D3 Identify and estimate energy inputs and outputs for example devices and systems, and evaluate the efficiency of energy conversions

D3.1 identify the forms of energy inputs and outputs in a device or system

D3.4 compare energy inputs and outputs of a device, and calculate its efficiency, using the formula, percent efficiency = energy output/energy input × 100 (e.g., compare the number of joules of energy used with the number of joules of work produced, given information on electrical consumption and work output of a motor-driven device)

Input, Output, and Efficiency

Input refers to the amount of energy put into a device, and **output** refers to the amount of energy that comes out. A device may change the type of energy but not the amount. For example, a light bulb's input energy is the form of electrical energy, and its output energy is in the form of light and heat.

Efficiency

Efficiency is the ratio of useful energy that comes out of a device to the total energy that went into it. Remember that energy cannot be destroyed, but it can be converted from one form to another.

$$\%_{efficiency} = \frac{output}{input} \times 100\%$$

Example

What is the efficiency of an incandescent light bulb that releases 62 kJ of light energy from an input of 1560 kJ of total energy?

Solution

$$\%_{efficiency} = \frac{62\ kJ}{1560\ kJ} \times 100\%$$

= 4%

The incandescent light bulb is 4% efficient in producing light and washes 96% of the input energy in the form of heat. It is very inefficient. A fluorescent bulb is more efficient than an incandescent bulb. LEDs… the BEST!

D3.2 apply appropriate units, measures and devices in determining and describing quantities of energy transformed by an electrical device, by: – measuring amperage and voltage, and calculating the number of watts consumed by an electrical device, using the formula P = IV [power (in watts) = current (in amps) × voltage (in volts)] – calculating the quantity of electric energy, in joules, transformed by an electrical device, using the formula E = P × t [energy (in joules) = power (in watts) × time (in seconds)]

Power and Energy

Power, measured in watts, is the rate at which a device converts energy. Power is dependent on the current rating of an appliance and the voltage passing through it. Power is calculated using the following equation.

$$power\ (watts) = current\ rating\ (amps) \times voltage\ (volts)$$

$$P = I \times V$$

Example
What is the power rating in watts (W) of a curling iron that plugs into a 120 V circuit and used 9 A of current?

Solution
$$P = I \times V$$
$$P = 9\ A \times 120\ V$$
$$P = 1080\ W$$

Energy (E) is dependent on power (P) and time (t). Energy is calculated using the following equations.

$$E\ (joules) = P\ (watts) \times t\ (sec)$$

Example
How much energy is used by a 4 A appliance that is plugged into a 120 V circuit for 4 min?

Solution
Step 1
Calculate the power used.
$$P = I \times V$$
$$P = 4\ A \times 120\ V$$
$$P = 480\ W$$

Step 2
Calculate the energy used. ***Remember that time needs to be in seconds***

$$E = P \times t$$
$$E = 480\ W \times 4\ min \times 60 s/min$$
$$E = 115200\ J$$

Producing and distributing electricity is expensive. Power companies pass their costs on to the consumer and charge per kilowatt hour of use.

Example

What is the cost of operating a 2400 W heater two hours per day for a 20-day period? The charge per kilowatt hour is \$0.10.

Solution

Step 1

Change watts to kilowatts

$$2400\ W \times \frac{1\ kW}{1000\ W} = 2.4\ kW$$

Step 2

Multiply by the hours of use. (How many hours TOTAL?)

$$t_{total} = 2\ hours/day \times 20\ days = 40\ hours$$

$$2.4\ kW \times 40\ h = 96\ kWh$$

Step 3

Multiply the cost per kilowatt hour.

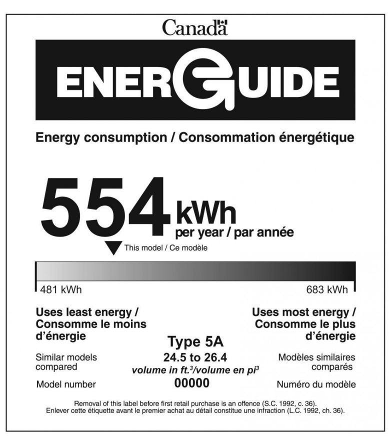
$$96\ kWh \times \frac{\$0.10}{kWh} = \$9.60$$

D3.3 the concepts of conservation of energy and efficiency to the analysis of energy devices (e.g., identify examples of energy dissipation in the form of heat, and describe the effect of these losses on useful energy output)

Analyzing Energy Devices

The Law of conservation of energy states that energy can be neither created nor destroyed; it can only be transformed. When efficiencies of energy devices are examined, there is sometimes much more energy put into the device than is converted into useful form of energy. The energy that has been lost is often lost in the form of heat as a result of friction. All mechanical devices will lose some useful energy because energy dissipates to the surroundings in the form of heat.

Many new models of appliances are more energy efficient than the were in the past. They are better designed and better insulated than previous models. Such appliances must carry EnerGuide labels that indicate their energy consumption ratings.



D3.5 investigate and describe techniques for reducing waste of energy in common household devices (e.g., by eliminating sources of friction in mechanical components, using more efficient forms of lighting, reducing overuse of appliances as in "overdrying" of clothes)

Conserving Electrical Energy

There are several simple things that you can do at home or in school to help cut back on energy usage:

- When leaving a room, turn off the lights.
- Replace incandescent light bulbs with fluorescent bulbs… or better yet LEDs
- Wash the dishes by hand instead of using the dishwasher.
- Hang wet clothes on a clothesline instead of using a clothes dryer.
- Turn off computers and the television when they are not being used.
- Use air conditioners only when necessary.
- Turn down the heat at night or when people are out of the house during the day.