Energy Fundamentals

Biomass 4.8%
Hydro 2.5%
Nuclear 8.5%
Gas 28%
Oil 35%
Other 2.4%
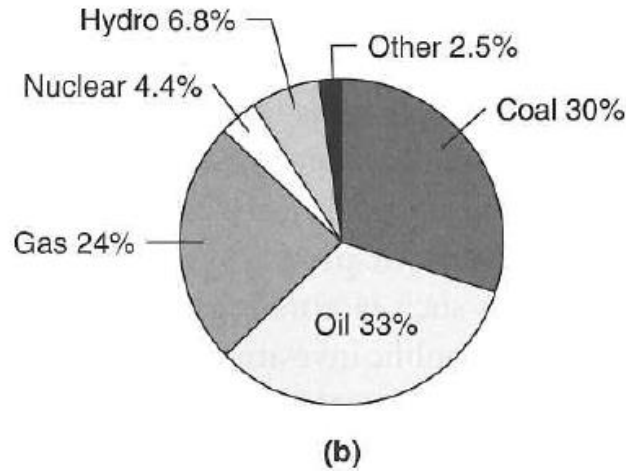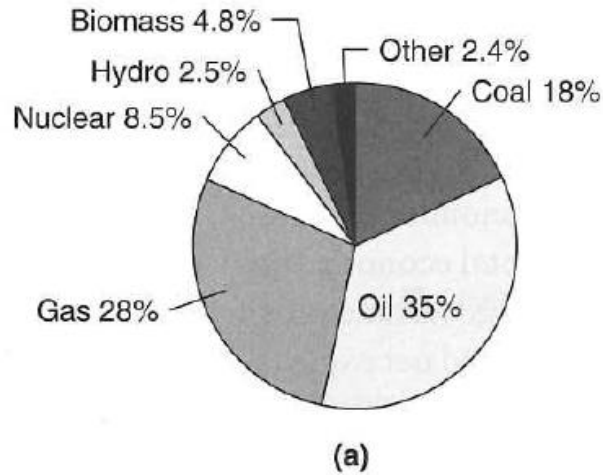Coal 18%

(a)

Hydro 6.8%
Nuclear 4.4%
Gas 24%
Oil 33%
Other 2.5%
Coal 30%

(b)

FIGURE 2.6

Sources of energy in the mid-2010s, shown as percentages. (a) Some 82% of U.S. energy comes from fossil fuels. The "Other" category includes geothermal, wind, and solar energy. (b) Fossil fuels supply about 86% of the world's energy. Here the "Other" category includes biomass, geothermal, wind, and solar energy.
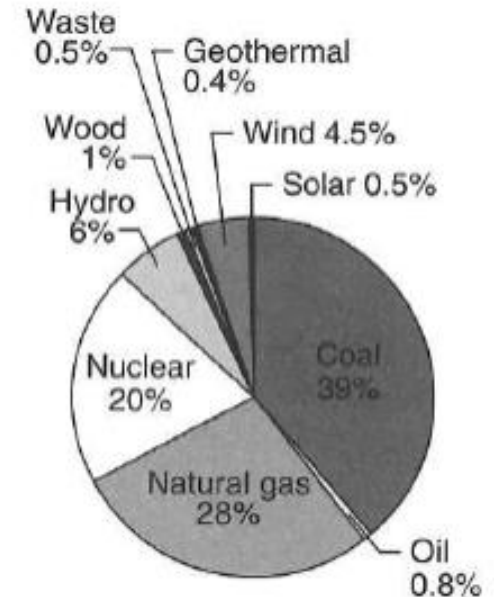
As of 2015…
U.S. consumes ~18% of global energy
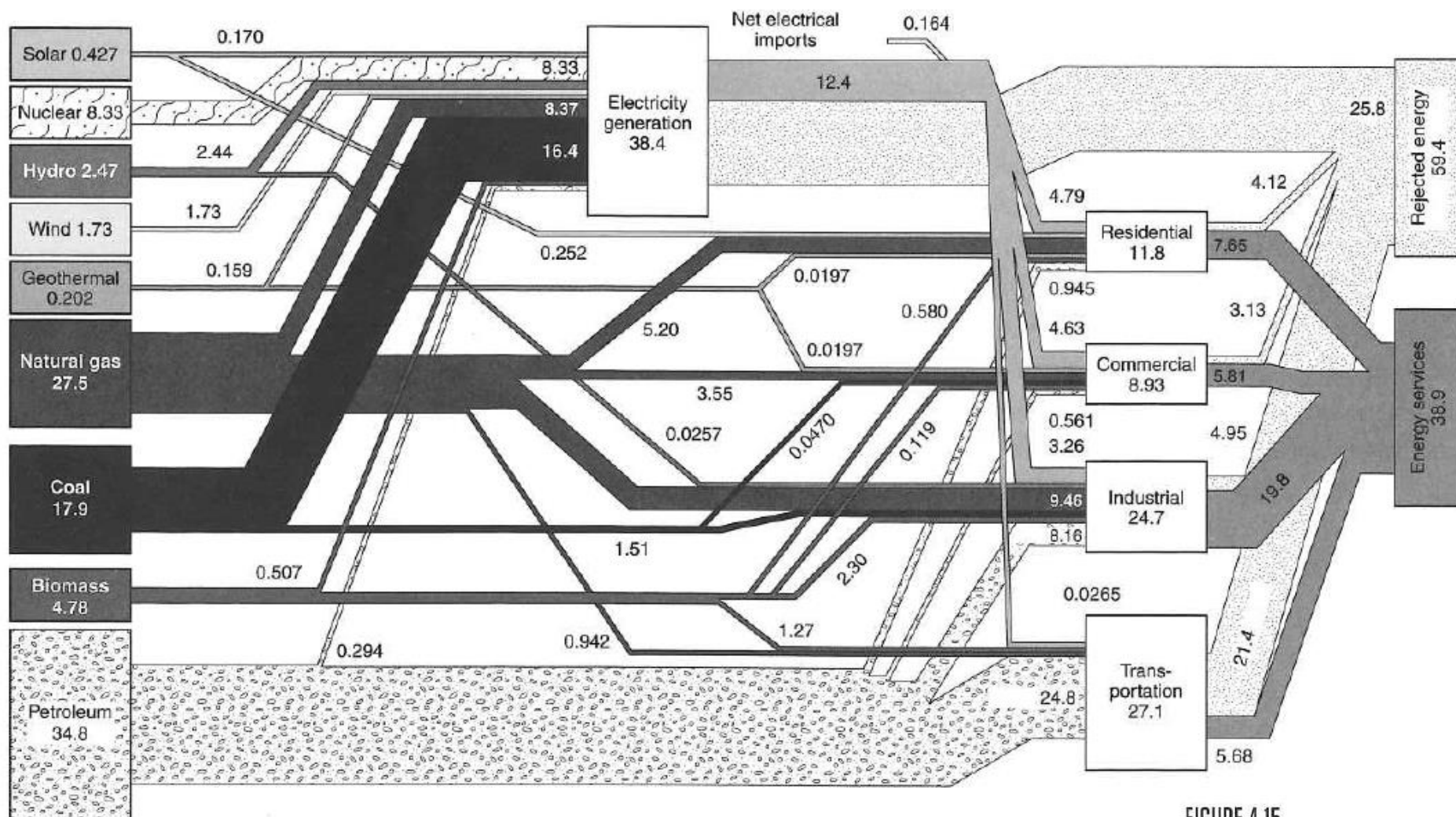*China consumes ~23%*

FIGURE 3.5

Sources of electrical energy in the United States. Data are for 2015, but the picture is evolving rapidly as natural gas replaces coal and the contributions from solar and wind surge.

Waste 0.5%
Geothermal 0.4%
Wood 1%
Wind 4.5%
Hydro 6%
Solar 0.5%
Nuclear 20%
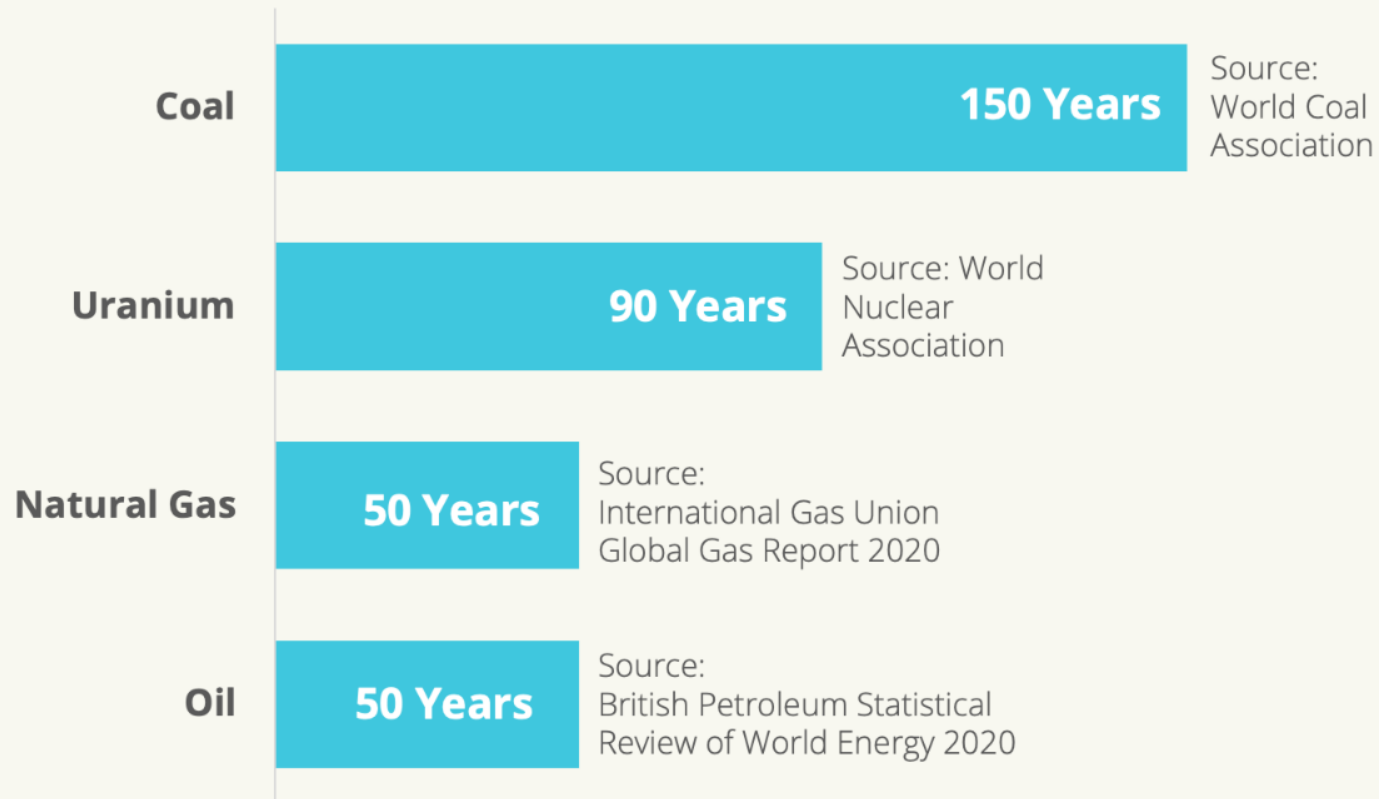Coal 39%
Natural gas 28%
Oil 0.8%

FIGURE 4.15

Energy-flow diagram for the United States in 2014, showing primary energy sources on the left and end uses and waste ("rejected energy") on the right. Numbers are in quads (10^{15} Btu).

Industry estimates of economically viable fossil fuel reserves

Fuel	Estimate	Source
Coal	150 Years	Source: World Coal Association
Uranium	90 Years	Source: World Nuclear Association
Natural Gas	50 Years	Source: International Gas Union Global Gas Report 2020
Oil	50 Years	Source: British Petroleum Statistical Review of World Energy 2020

FREEING ENERGY

The SI unit of energy is Joule and its commercial unit is kWh.

The relationship between 1 kWh and SI unit of energy is as follows:

1 kWh = 1 kW x 1 h   = 3,412.14 BTU

= 1000 W x 3600 s

1 watt - second = 1 joule

1 kWh = 3600000 J

Evolution of Energy

- Humans evolved ~2.8 Ma ago
- Energy derived from one's own body only (~100W)
- ~1 Ma developed fire (~10kW) and domesticated animals (1 HP is 746 W, and a horse max output is ~15 HP)
- Animal oil, natural tar/oil seeps
- Wind, water
- Coal, oil, natural gas, uranium (nuclear)
- Solar, geothermal, tidal
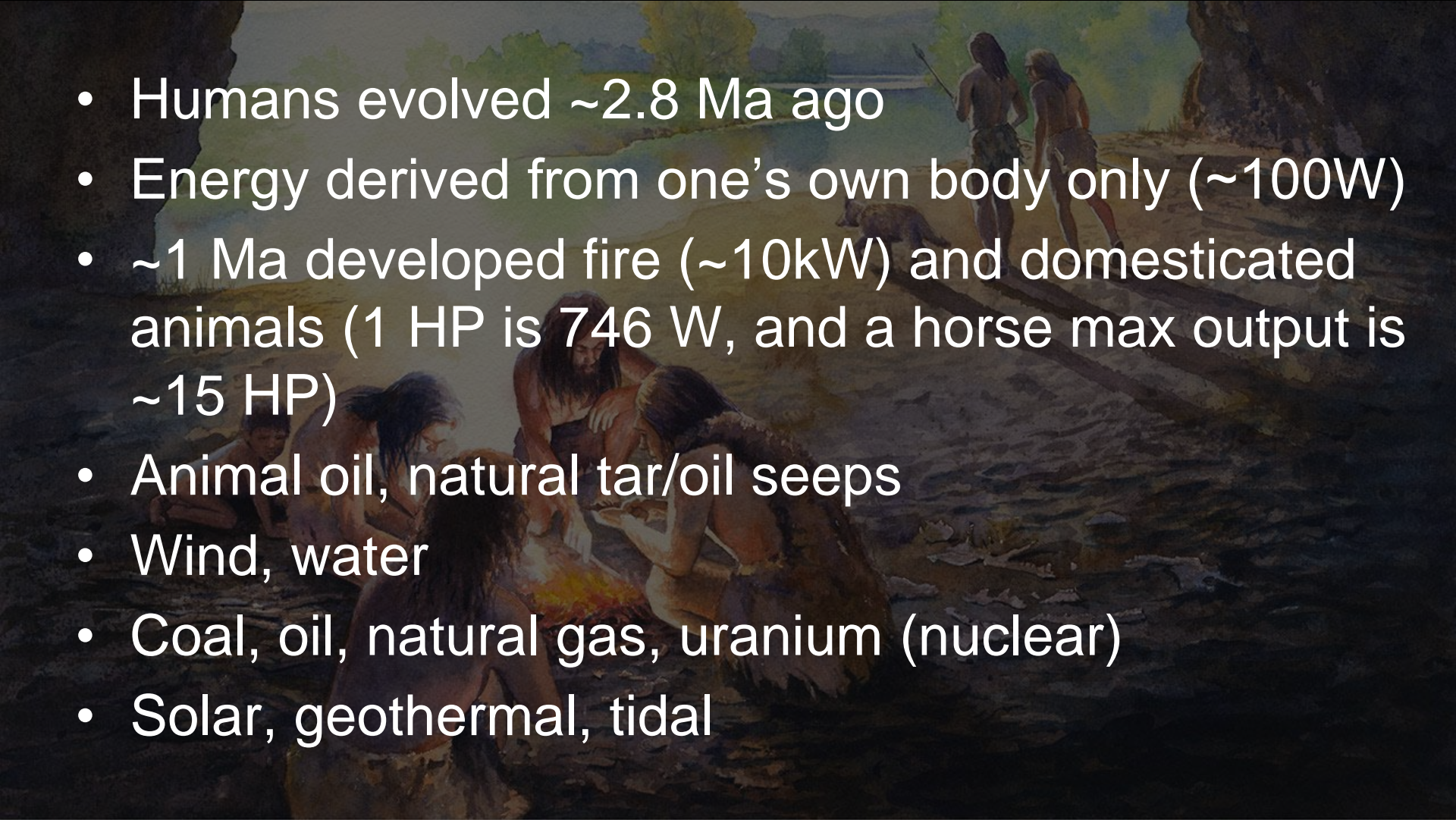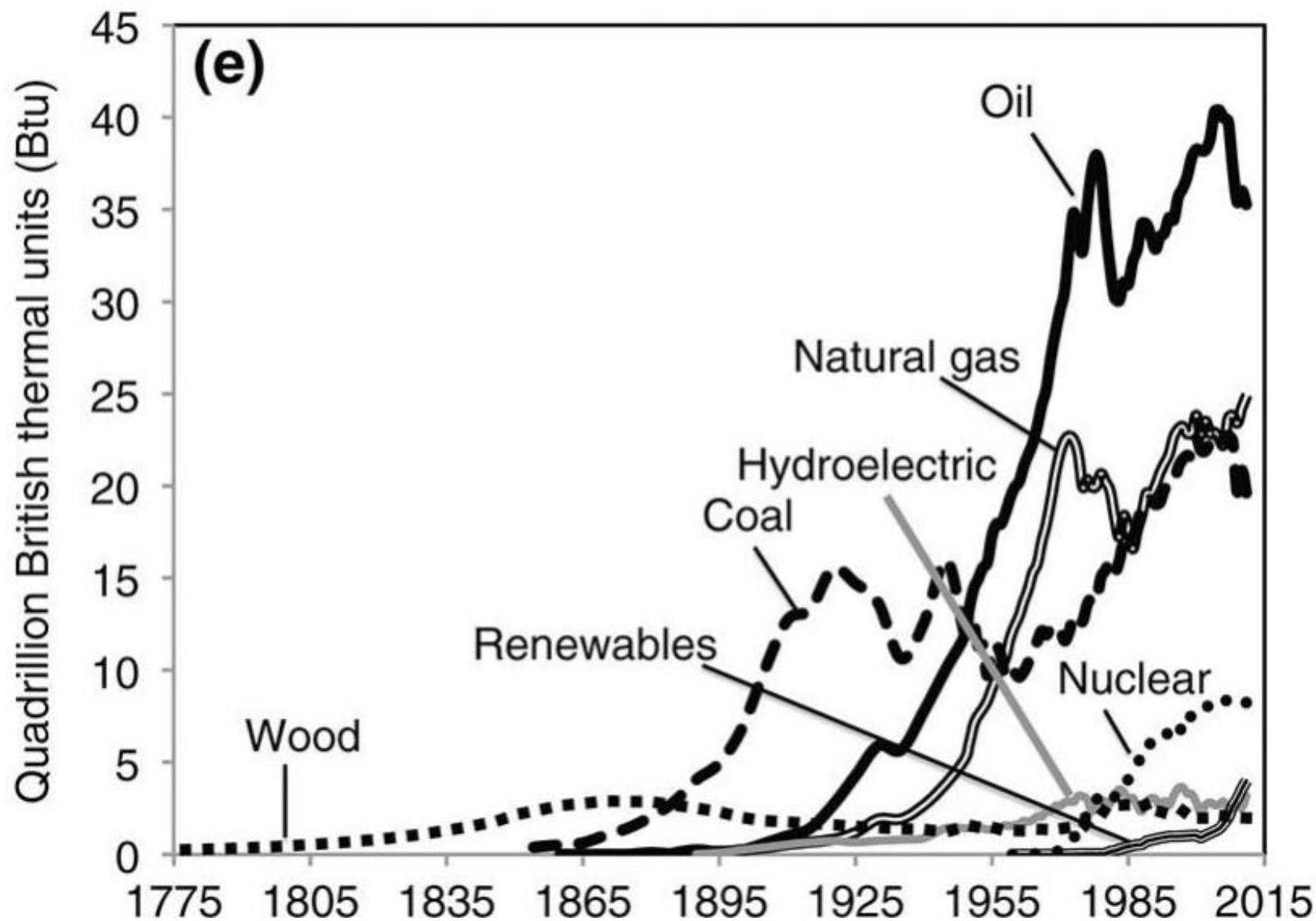
TABLE 3.3 | ENERGY CONTENT OF FUELS

Fuel	TYPICAL ENERGY CONTENT (VARIES WITH FUEL SOURCE)	
	SI units	Other units
Coal	29 MJ/kg	7,300 kWh/ton 25 MBtu/ton
Oil	43 MJ/kg	~40 kWh/gallon 138 kBtu/gallon
Gasoline	44 MJ/kg	36 kWh/gallon
Natural gas	55 MJ/kg	30 kWh/100 cubic feet 1,000 Btu/cubic foot
Biomass, dry	15–20 MJ/kg	13–17 MBtu/ton
Hydrogen gas (H_2) burned to produce H_2O	142 MJ/kg	320 Btu/cubic foot
Uranium, nuclear fission:		
Natural uranium	580 GJ/kg	161 GWh/tonne
Pure U-235	82 TJ/kg	22.8 TWh/tonne
Hydrogen, deuterium–deuterium nuclear fusion:		
Pure deuterium	330 TJ/kg	
Normal water	12 GJ/kg	13 MWh/gallon, 350 gallons gasoline equivalent per gallon water

(a)
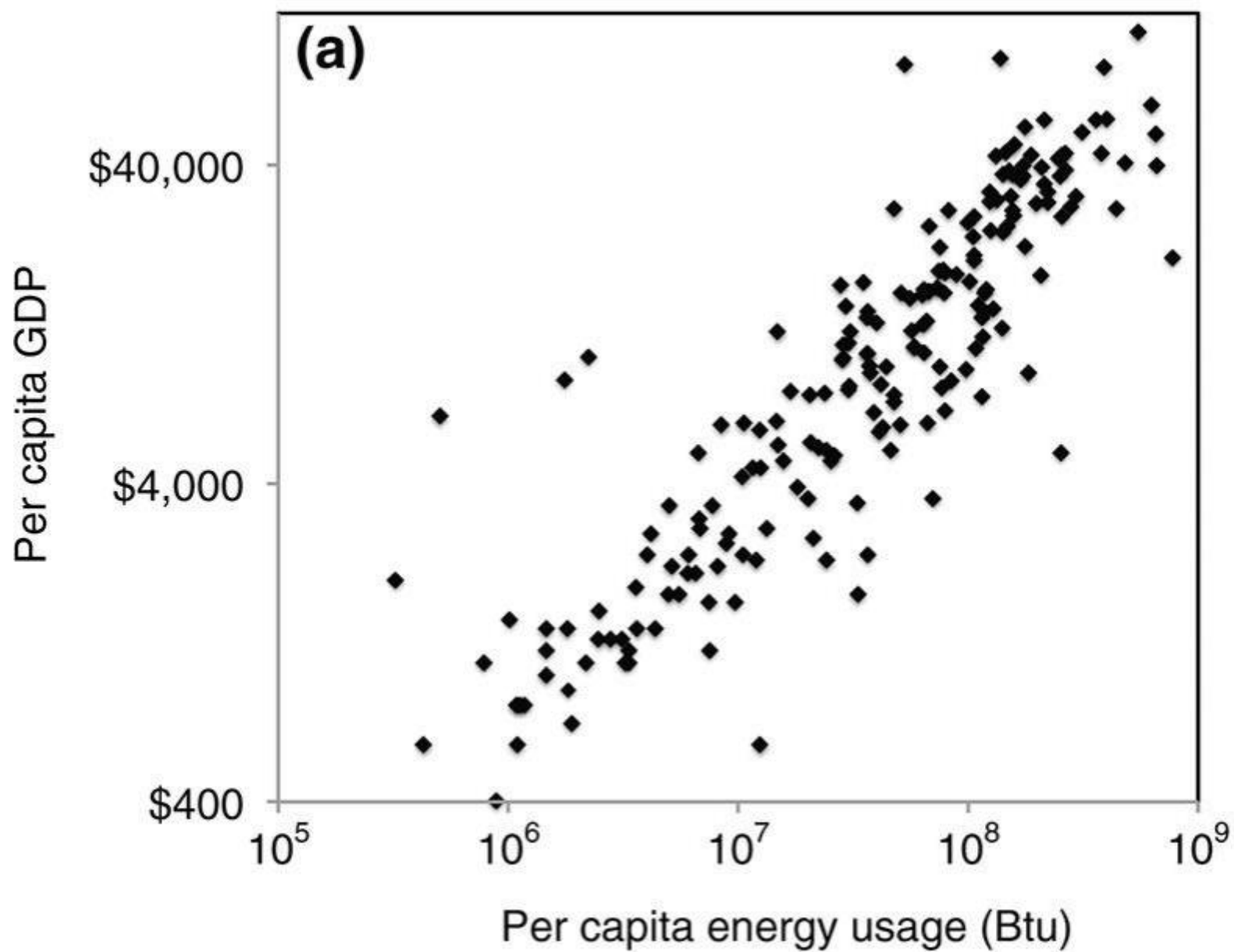
Basically, how efficiently do countries covert power
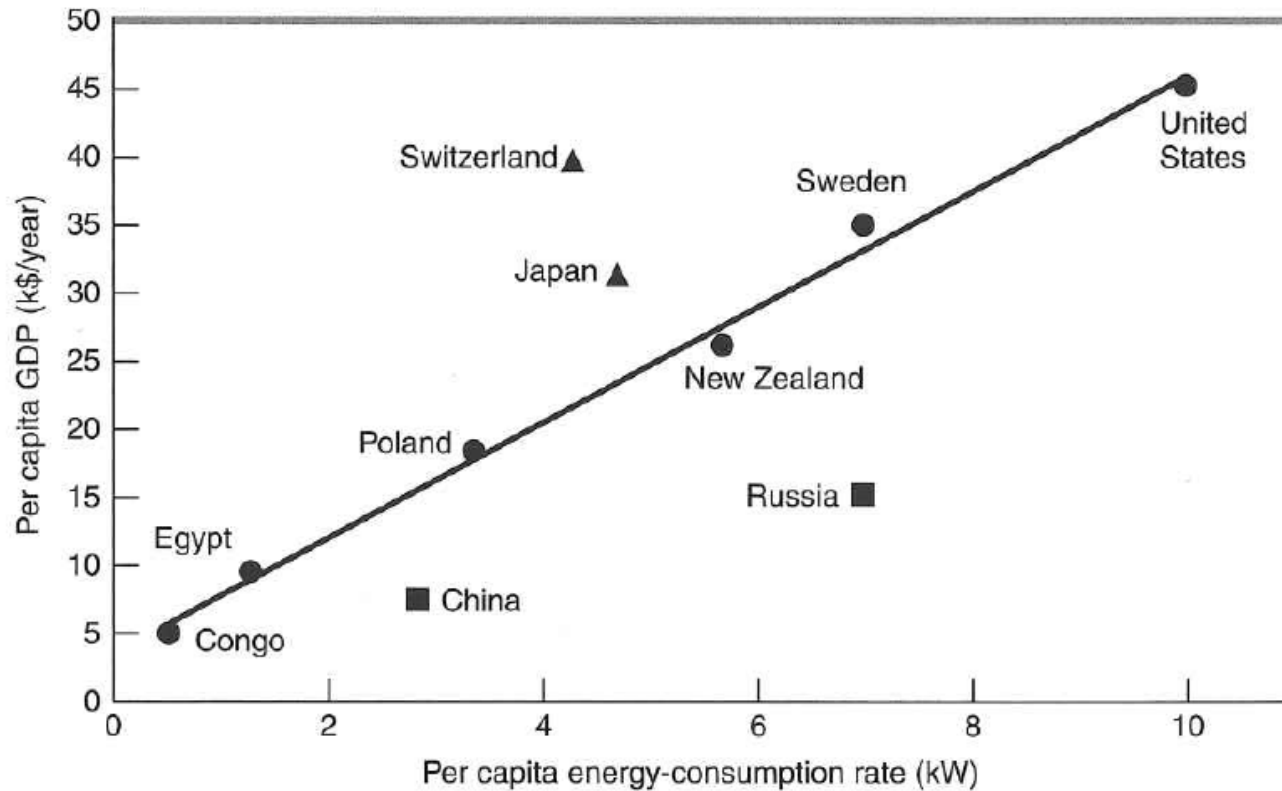to wealth? >> "energy intensity"

FIGURE 2.7

Per capita GDP (in thousands of U.S. dollars per year) versus per capita energy consumption for 10 countries. The 6 countries that fall near the straight line have approximately the same energy intensity, or energy consumed per unit of GDP (GDP figures used here are what economists call GDP *ppp*, for "purchasing power"). Japan and Switzerland are more energy efficient, and Russia and China less so. Multiplying the numbers on the horizontal axis by 10 gives the number of energy servants per capita.

Large countries = more transportation
Tropical countries = less heating
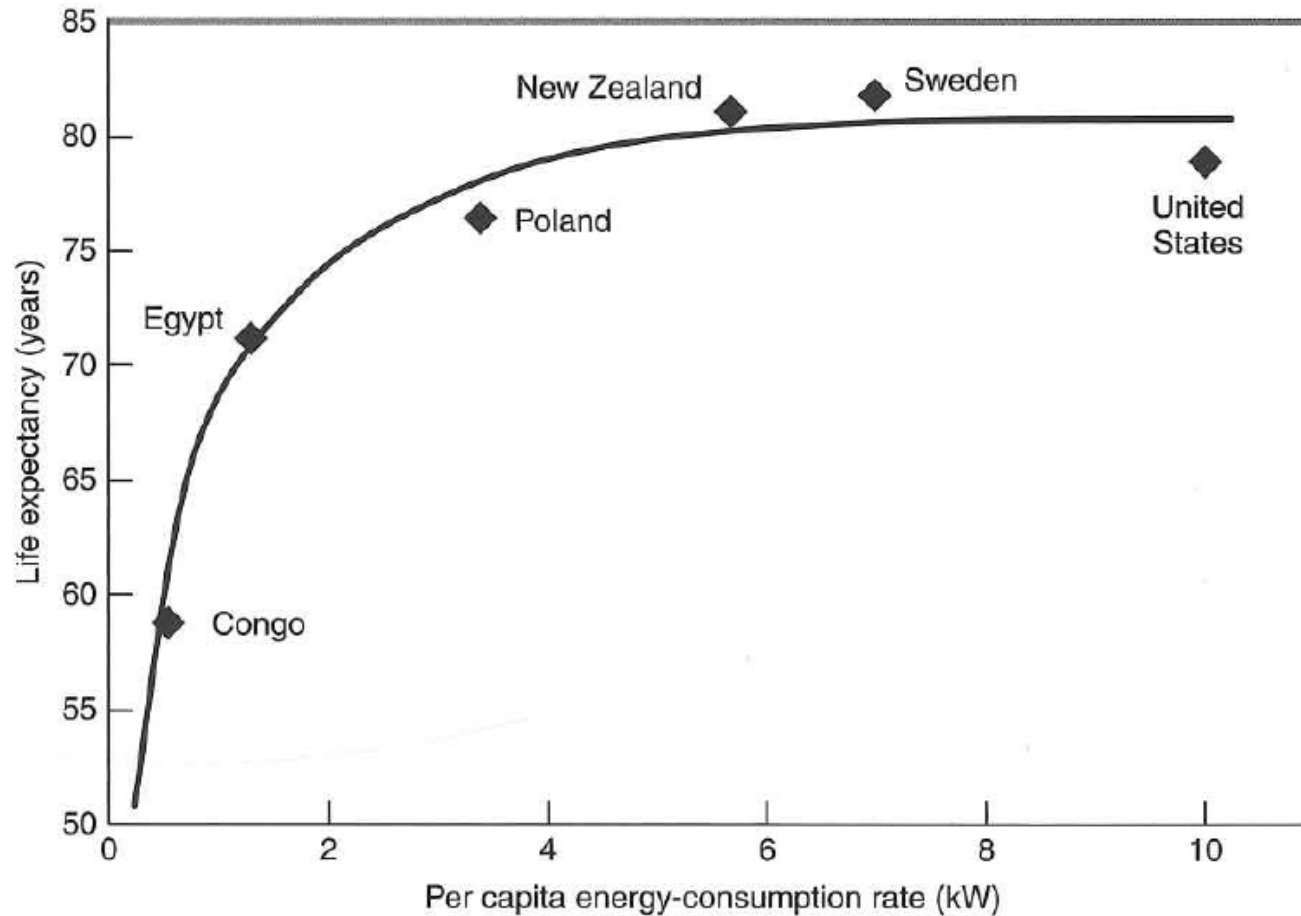
FIGURE 2.9

Life expectancy versus energy consumption for the six countries that lie near the line in Figure 2.7. Only at very low energy-consumption rates is there a correlation; at higher energy-consumption rates, the life expectancy curve saturates. Many other quality-of-life indicators show similar behavior in relation to energy consumption.

Why does the curve flatten?
Is GDP the best indicator of quality of life?
- cleaning up oil spills, building prisons, health care for an unhealthy population