Solutions to Chapter 1:

Exercise 1.1: Energy Content

a) W = 1 kg · 8.14 kWh/kg = 8.14 kWh

W = 8.14 kWh = 8140 W · 3.600 s = 29 304 000 Ws = 29.304 MJ

b) $W_{\text{Pot}} = m \cdot g \cdot h \;\Rightarrow\; h = \frac{W_{\text{Pot}}}{m \cdot g} = \frac{29.304 \cdot 10^6 \text{ J}}{1 \text{ kg} \cdot 9.81 \text{ m/s}^2} = 2987 \text{ km} \approx 3000 \text{ km}$

c) $W_{\text{Kin}} = \frac{1}{2} \cdot m \cdot v^2 \Rightarrow v = \sqrt{\frac{2 \cdot W_{\text{Kin}}}{m}} = \sqrt{\frac{2 \cdot 29.304 \cdot 10^6 \text{ Ws}}{1000 \text{ kg}}} =$

$= \sqrt{\frac{2 \cdot 29.304 \cdot 10^6 \text{ kg} \cdot m^2}{1000 \text{ kg} \cdot s^2}} = 242.1 \text{ m/s} = 871.6 \text{ km/h}$

Exercise 1.2: Environmental Effects of the Present Energy Supply

a) Tightening of the resources, Climate change, Hazards/disposals

b) $\vartheta_{\text{Today}} \approx +15$ °C, $\vartheta_{\text{without greenhouse effect}} \approx -18$ °C

c) Sketch see Figure 1.6:
Relevant effects: Short wave radiation heats the ground, this radiates long wave radiation, which is hold back by the greenhouse gases

Exercise 1.3: Finiteness of Resources

a) Primary energy demand of the world in 2008: $W_{\text{World}} \approx 12.5$ billion toe
$W_{\text{World}} = 12.5 \cdot 10^9$ toe = $12.5 \cdot 10^9 \cdot 10^3 \cdot 11.63$ kWh = $1.454 \cdot 10^{14}$ kWh

Per capita consumption in Germany: $W_{\text{Head}} \approx 50.000$ kWh/head

$\Rightarrow W_{\text{World}}/W_{\text{Head}} = 1.154 \cdot 10^{16}$ kWh / (50.000 kWh/head) = 2.91 billion people

b) Total consumption after n years:

$W_n = W_{2008} \cdot (q^0 + q^1 + q^2 + \ldots + q^{n-1})$ with $q = 1 + p$,

With equation of geometrical series we have:

$W_n = W_{2008} \cdot \frac{q^n - 1}{q - 1}$, solving to n results in: $n = \frac{\log\left[\frac{W_n}{W_{2008}} \cdot (q-1) + 1\right]}{\log(q)}$

Result for p = 2.2 %: oil: 29.5 a, gas: 38.2 a, coal: 64.6 a

Result for p = 4.4 %: oil: 23.9 a, gas: 29.7 a, coal: 457 a

Exercise 1.4: Properties of Renewable Energies

a) Solar radiation, Earth heat, movement of the planets

b) Pros:
Practically inexhaustible, no fuel costs, decentralized availability, almost free of emissions, hardly any hazards and environmental effects

c) Cons:
Varying energy supply, small energy densities, high investment costs

Exercise 1.5: Yields of a Photovoltaic Plant

a) STC: Standard Test Conditions,

- $E_{STC} = 1000\ W/m^2$
- $\vartheta_{Module} = 25\ °C$
- Standard light spectrum AM 1.5

b) $$P_{STC} = \frac{W_{Year}}{w_{Year}} = \frac{3500\ kWh/a}{900\ \frac{kWh}{kW_P \cdot a}} = 3.89\ kWp \approx \underline{4\ kWp}$$

$$A = \frac{P_{STC}}{E_{STC} \cdot \eta_{Module}} = \frac{4\ kW_P}{1000\ \frac{W}{m^2} \cdot 0.15} = 26.67\ m^2 \approx \underline{27\ m^2}$$