

Homework Set #1

You must show all your work for calculations in order to receive full credit..

1. *Choose the **two** correct answers.*

Choose the **two** countries that are projected to increase in energy demand the most.

- | | |
|------------------|-----------------|
| A. United States | B. Russia |
| C. Italy | D. Japan |
| E. India | F. China |

2. *Choose the correct answer.*

Which sector is natural gas **not** used?

- | | |
|---|---|
| A. Industrial | B. Residential and Commercial |
| C. Electric Power | D. Natural gas is used in all of the above |
| E. Natural gas is used in none of the above | |

3. *Find the correct answer. Show all work for full credit.*

The United States uses approximately 100 quad of energy each year. How many barrels of oil is this?

$$100 \text{ quads} * \frac{1 \text{ MBOE}}{.00555 \text{ quads}} = 18018 \text{ MBOE}$$

4. *Answer the following question.*

In your own words, describe the difference between reserves and resources.

Reserves are all the natural materials we can get economically, but resources are all the natural materials that are located within a country protected economic zone.

5. *Choose the correct answer.*

Which of the following is true?

- | | |
|--|---|
| A. Estimating <i>reserves</i> is an exact science, and these estimations have serious economic and political consequences. | B. Estimating <i>reserves</i> is an approximate science, but these estimations have little economic or political impact. |
| C. Estimating <i>reserves</i> is an exact science, but these estimations have little economic or political impact. | D. Estimating <i>reserves</i> is an approximate science, and these estimations have serious economic and political consequences. |

6. *Explain.*

From 1970 to 2010, the United States imported large amounts of oil. Since 2010 the amount of imported oil is much smaller. Explain why this happened.

The United States decided it wanted to become independent of the price fluctuations on the global oil market, especially since the creation of OPEC. To do this, we decided to tap into our own oil resources and stop using middle eastern oil.

7. *Choose the correct answer.*

Natural gas more expensive to transport by ship than oil. Explain (1) why this is and (2) why this has become important to international trade

Natural gas is more expensive to transport than oil because it is a gas that needs to be pressurized in high pressure vats to transport, which is different than the liquid oil as liquids can simply be pumped with much cheaper equipment and with lower requirements. This has become important in international trade as

8. *Choose the correct answer.*

Typically, coal costs more to transport than an equivalent amount (equal energy content) of natural gas. Think about the way each one is transported

A. True

B. False

Why? Explain your answer:

This is false as to get the most energy out of coal, it needs to be pulverized into a powder, which is very costly, however, this is only done at the power plant. During shipping, coal is transported as a solid, which makes it easier to transport than natural gas. Natural gas has to be pressurized in tanks to be transported, which means you need specific infrastructure for it alone.

9. *Choose the correct answer*

Where does the coal used for electricity production in Illinois come from?

A. The Rocky Mountain Area (The Western United States)

B. The Appalachian Mountain Area (The Eastern United States)

C. Illinois

D. Illinois does not burn any coal.

Why? Explain your answer:

We have large black coal reserves in Illinois, which are just sent to coal plants in Illinois instead of the plants importing coal.

10. *Choose the correct answer.*

In the last 2000 years, the gross energy consumption, in Quads, in the United States has _____.

A. Sharply increased

B. Gradually increased

C. Gradually declined

D. Remained approximately steady

11. *Give the correct answer.*

Give 3 reasons why the rate of global energy use has expanded rapidly since 2000.

Population Boom in Asia and Africa

Higher Standard of living globally

Urbanization (especially in China and Asia)

12. *Choose the correct answer*

Over the past 40 years, hydroelectric power in the world has _____.

A. sharply increased

B. gradually increased

C. gradually decreased

D. remained approximately constant

Explain your answer: Even with projects like the GERD and the Chinese dams, hydroelectric constitutes a very small portion of the total energy production, so even if it increases, it does not show as much as others.

13. *True or False*

Hydroelectric power is less efficient than a coal or nuclear power plant of comparable size.

A. True

B. False

Explain your answer: The efficiency of nuclear or coal is only about 30% as they use heat to produce power, so they must pay an “entropy tax.” In contrast, hydropower uses mechanical processes, which have a much higher efficiency as they do not generate power from heat, but from potential energy.

14. Briefly described the Otto Cycle. The Otto cycle is what is used to extract energy from gasoline through a process of adiabatic compression, ignition of the fuel modeled as isochoric heat addition, work extracted modeled as adiabatic expansion, and isochoric heat rejection to return to the point where you started. Thus, making it a cycle.

15. Briefly describe the Carnot cycle.

The Carnot cycle is a cycle that has no irreversibilities present (e.g., friction, heat loss) and generates the maximum efficiency of any power generation cycle. It follows the process of isothermal expansion, adiabatic expansion, isothermal compression, and adiabatic compression.

16. List the two main differences between the idealized Carnot cycle and the Otto cycle.

The Carnot cycle is a cycle that has no irreversible and is the maximally efficient cycle possible. The Otto cycle does include irreversibility as you must eject heat at the end of the cycle to return to the original point.

17. A system uses an enclosed “working fluid” so the number of moles of the gas is constant. What is the thermal efficiency of the system if the hot temperature is 288 C and then cold temperature is 363 K.

$$\eta = 1 - \frac{363}{288 + 273} = 1 - .6470588 \dots = 0.3539 = 35.29\%$$

18. There are two identical power plants operating in Alaska and Champaign. Assume that the surrounding temperatures in Alaska and Pisa are 10 degrees Celsius and 25 degrees Celsius respectively. What are the desired steam temperatures of the two plants in order to achieve an ideal (Carnot) efficiency of 40%?

$$\begin{aligned}\eta = .4 &= 1 - \frac{10 + 273}{T_A} \\ \frac{10 + 273}{T_A} &= .6 \\ T_A &= \frac{(10 + 273)}{.6} = 471.66 \text{ K} = 198.66 \text{ C}\end{aligned}$$

$$\begin{aligned}\eta = .4 &= 1 - \frac{25 + 273}{T_C} \\ \frac{25 + 273}{T_C} &= .6 \\ T_C &= \frac{(25 + 273)}{.6} = 496.66 \text{ K} = 223.66 \text{ C}\end{aligned}$$

19. An electric power plant calculated its Levelized Cost of Electricity (LCOE) at 0.10 \$/kW-h and plans to generate 1000 MW every day for 40 years.

(a) What is the amount of income for this plant over its 40 year lifetime?

$$(kW) * (hours\ of\ operation) * \left(\frac{price}{kWh}\right) = income$$
$$\left(1000\ MW * \frac{1000\ kW}{1\ MW}\right) * \left(40\ years * \frac{8765.82\ hours}{year}\right) * \left(\frac{\$.10}{kWh}\right) = \$35b$$

(b) What types of costs does this income cover from the beginning to the end of this project?

This seems like an absurd amount of money, but my calculations make sense, but this income has to cover the cost of construction, fuel, employee salaries, emission control, other operational costs, and decommissioning.

20. Land-based gas turbine plants are very popular for electricity production.

(a) Explain why gas turbines are so popular

They are popular because they are relatively small, low initial startup costs, ability to be turned on quickly, and have become highly efficient.

(b) Explain is the biggest risk with the cost of running a gas turbine plant.

The biggest risk is the price fluctuations of natural gas, which would render them useless if the price of natural gas cost more than the revenue from energy generated through combustion.

21. *Choose the correct answer.*

“Regeneration” in a power plant refers to:

A. After passing through a high pressure turbine, the steam is heated again in the original boiler before passing through a low pressure turbine.

C. After passing through the high pressure turbine, the steam is condensed to water and run through a water turbine. It is then pumped to a higher pressure to return to the boiler.

B. After passing through the high pressure turbine, steam passes through a condenser. The water is then pumped to a higher pressure before returning to the boiler.

D. After passing through the high pressure turbine, the steam is partially condensed, but is then run through the turbine again in order to extract all possible energy

22. *Choose the correct answer.*

“Reheating” in a power plant refers to:

A. After passing through a high pressure turbine, the steam is heated again in the original boiler before passing through a low pressure turbine.

C. After passing through the high pressure turbine, the steam is condensed to water and run through a water turbine. It is then pumped to a higher pressure to return to the boiler.

B. After passing through the high pressure turbine, steam passes through a condenser. The water is then pumped to a higher pressure before returning to the boiler.

D. After passing through the high pressure turbine, the steam is partially condensed, but is then run through the turbine again in order to extract all possible energy