Wasted energy

When energy is transformed, generally it is transformed into more than one other form of energy. The problem is that not all of these forms are useful. For example, in an electric circuit, the metal components have some resistance to the flow of electricity through them. As a result, their temperature increases. If a cell or battery is the source of the electrical energy, it too will get warmer. This means that not all of the chemical potential energy of the chemicals in the cell or battery is transformed into electrical energy. Some is transformed into heat energy.

One way to represent this energy transformation is known a Sankey diagram. An example is shown in Figure 1. Notice how the diagram indicates the relative proportions of the two forms of energy that are produced, by the relative sizes of the arrows.

The non-usable heat energy produced in an energy transformation can be considered as wasted energy.

Energy also can be wasted in another way. The spreading out of energy, so that not all the energy is transferred to a desired object, can cause a loss of useful energy as well. For example, when you heat a solution in a beaker over a Bunsen burner, not all of the heat energy supplied by the burning gas is transferred to the solution. Some is absorbed by the tripod and gauze mat and the glass of the beaker, and some is absorbed by the air. This loss of useful energy is termed the dissipation of energy.

Measuring energy

The international metric unit (SI unit) used for energy is the joule, symbol J.

The joule can be used to measure all forms of energy. Later you will learn about another energy unit, which is commonly used for electrical energy.

Prefixes

As with other measurement units, standard prefixes can be used for the units used to measure larger amounts of energy. The most commonly used prefixes are shown in Table 1.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Factor</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilo</td>
<td>k</td>
<td>1000</td>
<td>One kJ is a thousand joules</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>$1 000 000$, i.e. $10^6$</td>
<td>One MJ is a million joules</td>
</tr>
<tr>
<td>giga</td>
<td>G</td>
<td>$1 000 000 000$, i.e. $10^9$</td>
<td>One GJ is a thousand million joules</td>
</tr>
<tr>
<td>tera</td>
<td>T</td>
<td>$1 000 000 000 000$, i.e. $10^{12}$</td>
<td>One TJ is a million million joules</td>
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</tbody>
</table>
Measuring energy efficiency

Energy efficiency is a measure of the percentage of available energy that is useful, when energy loss has occurred. Ideally this should be as high as possible.

Energy efficiency is measured by the formula:

\[
\text{Percentage energy efficiency} = \frac{\text{amount of useful energy obtained}}{\text{original amount of energy available}} \times 100 \%
\]

Note: The energy can be measured in any unit. However, the two amounts of energy must be measured in the same energy units.

Example

![Heating water using a metal coil](image)

When water is heated by passing an electric current through a metal coil, as shown in Figure 2, some of the heat energy produced by the coil is wasted. Some heat is radiated into the air by the warm water, some is retained by the coil, and some is absorbed by the thermometer and stirrer and even by the cup.

In a certain experiment, the measured temperature rise showed that although 900 J of electrical energy was supplied to the coil, only 765 J of energy was absorbed by the water. Calculate the percentage energy efficiency of heating the water.

Solution

Original amount energy available = 900 J
Amount of useful energy obtained = 765 J

\[
\text{Percentage energy efficiency} = \frac{\text{amount of useful energy obtained}}{\text{original amount of energy available}} \times 100 \%
\]

\[
= \frac{765}{900} \times 100 \%
\]

\[
= 85\%
\]

This tells us that 85% of the available heat energy was used and 15% was wasted (100 – 85 = 15).

This energy efficiency is quite high, and occurs because the water container is well insulated to prevent heat energy escaping into the surrounding air.
QUESTIONS

1. In a hydroelectric power station, not all of the kinetic energy of the swiftly running water that turns the turbine is transformed into the mechanical energy of the turbine. After it has turned the turbine, the water runs down pipes to the local river system. So it still has some kinetic energy. Suppose that during a certain period, the kinetic energy of a certain quantity of the water passing through a particular turbine is 5600 MJ and after it leaves the turbine it is 1800 MJ.
   a. Calculate the amount of mechanical energy received by the turbine in that period.
   b. Calculate the percentage energy efficiency of this process. (In reality it would be much higher than this.)
   c. Show what you think a Sankey diagram might look like for this process.

2. Electrical energy is a very useful form of energy, because it can be converted into forms of energy we use daily, such as light energy, heat energy, sound energy and mechanical energy. An average Australian uses about 241 000 MJ of electrical energy per year! This is very high compared with the world average. How much electrical energy does the average Australian use each day?
Coal-fired power stations are the principal source of electrical energy in Australia. In a coal-fired power station, coal is burnt in big furnaces. Steam is passed through each furnace through a pipe. This heats the steam to a very high temperature, which makes it move much faster. Each pipe directs the steam to one of the giant turbines. The steam then hits the blades of the turbine, causing it to spin. This in turn causes the magnet or the wire coil inside the generator to spin, which generates an electric current. Meanwhile, the steam passes through a huge cooling tower to be cooled, a little is ‘bled off’ and replaced with pure water, and then the now cooled steam goes around the ‘circuit’ again.


Figure 3 The Loy Yang coal-fired power station in Victoria. The tall chimney stacks are above the furnaces. The huge towers with steam pouring from them, often mistaken for the pollution from the furnaces, are the cooling towers.

a Draw a flow chart to show the main steps used to generate electricity in a coal-fired power station and attach your drawing to this document.

b The energy efficiency of a coal fired-power station is less than 30%. This means that less than 30% of the chemical potential energy of the coal is transformed into electrical energy. Suggest two ways in which energy would be lost in this kind of power station.

_____________________________________________________________________________________
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c Would you expect the overall energy efficiency of a hydroelectric power station to be higher than, lower than or the same as that of a coal-fired power station? Justify your answer.

_____________________________________________________________________________________
_____________________________________________________________________________________

4 It takes 4.2 J of heat energy to raise the temperature of 1 g of water by 1°C. How much heat energy would be needed to:

a raise the temperature of 1000 g of water (1 L) by 1°C?

b raise the temperature of 1000 g of water (1 L) from 20°C to 100°C? Give your answer in J and in MJ.