Problem Set #2 (due 9/30)

1. An inventor claims to have developed a wonderful new heat engine that operates with a relatively cool (and therefore non-polluting) flame at 150 °C and discharges waste heat to the environment at 20 °C. His promotional literature advertises that 45% of the fuel energy is converted into useful work. Calculate the maximum efficiency that can be expected into useful work. Calculate the maximum efficiency that can be expected for such an engine and compare it to the inventor's claim.

2. An electric heat pump can deliver more energy than it draws from the power line without violating energy conservation. Explain how this can happen. Then, describe how a "geothermal" or "ground-loop" heat pump differs from one that uses air. What advantages/disadvantages can you find from a Web search?

3. An electric power plant can deliver 1 GW (10^9 W) of electrical power continuously.

   (a) Assuming the overall thermal efficiency of the plant is 33%, how many tons of coal need to be put into the boilers every day?

   (b) How many tons of CO_2 are released by the above plant to the atmosphere every day? Use the approx. that coal is 100% carbon.

   (c) How many BTU's of heat must be extracted by the heat exchanger and dissipated every day?

4. About 3.5×10^{12} kW hr of electricity could be used annually in the US. Using the parameters of the above plant

   (a) How many tons of coal would be needed annually?

   (b) How many tons of CO_2 would be given off? Use approximation that coal is 100% carbon.

5. A nuclear power reactor produces steam at 288 C and has an overall efficiency of 34%. If the condensor is at 30 °C, what fraction of its theoretical maximum efficiency is it achieving?

6. Show that the combination of a 40% efficient power plant with a heat pump having $COP = 4$ would actually deliver 60% more heat than if the fuel was used directly to heat the house with 100% efficiency.