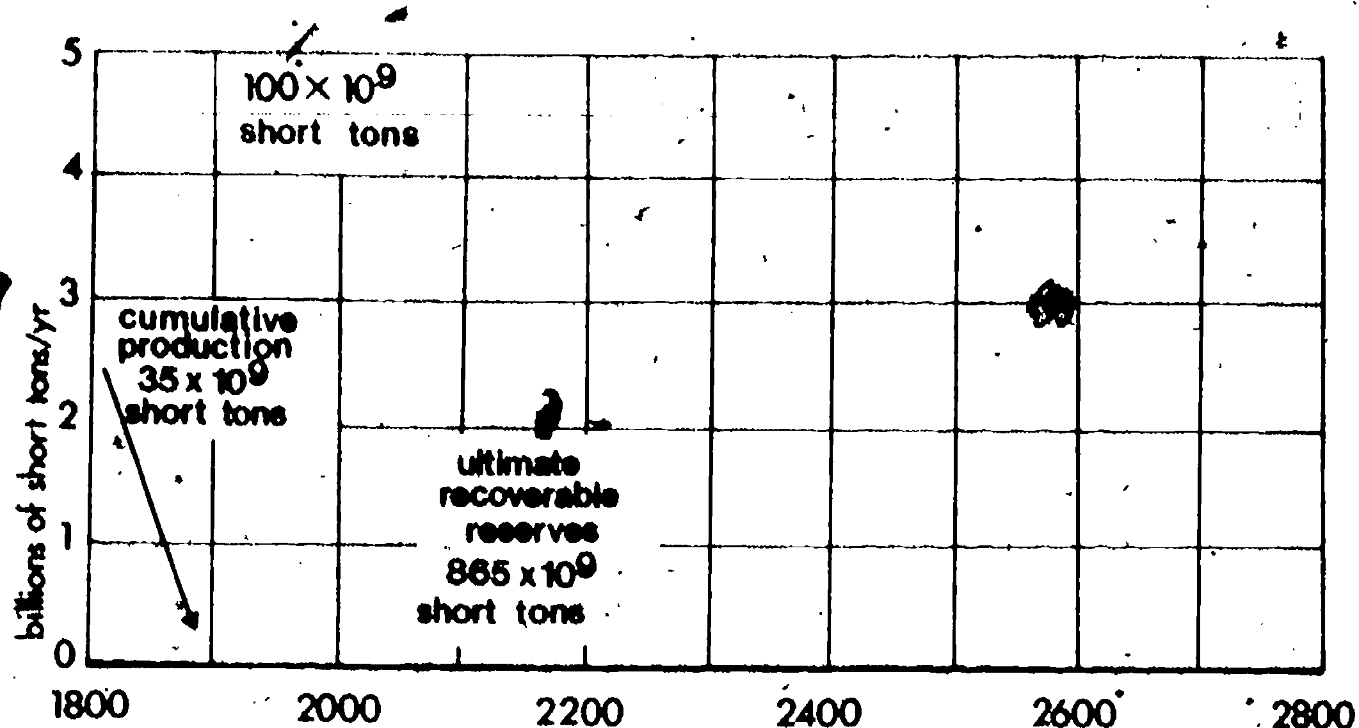
3. What is our percent per year production of natural gas in terms of our total potential production?

4. How many cubic feet of natural gas is estimated to be produced between the years 1980 and 2000?

5. During this 160 year period, the slope of the bell curve becomes zero in what year?

INSTRUCTIONS:

5. Restart the audio cassette tape. Listen to the tape and view the slides until you are told to stop the tape. Then STOP THE TAPE AND SLIDES. Study the grid entitled "Ultimate U.S. Coal Production" and the data below it on the next page and from the data provided plot the curve on your STUDENT RESPONSE SHEET.



ULTIMATE U.S. COAL PRODUCTION

YEAR	BILLIONS OF SHORT TONS PER YEAR
1800	.02
1900	.30
2000	1.40
2100	2.20
2200	2.30
2300	2.00
2400	1.10
2500	.60
2600	.25
2700	.05
2800	.02

INSTRUCTIONS:

6. Restart the audio cassette tape. Listen to the tape and view the slides until told to stop the tape. Then STOP THE TAPE AND SLIDES and answer the questions under Frame 3 on your STUDENT RESPONSE SHEET.

Frame 3

1. Who are the primary consumers of coal, both past and present?

Frame 3 (continued)

2. Name 2 factors which might have caused peaks and dips during the years 1900 and 1970 on the graph above.

3. Name 4 pollutants emitted in the burning of coal.

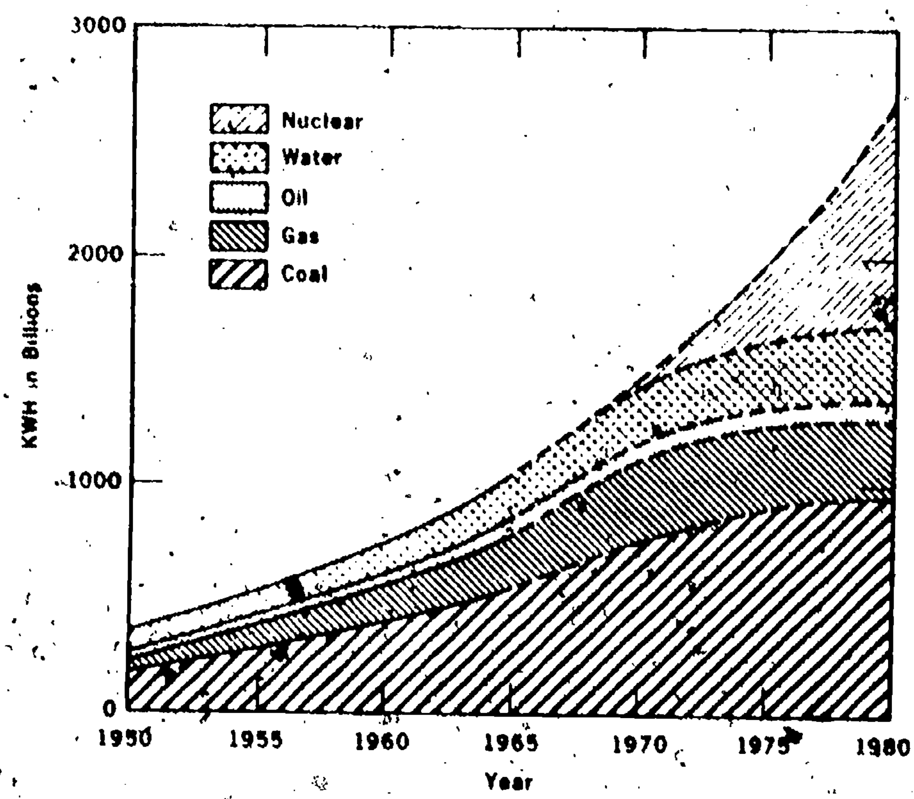
INSTRUCTIONS:

7. Restart the audio cassette tape. Listen to the tape and view the slides until you are told to score your answers. Mark your score on the STUDENT RESPONSE SHEET.

INSTRUCTIONS:

8. Restart the audio cassette tape. Listen to the tape and view the slides until you are told to stop the tape. Then STOP THE TAPE AND SLIDES, and study the graph below and answer the questions under Frame 4 on your STUDENT RESPONSE SHEET.

ANNUAL ENERGY REQUIREMENTS FOR ELECTRIC GENERATION



Frame 4

1. In 1980 nuclear fuels will contribute _(?)_ billion kilowatt hours (KWH) toward the total generation of electricity.

2. In 1980 coal will contribute (a) _(?)_ billion KWH toward the total generation of electricity or (b) _(?)_ percent of the 5 major contributors.

3. Referring to the graph of "Ultimate U.S. Coal Production," you might conclude that 900 billion KWH is equivalent to _(?)_ short tons of coal (assuming all coal production is used in the generation of electricity).

4. In 1980, which of the 5 sources will contribute least to electric generation?

INSTRUCTIONS:

9. Restart the audio cassette tape. Listen to the tape and view the slides until you are told to score your answers. Then STOP THE TAPE AND SLIDES and record your score on the STUDENT RESPONSE SHEET.

10. Restart the audio cassette tape. Listen to the tape and view the slides until told to stop the tape. Then STOP THE TAPE AND SLIDES. You will need to continue viewing the graph "Projected Electric Generation by Source - 1965-2000," in order to fill in the blanks on the chart below. Fill these in on your STUDENT RESPONSE SHEET.

11. Restart the audio cassette tape and listen to the tape and view the slides until you are given instructions to check your answers with those on the slide. Then STOP THE TAPE AND SLIDES and mark your score on the STUDENT RESPONSE SHEET.

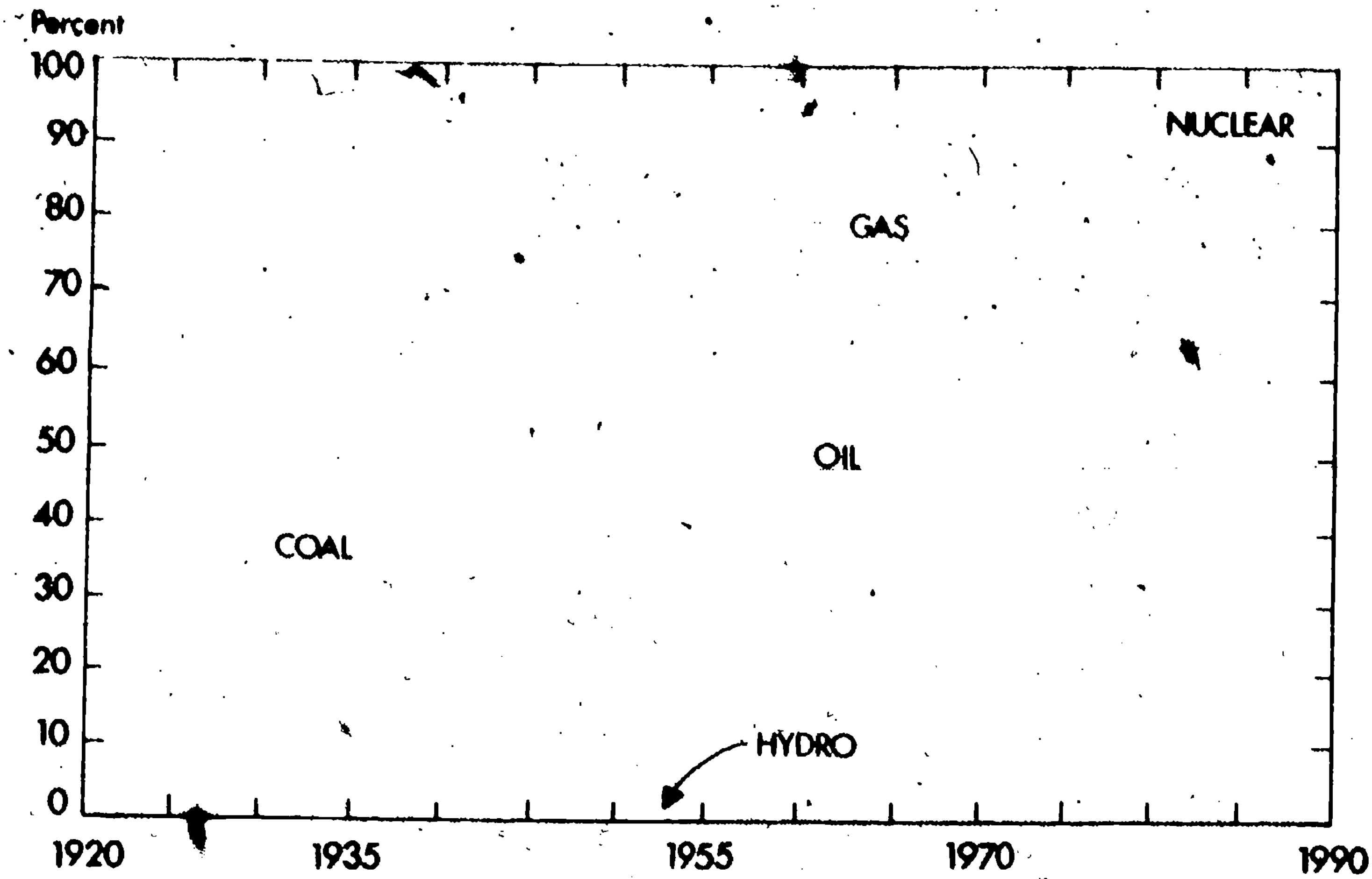
Frame 5

PROJECTED ELECTRIC GENERATION BY SOURCE--1965-2000

SOURCE	TRILLION KILOWATT HOURS		
	1965	1980	2000
Nuclear-fueled steam	.2	.7	(?)
Coal-fueled steam	.4	.8	(?)
Oil-fueled steam	.2	(?)	.6
Gas-fueled steam	.1	.2	(?)
Other	.1	.1	(?)
Pumped-storage hydro	.05	.05	.1
Conventional hydro	.2	(?)	.4

INSTRUCTIONS:

12. Restart the audio cassette tape. Listen to the tape and view the slides until you are instructed to stop the tape. Then STOP THE TAPE AND SLIDES and complete the following graph as instructed. Your graph should be made on the STUDENT RESPONSE SHEET.



TOTAL U.S. ENERGY CONSUMPTION, PERCENT BY TYPE OF FUEL.

TYPE OF FUEL	YEARS 1920	1935	1955	1970	1990
Nuclear	--	--	--	1%	25%
Gas	5%	10%	25%	35%	20%
Oil	15%	35%	45%	45%	35%
Coal	75%	50%	25%	14%	15%
Hydro	5%	5%	5%	5%	5%

INSTRUCTIONS:

13. Restart the audio cassette tape. Listen to the tape and view the slide. Compare the graph on the slide with the one you have made. Then STOP THE TAPE AND SLIDES and answer the questions below on your STUDENT RESPONSE SHEET.

Frame 6

1. Coal contributed (?) % to the total U.S. energy consumption in 1920.

Frame 6 (continued)

2. In 1920, hydro contributed (?) % to the total U.S. energy consumption. In 1990 it is projected that hydro will contribute (?) % to our total energy consumption.

3. In 1970 oil contributed (?) % to the total U.S. energy consumption.

INSTRUCTIONS:

14. Restart the audio cassette tape. Listen to the tape and view the slide showing answers to the questions you have just answered under Frame 6. Then STOP THE TAPE AND SLIDES. Record your score on your STUDENT RESPONSE SHEET.

15. Restart the audio cassette tape. Study the graph in the next slide, "United States Uranium Requirements and Production Capability," and follow the discussion on the tape. When told to do so, STOP THE TAPE and answer the questions under Frame 7 on your STUDENT RESPONSE SHEET. You will need to view the slide continuously to find answers to these questions.

Frame 7

1. What is the projected cumulative production capability of uranium in 1980?

2. In 1985 the annual production/requirement will be (?) % greater than the annual production capability.

3. During the period between 1970 and 1985 our cumulative production capability will have increased (?) %. In this same period our cumulative requirement will have increased (?) %.

4. How do you think projected requirements are determined?

5. How would the introduction of a breeder reactor in 1970 have affected these projections for production capability?

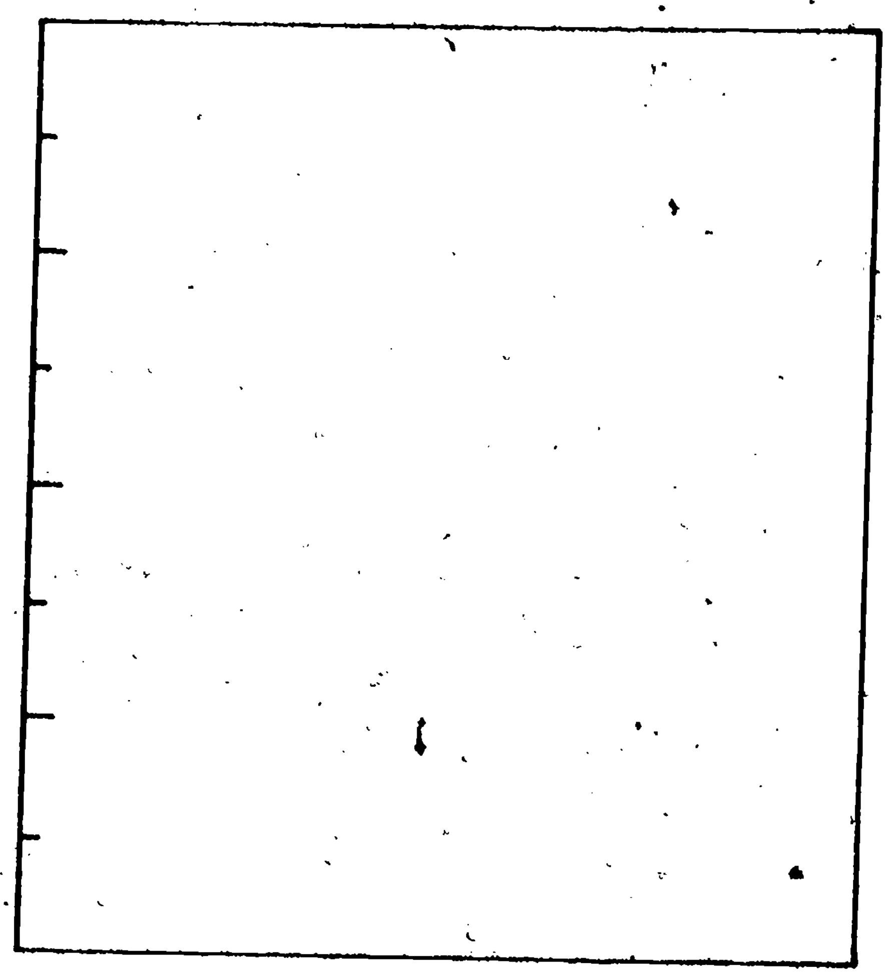
INSTRUCTIONS:

16. Restart the audio cassette tape. Listen to the tape and view the slide with answers to the first four questions under Frame 7. Then STOP THE TAPE AND SLIDES. Mark your score on your STUDENT RESPONSE SHEET.

17. Restart the audio cassette tape and follow instructions for the following graph entitled "Fuel Required." STOP THE TAPE AND SLIDES to complete this graph on your STUDENT RESPONSE SHEET.

Frame 8

FUEL REQUIRED



TYPE OF FUEL	TONS OF COAL PER YEAR		
	1968	1980	1990
Oil	50	90	175
Gas	120	150	180
Nuclear	20	260	600
Coal	300	430	630

INSTRUCTIONS:

18. Restart the audio cassette tape. Listen to the tape and view the slides and compare it with the graph you have made. Then STOP THE TAPE AND SLIDES and answer the questions under Frame 9 on your STUDENT RESPONSE SHEET.

Frame 9

1. Which fuel type is projected to have the highest rate of increase in requirement over the 22-year period?

2. Which fuel type is projected to have the lowest rate of increase in requirement in the 22-year period?

3. Give probable causes for your answers in 1 and 2.

4. List 2 environmental hazards associated with the consumption or production of each of the given fuel types. Do you think these environmental hazards could influence the projections given for each fuel type in 1990?

INSTRUCTIONS:

19. Restart the audio cassette tape. Listen to the tape and view the slides and review your answers to the first two questions above. Then STOP THE TAPE AND SLIDES and record your score on your STUDENT RESPONSE SHEET.

20. Restart the audio cassette tape. Listen to the tape, view the slide, and listen to the description of the graph entitled "Fuel Source Distribution for Electrical Power (1965)." Then STOP THE TAPE AND SLIDES and answer the questions under Frame 10 on your STUDENT RESPONSE SHEET.

21. Restart the audio cassette tape and compare your answers to the above questions with those on the slide. Mark your score on the STUDENT RESPONSE SHEET.

Frame 10

1. What fuel is used in your city to generate electricity?

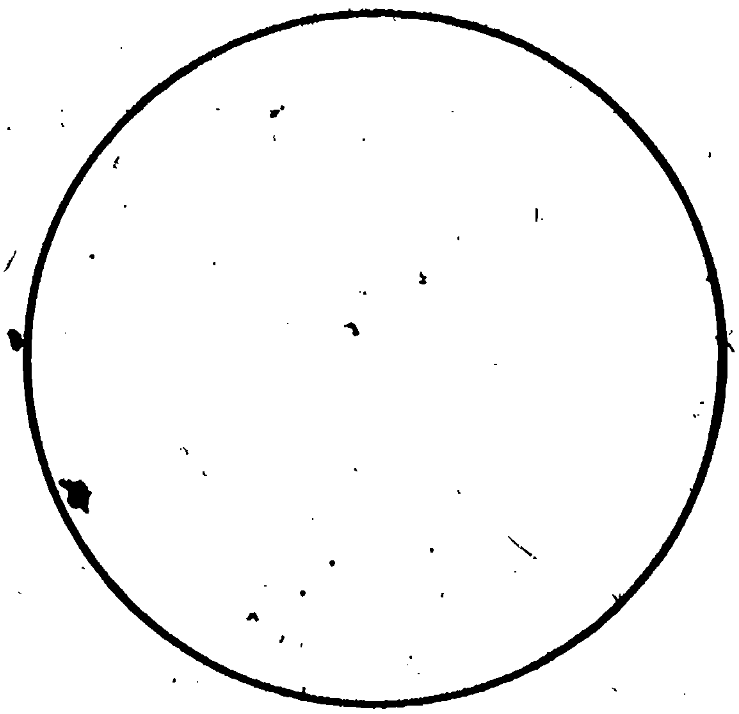
2. Predict what you believe will be the approximate contribution by fuel type to the total U.S. electric power generation in 1980.

Fuel type	Percent Contribution	Trend
A.		
B.		
C.		
D.		
E.		

INSTRUCTIONS:

22. Restart the audio cassette tape. Listen to the tape and view the slides until told to stop the tape. Then STOP THE TAPE AND SLIDES. Complete the graph under Frame 11 on your STUDENT RESPONSE SHEET using the data given below for fuel source distribution for electrical power projected for 1980.

Frame 11



FUEL SOURCE	PERCENT DISTRIBUTION
Nuclear Power	32%
Gas	15%
Oil	3%
Hydro	13%
Coal	37%

FUEL SOURCE DISTRIBUTION FOR ELECTRICAL POWER (1980)

INSTRUCTIONS:

23. Restart the audio cassette tape. Listen to the tape and view the slides. Compare your graph with the one on the slide and record your score on your STUDENT RESPONSE SHEET. Then STOP THE TAPE AND SLIDES.

24. Restart the audio cassette tape. Listen to the tape and view the slides until the end of the lesson.

ANSWERS TO QUESTIONS IN STUDY GUIDE

OBJECTIVES OF THIS LESSON:

The objectives of this lesson are listed below. As you proceed through the program, place a checkmark in the column(s) which indicates in what part of the lesson each objective was discussed. (USE STUDENT RESPONSE SHEETS)

Upon completion of all the exercises associated with this lesson you should be able to:

Part I	Part II	Objectives
	X	1. state length of time undiscovered gas and oil will last in the United States
X		2. state the lead time in discovering oil
X		3. state 2 difficulties involved in importing hydrocarbons
	X	4. state 4 methods of mining coal
	X	5. explain the fluctuation in the utilization of coal from 1900 to 1980
	X	6. state the years in which hydrocarbons and coal are expected to reach peak production in the United States
	X	7. identify 2 fuels which can be used in a nuclear electric installation
X		8. describe the process involved in converting Uranium-238 into Plutonium-235
X		9. define lead time as used in this lesson
	X	10. state length of time known recoverable reserves of gas and oil in the United States will last
X		11. state 4 reasons for the current and expected continuance of the energy crisis in the United States
X		12. evaluate ramifications of a decrease in available energy in the United States in terms of the gross national product, unemployment, and per capita income
	X	13. identify trends in energy consumption by fuel type during the next 10 years

FRAME 1 Answers

Trends to about 1960:

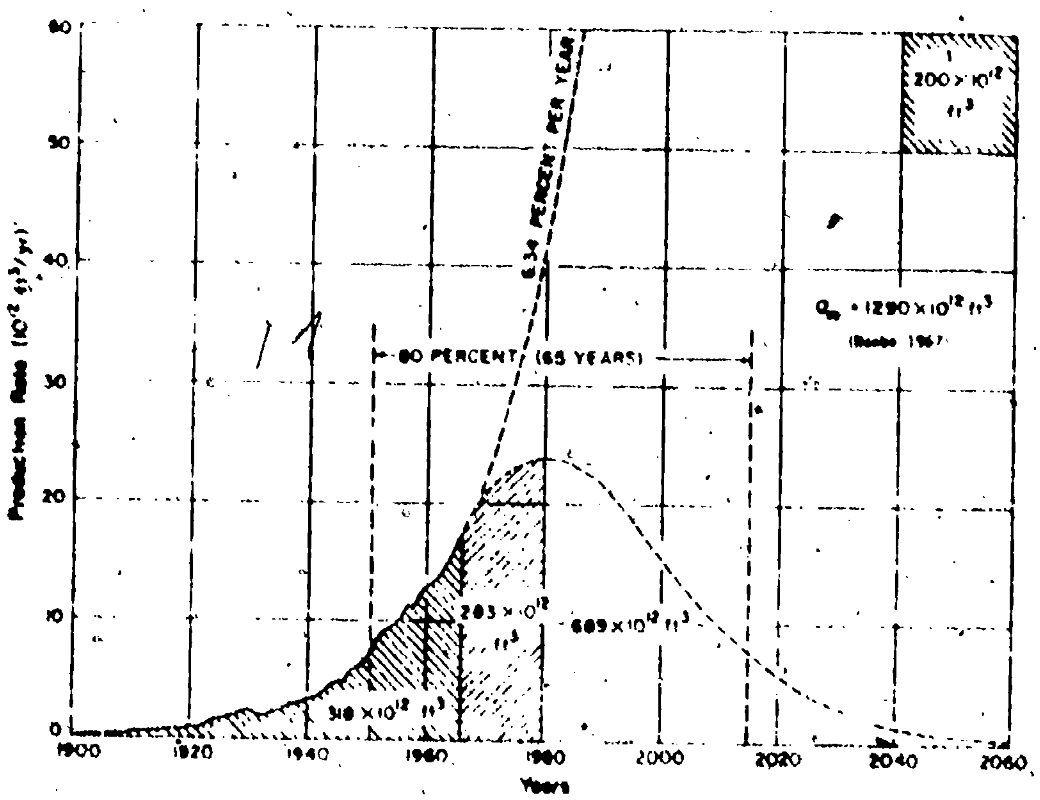
1. increased consumer demand
2. increased production technology
3. increased geologic information about oil formations and locations
4. high profits for many industries (production, refining, transporting, etc.)
5. governmental regulation

Trends after 1960--decrease in rate of production due to:

1. cost increasing faster than profit
2. desirable and profitable well sites diminishing
3. output from individual wells diminishing
4. technology unable to keep pace with demand
5. governmental regulation

FRAME 2 Answers

Answers to the questions below can be determined by a study of the graph or the slide projected on your viewing screen. The same graph is reproduced below.



Complete cycle of natural gas production in the United States and adjacent continental shelves, exclusive of Alaska. (from Hubbert, 1969, p. 190)

1. The projection for the production of natural gas between 1966 and 1980 is how many cubic feet?

   283×10^{12} ft^3. To obtain this answer, read data directly from your graph. On the horizontal axis (abscissa), locate the time period between 1960 and 1980. The projected production for natural gas is already calculated for you between these years and is identified by the numeric value given in this column prepared with repeating diagonal lines. This value represents the total amount of projected production of natural gas (in cubic feet) during the period between 1966 and 1980.

2. What is our total capacity for the production of natural gas during the 160 years plotted on the graph?

   1290×10^{12} ft^3. Add the production values of the 3 primary areas under the curve for the total capacity of production of natural gas during the 160 year period plotted on the graph (i.e., 318×10^{12} ft3 + 283×10^{12} ft3 + 689×10^{12} ft3 = ?)

3. What is our percent per year production of natural gas in terms of our total potential production?

   6.34% per year. Read the numeric value directly from the graph. The slope of the curve in 1966 is used to determine the percent per year production value and is given on the graph as a dotted line extending above the curve to the top of the graph.

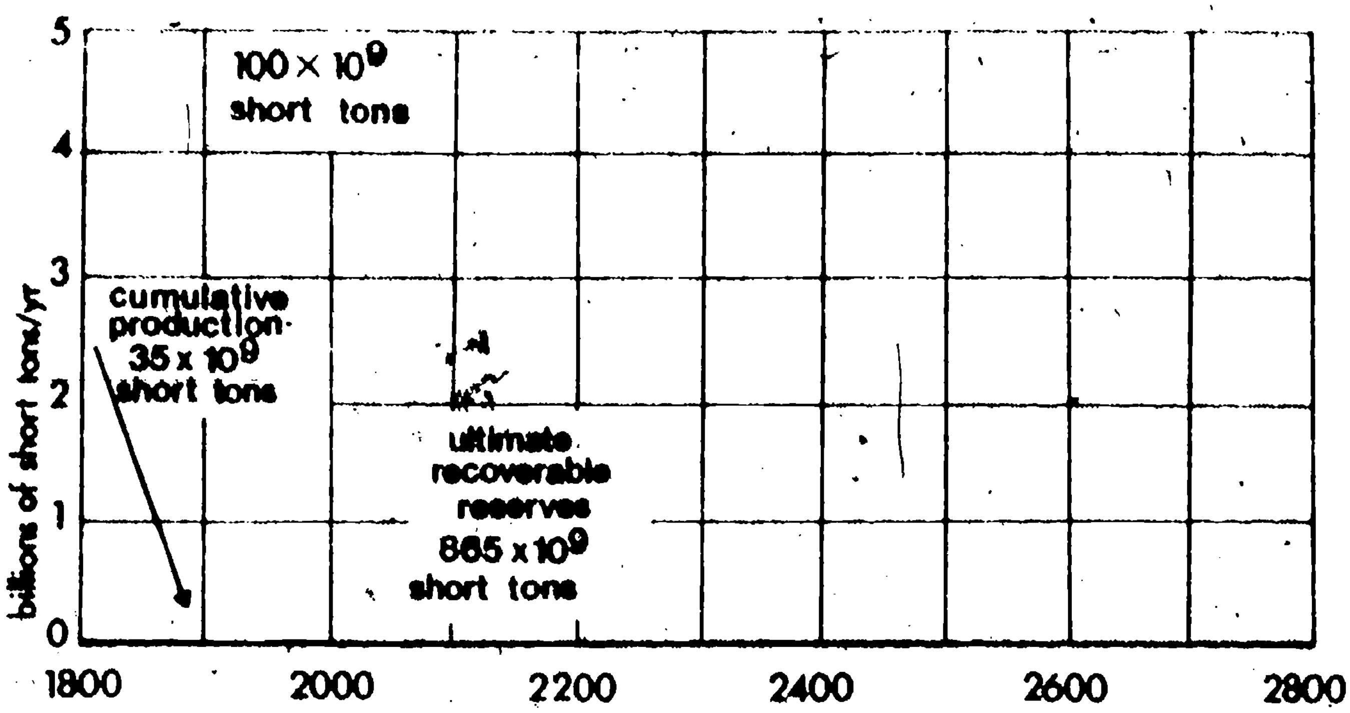
4. How many cubic feet of natural gas is estimated to be produced between the years 1980 and 2000?

   410×10^{12} ft^3. In the upper right-hand corner of the graph is a reference square labeled 200×10^{12} ft^3 to help you determine absolute quantities in terms of area under the curve. Using this square you can approximate the absolute value of projected production during the years between 1980 and 2000 much like you would have done in answer #1 above.

5. During this 160 year period the slope of the bell curve becomes zero in what year?

   1980. The apex (highest point) of the curve is shown in the year 1980.

Graph for Ultimate U.S. Coal Production



ULTIMATE U.S. COAL PRODUCTION

YEAR	BILLIONS OF SHORT TONS PER YEAR
1800	.02
1900	.30
2000	1.40
2100	2.20
2200	2.30
2300	2.00
2400	1.10
2500	.60
2600	.25
2700	.05
2800	.02

FRAME 3 Answers

1. Who are the primary consumers of coal, both past and present?

PAST

1. railroads
2. residential consumers
3. industry (power generation)

PRESENT

1. municipal power generating plants
2. industrial power generating plants
3. heavy industry (used in making steel)

2. Name 2 factors which might have caused peaks and dips during the years 1900 and 1970 on the graph as shown on the slide.

   a. depression of the 1930's
   b. environmental concerns

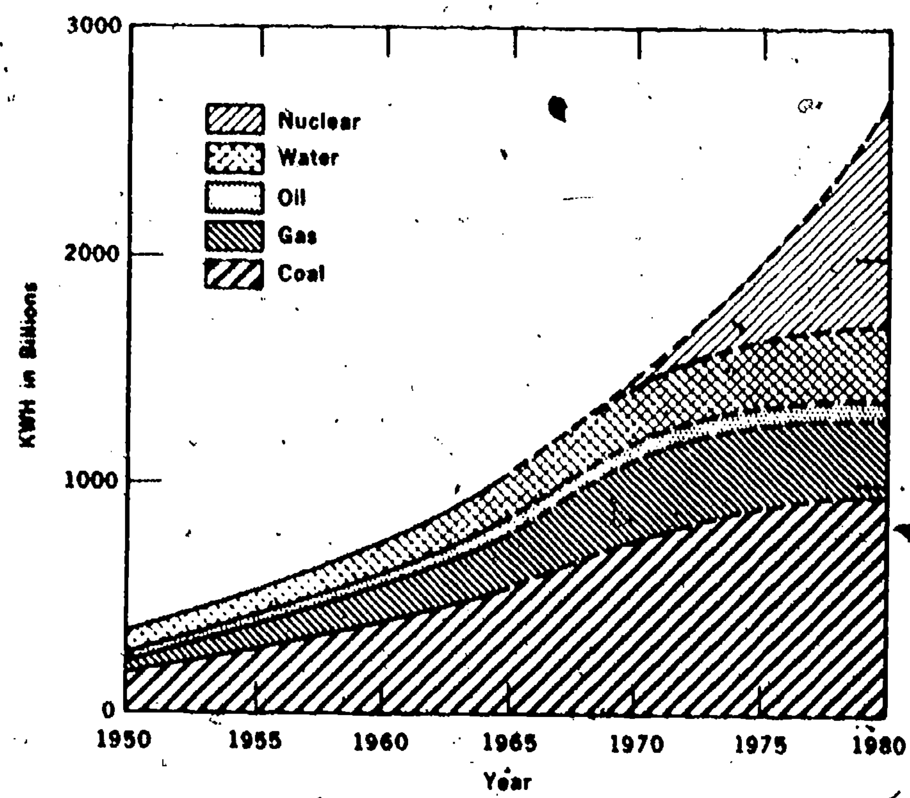
3. Name four pollutants emitted in the burning of coal.

   SO_2-- sulfur dioxide   Cd -- cadmium
   Hg - mercury   Pb -- lead

FRAME 4 Answers

The following graph is taken from: Singleton, Arthur L. Sources of Nuclear Energy, Atomic Energy Commission, 1968, p. 54.

ANNUAL ENERGY REQUIREMENTS
FOR ELECTRIC GENERATION



1. In 1980 nuclear fuels will contribute 1000 billion kilowatt hours (KWH) toward the total generation of electricity.

   To obtain this figure, locate the year 1980 on the horizontal axis. Now locate the nuclear contribution for this year and determine the approximate amount of KWH's produced in this year from the index given on the vertical axis (ordinate) on the left side of the graph. Remember the abscissa is given in increments of 1000 KWH intervals.

2. In 1980 coal will contribute (a) 900 billion KWH toward the total generation of electricity or (b) 33 percent of the 5 major contributors.

   To obtain these figures, determine the absolute requirement of coal in 1980 by first following the steps given in answer #1. Next, determine the total requirement for all contributors in 1980 by adding the individual fuel contributors or reading the cumulative annual requirements directly from the graph (i.e., in 1963 the cumulative annual requirement was 1000 billion KWH). Using the following formula, determine the percent requirement of coal to the total requirement:

$$\frac{\text{coal requirement (1980)} \times 100}{\text{total annual requirement 1980}} = \text{-\% requirement}$$

3. Referring to the graph of "Ultimate U.S. Coal Production," you might conclude that 900 billion KWH is equivalent to 1 billion short tons of coal (assuming all coal production is used in the generation of electricity).

   900 billion KWH is the projected requirement of coal in 1980 (reading from the graph of "Annual Energy Requirements for Electric Generation"). Determine from the graph of "Ultimate U. S. Coal Production" how much coal will be produced in 1980. Assuming all coal production is used in the generation of electricity, these two values should be equivalent.

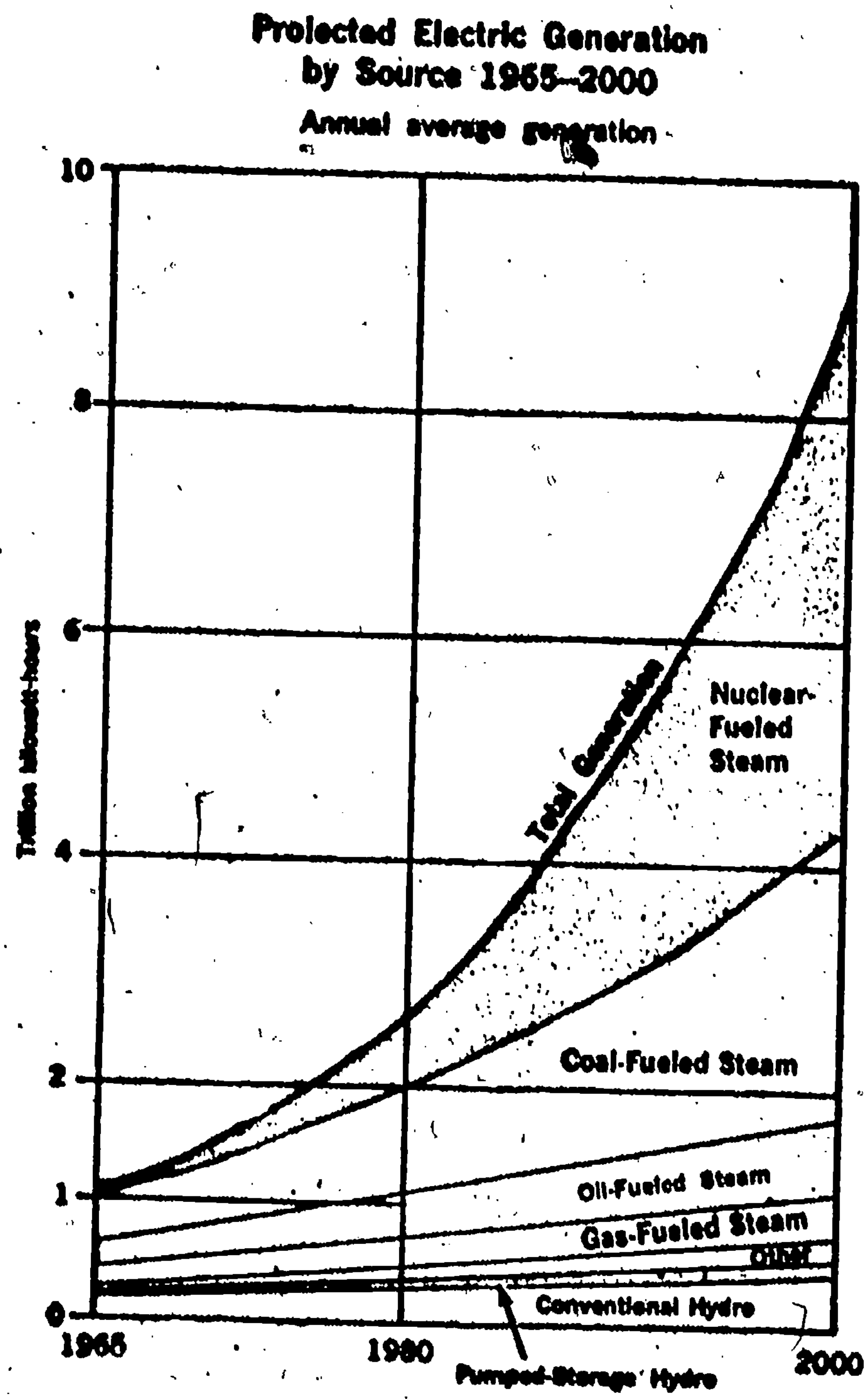
   coal requirement for electric generation (1980) = United States coal production (1980)

4. In 1980, which of the 5 sources will contribute least to electric generation?

   Oil. According to the graph of "Annual Energy Requirements for Electric Generation (1950-1980)," oil will contribute least to electric generation. How do you think oil will be used in 1980?

FRAME 5 Answers

The following data are taken from a bulletin published by The Council on Environmental Quality, 1970, p. 81.

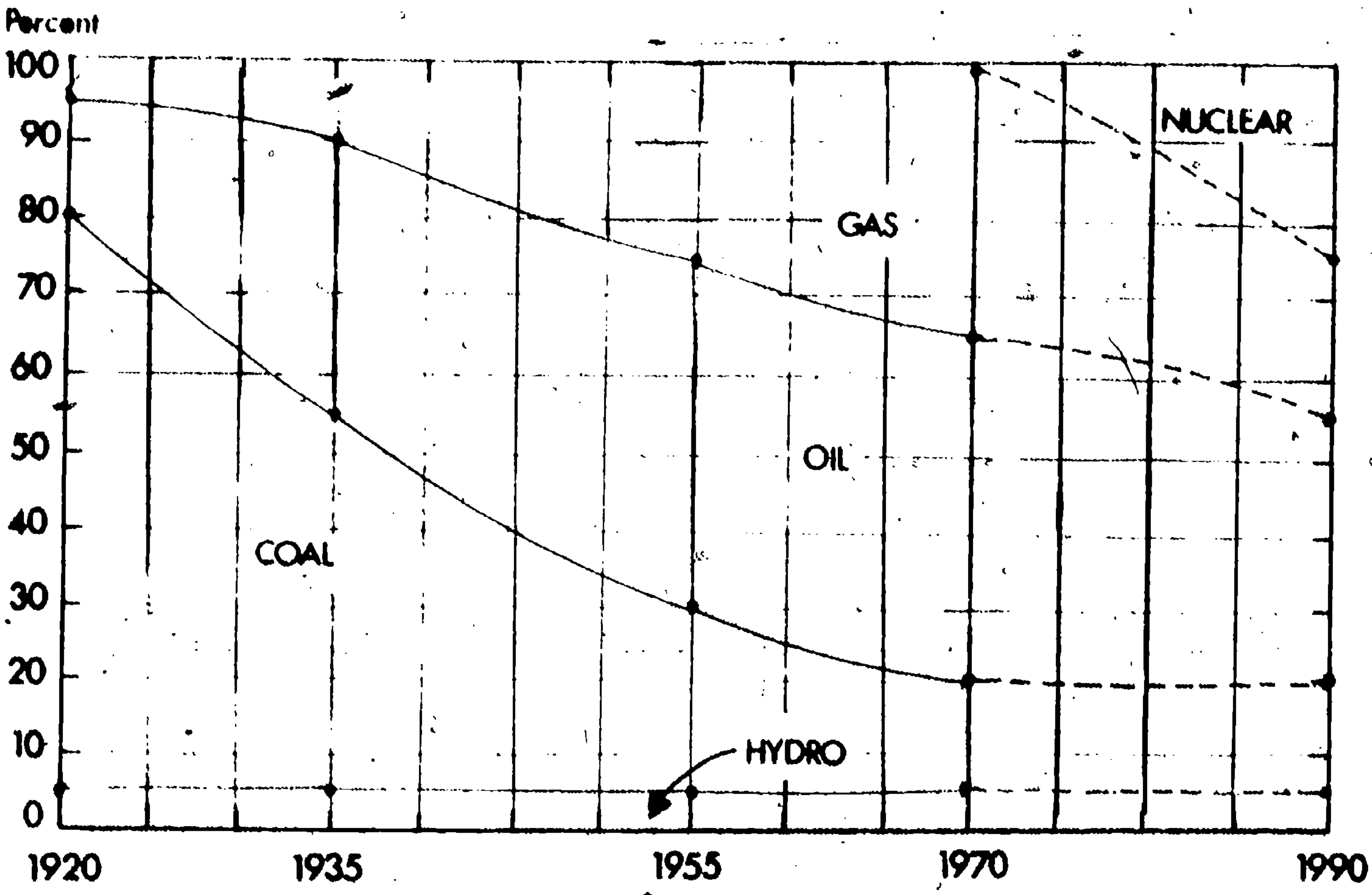


Sources: Water Resources Council; Bureau of Mines, Department of the Interior.

To complete the table below, find the year in question on the horizontal axis of your graph. Locate the energy source in question and determine its maximum and minimum values in trillion KWH for the year in question. The absolute difference between these two values determines the equivalent energy generation for a particular source.

SOURCE	TRILLION KILOWATT HOURS 1965	1980	2000
Nuclear-fueled steam	.2	.7	4.5
Coal-fueled steam	.4	.8	2.5
Oil-fueled steam	.2	.4	.6
Gas-fueled steam	.1	.2	.4
Other	.1	.1	.2
Pumped-storage hydro	.05	.05	.1
Conventional hydro	.2	.3	.4

FRAME 6 Answers



TOTAL U.S. ENERGY CONSUMPTION, PERCENT BY TYPE OF FUEL.

TYPE OF FUEL	YEARS 1920	1935	1955	1970	1990
Nuclear	--	--	--	1%	25%
Gas	5%	10%	25%	35%	20%
Oil	15%	35%	45%	45%	35%
Coal	75%	50%	25%	14%	15%
Hydro	5%	5%	5%	5%	5%

1. Coal contributed 75% to the total U.S. energy consumption in 1920.

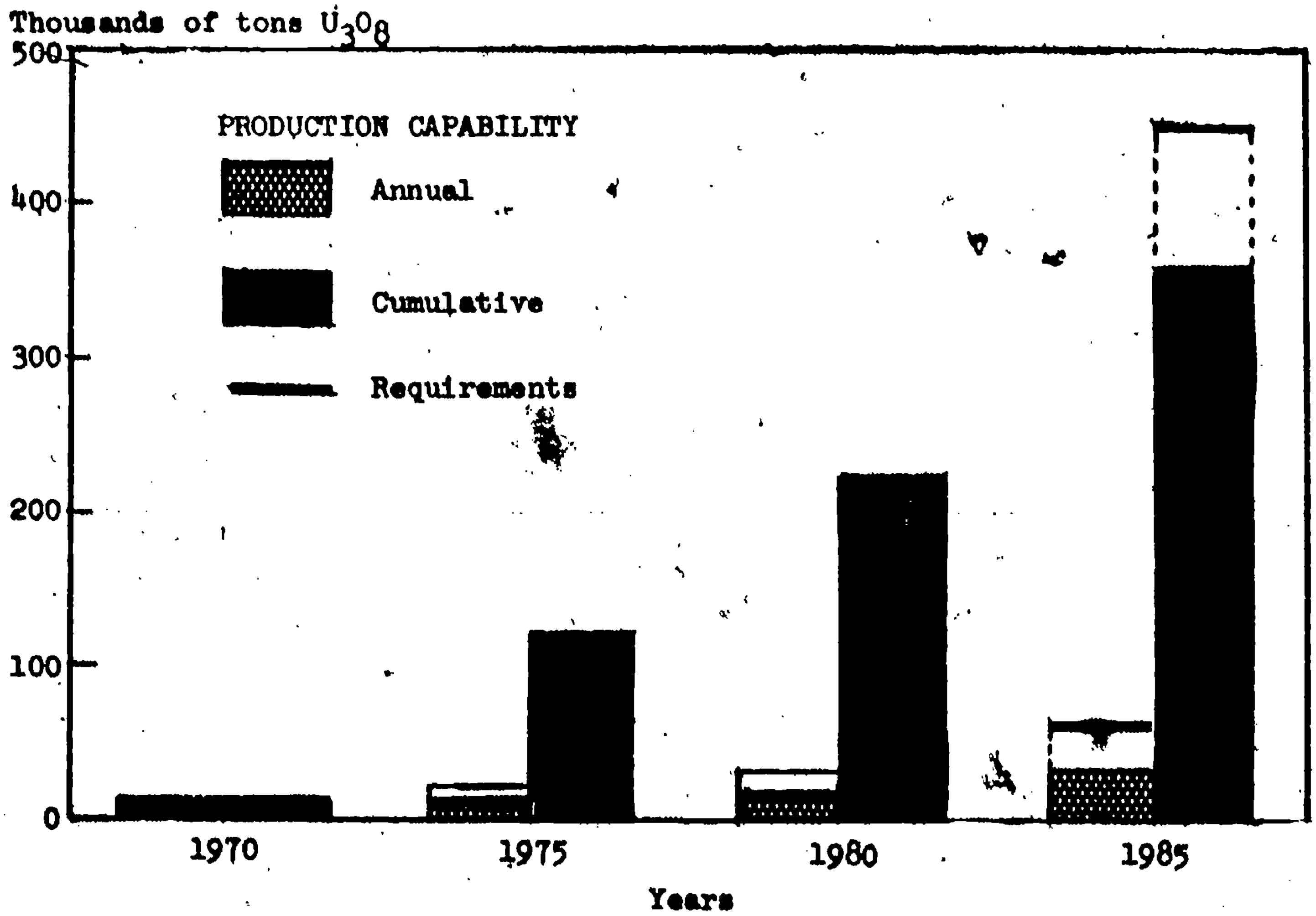
2. In 1920 hydro contributed 5% to the total U.S. energy consumption. In 1990 it is projected that hydro will contribute 5% to our total energy consumption.

3. In 1970 oil contributed 45% to the total U.S. energy consumption.

You can read these answers directly from the graph (width of the band in %) or the table.

FRAME 7 Answers

The following graph is copied from the one shown on the slides you have viewed. It was used as a basis for answers to the questions that follow.



UNITED STATES URANIUM REQUIREMENTS AND PRODUCTION CAPABILITY

1. What is the projected cumulative production capability of uranium in 1980?

230 Thousands of Tons of U_3O_8

2. In the 1985 the annual production requirement will be 100% greater than the annual production capability.

To determine this answer:

$$\frac{\text{annual production requirement} - \text{annual production capability}}{\text{annual production capability}} \times 100 = \%\ \text{Increase}$$

or $\frac{66 - 33}{33} \times 100 = 2900\%$ Increase

3. During the period between 1970 and 1985 our cumulative production capability will have increased (a) 2900%. In this same period our cumulative production requirement will have increased (b) 7483%.

a. $$\frac{\text{cumulative production capability (1985)} - \text{cumulative production capability (1970)}}{\text{cumulative production capability (1970)}} \times 100 = \%\ \text{Increase}$$

$\frac{360 - 12}{12} \times 100 = 2900\%$ Increase

b. $$\frac{\text{cumulative production requirement (1985)} - \text{cumulative production requirement (1970)}}{\text{cumulative production requirement (1970)}} \times 100 = \%\ \text{Increase}$$

$\frac{455 - 6}{6} \times 100 = 7483\%$ Increase

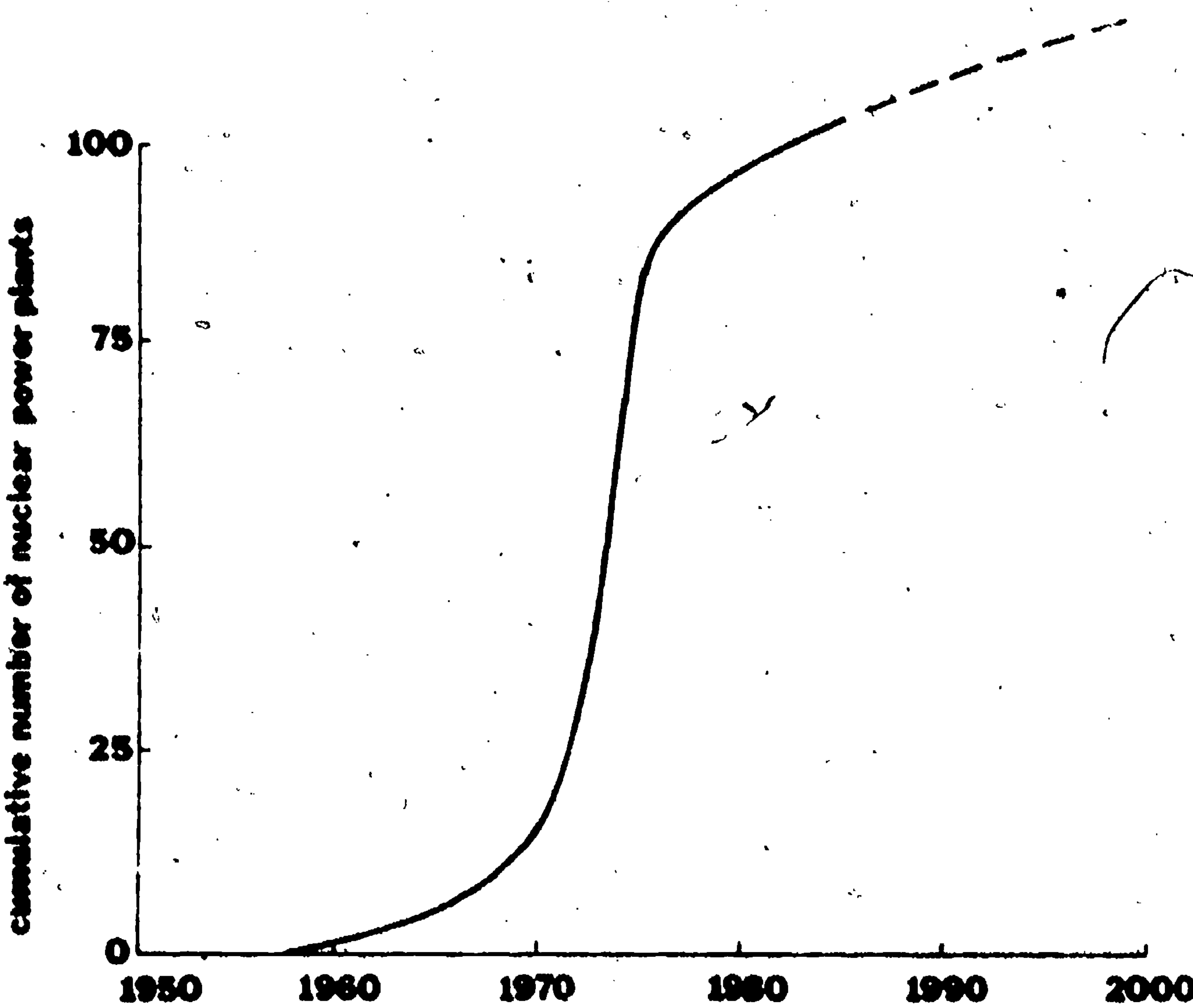
Note: How do answers (a) and (b) compare? What is the significance of the differences?

4. How do you think projected requirements are determined?

Government and private studies based on trends in consumption of electrical power greatly influence projections for the requirement of nuclear fuels. Remember, all of this energy resource is ultimately converted to electricity. There is an expected high correlation between power consumption and economic indices, such as gross national product, unemployment, consumer activity, and even population. The lack of other available fuels at competitive prices has perhaps the greatest influence on projections for the use of nuclear fuels.

5. How would the introduction of a breeder reactor in 1970 have affected these projections for production capability?

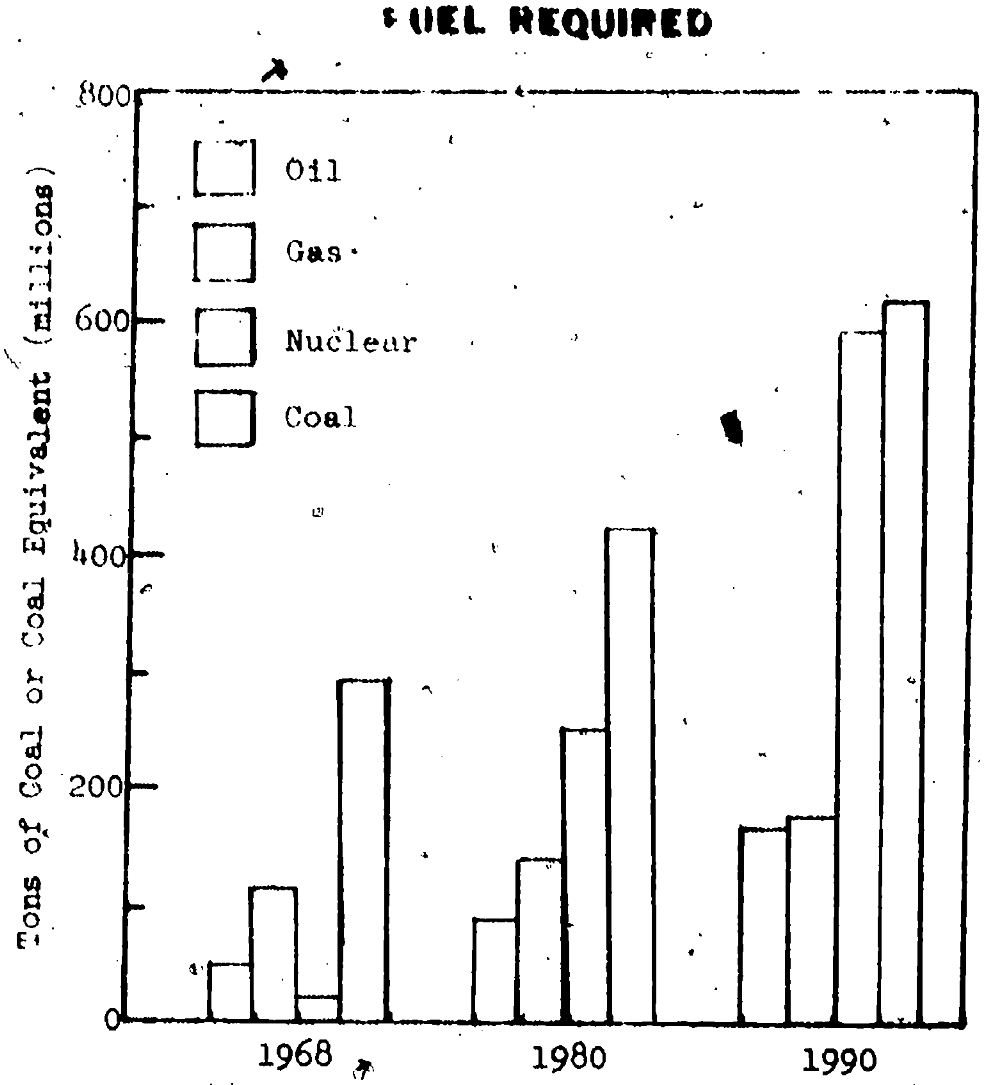
At current prices there are only about 550 plant years of known recoverable Uranium 238 in existence in the U.S. This means that if only one nuclear plant were built, we could expect it to have sufficient fissionable fuel for only 550 years. If two plants were built, this time factor would be cut in half, or 225 years. In the graph below projections for the cumulative number of nuclear power plants in the U.S. in 1980 are given. If 100 plants do exist in 1980, each plant would have less than 5 years of productive life -- assuming equal fuel consumption at each plant site.



PROJECTED INCREASE IN NUCLEAR POWER PLANTS in UNITED STATES

Compare the graph above with the graph of "United States Uranium Requirements and Production Capability."

FRAME 8 Answers



TYPE OF FUEL	TONS OF COAL PER YEAR 1968	1980	1990
Oil	50	90	175
Gas	120	150	180
Nuclear	20	260	600
Coal	300	430	630

FRAME 9 Answers

1. Which fuel type is projected to have the highest rate of increase in requirement over the 22-year period?

   Nuclear. Examination of each bar should reveal which fuel type is projected to have the highest rate of increase in requirement. The rate of increase may be determined by calculating the percent growth of requirement over the 22-year period.

   Example:

   $$\frac{\text{coal (1990)} - \text{coal (1968)}}{\text{coal (1968)}} \times 100 = \%\ \text{Increase}$$

2. Which fuel type is projected to have the lowest rate of increase in requirement in the 22-year period?

   Gas. Use the above procedure to identify the fuel type projected to have the lowest increase in requirement.

3. Give probable causes for your answers in 1 and 2 above.

   Indications are that nuclear fuels will become inexpensive to produce and consume and may ultimately prove harmless to the environment. Gas will have the lowest rate of increase because we have already recovered nearly all that is economically feasible to do so. Without changes in technology and price structures, little more gas can be expected to be recovered relative to our needs because we are already producing natural gas at a maximum rate.

4. List 2 environmental hazards associated with the consumption or production of each of the given fuel types. Do you think these environmental hazards could influence the projections given for each fuel type in 1990?

   Nuclear: thermal pollution, disposal of radioactive wastes, radiation emission
   Gas: SO_2 discharge, LNG transportation
   Oil: oil spills, SO_2 discharge
   Coal: strip mining, SO_2 discharge

   The protection of the environment will probably plague the energy industry for a long time to come. Should the production or consumption of any fuel prove too dangerous to public health and welfare, it would be reflected in scaled down projections for its use. Of course, the opposite holds true as well. Unless satisfactory substitutes are developed, future projections will also reflect scaled down values for our standard of living.

FRAME 10 Answers

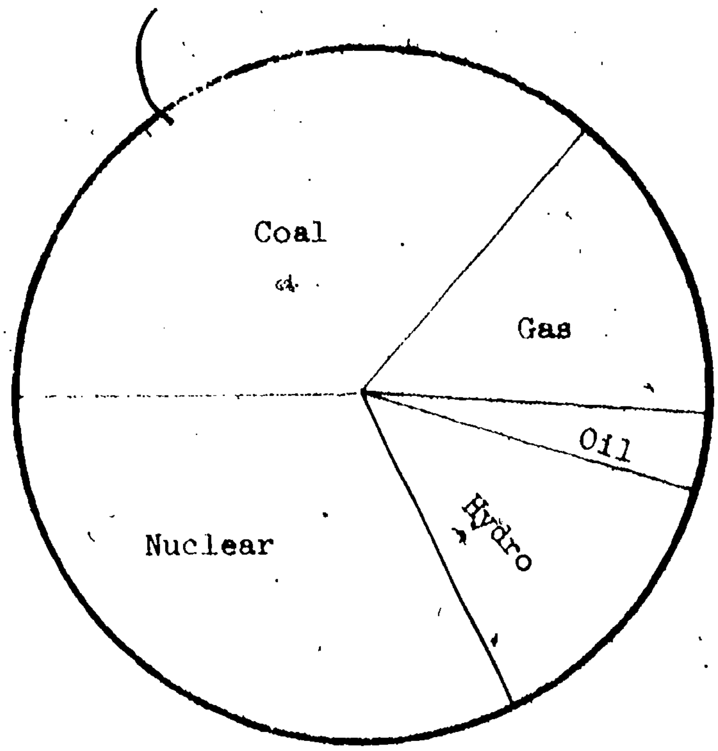
1. What fuel is used in your city to generate electricity?

   Austin, Texas - Natural gas with oil used as a reserve fuel in an emergency.

2. Predict what you believe will be the approximate contribution by fuel type to the total U.S. electric power generation in 1980.

Fuel type	Percent Contribution	Trend
A. Nuclear	32%	Increase
B. Coal	37%	Decrease
C. Natural Gas	15%	Decrease
D. Oil	3%	Decrease
E. Hydro	13%	Decrease

FRAME 11 Answers



FUEL SOURCE	PERCENT DISTRIBUTION
Nuclear Power	32%
Gas	15%
Oil	3%
Hydro	13%
Coal	37%

To prepare this pie-graph above, locate the center of the circle with a ruler placed on the diameter of the circle. Draw a radius. Place a protractor on the radius with the "0" on the center and the straight edge of the radius. For 37% coal, compute 37% of 360° = 133°. Make a new radius at this point. Move the protractor to this radius and compute for gas, 15% of 360° = 54°. Repeat this procedure to calculate oil, 3% = 11°, hydro, 13% = 47°, and nuclear, 32% = 115°.

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SCRIPT FOR LEARNING CARREL LESSON

6.6

FUTURE PROJECTIONS

ENVIRONMENTAL STUDIES

A Cooperative Project of the Department of Geological Sciences and the Science Education Center

THE UNIVERSITY OF TEXAS AT AUSTIN

1

Blank
Slide

2

Energy
Future Projections
L.C.L. 6.6

(title)

3

National Week in Review (photo of group seated around a coffee table)

Good Evening. This is National Week in Review. Tonight . . . "A Crisis in Energy."

4

A Crisis in Energy (group photo)

Our guests this evening include Dr. Wilson Laird, Director of the American Petroleum Institute, Washington, D.C., Dr. Samuel Ellison, Professor of Geological Sciences and Dean of the College of Natural Sciences at The University of Texas at Austin, and Dr. Herbert Woodson, Chairman, Department of Electrical Engineering, also from The University of Texas at Austin. Your moderator, Mr. Stan Prescott.

5

Dr. Wilson Laird

(Laird) "I think that we should clarify the situation a little bit to say approximately how much of the energy is made up by oil and gas."

6

Dr. Wilson Laird

"Approximately 75 percent of all of the energy that we use in the United States is generated by oil and gas. A relatively small amount, about 4 percent, by water, an infinitesimal amount at this moment (percentage-wise) from the nuclear, and the remainder being coal."

7

Dr. Wilson Laird

"Now we are using at the present time in the United States about 15 million barrels of oil a day, which is roughly five million barrels a day more than we are able to produce."

8

Graph of U.S. petroleum self-sufficiency 1954-1975

"We have to import the remainder from other countries. We are in a situation where the gas has to be rationed in approximately twenty different states, and over sixty communities. We have a situation where coal, of which we have abundant supplies in the United States, has to be rationed in as far as use is concerned, relative to the sulfur content."

9

Mr. Prescott and Dr. Laird

(Prescott) "Dr. Laird, we read in the newspaper every day about rationing and our dwindling reserves and what not, but why are we faced with a shortage?"

10

Dr. Laird

(Laird) "We are faced with a shortage simply because we have not gone out and actually looked for it in the last fifteen years in the same way that we used to because of governmental policies, because of economics. And secondly, there has been a tremendous increase in demand over the last fifteen years, more so than average."

11

Map titled "International Flow of Petroleum - 1967"

(Prescott) "Hasn't industry been able to keep up with this demand?"

(Laird) "The industry is able to keep up with this demand primarily by the importation of cheaper foreign oil, and to a considerable extent, gas."

(Prescott) "I see."

12

Photo of entire group

(Prescott) "Dr. Woodson, can you tell me and tell our audience why we are faced with a shortage of fuels? This is a fundamental question people are asking these days."

13

Dr. Herbert H. Woodson

(Woodson) "I think one of the things that's aggravated our problems with oil and natural gas has been the problem with burning coal in power plants. There's been so much pressure to cut down the emissions from power plants that there's been a tremendous increased demand for petroleum, for oil and gas, to burn in power plants where we burned coal before. And I think this has aggravated the shortage of oil and gas."

14

Mr. Prescott and Dr. Laird

(Laird) "Yes, because the amount of power that was produced by coal now has to be taken up by oil simply because the gas is not available to do it."

15

Mr. Prescott and Dr. Laird

(Prescott) "Dr. Laird, you're from the American Petroleum Institute. In your opinion, do you think it's a good idea to be burning petroleum in order to generate electricity?"

16

Dr. Laird

(Laird) "I have no inhibitions about burning residual fuel oil to produce electricity. I do have some reservations about burning gas under boilers because of the fact that gas has other higher uses, for example, domestic home heating and for chemical uses."

17

Mr. Prescott and Dr. Laird	(Laird) "But it's again a problem of economics. And one of the reasons we're in this situation right now, to amplify the former remarks, is that the government, because of the importuning primarily of people of environmental persuasion, have kept down the amount of leasing that is being done. For example, in the Gulf of Mexico, where we do know reserves of a considerable magnitude lie."

18

Dr. Samuel P. Ellison	(Ellison) "The environmentalists in their effort to keep a clean environment have really prevented the United States from gaining the use of energy that might be available off our Atlantic and coastal areas, and denial of the right to the Alaska pipeline to be built is denying the use of the North Slope oil reserves right now."

19

Graph titled "Energy Consumption Per Capita"	(Ellison) "I think more importantly, the United States uses about 25 percent of the world's production of oil and gas each day, and yet we have only about 6 percent of the reserves of these things; therefore, our future is, by 1985 we will be depending upon 50 to 60 percent of our oil and gas needs on foreign oil supplies."

20

Group photo	(Prescott) "Dr. Ellison, assuming then that we are running low on domestic oil, I guess the alternative is to import oil and import other fuel needs; however, do you see this as a viable alternative to the growing rate of consumption?"

21

Dr. Ellison

(Ellison) "My reaction is in this world we're going to need all the sources of energy in the future, and certainly importation, as long as that is the economically proper thing to do, is one way of doing it. However, if we try to import all of our fuel needs, that means then that our balance of payments are disappearing very, very quickly and we're spending all of our money and giving it to some foreign country for this fuel."

22

Dr. Ellison and Dr. Laird

(Ellison) "There are other alternatives eventually as the economics are adjusted. We do have tar sands in North America, and we have oil shales in North America; but these will be a long time in developing because of the many complex technical things that allow them to be developed. There is also the possibility of nuclear fuels, and if we go to the nuclear fuels, it's my belief that nuclear energy will be the major source for electrical energy in the future, and that the portable fluid fuels such as oil and gas will have to be reserved and rationed for portable transportation, such as airplanes, automobiles, and boats."

23

Group photo

(Woodson) "If I could just amplify what Dr. Ellison said a moment ago with some quantitative things,"

24

Chart titled "U.S. Energy Balance"

(Woodson) " .. if we refer to the chart on the U.S. energy balance up here, you notice that the projection by 1985 has us importing about 15 million barrels of oil a day."

25

Chart titled "Initial Appraisal 1970-1985"

(Woodson) "Now in terms of today's dollars, I believe that's equivalent to an outflow of money of an amount of 25 billion dollars a year in imbalance of payments,"

26

Dr. Woodson and Stan Prescott

(Woodson) ".. and I think it simply is a matter of fact that this country cannot afford that kind of luxury, to export 25 billion dollars a year."

27

Dr. Ellison and Mr. Laird

(Woodson) "Now it is also an interesting piece of information that in order to build plants to either get crude oil from the oil shale in Colorado, or to built a plant to get this same petroleum liquid from coal would require a capital expenditure of 75 billion dollars, and that's only three years worth of cash outflow from the imports."

28

Dr. Woodson

(Woodson) "Seventy-five billion dollars is an awful lot of capital, but it still seems small compared to 25 billion dollars a year in imbalance of payments caused by the importing of oil. But if we're going to spend the 75 billion dollars to develop this alternative source of petroleum liquids, we have to start now; we can't wait until 1982 or '83."

29

Dr. Laird
and
Dr. Ellison

(Laird) "I would like to make a comment on this. I don't regard the oil shale or the gas from coal or anything else, with the possible exception of nuclear in the power generation field, as being alternatives."

30

Whole group
(Laird speaking)

(Laird) "I regard them as supplements, assuming for example that the rate of energy demand will increase along the lines it has in the last five or ten years. That's point one I'd like to make."

31

Dr. Woodson
and
Stan Prescott

(Laird) "Point two is, I feel myself that we have within the United States and its continental shelf .... I think that we have large reserves of oil and gas as yet undiscovered which we can get now if we were allowed to get at it."

32

Dr. Laird
and
Stan Prescott

(Prescott) "It's my understanding that the lead time in developing an oil well is five years."

(Laird) "The average is five years. I would say that any time, anything from the time that this is an inception of an idea in some geologist's mind until the well is producing oil into the pipeline, can vary anywhere from three to ten years lead time needed. The same thing is true of building refineries or nuclear plants or anything else, and unless we start now to do some of these things, this gap in time is going to go through time. You can't compress it, in other words. So time lost now is time lost forever."

33

Whole group

(Prescott) "I have a question for Dr. Woodson which deals with nuclear fuels. I would be interested in hearing him take this concept of lead time and apply it to the nuclear industry."

34

Dr. Woodson and Stan Prescott

(Woodson) "I think at the moment it is fairly well proven that electric energy generated from nuclear fuels and in light-water fission plants and gas-cooled reactors costs about the same amount as it does to generate the same energy with fossil fuels."

35

Dr. Woodson

(Woodson) "As the cost of fossil fuels go up the nuclear generated electric energy looks better and better, and I think this is especially true in the fact of environmental problems, that as the environmental problems get more and more severe, nuclear energy begins to look better and better."

36

Dr. Woodson and Stan Prescott

(Prescott) "But aren't environmental problems plaguing the nuclear industry these days?"

(Woodson) "They are, but I have a feeling that this is somewhat temporary and the subject of some misunderstanding,"

37

Diagram of how energy is produced in a nuclear power plant

(Woodson) ".. and I think these misunderstandings will be resolved and we will have a continued, almost explosive, growth in the use of nuclear energy to generate electricity."

38

Whole group photo

(Prescott) "Dr. Ellison, are there any cleaner fuels than those fuels we've been mentioning, that is, the petroleum fuels, fossil fuels?"

(Ellison) "There are other fuels, but they are not economically acceptable just yet. One is solar energy, but there are no solar energy plants that can compete with the price of either nuclear or fossil fuels. And I think it's also possible to harness tides and a few other things, but these will be minor things until they become, as Dr. Laird said, supplemental to the total energy needs,"

39

Dr. Laird and Dr. Ellison

(Ellison) ".. and my feelings are that we're going to need all the energy if we want to keep our standard of living high and give the rest of the world a chance at a high standard of living."

(Prescott) "Dr. Laird, can you tell us, in terms of our gross national product, unemployment, and per capita income, what are some of the specific ramifications of a decrease in available energy in the United States as it could affect the average consumer?"

40

Dr. Laird and Stan Prescott

(Laird) "There's no question about the fact that energy is the glue that keeps the whole economic system going and without energy we don't have any products produced, and it's also true that there is a direct correlation between the gross national product of any nation and the amount of energy consumed."

41

Dr. Laird and Stan Prescott

(Laird) "We use in the United States about six or seven times per capita as much energy as any other nation in the world. So as a result, we also have the highest standard of living. Now, if we restrict the use of energy or if energy is not available for any use, obviously, of course, we're going to cut down our economy; we're going to cut down our gross national product, and this will hit the people at the lower end of the economic scale harder than anybody else. And so it's for this reason that the development of additional energy resources and the development of our indigenous resources that we know or think are there. It is important that it be done right now."

42

Dr. Laird and Dr. Ellison

(Prescott) "What is the role of the environmentalist in this?"

(Laird) "I personally feel that the environmentalist has served a very good purpose in the whole thinking of the United States from the sense that they have called our attention to some things that should have been done long ago. But I feel many of them have may well have gone too far and I think that now we've got to compromise to do these things with a minimum damage to the environment, but they forget that man is a part of the environment."

43

Group picture (Woodson speaking)

(Woodson) "Back in the thirties, the name of the game was to exploit the resources, to raise our standard of living and to raise our gross national product, no matter what,"

44

Dr. Woodson and Stan Prescott

(Woodson) ".. and we have now reached a level of affluence and a level of exploitation that we have decided as a society we don't want to do that anymore, and we're right now doing some soul-searching to decide exactly where we do want to get in the spectrum of absolutely no industry all the way to total exploitation of all the resources, and I think the environmentalists are just one component of this society that's trying to decide exactly where it wants to go next. The only frustration I feel is that in all of this you can't have instant gratification and too many environmentalists are asking for instant gratification. There's a lead time to do it".

45 Group Photo

(Ellison) "I also think that it's only in these last few years that people have realized that certain things like fossil fuels are finite, and once we discover all of them and use them, they're gone forever. Of course, we still think there are many more to be discovered world-wide, but the United States has been explored to a greater extent than any other area in the world because of the private ownership of mineral rights."

---

46 Dr. Ellison

(Ellison) "And to expect to find huge discoveries in the future within the land boundaries of the United States that would be comparable to the needs is a pretty slim thing right now. I'm a little pessimistic on that point now, but when we go off-shore, we do very well."

(Woodson) "Or if we use the coal."

(Ellison) "Yes."

---

47 Group picture

(Laird) "Or if we went and did better with more exploration of Alaska, particularly on the North Slope."

---

48 Acknowledgements (group photo)

49 The End Part I

In the next few minutes you will be asked to interpret data presented in a variety of graphs. We'll take a look at a number of them, and then you will be asked to make a few of your own. It's important that you work at your own pace, so take as much time as you need.

Your forthcoming graphs will be followed by a series of short questions which you can find in your Study Guide. In checking your answers against those we will provide you, remember to erase or cross out any mistakes you might have made and record the correct answer. Because you can only benefit from being honest in this program, you will finish each exercise by tabulating your score in the lower right-hand corner of each page. Remember, you're working against no one but yourself.

Try to keep general trends in mind as you participate in this final segment of your lesson. Remember, an inquiry into current energy consumption trends by fuel type could be a keynote of your personal review.

---

50 Graph labeled "Complete cycle of production of petroleum in the U.S. & adj.cont. shelves"

Let's look at this graph labeled "COMPLETE CYCLE OF PRODUCTION OF PETROLEUM LIQUIDS IN THE UNITED STATES AND ADJACENT CONTINENTAL SHELVES EXCLUSIVE OF ALASKA." Notice that a production rate of one billion barrels of oil per year is plotted against less than 3 centuries of time.

The shape of this curve approximates what is commonly called a bell-shaped curve or simply a bell curve. You can see that this curve actually has peaks and dips, such as those leading up to and during the depression and during the 1960's.

In this graph, you are given whole production values during particular time periods. For example, 90 billion barrels of petroleum have been produced to the present. Thirty-nine billion barrels more are expected to be produced by 1980. After that, 71 billion barrels are all that remain to be produced within the United States and its continental shelves.

We will go to another graph in just a moment, but first notice that 80 percent of our total available petroleum will have been produced in a period of 64 years. Our total potential production of 200 billion barrels is currently being realized at a rate of 5.13 percent per year.

Can you think of any factors which might have had an influence on this curve -- for instance, a rise in demand reflected by an increasing population? What about technology? Or government policies? Or even your own geological input? If you wish, take a few moments to name a few trends which you think might influence our rate of petroleum production. Remember, our curve approximates a bell curve. Space is provided for you on the top of page 5 in your Study Guide to record these trends. Stop the tape now. When you are ready, we'll try another.

51 Graph of natural gas production in U.S. and adjacent continental shelves

This graph is very similar to the one you had previously. The title of this graph reads "COMPLETE CYCLE OF NATURAL GAS PRODUCTION IN THE U.S. AND ADJACENT CONTINENTAL SHELVES." This time a production rate of 1 trillion cubic feet per year is plotted against a 160 year period. As in the earlier graph, the box in the upper right-hand corner gives you a reference to use in determining area under the curve.

Turn to page 5 in your Study Guide. You'll see a few questions concerning this graph near the bottom of the page. These questions simply ask you to read data from this graph. You will soon be asked to construct your own curve, so read these questions carefully. Take as much time as you need and when you are ready, restart the tape. Stop the tape now.

---

52 Frame 2 Answers

Here are the answers to the questions you found near the bottom of page 5 in your Study Guide. Give yourself one point for each correct answer and place your total in the bottom right-hand corner on that page. We'll be back in 5 seconds.

---

53 Grid of ultimate U.S. coal production

On the next page of your Study Guide you will find a grid entitled "ULTIMATE U.S. COAL PRODUCTION" and a list of data. We want you to take as much time as you need to plot your own curve from the data provided. A quick survey of the data will tell you to expect something resembling a bell curve. Stop the tape now. When you are ready, we will show you the curve we made from this same data.

---

54 Curve of ultimate coal production

If you had any trouble plotting your curve, stop the tape and examine this graph carefully. You'll notice that we included a peak and a dip in our graph between the years 1900 and 2000. Think again what factors might have influenced this curve during the last 70 years. Try to name the principal consumers of coal -- both past and present. Is there a relation between this curve and environmental impact? There are a few questions at the bottom of the page for you to answer. Stop the tape now Restart when you are ready to continue.

55 Frame 3 Answers

Here are the answers to the questions you found at the bottom of page 6 in your Study Guide. Give yourself one point for each correct answer and place your total in the bottom right-hand corner on that page. We'll be back in 5 seconds.

Here's another type of graph for you to consider. You can see that trends are easily defined with this type of band graph, although you must do some subtraction to determine any value for a given year. The title of this graph is "PERCENTAGE OF TOTAL U.S. PRODUCTION OF BITUMINOUS COAL AND LIGNITE BY TYPE OF MINING."

56 Graph: Percent of total U.S. production of bituminous coal and lignite by type of mining

These curves encompass a 27-year period between 1940 and 1967. You can see that conventional mining with hand loaders has been declining while continuous mining and strip and auger mining are increasing steadily. You can determine the percent contribution of these two types of coal to the total U.S. production in each given year by subtracting the minimum percent from its maximum. For example, in 1954 continuous mining contributed 6 percent to the production while conventional mining mechanical-loaders contributed 56 percent, conventional mining hand-loading, 12 percent, and strip and auger mining, 26 percent. If you had to plot this graph, you would probably start by plotting first continuous mining, then conventional mining mechanical-loading, followed by hand-loading, and then strip and auger mining.

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57 Graph: Annual energy requirement for electric generation

This next graph reads "ANNUAL ENERGY REQUIREMENT FOR ELECTRIC GENERATION." Billions of kilowatts are plotted against a 30-year period. Notice that there are five contributors to electric generation: nuclear fuels, water, oil, gas, and coal.

At the top of page 8 in your Study Guide you will find a short list of questions to answer concerning this graph and the one you plotted on the previous page. We want you to work carefully, so take as much time as you need. Stop the tape now. Only when you are ready to continue should you restart the tape.

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58 Frame 4 Answers

Here are the answers to your previous questions. Again give yourself one point for each correct answer and place this total at the bottom of the page. We'll pause 5 seconds for you to do this.

59 Graph: Projected electric generation by source -- 1965-2000

This graph is similar to the previous one with the addition of a few new contributors. Along the abscissa you will find a period of time equal to 35 years. This time your ordinate is given in trillion kilowatt hours. The title of this graph reads "PROJECTED ELECTRIC GENERATION BY SOURCE -- 1965-2000."

In your Study Guide at the bottom of page 8 you will find a list of data which defines this graph. You will notice that by the year 2000 conventional hydro, pumped storage hydro, gas fueled steam, and others will be only minor contributors to our total electric generation. Blanks have been left in this list of data for you to fill in from information you receive from this graph.

This exercise is to help you understand projections for the generation of electricity by certain types of energy sources. This will be useful in understanding how each energy source contributed to our total energy production in related graphs to follow. Stop the tape now and complete this short exercise. Restart when you are ready.

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60 Frame 5 Answers

Here are the answers to the questions you found in your Study Guide. Give yourself a slight margin of error and one point for each correct answer. Place your total at the bottom of the page. Take a moment now and in the future to correct any wrong answers if you have not done so already. You will find correct answers are a useful study aid. We'll be back in 5 seconds to ask you to make another graph of your own.

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61 Grid of total U.S. energy consumption - percent by fuel type

Please turn now to page 9 in your Study Guide. There you will see a grid labeled "TOTAL U.S. ENERGY CONSUMPTION -- PERCENT BY FUEL TYPE," identical to this slide. Your abscissa spans a period of 70 years and your ordinate gives you a range from 0 to 100 percent. Below this grid is a list of data from which you will plot a graph.

Notice that you are given five contributors to our total energy consumption. Look in the first column labeled the year 1920. As you read down this column, choose one of those fuel types which least contributed to our energy consumption. We recommend that you first plot the hydroelectric contribution for the entire period between 1920 and 1990 and then continue to coal, oil, gas, and nuclear fuels, plotting their prospective contribution. Finally, draw a line between each of the points you have plotted.

Because you have more than one contributor to the total energy consumption, you might expect to arrive at a band graph. Give it a try and, of course, take as long as you need. We will show you one possible graph which can be made from these data when you are ready.

62

Curve: Total U.S. energy consumption percent by fuel type

If you had any trouble plotting those curves, stop the tape and examine your data and this graph carefully. For convenience, we plotted our data beginning with the hydroelectric contribution and finishing with the nuclear contribution. Of course, you may have plotted your graphs in a different order, but be sure your trends look similar to those shown in this graph.

Using this graph or your own, answer those few questions at the bottom of the page. If you used dotted lines on your graph in the period after 1970, give yourself a bonus point for remembering that the period between 1970 and 1990 is only a projection. These questions will be important in understanding the relationship between percentage contribution to total energy consumption by fuel type and the absolute amount consumed of each. We will try to draw additional conclusions in the few remaining graphs ahead. Stop the tape now and answer your questions. When you are ready, restart the tape.

63

Frame 6 Answers

Here are the answers you should have. Give yourself one point for each correct response and total your score at the bottom of the page. Remember to include your bonus point if you earned it. When you have finished this, we will take a short break before looking at the final 4 graphs. Take 5 seconds now to tabulate your score.

64

Bar Graph: U.S. uranium requirements and production capability

This first type is called a bar graph, or histogram. We will finish by looking at a pie graph. Notice that this graph is entitled "UNITED STATES URANIUM REQUIREMENTS AND PRODUCTION CAPABILITY."

You can see that every fifth year between 1970 and 1985 is represented against thousands of tons of U_3O_8. The annual and cumulative production capability is plotted at each given year and each corresponding requirement is shown with a heavy line.

You should remember that the cumulative production capability is the sum of a 5-year growth. Thus, you can assume the cumulative production quantities shown will be approximately equal to 5 times the annual production capabilities given 5 years before. Also notice that both the annual and cumulative requirements can be determined in thousands of tons of U_3O_8.

On page 11 in your Study Guide you will find a series of questions related to this histogram. You will be asked to draw data from this graph as well as consider how these projections are made. Stop the tape now. When you are ready to continue, restart the tape.

65

Frame 7
Answers

The answers to your first four questions are given here. If you missed more than two questions, turn to page 20 in your Study Guide and review that material. Give yourself one point for each correct answer and place your total at the bottom of the page. We'll pause 5 seconds for you to do this.

66

Reference line: "Fuel Required"

On page 13 in your Study Guide, you will find a reference line labeled "FUEL REQUIRED." This line encloses a space in which you will draw a histogram with the data provided below. In preparing this graph, be sure to label all necessary components. Remember, you may take as long as you need. Stop the tape now and restart when you are ready.

67

Bar graph: Fuel Required

As you can see, we prepared our graph with four different colors, each representing a major contributor to our total energy requirement. From the data provided in your Study Guide, we have plotted each source as equivalent tons of coal against 3 separate points in time. You will notice that the trends in this graph encompass a period of only 22 years. Turn now to page 14 in your Study Guide if you are not already there. At the top of the page in Frame 9 you will find a series of questions which you are asked to answer very carefully related to the graph you have just made on the previous page. By now you should be able to read data from a graph with some skill. This exercise will help you understand significant trends which can be interpreted from this histogram and others like it. Stop the tape now and take as long as you need. We'll have the answers for you when you return.

68

Frame 9
Answers

The answers to your first two questions are given here. Again, give yourself one point for each correct answer and total your score below. Stop the tape now. Restart when you have finished evaluating your work.

69 Pie Graph
Fuel source distribution for electrical power (1965)

This is the last type of graph we will consider in your lesson. It's called a pie graph and is labeled "FUEL SOURCE DISTRIBUTION FOR ELECTRICAL POWER (1965)." Four fuel types are shown, each representing it's percentage contribution to the total fuel source distribution for electrical power.

In a moment we will ask you to make a pie graph of your own with data provided in your Study Guide, but first consider which fuel source is used to generate your local supply of electricity. Turn to page 14 in your Study Guide and answer the questions found in Frame 10 related to your own projections for the contribution by fuel type of each of these sources in 1980. Stop the tape now. We will be back with your last graph exercise when you are ready.

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70 Frame 10 Answers

The answers to your previous questions are shown in this slide. If you included a projection for nuclear contribution, give yourself a bonus point. The band graph you plotted on page 9 could have helped you determine which fuel will contribute to our total electric power production. If your answers reflected the trend as shown, give yourself one additional point for each correct answer. Total your score at the bottom of the page. We'll be back in 5 seconds..

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71 Pie Graph
Fuel source distribution for electrical power (circle is given to prepare the graph)

On page 15 in your Stude Guide we have given you a circle in which to prepare your own pie graph. You will notice that the data given is the fuel source distribution for electrical power projected for 1980. As a final exercise, prepare a pie graph with these data. Be sure to label all elements and include a title. We'll show a graph we made from these data when you are finished. Stop the tape now. Restart when you have finished your work.

---

72 Fuel source distribution for electrical power (completed graph)

We hope your graph looks something like this. Check to be sure you have labeled all of your fuel sources as well as their percent contribution.

By now your Study Guide should be fairly complete. It should serve you well in reviewing this lesson. Remember what you have learned in Parts I and II and try to draw conclusions in trends in our country's energy production and consumption. As an environmentalist you should know the consequences of the use of each fuel type on our environment. In your opinion, what is our energy situation? Are we faced with an energy crisis and if so, why?

Take a moment now to tabulate your score for Part II. If you have accumulated 42 points or more, give yourself an excellent rating. If you have accumulated 32 points or less, we suggest you try this lesson again or refer to your Bibliography for additional reading.

73

The End of This Lesson

We hope you have found this lesson helpful in understanding our current energy problems. Look carefully through your Study Guide if you have particular questions. Your Proctor will give you a review examination which you may take with you and answer at your leisure. Stop the tape now. This completes your lesson.

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEETS

Name ____________________

Date ____________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

OBJECTIVES OF THIS LESSON:

The objectives of this lesson are listed below. As you proceed through the program, place a checkmark in the column(s) which indicates in what part of the lesson each objective was discussed. Make your checkmarks on your STUDENT RESPONSE SHEET.

Upon completion of all the exercises associated with this lesson, you should be able to:

Part I	Part II	Objectives
		1. state length of time undiscovered gas and oil will last in the United States
		2. state the lead time in discovering oil
		3. state 2 difficulties involved in importing hydrocarbons
		4. state 4 methods of mining coal
		5. explain the fluctuation in the utilization of coal from 1900 to 1980
		6. state the years in which hydrocarbons and coal are expected to reach peak production in the United States
		7. identify 2 fuels which can be used in a nuclear electric installation
		8. describe the process involved in converting Uranium-238 into Plutonium-235
		9. define lead time as used in this lesson
		10. state length of time known recoverable reserves of gas and oil in the United States will last
		11. state 4 reasons for the current and expected continuance of the energy crisis in the United States
		12. evaluate ramifications of a decrease in available energy in the United States in terms of the gross national product, unemployment, and per capita income
		13. identify trends in energy consumption by fuel type during the next 10 years

Name ______________________

Date ______________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 1 List trends that you think might have influenced the rise in the rate of petroleum production in the United States.

Frame 2 Answer the following:

1. The projection for the production of natural gas between 1966 and 1980 is now many cubic feet?

2. What is our total capacity for the production of natural gas during the 160 years plotted on the graph?

3. What is our percent per year production of natural gas in terms of our total potential production?

Name ______________________

Date ______________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

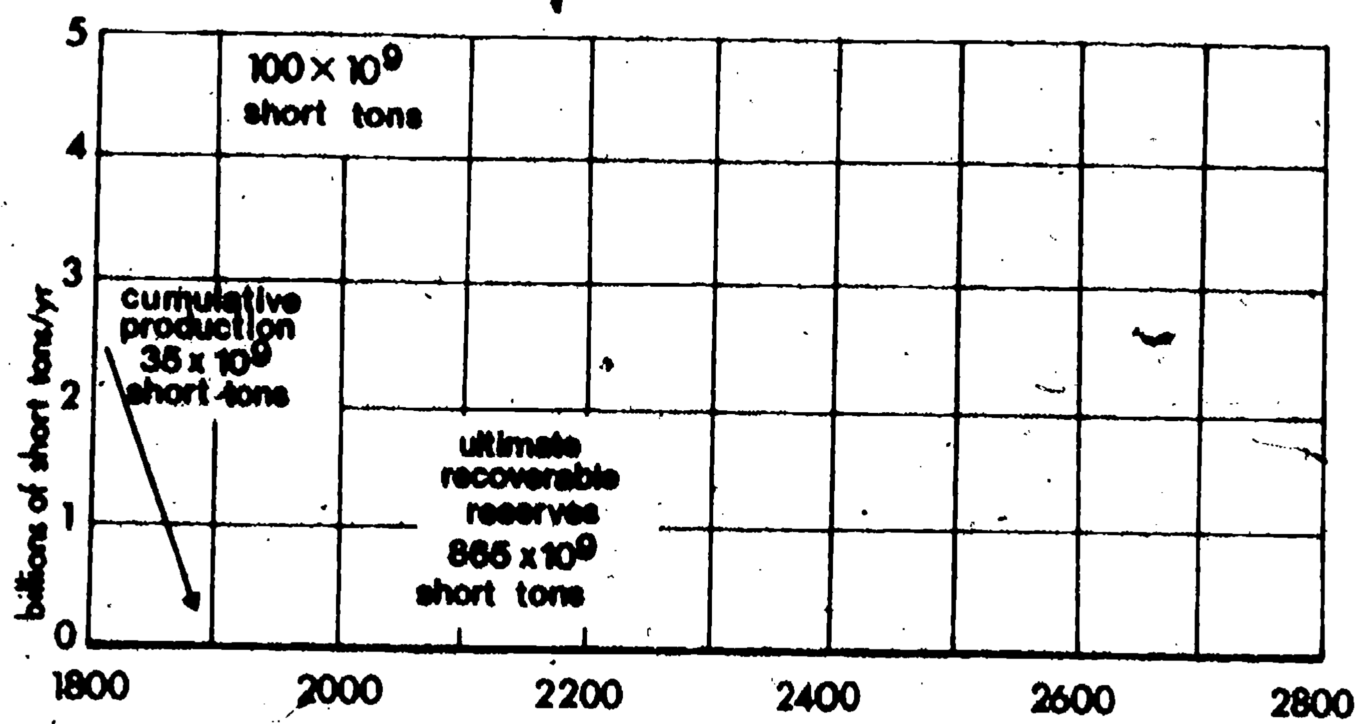
Frame 2 continued

4. How many cubic feet of natural gas will be produced between the years 1980 and 2000?

5. During this 160 year period, the slope of the bell curve becomes zero in what year?

FRAME 2 SCORE ________

Complete the graph below using data from the table below.



ULTIMATE U.S. COAL PRODUCTION

YEAR	BILLIONS OF SHORT TONS PER YEAR
1800	.02
1900	.30
2000	1.40
2100	2.20
2200	2.30
2300	2.00
2400	1.10
2500	.60
2600	.25
2700	.05
2800	.02

Name ____________________

Date ____________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 3 Answer the following:

1. Who are the primary consumers of coal, both past and present?

2. Name 2 factors which might have caused peaks and dips during the years 1900 and 1970 on the graph above.

3. Name 4 pollutants emitted in the burning of coal.

FRAME 3 SCORE ________

Frame 4

1. In 1908 nuclear fuels will contribute _______ billion kilowatt hours (KWH) toward the total generation of electricity.

2. In 1980 coal will contribute (a) _______ billion KWH toward the total generation of electricity or (b) _______ percent of the 5 major contributors.

3. Referring to the graph of "Ultimate U.S. Coal Production," you might conclude that 900 billion KWH is equivalent to _______ short tons of coal (assuming all coal production is used in the generation of electricity).

4. In 1980 which of the 5 sources will contribute least to electric generation?

FRAME 4 SCORE ________

Name ____________________

Date ____________________

LESSON 6.6: FUTURE PROJECTIONS

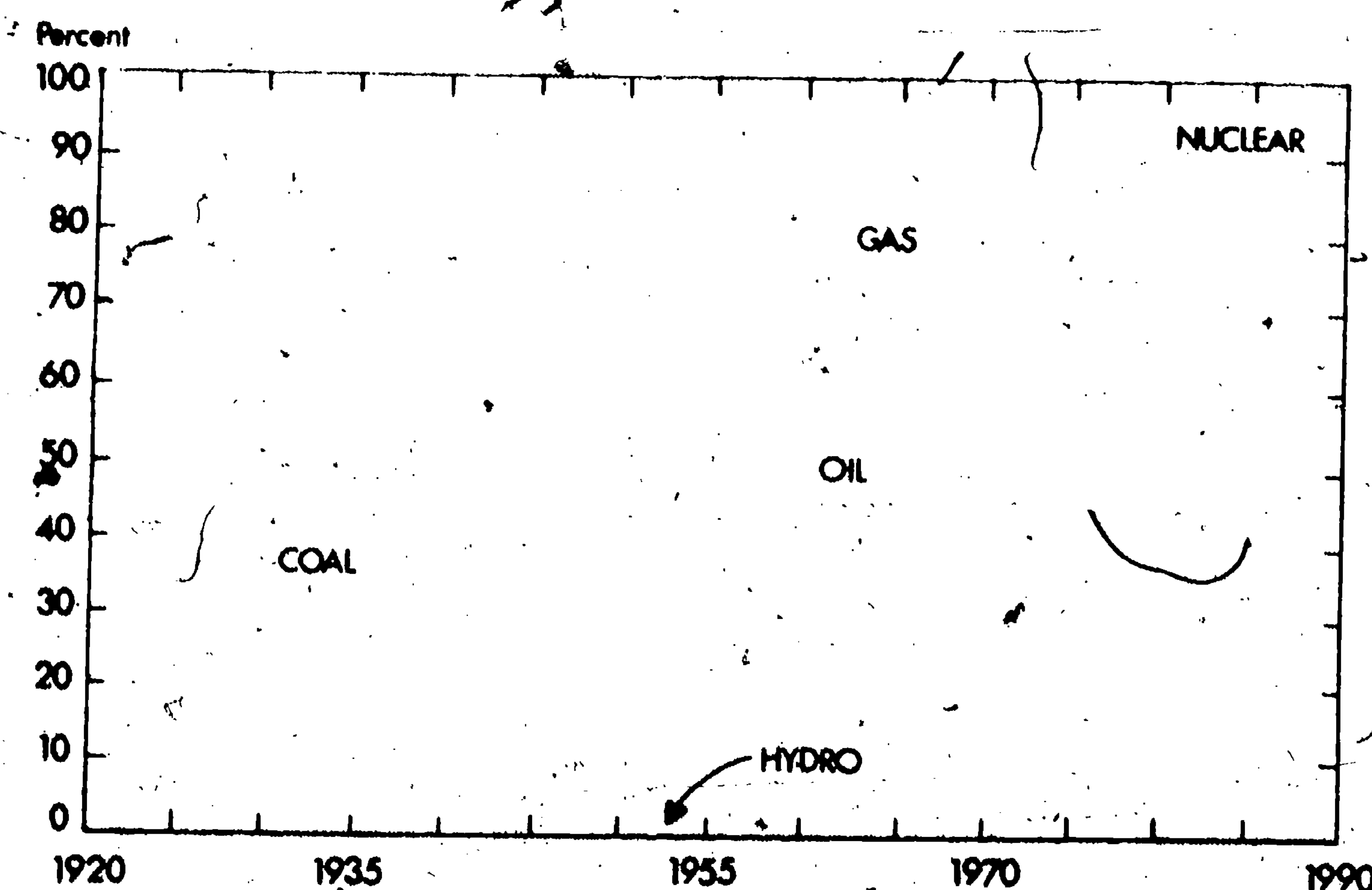
STUDENT RESPONSE SHEET

Frame 5 Using the chart on the slide or in your Study Guide, fill in the blanks in the table below:

SOURCE	TRILLION KILOWATT HOURS 1965	1980	2000
Nuclear-fueled steam	.2	.7	
Coal-fueled steam	.4	.8	
Oil-fueled steam	.2		.6
Gas-fueled steam	.1	.2	
Other	.1	.1	
Pumped-storage hydro	.05	.05	.1
Conventional hydro	.2		.4

FRAME 5 SCORE ________

Frame 6 Complete the graph below using data from the table on the following page.



TOTAL U.S. ENERGY CONSUMPTION, PERCENT BY TYPE OF FUEL.

Name ______________________

Date ______________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 6 Continued

TYPE OF FUEL	YEARS 1920	1935	1955	1970	1990
Nuclear	--	--	--	1%	25%
Gas	5%	10%	25%	35%	20%
Oil	15%	35%	45%	45%	35%
Coal	75%	50%	25%	14%	15%
Hydro	5%	5%	5%	5%	5%

1. Coal contributed _____% to the total U.S. energy consumption in 1920.

2. In 1920 hydro contributed _____% to the total U.S. energy consumption. In 1990 it is projected that hydro will contribute _____% to our total energy consumption.

3. In 1970 oil contributed _____% to the total U.S. energy consumption.

FRAME 6 SCORE _______

Frame 7 Using the data on the slide or in your Study Guide, "United States Uranium Requirements and Production Capability," answer the questions below.

1. What is the projected cumulative production capability of uranium in 1980?

2. In 1985 the annual production requirement will be _____% greater than the annual production capability.

3. During the period between 1970 and 1985 our cumulative production capability will have increased _________%. In this same period our cumulative requirement will have increased _________%.

4. How do you think projected requirements are determined?

5. How would the introduction of a breeder reactor in 1970 have affected these projections for production capability?

FRAME 7 SCORE _______

Name ____________________

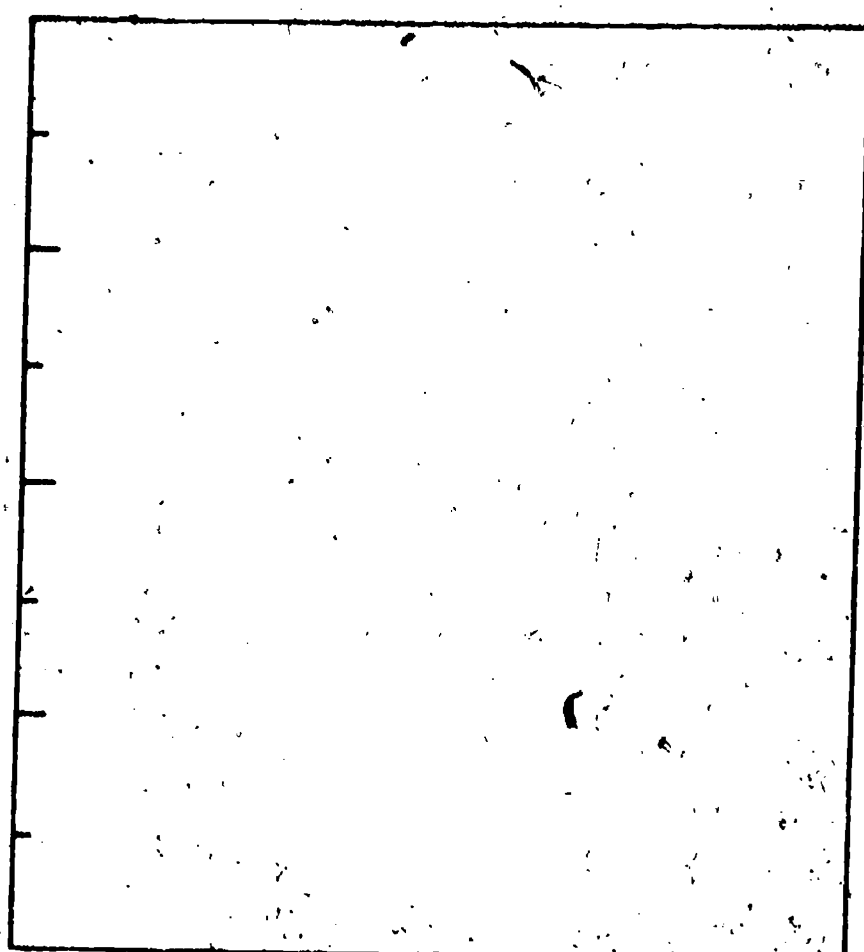
Date ____________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 8 Using data from the table below draw and label a bar graph in the space below.

FUEL REQUIRED



TYPE OF FUEL	TONS OF GOAL PER YEAR 1968	1980	1990
Oil	50	90	175
Gas	120	150	180
Nuclear	20	260	[illegible]
Coal	300	430	630

FRAME 8 SCORE ____________

Name ______________________

Date ______________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 9 Answer the following:

1. Which fuel type is projected to have the highest rate of increase in requirement over the 22-year period?

2. Which fuel type is projected to have the lowest rate of increase in requirement in the 22-year period?

3. Give probable causes for your answers in 1 and 2.

4. List 2 environmental hazards associated with the consumption or production of each of the given fuel types. Do you think these environmental hazards could influence the projections given for each fuel type in 1990?

FRAME 9 SCORE ______

Name ____________________

Date ____________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 10 Answer the following:

1. What fuel is used in your city to generate electricity?

2. Predict what you believe will be the approximate contribution by fuel type to the total U.S. electric power generation in 1980.

Fuel type	Percent Contribution	Trend
A.		
B.		
C.		
D.		
E.		

FRAME 10 SCORE ______

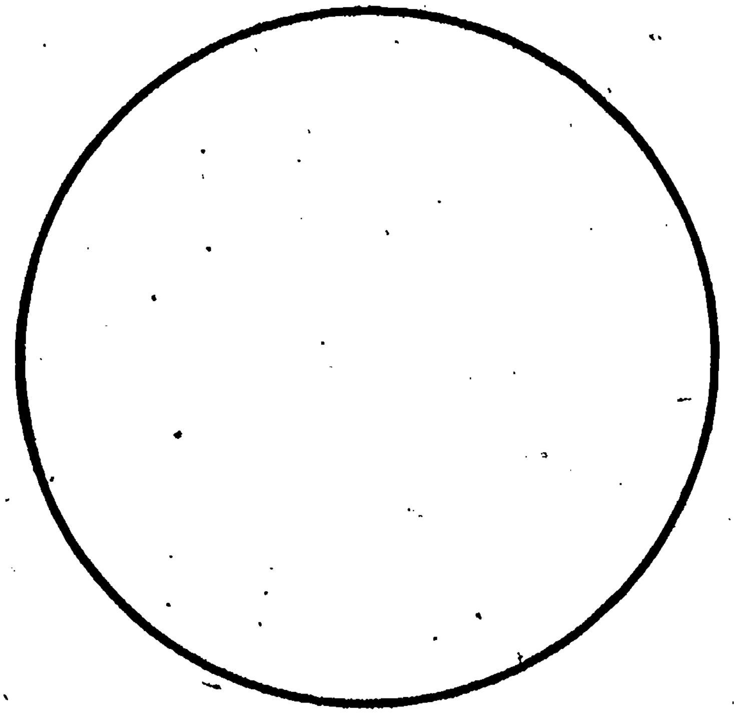
Name ______________________

Date ______________________

LESSON 6.6: FUTURE PROJECTIONS

STUDENT RESPONSE SHEET

Frame 11 Make a pie graph in the circle below using data from the table below.



FUEL SOURCE	PERCENT DISTRIBUTION
Nuclear Power	32%
Gas	15%
Oil	3%
Hydro	13%
Coal	37%

FUEL SOURCE DISTRIBUTION FOR ELECTRICAL POWER (1980)

TOTAL SCORE FOR ALL FRAMES ______________