Questions

1. Of what possible use could a weed be? Explain how weeds can be useful. Start by stating your definition of a weed.
   Solution: Weeds are plants that people don't find useful. So, by my definition, a weed can not be useful. All that highlights is the fact that we shouldn't be so quick to classify something as a nuisance (which is the first step toward eradiation), you never know when something you once considered a weed might prove useful in the future. This relates to the chapter on biofuels in that all plants capture a lot of the sun's energy. Some that are not benifical as food crops, may turn out to be useful a "fuel crops".

2. Describe the differences between ethanol, methanol, biogas, and biodiesel. (You'll need to research biodiesel from an outside source, I suspect.)
   Solution: Ethanol is a form of alcohol that can be made from plant sources. It is frequently blended with gasoline
   Methanol is another type of alcohol, typically derived from woody plants, it makes a very good fuel for internal combustion engines
   Biogas is the gas that is emitted from, typically, manure in a digester. The gas is mostly methane (60%) and carbon dioxide.
   Biodiesel is a fuel produced from vegetable oils and animal fats. It meets very specific industry standards and can be burned in a conventional diesel engine

3. There is a huge amount of geothermal energy available. Why is generally not very useful?
   Solution: Only in certain areas of the world is the power density (W/m^2) of geothermal energy high enough for it to be economically reasonable to extract it.

4. Carefully explain what is misleading about this statement: "The available energy from hydrogen resources is considerably large."
   Solution: True, hydrogen is one of the most abundant elements at the surface of the Earth. That said, nearly all of it is chemically bound to other atoms. To make use of it, it must first be liberated, which requires energy.

5. Explain the disadvantages of superinsulating your home.
   Solution: It's very expensive and it greatly reduces the mixing of interior air with exterior air, which has potential repercussions for indoor air quality.

Problems

6. Several small villages band together to purchase a 25 MW_e electrical generator to be supplied with wood from the nearby pine forests. How large an area of woods would they need if the forests can sustain a Assume the energy of combustion for pine is 19 MJ/kg.

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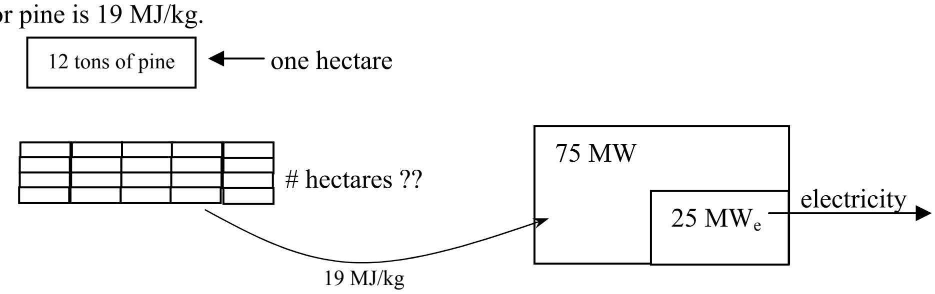

Knowns: 1 ton = 907 kg
the plant will produce 25 MW_e
energy of combustion for pine is 19 MJ/kg
yearly production of 12 tons per hectare

Unknowns: How many hectares will be required to supply the 75 MW necessary to run the plant

Assumptions: The generator's efficiency is about 1/3; forest production is the same from year to year; all pine has the same energy of combustion

SOP: The amount we need will be proportional to its energy content and the rate that we use it

Equations: Amount = rate × energy content

Solution: A 25 MW_e need about 75 MW of energy to run.

$$75MW = \frac{75MJ}{s} \rightarrow \frac{75MJ}{s} \cdot \frac{kg}{19MJ} = 3.9kg/s$$

Over the course of one year this is $\frac{3.9kg}{s} \cdot \frac{60s}{\min} \cdot \frac{60m}{hr} \cdot \frac{24hr}{day} \cdot \frac{365day}{year} = 3.4 \times 10^5 kg/year$

This is $\frac{3.4\times10^5 kg}{year}\cdot\frac{ton}{907kg}=3.8\times10^2 ton/year$

So, the village will need $3.8\times10^2 ton\cdot\frac{hectare}{12ton}=31.7hectares$

As an aside 1 hectare = 2.4 acres, so this area is about 79.2 acres.

7. What is the average geothermal power available through the surface area of the United States?

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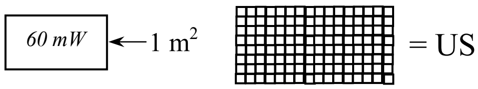

Knowns: Average geothermal power through crust is 60 mW/m^2
Land area of US is 9,384,658 km^2

Unknowns: The power that comes through the surface in the US

Assumptions: The average geothermal power through crust is the same for the US as it is for the globe

SOP: The amount we get is proportional to the rate that it comes through and the area that it comes through

Equations: Amount = rate × area

Solution: The total land area of the US in m^2 is 9,384,658 km^2 × (1,000 m/km)^2 = 9.38 × 10^{12} m^2
The total power is 0.060 W/m^2 × 9.38 × 10^{12} m^2 = 5.6 × 10^{11} W = 0.56 TW
For comparison, the US power consumption is 3.2 TW, so if we tapped all the geothermal power at the surface, it would cover about 1/6 of our power demands.

8. Compact fluorescent (CF) bulbs cost about $10/bulb and last about 20,000 hours. Incandescent bulbs cost about 50¢/bulb and last about 2,000 hours. For the lighting requirements of a typical reading area, a CF bulb draws about 10 W of power, while an incandescent bulb needs to draw about 75 W. Over the course of 20 years, which kind of bulb is the better buy?

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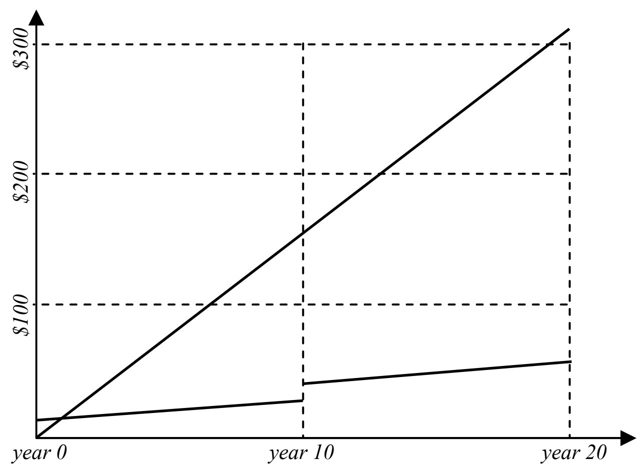

Knowns: Compact fluorescent (CF) bulbs cost about $10/bulb and last about 20,000 hours
incandescent bulbs cost about 50¢/bulb and last about 2,000 hours
CF's require about 10 W; incandescents 75 W

Unknowns: The total operating cost over twenty years

Assumptions: Lights are on 5½ hours per day
Energy cost = 10¢/kWh

SOP: The cost for each bulb is the sum of the operating cost and the item cost
The operating cost is proportional to the utility rates, running time, and power

Equations: Total Cost = operating cost + item cost
operating cost = rate × power × time

Solution:

	Incandescent bulb	Compact florescent bulb
Number of hours	5½ hours per day × 365 days/year × 20 years = 40150 hours	
Number of bulbs	40150 hours / (2,000 hours/bulb) = 20.1 bulbs ≈ 20 bulbs	40150 hours / (20,000 hours/bulb) = 2.01 bulbs ≈ 2 bulbs
Cost for bulbs	20 bulbs × 50¢/bulb = $10	2 bulbs × $10/bulb = $20
Number of kWh	40150 hours × 0.075 kW = 3011.3 kWh	40150 hours × 0.01 kW = 401.5 kWh
Cost of electricity	3011.3 kWh × $0.1/kWh = $301.13	401.5 kWh × $0.1/kWh = $40.15

Total cost $10 + $301.13 = $311.13 $20 + $40.15 = $60.15

So, the incandescent cost $311.13 - $60.15 = $250.98 more over the course of 20 years. Seems like a no-brainer to use to the CF. In a home with, say, 20 light bulbs, that's over $5,000 in twenty years, or about $250/year in savings!! If you replaced all 20 bulbs in this house it would cost you $200, which you would recoup in less than one year.

9. Estimate the amount of power radiated by a house through its windows. To how many 75 W light bulbs is this equivalent?

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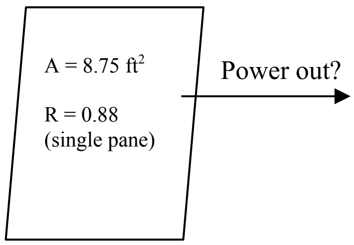

Knowns: 1 Btu/hr = 0.293 W

Unknowns: How much power is radiated by the window

Assumptions: One window measures 2.5 ft by 3.5 ft
Heating degree days in DC is 4,330
We have about 150 heating days (November - March)
R-values (hr·^{o}F·ft^2/Btu):
Window: 0.03
Inside air layer: 0.68
Outside air layer: 0.17

SOP: The heat lost is proportional to the area and the number of degree days and inversely proportional to the R-value

Equations: Q = 24(A/R) × (heating days)

Solution: For single-pane window, the R-value is 0.03 + 0.68 + 0.17 = 0.88 hr·^{o}F·ft^2/Btu
The area of our window is 8.75 ft^2
The total heat flow is Q = 24(A/R) × (heating days) = 24(8.75 ft^2/0.88) × (4,330) = 1.03×10^6 Btu
The total number of heating is 150 heat days × 24 hr = 3600 hr
So the power radiated by the window is

$$\frac{1.03 \times 10^6 \text{ Btu}}{3600 \text{ hr}} = 286.1 Btu/hr \rightarrow 286.1 Btu/hr \cdot \frac{0.293W}{1 Btu/hr} = 84W$$

This is equivalent to 1.1 75 W light bulbs. So, if your house has 25 windows, you losing the equivalent of twenty-eight 75 W light bulbs worth of power to the outside.

Just for fun, let's run through the calculation again, but this time with double-pane windows. The R-value for double pane windows is given by 2(0.03) + 3(0.68) + 0.17 = 2.27. I multiplied the glass R-value by two because there are two layers of glass. I multiplied the inside air by three because the two layers of glass are separated, so the gap between them works like two "inside" air layers, then we still get to count the air layer that is actually inside the house.
The total heat flow is Q = 24(A/R) × (heating days) = 24(8.75 ft^2/2.27) × (4,330) = 4.0×10^6 Btu
The total number of heating is 150 heat days × 24 hr = 3600 hr
So the power radiated by the window is

$$\frac{4.0 \times 10^5 \text{ Btu}}{3600 \text{ hr}} = 111.3 Btu/hr \rightarrow 286.1 Btu/hr \cdot \frac{0.293W}{1 Btu/hr} = 32.6W$$

This is equivalent to 0.4 75 W light bulbs. So, if your house has 25 windows, you losing the equivalent of just under eleven 75 W light bulbs worth of power to the outside. This is significantly less than the single-pane windows.