Model Answers for Homework Week 0

2. Nuclear energy

Solution:
First, I'll calculate how much energy is released per gram of U^{235}

$$\left(3\text{ x }10^{-11}\ \frac{\text{J}}{\text{atom}}\right)\cdot\left(6\ \times\ 10^{23}\,\frac{\text{atoms}}{\text{mole}}\right)\cdot\left(\frac{1}{235}\frac{\text{mole}}{\text{g}}\right) =\ 7.7\text{ x }10^{10}\,\frac{\text{J}}{\text{gram}}.$$

We have 10 pounds of U^{235} atoms, which is equal to about 4000 g. I expect 30% of the energy to be converted to electricity. Therefore, the expected energy per day is

$$\left(7.7\ \times\ 10^{10}\,\frac{\text{J}}{\text{g}}\right)\cdot\left(4\ \times\ 10^{3}\,\frac{\text{g}}{\text{day}}\right)\cdot\left(\frac{0.3\text{ J electrical energy}}{1\text{ J of heat energy}}\right) = 10^{14}\text{ J per day.}$$

Finally, converting this rate into Joules per second

$$\left(10^{14}\,\frac{\text{J}}{\text{day}}\right)\cdot\left(\frac{1\text{ day}}{86{,}400\text{ sec}}\right)\approx\ 10^{9}\text{ J/s}$$

This is 10 times less than the max rate of electrical energy production by hydroelectric power in Oregon. It is similar to the rate that a typical coal-burning power plant produces electricity.