Sustainable Housing TEACHER EDITION

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Introduction and Curriculum Connections

Introduction to the Sustainable Housing Unit

This unit introduces Climate Change and what students can do to reduce their impact on the environment. It highlights relevant principles in science, connects to the Australian curriculum including General Capabilities and Cross-Curricular Priorities in Sustainability, and focuses on the Australian context where possible. Each module contains different modes, including online learning activities, videos, simulations, small and large group discussions and practical hands-on activities. This unit begins with a survey to enable teachers to assess their students' prior knowledge and any misconceptions students might have to inform the most effective teaching approach. Additional features include a career section and summative activities.

Links to Australian Curriculum

YEAR 7

Biological Sciences: Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions (ACSSU112)

Earth & Space Sciences: Some of Earth's resources are renewable, but others are non-renewable (ACSSU116).

Science as a Human Endeavour: : Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE134); Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226); Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135); People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136).

Science Inquiry Skills: Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124); Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125); Measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS126): Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS129); Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS130); Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131); Use scientific knowledge and findings from investigations to evaluate claims (ACSIS132); Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133).

YEAR 8

Chemical Sciences: Properties of the different states of matter can be explained in terms of the motion and arrangement of particles (ACSSU151); Chemical change involves substances reacting to form new substances (ACSSU225).

Physical sciences: Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within systems (ACSSU155).

Science as a Human Endeavour: Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE134); Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226); Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135); People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136).

Science Inquiry Skills: Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139); Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS140); Measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS141); Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS144); Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS145); Reflect on method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS146); Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS234); Communicate ideas, findings and solutions to problems using scientific language and representations, and using digital technology as appropriate (ACSIS148).

YEAR 9

Biological Sciences: Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (ACSSU175); Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176).

Chemical Sciences: Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed (ACSSU178).

Physical Sciences: Energy transfer through different mediums can be explained using wave and particle models (ACSSU182).

Science as a Human Endeavour: Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community (ACSHE157); Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158); People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions (ACSHE160); The values and needs of contemporary society can influence the focus of scientific research (ACSHE228).

Science Inquiry Skills: Formulate questions or hypotheses that can be investigated scientifically (ACSIS164); Plan, select and use appropriate investigation methods, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165); Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166); Analyse patterns and trends in data, including describing relationships between variables and identifying

inconsistencies (ACSIS169); Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170); Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171); Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems (ACSIS172); Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174).

YEAR 10

Earth & Space Sciences: Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189).

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

Science as a Human Endeavour: Scientific understanding, including models and theories, is contestable and are refined over time through a process of review by the scientific community (ACSHE191); Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE192); People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE194); The values and needs of contemporary society can influence the focus of scientific research (ACSHE230).

Science Inquiry Skills: Formulate questions or hypotheses that can be investigated scientifically (ACSIS198); Plan, select and use appropriate investigation methods, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199); Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS200); Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203); Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204); Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205); Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems (ACSIS206); Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208).

General Capabilities

All seven general capabilities are addressed throughout this unit: literacy, numeracy, information and communication technology (ICT) capability, critical and creative thinking, personal and social capability, ethical understanding and intercultural understanding.

Cross-Curriculum Priorities

This unit address all the Organizing Ideas in Sustainability (i.e., Systems, Worldviews and Futures).

Your ideas about energy

- Survey: Sustainable Housing
- Energy Word Cloud

Your first two tasks in this topic are to complete this survey and word cloud, which is designed to find out what you currently know about energy and climate change.

Key ideas

- Climate change is happening, resulting in environmental, social, and economic challenges.
- Changes in the composition of greenhouse gases, attributed mainly to human activities in the last century, is the cause of climate change.
- Energy transfer through different media can be explained using wave and particle models.
- A knowledge of energy transfer involving energies associated with sound, light and thermal energy inform the best practical activities associated with the use and transfer of energy in sustainable houses.
- There are a number changes that can be made to reduce the impact by climate change, at the individual, community, national and global level.

Teacher Notes:

This Introductory Module contains the following two activities:

Survey: What do I currently know about energy?

Students undertake a pre-test by accessing STILE. Key ideas related to energy and energy transfer are tested. The pre-test can be done at least a week in advance of commencing the unit to give teachers time to review student understanding of topics covered. A results and analytics report is generated automatically by STILE. This will determine if misconceptions are prevalent and how common they might be.

Energy Word Cloud

Students are given the representational challenge to construct a word cloud from words they associate with Energy and Sustainable Housing.

If they think some words are more important than others they need to include them multiple times in creating the word cloud.

Once the word clouds are generated they might be shared in a class discussion about what words students associate most with energy and sustainable housing.

Note: The free iPad app saves the word cloud in the iPad's photos as a jpg. This can then be uploaded into STILE.

If students are using a PC, Wordle or Tagxedo are the best used.

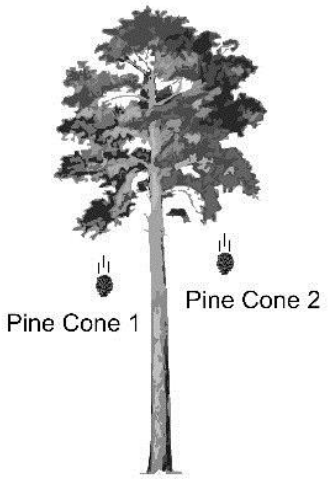
Survey: Sustainable Housing

Choose the best answer to the following questions.

Before getting started with the activities, complete this short survey. It will help evaluate what you already know and get you thinking about the upcoming lessons.

1. Weather and climate are the same thing. ☐ True ✓ False ☐ I don't understand the question ☐ Not sure	
2. Which of the following best describes the greenhouse effect on Earth? ✓ The greenhouse effect is the 'trapping' of some of the Earth's infrared radiation in the atmosphere. ☐ The greenhouse effect gives the sky its blue colour and the sea its blue-green colour. ☐ The greenhouse effect is the result of industrial pollution and human-caused fires. ☐ The greenhouse effect is caused by the hole in the ozone layer.	3. Which answer best completes the following sentence correctly? The greenhouse effect is necessary for life on Earth because: ☐ it provides the carbon dioxide necessary for plants to photosynthesise. ☐ it provides us with the oxygen gas we need for life. ☐ it shields us from the Sun's ultraviolet radiation. ✓ it helps keep the temperature of the Earth not too hot and not too cold.
4. CO_2 is the only greenhouse gas that causes climate change. ☐ True ✓ False ☐ I don't understand the question ☐ Not sure	

5. The invisible carbon dioxide released when coal, oil, and gas are burned is the single most important contributor to climate change. ✓ True ☐ False ☐ I don't understand the question ☐ Not sure	6. This type of radiation from the sun is related to climate change: ✓ Infrared ☐ Ultraviolet ☐ I don't understand the question ☐ Not sure
7. Air pollution (e.g., ozone, carbon monoxide, sulfur dioxide, lead) causes climate change. ☐ True ✓ False ☐ I don't understand ☐ Not sure	
8. Which answer best completes this sentence correctly? Solar panels do not contribute to the enhanced greenhouse effect while they are being used because: ✓ they do not produce any carbon dioxide gas while operating. ☐ they do not produce any waste heat energy while operating. ☐ they are very efficient. ☐ they do not damage the ozone layer.	9. For a solar panel installed on an Australian home that has a sloping roof, the position of the solar panel on the roof that would deliver the greatest electrical power is: ☐ vertical, on the top edge of the roof, pointing due south. ☐ horizontal, on the top edge of the roof. ☐ lying against one of the sloping faces that points towards the east. ✓ lying against one of the sloping faces that points towards the north.

10. Energy sources that can be replenished by nature in a relatively short period of time are called renewable energy forms. ✓ True ☐ False ☐ I don't understand the question ☐ Not sure	
11. The particles in a solid that is heating up move farther and farther apart because: ☐ the particles slow down. ☐ the particles begin to lose their shape. ☐ the particles repel each other more intensely. ✓ the particles have more energy and bump into each other more often	12. Which of the following has thermal energy? ☐ A piece of metal that feels cold but not a piece of metal that feels hot. ☐ A piece of metal that feels hot but not a piece of metal that feels cold. ☐ Both a piece of metal that feels hot and a piece of metal that feels cold. ☐ Neither a piece of metal that feels hot nor a piece of metal that feels cold. ✓ I don't understand the question or I am not sure.
13. Two pine cones are falling from a pine tree. Both pine cones are falling at the same speed. If Pine Cone 1 weighs less than Pine Cone 2, which pine cone has more motion energy (kinetic energy)? ✓Pine Cone 1 has more motion energy. ☐ Pine Cone 2 has more motion energy. ☐ Both pine cones have the same amount of motion energy. ☐ Neither pine cone has any motion energy. ☐ I don't understand the question or I am not sure.	

14. A student is holding a cold piece of metal in her hand. While she is holding the piece of metal, her hand gets colder. Does the piece of metal get warmer? Why or why not?

✓ Yes, the piece of metal will get warmer because some thermal energy is transferred from the student's hand to the metal.

☐ No, the piece of metal will stay at the same temperature because thermal energy is not transferred between the student's hand and the metal.

☐ No, the piece of metal will stay at the same temperature because an equal amount of thermal energy is exchanged between the student's hand and the metal.

☐ Yes, the piece of metal will get warmer because some thermal energy is transferred from the metal to the student's hand.

☐ I don't understand the question or I am not sure.

15. A rock is resting on a flat surface at the top of a cliff. Which of the following always affects the amount of gravitational potential energy a rock has?

✓ Its mass.

☐ Its shape.

☐ How close it is to the edge of the cliff.

☐ A rock cannot have any gravitational potential energy unless it is falling.

☐ I don't understand the question or I am not sure.

16. Which of the diagrams to the right is an example of the transformation of gravitational potential energy into motion energy (kinetic energy)?

✓ A

☐ B

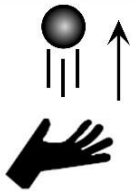
☐ C

☐ D

A.

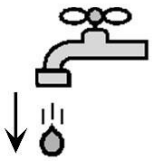
A tire rolling along a level floor

B.



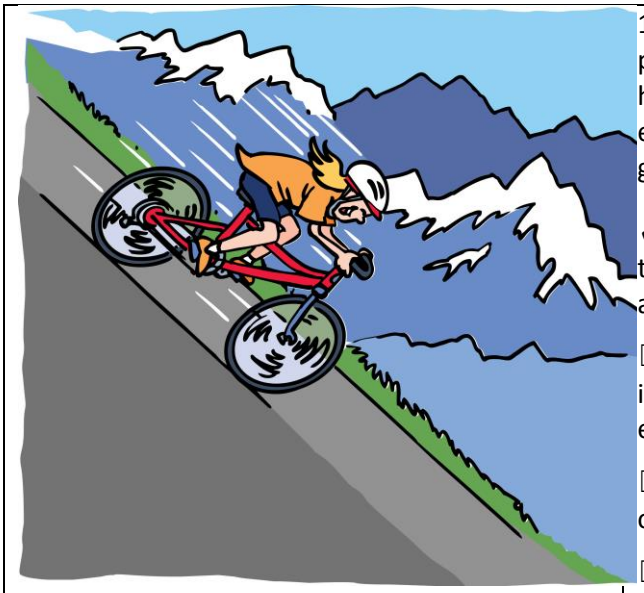
A ball going up after being tossed into the air

C.



A drop of water falling from a faucet into a sink

D. None of these because gravitational potential energy cannot be transformed into motion energy



17. A girl is riding her bicycle down a hill without pedalling. She speeds up as she goes down the hill, and the tyres get a little warmer. What energy transformations happen while she is going down the hill?

✓ Motion energy (kinetic energy) is transformed into gravitational potential energy and thermal energy.

☐ Gravitational potential energy is transformed into motion energy (kinetic energy) and thermal energy.

☐ Gravitational potential energy is transformed only into motion energy (kinetic energy).

☐ No energy transformations are involved while she is going down the hill.

☐ I don't understand the question or I am not sure.

18. A student places a warm can of soda into a bucket filled with cold water. She puts the lid on the bucket. Which of the following describes the energy transfer between the water and the can of soda in the bucket?

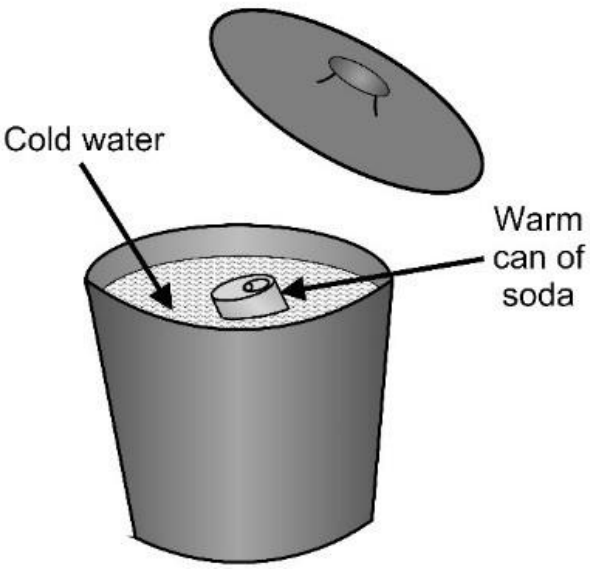
✓ Thermal energy is transferred from the can of soda to the water so the can of soda gets cooler and the water stays the same temperature.

☐ Thermal energy is transferred from the can of soda to the water so the can of soda gets cooler and the water gets warmer.

☐ Coldness is transferred from the water to the can of soda so the can of soda gets cooler and the water stays the same temperature.

☐ Coldness is transferred from the water to the can of soda so the can of soda gets cooler and the water ice gets warmer.

☐ I don't understand the question or I am not sure.



19. Consider the following situations:

Situation 1: A cold spoon is placed in a cup of hot tea. **Situation 2:** An ice cube is placed in a cup of hot tea. Is energy being transferred in either of these situations?

☐ Energy is transferred when an ice cube is placed in a cup of hot tea, but energy is NOT transferred when a cold spoon is placed in a cup of hot tea.

☐ Energy is transferred when a cold spoon is placed in a cup of hot tea, but energy is NOT transferred when an ice cube is placed in a cup of hot tea.

✓ Energy is transferred in both situations.

☐ Energy is NOT transferred in either situation.

☐ I don't understand the question or I am not sure.

20. A girl is sitting under an umbrella at the beach on a sunny day. When she moves out of the shade and into the sunlight, she will feel warmer. Why?

✓ Because energy is being transferred directly from the sun to the girl.

☐ Because energy is being transferred from the sun to the air and then from the air to the girl, but no energy is being transferred directly from the sun to the girl.

☐ Because energy is being transferred from the sun to the ground and then from the ground to the girl, but no energy is being transferred directly from the sun to the girl.

☐ Because the sun is shining on the girl, not because energy was transferred from the sun to the girl.

☐ I don't understand the question or I am not sure.

21. Consider a light bulb and an ice cream cone.

Which gives off energy by radiation and why?

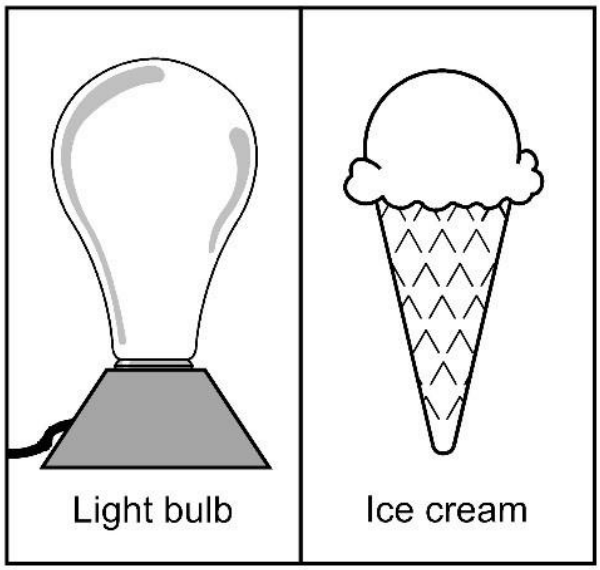
✓ Both a light bulb and an ice cream cone because all objects radiate energy.

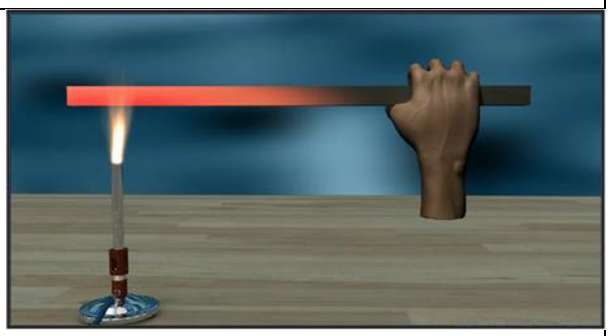
☐ Neither a light bulb nor an ice cream cone because only the sun radiates energy.

☐ Only a light bulb when it is glowing because only glowing objects radiate energy.

☐ Only a light bulb when it is hot because only hot objects radiate energy.

☐ I don't understand the question or I am not sure.



22. Garments that are made of wool keep you warm in winter as the material contains pockets of air. Explain how a woolen glove would keep your hand warm if, for example, you picked up a snow ball. You can use text and/or drawings to provide an answer. *It acts as an insulator, slowing the transfer of heat from the hand to the snow.*	 Photograph of a person holding a snowball
23. If you place one end of an iron rod in a fire and you hold the other end after a while the end you are holding feels warm. Explain the process that results in your hand feeling warm. You can use text and/or drawings to provide an answer. *Slowly, the heat/energy will be transferred via conduction along the rod, from the point of highest energy (flame) toward the point of lowest energy (the hand). The solid particles vibrate the fastest near the flame, and slowly increase in vibration as they heat energy moves along the rod to the hand.*	 Picture of a hand holding an iron rod

24. Imagine a bundle of energy that is emitted from the sun travels through space and reaches Earth. Describe the different ways in which the bundle of energy might interact with the Earth. You can use text and/or drawings to provide an answer. *The energy can be absorbed, reflected, or transferred.*	 Photograph of a sunset

Energy Word Cloud

Your task will be to create an Energy word cloud using the free ipad app called Word.

The app saves the Word Cloud in the iPad's photos as a jpg. Print out your Word Cloud and place it in this booklet.

What is sustainable housing?

- What does “sustainable mean”?
- Ecological Footprint
- Case Study: Illawarra Flame House
- Net Zero Home

Explore the ideas of sustainable housing and ecological footprint, and learn how you can make changes to your lifestyle to reduce your impact on the environment.

Key Questions

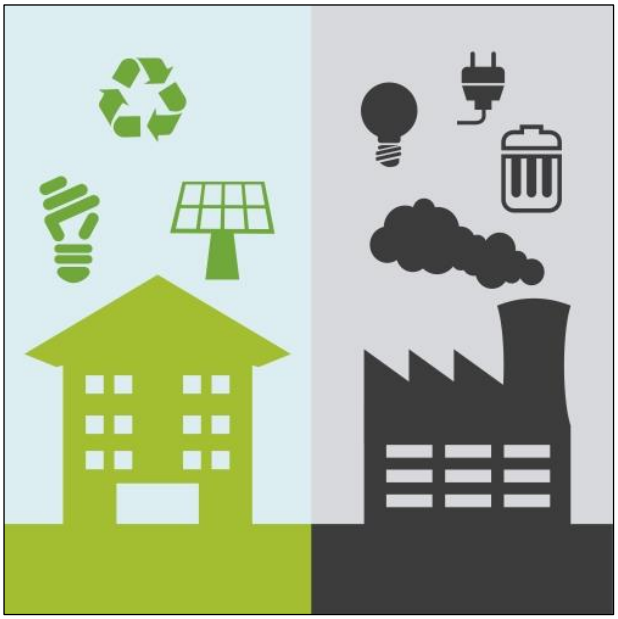
- What are the changes we can make in our everyday life to reduce the carbon emissions that contribute to climate change?
- What is your ecological footprint? How does it compare with the average Australians' footprint?
- How much energy and water does your current household use?
- What are main features of a sustainable home?
- How will you modify your home or design a new house to reduce carbon emissions and ecological impact?
- What does "sustainable" mean?

What Does Being "Sustainable" Mean?

Being sustainable means understanding that the Earth's resources are limited and working to conserve them so we can live comfortably now without affecting future generations.

Being sustainable means making smart choices about how we use things such as energy and water and how much waste we produce.

Being sustainable is important on a global and national scale, but everyone can help by being sustainable in their own home.



Question 1. Create a mindmap on ENERGY to explore how you use and waste energy and water around your own home.

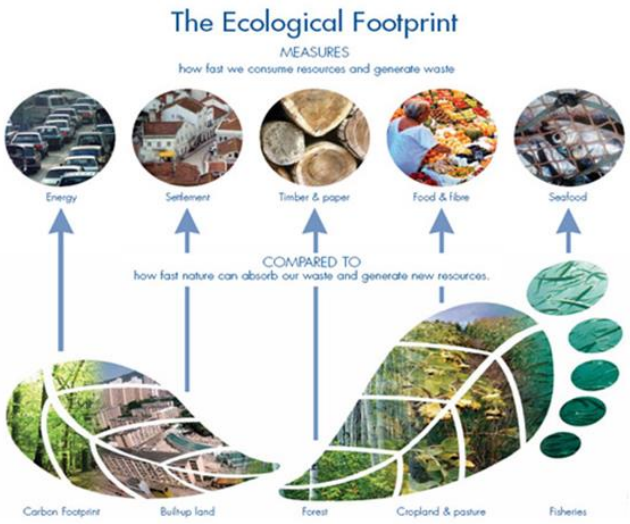
Ecological Footprint

The Ecological Footprint is a measure of the amount of productive land needed to support how we live. This includes the food we eat and where we live, but also the amount of land that supports all the activities and infrastructure to sustain this: energy and materials to support transportation, raw materials for building, and the land used to absorb the waste. According to the WWF Living Planet Report for 2014, the world consumes 1.5 times the resources it has, meaning we need 1.5 planets Earths to sustain our lifestyle. We are depleting the resources that sustain us, faster than they can be replenished. Of the 152 nations, Australia has the 13th largest Ecological Footprint. The most significant factor in Australia's Ecological Footprint is carbon emissions. If everyone on the planet had the same lifestyle of Australians, we would need 3.6 planet Earths.

There are many things we can do to reduce our individual Ecological Footprints. You can take a QUIZ to measure your own Footprint and learn ways to reduce it. In this unit, we will be looking at how sustainable housing addresses key areas such as energy and water use.

Link to Living Planet Report 2014:
www.wwf.org.au/our_work/people_and_the_environment/human_footprint/living_planet_report_2014/

Link to Quiz:
www.wwf.org.au/our_work/people_and_the_environment/human_footprint/footprint_calculator/



Case Study: Illawarra Flame House

In 2013, the University of Wollongong teamed up with TAFE Illawarra Institute to form Team UOW Australia. Team UOW was the first team from Australia to gain entrance into the Solar Decathlon, which is an international competition to develop and adopt "advanced building energy technology in new and existing homes".

Over 50 students and staff designed and built the Illawarra Flame House which won the competition.

Many materials in the house and its landscape are reclaimed or recycled, including hardwood and crushed terracotta roof tiles which could be sourced from an original fibro house under renovation. You can see how they retrofitted an old fibro house to make it into an award-winning solar-powered sustainable house by watching these videos. After watching the videos, answer the questions below.

VIDEO **Team UOW Australia's Illawarra Flame House**
www.youtube.com/watch?v=kOXFoRZ8y2k

VIDEO **Illawarra Flame House Animated Walk-Through**
www.youtube.com/watch?v=Q4P-NrYDGbo

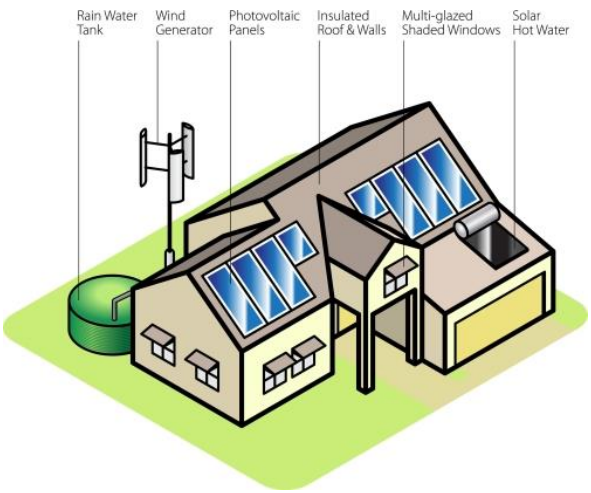
Question 1. What proportion of Australia's carbon dioxide emissions come from people's homes? ☐ 3 % ☐ 5 % ☐ 10 % ✓ 13 % ☐ 15 %	Question 2. What does "retro-fit" mean? ☐ Demolishing a home ☐ Building new homes ✓ Adapting existing homes ☐ Making new homes look old-fashioned
Question 3. In Australia, on which side of the house should you put solar panels to collect the most energy from the Sun? ✓ North ☐ South ☐ East ☐ West	Question 4. In winter, the Sun is higher in the sky than in summer. ☐ True ✓ False
Question 5. Explain how the thermal wall works.	

Net Zero Home

The picture represents a zero energy home.

A zero energy or net-zero home generates all the energy that it uses without having any negative impact on the environment, for example by burning a conventional fuel for heating.

Look carefully at the house in the picture and answer the following questions:



Question 1. Explain how this house is generating electricity. *Wind generator* *Photovoltaic panels*	Question 2. Explain how the house reducing the amount of lost energy. *Insulated roof & walls* *Multi-glazed shaded windows*
Question 3. What features help this house stay cool in summer? *Insulated roof & walls* *Multi-glazed shaded windows*	Question 4. Explain how the water for showers, baths or for washing dishes and clothes is heated. *Solar Hot Water*
Question 5. Water is a precious resource. How can we reduce the amount of water we use? *Example: Use less water (e.g., take shorter showers, do only full loads of laundry, use water from rainwater tank)*	Question 6. Explain how we minimise the impact on the environment when building the house. *Example: Generate power through renewable resources (e.g., sun and wind);Reduce water usage; Reduce loss of heat loss (or cooling)*

Sustainable living means to reduce our use of Earth's natural resources in our day-by-day life. It means "enough for everyone" without affecting generations to come.

Sustainable housing looks at:

- The building materials used
- The energy and water usage
- The waste generated by households
- The location in terms of access to public transportation or alternative transportation (e.g., walking, cycling)

Question 7. Discuss with a partner what one thing you can do to live more sustainably in your home. Record your ideas below.

Answers may vary.

Temperature, thermal energy and heat

- Survey of Prior Knowledge
- Representational Challenge Series 1
- Temperature Role Play
- Representational Challenge Series 2

Learn about temperature, thermal energy and heat and how they apply to sustainable housing.

Key Ideas

- The temperature of an object is related to average kinetic energy of the particles that make up the object.
- The thermal energy of an object related to the total kinetic energy (i.e., movement) and of the particles that make up the object.
- Heat is the energy that gets transferred from hot objects to cooler objects.

Teacher's Notes

Survey of Prior Knowledge

Ask students to complete a brief survey designed to explore their understanding of the particle model.

Representational Challenge Series 1

Provide students with a series of representational challenges that ask them to incorporate particle ideas to exemplify the following properties of matter. Discuss whether their drawings reflect the given property.

Challenge 1: the drawing needs to show particles and connectedness (connections or bonds).
Challenge 2: the students might draw a before and after to show that bonds remain but arrangement of particles change.
Challenge 3: again, before and after showing weak bonds that are broken.
Challenge 4: a series of drawings showing bonds that can be stretched.
Challenge 5: water particles and cordial particles mixing.
Challenge 6: either more particles or larger particles to show difference.

Temperature Role Play

Students are initially given the challenge to represent how a lump of plasticine holds it shape through role play.

Introduce the concept Temperature as a measure of average kinetic energy of the particles in a substance. There is an" absolute zero temperature" (0 Kelvin) at which particles have no energy. For any temperature, the particles must be moving.

Challenge the students to represent a lump of plasticine that holds its shape and is at 21°C. Students need to stay connected and move.

Discuss the difference between temperature and thermal energy: A very hot iron nail can have a higher temperature than a bucket of water but the bucket of water has more thermal energy.

Discuss what happens at the particle level when a very hot iron nail is dropped into a bucket of water: The nail has higher temperature so the nail particles on average have a higher kinetic energy

than the average water particles. When the nail is dropped into the bucket the temperature of the nail decreases and the water temperature increases a little bit. On a particle level the nail particles collide with the water particles and lose energy. Collisions between more energetic particles and less energetic particles continues until, on average, the kinetic energy of the nail and water particles are the same.

Representational Challenge Series 2

Show students animations of particles of substances in different states. Students are given the representational challenge to first of all describe the motion of the particles that represent each state in words and the draw visual representations. In a solid the particles vibrate, in a liquid they move around each other and in a gas the particle travel in straight lines.

Survey of Prior Knowledge

Complete a brief survey of your "ideas about matter".

Question 1. When a substance freezes the temperature must always be less than 0°C. ☐ True ✓ False ☐ I Don't Understand ☐ Not Sure	Question 2. It is possible to heat an object to +1000°C but it is not possible to cool it -1000°C. ✓ True ☐ False ☐ I Don't Understand ☐ Not Sure
Question 3. When wax melts the molecules that make up the wax change from being hard and firm to being soft and 'gooey'. ☐ True ✓ False ☐ I Don't Understand ☐ Not Sure	Question 4. A closed bottle with small amount of water at the bottom is left in the sun. After a while, when the water has evaporated, the mass of the bottle is now less than before. ✓ True ☐ False ☐ I Don't Understand ☐ Not Sure
Question 5. The molecules inside liquids and gases are moving but in solids they are stationary. ☐ True ✓ False ☐ I Don't Understand ☐ Not Sure	Question 6. In the spaces between atoms of an object there is air. ☐ True ✓ False ☐ I Don't Understand ☐ Not Sure
Question 7. A pie that heats up in a gas-fired oven can be explained by air molecules in the oven colliding with pie molecules. (1 mark) ✓ True ☐ False ☐ I Don't Understand ☐ Not Sure	

Representational Challenge Series 1

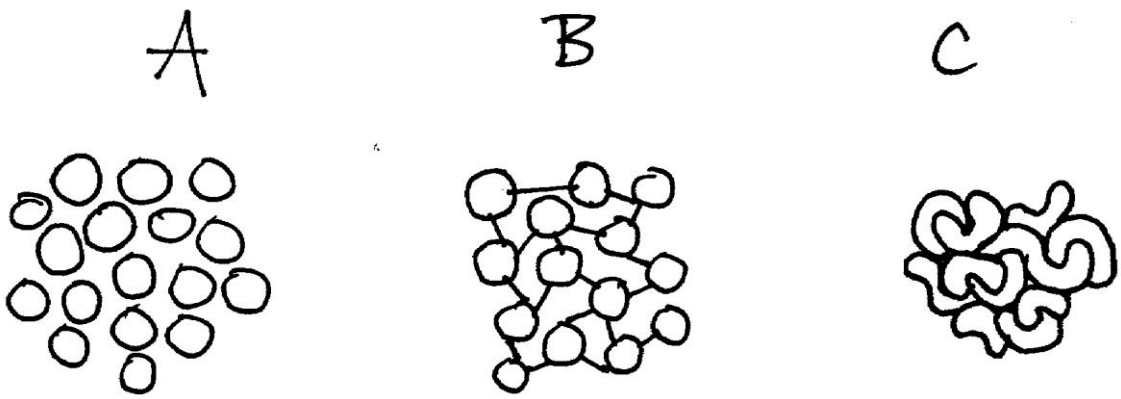
Scientists use particle ideas to explain what they observe about matter. The task below asks you to imagine and draw particles that will explain the property of the object that is given.

For example, the first challenge asks you to represent how a lump of plasticine can hold its shape. There are three examples that students have drawn below.

We need to evaluate each representation in terms of whether they can explain that the plasticene is made of particles and that it can hold its shape. This will mean that the representation needs to show particles as well as representing that the particles are connected in some way.

Representation A shows particles but doesn't show them connected in any way. Therefore, this is not a useful representation.

Representations B & C show particles as well as being connected. Therefore, each of these representations are useful in explaining that a lump of plasticene is made of particles that holds its shape.



Particle representations to show that a lump of plasticene holds its shape

In your workbooks, use particle ideas to represent the property of the object that is given. Once you have completed your drawings take a photo and upload them below. Respond to the following representational challenges that ask you to incorporate particle ideas.

- A lump of plasticine holds its shape.
- A lump of plasticine can be changed into a different shape.
- A piece of chalk can’t change shape it breaks easily (brittle).
- A rubber band can stretch and return to its original shape.
- Red cordial and water mix easily.
- An iron cube is much heavier than an aluminium cube of the same size.

Temperature Role Play

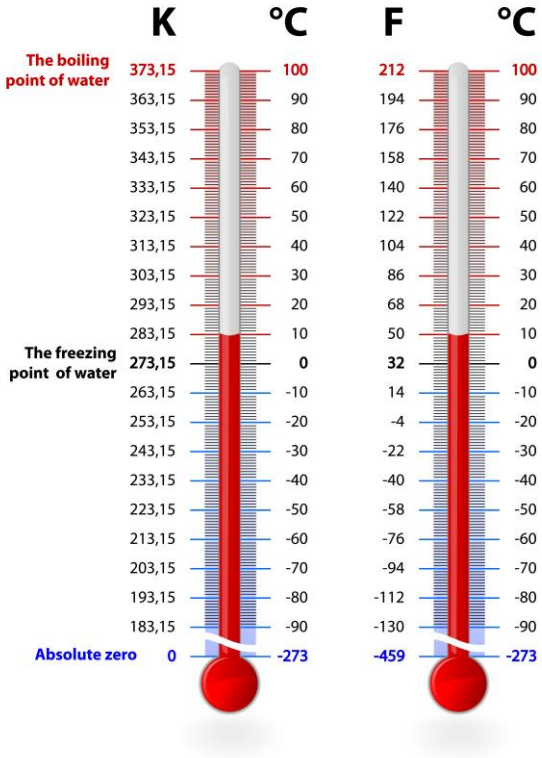
Temperature is a measure of the average kinetic energy of the particles in a substance. There is a temperature (0 Kelvin), at which particles have no energy. At any other temperature, the particles must be moving.

Temperature and thermal energy are different. A very hot iron nail can have a higher temperature than a bucket of water but the bucket of water has more thermal energy.

Activity

What happens at the particle level when a very hot iron nail is dropped into a bucket of water?

Represent how a lump of plasticine holds its shape at 21°C through role play. You need to stay connected and move.



Representational Challenge Series 2

Draw visual representations to describe the motion of the particles of substances in different states (solid, liquid and gas).

Heating and Cooling

- The Particle Model
- States of Matter
- Temperature, Heating, and Cooling
- Practical Activity 1: Cooling and Evaporation
- Practical Activity 2: Cooling and Evaporation

Learn how concepts in science (e.g., particle theory of matter, changes of state) explain the nature of heating and cooling.

Key Ideas

- All matter (i.e., everything) is made up of atoms. All the atoms we know are described in the Periodic Table of Elements.
- Atoms are made of protons, neutrons and electrons.
- Molecules are particles made up of more than one atom that are bonded together.
- All atoms and molecules are in constant motion.
- When atoms or molecules (i.e., particles) are heated, they gain kinetic energy and vibrate more. As the particles vibrate more they spread out and the volume of the object increases. Therefore, most substances expand when heated.
- Particles exist as a solid, liquid or gas. In a solid, particles vibrate, in liquid, they move around each other, in a gas, the particles travel in straight lines. As particles gain kinetic energy, they change states from a solid, to liquid or gas. As they lose energy, the reverse occurs.
- Temperature is a measure of the average kinetic energy of the particles, or how fast the particles are moving. The faster the particles move the higher the temperature.
- If you cool a material down the particles in it will move less. The coldest temperature possible is called Absolute Zero or zero Kelvin, which is -273°C. This is the temperature of where all particles are completely motionless.

Teaching Notes

Students will be exploring videos and participating in demonstrations and activities to learn about the particle model, states of matter, and heating and cooling.

The Particle Model

For the ***Particles in Motion Activity***, students will be observing the rate of diffusion in hot and cold water. You can do this as a demonstration or prepare the equipment for all students to do (e.g., beakers, flasks, food colouring, hot water).

State of Matter

For the ***Solid or Liquid Activity***, students will explore the properties of jelly, slime, *oobleck* and toothpaste. For the ***Changes of State Role Play***, you can direct students through the changes of states or students may choreograph their own demonstration.

Temperature, Heating & Cooling

For the ***Thermal Expansion Activity***, prepare a retort stand, rod and ring, and source of heat. Alternatively, you may choose to show the video.

Practical Activity 1 and 2

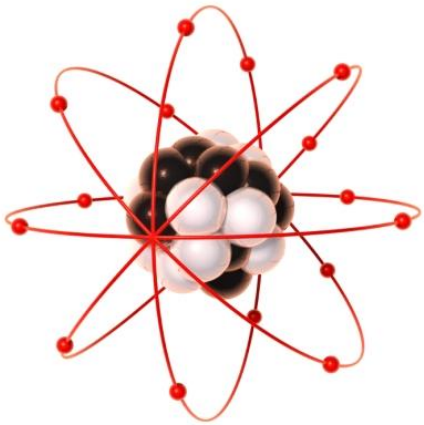
For these activities, you will be using the STELR Sustainable Housing Equipment. For Practical Activity 2, you will need, in addition, a wet cloth.

The Particle Model

Matter is made up of atoms. If we try to cut any piece of matter in half and the half in half and so on, we can do this a finite number of times until we get to a smallest particle that cannot be divided anymore and still be the same material.

Atoms are particles that cannot be divided anymore and still be the same material (e.g., gold)

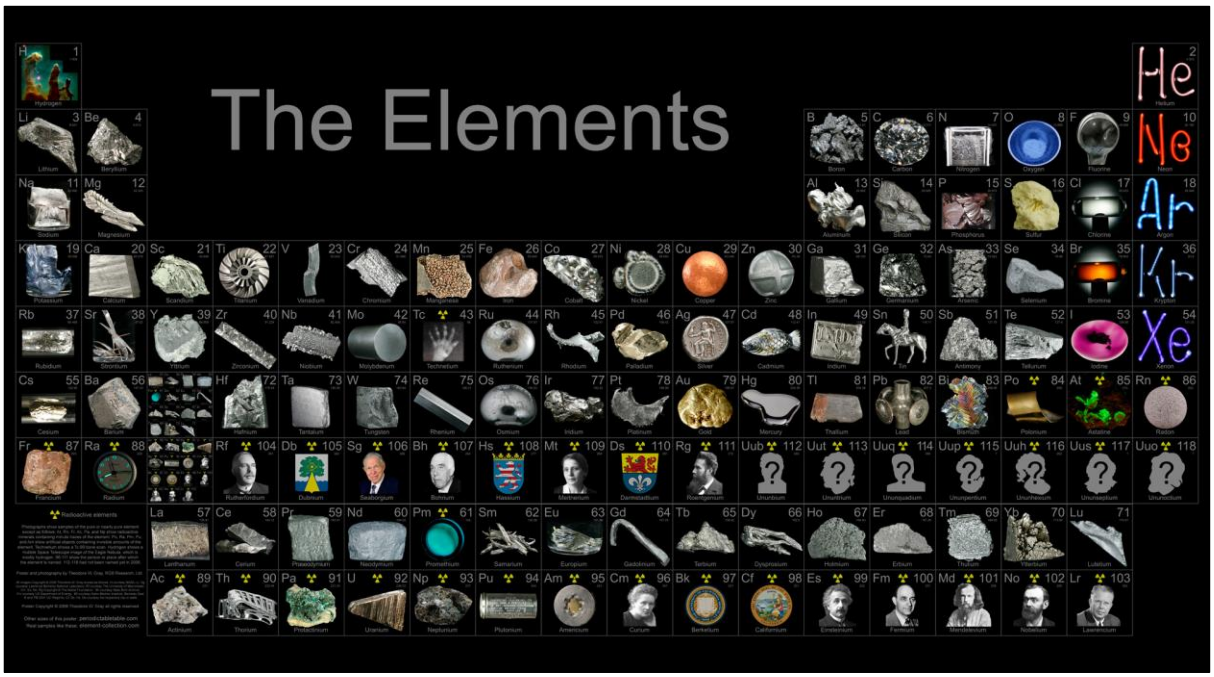
Atoms are made of a very small nucleus made of positively charged protons and neutral neutrons, which have no charge. Negatively charged electrons orbit around the nucleus. The number or protons determines which element the atom is.



Model of an atom

Molecules are particles made up from more than one atom chemically bound together. For example a water molecule (H_2O) is made from an oxygen atom bound to two hydrogen atoms. All atoms we know of are organized as elements on the Periodic Table.

A visual presentation of elements in the periodic table:



Particles in Motion Activity

Atoms and molecules are always moving. When a substance is heated, its particles gain kinetic energy and move around more.

You will need:

- Two bottles/flasks/large beakers
- Food colouring

Fill one with cold water and one with hot water.

Put a drop of food colouring in each, observe and answer the following questions.

Question 1: Describe what you saw. In which bottle did the food colouring diffuse (spread out) the fastest?	Question 2: Why do you think this happened? Explain it in terms of the particle model.
Question 3: Watch the video for an explanation of how diffusion works and compare with your answer for Question 2. Make any changes as needed.	

VIDEO

How Diffusion Works Error! Hyperlink reference not valid.

States of Matter

Watch the video and fill in the table below regarding the properties of solids, liquids, gases.

State of Matter
www.youtube.com/watch?v=s-KvoVzukHo

Question 1. Complete the table below regarding the properties of solids, liquids, gases. You may perform simple experiments designed by yourself in order to establish some properties.

	Solid	Liquid	Gas
Does it have a fixed shape?			
Does it have a fixed volume?			
Can it be compressed?			
How do particles move when matter is in this state?			
What can it turn into?			
Name of the transition process.			
What is the distance between particles?			
How strong are the forces between the atoms or molecules (i.e., intermolecular forces)?			

Activity: Solid or Liquid?
Make and play with some or all of the following substances.

- Jelly
- Slime/Oobleck
- Toothpaste

Question 2. Describe the materials. Are they solid or liquid or a bit of both? What properties do they have? How are their particles arranged to give them these properties? You can draw your answers and paste any pictures you take below.

<table>
<tr><td colspan="2">Question 3. Watch the video below animation on the behaviour of solids, liquids and gases and the transitions between these states, then answer the questions below.

VIDEO <u>Solids, Liquids, Gases</u>
<u>www.youtube.com/watch?v=UnBoQe2rsgo</u></td></tr>
<tr><td>Question 4. When a solid turns into a liquid (e.g., ice turning into water) it is called:

☐ Condensation
☐ Evaporation
☐ Sublimation
☐ Freezing
✓ Melting</td><td>Question 5. When a gas turns into a liquid (e.g., steam turning into water) it is called:

✓ Condensation
☐ Evaporation
☐ Sublimation
☐ Freezing
☐ Melting</td></tr>
<tr><td>Question 6. When a liquid turns into a solid (e.g., water turning into ice) it is called:

☐ Condensation
☐ Evaporation
☐ Sublimation
✓ Freezing
☐ Melting</td><td>Question 7. When a solid turns straight into a gas or a gas turns straight into a solid (e.g., dry ice turning into carbon dioxide gas) it is called:

☐ Condensation
☐ Evaporation
✓ Sublimation
☐ Freezing
☐ Melting</td></tr>
</table>

Temperature, Heating, and Cooling

Temperature is a measure of the average kinetic energy of the particles, or how fast the particles are moving.

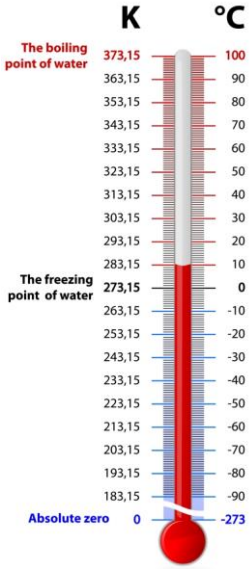
The faster the particles move the higher the temperature.

If you cool a material down the particles in it will move less. The coldest temperature possible is called Absolute Zero. This is the temperature of where all particles are completely motionless.

Absolute Zero is -273°C.

This is also called zero Kelvin, or 0 K.

Watch the video below and answer the following questions.



Fahrenheit, Celsius and Kelvin explained in ten seconds
www.youtube.com/watch?v=Xy2qVIhTtG8

Question 1. Water boils at 100 degrees Celsius. How would this temperature be written on the Kelvin scale? ☐ 100 Kelvin ☐ 173 Kelvin ☐ -173 Kelvin ✓ 373 Kelvin ☐ 273 Kelvin	Question 2. Explain why it is not possible to have a temperature below absolute zero. *Because particles are always in motion.*

Heating: Thermal Expansion

When a solid is heated, its particles gain kinetic energy and vibrate more. As the particles vibrate more they spread out and the volume of the object increases. This is called thermal expansion.

Activity / Demonstration

For this activity, your teacher may do a demonstration or you can watch the video below.

Activity: Retort stand, rod with a ring at its end, ball that cannot pass through the ring but with a diameter that is very close to that of the ring's internal diameter, Bunsen burner or another source of heat

Method: Use the retort stand to set up the rod with the ring horizontally.

- Try to pass the ball through the ring when the ring is cold.
- Heat up the ring again and pass the ball through the ring.
- Make sure you do not burn your fingers in the process.

Watch the following video demonstration and answer the questions below.

Heating a Metal
www.youtube.com/watch?v=3pnj4ytORQw

Question 1. Predict what will happen when you heat up the ring. Will the internal diameter of the ring increase? How do you explain that?
Question 2. Engineers have to consider thermal expansion when designing buildings and other things. How do engineers account for thermal expansion when they design bridges or railways?

Cooling & Evaporation

Watch the video and explain the questions below.

Evaporation and Condensation
www.youtube.com/watch?v=zsb4ZEQLFxQ

Question 1. Give examples of evaporation and cooling as it relates to your home.

Practical Activity 1: Cooling and Evaporation

Activity: Find out how a fan influences temperature.

In this activity, you will be using the STELR Sustainable Housing materials. Set up the STELR sustainable test house as follows:

- First side: Fan
- Opposite side: Temperature sensor (top of wall)
- Remaining sides, ceiling and floor: insulation

Answer Question 1, record the initial temperature then turn the fan on.

Question 1. What do you think will happen to the temperature of the test house with the fan turned on? Why?	Question 2. What actually happened to the temperature in the test house with the fan on? Was this what you expected? Explain.
Question 3. Hold your finger in front of the fan? How does it feel?	Question 4. Wet your finger then hold it in front of the fan again. How does it feel this time? Is it different to when your finger was dry?

Practical Activity 2: Cooling and Evaporation

Activity: To find out how evaporation cools a home.

Evaporation is a process by which a liquid becomes gas at temperatures lower than its boiling point. Evaporation occurs only on the surface of the liquid. It is a lot faster when the air moves above the surface of the liquid.

Use the STELR Sustainable Test House to investigate how evaporation can be used to cool a house.

Equipment:

- Test House
- Fan and power supply
- Cloth (wet and dry)

Measure how the temperature in the house changes with the cloth replacing different insulated walls. Find out whether the house is cooler with the fan off, the cloth wet or dry and which position the cloth should be in to keep the house coolest.

Question 1. Explain how you set up your apparatus (you can include diagrams and photos) and what you did to make sure it was a fair test.

Question 2. Record your results.	
Question 3. Which combination of fan and cloth kept your house coolest. Explain why you think this was in terms of particles, energy and evaporation.	Question 4. Explain what happens to the temperature inside the house as the fan blows towards the wet cloth.
Question 5. How is the energy lost from the house to cool it?	Question 6. Explain how evaporation of water can cool down an entire house?
Question 7. Compare the advantages of an evaporative cooling system with traditional air conditioning.	

Energy transfer and transformations

- Types of Energy
- Energy Transfer
- Energy Transformation
- Practical Activity: Storing Thermal Energy


Learn how energy play a role in all aspects in our lives, is a key concept in science, and how it applies to sustainable housing.

Key Questions

- Why do we need energy?
- What types of energy are there?
- What is the difference between energy transformation and energy transfer?
- What are energy resources?
- Why is energy important for housing?
- What are the consequences of our energy production and use?

Key Ideas

- Energy can be transferred from one system to another (or from a system to its environment) in different ways: by conduction, convection, or by radiation (electromagnetic waves).
- Conduction is the transfer of energy between objects that are in physical contact.
- Convection is the transfer of energy between an object and its environment, due to fluid motion either in a gas or liquid.
- Radiation is the transfer of energy from the movement of charged particles within atoms and is converted to electromagnetic radiation which can travel through space.
- Energy can be transformed from one form to another. Changes occur when energy is transformed and these changes may be observed and measured.
- Energy cannot be created or destroyed, but only changed from one form to another. When energy changes in form, the total amount of energy remains constant.
- In systems undergoing change, energy spreads out from the source. This is called dissipation of energy.

Types of Energy

Energy is all around you and even inside you. There are many different types of energy. The table below lists the main types of energy and gives some examples.

Question 1. Think of your own examples and add them to the table in the right hand column.			
Energy Type	**Definition**	**Example**	**Your own Example**
Kinetic Energy	Movement or motion	Any moving object like a car	
Elastic Potential Energy	The energy contained in a stretched or compressed elastic object	Springs	
Gravitational Potential Energy	Gravitational potential energy is the energy stored in an object as the result of its vertical position or height, due to the Earth's gravitational field.	Any raised object like a boulder on the top of a hill.	
Chemical Potential Energy	Energy stored in the bonds of molecules	Fossil fuels	
Thermal	Heat	Heat from fire	
Sound	Fossil fuels	Someone shouting	
Light	Energy found in photons	Visible light from the sun	
Electrical Energy	Energy possessed by electrons in a flow of electric charge	The energy in the power lines as they leave the power station	
Nuclear Potential Energy	Energy stored in the way that the particles in the nucleus are held together	A deposit of uranium ore	

Are you starting to understand more about the main energy types? Watch the following video and complete the second table.

Keep Moving Rover
www.youtube.com/watch?v=1KUmVTGoLzg

Question 2. For each of the scenes in the above animation, identify the main energy type that is being portrayed. Hint: each of the energy types listed in table 1 has been represented in its own scene.

Scene	Main energy type portrayed in the scene
1	*nuclear*
2	*heat*
3	*light*
4	*chemical*
5	*kinetic*
6	*gravitational*
7	*elastic*
8	*electrical*
9	*sound*

Question 3. Which ones of these energy types have consequences that are damaging to the planet? What are the consequences?

Energy Transfer

Rather than staying in the same place, energy frequently moves from one place to another. This is known as energy transfer. The Law of Conservation of Energy states: energy cannot be created or destroyed, and energy can only transform from one form into another.

Imagine yourself at home, sitting down after a long day at school and switching the TV on to watch your favourite TV show. The TV lights up and the show theme song begins to play. How does the sound get from the TV to your ears?

The answer is that the TV's speakers produce the sound, which is then transferred through the particles in the air all the way to your ears. In fact, if there weren't any particles in the air (if you were watching your TV show in outer space, for example) you wouldn't hear anything at all!

Question 1. Electrical energy is transformed into which type(s) of energy in speakers? Tick all that apply. ✓ Sound ✓ Kinetic ☐ Thermal ☐ Light ☐ Chemical	
Question 2. Electrical energy is transformed into which type(s)? ✓ Sound ☐ Chemical ✓ Thermal ☐ Kinetic ☐ Light	

You may have also observed energy transfer occurring in your home kitchen. If you place a metal saucepan containing water on a hot stove, the water and saucepan handle soon become hot. This is because the heat energy of the flame or heating element is transferred from the base of the saucepan to the water and to the saucepan handle.

Heat energy can be transferred from one place to another in three ways:

> **Conduction** – heat energy is transferred through a material or between materials (this happens in a heated saucepan).
> **Convection** – liquids or gases gain heat energy and then move from one place to another.
> **Radiation** – objects give off heat energy in the form of infrared radiation.

Did you know that convection and radiation are the reason your skin can sense the saucepan is hot without even touching it? Convection causes the air around the saucepan to heat up and rise to where you are holding your hand. A hot saucepan also emits invisible infrared radiation, which warms our skin when it reaches it. This same radiation is what makes it so warm to lie in the sun on a sunny day. Neat!

Question 3. Which of these is an example of heat transfer by conduction? ✓ The handle of a metal spoon becomes hot when you use it to stir a pot of soup on the stove. ☐ The air near the ceiling is normally warmer than air near the floor. ☐ Smoke rises up a chimney. ☐ You feel the heat from a bonfire even though you are several meters away from it.	Question 4. Radiation is heat transfer by: ☐ direct contact. ✓ electromagnetic waves. ☐ molecular and electronic collisions. ☐ atmospheric currents.

Energy Transformation



Energy transformation is the process of changing energy from one form to another. This is shown in the following examples.

1. Energy transformations in an iPod

When you turn on an iPod that is plugged into a power point, electrical energy is transformed into sound energy. One simple way to represent the transformation of energy is with a flow chart such as the one shown below:

Electrical energy → Sound energy

If the iPod is powered by a battery, however, two energy transformations take place, one after the other. This is because the battery contains certain chemicals that react with one another when the circuit is completed by turning on the switch. The chemical reaction produces electrical energy. In this case, the series of energy transformations is:

Chemical potential energy → Electrical energy → Sound energy

2. Energy transformations in a light bulb

Using a torch involves energy transformations to generate light and also heat at the same time. When we switch on the light, electrical energy is transferred through wires to the light bulb where it is transformed into light energy and heat energy. We can represent this by the following flow chart:

Electrical energy → Light energy + Heat energy

3. Energy transformations in a hydroelectric power plant

A hydroelectric power station uses energy transformations to generate electricity. As the water flows down the pipes its gravitational potential energy is transformed into kinetic energy. In the power station, turbines and generators transform the kinetic energy of the water into electrical energy.

Gravitational potential energy → Kinetic energy → Electrical energy

A hydroelectric power station also uses energy transfers to generate electricity. The mechanical kinetic energy of each spinning turbine is transferred to a generator by a driving shaft.

Question 1. Energy is lost during transformation, making the process less than 100% efficient, because: ☐ the energy input is always less than the energy output. ☐ some of the energy input is always transformed into gravitational potential energy ✓ some of the energy input is always transformed into thermal energy. ☐ none of the above	Question 2. In your own words, describe the difference between energy transformation and energy transfer.
Question 3. Why is it important to understand energy conversions in order to provide sustainable housing?	

Optional Activity 1: Cotton Reel Car

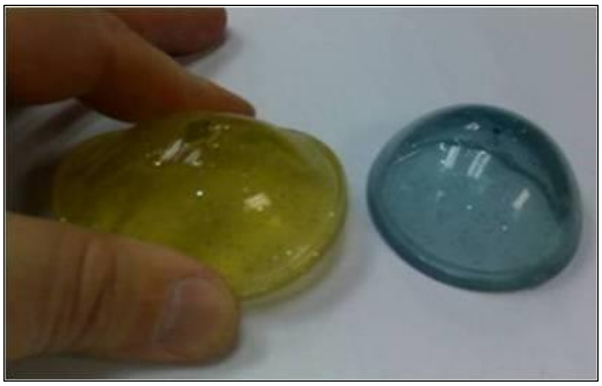
Watch the video below to learn how to make your very first car: a cotton reel car! Once you have watched it, make your own and have a play.

STELR Cotton Reel Car Activity
www.youtube.com/watch?v=yzNwSYE03y0

Question 1. Describe how you think a cotton reel car works.	Question 2. What different energy types can you identify when you observe the cotton-reel car?
Question 3. Identify the starting energy for the cotton-reel car.	Question 4. Identify the finishing energy for the cotton-reel car.
Question 5. Represent the main energy transformation in the cotton-reel car with a flow chart.	
Challenge: Can you improve the design of the cotton reel car so it can go faster or further than anyone else's? What did you do to make it go faster or further?	

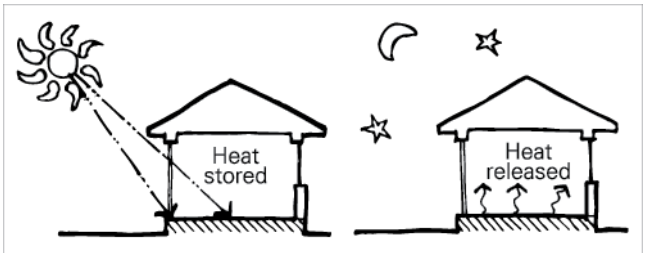
Optional Activity 2: The Jumping Cup

Take a jumping cup by its edges, turn it inside out and carefully place it on a smooth surface. Let go, leave it and stand clear...



Question 1. Describe how you think a jumping cup works.	Question 2. What different energy types can you identify in the jumping cup?
Question 3. Identify the starting energy for the jumping cup.	Question 4. Identify the finishing energy for the jumping cup.
Question 5. Represent the main energy transformation in the jumping cup with a flow chart.	
Challenge: Can you change the shape of the cup in any way so it can go higher than anyone else's? What did you do to make it go higher?	

Practical Activity: Storing Thermal Energy



Passive Storage of Heat

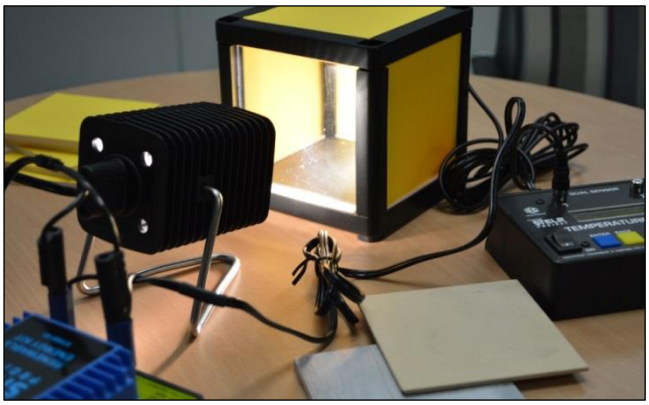
The thermal mass of a material is its ability to absorb and store heat energy. A lot of heat energy is required to change the temperature of high-density materials like concrete, bricks and tiles. They are therefore said to have high thermal mass. Lightweight materials such as timber have low thermal mass. Appropriate use of thermal mass throughout your home can make a big difference to comfort and heating and cooling bills.

If a house has a concrete floor, it can absorb radiant heat in daylight hours and re-radiate the heat energy back into the room at night.

Find out more about thermal mass by downloading the PDF brochure.

Thermal Mass
www.yourhome.gov.au/passive-design/thermal-mass

Activity: Find out which material is best at storing and releasing heat



In this activity you will gather data for one test sample and share your results with the rest of the class.

Equipment:

- Cube to form a one room house (test chamber)
- Perspex window
- Temperature sensor panel
- Yellow insulated walls to form 2 side walls and ceiling
- Power supply
- Lamp
- Materials to test (either thick card, steel, aluminium, ceramic or CSM plaster)
- Data logger

Method:

Place the temperature sensor in the back wall with the sensor at the top. Place a *Perspex* in the opposite face of the cube (window). Insert thick black steel square into the floor. Connect the temperature sensor to the data logger. Place the lamp 20 cm from the window, angled down to shine on the floor. Activate the lamp and the data logger at the same time.

Question 1. Record your results in the table below.

Sample	Start Temperature	Temperature at 30 minutes	Temperature at 60 minutes
Thick card			
Steel			
Aluminum			
Tile			

Question 2. Discuss how to design this group investigation to support fair testing.	Question 3. Compare the results of your sample with other groups' samples. Determine which sample was best at storing and releasing heat.

Convection

- Convection
- Practical Activity 1: Convection in a Room
- Practical Activity 2: Visible Convection Currents
- Convection in Houses

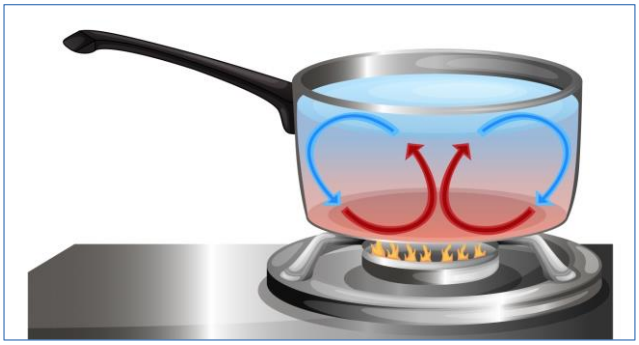
Learn about convention through activities and videos and apply your knowledge to making homes more energy efficient.

Key Ideas

- Energy can be transferred from one system to another (or from a system to its environment) in different ways: by conduction, convection, or by radiation (electromagnetic waves).
- Convection is the transfer of energy between an object and its environment, due to fluid motion either in a gas or liquid.

Convection

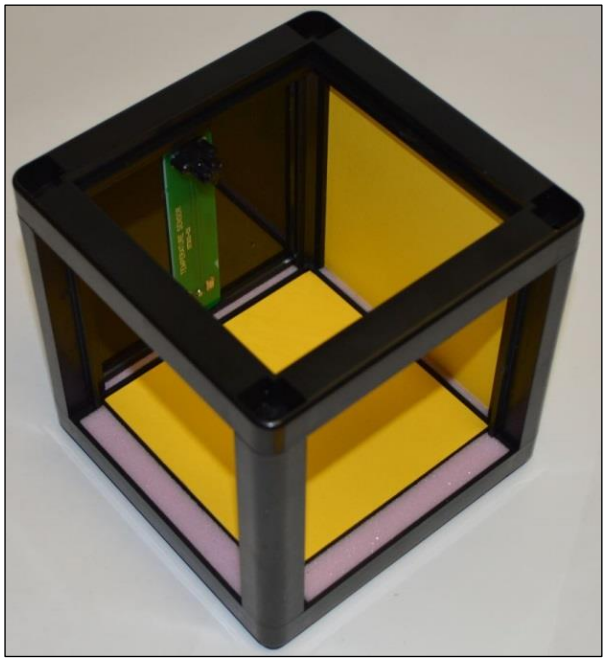
When a solid is heated, the particles vibrate more and take up more room. The solid expands. When a fluid (for example air in a room or water in a saucepan) is heated it becomes less dense and rises. As it rises colder, higher density fluid to moves in to replace the hot fluid.
When the colder fluid reaches the source of heat it is also heated up and rises. The process starts again and continues indefinitely until the source of heat stops. This cycling creates convection currents. Watch the video below and answer the following questions.



Convection in Lava Lamps
www.youtube.com/watch?v=DL3Ez9bxMTo

Question 1. Convection takes place in:	Question 2. Rising air tends to:
✓ liquids and gases.	☐ expand and become warmer.
☐ solids only.	☐ become denser and warmer.
☐ liquids only.	✓ become denser and cooler.
☐ gases only.	☐ expand and become cooler.

Practical Activity 1: Convection in a Room



Activity: Find out how convection affects temperature in different parts of a house
Set up the STELR sustainable test house. You will need the 12V power supply to connect to the heater.

The panels you need are:

- Bottom - Heater
- First wall - Temperature sensor at bottom of wall
- Second wall - Temperature sensor at top of wall
- Ceiling and other walls - Insulation

Connect the temperature sensors to the data collection module and answer Question 1 below before turning on the heater.

Question 1. Which temperature sensor do you think will record the highest temperature, the one at the top of the house or the one at the bottom? Explain your answer.	Question 2. Which temperature sensor actually recorded the highest temperature? What was the difference in temperature between the top and the bottom?
Question 3. How did you prediction compare with the actual result?	

Practical Activity 2: Visible Convection Currents

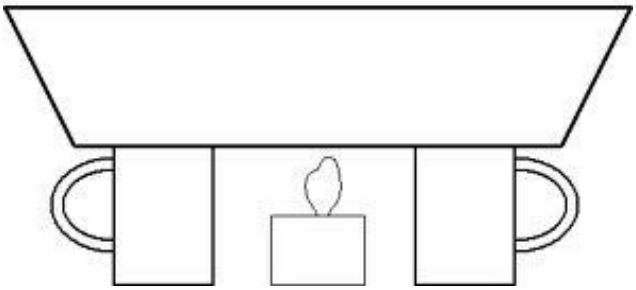
Some Other Tricks with Convection Currents
www.youtube.com/watch?v=RCO90hvEL1I

Convection Demos
www.youtube.com/watch?v=WEDUtS0IMws

Activity: Learn about the nature of convection currents.

Fill up a flat glass container with water. Place the container on two cups and place candles underneath. Wait for 1-2 minutes and then drop a few millilitres of blue dye in the middle of the container. Observe what happens with the dye and record your findings on a diagram similar to the one above.

Thermal Convection Experiment
(template for sketching flow directions)



Equipment:

- candle or tea light
- flat bottomed ceramic or glass bowl
- food colouring
- 2 ceramic or glass cups
- water

Question 1. Explain what will happen to the dye particles.	Question 2. Describe the relationship between the position of the flame and the direction of the stream of water and dye.
Question 3. Why is the current of dye particles ascending and then descending?	Question 4. How is convection involved in heating or cooling a house?
Question 5. How would a ceiling fan help convection?	

Convection in Houses

Controlling the flow of heat: None of us want to live in a house that is freezing cold or stifling hot. Therefore, it is really important to decide how best to control the temperature of the house. Thinking about convection currents is important when heating or cooling a house.

Question 1. Where in a room would you put a heater to maximise heating? Consider convection currents in your answer.	Question 2. Where in a room would you put an air-conditioner to maximise cooling?
Question 3. Roof insulation is one way to reduce heat losses in a house. Why is extra insulation needed above the ceiling and not under the floor?	
Question 4. House heating is based on convection. The heater warms up the air at a certain location in the house and then the air must be circulated around the house in order to transport the energy everywhere. Design a room including the following features: • Door • Window • Heater • Fan • Draft excluder	

Conduction

- Conduction
- Insulation
- Practical Activity: Best Materials for Insulation

Learn about convention and apply your knowledge to making homes more energy efficient.

Key Ideas

- Energy can be transferred from one system to another (or from a system to its environment) in different ways: by conduction, convection, or by radiation (electromagnetic waves).
- Conduction is the transfer of energy between objects that are in physical contact.

Teacher Notes

As an optional activity, students can do a role-play on energy transfer, enacting how particles collide: Representational Challenge: One end of a metal bar is placed in hot coals. Explain why the other end heats up after a little while. Show by role-play

Teacher's Notes:

Fire particles and iron particles need to be represented. The faster fire particles collide with iron particles, which then collide with other iron particles. Conduction can be explained as a set of collisions of particles in the solid.

Conduction

Conduction is one of three ways heat can be transferred through a material. Heat is transferred by conduction when particles are heated, vibrate more and then pass on their energy to the particles around them.

Metals are good conductors because their electrons are more loosely bound and travel quickly and easily throughout the structure. Metal atoms become ions, and the electrons transfer heat by vibrating and colliding with other atoms and electrons in the metal. This kinetic energy travels from the hotter parts of the metal to the cooler parts by free electrons, transferring the heat energy. The hotter the metal, the more kinetic energy these vibrations have.

Non-metals are generally poor conductors. There are no loosely bound electrons to transfer the heat energy through the material. The heat is transferred only by contact between the atoms or molecules.

Gases are poor conductors as the atoms are much further apart than they are in liquids or gases. Insulators often contain small air pockets are also poor conductors.
Heat is transferred by conduction when particles are heated, vibrate more and then pass on their energy to the particles around them.

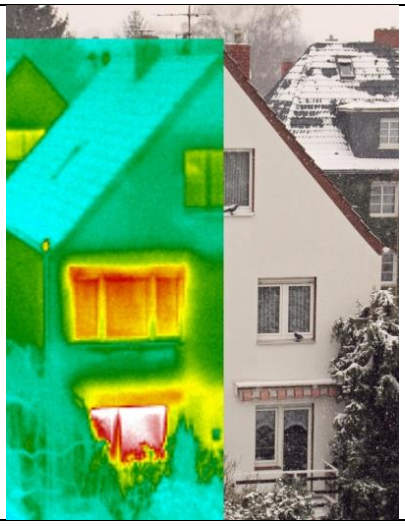
Watch the video below and then answer the following questions.

Heat Transfer
www.youtube.com/watch?v=9joLYfayee8

Question 1. Which materials are the best thermal conductors?	Question 2. Which of the following materials would be the best conductor?
☐ Plasmas ✓ Solids ☐ Liquids ☐ Gases	☐ Wool ✓ Iron ☐ Polystyrene ☐ Oak
Question 3. Would you make the walls, doors and roof of a house from a conductor or an insulator? Why?	

Question 4. Suggest a material that would be used to make the following and explain why. ▪ saucepan base ▪ saucepan handle ▪ saucepan lid ▪ saucepan lid handle	
Question 5. What are the best materials to make windows and window frames? Why?	
Double glazing has two pieces of glass separated by an air gap. Triple glazing has three pieces of glass and two air gaps. Question 7. Explain how the air gap prevents heat transfer by conduction.	
Question 8. In a group, make a human model of conduction. Things to consider: ▪ How are the particles arranged? ▪ What happens at the heat sources? ▪ How is the heat transferred? Draw a diagram to explain.	

Insulation

This picture of a house was taken in partly in infrared. It shows where heat is escaping from the house. Question 1. Was it taken in winter or summer? Would you want it to be warmer or cooler inside compared to outside?	
Question 2. What parts of the house emit more heat? How are they coloured?	Question 3. If heat is being given out through some parts of the house, how can you keep the house at a constant temperature in winter?
Question 4. Describe how the owner of the house could minimise heat transfer in the walls.	Question 5. What could the owner do to reduce heat transfer through the windows?
Question 6. What effect would insulating the house have in summer?	Question 7. Investigate how *thermoimaging* (i.e., taking pictures in infrared) could be used in converting houses into sustainable houses.

Practical Activity: Best Materials for Insulation

Activity: Learn how different materials conduct heat. Use the STELR Sustainable Test House set up as follows:

- Heat source (bottom surface of house)
- First wall - Temperature sensor
- Second wall - samples of different materials (wood, card, metal, glass, viridian glass, double pane glass, foam panel etc.)
- Other walls - foam

Set up your heat source and the temperature sensor. Measure the temperature inside the test house using the different materials. Record your findings in the table below.

Material	Temperature	Would the material make a good insulator?

Question 1. Which materials were the best insulators?	Question 2. Why do we need good heat insulators when we build a house?
Question 3. What type of glass would you use for your windows? Explain why.	
Question 4. Copper pipes that carry hot water are often wrapped in foam. What benefit would this have in terms of sustainability?	

Radiation

- Radiation
- Reflective Paints
- Windows
- Practical Activity 1: Summer and Winter Radiation
- Practical Activity 2: Materials and Radiation

Learn about how radiation of part of the electromagnetic spectrum and is used in a variety of ways in our daily life. Light energy from radiation is transformed into heat energy, which has implications for the design of homes.

Key Ideas

- Energy can be transferred from one system to another (or from a system to its environment) in different ways: by conduction, convection, or by radiation (electromagnetic waves).
- Radiation is the transfer of energy from the movement of charged particles within atoms. This movement is converted to electromagnetic radiation, which can travel through space.

Radiation

Radiation is how energy travels through a vacuum. This is how the energy generated by the Sun reaches the Earth.

Infrared radiation is part of the electromagnetic spectrum as is visible light and several other types of electromagnetic radiation. We cannot see the infrared radiation but our skin can detect it.

All things at temperatures above absolute zero give out infrared radiation.

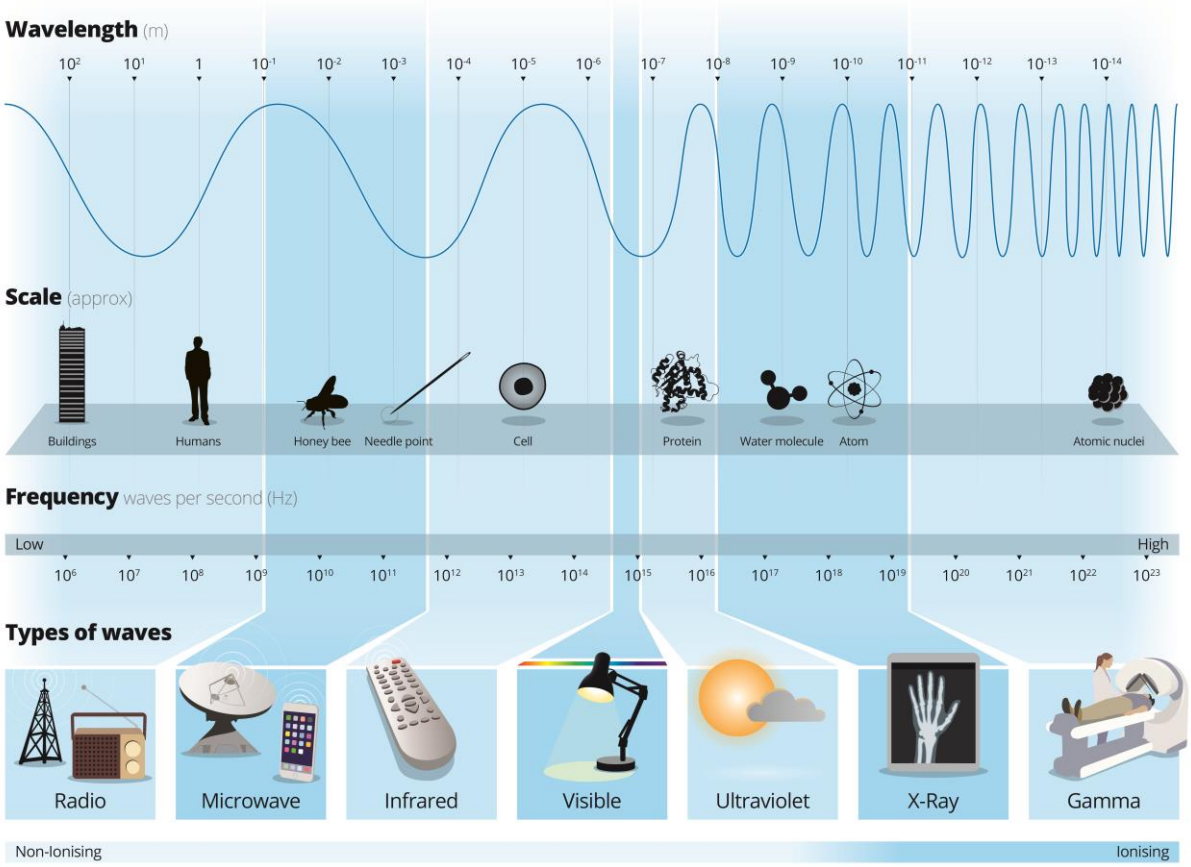
When radiation (including visible light and infrared radiation) hits a surface it can be transmitted, reflected or absorbed. Glass is a material that transmits visible light and infrared radiation. When a material absorbs radiation it is transformed into heat (thermal) energy.

The wavelength of the light determines its colour. The colour of an object depends on the frequencies of light that it reflects. Black objects absorb all visible wavelengths of light, white objects reflect all visible wavelengths.

Watch the video below and answer the following questions.

Heat Transfer – Radiation
www.youtube.com/watch?v=tZliZyoYT80

Question 1. Radiation is one way heat is transfer. Radiation travels by:	Question 2.The best surfaces to absorb radiation are:
✓ waves. ☐ particles. ☐ convection currents. ☐ conduction.	✓ dark coloured. ☐ white. ☐ shiny. ☐ green.



Electromagnetic radiation; courtesy of the Australian Nuclear Science and Technology Organisation – ANSTO

Question 3. Name five types of electromagnetic radiation and described how they are used.	Question 4. What colour are solar panels? Why?

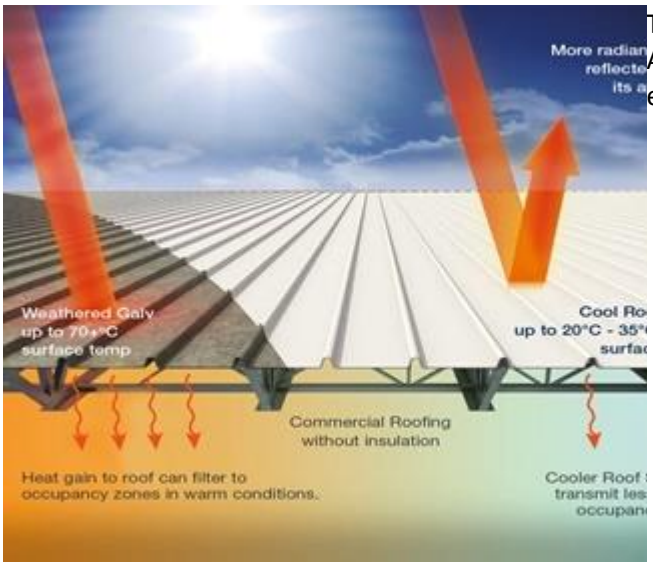
Reflective Paints

The roofs of buildings are large areas that can absorb the Sun's radiation. Some of the radiant energy from the Sun is transformed into heat (thermal) energy. The rest is reflected.
Some paints have been developed to reflect more infrared radiation as a way to control heat absorption.

Dulux has developed paints to reflect the Sun's rays before they are absorbed as heat.
By reflecting more of the Sun's radiation, Dulux paint technology can keep surfaces cooler. This reduces heat build-up in roof spaces that can be conducted into the living spaces of the house.

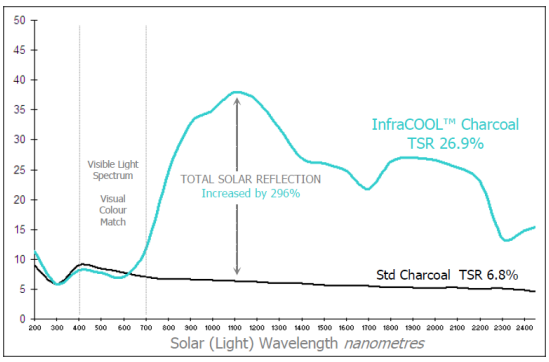
The cooling effect of the paint depends on variables such as colour choice, building design (including roof pitch, materials & window placement), insulation, ventilation, occupancy use, shading, location, climate and ratio of exposed roof area to floor area. Cool Roof White and Pastel shades are the coolest colour choice overall.

Examine the information in the diagram and graph and design an experiment that would investigate these claims.



The roof can absorb and reflect light energy. Absorbed light is transformed into thermal energy.

Total Solar Reflectance (TSR) of 2 visually equal panels is measured at individual wavelengths from 200-2500 nanometers. There is significantly higher reflectance of InfraCool® across the infrared region.



Question 1. The Sustainable Housing kit has metal samples that have been coated with different types of Dulux paint. Use the space below to design and carry out an experiment that will test claims made about the different paints. Write down the list of materials that you need, draw a diagram and explain the method that you intend to use.
Question 2. Which treatment was hottest when exposed to light?

Question 3. How can roof paint make a building more energy efficient?	

Windows

How important are windows to the energy efficiency of a building? Watch these videos and answer the questions for each video.

What do Windows do?
https://youtu.be/lpCbV95Q4Fg

Question 1. What are the main considerations for windows during hot weather? How about cold weather?

House and Window Design and Orientation
www.youtube.com/watch?v=_4_IHSBGUr0

Question 2. Explain cross ventilation. Why is it important?
Question 3. What is the best way to orient a house? Why is this important?
Question 4. In Australia, which side of the house should have the most glass? Why?

Shading Windows
https://youtu.be/V-ZqeCqqQQM

Question 5. What can you do to allow winter sun into a room, but keep summer sun out?
Question 6. How can you protect the east and west sides of buildings from sunlight?

Making Low Emmisivity Glass

How is Glass Made? Watch the video below and answer the questions.

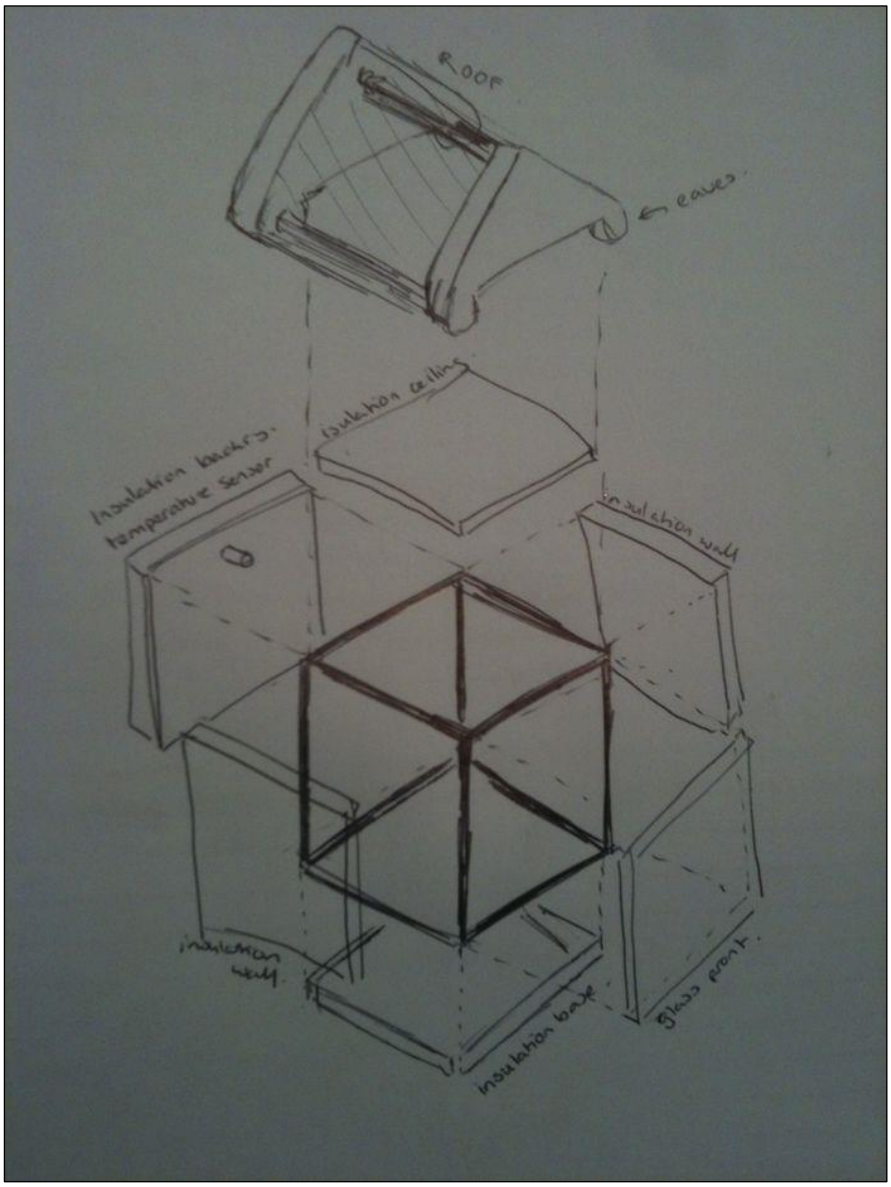
How is Glass Made?
https://youtu.be/mjnhTkdhfBw

Question 7. Name the 4 materials that are used to make glass.
Question 8. To what temperature is the mixture heated to turn it into glass?
Question 9. What does the smart glass (low E) coating do?

Practical Activity 1: Summer and Winter Radiation

Activity: Find how the angle of the sun influences temperature. Use the STELR sustainable test house to model infrared radiation in summer and winter.

Method: Set up the test house as shown in the diagram below. Use a lamp (or two lamps if possible) to represent the sun. In winter, the Sun is low in the sky. Represent this by setting up your lamp at an angle of 30°. In summer the Sun is higher in the sky. Represent this by setting up your lamp at an angle of 60°. Measure how the temperature inside the house changes at these angles. Try turning the roof around and see how your results are affected with and without eaves facing the lamp.



Blueprint of how to set up the STELR Test Home

Question 1. How will you ensure that your experiment is a fair test?	Question 2. How does changing the type of glass affect the temperature in your house?

Results

Table 1 – Temperature inside the house without eaves (lamp at 60° to the horizontal)

Number	Time	Temperature

Table 2 – Temperature inside the house without eaves (lamp at 30° to the horizontal)

Number	Time	Temperature

Question 3. Does the temperature in the house rise faster with the lamp at 30° or 60°? By how much?	Question 4. On which side of your house would you want windows to capture the most energy from the Sun during winter?
Conclusions – The infrared radiation (heat) coming from the Sun plays a very important role in the human life. Question 5. During summer time we need less infrared radiation, as we want our houses cooler. What feature(s) of a house would ensure that? Question 6.During winter we want to capture more energy from the Sun to warm up our houses in a natural way rather than with fossil fuel derived energy. What should the orientation of the house be such that it captures a maximum amount of infrared radiation?	

Practical Activity 2: Materials and Radiation

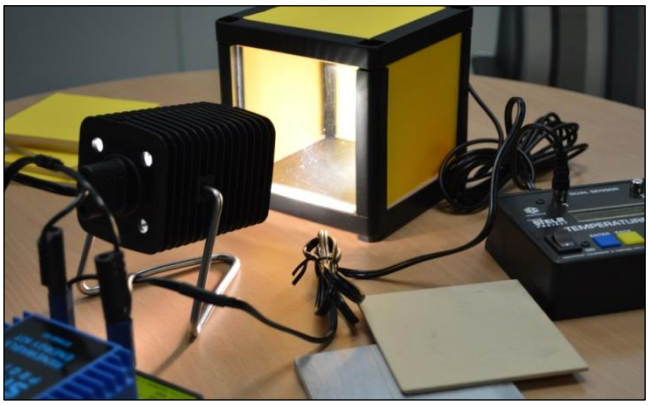
Background information
Light is transmitted through windows. When it hits the surfaces inside the room it is mostly absorbed. Light energy is transformed into thermal energy, increasing the temperature of the room. Some types of glass have been developed to reflect more light to keep the room cooler.

Low E glass
The low emissivity (low E) glass is treated with a coating that affects some wavelengths of radiation but not others. The Sun emits short wave infrared. Long wave infrared is the part of the spectrum that represents the heat generated by our bodies, room heaters and the furnishings in a warm room. The low E glass has a high transmission of short wave infrared energy. However, it also reflects long wave infrared energy.

On cold sunny days, low E glass will let short wave infrared radiation into the room.
It will reflect long wave infrared radiation back into the room. This greatly reduces the amount of heat escaping through the glass. The room is kept warmer and less heat is required to be generated by the heater, which in turn, reduces energy consumption.

VIDEO **STELR Sustainable Housing: Different types of glass and double glazing**
https://youtu.be/n8Bx8vIdYM8

Activity: Discover which kind of windows and surfaces are the best absorbers of radiation.



Use the STELR sustainable test house, power supply, and lamp.

- First wall: Windows (e.g., glass, single glazed, double glazed)
- Second wall: Temperature sensor
- Other walls, floor and ceiling: insulation covered in test materials (e.g., black/white, matt/shiny)

Measure how the temperature in the house changes when the glass wall is illuminated by the lamp. Record your data in the table below.

Results

Material	Temperature

Question 1. How will/did you make sure the comparison between materials was fair?	Question 2. Which material was the best absorber of radiation?
Question 3. Which materials was the poorest absorber of radiation?	Question 4.Using your results, suggest what materials would be best for the following surfaces in a sustainable house. ▪ Thermal wall ▪ Window shades ▪ Lining of insulation material

Using energy sustainably

- Solar Hot Water Systems
- Activity: Solar Hot Water
- Geothermal

Explore how renewable energy technologies provide heat and hot water to make housing more sustainable.

Key Ideas

- In solar water systems, water moves through a tube in the solar panel, absorbing the Sun's energy. The water circulates through the system by convection as warmer water is less dense than cooler water and rises. The heated water is stored in a reservoir.
- Geothermal energy uses heat contained within the Earth.
- The temperature of the first few metres of the Earth's surface remains relatively constant, between 10-16°C, regardless of the season.

Key Questions:

- How can we best design a solar heating system?
- How can we use the Earth to heat and cool our houses?
- How can we use the Earth to heat up the hot water used in our house?
- What other sustainable methods can we use to generate electricity in our homes?

Solar Hot Water Systems

Solar hot water systems are a great way to save energy and contribute to sustainable living. They are systems that use the Sun's energy to heat the hot water instead of using gas or electricity.

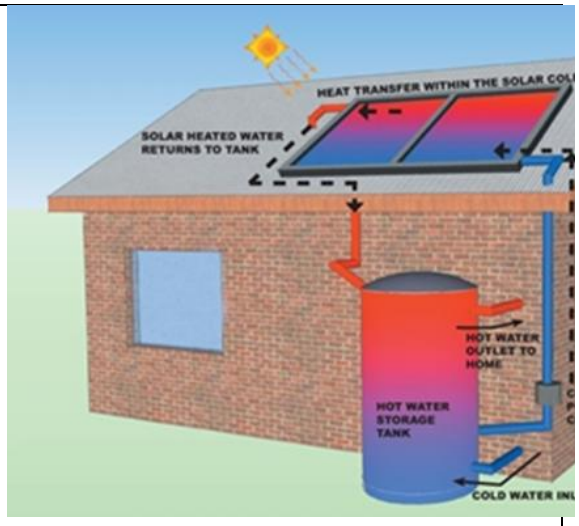
Solar hot water systems use convection as a way to circulate the water.

Watch the video and answer the following questions.

Solar Hot Water Heating
www.youtube.com/watch?v=XCu_WxGTDyE

Question 1. Explain why the pipe that extracts the hot water is placed at the top of the solar hot water panel.

Question 2. As the water exits the panel and flows down into the tank, the cold water is pumped from the tank into the solar hot water roof panel. Explain why.

Question 3. Explain why the pipe that takes hot water inside the house is placed at the top of the water tank rather than at the bottom.	
Question 4. Could the system function without the pump that pushes the cold water up?	

Activity: Solar Hot Water

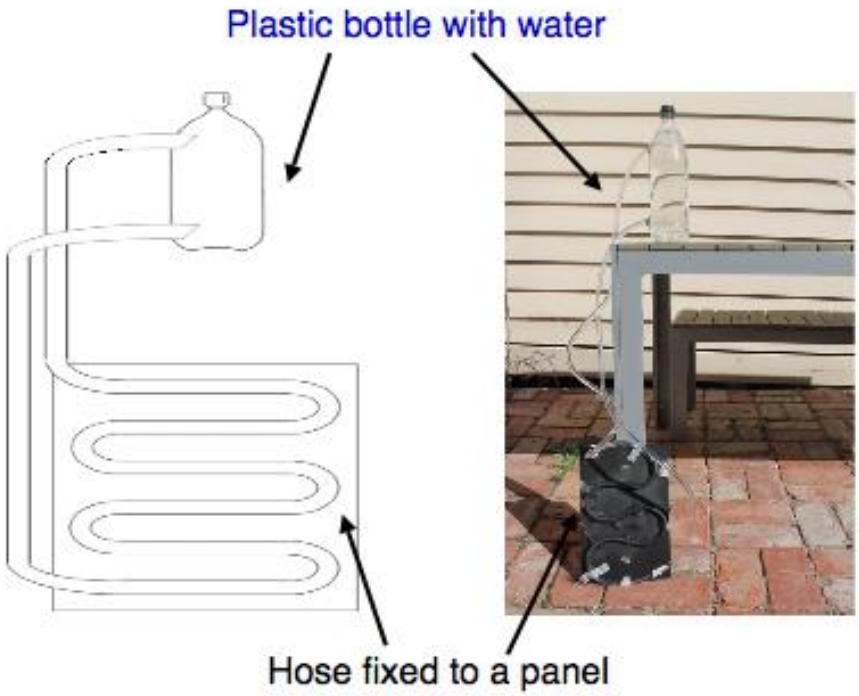
Water moves through a tube in the solar panel, absorbing the Sun's energy. The water circulates through the system by convection as warmer water is less dense than cooler water and rises. The heated water is stored in a reservoir.

- How can you maximise the radiation absorbed from the Sun?
- How can you ensure the water moves through the heating system?

Activity: Design and build a model a solar hot water system that can heat the greatest amount of water.

Materials: (you can use some of all of these in your design)

- plastic hose (various diameters)
- mounting board / cardboard box
- black paint, white paint, silver paint/ foil
- 2 litre transparent plastic bottle (water reservoir)
- hose/pipe connectors
- plasticine / blu-tak
- two thermometers
- sticky tape



Draw a diagram of your design here and check with your teacher before starting construction.

Method:

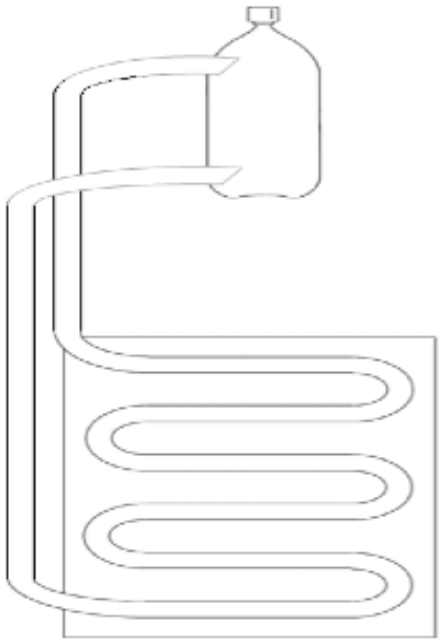
1. Fix the hose on a panel using sticky tape.
2. Place the solar panel low and the bottle high up on a table/chair.
3. Insert the hose from the bottom of the solar panel into the bottom of the bottle.
4. Insert the hose from the top of the solar panel into the top of the bottle.

5. Insert the two thermometers in the water bottle so that you can measure the temperature at the top and bottom of the bottle.
6. Use the heat source to warm up the panel.
7. Record the temperatures of the two thermometers in the table below.

Results: Temperatures of the top and bottom of the heat reservoir (water bottle).

Time (minutes)	Temperature at the top of the bottle (°C)	Temperature at the bottom of the bottle (°C)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Question 1. What do you notice when you analyse the trends in the temperatures recorded in your table? Do they increase or decrease? Which ones are higher? Explain your findings.	Question 2.What do you notice when you drop the food colouring in the bottle?
Question 3. In what direction is the water flowing through the system? ➔Draw blue arrows on the diagram to show the direction the cooler water moves in. ➔Draw red arrows on the diagram to show the direction the warmer water moves in.	



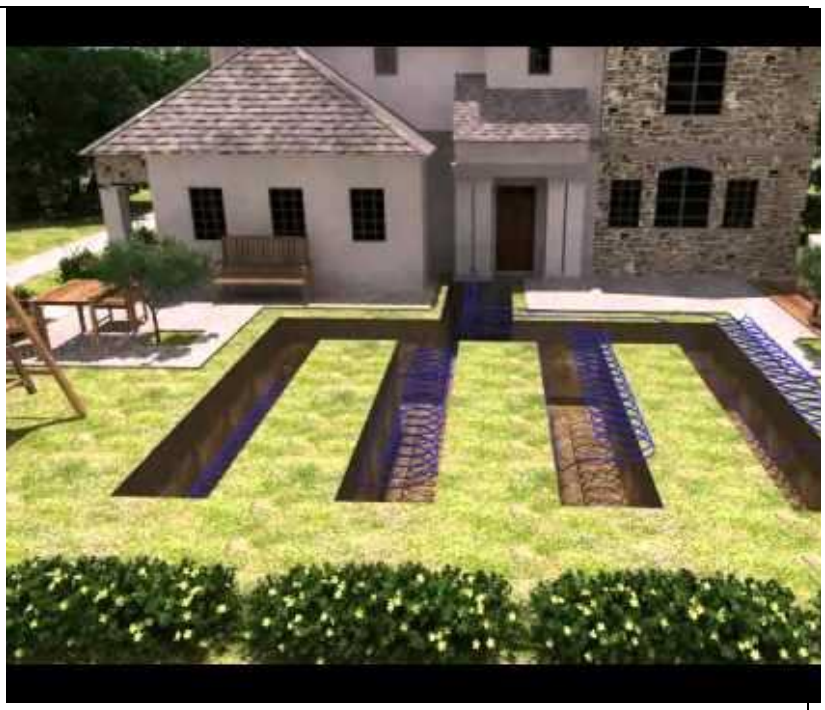
Question 4. What is the source of energy for the water rising in the hose?	Question 5. Would the system work if the panel was on the table and the bottle on the floor? Explain your answer
Question 6. What features did the most successful design have? Explain how each feature worked.	

Geothermal

Geothermal energy is the thermal energy of the Earth.

The Earth can be used both to heat houses in winter and cool them in summer.

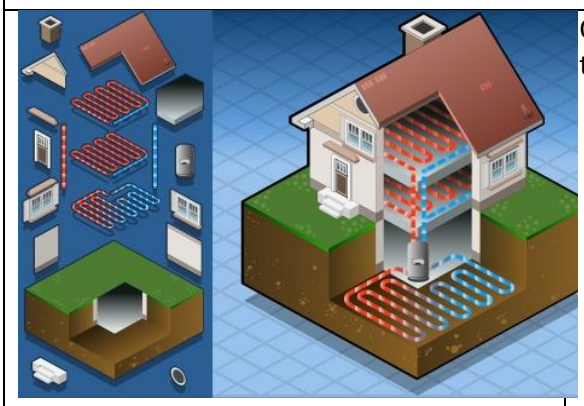
Watch the video below and answer the questions about how geothermal energy can be used in the home.



Geothermal Heating System by TerraSource Geothermal

What is Geothermal Heating?
www.youtube.com/watch?v=h1LMFyCgs14

Question 1. Give two reasons that would motivate somebody to use geothermal technology in order to heat or cool their house.



Parts of a geothermal heating system

Question 2. What is special about the temperature of the ground?

Question 3. How would the environment benefit from this system? Think about geothermal energy at both industrial and residential level.	Question 4. Some energy needs to be put into a geothermal system to make it work. Why do you think this is needed?

Sustainable housing projects

- Passive Design
- Model Sustainable House Challenge
- Passive Design Challenge
- Careers in Sustainable Housing

Learn about key features of passive design apply the principles of science to sustainable housing challenges.

Key Ideas

- Passive design considers takes advantage of the climate and specific design features to maintain a comfortable temperature range in the home.
- A passive system uses only locally available energy sources and natural energy flow paths in and around the house.
- At least 30% of all home energy use is for heating and cooling the home.

Passive Design

A sustainable house is one that uses a number of good design principles, which can save energy, water and money, while creating a more enjoyable and comfortable home for its occupants. One of these design principles is called passive design, which takes advantage of the climate to maintain a comfortable temperature range in the home. Passive design reduces or eliminates the need for extra heating or cooling, which accounts for about 30% (or much more in some climates) of energy use in the average Australian home (McGee, 2013).

A passive system is one that uses only locally available energy sources and utilises natural energy flow paths in and around the house. In other words, no extra equipment (such as fans or pumps) are required to make the system function.

Watch the video below, answer the following questions and build a concept map regarding the concepts you think would be useful to learn in order to understand sustainable housing.

Passive Design Strategies for Heating, Cooling & Ventilation
www.youtube.com/watch?v=650qSb2xI4Q

Question 1. The heating and cooling systems for building use up to how much total energy use: ☐ 10% ☐ 20% ☐ 30% ☐ 40% ☐ 50%	Question 2. Passive design works with the surrounding weather conditions. Which of the following features are adapted to optimize energy use? ☐ Orientation of the building ☐ Size and materials used in windows ☐ Overhangs above the windows ☐ Materials used to construct building ☐ All of the above
Question 3. Start with the concept of “sustainable housing” and build the concept map below using the concepts in the video. Show on your map the key elements that allow specialist to build net zero energy houses.	

Model Sustainable House Challenge

Humans are builders. Even pre-historic peoples lived in homes they built and constructed themselves. In 1910, only 20% of people lived in towns and cities. By 2010 more than 50% of the world's population lived in an urban area. This trend is set to continue.

Activity: Design and build a model house that uses as little energy as possible. You should use any discoveries you made doing the STELR Sustainable Housing investigations.

Figure 1. An example of a model house.

What to do:

Design your house. Record any drawings you do and the reasons behind the different design features in the project space below.

Make a list of materials you will need.

Discuss the design and materials with your teacher.

Build your model, recording in the project space any changes you make to your design and the reasons for them.

Test the model to see how it performs. How will you do this? Record your findings in the project space below. Think about your results. What modifications might make the house even more efficient? Try these out and record the results you achieve.

Watch the video below for some ideas.

Things to consider:

- How many people will live in the house?
- How many rooms will the house have?
- Where is the house located?
- What is the local climate like?
- What building materials will you use?
- How will you cool the house in hot weather?
- How will you warm the house in cold weather?

Passive Solar Design Principles
www.youtube.com/watch?v=YylmeMilok8

Sketch or take a photo or video of your model house and place it here.
Project Space: Produce your final report here, and include some of the following ways of presenting your information: digital images, diagrams, models, flowcharts, maps, tables, graphs, screen capture, video clips, etc.

Passive Design Challenge

Activity: Investigate a Passive Design Strategy

This project involves you working in a group to investigate one passive design strategy that might be used for a sustainable house. As a group you are to select from one the following passive design strategies (each strategy is described briefly below):

House orientation and shading:

- Sealing your house
- Insulation
- Thermal mass
- Glazing
- Skylights

Each group in the class is to choose a different passive design strategy to investigate. Your investigation will involve:

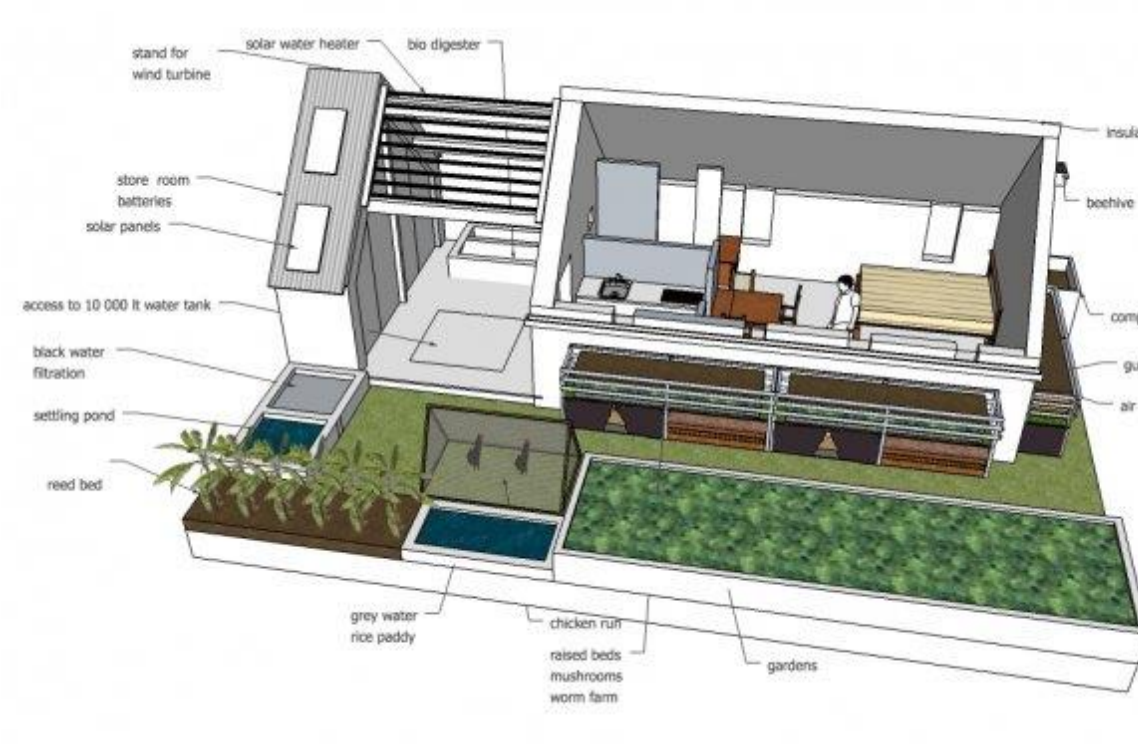
1. The design and construction of a model that the group can test, taking light and/or temperature measurements, to determine effects of changes to the critical variables associated with the passive design. For example, critical variables in insulation are the type and thickness of insulation, or a critical variables in sealing your home are the size and location of air gaps.
2. Constructing an explanation of the key science processes in terms of energy transfer and transformation that is involved in the operation of the passive design strategy. Include a visual representation of the energy flow. For example, energy flow diagram, graph or Sankey diagram.

3. Collecting information from the internet about your chosen passive design strategy for houses. Provide a description about how modern building actually use your chosen passive design and what benefits there are for occupants.
4. Production of a report that includes:
   a) Name of the passive design with a description.
   b) Details of the design of a model of the passive design strategy. Describe those aspects of the model that match what happens in houses and those aspects of the model that do not match. Also provide details of the testing of the model – what are your findings (draw on evidence from your testing data)?
   c) How the passive design strategy reduces heat flow into or out of a house using scientific explanations.
   d) How the passive design is used in current sustainable houses with an explanation of the benefits to sustainable living.
   e) Present your findings to the rest of the class.

Visit Your Home, Australia's Guide to Environmentally Sustainable Homes:

www.yourhome.gov.au/passive-design

Locate the Case Study in your region and describe some of its main features.



Inside a Passive Design House

Careers in Sustainable Housing

There are many career options in sustainable housing

There are many careers to be had in the sustainable housing industry. These jobs range from working as a plumber, carpenter or electrician to designing the buildings to be energy efficient or to researching and inventing new materials or energy efficient appliances.

Investigate the work of someone who works in the sustainable housing industry and write a career profile for that person. You may use the internet, search science magazines, or even contact the person themselves.

You can find sample career profiles of people working in the sustainable housing industry on the STELR website.

Questions to Research

Use the following prompts to guide your research:

- name of the person being profiled
- name of the organisation the person works for
- brief description of what the organisation does
- description of the position the person has in the organisation
- subjects they studied at upper secondary school level
- course(s) taken after leaving secondary school
- duties involved in their job
- why they chose this job
- the most enjoyable aspects of the job
- the challenges they face in the job
- how they think this job will change over the next decade
- salary range of people working in this kind of job

Use the space below to complete your report. Be creative in your use of the widgets and include a variety of content such as images, a video, a written report, and so on. Present the findings of your report to your class before submitting it to your teacher.