

- Given that 1 kcal of heat is required to increase the temperature of 1 kg of water by 1°C:
 - How many kcals would be required to heat 100 kg of water by 20°C for a bath?
 - How many joules is this?
 - How many Btus?
 - If your water heater can supply 40 kBtu/h, how long will it take to heat this water?
- Given that 1 kWh = 3.6 MJ and that 1 Btu = 1055 J, show that 1 kWh = 3412 Btu.
 - Why would it be incorrect to use this conversion factor directly to determine the amount of coal required to generate electricity in a power plant?
- A typical home in the northern U.S. might require 120 MBtu of heat for the average winter.
 - If this heat were supplied by a natural gas furnace operating at 60 percent efficiency,
 - How many BTU is needed?
 - How many cubic feet of gas would need to be purchased?
 - At a cost of \$0.90/ccf, what would it cost to heat this house for one season?
 - If a new 80 percent efficient furnace could be installed at a cost of \$4,000
 - How many Btu for the new furnace?
 - How many ccf?
 - What would it cost to heat this house for one season *with the new furnace*?
 - How long would it take to pay back the cost of this furnace assuming gas prices remained the same?
- Suppose the house in question 3 is located in Cleveland where the annual average solar flux is 160 W/m². If 10 m² of solar panels operating at 20 percent efficiency were installed on this house to collect and store solar energy in the form of hot water:
 - How much energy could be gained in one year in this manner?
 - What fraction of the annual heating requirement is this?
 - Using the hot-water heating requirements for a bath from question 1(c), how many hot baths would this energy supply in one year?
- The annual average solar flux in Tucson is 250 W/m². Suppose 10 m² of solar electric panels operating at 10 percent efficiency were installed on a home there.
 - How many kilowatts would be collected?
 - How many kWh of electricity would these panels collect in one year?
 - What fraction of the annual electrical requirement of 10,000 kWh for the average home does this represent?
 - How many square meters of solar panels would be required to supply 10,000 kWh per year?
- Solar energy is converted naturally into wood biomass with an efficiency of about 0.1 percent. Suppose a wood lot of 100 hectares (10⁶ m²) is located in Missouri, where the average annual solar flux is 200 watts/m². Given that the heat value for wood is 12 MBtu/ton,
 - The wood is equivalent to how many kilowatts?
 - How many kilowatt-hours for the year?
 - How many BTU's?
 - How many tons of wood can be produced by this property each year?
- With moderate winds, a modern large wind turbine can generate about 250 kW of electricity, whereas a large nuclear power plant can generate 1,000 MW.
 - How many wind turbines would be required to give the same output as one nuclear power plant?
 - Discuss some of the advantages and disadvantages to providing electrical power by each method.
- Batteries are usually rated in terms of ampere-hours, indicating the current that the cell is capable of delivering for a specified time. Typical D-cell flashlight batteries might be rated at 3 ampere-hours. The total electrical energy available from such a battery is found by multiplying the ampere-hour rating by the battery voltage. Thus this same 1.5 volt D cell could deliver 4.5 watt-hours of electrical energy.
 - Convert this energy to kWh and compare the cost of electrical energy derived in this manner to that of standard "grid-based" electricity. Assume that the battery costs \$1.00 and that electricity from the power company is available at \$0.10/kWh.
- The table below gives prices and heat energy content for various fuels that are commonly used for home heating. Fuel prices are given as a per-unit cost for fuel delivered to the home. Complete the table by filling in the last two columns and then compare the cost of home heating by these various methods. In your computations, assume that the home requires 120 MBtu of heat for a season and that gas- or oil-fired furnaces operate at 80 percent efficiency. Assume that electrical heating is 100 percent efficient.

Fuel	Price	Energy Content of Fuel	Cost per MBtu	Cost of Home Heating
Nat. gas	\$1.14/ccf	1030 Btu/cf		
Propane	\$1.69/gal	92 k Btu/gal		
Fuel oil	\$1.93/gal	133 k Btu/gal		
Electricity	\$0.10/kWh	3412 Btu/kWh		

- The complete combustion of gasoline produces water and CO₂ as products.

$$2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$$
 - For each gasoline molecule, how many CO₂ molecules are produced?
 - What is the molecular mass for the gas (C₈H₁₈) and for CO₂?
 - For each gallon of gasoline (6 pounds) used, how pounds of CO₂ are produced?
 - If you have a car that gets 25 miles per gallon, how pounds of CO₂ do you produce per mile?
 - The car goes 12,000 miles per year, how pounds of CO₂ are produced per year?
 - How many tons of CO₂ do you produce per year?
 - If there are 250 million cars in use in the United States, how many tons of CO₂ are produced per year?