



## *T206 Energy For a Sustainable Future*

### **Units and dimensions**

In the design and operation of processes the type of question most commonly asked is how much? how big? In order to answer such questions it is important to have systems of measurement which are consistent and understood by all.

**A dimension** is a property that can be measured such as distance, time, temperature, speed.

**A unit** is a basic division of a measured quantity and it enables to say how much of the quantity we have - 10 miles, 2 hours etc.

### **Base units and derived units**

**Base units** are units that are defined by reference to some external standard. This external standard is arbitrary but is a matter of common agreement.

**Derived units** are units that are defined by reference to combinations of the base units.

### **The SI system of units.**

The SI system is an internationally agreed system of units based on seven base units. These are listed in table 1 below. Some of the more important derived units are listed in table 2.

**Table 1 Base units of the SI system of units**

<b>Quantity</b>	<b>Unit</b>	<b>Symbol</b>
Mass	kilogram	kg
Length	metre	m
Time	second	s
Mole	mole	mol
Temperature	Kelvin	K
Electric current	ampere	A
Light intensity	candela	cd

**Table 2 Some derived units in the SI system**

Quantity	Unit	Symbol
Area	square metre	m <sup>2</sup>
Land area	Are (= 100 m <sup>2</sup> )	a
Volume	cubic metre	m <sup>3</sup>
Force	Newton = kg m s <sup>-2</sup>	N
Pressure	Pascal = N m <sup>-2</sup>	Pa
Work, Energy	Joule = N m	J
Power	Watt = J s <sup>-1</sup>	W

Multiples of the basic units are used to avoid having to write very large or very small numbers. These are listed in table 3.

**Table 3 Multipliers for SI units**

Prefix	Abbreviation	Multiplier	Prefix	Abbreviation	Multiplier
Exa	E	10 <sup>18</sup>	deci	d	10 <sup>-1</sup>
Peta	P	10 <sup>15</sup>	centi	c	10 <sup>-2</sup>
Tera	T	10 <sup>12</sup>	milli	m	10 <sup>-3</sup>
Giga	G	10 <sup>9</sup>	micro	μ	10 <sup>-6</sup>
Mega	M	10 <sup>6</sup>	nano	n	10 <sup>-9</sup>
Kilo	k	10 <sup>3</sup>	pico	p	10 <sup>-12</sup>
hecta	h	10 <sup>2</sup>	femto	f	10 <sup>-15</sup>
deca	D	10 <sup>1</sup>	attia	a	10 <sup>-18</sup>

**Note also:** 1 million = 10<sup>6</sup> and 1 billion = 10<sup>9</sup>.

### Units of Energy and Power

The **Joule** is the basic SI unit of energy and is the energy expended when an object is moved through a distance of one metre as a result of a force of one Newton being applied to the object.

Power is the rate at which energy is expended and is calculated from;

$$\text{Power} = \frac{\text{Energy used}}{\text{time}}$$

The SI unit of power is the **Watt** and is equal to one Joule per second ( 1.0 W = 1.0 J s<sup>-1</sup>)

One unit of energy which causes confusion is the kilowatt-hour. This is a unit of *energy*, not of power as it is derived by multiplying the Power in kilowatts by the time in hours. One kilowatt-hour is equal to 3600 kilojoules or

$$1.0 \text{ kWh} = 3600 \text{ kJ} = 3.6 \text{ MJ}$$

It is important to be clear about the distinction between kilowatt-hours and kilowatts, as it can often lead to errors in calculations if you are not.

The table below gives conversions for kWh to Joules.

**Table 4. Power/Energy conversions involving kilowatt-hours.**

1. Energy conversions		2. Power conversions	
kWh → Joules		kWh/day → Watts	kWh/year → Watts
1kWh	= 3.6 MJ	1kWh/day = 42 W	1kWh/yr = 114 mW
1MWh	= 3.6 GJ	1MWh/day = 42 kW	1MWh/yr = 114 W
1GWh	= 3.6 TJ	1GWh/day = 42 MW	1GWh/yr = 114 kW
1TWh	= 3.6 PJ	1TWh/day = 42 GW	1TWh/yr = 114 MW
1PWh	= 3.6 EJ	1PWh/day = 42 TW	1PWh/yr = 114 GW

**Note:** The power conversions give the average rate of power generation for the required total energy output

### Units of land area

Since renewable energy sources are often quite diffuse, land area plays a prominent role in some aspects of T206.

The formal metric unit of land area is the Are which is 100 m<sup>2</sup>. However the most useful unit is the hectare (ha) ie. 100 Are or 10 000 m<sup>2</sup>. This is the metric equivalent of the Acre and 1.0 ha ≈ 2.5 Acres. Also 100 ha = 1 km<sup>2</sup> (= 10<sup>6</sup> m<sup>2</sup>)