

- Examples of **energy transformations** that everyday electrical devices bring about.
- The amount of **electrical energy** a device transforms depends on **how long the device is switched on** and the **rate at which the device transforms energy**.
- The **power** of a device is measured in **watts (W)** or **kilowatts (kW)**.
- Energy is normally measured in **joules (J)**. 1 watt = 1 joule/second.
- To calculate the **amount of energy transferred** from the mains using :

$\text{energy transferred (in J or kWh)} = \text{power of appliance (in W or kW)} \times \text{time in use (in s or h)}$
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- To calculate the **cost of energy transferred** by the mains using :

$\text{total cost} = \text{number of kWh} \times \text{cost per kWh}$

THE USE OF ELECTRICAL ENERGY

- Most of the energy which is transferred to domestic and industrial consumers is **electrical energy**. This is because we are able generate it by a variety of different methods and have found ways of transmitting it over long distances with relatively low energy loss. Additionally, electrical energy is easily transformed into all the other energy forms which we utilise in the home as well as in industry.
- **Electrical devices** transform **electrical energy** into other **useful** energy forms, but some of the energy supplied is always changed into **non-useful** forms (i.e. wasted energy).
- The number of electrical appliances used in the home has grown tremendously over the years. *Have a careful look around your own home and make a list.* Its sheer size will surprise you and it will show you just how dependent we are on electricity in our daily lives.
- In the table shown on the right, we are going to look at a few domestic appliances and write down the **useful** and **non-useful** energy forms each of them produces.

APPLIANCE	USEFUL ENERGY	NON-USEFUL ENERGY
Television set	..... from the screen and from the loudspeakers.	..... transferred from the components to the surroundings.
Electric cooker	..... from the elements transferred to the food being cooked.	None
Electric kettle	..... from the element transferred to the water.	None
Filament bulb	..... from the glowing filament.	..... transferred from the bulb to the surroundings.
Electric toaster	..... from the screen and from the loudspeakers	..... transferred from the elements to the body of the toaster and the surroundings.
Microwave oven	..... from the elements transferred to the bread.	..... energy
Radio	..... from the loudspeaker.	..... transferred from the components to the surroundings.
Washing machine	..... from the element and energy from the rotating drum.	..... transferred to the machine and surroundings. of rotating drum.
Hair drier	..... from the element and energy of the air blown out.	..... transferred to the body of the drier and of the fan motor.

ELECTRICAL POWER (P)

- The amount of energy transformed by an electrical appliance depends on :
 - The **time** for which the appliance is used.
 - The **rate** at which the appliance **transforms energy** (i.e. the **electrical power**)

The **electrical power (P)** of a device is the rate at which it transforms electrical energy into other energy forms.

$$\text{POWER} = \frac{\text{ENERGY TRANSFORMED}}{\text{TIME TAKEN}}$$

$$P = \frac{E}{t}$$

(watts) (joules) (seconds)

- Power** is measured in **watts (W)**.
- 1 watt = 1 joule/second
1 W = 1 J/s
- 1 kilowatt (kW) = 1000 watts (W)
1 megawatt (MW) = 1000 000 watts (W)

- The rate at which an appliance transforms electrical energy into other energy forms is called the **power rating** of the appliance.

All electrical appliances have their power rating marked on them.

Check this at home and complete the table shown below :

APPLIANCE	POWER RATING/W
Electric kettle	
Low energy light bulb	
Hair drier	
Television set	
Toaster	
Microwave oven	
DVD player	
Electric fan	

USING ELECTRICAL APPLIANCES

- The amount of **energy** in **joules (J)** which is transferred by an electrical appliance when it is being used may be calculated using :

$$\text{energy transferred (in joules)} = \text{power of appliance (in watts)} \times \text{time in use (in seconds)}$$

- When electricity is used at home or at work, the amount of electrical energy transferred from the mains is measured in :

KILOWATT-HOURS (kWh)

- 1 kilowatt-hour (kWh) is the amount of electrical energy used by a 1 kilowatt (kW) appliance when it is used for 1 hour.

$$1 \text{ kWh} = 1 \text{ UNIT of electricity.}$$

$$\text{energy transferred (in kWh)} = \text{power of appliance (in kW)} \times \text{time in use (in hours)}$$

- The number of **joules** in 1 kWh is calculated from :

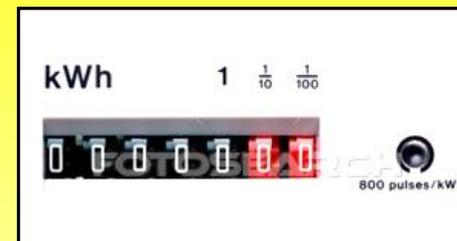
$$\begin{aligned} \text{Energy transferred} &= \text{power} \times \text{time} \\ &= 1 \text{ kW} \times 1 \text{ h} \\ &= 1000 \text{ W} \times 3600 \text{ s} \end{aligned}$$

$$= 3\,600\,000 \text{ W} = 3.6 \text{ MW}$$

- The **cost of the energy transferred** is calculated using :

$$\text{Total cost} = \text{number of kWh} \times \text{cost per kWh}$$

- The electricity meter in your home measures the amount of electrical energy (in kWh or units) which have been used over a given time period.



The bill for the electrical energy used is calculated from the **increase** in the meter reading since it was last read.

A typical electricity bill is shown below.

Complete the bill by calculating the **charge amount**.

Present reading	Previous reading	kWh used	Cost per kWh (p)	Charge amount (£)
E 10575	E 10895	E 320	E 10	
N 25604	N 25894	N 290	N 24	
Total VAT exclusive charges				
VAT @ 5%				
Total charge : inclusive of VAT				

E - These are the **economy** readings for cheaper electricity used during the night.

N - These are the **normal** readings for full-priced electricity used during the daytime.

5 Given that the cost of 1 kWh is 24 p, calculate the cost of each of the following :

- (a) Using an 8 kW electric shower for 15 minutes.
 (b) Using 5, 60 W light bulbs for 8 hours.
 (c) Heating water for 2.5 hours using a 5 kW immersion heater.

7 The diagram below shows the readings on a domestic electricity meter, in kWh, at the beginning and end of one week. Each kWh of electricity costs 24 p.



beginning of week



end of week

- (a) How many kWh of electricity were used during the week?
 (b) What is the total cost of the electrical energy used during the week?
 (c) On one particular day, 30 kWh of electricity were used. How much would this cost?
 (d) During the week, a 2 kW iron was used for 2.5 hours. How much energy was transformed by the iron?
 (e) How much does it cost to use a 9 kW shower for half an hour?

• PRACTICE QUESTIONS

1 (a) Name a device that usefully transforms electrical energy into :

- (i) Light and sound energy. (ii) Kinetic energy.

(b) Complete the following sentences :

(i) In an electric bell, electrical energy is transformed into useful energy in the form of energy and energy.

(ii) In a washing machine, electrical energy is transformed into useful energy in the form of energy and energy.

2 How much energy is used by : (a) A 100 W light bulb in 25 s?

(b) A 2.5 kW electric heater in 30 minutes?

(c) An 8.5 kW electric shower in 7.5 minutes?

3 (a) How long will a 7.5 kW electric shower operate if it is supplied with 2.5 MJ of electrical energy?

(b) What is the power rating of an electric kettle which if it consumes 150 kJ of electrical energy per minute?

4 (a) Which two units in the list below may be used to measure energy?

Joule kilowatt kilowatt-hour watt

(b) Rank the electrical devices below in terms of energy used from highest to lowest.

- A. A 0.5 kW heater used for 4 hours.
 B. A 100 W lamp left on for 24 hours.
 C. A 3 kW electric kettle used 6 times for 10 minutes each time.
 D. A 750 W microwave oven used for 10 minutes.

The diagram below shows the readings on a household electricity meter at the beginning and at the end of a particular day.

Each kWh of electricity costs 24p.



Beginning of day



end of day

- (a) How many kWh of electricity were used during the day?
- (b) On the following day, 30 kWh of electricity were used. How much would this cost?
- (c) During one week, a 7.5 kW shower heater was used for 3 hours. How much energy was transferred by the heater?

• HOMEWORK QUESTIONS

- 1 What is the **cost** of running each of the following electrical devices :
- (a) A 2.5 kW fire for 2 hours a day over a 2 week period.
- (b) An 18 W low energy light bulb used for 4 hours a day over a whole year.
- (c) A 225 W DVD player used for a total time of 15 hours.
(1kWh costs 24p)
- 2 (a) Calculate the number of kWh transformed in each of the following cases :
- (i) A 3 kW electric kettle used 6 times for 5 minutes each time.
- (ii) A 1000 W microwave oven used for 30 minutes.
- (iii) A 100 W light bulb used 5 hours a day for a whole week.
- (iv) A 6 kW electric immersion heater used for 8 hours.
- (b) Given that electricity costs 24p per kWh, calculate the total cost of all the electricity used in (a).
- 3 An escalator in a shopping centre is powered by a 70 kW electric motor. It is used for 10 hours each day.
- (a) How much electrical energy, in kWh, is supplied to the motor each day?
- (b) If electricity costs 24 p per kWh, what is the daily cost of running the escalator?
- (c) How much would be saved each day if the original motor was replaced by a more efficient 40 kW version?