Chapter 4.

Renewable Energy

Syllabus Links

- Geography Stages 2, 3, 4 and 5
- Curriculum Priority Sustainability – Geography – Stages 2, 3, 4 and Science – Stages 2, 3 and 4
- Science and technology and Science Stages 1, 2, 3 and 4
  Science and technology and Science Stages 2, 3 and 4.

Terms and concepts

Renewable energy, non-renewable energy, alternative energy, photovoltaic cells (PVCs), carbon dioxide emissions, greenhouse gases, climate change, global warming, solar panels, kilowatts (kW), kilowatts/hour (kWh).

Background Information

The Coal Loader Centre for Sustainability is using renewable energy to create electricity and reduce its environmental impact. Renewable energy, (also known as alternative energy), is defined as energy from sources that do not use up all of the natural resources or harm the environment, for example, wind turbines, solar, geothermal and fuel cells. Alternative energy sources mostly use renewable resources, which reduce pollution, especially carbon dioxide emissions and so, help slow down climate change. Energy from all of these alternate, renewable sources can be used to create electricity to power our homes, factories, cities and our 21st century lifestyles. In 2024 renewable energy supplied around 20% of the national electricity grid, in Australia.

The Coal Loader has not always been a place where alternative energy has been promoted and used. The Coal Loader was once a place where coal was transferred from ships called colliers to even smaller coal fired ships which delivered coal around the harbour. Over the last 100 years, coal was the main source of energy and coal was burned in power stations to make electricity which flowed through the grid to our homes.

Recently the old infrastructure of coal that produced electricity for our economy for 150 years has been overlaid with new technologies. For example, to reduce total electricity consumption, the original caretaker's cottage has a passive lighting system that collects sunlight using a light tube lined with reflective material. The light tube directs light into the work areas naturally, without using overhead lights.

More significantly though, many governments, councils, companies and individuals have decided to stop using electricity from coal fired power stations and use alternative energy technologies to create electricity, reduce carbon dioxide emissions and slow down the rate of climate change.

How does sunlight create electricity?

When sunlight (solar energy) hits the photovoltaic cell, the energy loosen the electrons from the atoms in the pvc material. The electrons flow as electricity into the house or into the grid.

Since 2010 North Sydney Council has concentrated on using solar power as its renewable energy and has installed photovoltaic cells (PVCs) which are often called solar panels, to generate electricity from the sun.

North Sydney Council has installed large numbers of photovoltaic cells in five areas. These are:

1. **The roof of the Caretaker's cottage –** Here 16 PV cells produce 2.96 kilowatts (kW) of power (electricity) at their peak. The cells produce 3000kWh of electricity every year. This reduces greenhouse gas emissions from the Centre by 2.7 tonnes annually.
2. **The cafe** has 10kW of solar PV panels on the roof. During the daytime, sometimes the solar electricity meets all of the cafe's power needs and sends some back to the grid too.
3. **The Mess Hall and adjoining sheds** have a 25KW PV system and that system alone is enough to power all of the Coal Loader site activities during the daytime on a typical sunny and partly cloudy day.

4. **The Colonnade (or Platform) –** This is on the western side of the Coal Loader Platform. It is a 154-metre-long walkway, and is partially covered with raised semi-translucent photovoltaic cells for daytime shade and solar power (electricity) generation.
5. **Raised panels –** On the southern side of the Coal Loader Platform the raised solar-tracking panels (PVCs), produce a considerable amount of solar power for the site. These raised PVCs face the sun and move with it as the sun moves across the sky during the day. However, the sun tracking function is usually not required. The tracking technology would only be used if maximum output was required in a remote location.

The photovoltaic cells work in all weather but produce the most electricity when the sun is shining on clear, cool days. A solar battery was installed in 2015 so that when excess electricity is produced when the sun is shining, it can be stored and used overnight.

The solar energy produced by the Coal Loader's photovoltaic cells is also used to heat water on site. Hot water is generated by a solar boosted heat pump hot water system, sometimes called a hydronic heating system. All the hot water pipes are insulated to minimise loss from the system. Hot water at the Coal Loader is used for showers, washing hands and heating the building.

Did you know that water heating is responsible for 25% of the electricity used in an average home? That makes it a very good reason to use renewable energy to heat water. Installing an energy efficient system can save a family hundreds of dollars off electricity bills and 2- 3 tonnes of greenhouse gas emissions each year.

Diagram X shows the hot water tank and compressor which make up the Hot water heat pump system.

For more information on alternative energy

Before your visit, watch the 'Alternative Energy' three minute video which will give your class an overview of what you will find at the Coal Loader.

Check out the following useful sites:

- Clean Energy Council *www.cleanenergycouncil.org.au*
- Climate Clever Shop *climateclever.org*
- Australian Government *arena.gov.au*
- Primary connections *www.science.org.au/primaryconnections*
- Australian Academy of Science *https://www.science.org.au/curious/technology-future/solar-pv*
- Open Electricity *https://opennem.org.au/energy/nsw1*

Activity 1 – Student Worksheet
Part A: Compare coal-fired electricity to renewable energy at the Coal Loader

Syllabus Outcomes

- Describe processes and influences that form and transform places and environments. GE4-2
- Explains how interactions and connections between people, places and environments. GE3-2
- Describes the characteristics and effects of common forms of energy, such as light and heat. ST2-8PW-ST
- Explains how energy is transformed from one form to another. ST3-8PW-ST

Inquiry questions:

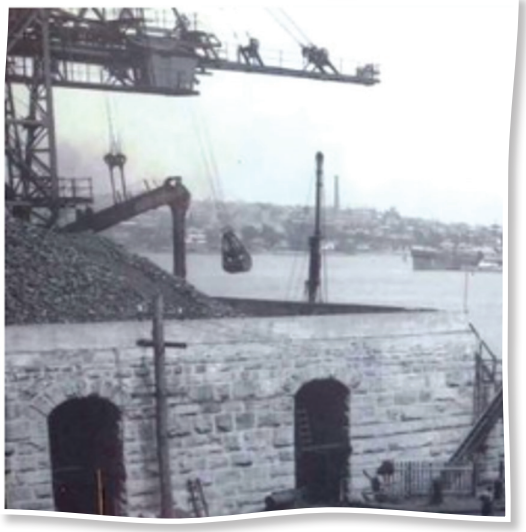
1. How does coal create electricity?
2. What are the impacts of coal powered electricity?
3. How does solar energy make electricity?
4. Where are the photovoltaic cells at the Coal Loader?
5. How can solar electricity be stored for use at night?

Materials and Preparation:

- Teachers to use the background information below and the poster 'Powered by the Sun' for class discussion.
- Students to bring a clipboard and writing equipment.
- A4 Coal Loader Map.

Background information

The old infrastructure of coal that powered our economy for 150 years has now been replaced with new renewable technologies that reduce pollution, carbon dioxide emissions and slow down climate change. The Coal Loader's primary function when it was built over 100 years ago, was to distribute coal from coal ships to train carriages and smaller ships so the coal could be moved all around Sydney to the factories and small power stations near Sydney harbour.



Activity 1 – Student Worksheet
Part A: Compare coal-fired electricity to renewable energy at the Coal Loader *continued*

Name .....

Location – Outside the Caretakers cottage on the Colonnade /Platform

1. Look at the diagram below and describe in the space below the flow of electricity from the coal fired power stations through the grid to a home.

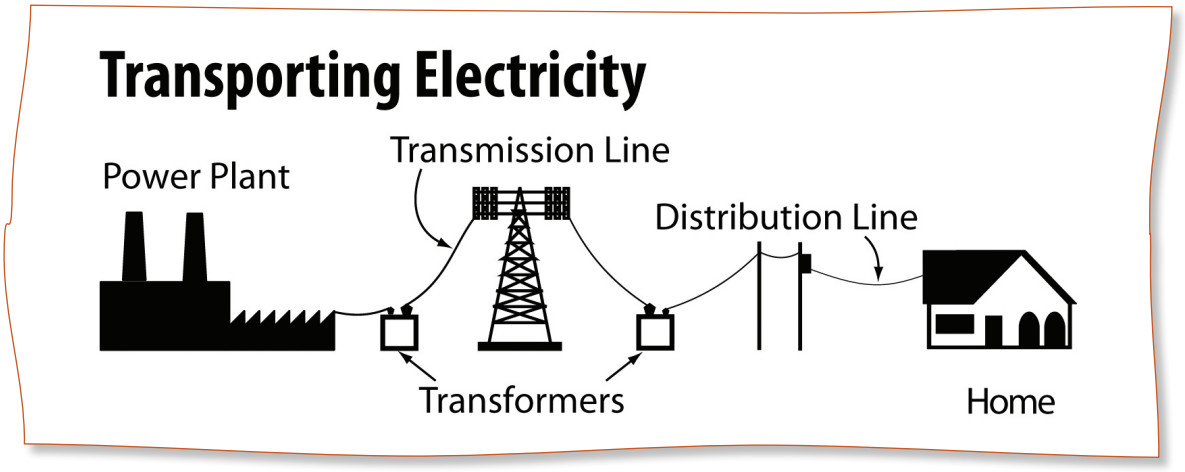
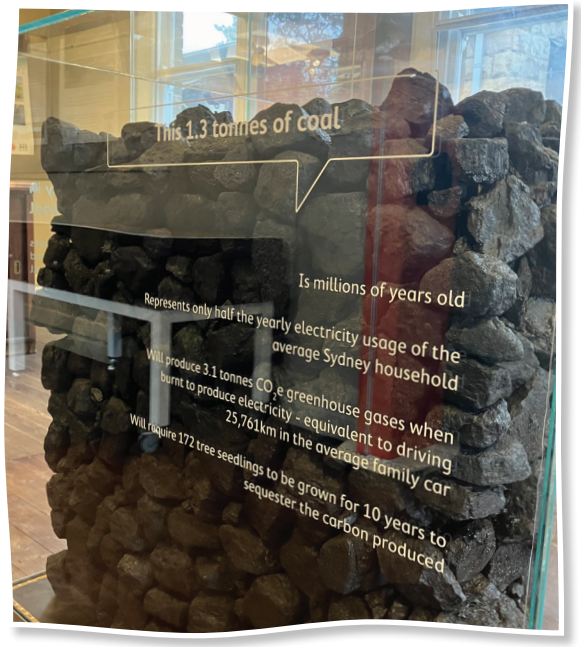


Diagram X shows a power plant, transmission lines, distribution lines, poles and a home.

2. Visit the front room in the Caretaker's cottage and find the cabinet with 1.3 tonnes of coal in it and answer these questions. (or read the info on the photos below).



Activity 1 – Student Worksheet
Part A: Compare coal-fired electricity to renewable energy at the Coal Loader *continued*

a. Estimate if this 1.3 tonne of coal is the about the same size (and weight) as a
i. Large truck__? ii. Medium car__? iii. Bike__? (✓ tick your answer)

b. What sentence suggests that coal is a non renewable resource?

_____

c. Calculate how many tonnes of coal would an average Sydney household need to use for their electricity for a whole year?

_____

d. How much carbon dioxide (CO_2) did 1.3 tonnes of coal produce when burnt to produce electricity?

_____(tonnes).

e. Estimate what this amount of CO_2 is approximately equivalent to in size and weight
i. Small truck__? ii. Bike__? iii. Small car__? (✓ tick your answer)

f. Carbon dioxide (CO_2) emissions from the Coal Loader Centre used to be 2.7 tonnes per year when the Centre used coal fired electricity.
The following devices and appliances are found in the Coal Loader buildings.
The more electricity (kWh) an appliance uses, the more CO_2 is created. Read how much electricity (kWh) each device uses.
A. Desktop computer per day (600kWh)
B. LED light per day (.05kWh)
C. ZIP instant hot water per day (2kWh)
D. Dishwasher per load (1.5kWh)
Write down from 1-4 here with 1 being the highest CO_2 emitter and 4 being the least.

_____

g. What significant global environmental problem has been caused by having too much carbon dioxide (CO_2) in the atmosphere?

_____

h. From the coal cabinet, outline the two main ways you can reduce your greenhouse gas emissions.

i _____

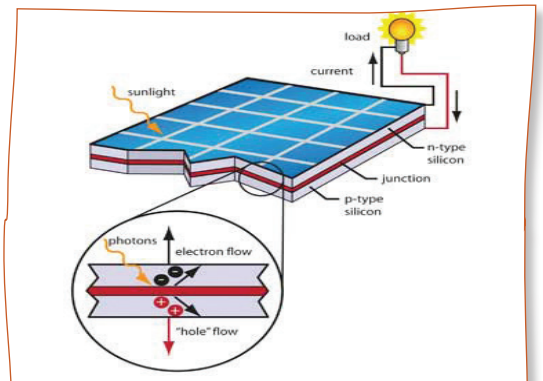
ii _____

Activity 1 – Student Worksheet
Part B: Mapping and investigating photovoltaic cells at the Coal Loader

Name .....

Below is a diagram to show how the sun's energy works to produce solar electricity.

1. Underline or label on the diagram photovoltaic cells, sunlight, electron flow, current (to show the flow of electricity) and light (represents a home).



https://climatekids.nasa.gov/sun-people/

Hand out the A4 Coal Loader laminated maps so that students can view a larger map, and find out where they are.

2. Let's take a walk around the Coal Loader site to find the renewable energy features.
Tick them off ✓ and fill out the questions below.
It's best to start at the (**i**) outside the Caretakers cottage. Walk across to the Colonnade/Platform, then to the southern end where the pvc's are on posts.

a. On the Coal Loader map below, circle or underline:
- The Coal Loader Platform (at M),
- Caretakers Cottage /Genia McCaffery Building (i) and (I).
- Cafe (G) and Mess Hall (D)
- Southern end of platform

Diagram X shows map of Coal Loader.

Activity 1 – Student Worksheet
Part B: Mapping and investigating photovoltaic cells at the Coal Loader *continued*

3. Look up on the roof of the Genia McCaffery Centre, also known as the Caretaker's cottage and find the older photovoltaic cells (PVCs).

Photo X shows aerial photo of Genia McCaffery Centre, Cafe and Mess Hall with photovoltaic cells.
Source: North Sydney Council

a. Annotate the photo above by writing PVCs next to each group of solar panels.

b. How many solar panels/photovoltaic cells are there on the tiled roof at the Cottage (Genia McCaffery Centre)? _____

   Also write your answer on the map on the page above at Genia Centre.

c. How many new solar panels/photovoltaic cells are there on the roof at the Cafe? _____

   Write your answer on the map on the page above at Cafe.

d. How many new solar panels/photovoltaic cells are there on the roof of the Mess hall? _____

   Also write your answer on the map on the page above at Mess Hall.

e. The 14 PV cells on the Cafe produce about 10kW of electricity which powers the Cafe and on sunny days, sends unused solar electricity to the grid. Suggest what appliances would use electricity in the Cafe? _____

f. The 21 PV cells on the Mess Hall (and together with other PV cells on other sheds) produce over 25kW of electricity. This amount of electricity energy is enough to power the whole Coal Loader site. How does this help the environment?

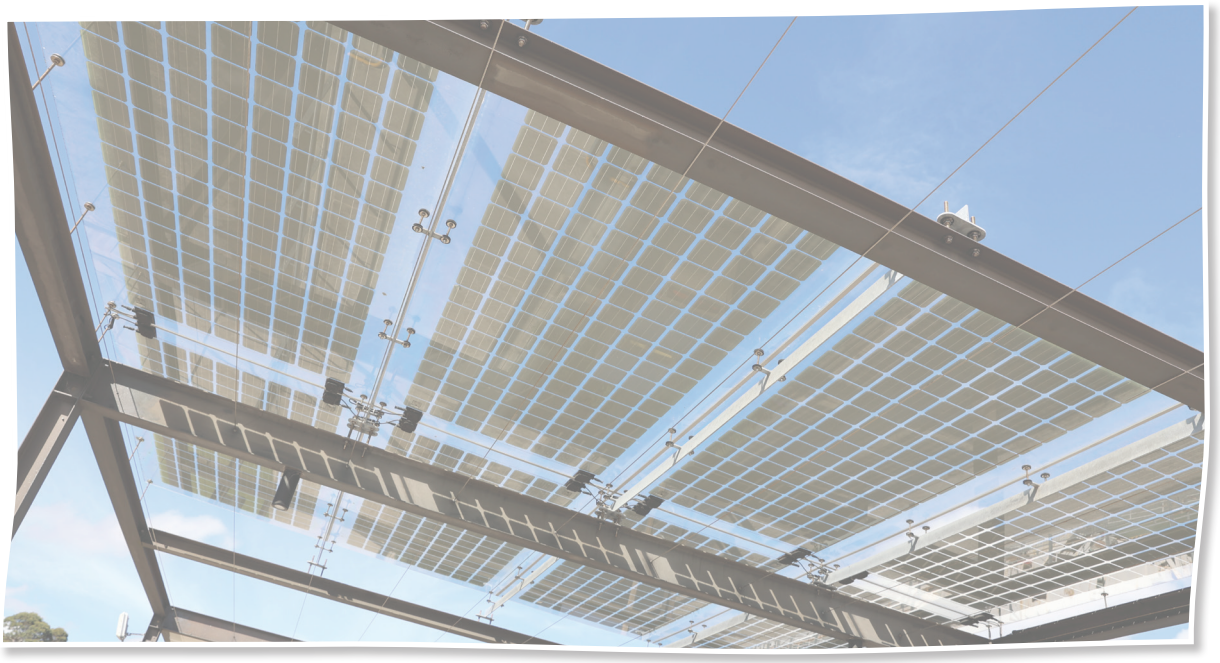
   _____

   _____

Activity 1 – Student Worksheet
Part B: Mapping and investigating photovoltaic cells at the Coal Loader *continued*

Name .....

Location - Walk out to the Coal Loader Platform and stand on the Colonnade.



a. Draw an arrow and label photovoltaic cells (PVCs) on the photo above.

b. Label 8 PVC stands on the Collonade/Platform on the map on the previous page.

c. How many panels are there per stand? _____

d. How many panels are there in total along the Colonnade/Platform? (don't count the panels on the poles at the southern end just yet) _____

4. Walk down to the southern end of the platform where the PVCs are on tracking poles.

g. How many large raised solar tracking poles are there? _____

Label these as TP on the map on the previous page.

h. (How many PVCs are there on these poles? (Try counting from below!)

_____

i. Sunflowers actually turn and follow the sun through the day. Suggest why the raised PVCs on the southern end of the platform can also do this?

Activity 1 – Student Worksheet
Part B: Mapping and investigating photovoltaic cells at the Coal Loader *continued*

Did you know?

The photovoltaic cells on the Platform and Colonnade are new and efficient technology and are an 85kW system. Each panel produces 4kWh per hour of solar electricity each day. This adds up to 340kWh per day or 124,100kWh per year.

Only 1kWh of electricity (produced by 2 average home solar panels) is needed to power an electric car for 6km. Most families drive about 15,000km a year or 42km a day.

j. If the average home uses about 20 kWh of energy each day, how many homes would these PVC's be able to support? _____

k. How many kW hours of solar electricity are needed for the average family car to drive 42 km? _____

l. How many solar panels/PVCs would you advise a family to install to power their electric car? _____

m. Compare an EV car using solar electricity to a car using petrol. What are the similarities and differences?

_____

_____

n. What are two things that can happen to the solar electricity produced by these panels if the appliances/devices in the Coal Loader Centre do not use all of the electricity produced?

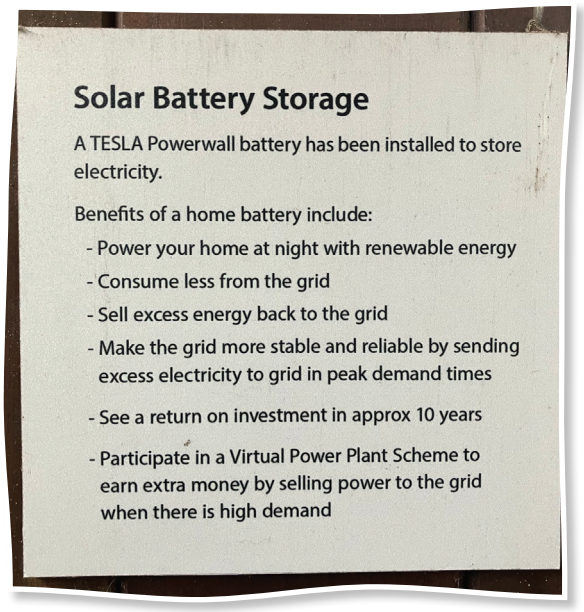
i _____

ii _____

Activity 1 – Student Worksheet
Part C: What is a solar battery?

Name .....

1. The Coal Loader has a lithium ion solar storage battery (Tesla), draw an arrow on the photograph below and mark it as an **SB** on the map on the previous page.



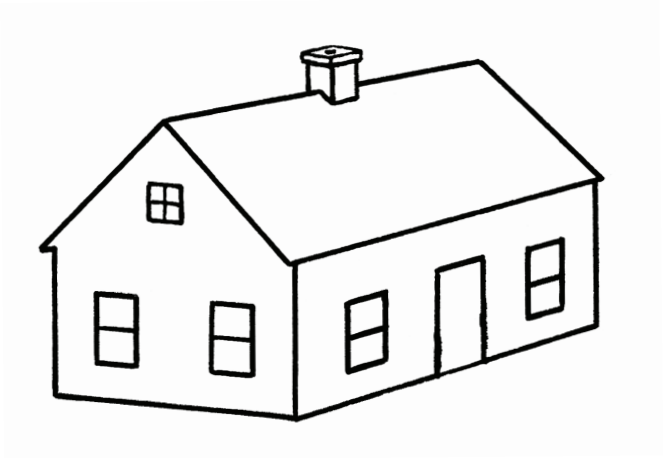
a. Read the information plaque and the information below and complete the questions.
Tesla is a brand name of solar storage batteries. Solar energy is collected during the day and stored as chemical energy. Overnight when the solar PVCs are not making electricity the solar battery uses the chemical energy to make electricity. This means that your solar PVC cells can make electricity through the day which the battery stores so there is solar electricity available at night.
The Coal Loader lists a number of benefits it receives from using a home solar battery.

b. Read the benefits and draw an arrow → to match the start and finish of the sentences.

1. Power your home at night with	by sending excess electricity to the grid in peak demand times.
2. Consume less	in approx 10 years.
3. Participate in a Virtual Power Plant scheme to earn extra money by	from the grid.
4. Make the grid more stable and reliable	back to the grid.
5. See a return on investment	renewable energy.
6. Sell excess energy	selling power to the grid when there is high demand.

c. 'Think, pair and share'. Choose one of these statements and explain to another student what it means in your own words. Get ready to share your answer to the whole class.

d. Draw a diagram showing how a home storage 'Tesla' battery can provide electricity to the home/office and to the grid for other homes and uses. Draw these features – at least one appliance or device in the home, solar battery, electricity wires, photovoltaic cells, electricity power poles.



e. Can you name any disadvantages of a solar storage (Tesla) battery?

_____

_____

f. There are at least three separate areas of photovoltaic cells at the Coal Loader. These are the Caretaker's cottage, the Colonnade and the raised panels. How does this help the environment?

_____

_____

Activity 2 – How can solar energy be used to heat water?

Name .....

Syllabus Outcomes

Students will be able to:

- Explain interactions and connections between people, places and environments.GE3-2
- Describe processes and influences that form and transform places and environments. GE4-2
- Explains how energy is transformed from one form to another. ST3-8PW-ST

Inquiry questions:

1. How can solar electricity be used with a heat pump to heat water for use at home?

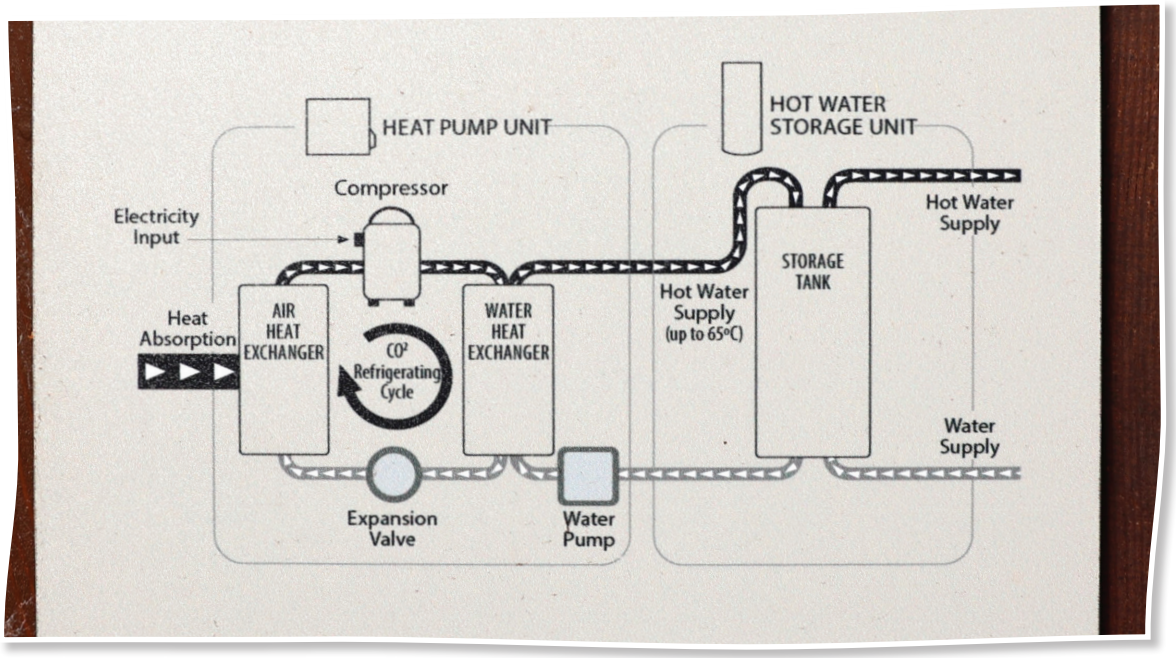
Materials and Preparation

- Teachers to use the background information below and the poster 'Powered by the Sun' for class discussion.
- Students to bring a clipboard and writing equipment.
- A4 Coal Loader Map.

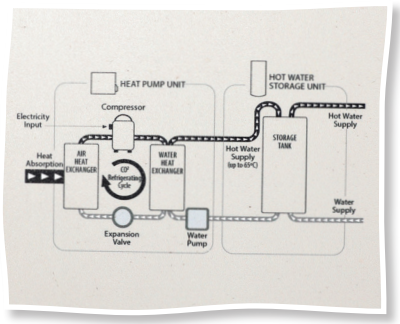
Background information

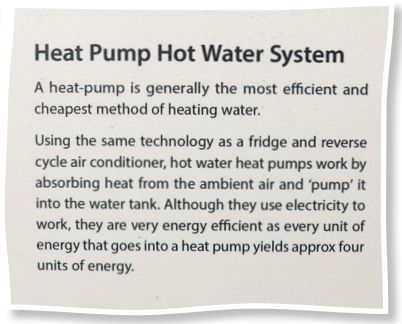
The main system that the Coal Loader uses to heat water is a

- A solar powered heat pump system which is complex and energy efficient.



Name .....





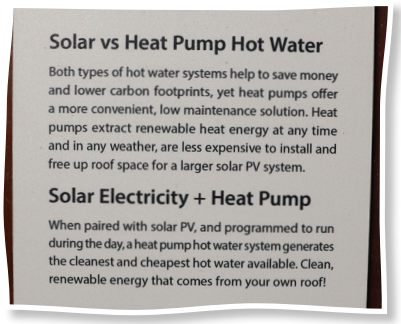


Diagram X shows information about the solar boosted heat pump and hot water system.

a. Mark the location of the solar powered heat pump on the map you have used before and mark it with a SHW.

b. Look at the diagram of how a heat pump works.
What piece of equipment takes out heat from the air and transfers this heat to the water?

_____

d. Where else may you have seen this piece of equipment?

_____

e. Look at the info plaque 'Heat Pump Hot Water System' and describe how heat pumps work:

_____

_____

_____

_____

f. Where does the heat pump system get its electricity from?

_____

g. Label the photos below
1. Hot water storage 2. Heat pump.

Activity 3 – How much electricity is used and what energy source should be used?

Pre and post excursion – Investigation and research activities

Activity Summary:

Students research secondary sources to investigate how much electricity a small office consumes and which energy source best fits the needs of the office.

Inquiry questions

1. How much electricity do everyday appliances use?
2. What are the benefits and costs of alternative energy sources?
3. Can you justify recommending spending money on installing a new form of energy?

Syllabus Outcomes

- Explains how energy is transformed from one form to another. ST3-8PW-ST
- Discusses how scientific understanding and technological developments have contributed to finding solutions to problems involving energy transfers transformations. SC4-11PW
- Describe processes and influences that form and transform places and environments. GE4-2

Preparation

- Students need access to computers to research options.
- Students may need to be paired or grouped with other students.

Activity 3 – How much electricity is used and what energy source should be used? *continued*

Caretaker's Cottage

1. Find out how many kWh of electricity are used in a 10 metre by 10 metre office space.
To do this, first brainstorm a list of the appliances and devices used in an office like the Caretaker's cottage, then estimate how many appliances are needed and how many kWH each appliance typically uses in a day.

Appliance/Device	Number of?	kWH?
a. eg, lighting office space		
b.		
c.		
d.		
e.		
f.		

2. Use this research to estimate the total amount of energy/electricity required for a small office, approximately 10 metres by 10 metres in size each day.

3. Researching and recommending alternative energy options.
This activity is about investigating energy options and making recommendations to the mayor or cottage caretaker about which source of energy is best to provide the source of electricity for the Coal Loader.

Students could work in two's and three's and work in a small group to research each alternative energy and fill out the table below. Alternatively, students could research one option only and present their findings to the class. Students can also add extra columns to suit their research findings, eg, sustainability.

Type of energy	Upfront costs	Ongoing costs	Benefits (eg, carbon emissions?)	Concerns (eg, emissions?)	Renewable non/renewable ✓
Natural gas					
Coal					
Wind					
Solar					
Hydrogen					

Activity 3 – How much electricity is used and what energy source should be used? *continued*

4. Use this information to write a paragraph recommending to the Mayor of North Sydney which energy option is best for the Coal Loader to buy and invest in. Factors such as cost and sustainability should be referred to.