key

Energy Problems Worksheet

Show all calculations with units

British Thermal Units are usually abbreviated to BTUs, and are equal to the amount of heat energy necessary to raise one pound of water 1 degree F (or = 252 calories = 1056 joules = 1.056 kilojoules

Power (watts) = current (amps) x voltage (volts)
1 MW = 1000 KW

1. West Fremont is a community consisting of 3000 homes. A small coal-burning power plant currently supplies electricity for the town. The capacity of the power plant is 12 megawatts (MW) and the average household consumes 8000 kilowatt hours (kWh) of electrical energy each year. The price paid to the electric utility by West Fremont residents for this energy is $0.10 per kWh. The town leaders are considering a plan, the West Fremont Wind Project (WFWP), to generate their own electricity using 10 wind turbines that would be located on the wooded ridges surrounding the town. Each wind turbine would have a capacity of 1.2MW and each would cost the town $3 million to purchase, finance, and operate for 25 years.
   a. Assuming that the existing power plant can operate at full capacity for 8000 hrs/yr, how many kWh of electricity can be produced by the plant in year? 96,000,000 (9.6×10^7) kwh/year

      $(12\ \cancel{MW})\left(\frac{1000\ KWh}{1\ \cancel{MW}}\right)\frac{8000\ hrs}{year}$
   b. At the current rate of electrical energy use per household, how many kWh of electrical energy does the community consume in one year? 24,000,000 (2.4×10^7) Kwh/year

      $(3000\ homes)\frac{8000\ Kwh}{year}$
   c. Assuming that the electrical energy needs of the community do not change during the 25 year lifetime of the wind turbines, what would be the cost to the community of the electricity supplied by the WFWP over 25 years? Express your answer in dollars/kWh.

      $\left(\frac{2.4 \times 10^7\ kwh}{\cancel{year}}\right) 25\ \cancel{years} =$ 600000000 (6×10^8)

      (10 turbines) \$3,000,000 = \$30,000,000

      $\frac{30,\cancel{000,000}}{600,\cancel{000,000}} = 0.05$ ¢ Kwh

2. Electric vehicles often have been proposed as an environmentally sound alternative to the gasoline engine for transportation. In response to state initiatives, several car manufacturers now include electric vehicles among their available models. In spite of these state initiatives, the penetration of electric vehicles into the transportation sector of the US, as well as other countries, remains modest.

   Estimate the potential reduction in petroleum consumption (in gallons of gasoline per year) that could be achieved in the US by introducing electric vehicles under the following assumptions:
   - The mileage rate for the average car is 25 miles per gallon of gasoline.
   - The average car is driven 10,000 miles per year.
   - The United States has 150 million cars.
   - 10% of US cars could be replaced with electric vehicles.

   $\frac{(150,000,000\ cars)\ 10,000\ miles\ per\ year}{25\ mpg}$ (60000000000 = 6×10^{10} gallons of gas per year) .10 =

   6,000,000,000
   6×10^9

$\left(\frac{12,000,000 \text{ kwh}}{\text{day}}\right) \frac{10,000 \text{ BTUS}}{1 \text{ kwh}} = 120000000000$
1.2×10^{11} BTUS/day

3. A large, coal-fired electric power plant produces 12 million kilowatt-hours of electricity each day. Assume that an input of 10,000 BTU's of heat is required to produce an output of 1 kilowatt-hour of electricity.
    a. Showing all steps in your calculations, determine the number of
        i. BTU's of heat needed to generate the electricity produced by the power plant each day.
        ii. Pounds of coal consumed by the power plant each day, assuming that one pound of coal yields 5,000 BTU's of heat.
        iii. Pounds of sulfur released by the power plant each day, assuming that the coal contains one percent sulfur by weight.
    b. The Environmental Protection Agency (EPA) standard for power plants such as this one is that no more than 1.2 pounds of sulfur be emitted per million BTU's of heat generated. Using the results in part (a), determine whether the power plant meets the EPA standard.

ii $\left(\frac{1.2 \times 10^{11} \text{ BTUS}}{\text{day}}\right) \frac{1 \text{ lb coal}}{5000 \text{ BTUS}}$
$= 24,000,000 \ (2.4 \times 10^7)$
lbs/coal/day

iii $\left(\frac{2.4 \times 10^7 \text{ lbs}}{\text{day}}\right) \frac{.01}{1 \text{ lb sulfur}}$
$= 240000 \ (2.4 \times 10^5)$
sulfur/day

140000 lbs sulfur/day $= 1.4 \times 10^5$

$\left(\frac{1.2 \times 10^{11} \text{ BTUS}}{\text{day}}\right) \frac{1.2 \text{ lbs}}{1,000,000} =$

OR

$\frac{2.4 \times 10^5}{1.2 \times 10^{11}} = \frac{x}{1,000,000}$
$x = 2 \text{ lbs.}$

4. If you replace one 75-watt incandescent light bulb with fluorescent light bulb that give the same amount of light by drawing only 20 watts. You use the light bulb for an average of 4 hours a day.
    a. How many kWhs of energy would you save in one day?
    b. How many kWhs of energy would you save in one year?
    c. The cost of one kWh is \$0.10. How much money does the fluorescent light bulb save in one year?

$(75 \text{ w})\left(\frac{1 \text{ kw}}{1000 \text{ w}}\right)\frac{4 \text{ hours}}{\text{day}}$

$(20 \text{ w})\left(\frac{1 \text{ kw}}{1000 \text{ w}}\right)\frac{4 \text{ hours}}{\text{day}} = 0.08$

$= .3 \text{ kWh}$
$- .08 \text{ kWh}$

a) $\left(\frac{.22 \text{ kWh}}{\text{day}}\right) \frac{365 \text{ day}}{1 \text{ year}}$

b) $= 80.3$ kwh/year

c) $\left(\frac{80.3 \text{ kwh}}{\text{year}}\right) \frac{.10 ¢}{\text{year}} = \$8.03$

5. Answer the questions below regarding the heating of a house in the Midwestern United States. Assume the following:
    - The house has 2000 square feet of living space.
    - 80,000 BTUs of heat per square foot are required to heat the house for the winter.
    - Natural gas is available at a cost of \$5.00 per thousand cubic feet.
    - Once cubic foot of natural gas supplies 1000 BTUs of heat energy.
    - The furnace in the house is 80% efficient.

Calculate the following showing all steps of your calculations, including units.
    a. The number of cubic feet of natural gas required to heat the house for one winter.
    b. The cost of heating the house for one winter.

a) $(2000 \text{ square feet})\left(\frac{80,000 \text{ BTUS}}{\text{ft}^2}\right)\frac{1 \text{ ft}^3}{1000 \text{ BTUS}} = 160,000 \text{ ft}^3$ natural gas

$\left(160,000 \text{ ft}^3\right) \frac{\$5}{1000 \text{ ft}^3}$ \$800