ENERGY: DEFINITIONS AND UNITS

Forms of energy

With the exception of nuclear reactions which convert matter to energy, energy can be neither created nor destroyed. There are, however, different forms of energy:

heat - energy which makes a body hotter, or causes it to melt or evaporate

work - energy which moves a body or changes its shape or volume

chemical energy - energy stored in the chemical bonds of a substance which can be released by a chemical reaction (such as burning a fuel).

Energy can be transformed from one form to another, but the forms are not completely interchangeable. Work can be dissipated as heat, but heat cannot be transformed completely to work (see box 3A). Electrical energy is effectively a form of work.

Units for energy

The **joule** is the *Système Internationale*[1] unit for energy, defined as the energy of one kilogram moving at one metre per second. One **watt** is equivalent to one joule supplied each second. The following standard prefixes are used for joules and watts:

K = kilo = thousand = 10^3	M = mega = million = 10^6
G = giga = billion = 10^9	T = tera = trillion = 10^{12}

The two most commonly employed measures of quantities of energy supplied or used, at national and global levels, are millions of tonnes of oil equivalent (MTOE) for fossil fuels and terawatt hours (TWh) for electricity. We have departed from convention; neither of those measures features in this report. Rather than *quantities*, our numerical discussion of energy concerns *rates* of energy supply or use, usually averaged over a year. For clarity and simplicity, we refer to energy use and supply in terms of gigawatts (GW); one GW is a billion (thousand million) watts. This allows easy numerical comparisons between different primary sources of energy (fossil fuels, nuclear power, renewable sources), between different forms of energy, and between the different stages of energy supply and use.

Dispensing with MTOE and TWh as measures of energy also simplifies discussion of the capacity and average output of energy sources. The *maximum rate* of energy supply from a plant which generates electricity is referred to as its *capacity*, commonly expressed in GW or MW. Where we refer to the capacity of a plant, we follow the same convention. But most plants do not operate at maximum capacity over extended periods of time, so their *average output* is less. We express this actual output in terms of the average rate of supply in GW over a year. The *load factor* of a generating plant is its average output divided by its capacity; thus a power station of 1 GW capacity with an average output of 0.5 GW over a year would have a load factor of 0.5.

For purposes of comparison with the more conventional measures, one MTOE is the amount of energy released when one million tonnes of crude oil is burnt. (One million tonnes of gas would release rather more than one MTOE of energy when burnt, one million tonnes of coal rather less.) One MTOE is equivalent to an average rate of energy supply of 1.33 GW over a period of one year and an average rate of energy supply of one GW over one year is equivalent to 0.754 MTOE.

One TWh is the quantity of energy supplied when one trillion watts of electrical power is generated continuously for one hour (or one billion watts for 1,000 hours). One TWh supplied over one year (1 TWh/year) is equivalent to an average rate of energy supply of 0.114 GW and an average rate of energy supply of one GW is equivalent to 8.78 TWh/year.