**Introduction to Solar Energy**

Energy has a large number of different forms, and there is a formula for each one. These are: gravitational energy, kinetic energy, heat energy, elastic energy, electrical energy, chemical energy, radiant energy, nuclear energy, mass energy. If we total up the formulas for each of these contributions, it will not change except for energy going in and out. It is important to realise that in physics today, we have no knowledge of what energy is. We do not have a picture that energy comes in little blobs of a definite amount. It is not that way. However, there are formulas for calculating some numerical quantity, Energy and when we add it all together it gives . . . always the same number. It is an abstract thing in that it does not tell us the mechanism or the reasons for the various formulas.

**Some definitions**

We will now state some basic physical connections between the three very important physical quantities of energy, force, and power. These connections are taken from classical mechanics but generally valid. We start with the force F, which is any influence on an object that changes its motion. According to Newton’s second law, the force is related to the acceleration a of a body via

**F** = m**a**

where m is the mass of the body. The bold characters denote that F and a are vectors. The unit of force is Newton (N), named after Isaac Newton (1642-1727). It is defined as the force required to accelerate the mass of 1 kg at an acceleration rate of 1 m/s2, hence 1 N = 1 kg·m/s2.

In mechanics, energy E, the central quantity of this book, is given as the product of force times distance,

E = Z F(s) ds

where s denotes distance. Energy is usually measured in the unit of Joule (J), named after the English physicist James Prescott Joule (1818-1889), which it defined as the amount of energy required applying the force of 1 Newton through the distance of 1 m, 1 J = 1 Nm.

Another important physical quantity is the power P, which tells us the rate of doing work, or, which is equivalent, the amount of energy consumed per time unit. It is related to energy via

E = Z P(t) dt,

where t denotes the time. The power is usually measured in Watt (W), after the Scottish engineer James Watt (1736-1819). 1 W is defined as one Joule per second, 1W = 1 J/s and 1 J = 1 Ws.

As we will see later on, 1 J is a very small amount of energy compared to the human energy consumption. Therefore, in the energy markets, such as the electricity market, often the unit Kilowatt hour (kWh) is used. It is given as

1 kWh = 1000 Wh × 3600 s

h = 3 600 000 Ws.

On the other hand, the amounts of energy in solid state physics, the branch of physics that we will use to explain how solar cells work, are very small. Therefore, we will use the unit of electron volt, which is the energy a body with a charge of one elementary charge (e = 1.602 × 10−19 C) gains or looses when it is moved across a electric potential difference of 1 Volt (V),

1 eV = e × 1 V = 1.602 × 10−19 J.