Power-Mate Lite Instructions

What is it?

The Power-Mate Lite is a simple device for measuring how much electricity appliances use, the amount of greenhouse gas emissions they produce from the electricity they use and their running costs.

What can you do with it?

There are many experiments you can do with the Power-Mate. You can find some examples in this lesson book or you can design your own.

Stay safe

- The Power-Mate has electricity running through it so don't use it if it's wet or in wet areas or if the case or cord is broken.
- Don't leave it in the sun because it can get very hot.
- If you plug the Power-Mate into a device and your screen says "warning overload", turn off the device at the power point and then unplug it.
- The Power-Mate is to be used with domestic appliances only.

How to use it?

There are two basic ways you can use The Power-Mate Lite:

A. Taking instantaneous power readings of an appliance; or
B. Measuring the energy, greenhouse or running costs of an application over a period of time

A. Taking instantaneous power readings of an appliance

1. Plug the Power-Mate into a power point and the appliance into the Power-Mate's socket.
2. Press MENU button until you see the "Meter" heading on the screen.
3. Use the **ZOOM** button to scroll through the various meter readings and **HOLD** the **ZOOM** button to enlarge the meter measurement such as Power, Volts, Amps or PF (power factor).
4. The "Power" measurement in watts is the most relevant and shows you the rate at which electricity is being used. The higher the watts the more electricity the appliance is using at that instant.

B. Measuring energy, greenhouse or running costs over a period of time

The longer the Power-Mate runs the more accurate your results. Measuring over 24 hours is recommended for appliances that run according to temperature such as fridges and heaters, or for appliances that turn on or remain on standby like TVs and computers. Remember even though your appliances are on standby, they still use energy!

1. Plug the Power-Mate into a power point and the appliance into the Power-Mate's socket.
2. Press the **MENU** button until you see the "Run Time" heading on the screen.
3. **HOLD** down the **RUN** button to clear data from the last appliance.
4. **HOLD** down the **MENU** button until you see the "Timer Duration" screen.

5. Press the **ZOOM** button to look through measuring times, e.g. 1 hour, 8 hours, 24 hours etc. (if you don't want a measuring time, select "not set").
6. Press the **MENU** button to select a time period for measuring.
7. Press the **RUN** button to start the Power-Mate measuring. A small triangle should appear in the top right of the screen – this means it's measuring.
8. Press the **MENU** button to look through the different things you can measure for an appliance:
   - **Cost screen:** how much is the appliance costing to run?
   - **G/Gas (Greenhouse Gas):** the amount of greenhouse gas emissions created from the electricity it uses.
   - **Energy screen:** how much electricity the appliance has used during the logging period.
9. Use the **ZOOM** button to scroll through measurements on the individual screens, and **HOLD** the **ZOOM** button to enlarge any readings.
10. Run the Power-Mate for as long as you want – the longer it runs the more accurate your results. You can use the **RUN** button to pause as well.
11. When you're ready, press the **RUN** button to stop measuring.
12. Look at the overall results by scrolling through the various screen and measurements using the **MENU** and **ZOOM** buttons.
13. Before you measure a new appliance, **HOLD** down the **RUN** button then press it to clear data. Remember to write down any information before measuring a new appliance.

How to change the price

For the best results, the Power-Mate should be programmed with the average regulated electricity price for Ausgrid's network areas of 28 c/kWh from 1 July 2013. You can change this setting to actual prices you pay. To find out how much you pay for electricity, check your electricity bill or contact your electricity retailer.

1. Press the **MENU** button until you get "Cost" on your screen, the **HOLD** down the **MENU** button to set the cost.
2. Press the **ZOOM** button to change the number and the **RUN** button to move between decimal places.
3. When you're ready, press **MENU** button to exit.
4. You can use the same steps to change the greenhouse gas assumptions. The greenhouse gas emission factor of 1.05kg/kWh is for electricity used in NSW and is published by the Departments of Climate Change & Energy Efficiency in the National Greenhouse Accounts Factors (July 2013).

Remember to change the settings back to the standard regulated electricity price (28 cents /kWh) and greenhouse gas factor (1.05kg/kWh) before another person uses the Power-Mate.

Need help?

I can't find the "run time" screen, just the "end time" screen.

Your Power-Mate has been set to run for a specific time period. Go to the previous page on the section 'Measuring appliances over a longer period' and repeat the steps.

There's too much information on the screen, I just want to see one value.

Some of these screens have multiple lines in small print. To select one line, use the ZOOM button to highlight the line you want, and then HOLD down the ZOOM button to show only the line highlighted

in larger print. You can scroll through the lines with the ZOOM button or hold it down to go back to the multiple lines.

My screen says 'set greenhouse gas' or 'set cost.'

For the best results, the Power-Mate should be programmed with the average regulated electricity price for Ausgrid's network area of 28 c/kWh from 1 July 2013.

If the settings show 27 cents/kWh for electricity prices and 1.05kg/kWh for the greenhouse gas factor, then you're in default mode – press the MENU button to exit. If you accidentally changed the numbers, press the ZOOM button to change the numbers and the RUN button to move between decimal places. Press the MENU button to exit.

There's an 'unplugged' icon on my screen.

Your Power-Mate has accidentally been unplugged which means your results won't be accurate. Re-plug your Power-Mate into the power point, hold down the RUN button then press it to clear data and start measuring your appliance again.

There's a 'warning overload' icon on my screen.

Turn off the device at the power point and then unplug it.

Lesson 1 – Research Project – Home Energy Audit

Teacher background information

It is predicted that human-induced increases of carbon dioxide in the atmosphere can result in climate change. A single household makes a real contribution to carbon dioxide emissions also known as a carbon footprint, but how much does a family really contribute in the running of a household?

The Power-Mate Lite meter enables the estimation of energy use, output of greenhouse gases or costs by determining the energy use of appliances that are switched on or in standby mode. .

Home energy audit

To estimate the contribution that households make to greenhouse gas emissions, the first step is to audit all appliances used in the home.

This audit will provide the basis of estimating a home's carbon footprint. The Power-Mate lite® meter allows estimation of greenhouse emissions and energy consumption of individual appliances or groups of appliances connected to one power board.

This may be useful for estimating the power consumption of devices used together for example the TV, DVD and cable box if they are all connected to a single appliance. Similarly that could be the case for a computer, printer and monitor all connected to a single power board.

When using the Power-Mate lite® meter, remember the longer it runs, the more accurate its estimation of greenhouse gas emissions and energy consumption will be. Using the device is relatively easy but care must be taken.

1. Connect an appliance to the plugged in Power-Mate Lite and put it on the 'run time' menu by pushing the menu.
2. Leave it running for at least 30 minutes including a period when the equipment is running in typical mode.
3. Record the energy consumption results for each appliance in a table indicating standby energy consumption and running energy consumption.
4. If the appliance has an indication of power consumption on its manufacturing label, you can note whether the Power-Mate lite ® reading for that value correlates with the Power-Mate lite® meter reading.
5. Use the Power-Mate lite® to estimate the greenhouse gases produced by the appliance per hour using the G/Gas menu.
6. Estimate the hours of use for each appliance per week then calculate the energy use and greenhouse gases emitted per week for each appliance.
7. Add up all the estimations for all appliances tested then estimate the greenhouse gas production for more difficult to test appliances such as air conditioners.
8. Use all the data to estimate the family carbon footprint.
9. Present the data that backs up your estimation with data gathered presented in tables or graphs.

After estimating your family's carbon footprint, discuss the energy consumption habits with them. See if they are interested in reducing their carbon footprint by using appliances more efficiently or making decisions to use appliances that are more efficient.

Stage 5 Science Syllabus for the Australian Curriculum outcomes

PW4 - Energy conservation in a system can be explained by describing energy transfers and transformations. (ACSSU190)

Students:

a. apply the law of conservation of energy to account for the total energy involved in energy transfers and transformations
b. describe how, in energy transfers and transformations, a variety of processes can occur so that usable energy is reduced and the system is not 100% efficient
c. discuss, using examples, how the values and needs of contemporary society can influence the focus of scientific research in the area of increasing efficiency of the use of electricity by individuals and society (ACSHE228, ACSHE230)

ES3 - People use scientific knowledge to evaluate claims, explanations or predictions in relation to interactions involving the atmosphere, biosphere, hydrosphere and lithosphere. (ACSHE160, ACSHE194)

Students:

d. evaluate scientific evidence of some current issues affecting society that are the result of human activity on global systems, eg the greenhouse effect, ozone layer depletion, effect of climate change on sea levels, long-term effects of waste management and loss of biodiversity.

Lesson 2 – Experiment – Energy efficiency in transformations

In this experiment you will investigate the transformation of electrical energy into heat energy.

The *Law of Conservation of Energy* states that energy cannot be destroyed but rather simply changes form. We often refer to electrical energy as electrical power, which is really a measure of energy consumption per second (measured in watts).

One watt is a joule of energy transformed per second. If we know the power or wattage of an electrical appliance, we can then calculate the energy it consumes per second. If the appliance runs for 60 seconds then we simply multiply the wattage by 60 to determine the energy consumed by the appliance in the 60 seconds in joules.

Pure water behaves very predictably when it comes to absorbing energy. For every one gram of water (or 1mL since one mL has a mass of one gram), if we raise the temperature of water by one degree Celsius then the water has absorbed 4.18 joules of energy. That value is known as the special term for specific heat capacity of water and has a symbol **c**.

The amount of energy gained by a mass of water can be calculated from the relationship:

$Q = mc\Delta T$

Where Q is the energy the water has gained, m is the mass in grams, c is 4.18 joules per gram per degree Celsius for water and ΔT is the difference in temperature.

Most homes now have a microwave oven as part of their cooking arsenal. It is a convenient and simple appliance to use. The question is whether or not it is an efficient appliance. If you think about one of the most obvious uses of electricity in your home, it is probably the heating of foods containing water in a microwave oven.

The microwave energy produced by the electricity is absorbed by the water molecules causing them to vibrate and gain energy.

In this investigation you will examine the efficiency of the energy conversions in heating water using a microwave oven. You will use a Power-Mate lite® meter to measure energy consumption.

Aim

To determine the efficiency of energy conversions that occur when released from an electric circuit. Make a prediction about what you expect to happen during the energy conversions from electricity to microwaves to heat a sample of water. Do you think the energy conversion will be 100% efficient? Write that prediction down then perform your investigation to test your prediction.

Apparatus (Equipment)

- A Power-Mate Lite energy meter. If you don't have access to a Power-Mate Lite another brand of energy measuring electricity meter will do.
- A microwave oven that is portable and with easy access to a power point
- One foam insulated cup
- One 100mL measuring cylinder
- One thermometer

Method

1. Switch off and disconnect the microwave from the power point.
2. Insert the Power-Mate Lite meter into the power point then plug the microwave back into the Power-Mate Lite meter socket. Turn on the power point.
3. Measure 100mL of water with the measuring cylinder and pour it into the foam cup.
4. Measure the temperature of the water and note it down. Note 1mL of water has a mass of 1 gram so there is no need to measure the mass of the water, though you could do that to check.
5. Place the cup of water inside the microwave.
6. Follow the instructions for taking an instantaneous power reading of an appliance. Set up the Power-Mate Lite to the meter setting by pressing Menu until the meter setting is reached. This will show the standby energy consumption of the microwave under the power heading. This energy runs things such as the display. Write down its value.
7. Turn on the microwave for 40 seconds to heat the water. Write down the power output of the microwave meter during this time. It will be a value in watts and may vary slightly. If so take a midrange value reading.
8. Remove the water in the cup and immediately take the new temperature. Make sure you allow the temperature reading of the thermometer to equilibrate for 15 seconds. Be aware that the water is heated so take care. Write down the new temperature.
9. Calculate the energy put out by the microwave by multiplying the midrange meter value reading during the heating by the time the water was heated (40 seconds).
10. Energy used in heating = wattage of operating appliance multiplied by time heated.
11. You might like to subtract the standby power reading if it is significant but usually it isn't for this purpose and is less than 2 watts.
12. Calculate the energy gained by the water in the cup using **$Q = mc\Delta T$** where Q is the energy the water has gained, m is the mass in grams, c is 4.18 joules per gram per degree Celsius for water and ΔT is the difference in temperature**.**

Questions

- How did the two energy values compare? Was the energy gained by the water much less than the energy input from the microwave oven?
- Calculate an energy efficiency value for the microwave by dividing the energy gained by the water (output energy) by the energy input from the microwave and convert this fraction to a percentage by multiplying it by 100.

Output/input X 100 = Efficiency percentage

- Describe the energy transformations that occurred in the microwave? Are there more transformations than those involved in the heating alone? Does this explain the efficiency of the microwave?
- Plan how you could perform a similar experiment using an electric kettle as the heating appliance rather than a microwave oven. Consider that you will need to add more water to avoid issues with overheating the kettle heating element.

Stage 5 Science Syllabus for the Australian Curriculum outcomes

Knowledge and understanding

PW4 Energy conservation in a system can be explained by describing energy transfers and transformations. (ACSSU190)

Students:

a. apply the law of conservation of energy to account for the total energy involved in energy transfers and transformations
b. describe how, in energy transfers and transformations, a variety of processes can occur so that usable energy is reduced and the system is not 100% efficient

Skills

WS5.2 Students plan first-hand investigations by:

a. planning and selecting appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data (ACSIS165, ACSIS199)
b. describing a logical procedure for undertaking a range of investigation types
c. designing controlled experiments to collect valid first-hand data

WS7.1 Students process data and information by:

c. accessing data and information by using a range of appropriate digital technologies
d. applying numerical procedures and mathematical concepts and using digital technologies, where appropriate

Lesson 3 – Experiment – Energy transformations in light globes

In this experiment you will investigate the transformation of electrical energy into light energy.

The Law of Conservation of Energy states that energy cannot be destroyed but rather simply changes form. We often refer to electrical energy as electrical power, which is really a measure of energy consumption per second (measured in watts).

One watt is a joule of energy transformed per second. If we know the power or wattage of an electrical appliance we can calculate the energy it consumes per second. If the appliance runs for 60 seconds then we simply multiply the wattage by 60 to determine the energy consumed by the appliance in the 60 seconds in joules.

Most homes use electrical power to illuminate the house. Electrical energy runs electrical lights.

In 2009 the manufacture of incandescent lights ceased in Australia and legislation was passed by governments to stop their use. This decision was not universally popular. Some people preferred incandescent lighting, claiming for example, a greater comfort for their eyes.

The legacy of these incandescent light globes still exists and many are still around today. Instead the incandescent globe was replaced by the compact fluorescent globe, halogen globe or LED lights. While these globes emit similar amounts of light, their energy consumption is vastly different.

The Power-Mate lite® meter can be used to determine the identified energy consumption of light globes compared to their published energy consumption. Subjective decisions can then be used to determine whether the light is of equivalent luminosity, or alternatively a light meter may be used, possibly one downloaded as an application on a mobile phone or tablet computer.

Aim

To explore the efficiency of energy conversions that occurs in light globes and consider reasons of quality of illumination that affect people's decisions about lighting.

Make a prediction about what you expect to happen during the energy conversions from electricity to the light globes. Do you think the energy conversion will be 100% efficient? Write that prediction down then perform your investigation to test your prediction.

Apparatus (Equipment)

- A Power-Mate Lite energy meter. If you don't have access to a Power-Mate Lite another brand of energy measuring electricity meter will do.
- An electric lamp.
- One 60 watt incandescent light globe
- One 12 watt compact fluorescent light globe
- One 42 watt halogen electric light globe
- One 6 watt LED light globe
- Optionally, a light meter or phone with a light meter application.

Method

1. Switch off and disconnect the lamp from the power point.

2. Insert the Power-Mate Lite meter into the power point then plug the lamp back into the Power-Mate Lite meter socket.
3. Insert one of the available light globes.
4. Prepare a suitable table to record your results and observations.
5. Turn on the power point.
6. Measure the power consumption of the light globe with the Power-Mate Lite meter. If using a light meter, place it one metre from the light globe pointing directly at the light and record the lux measurement.
7. Record your opinion of the quality of the light.
8. Repeat the procedure for all light globes.

Questions

- How did the power consumption values compare for all light globes in relation to their advertised power consumption? Were there any misleading claims?
- The power consumptions of the light globes listed are supposedly those that provide an equivalent level of illumination. Was that the finding of your investigation? If not describe what you found.
- If the purpose of a light globe is only to produce light, which globes are most efficient to least efficient at doing that job?
- For inefficient light globes, what other transformations occur that decrease efficiency of the light globe?
- Is the efficiency of the light globe the most important factor in deciding which light globe to purchase? What other factors might affect your decision?
- Assess whether the Government initiative to legislate for light globe efficiency improvements should be supported by society or be reversed.

Stage 5 Science Syllabus for the Australian Curriculum outcomes

Knowledge and understanding

PW4 Energy conservation in a system can be explained by describing energy transfers and transformations. (ACSSU190)

Students:

c. apply the law of conservation of energy to account for the total energy involved in energy transfers and transformations
d. describe how, in energy transfers and transformations, a variety of processes can occur so that usable energy is reduced and the system is not 100% efficient

Skills

WS5.2 Students plan first-hand investigations by:

d. planning and selecting appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data (ACSIS165, ACSIS199)
e. describing a logical procedure for undertaking a range of investigation types
f. designing controlled experiments to collect valid first-hand data

WS7.1 Students process data and information by:

e. accessing data and information by using a range of appropriate digital technologies
f. applying numerical procedures and mathematical concepts and using digital technologies, where appropriate