ENERGY, ENVIRONMENT, AND CLIMATE, Third Edition

CHAPTER 2: High-Energy Society

QUESTIONS

1. Megawatts are not energy units—they measure power, or the *rate* of energy use. The newspaper editor should strike the phrase "of energy each hour" to correct the statement.

2. Efficiencies, economies of scale, and the inaccessibility of the technologies to most people worldwide, among other things, might account for the apparent discrepancy.

4. Energy intensity (Fig. 2.7). Although Egyptians use less energy and make less money than U.S. Americans, Egypt's energy use and GDP have about the same ratio as that of the United States.

5. No. If 300 million Americans need the equivalent of 100 energy servants each, that requires at least 30 billion people to supply energy. Only about 7 billion people live on the planet, and they are not our energy servants.

6. Japan is more compact than the United States, and has a more efficient transportation system. Ghana is poorer, and has fewer developed commercial and industrial sectors, than the United States or Japan.

7. Spending billions of dollars to try to clean up a blowout of a deepwateroil drilling platform in the Gulf of Mexico, for example, could increase the GDP, whereas the accident could decrease the quality of life for countless citizens (and end life for some).

EXERCISES

1. Production of 1 kW = 1,000 watts would require 10 energy servants producing 100 watts each. To get a total of 1 kWh, I'd have to hire all the energy servants for an hour, at a cost of 10 × \$8 = <u>\$80</u>. That's a factor of \$80/\$0.10 = 800 times more than the typical cost for a kilowatt-hour.

2. To make the energy servants' power competitive with conventionally produced electrical power, I'd have to pay them 1/800 what I paid them in Exercise 1. Their hourly wage would be just \$8/800 = <u>1¢ per hour</u>.

3. Nuclear energy constitutes 8% of total energy, and 20% of electrical energy. Therefore, (0.20)(U.S. electrical energy) = (0.08)(U.S. total energy). So the ratio of electrical energy to total energy is 0.08/0.20 = 0.40 = <u>40%</u>. This means that 40% of U.S. *primary* energy goes toward making electricity.

4. Power = rate of energy use = energy per time, so <u>energy used = power × time</u>.

A survey of students at Evergreen State College yielded these data for daily uses:

Device	Power (W)	Time (h)	Energy (W×h)
Light bulb	100	4	400
Fluorescent bulb	10	10	100
Hair dryer	1,000	0.2	200
Computer	90	5	450
Fridge	400	6	2,400
Freezer	288	12	3,456
Electric kettle	1,500	0.2	300
Microwave	1,000	0.1	100
Toaster	1,150	0.1	115
Ceiling fan	60	12	720
Dishwasher	1,300	0.5	650
Coffee maker	800	0.2	160
Blender	400	0.05	20
Vacuum cleaner	1,400	0.1	140
Cell phone	1	24	24
Subtotal for misc. devices			9.2 kWh

5. $\text{power} = \dfrac{\text{energy}}{\text{time}} = \dfrac{\text{rate of energy}}{\text{consumption}} = \dfrac{350\ \text{kWh}}{\text{mo}}\left(\dfrac{\text{mo}}{30\,\text{d}}\right)\left(\dfrac{\text{d}}{24\,\text{h}}\right)\left(\dfrac{1{,}000\ \text{W}}{\text{kW}}\right) = 470\,\text{W}$

6. As of spring 2017, Puget Sound Energy (in Washington State) charges about 11¢ per kWh and gasoline costs about \$2.50 per gallon:

$$\frac{\text{gas cost}}{\text{kWh}} = \frac{\$2.50}{\text{gal}}\left(\frac{\text{gal}}{40\ \text{kWh}}\right) = \$0.063/\text{kWh}$$

It appears that gasoline is cheaper—but if you were to make electricity with that gasoline, you'd achieve a conversion efficiency of only about 35%. So<u>electricity from PSE</u> is a better deal—especially because that is mostly from hydropower, not coal.

7. Measuring the slope of the line in Fig. 2.7 gives approximately 4.2 k\$/y/kW.The slope represents the ratio of per capita GDP to per capita energy consumption, or the <u>inverse of the energy intensity</u>. The energy intensity of the countries near this slope is therefore $0.24\,\dfrac{\text{kW}}{\text{k\$/y}}$.

8. A country using 3.5 kW per capita, with $7,500 GDP per capita, would be almost directly below Poland. This country's energy intensity is higher than those on the diagonal line. It uses energy <u>less efficiently</u>.

$$\frac{3{,}500\,\text{W}}{\$7{,}500\,/\,\text{y}} = \underline{\frac{0.47\,\text{kW}}{\text{k\$}\,/\,\text{y}}}$$, while the average energy intensity from Exercise 7 is $\frac{0.24\,\text{kW}}{\text{k\$}\,/\,\text{y}}$

ARGUE YOUR CASE

1. Primary-use accounting is necessary for complete consideration of energy costs.

2. Possible responses:

> Pro: The United States has done our share and brought our energy use into line with that of the world community, as evidenced by our drop in energy intensity. Don't ask more of us.
>
> Con: Energy intensity is not the only measure that should be considered. The United States is one of the richest nations, and we use about six times as much energy per capita as the average world citizen. We have historically been the worst greenhouse-gas polluters (and are still a close second). We can afford to invest in better technologies for energy generation and transportation, and to pay the real costs of carbon emissions. Better, we can, and should, replace carbon emitters with renewable energy as far as possible.