TEACHER RESOURCE

STELR

SUSTAINABLE HOUSING

SECOND EDITION

TEACHER RESOURCE


ORICA
COMMISSIONING
Bisley

STELR

SUSTAINABLE HOUSING

TEACHER RESOURCE

SUSTAINABLE HOUSING was written and produced by the STELR team.

https://stelr.org.au/

Science and Technology Education Leveraging Relevance (STELR) is the key school education initiative of the Australia Academy of Technology and Engineering (ATSE). www.atse.org.au

2nd Edition 2020

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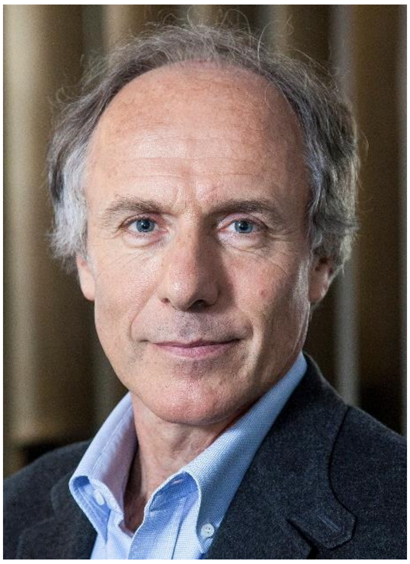
INTRODUCTION



In 2007 I had just been elected a Fellow of ATSE. Bright eyed and bushy tailed, I attended an Education Committee meeting. In front of us was a stack of papers describing 200 or so extracurricular science and technology programs for Australian schools.

The problem? Performance and participation rates in school science were down; too few teachers had science degrees; students saw no job security in science careers; and the science curriculum did not engage many of our brightest students.

The challenge? A contribution by ATSE, perhaps to back some of the existing programs.

With the naivety of a new recruit and Silicon Valley brashness (I'd just left my role as a CEO there) I asked, what's the point? If these activities have not helped so far, we need something different.

'So smarty pants, what would you do?' was the appropriate response. Stuck for an answer – but not one to shy away from a schoolyard dare – I spent the weekend researching.

The key, I discovered, was relevance. Our kids are growing up in a wealthy, comfortable society – complacency is knocking at the door.

Wondering what was on their minds, I found the 2006 Australian Childhood Foundation survey. After personal issues, global warming ranked third – young people are extremely concerned about the future of their planet.

After perusing many reports and long discussions, I proposed a co-curricular activity based on renewable energy – not only because it complemented the science curriculum but also because it is a significant weapon in the fight against global warming.

The program would have two goals: capture the interest of students who might consider science or engineering careers, but also introduce *all* students to real-world science and technology, giving them an appreciation of the power of science.

We agreed that to truly engage students it needed a hands-on component – a kit of equipment for every school. And finally, we knew that teachers are central, so we had to provide professional development.

By 2008 Peter Pentland was in his stride as the program manager. I stayed deeply involved for several more years and then happily withdrew. I am delighted that there are now approximately 780 Australian STELR schools (nearly a quarter of all secondary schools in Australia) and over 40 international STELR schools.

Science teaching needs relevance. And so it was, and so it is, and so it will be.

Dr Alan Finkel AO FAA FTSE

Dr Finkel, President of ATSE 2013–2015, initiated and championed the STELR project.

THE STELR Project

The STELR Project is a set of in-curriculum STEM teaching modules for secondary schools, developed by the Australian Academy of Technology and Engineering (ATSE). ATSE is a learned academy of scientists and engineers who have made notable contributions in their fields.

Note: STELR is an acronym for Science and Technology Education Leveraging Relevance*. STEM refers to science, technology, engineering and mathematics.*

OUR VISION

In Australia, science participation rates in the senior years of secondary school have been flat or declining for some decades. Despite the manifest importance of science and technology in their lives, secondary school students largely do not perceive science or mathematics as relevant to them.

STELR aims to increase senior school science participation by inspiring younger secondary school students with relevant, engaging STEM lessons. It leads them to an appreciation of the role that science, technology and mathematics have in the world, which, it is hoped, will inspire many of them towards careers in these fields. Beyond this, it uses evidence-based scientific inquiry as a means to develop students' scientific literacy and their general capacity for critical thinking.

THE KEY COMPONENTS

In order to meet its vision, STELR builds a number of key elements into its modules, explained below.

Relevance

STELR modules are built around issues that students consider relevant to their lives, giving them a fundamental reason to engage with the lessons. Research shows that global warming and sustainability rank highly in students' concerns, so these provide the underlying theme to most of the modules.

Related to this, student activities within the modules are designed to be *authentic* – incorporating projects, plans, and presentations that mirror what students will be required to do in their careers.

Inquiry-based, equipment-based

A large body of evidence shows that students learn best when they develop their own questions about a topic that engages them, and follow their own path of inquiry to answer those questions. While pure applications of this methodology are beyond the resources of most schools, STELR incorporates inquiry-based learning as a significant component of its modules. The robust, purpose-built equipment used in the modules actively promotes inquiry-based learning. In using the equipment, students engage with it and questions naturally arise. Students can make and test hypotheses in order to answer their questions.

Independent & collaborative

Evidence shows that students learn well in collaboration with one another. They also need to develop their capacity to concentrate and focus in independent work. The STELR modules provide opportunities for both.

Scientific method

The large number of experiments in the modules give students good practice at forming experimental aims and hypotheses, identifying variables, gathering and manipulating results data, and reflecting on their procedures and results. These are all key scientific inquiry skills that are applicable in much broader contexts.

STEM & society

Inquiry-based learning is not defined by traditional subject areas. While STELR modules primarily focus on the underlying science, they are genuinely inter-disciplinary with mathematics, technology and engineering deeply embedded. For example, students gather and manipulate numerical data to see how scientific principles apply in technological contexts.

STELR's focus on real-world engineering and technology leads naturally into questions about the roles of these disciplines within society. The STELR modules include such issues as an integral part of the lessons.

In-curriculum

STELR operates within the curriculum so that all students participate, and teachers do not have to find time for it beside other, curriculum-mandated topics.

The three science curriculum strands of the Australian Curriculum – Science Inquiry Skills, Science as a Human Endeavour and Science Understanding – as well as cross-curriculum elements are interwoven.

The program actively works to support participation by girls and other groups traditionally under-represented in STEM programs.

Teacher support

STELR incorporates contemporary teaching and learning practices and includes teacher professional learning and ongoing teacher support. Teacher's notes provide additional information, advice, and suggestions, and the STELR web site provides additional backup and resources. Answers are provided.

The ATSE and STELR gratefully acknowledge the many teachers, mentors and education and industry experts who have contributed their ideas, advice, sample materials and other resources as the STELR program has evolved. Their contribution has been crucial to the success of the program and is greatly appreciated.

CONTACT

For all inquiries about the STELR Project, including advice or support to run the program, please contact:

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THE SUSTAINABLE HOUSING MODULE

OVERVIEW

Sustainable Housing is a module of work about energy, in particular heat energy and the thermal properties of matter. It makes extensive use of the STELR Sustainable Housing equipment to provide a relevant context for students to study how heat is transferred through convection, conduction and radiation. As such it is designed primarily for Year 9 (Australia) students.

The module integrates mathematics, technology and engineering, and societal issues. It takes an inquiry-led approach and offers many opportunities for discussion and group work. It includes practical demonstrations, a research project, and career profiles. There are many experiments, with varying degrees of guidance. In these, students reflect on the scientific methodologies they use as well as endeavouring to get results that demonstrate the scientific principles they are learning. There are extensive notes for teachers.

The course begins with an introduction to energy and sustainability. The students then revise their knowledge of energy types and energy transfers and transformation in section 2. Section 3 focusses into heat energy with sub-section on heat transfers by radiation, conduction and convection. The activities in this section all use the STELR Sustainable Housing equipment and use the context to sustainable house design to reinforce the concepts. Section four focuses on passive design principal relating to solar radiation and brings in revision of the seasons and how they depend on geographic location. The course culminates with a student-designed, open-ended inquiry, followed by a *STEM at Work* exercise looking into careers in sustainable building

The module is a complete unit of work, building up and reinforcing concepts as it progresses. As such, it can be used from start to finish, however teachers can easily extract sections and adapt these for their classes, including for other year levels.

Even students familiar with the concepts taught in the module are likely to benefit by carrying out the demonstrations and experiments it includes, providing hands-on experience that will reinforce the concepts.

MODULE STRUCTURE

The *Sustainable Housing* module has six units: *Energy and Sustainability*, *Energy*, *Transferring Heat Energy*, *Sustainable Design*, *Open Inquiry* and STEM at Work

Within these units, individual sections are identified as *lessons*, *demos*, *activities*, *projects* or *tests*. Most can be completed within one class period, but you should always preview and plan to confirm this.

- *Lessons* often include group discussions and interactive activities, but focus primarily on the teaching of key concepts.
- *Demos* are informal hands-on demonstrations, used to stimulate interest and raise questions.

- *Activities* are experiments. These vary in their degree of guidance.
- *Activity/Lessons* integrate hands-on activities with teaching of content.
- *Project* – there is one project, to research and present on a specific energy resource. It is a good idea to give this to students early in the module to give them time to work on it.

MODULE RESOURCES

This STELR Sustainable Housing Teacher Resource is designed to be used in conjunction with the STELR Sustainable Housing Student Book and the STELR Sustainable Housing class sets of equipment. There is information about all the Module resources on the STELR website where all the written resources and videos van be downloaded.

STELR
https://stelr.org.au/stelr-modules/

STELR Sustainable Housing Teacher Resource

This teacher resource is available online.

STELR Sustainable Housing
https://stelr.org.au/stelr-modules/sustainable-housing/#curriculum-materials

It contains all the lesson content included in the student book as well as notes and suggestions for teachers. It has sample answers to questions.

STELR Sustainable Housing Student Book

STELR Sustainable Housing Student Books are available on-line at the STELR website in both Word and PDF formats. The online resources can be modified to suit the needs of your students. The files can be shared on internal school hard drives to provide access to teachers and/or students within the school.

STELR Sustainable Housing USB

When you purchase a class set of STELR Sustainable Housing equipment, you will be sent a STELR Sustainable Housing USB. It contains the following:

- copies of the teacher and student books
- STELR background information
- fact files
- additional activities
- case studies
- PowerPoint presentations
- additional resources including Sustainable Housing videos and Women in STEM videos

It also contains an important **LOGGER** file.
This file contains a program that allows data to be downloaded from the STELR temperature logger as Excel spreadsheets. Students can use these spreadsheets to manipulate to analyse their data. Instructions on how to download the data can be found in Appendix 3.

We strongly recommend that the contents of the USB are uploaded to the school network to provide a back-up copy in case the USB is misplaced. Additional Sustainable Housing USBs can be ordered from using a form on the STELR website here:

STELR Sustainable Housing
https://stelr.org.au/stelr-modules/sustainable-housing/#curriculum-materials

STELR Sustainable Housing Equipment

It is assumed that you are using this book because you have already purchased STELR Sustainable Housing equipment for use in your school. To purchase additional kits or spare parts please download an order form from the STELR website here:

STELR Sustainable Housing
https://stelr.org.au/stelr-modules/sustainable-housing/#equipment-kits

You can also see videos and written instructions on how to use the equipment on the STELR website here:

How to use STELR Sustainable Housing Equipment
https://stelr.org.au/stelr-modules/sustainable-housing/#how-to-use

Sustainable Housing Temperature Logger

The temperature logger has a digital display as well as recording the temperatures. In all the activities in this resource, students are asked to record the temperatures and then draw their own graphs. As an alternative, they can ‘set and forget’, allowing the data to be recorded and stored on the device. The data can be downloaded into an Excel spreadsheet and graphs created in Excel.

There are five memories on the device and each can take readings from one or two sensors at a time. The logger has the ability to store 1200 data points, so you can choose to collect data:

- Every 1 second for 20 minutes
- Every 2 seconds for 40 minutes
- Every 15 seconds for 5 hours
- Every 60 seconds for 20 hours

Detailed instruction in how to use the STELR Temperature Logger are printed in Appendix 3 on page 116. They are also on the STELR Sustainable Housing USB.

Investigating Science Depth Study

An additional resource has been developed to accompany the STELR Sustainable Housing Equipment. It was written specifically to support the New South Wales Stage 6 (Years 11 and 12) Investigating Science course.

Depth studies are designed to provide opportunities for students to:

- consolidate their learning
- develop competence and confidence in relation to their knowledge and skills
- foster creativity by allowing students to apply their knowledge and skills to new situations.

A depth study is any type of investigation/activity that a student completes individually or collaboratively that allows the further development of one or more concepts found within or inspired by the syllabus. It may be one investigation/activity or a series of investigations/activities.

Videos

A number of videos are included in the lessons within the module. They are indicated by this symbol.

The videos referred to in this module can be accessed in a number of ways.

- They have been downloaded to the STELR Sustainable Housing USB
- All the videos referred to in this module are available on the STELR YouTube Channel here: https://www.youtube.com/c/STELRProject
- Those that were produced by the STELR team specifically for the STELR Modules have also been uploaded to the STELR page at Australia's Science Channel here: https://australiascience.tv/department/stelr/
this provides alternative way to access the videos for schools who prefer not to use or block access to YouTube.

Please note that not all of the suggested videos are on Australia's Science Channel and can only be accessed through YouTube. You will see that some of the video symbols have two links. If only one link is supplied, this means it is not available through Australia's Science Channel.

STELR Website

Scroll to the bottom of the STELR Sustainable Housing page to find additional resources for this module. They include:

Sustainable Housing Curriculum links
https://stelr.org.au/stelr-modules/sustainable-housing/sustainable-housing-curriculum-links/

Sustainable Housing - additional Resources
https://stelr.org.au/additional-info/sustainable-housing-additional-resources/

Investigating Science Depth Study
https://stelr.org.au/stelr-modules/investigating-science-depth-study/

Climate Change
https://stelr.org.au/additional-info/climate-change/

Career Profiles – Sustainable Housing
https://stelr.org.au/stem-at-work/career-profiles-sustainable-housing/

You can also check out the STELR NEWS and EVENTS buttons at the top of the STELR web pages.

Other web sites

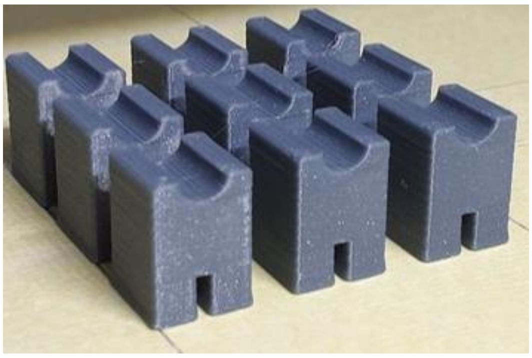
Some activities in the student book rely on real time data (such as wind maps or solar radiation maps) provided by external websites. They are indicated by this symbol with the URL.

External websites are checked regularly to ensure they are active and relevant.

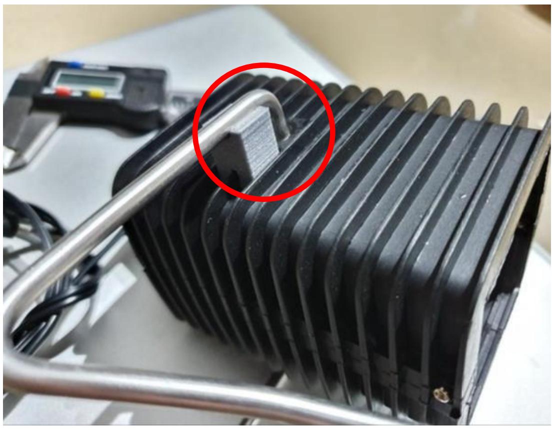
Additional resources

3D printed lamp spacer

The STELR lamp is on a stand that allows it to be angled up or down. One of the variables that is more difficult to control in the experiments is the angle of the lamp. A spacer has been designed by our colleagues and Casey Tech School in Berwick. It can be printed using a 3D printer and slipped between the lamp and the stand to hold it in position. The file for printing the spacer is found on the STELR website and the Sustainable Housing USB.



3D printed spacers



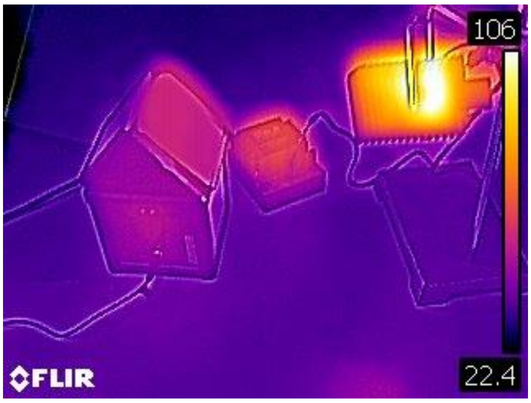
Spacer attached to lamp and stand

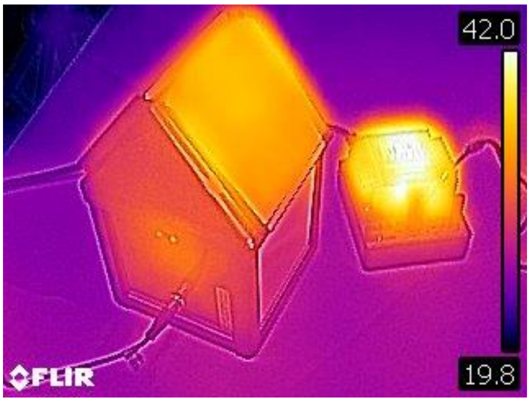
Infrared camera

You may have an infrared camera at school or you may consider purchasing one. The camera can be used to photograph the STEL Sustainable Housing experiments. Good quality infrared cameras allow you to zoom right in on the image and determine the temperature of each pixel.

Beware of downloadable smartphone apps that say they do the same thing.

The pictures below were taken with a Flir brand camera.





CURRICULUM COVERAGE

Sustainable Housing covers the three strands of the science component of the Australian Curriculum: science understanding (SU), science as a human endeavour (SHE), and science inquiry skills (SIS). The inquiry strand is strongly supported by equipment kits and experiments.

This summary describes coverage of the Australian Curriculum. In Australia, most schools follow either the Australian Curriculum or a state curriculum which, in most cases, overlaps significantly with the Australian Curriculum. Teachers from other countries are likely to find the following information useful in identifying elements in their own curricula covered by the module.

You can also see the Curriculum links on the STELR Website:

STELR Sustainable Housing
https://stelr.org.au/stelr-modules/sustainable-housing/sustainable-housing-curriculum-links/

The module is targeted primarily at Year 9 students but includes content covering curriculum elements from **Years 6 to 10**. Teachers may find parts of the module suitable for any classes within this range. Some teachers also find these activities useful as a basis for open-ended investigations in **senior Physics** classes.

As mentioned earlier, an additional resource (**Investigating Science Depth Study**) has been developed to support the New South Wales Stage 6 (Years 11 and 12) Investigating Science course.

Further details of curriculum coverage within each of the strands is provided below.

Science Understanding

Chemical Sciences

ACSSU177 All matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms

Physical Sciences

ACSSU182 Energy transfer through different mediums can be explained using wave and particle models

- exploring how and why the movement of energy varies according to the medium through which it is transferred
- investigating the transfer of heat in terms of convection, conduction and radiation, and identifying situations in which each occurs
- understanding the processes underlying convection and conduction in terms of the particle model

ACSSU190 Energy conservation in a system can be explained by describing energy transfers and transformations

- recognising that in energy transfer and transformation, a variety of processes can occur, so that the usable energy is reduced and the system is not 100% efficient
- using models to describe how energy is transferred and transformed within systems

Science Inquiry Skills

All of the Australian Curriculum science inquiry skills for Years 7 to 10 are covered to some degree within the module, in the nine formal experiments (based on given inquiry questions), one open experiment, and numerous demonstrations and opportunities for informal experimentation. The formal experiments are presented with different degrees of guidance – some model good scientific practice while others give students freedom to make their own decisions about how to run their investigations and present the results. Teachers should assess the experiments against their students' abilities and modify accordingly if they think students need more or less guidance. In particular, teachers delivering the module via the online platform can modify experiment directions as they see fit.

Students do all experiments collaboratively.

Questioning and Predicting

ACSIS 164/198 Formulate questions or hypotheses that can be investigated scientifically

- using internet research to identify problems that can be investigated
- evaluating information from secondary sources as part of the research process
- revising and refining research questions to target specific information and data collection or finding a solution to the specific problem identified
- developing ideas from students own or others' investigations and experiences to investigate further

Planning and Conducting

ACSIS 165/199 Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods

- explaining the choice of variables to be controlled, changed and measured in an investigation
- identifying the potential hazards of chemicals or biological materials used in experimental investigations
- using modelling and simulations, including using digital technology to investigate situations and events
- combining research using primary and secondary sources with students' own experimental investigation
- considering how investigation methods and equipment may influence the reliability of collected data

ACSIS 166/200 Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately

Processing and analysing data and Information

ACSIS 169/203 Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies

- using spreadsheets to present data in tables and graphical forms and to carry out mathematical analyses on data
- designing and constructing appropriate graphs to represent data and analysing graphs for trends and patterns

ACSIS 170/204 Use knowledge of scientific concepts to draw conclusions that are consistent with evidence

- comparing conclusions with earlier predictions and reviewing scientific understanding where appropriate
- suggesting more than one possible explanation of the data presented

Evaluating

ACSIS 171/205 Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data

- identifying alternative explanations that are also consistent with the evidence
- identifying gaps or weaknesses in conclusions (their own or those of others)

Communicating

ACSIS 174/208 Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

- presenting results and ideas using formal experimental reports, oral presentations, slide shows, poster presentations and contributing to group discussions
- using secondary sources as well as students' own findings to help explain a scientific concept
- using the internet to facilitate collaboration in joint projects and discussions

Science as a Human Endeavour

In *Sustainable Housing*, fundamental energy and heat transfer themes are placed within the context of global warming and sustainability. In this respect, the module focuses on science and technology as they impact an issue with significant societal consequences. Some specific links the module has to the curriculum are noted below. Teachers may choose to build on these connections.

ACSHE160 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

- considering the impacts of human activity on an ecosystem from a range of different perspectives
- recognising aspects of science, engineering and technology within careers such as medicine, medical technology, telecommunications, biomechanical engineering, pharmacy and physiology

ACSHE191 Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community

- considering the role of science in identifying and explaining the causes of climate change

ACSHE194 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

- considering the scientific knowledge used in discussions relating to climate change
- evaluating claims relating to environmental footprints

- recognising that scientific developments in areas such as sustainable transport and low-emissions electrical generation require people working in a range of fields of science, engineering and technology

1 ENERGY AND SUSTAINABILITY

Energy and Sustainability creates context and relevance by looking at energy use and how sustainable use of energy can help to reduce the effects of climate change.

1.1 *Your ideas about energy* is a pre-test which will provide an overview of student knowledge of all the content covered in the course.

In lesson 1.2, students are introduced to the concept of sustainable housing by thinking about energy use at home and how this can be reduced.

In lesson 3, students view a video about the construction of the Illawarra Flame House (pictured above) is used to introduce them to the basic design principals used in this award-winning home.

Lesson 1.4 introduces the concept of a net-zero home and challenges students to think about how they can live more sustainably.

This unit introduces Climate Change and what you can do to reduce your impact on the environment. Building houses sustainably means designing them so that they stay warm in winter and cool in summer and minimising the amount of energy used for heating and cooling. This reduces the amount of carbon dioxide going into the atmosphere and saves money. It also means choosing sustainably produced materials to build the house.

1.1 LESSON: YOUR IDEAS ABOUT ENERGY

This test is designed to give you an indication of your students' current understanding. However, it is very difficult to get an accurate picture of a class's understandings with a short multiple choice test. To improve the quality of information that you get from it:

- Encourage students to mark 'I'm not sure' if that is how they feel...you don't want them to guess.
- You may want to choose some questions for brief class discussion – this should provide more depth of information about students' grasp of the concepts.

KEY QUESTIONS

- What is climate change?
- How is energy transferred and transformed?
- How is heat transferred in different ways?

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

Choose the best answer to the following questions.

Question 1

Weather and climate are the same thing?

- ☐ true
- ☑ false
- ☐ I don't understand the question
- ☐ not sure

Question 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.

Question 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.

Question 4

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

Question 5

This type of radiation from the sun is related to climate change:

☐ Infrared

☑ Ultra violet

☐ I don't understand the question

☐ not sure

Question 6

Energy sources that can be replenished by nature in a relatively short period of time are called renewable energy forms.

- [x] true
- [ ] false
- [ ] I don’t understand the question
- [ ] not sure

Question 7

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.
- [x] Energy is transferred in both situations.
- [ ] Energy is NOT transferred in either situation.
- [ ] I don’t understand the question or I am not sure.

Question 8

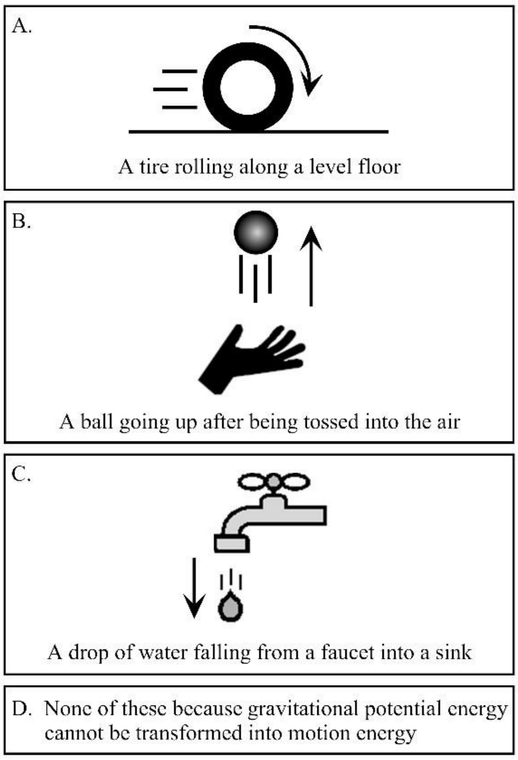
Which of the diagrams to the right is an example of the transformation of gravitational potential energy into motion energy (kinetic energy)?

☐ A

☐ B

☑ C

☐ D



Question 9

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

Question 10

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.

Question 11

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.

Question 12

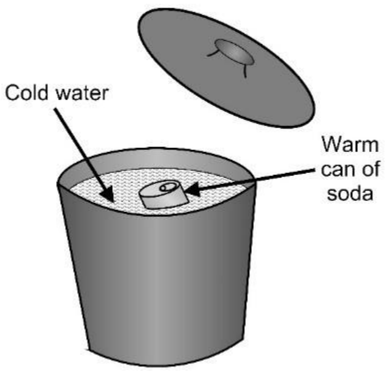
Consider a light bulb and an ice cream cone.

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.

Question 13

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.

Question 14

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.

Question 15

Garments that are made of wool keep you warm in winter as the material contains pockets of air. Explain how a woollen 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.

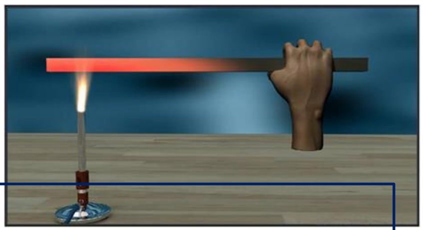
Answers will vary.

The air pockets in the wool fibres act as an insulator. Heat cannot easily be transferred (by conduction) from your hands to the snowball.

Question 16

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.



Answers will vary.

Metals are generally good conductors of heat.

As the metal heats up the atoms gain kinetic energy start to vibrate more vigorously. The vibrations are easily passed to nearby atoms because they are close together. Metals also contain free electrons that can move easily between the atoms, which speeds up the process. The heat is transferred relatively quickly along the rod.

Question 17

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.

Answers will vary.

The energy will firstly interact with the atmosphere, heating up the air and leading to weather events such as winds, air pressure changes, evaporation and precipitation.

Light energy is used by plants to photosynthesise.

As light energy passes though the atmosphere some of it is changed into heat energy. Heat energy warms us and our surroundings.

1.2 LESSON: WHAT IS SUSTAINABLE HOUSING?

In this lesson students are introduced to the concept of sustainable housing by thinking about energy use at home and how this can be reduced.

The lesson begins with a mind map about energy use at home. They should think about the source of energy (gas, electricity, solid fuel) as well as how and when it is used. Encourage students to think about where energy might be wasted and ways of reducing this waste. Consider the use of solar panels and battery storage if relevant.

The questions following the mind map exercise are based on the Australian government's Energy Website where students are asked to find out some general data about energy use in Australian households. Once they have answered these questions, teachers may wish to revisit the mind maps and further discuss energy use at home.

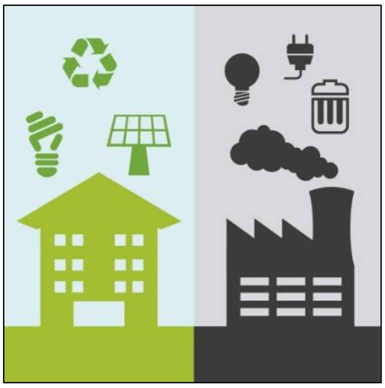
KEY QUESTION

- 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 mind map on ENERGY to explore how you use and waste energy around your own home.

Key words and ideas may include:

Gas

Electricity

Heating

Cooling

Cooking

Lighting
Summer
Winter
Entertainment
TV
Computers
Standby mode
Games
Charging
Music
Fire
Insulation
Hot water
Shutting doors
Drafts
Solar panels
Window coverings

Now, go to this website to find answers to the following questions:

Australian Government Energy Website page Energy Basics for householders

https://www.energy.gov.au/households/energy-basics-householders

Question 2

About what percentage of home energy is used for heating and cooling?

40%

Question 3

What is the recommended temperature range for:

Heating in winter? _____18 to 20 degrees

Cooling in summer? _____25 to 27 degrees

Question 4

What percentage of energy can be saved by sealing up the drafts in your house?

Up to 25%

Question 5

Give two other things that you can do to reduce heating and/or cooling costs.

Well fitted curtains

A transparent film on windows

Open windows in the summer

Using a fan instead of an air conditioner

1.3 CASE STUDY: ILLAWARRA FLAME HOUSE

This case study is based around The Illawarra Flame House videos which are provided on the STELR Sustainable Housing USB as well as on the STELR website and the STELR YouTube Channel (see below). The students who designed this house took it to China for the Solar Decathlon competition so they had to orientate it so that the solar panels were facing to the south in the northern hemisphere.
The house is named after the Illawarra Flame Tree which is common in the Wollongong area.

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 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?

☐ About 3 %

☐ About 5 %

☑ About 10 %

☐ About 13 %

☐ Over 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.

The thermal wall is made from a material that absorbs the Sun's energy as it falls onto it. The wall then releases the energy at night to keep the house warm. The windows and walls are placed in such a way, that when the Sun is higher in the sky in summer, the sunlight does not fall on the wall.

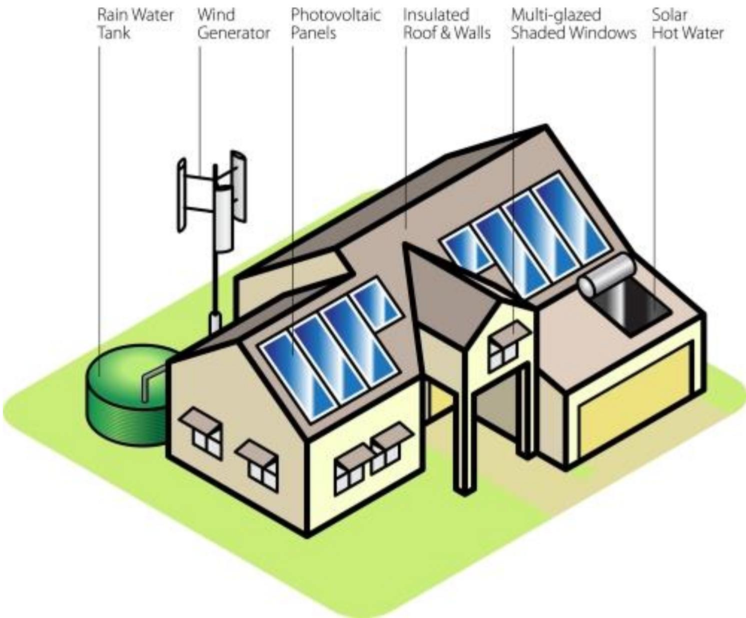
1.4 LESSON: NET-ZERO HOME

Students should use the picture below as well as the information they gained from watching the Illawarra Flame House videos in the previous case study to answer these questions. For questions 5 and 6, they can also draw on their general knowledge.

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.

It has solar panels (photovoltaic panels) and a wind generator

Question 2

Explain how the house reducing the amount of lost energy.

Insulated roofs and walls and multi-glazed windows

Question 3

What features help this house stay cool in summer?

Insulated roofs and walls

Multi-glazed and shaded windows

Question 4

Explain how the water for showers, baths or for washing dishes and clothes is heated.

Using a solar hot water device on the roof

Question 5

Water is a precious resource. How can we reduce the amount of water we use?

Answers will vary and could include the following:

Have shorter showers
Use waste water from washing to water the garden
Collect and use rainwater
Only use a dishwasher when it is full

Question 6

Explain how we could minimise the impact on the environment when building the house

Using recycled materials such as timber and crushed concrete.

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 usage
- The waste generated by households

Question 7

Discuss with a partner what things you can do to live more sustainably in your home. Record your ideas below.

Answers will vary and may include:

Have shorter showers
Put on more clothes instead of turning up the heating
Turn off lights and appliances when not in use
Use public transport instead of a car
Cycle or walk instead of going by bus or car
Buy fewer new things, shop at second hand stores
Upcycle old clothes and furniture
Recycle waste

2 ENERGY

We need energy to hold up a phone, and energy to charge it...what have these things got in common?

In this section students find out about different types of energy and how energy can be transferred and transformed.

2.1 Lesson: What is Energy? Building from students' current understanding, the first lesson looks at definitions of energy in the context of there being many different types. All of these involve motion or the potential for motion. The joule is introduced as the unit of energy.

2.2 Lesson: Transformations and Transfers Energy transformations and transfers are explained and energy transformation word formulas, i.e. [energy type 1] → [energy type 2], introduced. A simple overview of the transformations from kinetic to electrical energy in turbines and generators is given.

2.3 Activity: Transformations and Transfers This activity introduces students to the STELR sustainable housing equipment and explores how the Sun's energy is transferred and transformed as the house heats up.

It is hard to pin down exactly what energy is.

In this section, you use the STELR equipment to learn more about energy.

2.1 LESSON: WHAT IS ENERGY?

2.1 Lesson: What is Energy? aims to give a general understanding of energy and the fact that there are many different types, but all measured using the same unit. It does not attempt comprehensive coverage of energy types, but introduces a lot of examples.

Outline

1. Students are asked to find examples of energy in some pictures and then attempt a definition.
2. Two videos provide definitions and discuss different types of energy.
3. Energy is possessed either as movement (kinetic) or the potential to create movement.

Types of energy

Classification of energy types is vague, with overlapping categories, e.g. mechanical energy is simply kinetic energy in the case of machinery.
The issue is made more difficult because all forms of energy fall into one of two categories: kinetic or potential. This means that *kinetic* can be used to refer to a type of energy – the motion of objects – or an entire category, including heat, sound and electromagnetism. Further, both heat and sound are strictly just kinetic energy in the first sense – the motion of *small* objects (molecules).
Since these problems arise from accepted usage we have not attempted to solve them. Neither have we attempted to explain the difficulties to students. Rather, we have tried to be clear in every instance what our meaning is. Nevertheless*, it would be good to make the point to students that often more than one term can be correctly used to describe a type of energy*.
As a reference for you, the types of energy mentioned in these lessons are:
Kinetic types:

- *kinetic:* anything moving, but typically medium to large-sized objects
- *mechanical:* moving machinery
- *sound:* wavelike movement of particles, especially in a gas or liquid
- *heat (thermal):* random molecular motion
- *electromagnetic radiation: waves of alternating electric and magnetic fields, in a great range of wavelengths*
- *heat (infra-red radiation):* infra-red electromagnetic radiation
- *light:* electromagnetic radiation visible to the human eye, though sometimes used to mean all wavelengths

Potential types:

- *chemical:* energy in the bonds between atoms within molecules and lattices
- *nuclear:* energy inside atoms
- *gravitational:* energy in the attraction of matter to matter
- *electrical:* energy of separated electrically charged particles (can be transferred through an electric circuit)

- *elastic:* stretched or compressed objects, e.g. rubber or springs, also compressed gas

Common misconceptions

We don't explicitly address misconceptions in the lesson – depending on your students you may want to do this yourself.

- students often confuse energy and force – it may be good to remind them that a force is a push, pull or twist. Energy is related to forces, but not the same thing.
  a) suggestion: to make the energy-force distinction, use the diagram describing the joule later in this lesson – you have to apply a force to the tomato to raise it up against the force of gravity. It takes energy to move the tomato against gravity.
  b) a strict definition distinguishing energy from force refers to work: work is done when a force moves an object over a distance, which always involves energy being transformed from one form to another.
- students sometimes confuse energy with motion – moving things have kinetic energy, but not all forms of energy involve motion, e.g. all the potential forms of energy
- students often talk about power and energy as the same thing – power is the rate of energy transformation, so this is strictly incorrect. However, the terms are frequently used synonymously in common usage, so it's not unreasonable for students to conflate the two. You can tell students what power is, but at this stage of the unit they only need to understand that they are different.

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?

Question 1

All of the pictures below have something to do with energy – often more than one type. With a partner, see how many types you can identify. Put your answers in the table on the next page.

Note: Do not worry if you are not sure – this is to see what you know now, and you will get a chance to come back for another attempt later.

	Energy type 1	Energy type 2	Energy type 3
Skier	potential	kinetic	chemical
Wind turbines	kinetic	electrical	
Sun	chemical	light	heat
Dog on trampoline	kinetic	potential	chemical
Petrol pump	chemical	kinetic	
Energy drink	chemical		
Radio	sound	chemical	electrical
Cow	chemical	heat	
High jumper	kinetic	potential	
Power pylons	electrical		
Fire	chemical	heat	light

Question 2

Now, after discussing with your partner, have a go at saying what you think energy is.

[The question is difficult and students will offer a range of responses…the important thing is that they make an attempt.]

The text below provides a very quick account of energy as movement or potential for movement, and lists some examples of each. It moves past a great deal of content with very little explanation. Students may or may not have learned about the individual energy types (e.g. heat as movement of atoms, in particle theory), but the main point is simply to give them a working list of energy types. You may choose to offer more explanation.

Energy is about **moving** – either something *actually moving* or with the *potential* to move. Here are some examples.

Actually moving

- Anything that moves has **kinetic energy**.
- If it's a machine that's moving the kinetic energy is often called **mechanical energy**.
- **Light**, and all electromagnetic waves, move...they're a form of kinetic energy.
- **Heat** is the movement of the atoms that something is made up of, so it's a type of kinetic energy.
- **Sound** is the movement of atoms or molecules – also a type of kinetic energy.

Potentially moving

- Something above the ground has the potential to fall – that is, move – so it has **gravitational potential energy**.
- Anything that burns or is eaten as food contains **chemical potential energy**.
- **Electricity** can be used to make light, heat and sound, and to make things move – it is a form of potential energy.
- A spring, compressed or extended, will move when it's let go – it has **elastic potential energy**.

Question 3

When something is moving it has: *(choose the best answer)*

☐ potential energy

☐ electrical energy

☐ chemical energy

☐ mechanical energy

☑ kinetic energy

Question 4

Which of the following are types of potential energy? *(select one or more)*

☑ elastic energy

☑ gravitational energy

☐ sound energy

☐ kinetic energy

☐ chemical energy

Question 5

We classify heat as a type of _____________ energy because _____________.
(choose the best answer)

☐ kinetic; it can move from one object to another

☑ kinetic; the atoms in hot things move faster than in cold things

☐ potential; we store it in objects when they get hotter and hotter

☐ potential; though it doesn't involve movement itself, it can make things move, like a hot air balloon

Question 6

Think of your own examples and add them to the table in the right hand column.

Answers will vary, some examples provided.

Energy Type	Definition	Example	Your own Example
Kinetic Energy	Movement or motion	Any moving object like a car	*Any other moving object*
Elastic Potential Energy	The energy contained in a stretched or compressed elastic object	Springs	*Trampoline, wind-up toy, stretched rubber band, wind up clock*
Gravitational Potential Energy	Gravitational potential energy is the energy stored in an object as the	Any raised object like a boulder on the top of a hill.	*Skateboarder or skier at the tip of a jump, person at the*

	result of its vertical position or height, due to the Earth's gravitational field.		top of a ladder, pencil on the table
Chemical Potential Energy	Energy stored in the bonds of molecules	Fossil fuels	Any food, any other fuel such as wood or paper, batteries
Heat	Movement of atoms or molecules in a substance	Heat from fire	Heat from a heater, stove, electric kettle, hair dryer, hot water service
Sound	The vibrations of atoms or molecules	Someone shouting	Radio, TV, computer, birds singing, vehicles such as cars and planes
Light	Energy found in photons	Visible light from the sun	Light globes, computer screens, TV, candle, fire
Electrical Energy	Energy possessed by electrons in a flow of electric charge	The energy in the power lines as they leave the power station	Energy in the electrical wiring of your home
Nuclear Potential Energy	Energy stored in the way that the particles in the nucleus are held together	A deposit of uranium ore	Energy from the Sun

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 7

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 Question 6 has been represented in its own scene.

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

WRAP-UP

How have you gone in this lesson? These questions will check if you have understood the main points.

Question 8

Which is the best description of energy?

- [x] what moving things have, and what can make them move
- [ ] how active you feel
- [ ] what anything made of atoms has
- [ ] how fast something is going, or how hot it is

Question 9

All the different types of energy:

- [ ] are in or come from living things
- [ ] are basically different – we call them all energy but in physics they're different things
- [ ] always involve objects that are moving, or have moving parts
- [x] involve either things moving, or the potential to make things move

2.2 LESSON: TRANSFORMATIONS AND TRANSFERS

This lesson introduces the terms:

- Energy transformation in the context of household appliances.
- Transformations are represented with word formulas: [energy type 1] → [energy type 2]
- Energy transfer is explained with examples and students asked to find further examples.

KEY QUESTIONS

- What is energy transformation and how can we represent it?
- What is energy transfer?

ENERGY TRANSFORMATION

Fossil fuels such as coal, oil and natural gas contain chemical energy. When we use them, it's not chemical energy that we want. We want:

- kinetic energy, for example using petrol to power cars;
- heat energy, for example in a gas home-heating system;
- electrical energy, for example to run an air conditioner in your home.

We start with energy in one form, and then change or **transform** it into another.

We can represent energy transformations with word formulas, using arrows. For example, for a car using petrol the transformation is:

chemical energy → kinetic energy

Burning gas for heat it's:

chemical energy → heat energy

and in a coal-fired power station it's:

chemical energy → electrical energy

Question 1

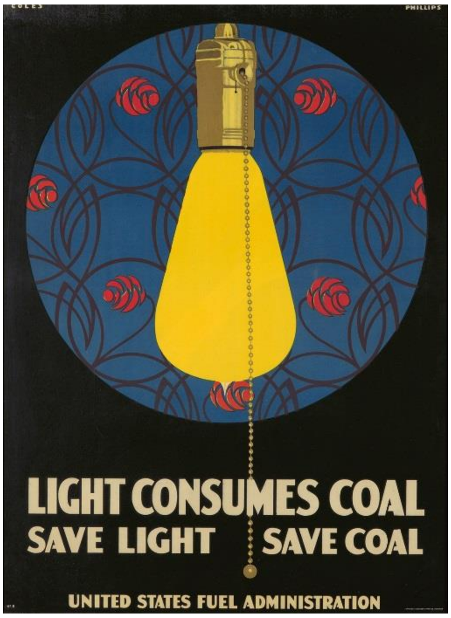
There are many appliances that you use at home that transform one type of energy into other types of energy. Write down the starting energy for each of these appliances and then then the main (useful) energy that it is transformed into. Sometimes there are other types of energy produced by an appliance that is not so useful.

For example, a hair dryer transforms electrical energy into heat (hot air) and movement (a fan to blow the air) which are both useful. It also produces sound energy which is not useful for drying your hair.

Complete the following table to show the energy transfers in the following appliances. (The first one has been completed for you.)

	Starting energy	Useful energy	Not so useful energy
Hair Dryer	Electrical	Heat and movement (kinetic)	Sound
Gas gook top	Chemical	Heat	Light
Phone	Electrical	Sound and light	Heat
Ceiling fan	Electrical	Movement/kinetic	Sound
Microwave oven	Electrical	Movement/kinetic and heat	Sound
Television	Electrical	Sound and light	Heat
Radio	Electrical	Sound	Heat
Light globe	Electrical	Light	Heat
Central heating system	Electrical	Heat and movement/kinetic	Sound
Air conditioner	Electrical	Heat and movement/kinetic	Sound
Solar panels	Solar/Light	Electrical	
Candle	Chemical	Light	Heat

Question 2



The poster to the left was issued in the United States during the First World War.

- Explain the message it is conveying.
- Do you think that 'consumes' is a good word to use here? What would be a more scientific way of saying 'light consumes coal'?

The chemical energy stored in

the coal is transformed into light energy.

by the light globe

ENERGY TRANSFER

Rather than staying in the same place, energy frequently moves from one place to another. This is known as energy transfer.

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!

Energy **transfer** is when energy stays in the same form, but moves from one place to another. Here are other examples:

- **The Sun warming your home**
  The heat produced by the Sun is transferred through space to surfaces outside or inside your home that then become warm.
- **Power lines**
  Electrical energy generated in power stations is transferred *via* power lines to houses and businesses where it is used.

Question 3

Describe two other examples of energy transfer that take place in your home.

Answers will vary.

Energy type	Transfer example
Sound	The sound from a TV/radio/phone/person's voice is transferred through the air to your ears
Heat	Heat is transferred from under-floor heating/electric blanket/radiator/fire to your body
Heat	Heat is transferred from the cooktop/oven to the food it is cooking

WRAP-UP

Are you on top of what energy transfers and transformations are?

Question 4

Which is the best description of what energy transformation is?

☐ when something gets more energy

☐ when energy in a particular form moves from one place to another

☐ when energy changes into matter

☑ when energy changes from one form into another

Question 5

Which is the best description of what energy transfer is?

☐ when something gets more energy

- [x] when energy in a particular form moves from one place to another
- [ ] when energy changes into matter
- [ ] when energy changes from one form into another

2.3 ACTIVITY: TRANSFORMATIONS AND TRANSFERS

This lesson introduces students to the STELR Sustainable Housing equipment and reinforces their understanding of energy transfer and transformation.

- The activity is based around students working in small groups (around 3 students per group).
- If possible, give students time to explore the equipment packs and point out to them that there is a 'key' on the inside of the lid, showing the name, quantity and position of each item.
- Students will be expected to repack the cases at the end of the lesson.

- You may wish to show students this video that demonstrates the use of the STELR Sustainable Housing equipment, or go through each piece of equipment with them yourself.

STELR Sustainable Housing Kit

https://australiascience.tv/episode/stelr-sustainable-housing-kit/

https://www.youtube.com/watch?v=vDumy77QQgI

STELR Sustainable Housing Kit - How to put in the panels

https://australiascience.tv/episode/stelr-sustainable-housing-kit-how-to-put-in-panels/

https://www.youtube.com/watch?v=JAzSGYlS4cs

These videos are also on the STELR Sustainable Housing USB here:

USB Sustainable Housing 2020\Sustainable Housing Videos\Kit related videos

- There is a list of all the STELR Sustainable Housing equipment in Appendix 2.
- There is a STELR Sustainable Housing Placement template in Appendix 1. You may wish to copy and laminate one for each group. It is supplied to assist students with keeping a constant distance between the lamp and the window of the house.
- Once the equipment is set up as shown below (noting that the lamp should be about 10 cm from the house), students should turn on the lamp and the temperature logger at the same time.
- The then record the temperature every minute up to minute 5, when they turn the lamp off and keep recording the temperature until minute 10.
- When plotting their results on the graph provided, students will have to work out the appropriate scale for the y axis.

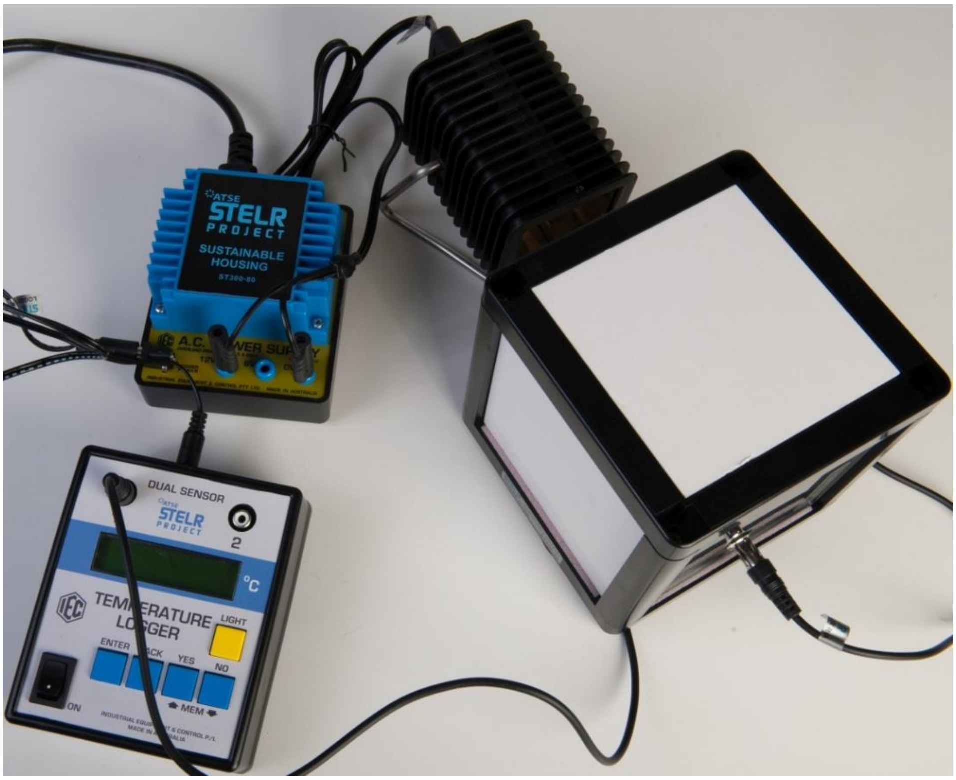
KEY QUESTIONS

- How dos the STELR Sustainable Housing equipment work?
- What energy transfers and transformations occur in a house?

In this activity, you will learn how to set up the STELR sustainable house and identify some energy transformations and transfers.

Materials

- STELR house cube
- STELR heat sensor panel
- Clear plastic panel
- 4 x white plastic panels
- STELR power supply
- STELR lamp
- STELR temperature logger
- STELR Sustainable Housing Placement template (optional)
- connecting cables



Note that in this photo he STELR lamp is too close to the window of the house. It should be at least 10cm away.

WHAT TO DO

Set up the equipment as shown in the picture, following these steps:

- Set one house cube on the bench (feet down) and drop one white plastic panel into the Base to make a floor.
- Put the temperature sensor panel into one wall of the house. Make sure the green stripe is on the inside and is positioned horizontally.
- Put a clear plastic wall panel in the wall opposite the temperature sensor panel.
- Put a white plastic panel in each of the other two side walls.
- Drop another white plastic panel into the top of the cube to make a flat roof.

Now set up the heat lamp (fake Sun)

- Attach the mains power cable to the STELR power supply (DO NOT SWITCH ON TH POWER)
- Plug one of the lamp cables into the 0V socket and the other lamp cable into the 12V socket of the power supply.
- Place the lamp so that it is facing the clear plastic window of the house and 10 cm from the house. (Your teacher may give you a template to use to get the positions right.

Take care as the STELR lamps can get quite hot. Always unplug them when not in use.

Now connect the temperature sensor panel to the Temperature logger.

- Firstly turn on the temperature logger to see if it is fully charged. If the display screen does not light up, connect the logger to the logger power socket in the power supply. Then turn the logger off.
- Connect the temperature sensor panel to the socket 1 on the temperature logger.

You are now ready to go. Get your teacher to check your set-up before proceeding to the experiment.

- Turn on the power to the lamp.
- Turn on the temperature logger.
- Press YES, ENTER, NO, ENTER, YES.
- As soon as you press the last 'YES' the temperature start to be displayed.

Write down the temperature in the table below, every minute from 0 minutes to five minutes.

At 5 minutes, turn off the lamp by unplugging one of the lamp cables from the power supply. Move the lamp away from the house.

Continue to record the temperature every minute until you reach 10 minutes.

Turn off the temperature logger. Turn off the power to the power supply.

RESULTS

Heating up (lamp on)

Results will vary. The will depend on the classroom conditions (temperature, drafts, season etc.), the angle of the lamp and the distance of the lamp from the temperature sensor panel. The results in the table below are samples only, to give an indication of what happened in one particular instance.

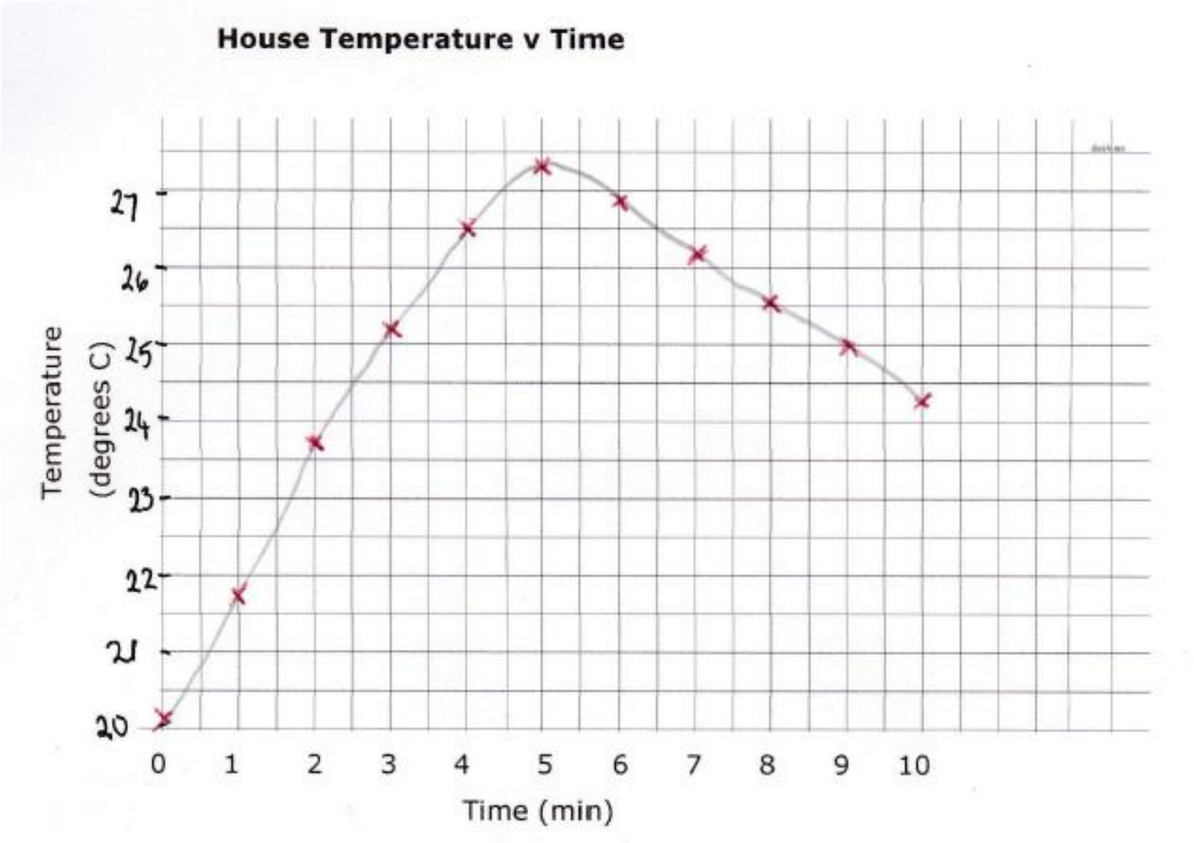
Time (Minutes)	**0**	**1**	**2**	**3**	**4**	**5**
Temp Degree C	20.1	21.6	23.7	25.2	26.5	27.3

Cooling down (lamp off)

Time (Minutes)	**6**	**7**	**8**	**9**	**10**
Temp Degree C	26.8	26.2	25.5	25.0	24.3

The temperature should drop but probably not back to the starting temperature.

Plot your results on the graph below



Question 1

What was the highest temperature reached by your house?

Answers will vary

After 10 minutes was your house cooler or warmer than when you started

Answers will vary

Question 2

Compare you results with other groups in the class. Suggest some reasons why different groups had different results.

The results are dependent on a number of variables which may have been different for each group. These could include:

- Starting temperature (this could be different in different parts of the room (see next point).
- Position in the classroom (near a sunny window, neat a draft, near the doorway etc.).
- Distance between the lamp and the temperature sensor panel.
- The angle of the light to the sensor panel.
- How the house was put together (if the panels are not inserted properly, there may be 'heat leakage' from the house.
- If the equipment was set up differently (for example, having the temperature sensor at the bottom or top of the house instead of at the side).
- Small differences in the equipment (for example each lamp may not heat up exactly the same).

Question 3

There were a number of energy transformations and energy transfers taking place in this experiment. Complete the following sentences by using the word **transformed** or **transferred** to fill in the gaps:

The power cable transferred electrical energy from the power point to the STELR power supply.

The STELR lamp transformed electrical energy into light energy and heat energy.

Heat energy was transferred through the window to the sensor panel.

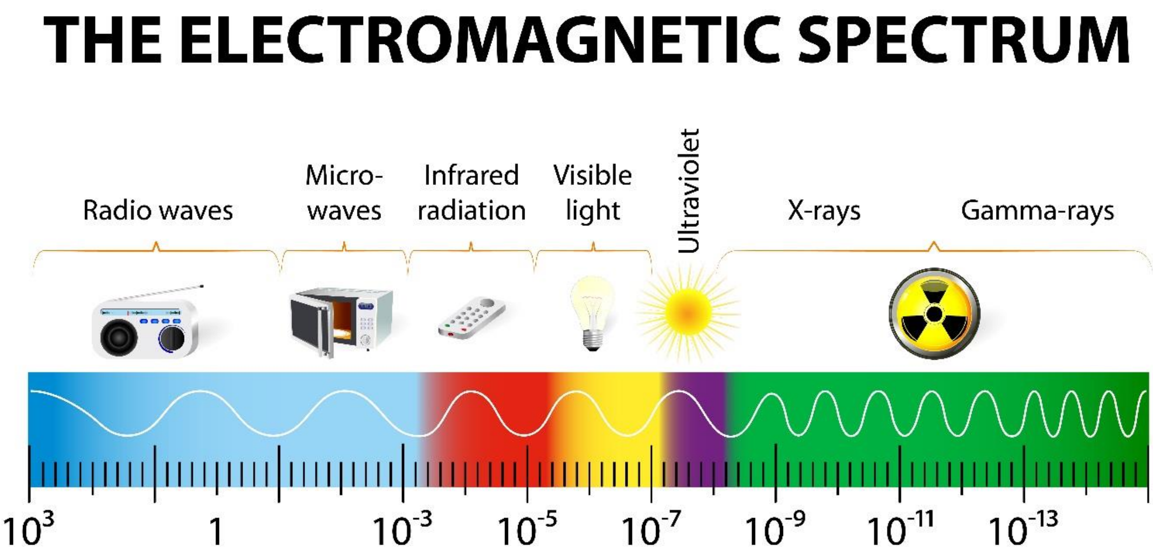
The heat sensor transformed heat energy into an electrical signal that was

transferred to the temperature logger.

When the lamp was turned off, heat energy from inside the house was

transferred to the surrounding environment as the house cooled down.

3 TRANSFERRING HEAT ENERGY



In this section we look at the different ways heat can be transferred. The first lesson introduces radiation, conduction and convection. Then the section is split into three sub-sections dealing with these three types of heat transfer.

2.1 Different ways heat can be transferred This introductory lesson introduces the concepts of radiation, conduction and convection.

3.2 Radiation
3.2.1 Lesson: What is Radiation This lesson starts with a short video about heat transfer by radiation. It also introduces the electromagnetic spectrum and asks students to research the uses of different types of radiation.
3.2.2 Activity: Roof Colours In this activity, students test how different coloured roofing materials absorb solar radiation differently.
3.2.3 Activity: Thermal Mass In this activity students test different flooring materials for their ability to absorb and reradiate heat in a home.
3.2.4 Lesson: Windows and Transmission This lesson uses a series of short videos to help students learn more about the greenhouse effect thermal and the properties of glass
3.2.5 Activity: Double Glazing In this activity, students test the effectiveness of double glazing
3.3 Conduction
3.3.1 Lesson: Conductors and Insulators Students learn about
3.3.2 Activity: Testing Building Materials Students build the sustainable house firstly using plastic wall panels and then using insulated wall panels. The compare the temperature change in the house as it heats up and then cools down.
3.3.3 Activity: Double Glazing Students compare the heat changes that occur when a single glazed window is replaces by a double glazed window.
3.4 Convection
3.4.1 Lesson: Hot Rises, Cool Falls Videos are used to introduce students to what happens to fluids when they are heated and how convection currents form.
3.4.2 Activity: Air Leakage and Convection In this activity, students compare a well-sealed home to one with air leakages to see how convection currents can result in the leakage of warm air out of the home.

In this section you will learn about the three different ways that heat energy is transferred from one place to another and how this can help you to design a more sustainable home.

3.1 LESSON: DIFFERENT WAYS HEAT CAN BE TRANSFERRED

KEY QUESTION

- How can heat energy be transferred from one system to another (or from a system to its environment)?

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.

Question 1

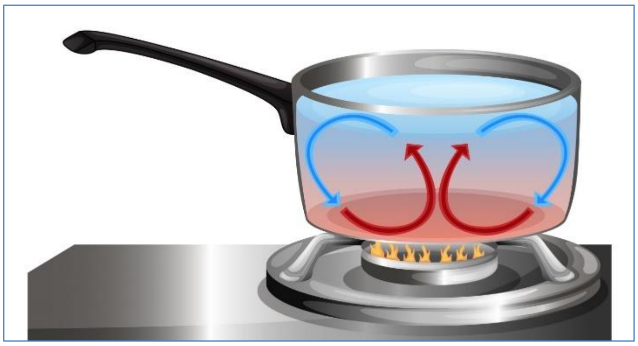
Which of these is an example of heat transfer by conduction?

- ☑ 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 2

Radiation is heat transfer by:

- ☐ direct contact.
- ☑ electromagnetic waves.
- ☐ molecular and electronic collisions.
- ☐ atmospheric currents.



Question 3

Write down which of the following are examples of convection, conduction or radiation

Situation	Convection, conduction or radiation?
Saucepan being heated by the flame	conduction
Saucepan handle becoming hot	conduction
The hot water at the bottom of the pot rising up to the top and pushing the cold water down	convection
When you put your hands near the pot you can feel the heat.	radiation

Watch the video below and answer the following questions.

Heat loss and gain in houses

https://www.youtube.com/watch?v=wLJRSP9utoID:\youtube.com\watch?v=wLJRSP9utoI

Question 4

Where does radiant heat come from and how does it get into a home?

Radiant heat comes from the Sun and enters homes mainly through the roof and windows.

Question 5

How can convection cause heat loss in a home?

The warm air rises and the cool air falls setting up a convection current in a room. The circulating air draws in cool air from the outside though small gaps or cracks in the building.

Question 6

How is heat conducted in a home in summer and in winter?

Heat energy is always conducted from something warmer to something cooler. Heat is generally conducted into the home is summer and out of the home in winter.

3.2 RADIATION

KEY QUESTIONS

- What is radiation?
- How can we use radiation to make our homes more sustainable?

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 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 as heat.

All things at temperatures above absolute zero give out radiation of some sort including radio waves, infrared radiation and visible light. The type and amount of radiation determines the temperature of the object

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 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.

3.2.1 LESSON: WHAT IS RADIATION

This lesson introduces students to heat transfer by radiation. It also looks at the electromagnetic spectrum and all the different types of electromagnetic radiation.

All objects emit electromagnetic radiation. The amount of radiation emitted at each wavelength determines the temperature of the object. Hot objects emit more of their radiation at short wavelengths. For example, a fire emits visible light as well as infrared radiation (heat). A colder object emit more of their radiation at long wavelengths. A person, (who is cooler than a fire) emits only infrared radiation (no light).

As far as Sustainable Housing goes, we are really only interested in infrared radiation (which we feel as heat) and visible light, which the human eye can see.

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:

- [x] waves.
- [ ] particles.
- [ ] convection currents.
- [ ] conduction.

Question 2

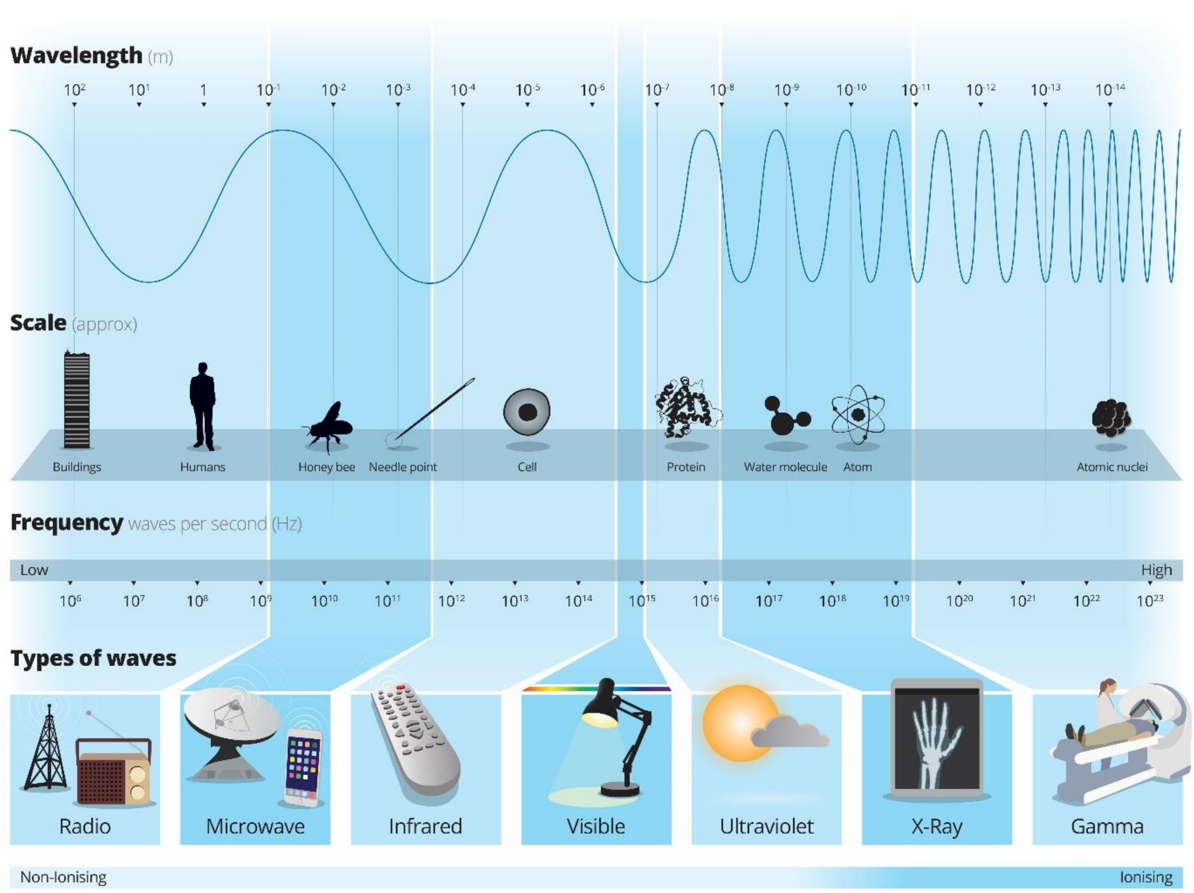
The best surfaces to absorb radiation are:

- [x] dark coloured.
- [ ] white.
- [ ] shiny.
- [ ] green.

Question 3

What colour are solar panels? Why?

Dark or black so that they absorb the maximum amount of energy to convert to either electricity (solar photovoltaic panels) or heat (solar hot water panels.



ELECTROMAGNETIC RADIATION; COURTESY OF THE AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION – ANSTO

The image above illustrates different types of radiation their wavelengths

This image can be downloaded from the ANSTO website:

Electromagnetic Spectrum Poster
https://www.ansto.gov.au/education/resources/posters

Encourage students to do further research to answer question 4.

Question 4

Name five types of electromagnetic radiation and described how they are used.

Radio waves are used to send messages or radio programs from one radio device to another. Radio waves are also emitted by stars and gases in space.

Microwaves cook your food by warming up the water it contains. Mobile phones receive microwave radiation from the nearest phone tower and send microwave signals back.

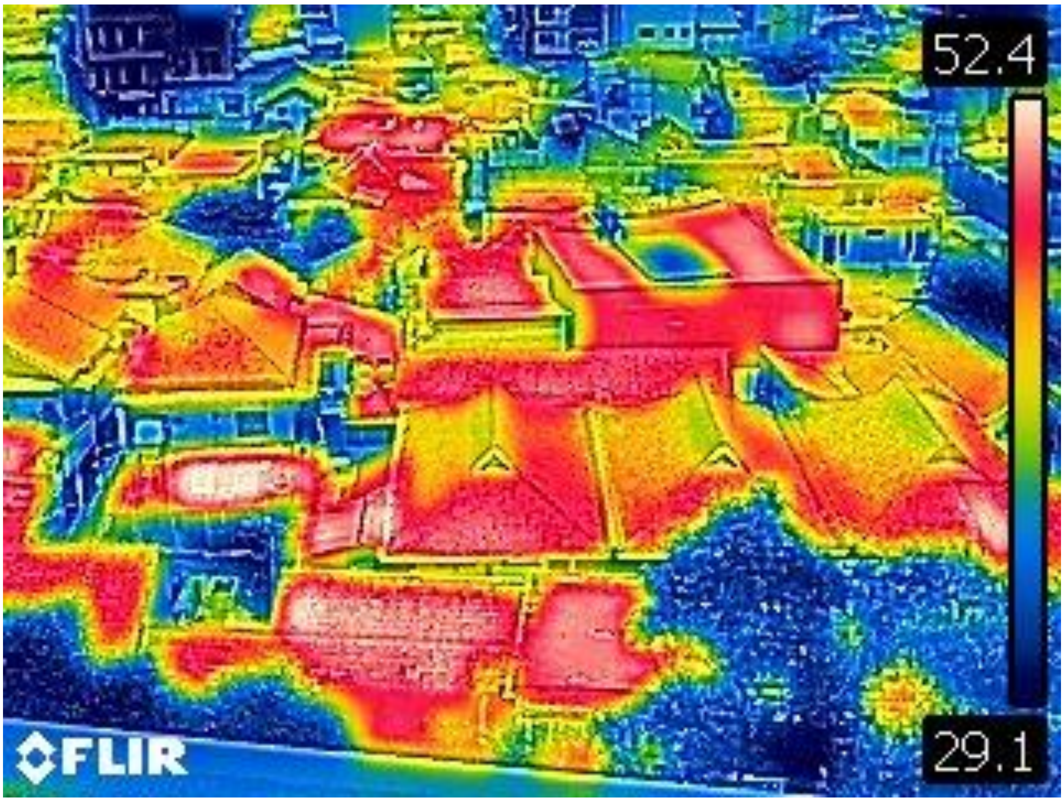
Infrared radiation is emitted by all objects. We detect it as heat. Night vision goggles or infrared cameras convert infrared energy into light energy so we can 'see' the heat. There is an image from and infrared camera on page 5. Infrared radiation is also used in remote control devices to send messages to your TV, air conditioner or gate opener.

Visible light is the radiation that human eyes can see. Fireflies, fires, light bulbs, computer screens and stars (including our Sun) all emit visible light. A normal camera detects visible light. Humans use visible light to see and communicate. Plants use visible light from the Sun for photosynthesis.

Ultra violet light from the Sun causes sunburn. The Earth's atmosphere absorbs most ultraviolet radiation from space. Fluorescent dyes glow under ultraviolet light and are often used in banknotes and credit cards as a security measure. The dye can only be seen if an ultraviolet light is used. Other hot objects in space emit ultraviolet light. Ultra violet light can also be used to sterilise medical laboratories and as a disinfectant in wastewater treatment.

X-Rays are used by dentists to take images of your teeth or by doctors to detect broken bones and to look for infections like pneumonia. Airport security uses them to see through your bags. X-rays are emitted from the Sun and stars. The Earth's upper atmosphere blocks X-rays from space.

Gamma rays are used in radiotherapy to kill cancer cells. Gamma rays are emitted from the Sun and stars. The Earth's upper atmosphere blocks Gamma rays from space.



3.2.2 ACTIVITY: ROOF COLOURS

This lesson uses the STELR roofing materials in the Sustainable Housing Teacher Kit. The teacher kit contains 2 each of the following colours: Monument (very dark grey), Shale Grey (light grey) and Surfmist (off-white). So, in total you should have four of each colour, so the class could be divided into four groups to perform the experiment.

This activity requires students to compare the samples' ability to absorb or reflect radiation from the Sun. It is best done outdoors on a sunny day because this gives the best chance of each of the three samples receiving the same amount of radiation. If you choose to do this indoors and use the STELR lamp, it may be more difficult to ensure that the samples are all receiving the same amount of radiation.

The samples are each placed on top of an insulating panel, to reduce the amount of heat conducted from the surface in which they have been placed.

Note that the light grey and off-while samples are quite similar, so students may not measure much of a difference between these.

When plotting their results on the graph provided, students will have to work out the appropriate scale for the y axis.

Extension ideas:
You may like to source British Paints paint samples from your local hardware chain. These and 10cm square and come in many different colours. And could be used to test other colours.

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, which will heat up the house. In this experiment you will investigate how rook colour effects heat energy absorbed

Materials

- STELR touch sensor
- 3 x BlueScope roof panels (dark grey, light grey and white)
- 3 x white insulation panels

- STELR temperature logger
- connecting cables
- a sunny flat surface outside

If it is not sunny you will also need:

- STELR power supply
- STELR lamp

WHAT TO DO

- Place each of the metal panels on an insulation panel.
- Before you put them in the sun or under the lamp, use the touch sensor to measure the temperature of each panel.
- Place the panels in direct sunlight (or use the STELR lamp if it is not sunny) for five minutes.
- Take the panels out of the sun and quickly measure the temperature of each one.
- Leave the panels for another five minutes (out of the sun) and measure their temperatures again.
- Record all of the temperatures in the table below.

RESULTS

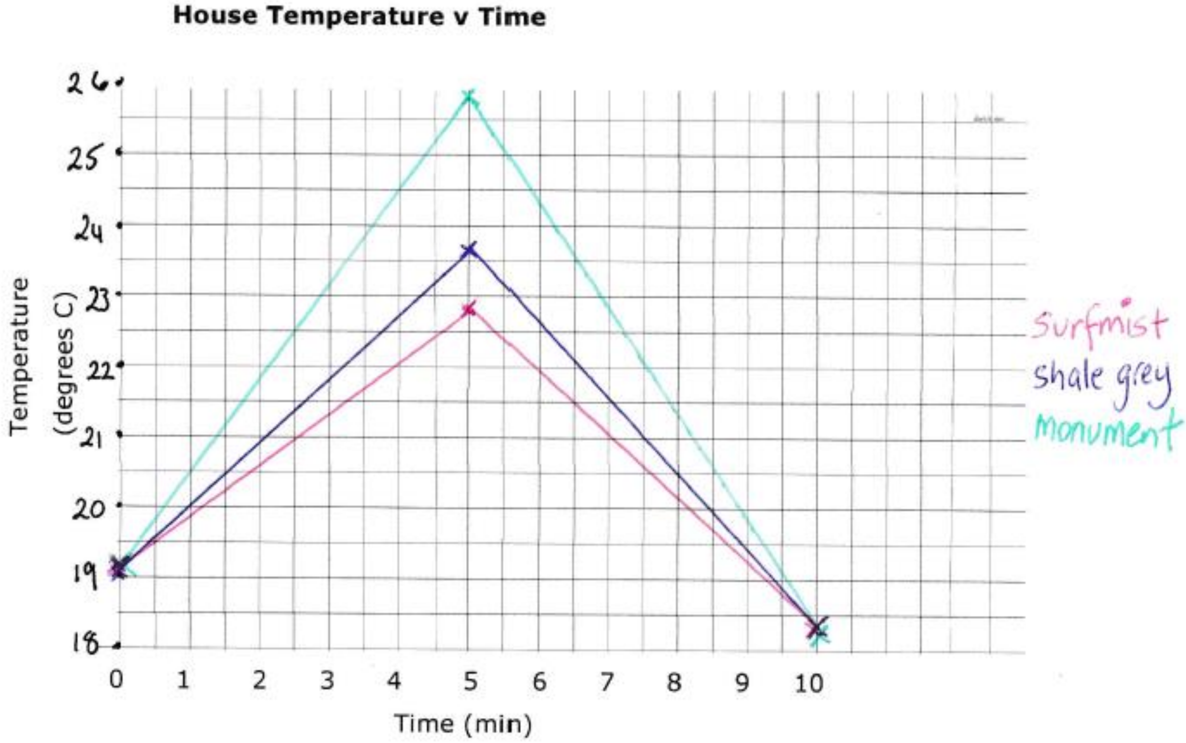
The results included here are indicative only. The actual results will be dependent on a number of variables which may have been different for each group. These could include:

- *Starting temperature and climate of your area*
- *Whether you are using the lamp or sunlight.*
- *If you are using the lamp, each panel may not get the same light coverage.*
- *The angle of the light to the roof panel.*
- *Small differences in the equipment (for example, the touch sensors may give slightly different readings).*

Note that all three colours cool down quite quickly. This is because metals have a low thermal mass. They heat up quickly and radiate their heat back into the environment quickly as well.

Colour	Starting Temp	Temp after 5 mins in sun	Temp after 5 mins out of sun
Surfmist (white)	19.3	22.9	18.4
Shale grey (light grey)	19.2	23.7	18.4
Monument (dark grey)	19.3	25.9	18.3

Plot your results on the graph below using a different pen colour for each panel



Question 1

- Which roof colour was most effective at absorbing solar radiation?

Monument (dark grey)

- Which roof colour was most effective at reflecting solar radiation?

Surfmist

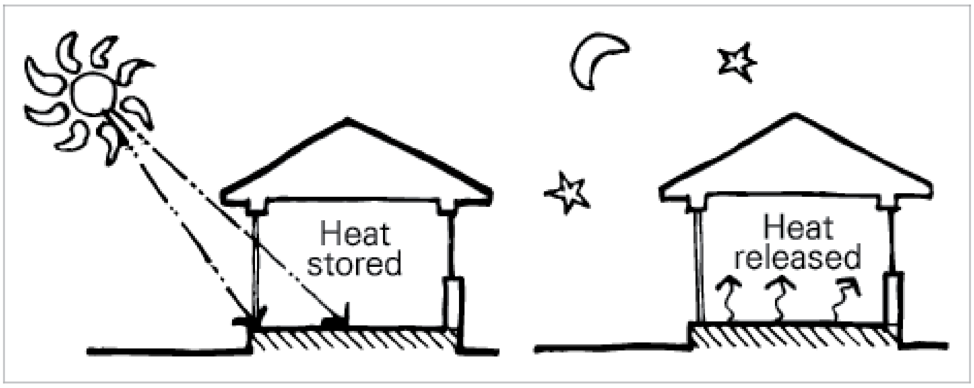
Question 2

Explain how you could use this information to choose a roof colour for an energy efficient home if you were living in a very cold climate or a very warm climate?

In a warm climate you would choose a light colour to reflect the sun's radiation and keep the home cooler.

In a cold climate you would choose a dark colour to absorb as much of the sun's radiation as possible to keep the home warmer.

3.2.3 ACTIVITY: THERMAL MASS



In this activity students look at the thermal properties of different materials that can be used for the floor of the STELR house. They use the thick aluminium, thick steel and the ceramic tile from the teacher's kit.

Students learnt in the previous experiment, metals are good at absorbing heat, but they also re-radiate heat quickly. That is why metal surfaces can feel hotter than, say, ceramic tiles event though they are at the same temperature.
For the materials used in this experiment, the ceramic tile has the highest thermal mass and the aluminium has the lowest.

You may refer students directly to the Australian Government's Your Home website for information about passive design (link below) or choose to download the information for them.

This activity also introduces the use of a **risk assessment** table that students should complete before undertaking the experiment. They will also be introduced to **dependent, independent and controlled variables**.

From this activity on, results will be recorded on a generic **Sustainable Housing student investigation sheet** found in appendix 1.

Depending on the time available, you may consider running activity with each group only testing one material, and then sharing the results.

IMPORTANT

You will need to show the students how to change the measurement interval on the temperature logger. The default interval is one second and recordings go for 20 minutes only. This experiment requires recording for 26 minutes. Use the instruction in Appendix x on Page x to change the measurement interval to two seconds so that the logger runs for 40 minutes.

Extension idea:
As an extension, students could also use the wood panels from the teacher kit. Use two wood panels together to approximate the same thickness as the tile and metal squares.

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.

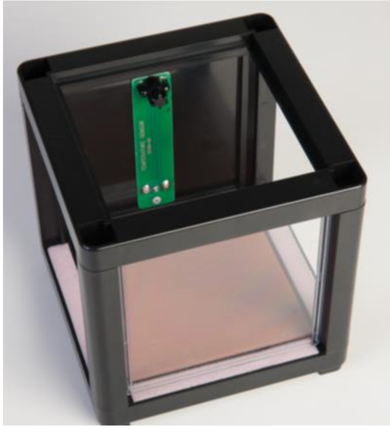
If a house has a concrete floor, it can absorb radiant heat in daylight hours and re-radiate the heat energy back into the room at night.

Find out more about thermal mass by looking at this website.

Thermal Mass

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

Materials



- STELR house cube
- STELR clear plastic window panel
- 3 x white insulation panels
- 1x STELR sensor panel
- Ceramic tile, thick steel and thick aluminium sample
- STELR temperature logger
- connecting cables
- STELR power supply
- STELR lamp
- STELR Sustainable Housing student investigation sheet for recording your results
- STELR Sustainable Housing Placement template (optional)

Risk assessment

Complete the following risk assessment.

Fact	Risk	Precaution
Halogen lamp gets very hot	Burning your hand	Turn off the lamp when not in use
Ceramic tile can break easily	You might cut yourself on the broken tile	Handle tile carefully. Report breakages to the teacher
Students may think of another here		

Variables

In any experiment, it is essential to know what the variables are, and to control them appropriately. This ensures that the experiment addresses the experiment aims and gives a meaningful result. You will need to consider the:

- **independent variable:** the variable you change to see the difference it makes;
- **dependent variable:** the variable you measure to see if/how it changes when you change the independent variable;
- **controlled variables:** other factors that you keep constant, so they don't have any impact on the dependent variable.

Identify which of the following variables are independent, dependent and controlled:

Type of wall panels | type of window glass | distance between lamp and house | temperature of the house | number minutes with the lamp on and off | type pf roof panel | type of floor panels | position of the heat sensor

Independent variable: type of floor panels

Dependent variable: temperature of the house

Controlled variables: all others

WHAT TO DO

- Place the temperature sensor in the back wall with the sensor at the **top**.
- Place the clear plastic window in the opposite face of the cube.
- Insert thick steel square into the floor.
- Place insulating panels in the side walls and on the top to make a flat roof.

- Connect the temperature sensor to the data logger.
- Place the lamp about 10cm the window, (you may use the placement template to help you)
- Angle the lamp so that it shines on the floor. Activate the lamp and the data logger at the same time.
- Record the temperature every minute for eight minutes on your student investigation sheet.
- Turn off the lamp and move it away from the house. Record the temperature every two minutes, for a further 18 minutes as it cools.
- Repeat the experiment using the thick aluminium sample and then the ceramic tile.

RESULTS

Results will vary. The will depend on the classroom conditions (temperature, drafts, season etc.), the angle of the lamp and the distance of the lamp from the house. The results in the tables below are samples only, to give an indication of what happened in one particular instance.

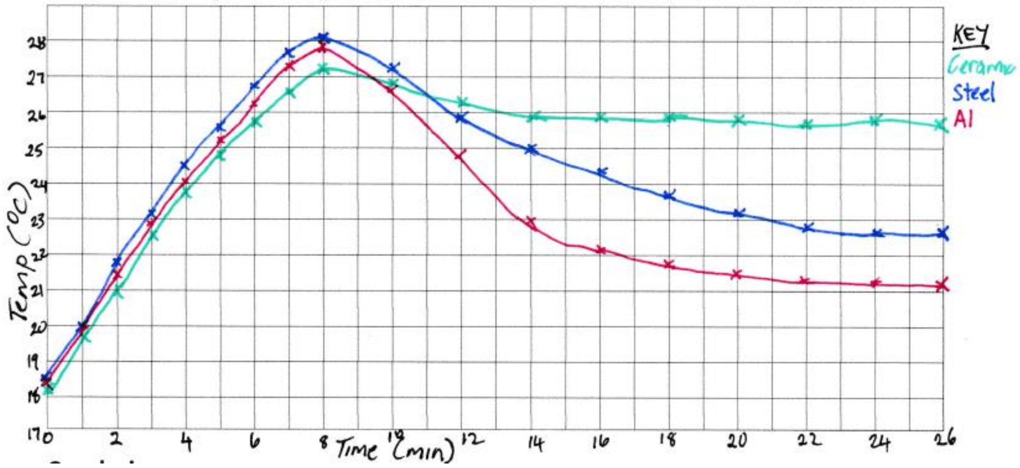
Heating up (lamp on)

Time (Mins)		0	1	2	3	4	5	6	7	8
Temp ° C	Ceramic	18.2	19.7	21.0	22.5	23.8	24.8	25.7	26.6	27.3
	Thick steel	18.4	20.0	21.9	23.1	24.5	25.6	26.8	27.7	28.1
	Thick aluminium	18.3	19.9	21.5	22.9	24.0	25.2	26.3	27.3	27.9

Cooling down (lamp off)

Time (Mins)		10	12	14	16	18	20	22	24	26
Temp ° C	Ceramic	26.9	26.3	25.9	25.9	25.9	25.8	25.7	25.8	25.8
	Thick steel	27.1	25.9	25.0	24.4	23.8	23.2	22.8	22.7	22.7
	Thick aluminium	26.7	24.8	22.9	22.1	21.8	21.5	21.3	21.2	21.1

Graph



Question 1

Discuss how to design this group investigation to support fair testing.

Answers will vary but they should include mention of controlled variables and if any of these were difficult to control. For example, the house may not be put back in the same place so the distance from the lamp changed.

Throughout the experiment the temperature of the house may go up due to constant heating. So that the next experiment may have a higher starting temperature that the one before. Should the starting temperatures be the same for a fair test?

Question 2

Compare the results of your sample with other groups' samples. Determine which sample was best at storing and releasing heat.

The ceramic tile would be expected to continue releasing heat into the house for the longest time.

3.2.4 LESSON: WINDOWS AND TRANSMISSION

Glass transmits visible light and some heat in the higher end of the infrared spectrum. The light is absorbed by the contents of the room (walls, floors. furniture) and it is converted into longer wavelength infrared energy which cannot escape through the glass as easily. This is known as the greenhouse effect.
That being said, at when it is cooler and there is no solar radiation, widows are generally better conductors of heat than walls so they contribute to heat loss from a home.
In these videos, students will find out about how the placement of windows, the number of windows and window shading can maximise the benefits of the sun in winter and reduce its effect on the summer.
You can find out more about Low E Glass here:

Build.com.au

https://build.com.au/low-e-glass

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

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?

Windows allow light and some heat into your home during daytime.

Windows allow heat to escape from your home at night.

In hot weather you want to minimise the amount of solar radation coming into your home so that it doesn't heat up too much during the day. You would want windows that let in light but to heat.

In cold weather you want to get as much heat and light into the house and not let it escape from the house at night.

VIDEO **House and Window Design and Orientation**

www.youtube.com/watch?v=_4_IHSBGUr0

Question 2

What is the best way to orient a house? Why is this important?

In the southrn hemisphere, a house should be oriented in an East-West axis with most of its livingroom and windows facing the North. If it is properly designed, this type of house will stay cool in summer amd warm in winter.

Question 3

In Australia, which side of the house should have the most glass? Why?

The north side to let in as much light as possible in the winter.

Question 4

Explain cross ventilation. Why is it important?

Cross ventilation is a breeze that flows through the house to remove hot air in the summer. Windows and/or doors that are on opposite sides of the house can be opened to facilitate cross ventilation. (Cross ventilation should be minimised in the winter, when keeping warm air inside a house is desireable.

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?

The Sun is higher in the sky in summer. Eaves or verandas can be designed so that they provide shade to the windows in summer, allow the winter sunlight into the home.

Question 6

How can you protect the east and west sides of buildings from sunlight?

By planting trees to shade the windows or using a veranda.

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.

sand
soda ash
dolomite
limestone

Question 8

To what temperature is the mixture heated to turn it into glass?

1500 degrees C

Different Types of Glass and Double Glazing? Watch the video below and answer the questions.

Different Types of Glass and Double Glazing?

https://www.youtube.com/watch?v=n8Bx8vIdYM8

Question 9

How does toned glass work?

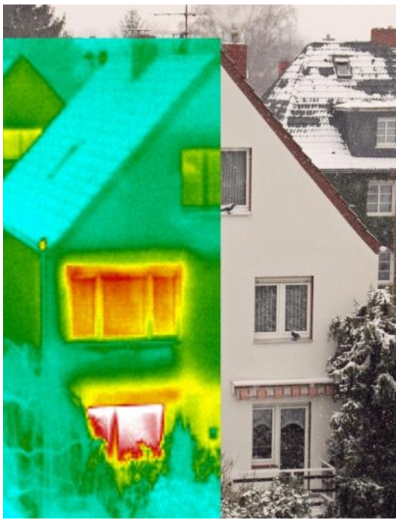
It absorbs some of the sun's radiation and keeps in out of your home.

Question 10

How is smart glass (glass with a low E coating) better than toned glass?

It stops some of the heat from the Sun entering the house and it also reflects heat inside the house back into the house. It is a better insulator than ordinary glass (up to 39% better than ordinary glass.

This picture of a house was taken in partly in infrared. It shows where heat is escaping from the house.



Question 11

Was it taken in winter or summer? Would you want it to be warmer or cooler inside compared to outside?

The picture was taken in winter. You can see snow on the roof in the background. It would be warmer inside the house than outside.

Question 12

What parts of the house emit more heat? How are they coloured?

The windows are giving off the most heat as shown by the red, orange and yellow colours (red is hottest).

Question 13

What could the owner do to reduce heat transfer through that part of the house?

A number of things including:

- Using heavy curtains or shutters to insulate the windows
- Use Low E class
- Install double glazing

3.2.5 ACTIVITY: TESTING DIFFERENT GLASS

Clear glass transmits visible light and some heat in the higher end of the infrared spectrum. The light is absorbed by the contents of the room (walls, floors. furniture) and it is converted into longer wavelength infrared energy which cannot escape through the glass as easily. This is known as the greenhouse effect.
That being said, at when it is cooler and there is no solar radiation, widows are generally better conductors of heat than walls so they contribute to heat loss from a home.
Tinted glass works by restricting some of the solar radiation from entering the home, thus keeping it cooler in summer. I still will conduct heat out of the home in the same way that clear glass does. Low E glass works in two ways. Firstly, by blocking some of the infrared energy (heat) from the Sun from entering the home, so it will keep the home cooler in summer. I also reflects some of the heat from inside the home back inside, making it a better insulator than both clear and tinted glass. So it will keep a home warmer both in winter and summer. If using Low E glass, it would be wise to be able to open the windows in summer to let a cool breeze through the home. Another issue with Low E glass arises if you are relying on the thermal mass of the walls or floor to heat a home in winter. Because the Low E glass blocks solar radiation from entering the home, there will not be as much heat stored in the thermal mass, so less will be released at night.
You can find out more about Low E Glass here:

Build.com.au

https://build.com.au/low-e-glass

In this activity you will test the effectiveness of different types of glass and determine how they allow affect the temperature of a room when the window is in full sunlight. You will begin with one glass sample and then swap with another group until you have tested all three types:

- Clear glass
- Grey glass
- Low E glass

Materials

- STELR house cube
- 1 STELR glass panel
- 4 x white insulation panels
- STELR temperature logger
- connecting cables
- STELR power supply
- STELR lamp
- STELR Sustainable Housing student investigation sheet for recording your results
- STELR Sustainable Housing Placement template (optional)

Risk assessment

Complete the following risk assessment.

Fact	Risk	Precaution
Halogen lamp gets very hot	Burning your hand	Turn off the lamp when not in use
Glass can break easily	You might cut yourself on the broken tile	Handle tile carefully. Report breakages to the teacher
Students may think of another here		

Variables

In any experiment, it is essential to know what the variables are, and to control them appropriately. This ensures that the experiment addresses the experiment aims and gives a meaningful result. You will need to consider the:

- **independent variable:** the variable you change to see the difference it makes;
- **dependent variable:** the variable you measure to see if/how it changes when you change the independent variable;
- **controlled variables:** other factors that you keep constant, so they don't have any impact on the dependent variable.

Identify which of the following variables are independent, dependent and controlled:

Type of wall panels | type of window glass | distance between lamp and house | temperature of the house | number minutes with the lamp on and off | type pf roof panel | type of floor panels | position of the heat sensor

Independent variable: type of window glass

Dependent variable: temperature of the house

Controlled variables: all others

WHAT TO DO

- Place the temperature sensor in the back wall with the sensor at the top.
- Place the glass window in the opposite face of the cube.
- Insert an insulation panel into the floor.
- Place insulating panels in the side walls and on the top to make a flat roof.

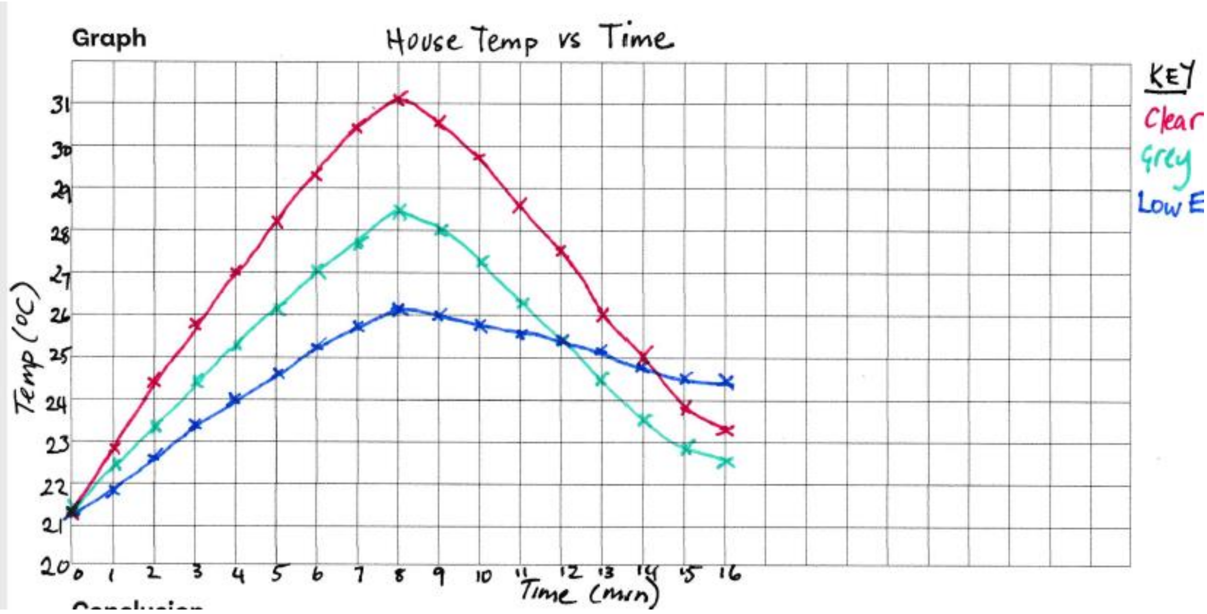
- Connect the temperature sensor to the data logger.
- Place the lamp about 10cm the window, (you may use the placement template to help you)
- Turn on the lamp and the data logger at the same time.
- Record the temperature every minute for 8 minutes on your student investigation sheet.
- Turn off the lamp and move it away from the house. Record the temperature for a further 8 minutes as it cools.
- Repeat the experiment using the other two glass samples. When you are changing the glass samples, allow the warm air to escape from the house cube.
- Record your results on the same student investigation sheet. Plot a graph to show the temperature against time.

RESULTS

Results will vary. The will depend on the classroom conditions (temperature, drafts, season etc.), the angle of the lamp and the distance of the lamp from the house. The results in the tables below are samples only, to give an indication of what happened in one particular instance.

Time (Mins)	**Lamp On**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Temp ° C	**Clear Glass**	21.3	22.9	24.4	25.8	27.0	28.1	29.2	30.4	31.1
	Grey Glass	21.4	22.5	23.4	24.4	25.2	26.1	27.0	27.7	28.2
	Low E Glass	21.3	21.9	22.7	23.4	24.0	24.6	25.2	25.7	26.1

Time (Mins)	Lamp Off	9	10	11	12	13	14	15	16
Temp ° C	Clear Glass	30.5	29.8	28.7	27.5	26.0	25.0	23.9	23.2
	Grey Glass	28.0	27.2	26.3	25.4	24.5	23.6	22.9	22.6
	Low E Glass	26.0	25.8	25.6	25.4	25.2	24.9	24.6	24.5



Question 1

When the lamp was on, which glass sample allowed the house to heat up the most?

Clear glass

Question 2

When the lamp was on, which glass sample allowed the house to heat up the least?

Low E Glass

Question 3

When the lamp was off, which glass sample allowed the house to cool down the most?

Clear glass

Question 4

When the lamp was off, which glass sample allowed the house to retain the most heat?

Low E Glass

Question 5

Discuss the results with your class and decide which type of glass would be best for keeping a house

a) Warm in winter

The Low E glass is up to 39% better at insulating the home from heat loss so would keep the home warmer in winter. The down side is that, if you are relying on passive heating to heat your house in winter, it reduced the amount of heat being transmitted through to warm the thermal mass (concrete/tile floor or brick wall).

b) Cool in summer

Low E glass blocks the most solar radiation from entering the home, so would keep the home cooler in summer. However, once the house does heat up, it is also better at stopping that heat from escaping through the window glass. Opening the windows to allow the warm air out and a cool breeze in could help to keep the home cooler in summer.

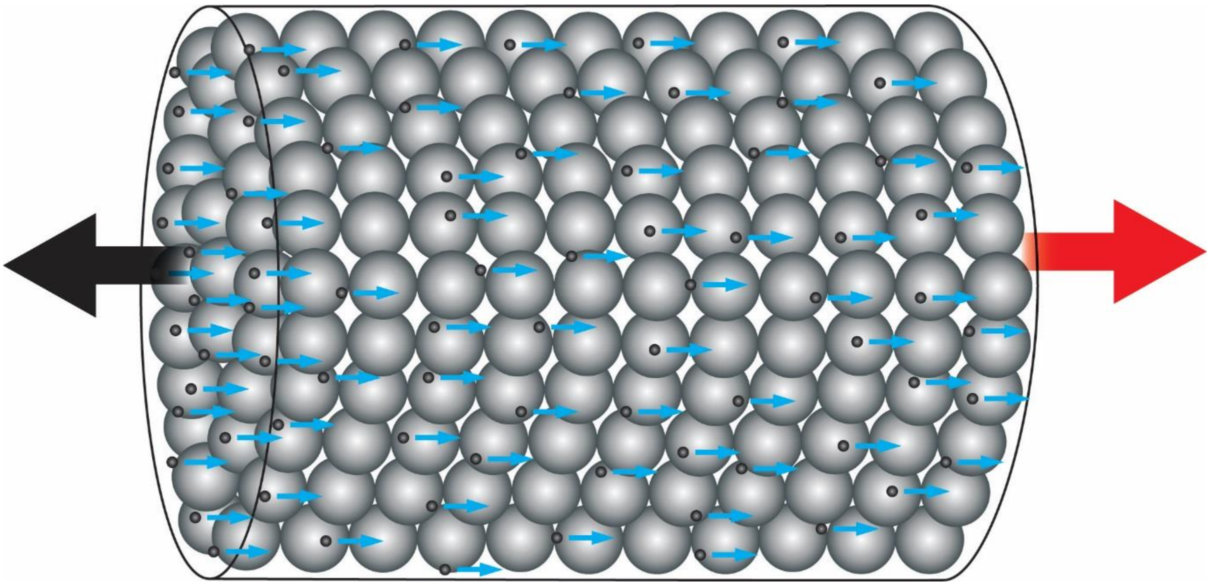
3.3 CONDUCTION

KEY QUESTIONS

- What is conduction?
- How can we use conduction to make our homes more sustainable?

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.

3.3.1 LESSON: CONDUCTORS AND INSULATORS

In this lesson students look at a video that explains how solids liquids and gases transfer heat by conduction. With solids in particular, the difference in behaviour of metals and non-metals id covered. They then apply this knowledge to the best materials to use for house construction.

They then look at the Australian government's Your Home website to find the answers about heat loss through homes and different types of insulation.

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.

Watch the video below and then answer the following questions.

VIDEO **Heat Transfer**

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

Question 1

Which materials are the best thermal conductors?

- ☑ solids
- ☐ liquids
- ☐ gases

Question 2

Which of the following solids do you think would be the best conductor?

- ☐ glass

- [x] iron
- [ ] polystyrene
- [ ] wood

Question 3

Would you make the walls, doors and roof of a house from a conductor or an insulator? Why?

It would be better to make the walls doors and roof from an insulator so that heat is prevented from moving into the home in summer (when the outside temperature is warmer than the temperature inside the home) and our of the home in winter (when the inside temperature of the home is warmer than the outside temperature).

Question 4

What are the best materials to make windows and window frames? Why?

In terms of heat transfer, it would be better to make the window frames of an insulator like wood or plastic rather than a good conductor such as metal. (Note that in some bushfire prone areas, metal window frames are mandated because they are less likely to burn.)

Double glazing has two pieces of glass separated by an air gap. Triple glazing has three pieces of glass and two air gaps.

Question 5

Explain how the air gap prevents heat transfer by conduction.

Air is a poor conductor of heat so stops heat from getting into or out of the house.

Insulation is the opposite of conduction. A good insulator is a poor conductor of heat.

Some solids contain trapped air which makes them better insulators. This roof insulation is made of glass fibres and trapped air.

Find out more about thermal mass by looking at this website.

Insulation

www.yourhome.gov.au/passive-design/insulation

Question 6

How much heat is gained or lost through the ceiling of an uninsulated house?

25% to 35% in both summer and winter.

Question 7

What are the two main categories of insulation? Give one example of each.

Bulk insulation such as glass wool, wool, cellulose fibre, polyester or polystyrene.
Reflective insulation such as shiny aluminium laminated onto paper or foil, sarking, concertina batts or multi-cell batts

Question 8

Where is the best place to put insulation in a house?

Where there is most heat loss from the house. Ceilings lose the most heat followed by walls and floors. So if all can be insulated that would be best. (Note windows are also good conductors of heat but it is impractical to insulate these without blocking out the light.)

3.3.2 ACTIVITY: TESTING BUILDING MATERIALS

In this activity, students build a house using the white plastic wall panels in the STELR Sustainable Housing student kit and measure how quickly it heats up and then cools down. The then replace the white plastic panels with the white insulating panels and repeat the experiment.

The students record their answers on the generic student investigation sheets fount in Appendix 1.

Extension ideas:

Other materials could also be tested including the wooden panels in the STELR Sustainable Housing Teacher Kit or materials like corrugated cardboard or Corflute. These can be cut to 10cm squares using a guillotine.

Students could also experiment with shining the lamp onto one of the walls of the house instead of into the window.

In this activity you will test the effectiveness of two different types of wall panels to determine how they are at insulating a house. The wall panels you will be using are the white plastic panels and the white insulating panels.

Materials

- STELR house cube
- STELR clear plastic window panel
- 4 x white insulation panels
- 4 x white plastic panels
- STELR temperature sensor panel
- STELR temperature logger
- connecting cables
- STELR power supply
- STELR lamp
- STELR Sustainable Housing student investigation sheets for recording your results
- STELR Sustainable Housing Placement template (optional)

Risk assessment

Complete the following risk assessment.

Fact	Risk	Precaution
Halogen lamp gets very hot	Burning your hand	Turn off the lamp when not in use
Students may think of another here		

Variables

In any experiment, it is essential to know what the variables are, and to control them appropriately. This ensures that the experiment addresses the experiment aims and gives a meaningful result. You will need to consider the:

- **independent variable:** the variable you change to see the difference it makes;
- **dependent variable:** the variable you measure to see if/how it changes when you change the independent variable;
- **controlled variables:** other factors that you keep constant, so they don't have any impact on the dependent variable.

Identify which of the following variables are independent, dependent and controlled:

Type of wall panels | distance between lamp and house | temperature of the house | number minutes with the lamp on and off | type pf roof panel | type of floor panels | position of the heat sensor

Independent variable: Type of wall panels

Dependent variable: temperature of the house

Controlled variables: all others

WHAT TO DO

- Place the temperature sensor panel in the back wall with the sensor at the top.
- Place the plastic window in the opposite face of the cube.
- Insert a white plastic panel into the floor.
- Place white plastic panels in the side walls and on the top to make a flat roof.
- Connect the temperature sensor to the data logger.
- Place the lamp about 10cm the window, (you may use the placement template to help you)
- Turn on the lamp and the data logger at the same time.

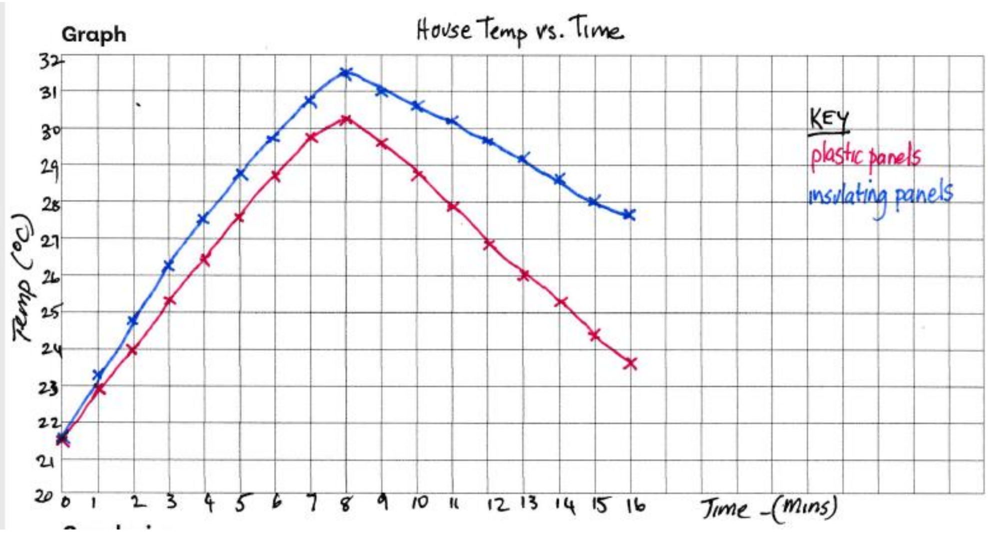
- Record the temperature every minute for eight minutes on your student investigation sheet.
- Turn off the lamp and move it away from the house. Record the temperature for a further eight minutes as it cools.
- Replace the four white plastic panels with four white insulation panels. When you are changing the panels, allow the warm air to escape from the house cube. Repeat the experiment.
- Record your results on the same student investigation sheet. Plot a graph to show the temperature against time.

RESULTS

Results will vary. The will depend on the classroom conditions (temperature, drafts, season etc.), the angle of the lamp and the distance of the lamp from the house. The results in the tables below are samples only, to give an indication of what happened in one particular instance.

Time (Mins)	Lamp On	0	1	2	3	4	5	6	7	8
Temp ° C	Plastic walls	21.5	22.9	24.0	25.3	26.4	27.6	28.7	29.5	30.2
	Insulating walls	21.6	23.3	24.9	26.3	27.6	28.8	29.8	30.8	31.6

Time (Mins)	Lamp Off	9	10	11	12	13	14	15	16
Temp ° C	Plastic walls	29.6	28.8	27.9	26.9	26.0	25.2	24.4	23.7
	Insulating walls	31.0	30.7	30.2	29.7	29.1	28.7	28.0	27.8



Question 1

Which of the two houses heated up quicker?

It would be expected that the house with the insulating panels heats up more quickly and to a higher temperature because not as much heat will be lost through the walls during the heating time.

Question 2

Which of the two houses cooled down quicker?

It would be expected that the house with the plastic panels cools down more quickly because heat is more easily conducted out of the building by the plastic panels.

Question 3

Which wall material the better insulator.

Insulating panels

Question 4

What do you think would happen if you wrapped the wall panels in shiny foil and repeated the experiment?

This would also enhance the insulating qualities of the walls. It would be most effective if the sunlight (lamp) was directed onto a wall rather than a window.

3.3.3 ACTIVITY: DOUBLE GLAZING

This activity is similar to the previous one, but double glazing is being compared with single glazing, using the clear plastic panels in the STELR Sustainable Housing Student Kit.

Be sure to point out to students the ridged and flat sides of the clear panels so that they have them correct way to trap an air gap. For a properly air test, when testing single glazing, students should use two clear panels with the flat sides together (no air gap). In this way they are using 2 panels in both experiments and the only independent variable is the air gap (and not also the number of clear panels used).

The students record their answers on the generic student investigation sheets fount in Appendix 1.

Extension ideas:

There are 3 clear panels in each STELR Sustainable Housing Student Kit so students could test the effectiveness of triple glazing.

Students could also experiment with shining the lamp onto one of the walls of the house instead of onto the window.

In this activity you will test the effectiveness of trapping air between two plastic window panels to simulate double glazing. The window panels have a ridge on one side and are flat on the other side. If two window panels are placed together with the ridges facing inwards (ridge to ridge) air is trapped between them. If the panels are placed with the flat sides facing each other, no air is trapped.

Materials

- STELR house cube
- 2 x STELR clear plastic window panels
- 4 x white plastic panels
- STELR temperature sensor panel
- STELR temperature logger
- connecting cables
- STELR power supply
- STELR lamp
- STELR Sustainable Housing student investigation sheet for recording your results
- STELR Sustainable Housing Placement template (optional)

Risk assessment

Complete the following risk assessment.

Fact	Risk	Precaution
Halogen lamp gets very hot	Burning your hand	Turn off the lamp when not in use
Students may think of another here		

Variables

In any experiment, it is essential to know what the variables are, and to control them appropriately. This ensures that the experiment addresses the experiment aims and gives a meaningful result. You will need to consider the:

- **independent variable:** the variable you change to see the difference it makes;
- **dependent variable:** the variable you measure to see if/how it changes when you change the independent variable;
- **controlled variables:** other factors that you keep constant, so they don't have any impact on the dependent variable.

Identify which of the following variables are independent, dependent and controlled:

Type of wall panels | distance between lamp and house | temperature of the house | number minutes with the lamp on and off | type pf roof panel | type of floor panels | position of the heat sensor | the orientation of the two window panels

Independent variable: the orientation of the two window panels (ridges facing in or out)

Dependent variable: temperature of the house

Controlled variables: all others

WHAT TO DO

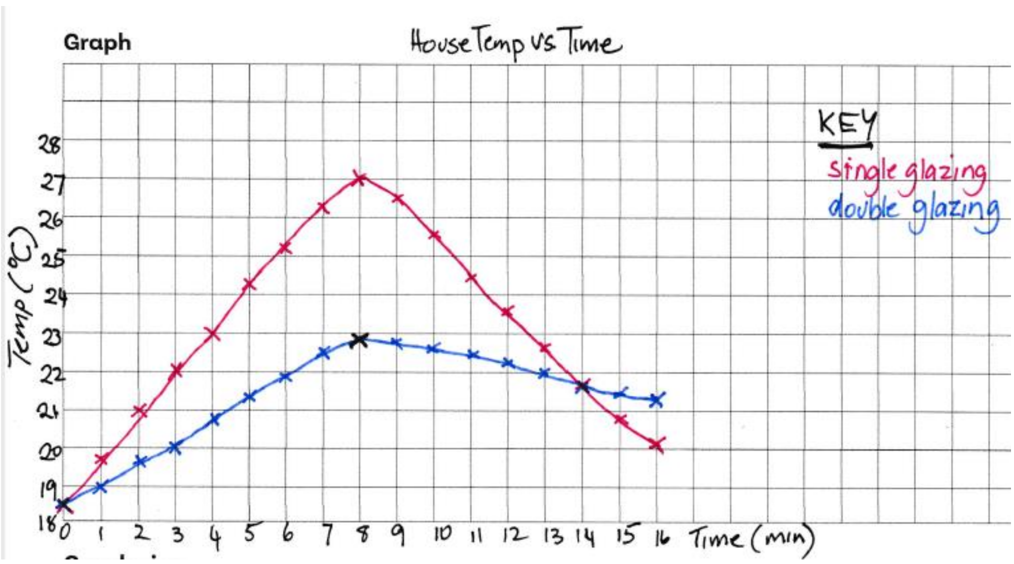
- Place the temperature sensor panel in the back wall with the sensor at the top.
- Place two plastic window panels in the opposite face of the cube ridge to ridge creating an air gap.
- Insert a white plastic panel into the floor.
- Place white plastic panels in the side walls and on the top to make a flat roof.
- Connect the temperature sensor to the data logger.
- Place the lamp about 10cm the window, (you may use the placement template to help you)
- Turn on the lamp and the data logger at the same time.
- Record the temperature every minute for eight minutes on your student investigation sheet.
- Turn off the lamp and move it away from the house. Record the temperature for a further eight minutes as it cools.
- Take out the two window panels and now put them with the flat sides together so that there is no air gap. When you are changing the window, allow the warm air to escape from the house cube. Repeat the experiment.
- Record your results on the same student investigation sheet. Plot a graph to show the temperature against time.

RESULTS

Results will vary. The will depend on the classroom conditions (temperature, drafts, season etc.), the angle of the lamp and the distance of the lamp from the house. The results in the tables below are samples only, to give an indication of what happened in one particular instance.

Time (Mins)	Lamp On	0	1	2	3	4	5	6	7	8
Temp ° C	Single glazing	18.3	19.8	21.0	22.0	23.0	24.1	25.1	26.2	27.0
	Double glazing	18.4	19.0	19.7	20.0	20.8	21.3	21.9	22.5	22.9

Time (Mins)	Lamp Off	9	10	11	12	13	14	15	16
Temp ° C	Single glazing	26.5	25.5	24.4	23.6	22.7	21.8	20.9	20.1
	Double glazing	22.8	22.7	22.5	22.2	22.0	21.8	21.5	21.3



Question 1

Which of the two houses heated up quicker?

The one with the single glazing

Question 2

Which of the two houses cooled down quicker?

The one with the single glazing

Question 3

What do you think would happen if you used three plastic window panels to make triple glazing?

It would be expected that triple glazing would be even more effective than double glazing as there is twice as much air trapped and it would be like having two separate layers if insulating air.

3.4 CONVECTION

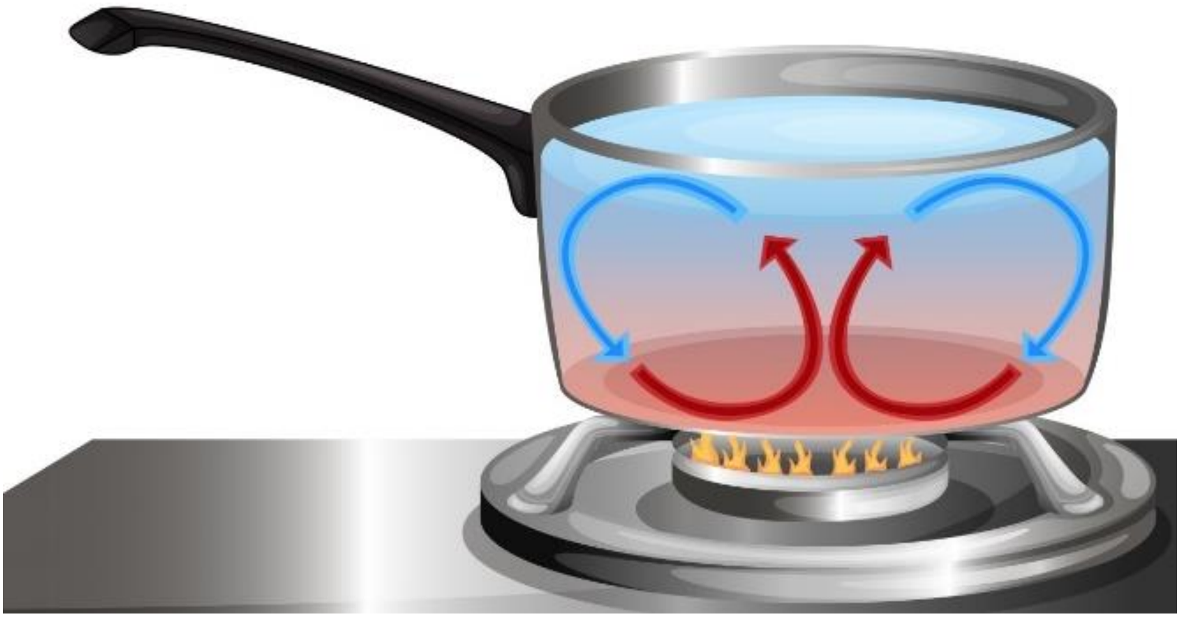
KEY QUESTIONS

- What is convection?
- How can we use convection to make our homes more sustainable?

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.

In the same way, convection currents can move air around your home.



3.4.1 LESSON: HOT RISES, COOL FALLS

Convection only takes place in fluids (liquids and gases). In this lesson, students watch two short videos to gain a better understanding of convection and convection currents. The first video shows how a lava lamp works, depicting convection in two immiscible liquids. The 'lava' bubbles, when heated, expand, become less dense and rise up the lamp. When they cool slightly at the top of the lamp, they contract, becoming denser and fall to the bottom.

Convection in a saucepan of water or in a room full of air is slightly different in that there is only on fluid. This means that the hot water or air will eventually mix with the cold water or air. This can be seen in the second video, where the hot water at the bottom rises and the cold water at the top falls and the two lots of water mix together and the temperature equilibrates.

The same thing happens in a room with a heater on the floor. The heated air will rise, pushing down cols air that will be, in turn, heated. Eventually all the air in the room will mix together giving a more even room temperature.

Watch the video and answer the following questions.

VIDEO **Convection in Lava Lamps**

www.youtube.com/watch?v=DL3Ez9bxMTo

This video I not realted to these questions!!!!

Question 1

Convection takes place in:

☑ liquids and gases.

☐ solids only.

☐ liquids only

☐ gases only.

Question 2

When a fluid is heated, it tends to:

☑ expand and become less dense so it rises.

☐ become denser and rise

☐ become denser and sink.

☐ expand and become less dense so it sinks.

Now watch this video

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

Question 3

What colour was the cold water?

Blue

Question 4

What colour was the hot water?

Yellow

Question 5

Explain what you think happened when the hot water was placed on top of the cold water.

The colours only mixed a little bit where the two bottles met in the middle. You could tell by the small green patch where blue and yellow had mixed. The yellow hot water mainly stayed in the top bottle and the blue cod water mainly stayed in the bottom bottle. Cold water is denser than hot water so it stayed at the bottom. Hot water is less dense than cold water so it stayed floating on top of the cold water.

Question 6

Explain what you think happened when the cold water was placed on top of the hot water.

The blue cold water was denser than the yellow hot water, so it sank down and the less dense yellow hot water rose up, causing the hot and cold water to quickly mix. Both bottles were green fairly quickly.

Question 7

Explain what you think would happen to the movement of air in a cold room when you turn on a floor heater.

The heater is on the floor so it will warm up the air at the bottom of the room near the heart. This air will become less dense and rise, pushing the cold air above it down towards the floor. This will start up a convection current of air circulating around the room.

3.4.2 ACTIVITY: AIR LEAKAGE AND CONVECTION

This activity is examines the effect of convection when there are air gaps in a house. Air caps could include an open window, poorly sealed doors and windows or small cracks in the structure of the house. (Most commonly where the walls meet the floor or cracks between floor boards. Older houses may also have vents high up in the walls which were used to prevent condensation in the wall cavity.)

Each group of students will need to make two wall panels from stiff card or corrugated card. Teachers may choose to pre-cut these using a guillotine or students can cut them themselves.

After the first part of the experiment is completed, students cut a small piece of one corner of each cardboard wall and reinsert the walls so that one has a small hole at the bottom and the opposite wall has a small hole at the top.

The students record their answers on the generic student investigation sheets fount in Appendix 1.

Results should reinforce the lessons learnt from the video below in lesson 3.2.4.

As well as discussing window placement and orientation, the architect talks about cross ventilatio and the number of air changes in an average house. A well designed house is well sealed to minimise air changes in winter, but has the capapbility of beining opened up in summer to promote cross ventilation.

VIDEO **House and Window Design and Orientation**

www.youtube.com/watch?v=_4_IHSBGUr0

Extension ideas:

Try having both air gaps at the top of opposite walls or both air gaps at the bottom of opposite walls.

Experiment with different sized holes.

Try only one hole and one solid wall.

Try the same experiment, but use the STELR floor heater panel as the heat source instead of the STELR lamp.

Sealing your home against air leakage is one of the simplest ways you can increase your comfort while reducing your energy bills and carbon emissions by up to 25%.

Air leakage accounts for 15–25% of winter heat loss in buildings and can contribute to a significant loss of coolness in climates where air conditioners are used.

In this experiment you will investigate how air leakage disrupts the convection currents inside a house by deliberately designing a house which is not airtight.

Materials

- STELR house cube
- STELR clear plastic window panel
- 2 x white insulation panels
- STELR temperature sensor panel

- Stiff card
- Scissors
- STELR temperature logger
- connecting cables
- STELR power supply
- STELR lamp
- STELR Sustainable Housing student investigation sheet for recording your results
- STELR Sustainable Housing Placement template (optional)

Risk assessment

Complete the following risk assessment.

Fact	Risk	Precaution
Halogen lamp gets very hot	*Burning your hand*	**Turn off the lamp when not in use**
Students may think of another here (for example: scissors are sharp)	*Cutting your self*	**Use scissors with care**

Variables

In any experiment, it is essential to know what the variables are, and to control them appropriately. This ensures that the experiment addresses the experiment aims and gives a meaningful result. You will need to consider the:

- **independent variable:** the variable you change to see the difference it makes;
- **dependent variable:** the variable you measure to see if/how it changes when you change the independent variable;
- **controlled variables:** other factors that you keep constant, so they don't have any impact on the dependent variable.

Identify which of the following variables are independent, dependent and controlled:

Type of wall panels | distance between lamp and house | temperature of the house | number minutes with the lamp on and off | type pf roof panel | gaps in the wall panels | type of floor panels | position of the heat sensor | the orientation of the window panels

Independent variable: gaps in the wall panels

Dependent variable: temperature of the house

Controlled variables: all others

WHAT TO DO

- Cut two 10cm squares from the stiff card to make the side walls of the house
- Place the temperature sensor panel in the back wall with the sensor at the top.
- Place the plastic window panel in the opposite face of the cube.
- Insert a white insulation panel into the floor.
- Place a card square into each of the side walls in the side walls.
- Place an insulating panel in the roof.
- Connect the temperature sensor to the data logger.
- Place the lamp about 10cm the window, (you may use the placement template to help you)
- Turn on the lamp and the data logger at the same time.
- Record the temperature every minute for eight minutes on your student investigation sheet.
- Turn off the lamp and move it away from the house. Record the temperature for a further eight minutes as it cools.
- Take out the two card walls. Cut off one corner of each. Allow the warm air to escape from the house cube. Place the walls so that the cut-off corner is at the bottom on one side and at the top on the opposite side. Repeat the experiment.
- Record your results on the same student investigation sheet. Plot a graph to show the temperature against time.

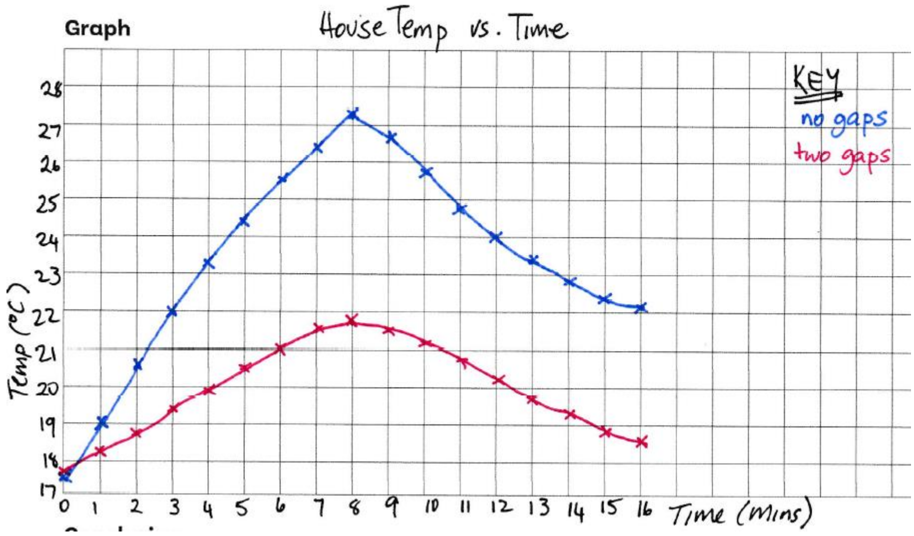
RESULTS

Results will vary. The will depend on the classroom conditions (temperature, drafts, season etc.), the angle of the lamp and the distance of the lamp from the house, the type of cardboard used for the walls and the size of the holes made for the air gaps. The results in the tables below are samples only, to give an indication of what happened in one particular instance.

Time (Mins)	Lamp On	0	1	2	3	4	5	6	7	8
Temp ° C	No gaps	17.5	19.0	20.6	22.0	23.2	24.4	25.5	26.4	27.3
	Two holes	17.7	18.2	18.8	19.4	19.9	20.5	21.0	21.5	21.8

Time (Mins)	Lamp Off	9	10	11	12	13	14	15	16
Temp ° C	No gaps	26.7	25.8	24.8	24.0	23.4	22.8	22.4	22.1
	Two holes	21.5	21.1	20.8	20.2	19.8	19.3	18.9	18.5

Graph



Question 1

Which of the two houses heated up quicker?

It is expected that the properly sealed house will heat up more quickly because as the air inside is heated, it stays in the house.

Question 2

Which of the two houses cooled down quicker?

It is expected that the house with the air gaps will not have warmed up as much and that it will cool down quicker as the cool air is drawn in at the bottom to replace the warm air escaping at the top.

Question 3

Discuss these results with your group and explain how your results could be used to make a more sustainable home in summer and winter climates.

Having a properly sealed home keeps in warm in winter. The warm air is trapped in the house. If there are air gaps, the warm air will escape and draw in the colder outside air.
In summer it is good to be able to open windows on the opposite side of the home so that you get cross ventilation when there is a cool breeze (especially in the morning or evening when the Sun has set.

EXTENSION

It is suggested that the following ideas could be given as an activity challenge for advanced students.

It brings together convection, conduction and radiation on one activity.

Pitched roofs and insulation.

A pitched roof encloses a roof space. An empty roof space is not really empty, it contains air which is a good insulator. So in theory, a pitched roof (with a ceiling) provides more insulation than a flat roof. However, as a roof space is warmed by the room below it on winter or the hot outside air in summer, a convection current will be set up and the warm air circulated. The roof space will quickly warm up and will conduct heat either into the house in summer or out of the house in winter.

By using bulk insulation in the ceiling, the air remains as a good insulator, but it is trapped in small pockets in the bulky material. The heat cannot circulate and has to move from one pocket of air to the next by conduction instead. As air is a poor conductor, this takes much longer than the heat movement by convection in the empty roof.

Students could design investigations to test:

- the effectiveness of a pitched roof (empty) and a flat roof
- the use of various materials inside the roof space as insulation, including:
  - cotton wool
  - wool fabric or scrunched up yarn
  - shredded paper
  - fabric wadding
  - scrunched up bubble wrap
  - packing foam
- the use of a ceramic tiled roof and a metal roof
- the use of insulating panels under metal roof panels.

4 SUSTAINABLE DESIGN

This section investigates the principles of passive design with a lesson and two activities on orientation and shading.

In this section, activities are given in less detail and students are asked to **write their own experimental design**. They can use the earlier activities in the previous section as a template.

4.1 Lesson: Orientation and Shading Students answer questions after watching a short video about how the passive design principles of orientation and shading combine to take advantage of the climate and keep a home cool in summer and warm in winter.

4.2 Activity: Summer and Winter Sun Students design an experiment to test the effect of using eaves to shade a window in summer and allow the sunlight through a window in winter.

4.3 Activity: North or South Facing House Students design an experiment to test how orientation can affect the temperature in a house.

No sample answers have been supplied for activities 4.2.and 4.3 because the answers will depend on how the students design their investigations.

The previous section investigated different materials that you can use in building a sustainable house. This section investigates how the design of a house can make it more energy efficient and sustainable for the particular climate in which it is situated.

4.1 LESSON: ORIENTATION AND SHADING

This lesson reinforces some of the concepts introduced in earlier sections through a video that looks at how the orientation of a house, in conjunction with the use of passive shading can reduce the need for heating in winter and cooling in summer.

Note that the video was designed for Australian conditions. In the Southern Hemisphere the Sun is in the northern sky. So houses should have their main living room windows facing north, The opposite is true for houses in the Northern Hemisphere.

The height of the Sun in the sky varies with the seasons. It is higher in the sky in the summer than in the winter. The amount of variation of the height between seasons depend on latitude. The variation between seasons increases the further away you are from the equator. In the tropics there is little variation. Near the poles, the variation is greatest. Passive shading works better when there is a bigger variation in the Sun’s height in the sky.

KEY QUESTIONS

- How can the orientation of a house and shading make it more sustainable?
- What is 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.

One of the elements of passive design is the way a house is its orientation.

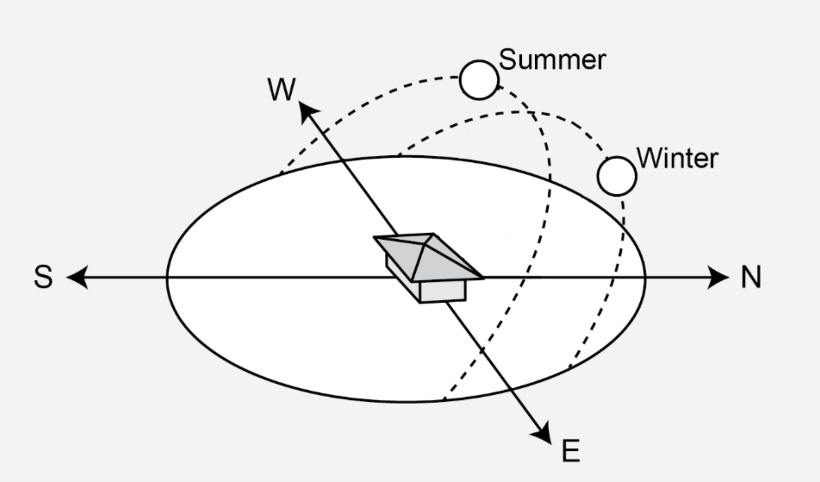
The way in which a house is facing is called its orientation.

The orientation relates to the position of the Sun in the sky in different places and at different times of the year.

This isn’t simple because the sun moves in two different ways:

- daily – across the sky from east to west;
- yearly – the daily path shifts from south to north and then back again.

So, where the sun is in the sky depends on the time of day and the time of year. It also depends on where you are on the planet.



Important: This diagram is for the southern hemisphere.

Every day, the sun goes from east to west (the dotted paths), but in summer the path is closer to the south, making the sun higher at noon (in the southern hemisphere), and in winter the path is more to the north, making the sun lower in the sky at noon.

Now watch this video

The 17 Things: Orientation and shading

https://www.youtube.com/watch?v=2JIwFDFCXrk

Question 1

What does "passive design" mean?

A way of designing a house to control how much heat is kept in the house in during winter months and out of the house during summer months. It's called passive because you don't need to do anything (except design and built the house) to get the benefits.

Question 2

What is "passive heating"?

Passive heating is natural heating from the Sun. If it can be directed into the home during winter, it is a free heating source. It reduces the need for heaters and so reduces your heating costs.

Question 3

What is the best orientation for the largest window in your living room?

In the southern hemisphere the best orientation is having the windows face True North. Or a range between 20 degrees west of True North and 30 degrees east of True North. This ensures that you are capturing the most amount of heat from the Sun.

Question 4

What happens when sunlight passes through glass?

Short waves (visible light and near infrared) of energy from the Sun can pass through glass and then be absorbed by the inside of the room and everything in it. The energy is then re-radiated as longer wavelengths (heat) which cannot be get through the glass as easily. This is called the Glasshouse or Greenhouse Effect

Question 5

How does passive shading keep the house cool in summer?

In summer, when the Sun is higher in the sky, shading over the windows stops the sunlight from entering the North-facing windows. (In the winter when it's lower in the sky, sunlight can get in through the windows.)

Question 6

What does the correct width of the shading depend on?

It depends on how high or tall the windows are. Floor to ceiling windows need wider shading than standard windows that are at about waist height.

Question 7

What does 'active shading' mean?

Active shading includes extendable awnings or adjustable louvers. They are 'active' because you have to remember to adjust them at the right time of the year or the right time of the day.

4.2 ACTIVITY: SUMMER AND WINTER SUN

This activity looks at the angle of the sun and the effect of shading or eaves to keep a house cool in summer and warm in winter. This passive design feature is most useful on more southerly region where there is greater variation in the Sun's apparent position in the sky with different seasons. It is least effective in tropical climates where the Sun is high in the sky throughout the year.

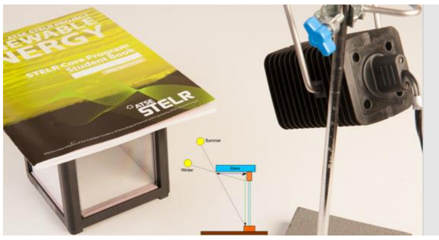
Students will have to design their own experiment.

Students use a retort stand and clamp to alter the angle of the Sun.

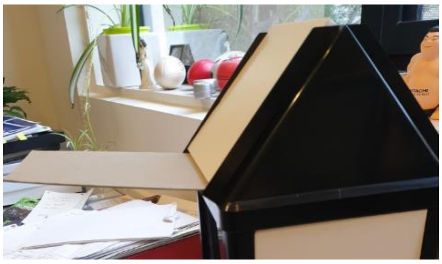
They will also have to think about how to put eaves onto the house. Note that the material for the eaves is not in the Equipment list.

There are two suggestions below:

Using a large book or piece of card in a flat-roofed version of the house like this:



Or folding a smaller piece of card and slotting it into the STELR roof like this and then putting a roof panel over the top:



Extension ideas:

Try different sized eaves and different Sun angles.

KEY QUESTIONS

- How does the angle that sunlight strikes a house affect the temperature inside the house?

- Can the design of eaves over widows keep a house cooler in summer and warmer in winter

In this activity, you will investigate how the angle of the sun influences temperature. Use the STELR sustainable house to model the effect of the Sun's radiation in summer and winter.

Materials

- STELR house cube
- STELR clear plastic window panel
- 4 x white insulation panels
- STELR temperature sensor panel
- STELR temperature logger
- connecting cables
- STELR power supply
- STELR lamp
- retort stand and clamp
- STELR Sustainable Housing student investigation sheet for recording your results

Use the retort stand and clamp to alter the angle of the Sun from 60° in the summer to 30° in the winter.

DESIGN AND RUN THE EXPERIMENT

Write up your experiment.

You must include:

- aim;
- hypothesis;
- method (consider including diagrams or photographs of your setup);
- risk assessment;
- variables (note: it is important to keep all variables except the independent variable at the same levels, to make your test fair);
- results, presented clearly (use the Sustainable Housing student investigation sheet)
- conclusion (addressing the aim)

Important! Have your teacher check your preparation before you carry out the experiment.

Now test the effect of adding eaves to shade the window from the summer Sun. You will have to think about how to construct the eaves and put them in place.

DISCUSSION

Did you results agree with your hypothesis? If so, repeat the hypothesis here. If not, describe how the results differed. Can you explain the results?

Assess the experiment that you carried out. For example, did it go well and do you think it was a fair test? (Reasons might be that the basic design was flawed or you had practical difficulties carrying it out.

Answers will vary

Write a conclusion for you experiment.

This will depend on the original hypothesis and the results.

4.3 ACTIVITY: NORTH OR SOUTH FACING HOUSE

Orientation is a passive design feature. In the southern hemisphere it is recommended that the windows in the main living area face North as the Sun is in the northern half of the sky. In this activity students design an experiment where they change the orientation of the house with respect to the Sun (lamp) to see how this affects its temperature in both summer and winter.

Students will have to design their own experiment.

In most experiments the temperature sensor panel has been placed opposite the window. In this case, if students want to test firstly and north facing window (by having the light shine into the window) and then rotate the house 180 degrees so that the window is on the opposite side of the light, then the light will be shining directly onto the sensor panel. This will not truly measure the temperature inside the house. In designing the experiment students should consider having the temperature sensor panel opposite the light source (and in some cases adjacent to the window).

KEY QUESTION

- How does the orientation of a house affect the temperature inside the house in both summer and winter?

In this activity, you will investigate how the orientation of a house affects the temperature.

Using similar equipment as in the previous experiment, design and experiment to test the difference between having north facing or south facing windows in your house.

DESIGN AND RUN THE EXPERIMENT

Write up your experiment.

You must include:

- aim;
- hypothesis;
- materials
- method (consider including diagrams or photographs of your setup);
- risk assessment;
- variables (note: it is important to keep all variables except the independent variable at the same levels, to make your test fair);

- results, presented clearly (use the Sustainable Housing student investigation sheet)
- conclusion (addressing the aim)

Important! Have your teacher check your preparation before you carry out the experiment.

DISCUSSION

Did you results agree with your hypothesis? If so, repeat the hypothesis here. If not, describe how the results differed. Can you explain the results?

Assess the experiment that you carried out. For example, did it go well and do you think it was a fair test? (Reasons might be that the basic design was flawed or you had practical difficulties carrying it out.

Answers will vary

Write a conclusion for you experiment.

The conclusion will depend on the initial hypothesis and the results.

4.4 PROJECT: SUSTAINABLE HOUSING

This project is intended as a substantial one, with students carrying out their own research, writing (drawing, assembling) their content, and making a presentation to the class. We suggest giving students some weeks for it – they can be working on it while you progress through other, earlier sections of this unit.

- We suggest students work in groups of three or four.
- We suggest each group does a class presentation of their work. Beyond this, we leave it to individual teachers what they will require as to written work, files, or posters, etc.

Note that students will have found out some information about Sustainable Housing in the previous sections – students should do more than simply reproduce the content covered there. On the other hand, weaker students might benefit from having the information presented here to get them started.

Research one of the sustainable housing features and make a presentation of your findings to the class.

Work in groups of three or four. Each group should investigate a different feature.

These could include:

- PV (photovoltaic) panels ('solar panels')
- solar water heating
- geothermal heating
- rammed-earth houses
- straw-bale houses
- different types of insulation materials used in building
- 'switchable' windows that can be turned to opaque
- green roofs (living roofs)
- the use of skylights
- building materials and their embodied energy
- the most energy efficient heating or cooling systems
- The Nationwide House Energy Rating Scheme (NatHERS)

WHAT TO FIND OUT

What is the science and technology behind the feature?

- How does this feature work?
- When was it invented or when did it first come into use?
- How does it make a house or building more sustainable?
- How commonly used is the feature?
- What sort of cost is involved?

HOW TO PRESENT YOUR PROJECT

The main product of your project is the class presentation, but upload any files that you use in the project space below:

- copy text into the text widget, so your teacher can read it in Stile;
- upload presentation files (e.g. PowerPoint) with the files and media widget;
- upload photographs of posters, models or other static material;
- if possible, upload a video of your presentation.

Think about the best way to present your information so that it engages your audience. For example, use:

- photographs;
- diagrams, models, flow charts and maps;
- tables and graphs of data;
- video clips;
- posters;
- your own recordings of interviews and site visits;
- a PowerPoint presentation.

RESOURCES YOU CAN USE

- experts in the field – it will help your project a lot if you can ask someone working in the industry questions about it;
- see the subject resources menu on the STELR website; and
- books and/or websites, but be sure to use trustworthy sites. Ask your teacher if you are not sure.

Important: You must include a bibliography, showing where you got all your information.

Answer the following question after you have seen all the other project presentations for your class.

Question 1

You should have learned a lot about your Sustainable house feature and quite a bit about other resources as well from other students' presentations.

What more would you like to find out about sustainable housing?

Answers will vary

5 OPEN INQUIRY

As much as possible encourage students to come up with their own ideas to investigate.

Some possibilities are listed below in the student book.

Other ideas are found on the *Sustainable Housing Kit Enquiry* Ideas video on the STELR Sustainable Housing USB. The video can also be found here:

Sustainable Housing Kit Enquiry Ideas

https://australiascience.tv/episode/stelr-sustainable-housing-kit-inquiry-ideas/

https://www.youtube.com/watch?v=RJgI9-hyDVQ

The students could also look at:

- The effect of using window panels to make a skylight.
- The difference between having a pitched roof with and without a ceiling
- Using windows on several walls rather than just one wall
- The use of local indigenous materials such as bark or bamboo as building materials

- Simulating a green roof using moss and soil
- ‘Burying’ part of the house into a ‘hillside’ of sand, soil or clay to provide better insulation

In groups, conduct your own investigation with the STELR Sustainable Housing equipment.

There are some suggestions below, but try to think of your own ideas. Of course, you will have to agree on your investigation as a group.

You must design, conduct and report on your investigation, using the same format as in previous experiments.

Important: Get permission from your teacher before you carry out your experiment.

Possible inquiry questions:

- How do different window materials perform in different climates?
- Different wall materials (cut your own) or roof materials
- Different paint colours on interior or exterior walls (use square paint samples from the hardware store)
- Why are houses often on stilts in warm climates?
- Are houses that are attached to each other (units or terrace houses) or above each other (multistorey apartments) more energy efficient than free-standing houses?
- Is a pitched roof more energy efficient than a flat roof?
- What is the effect of using a ceiling fan in summer or winter?

PLAN, CARRY OUT AND REPORT

First, plan your experiment. You will need to include enough information in your plan to convince your teacher that you are ready to go ahead. Use the investigation planner on the following page.

When you have permission, carry out the experiment. It may not work properly straight away – you may need to change materials and/or procedure before you take your data readings.

Finally, record your data and present it in a meaningful way. Then discuss what it shows.

In your final report, make sure you include:

- inquiry question (also, because this is your own question, include any background discussion to explain why you are interested in this question);
- aim;
- hypothesis;
- variables;
- materials;
- procedure;
- risk assessment;
- data table and, if appropriate, a graph;
- discussion, including:
    - c) how the experiment went, including any problems encountered and whether they were overcome;
    - d) if the results agreed with your hypothesis;
- conclusion.

INVESTIGATION PLANNER

What are you investigating?	
What are you going to investigate?	What do you think will happen? Explain why.
What is your hypothesis?	What is the aim of your investigation?
Designing your experiment	
What variables might affect the outcome of your investigation?	What variable(s) will you test?
How will you make your tests fair?	What observations and measurements will you need to take?
How will you ensure that your measurements are reliable?	What calculations (if any) will you need to make?
What risks might there be? What safety precautions do you plan to take?	What materials and equipment will you need?

Your results	
How will you record your observations and measurements?	What graphs can you draw? What spreadsheets can you design to display your results?
Conducting your investigation	
Once your teacher has approved your plans and you have the materials, conduct your investigation. Record how the investigation was performed. Include any modifications that you made and why you made them.	
Analysing your results: your conclusions	
Examine your results. Use them to answer your aim.	From your conclusions, were your predictions and hypothesis correct? Does your hypothesis need to be modified? Discuss.
Evaluating the investigation	
How reliable do you think your results were? Discuss.	How could you modify your procedure to make your results more reliable?
If you were given the opportunity, what further investigation would you carry out to build on what you learned from the investigation?	

6 STEM AT WORK

STELR Career Profiles, Sustainable Housing
https://stelr.org.au/stem-at-work/career-profiles-sustainable-housing/

This lesson gives students an insight into some careers in STEM-related fields – specifically buildings and sustainability. We ask them to consider two career profiles:
Davina Rooney (video) and one other from a selection on the STELR web site (text) or they could interview a family member of friend in the building industry, if appropriate.
Students answer basic questions about the roles then consider questions intended to make them think about how engineering contributes to society and about their own ambitions and skills.
Some of the questions would be good for class discussion.

Davina mentions in her video about her time at the Druk White Lotus School as being 'life changing'. You can find out more about that project here:

Arup – Druk White Lotus School

https://www.arup.com/projects/druk-white-lotus-school

There are many careers in STEM-related fields (science, technology, engineering and mathematics) – and not always as scientists, technicians, engineers or mathematicians. Renewable energy is a particular growth area.

Watch the video below and choose one person from the STELR *Career Profiles, Sustainable Housing* web page. Then answer the questions that follow.

Davina Rooney, Civil Engineer
https://stelr.org.au/career_profiles/davina-rooney/

STELR Career Profiles, Sustainable Housing
https://stelr.org.au/stem-at-work/career-profiles-sustainable-housing/

Question 1

Fill in some basic information about Sheena and the person you chose from the STELR website.

	Person 1	**Person 2**
Name	Davina Rooney	
Organisation & what it does		
Role		
High school subjects		
Other qualifications		
Job duties		

What they like about the job		

Question 2

In the video, Davina talks about a volunteer project building the Druk White Lotus School in the Indian Himalayas as being 'life changing'.

- What do you think this term means?

Answers will vary

Question 3

All of the people profiled carry out a variety of tasks within their jobs, often mixing fieldwork, office work on the computer, and liaising with a diverse range of people.

- From the two profiles that you have looked at, which type of task would you like best?

How could you train yourself to be better at this type of task?

Answers will vary

Question 4

Do you think there will still be jobs like the two you have looked at in 20 years? If not, do you think your two career profile people will be well equipped to adapt? Explain.

https://www.arup.com/projects/druk-white-lotus-school

GLOSSARY

Word or term	Meaning

Print this page at 'actual size' — do not scale to fit the page as this will shrink the template. Place the cube (house) directly in front of the lamp. There should be 11cm between the edge of the cube and the bulb (inside the lamp hosusing).

STELR

stelr.org.au

INVESTIGATION

SUSTAINABLE HOUSING

GROUP	
MATERIAL BEING TESTED	
DISTANCE TO LAMP	

Heating up

TIME minutes											
TEMP °C											

Cooling down

TIME minutes											
TEMP °C											

Graph

Conclusion

APPENDIX 2 EQUIPMENT

2.1 STELR Sustainable Housing Equipment photos

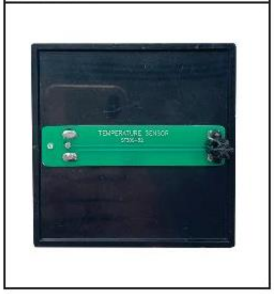
SUSTAINABLE HOUSING EQUIPMENT ITEMS & PART NUMBERS

Temperature logger
ST 301-80

Spring loaded cube
ST 300-40

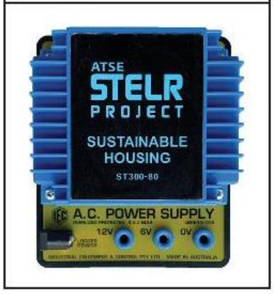
Roof unit
ST 300-50

Temperature sensor panel
ST 300-52

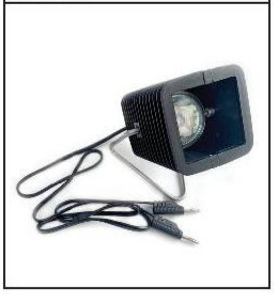


Contact temperature sensor
ST 300-53

12V Power supply
ST 300-80



50W lamp
ST 300-61



Panel with fan
ST 300-65

Plastic wall panel
ST 301-65

Polystyrene wall panel
ST 300-85

Perspex window panel
ST 301-70

Wall frame panel
ST 301-60

Floor heating panel
ST 300-60 & 61

Student kit
ST 300-01

Teacher kit
ST 310-01

2.2 STELR parts list

STELR, Sustainable Housing Temp. Logger, Dual,(no sensors or cables)	ST301-80
STELR, Sustainable Housing House Cube	ST300-40
STELR, Sustainable Housing House Roof	ST300-50
STELR, Sustainable Housing Power Supply 0-6V-12V AC	ST300-80
STELR, Sustainable Housing Heater Panel	ST300-60
STELR, Sustainable Housing Heater Clamp	ST300-61
STELR, Sustainable Housing Black Plastic Panels	ST301-65
STELR, Sustainable Housing Perspex Window Panels	ST301-70
STELR, Sustainable Housing Frames	ST301-60
STELR, Sustainable Housing Motor and Fan Panel	ST300-65
STELR, Sustainable Housing heating Lamp	ST300-61
STELR, Sustainable Housing Panel ,Foam Insulation Panels (Set/4)	ST300-85
STELR, Sustainable Housing Dual Temp Data Logger	ST301-80
STELR, Sustainable Housing Logger Power Cable	ST300-20
STELR, Sustainable Housing Sensor Cable (RCA)	ST300-25
STELR, Sustainable Housing USB Cable	ST300-30
STELR, Sustainable Housing Temp Sensor Panel	ST300-52
STELR, Sustainable Housing Touch Sensor	ST300-53

APPENDIX 3 USING THE LOGGER

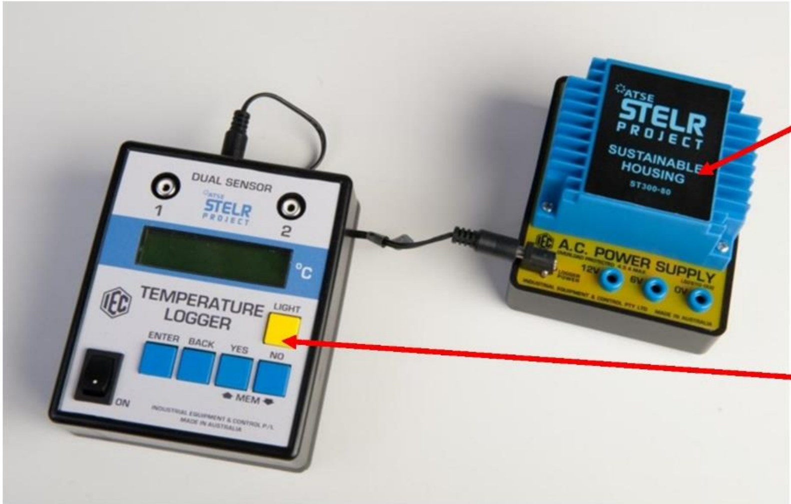
How to use the STELR Sustainable Housing Temperature Logger

This document contains the following instructions:

1. Setting up the temperature logger and recording temperatures
2. Transferring data from the temperature logger to a PC
3. Transferring data from the temperature logger to a Mac

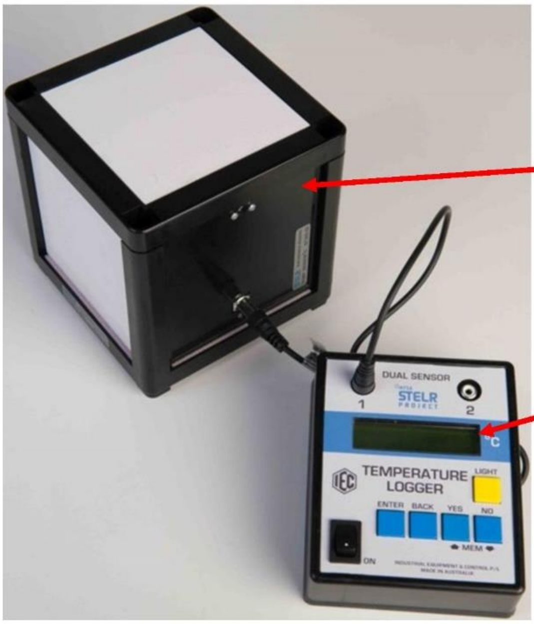
1. Setting up the temperature logger and recording temperatures

Step 1



Step 2

Connect the temperature logger to one (or two) of the temperature sensor panels using the long black cable(s).



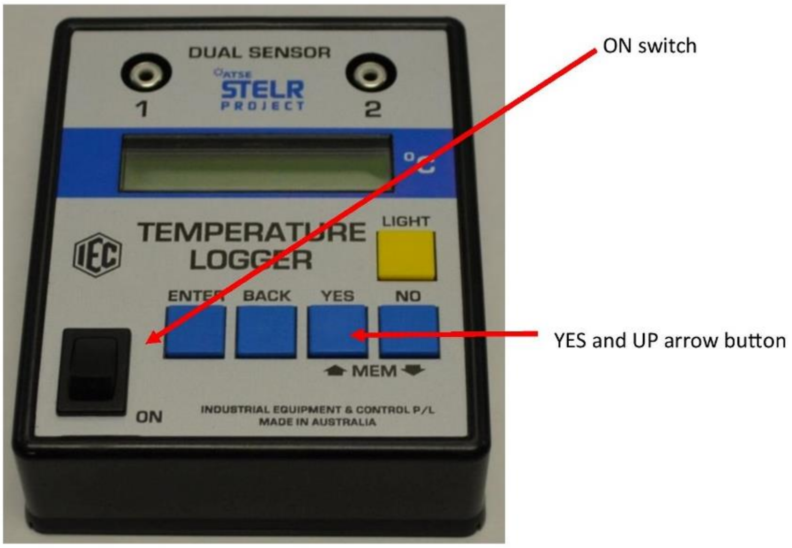
Step 3

Turn on the power supply.

(Note that the temperature logger also has a battery back-up. I is powered by one 9V battery). Use the power source where possible to maintain battery life).

Step 4

Turn on the temperature logger using the black 'ON' switch.



Step 5

You will be asked: DISPLAY OR LOG DATA?

Press the YES button

(Note that the YES button also acts as the UP arrow)

Step 6

You will be asked: SELECT MEMORY?

Press the UP or DOWN button to scroll through memories 1—5.

(Note that the NO button also acts as the DOWN arrow)

Press the ENTER button to choose the memory file you want to use.

Step 7

You will be asked: RECALL EXISTING DATA?

Press the NO button and old data will be overwritten.

Step 8

You will see RUN TIME and INTERVAL displayed on the screen. The temperature logger can store up to 1200 measurements per sensor. The choices you have are:

1-second intervals for 20 minutes
2-second intervals for 40 minutes
3-second intervals for 1 hour
15-second intervals for 5 hours
1-minute intervals for 20 hours
2-minute intervals for 40 hours

Press the ENTER button to lock in your choice.

Step 9

You will be asked: OK TO OVERWRITE THIS MEMORY?

Press YES and data will immediately be recorded to the selected memory location.

Interpreting the data recording display

Indicates the time since recording commenced

Indicates that Memory 2 has been chosen to store the data

Indicates the current temperature for the sensor number 1

Indicates the current temperature for the sensor number 2

If a sensor is not being used, a default reading of –99.9 C will be displayed.

Readings from sensors 1 and 2 will be simultaneously recorded into the one chosen memory.

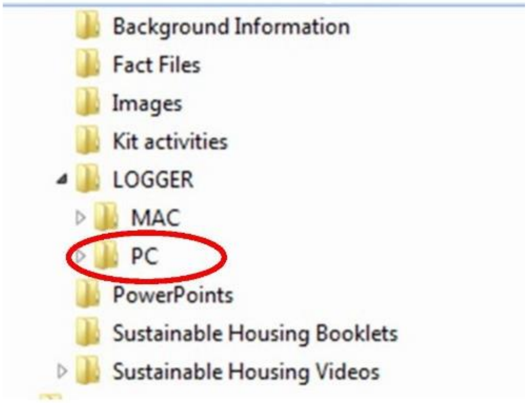
How to use the STELR Sustainable Housing Temperature Logger

2. Transferring data from the temperature logger to a PC

Step 1

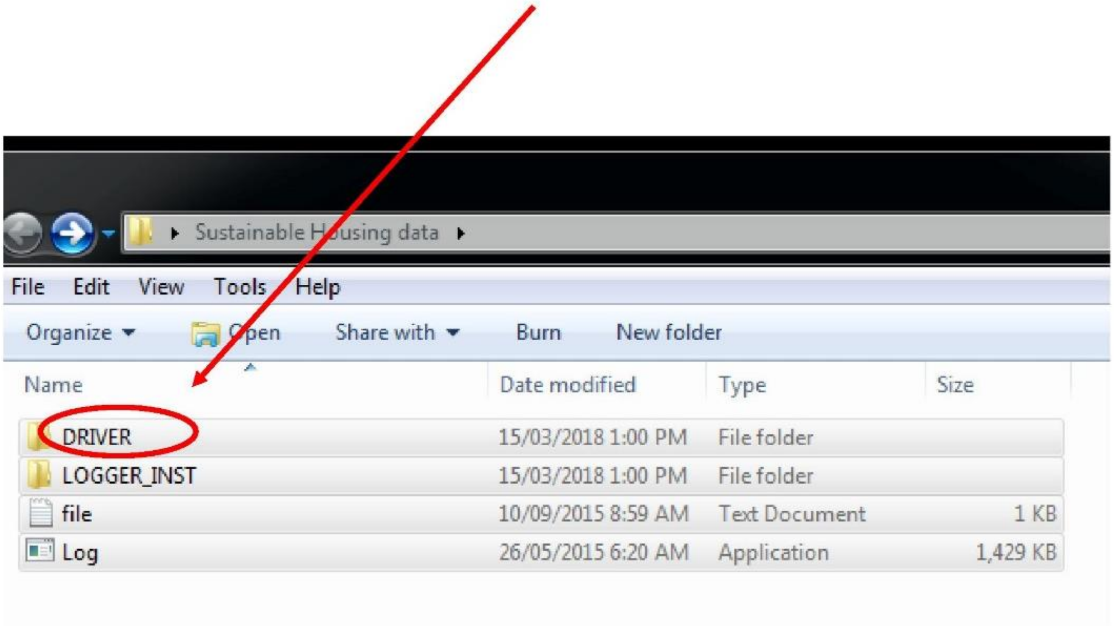
Set up a folder called 'Sustainable Housing data' on the desktop of your computer.

Plug the Sustainable Housing USB into your computer. Transfer the files from the PC sub-folder in the LOGGER folder on the USB to the Sustainable Housing Folder on your desktop.

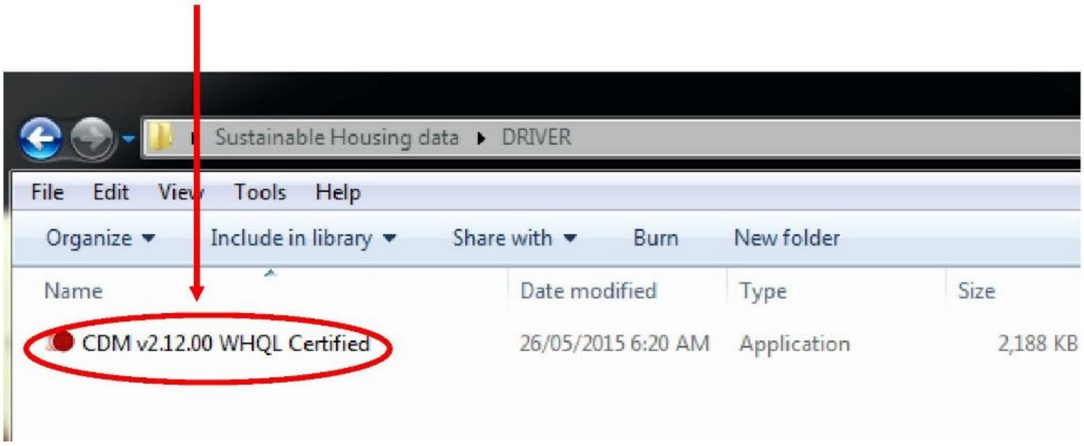


Step 2

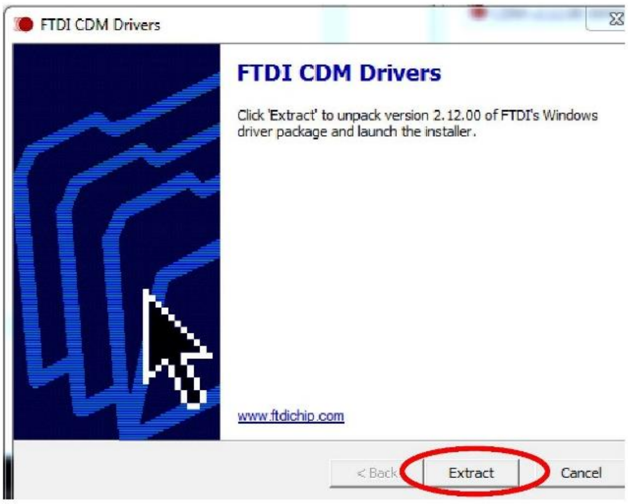
Four files should have been transferred. Open the DRIVER Folder



Right click on the CDM file and choose 'Run as Administrator'



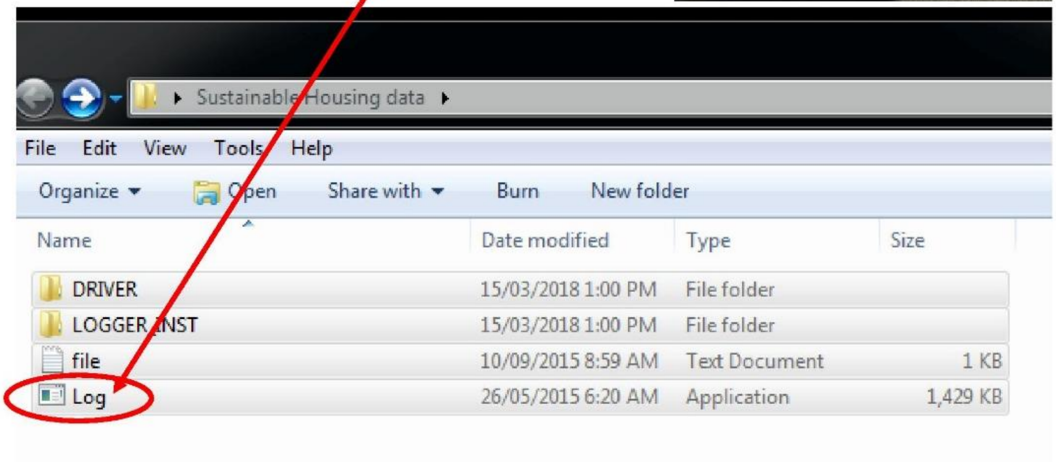
Extract the driver. When it is finished move on to the next step.



Step 3

Connect the temperature logger to a USB port in your computer using the cable provided.

Go back to the folder on your desktop and double click on the 'Log' file



This screen should appear.

Step 5

You will be asked: DISPLAY OR LOG DATA?

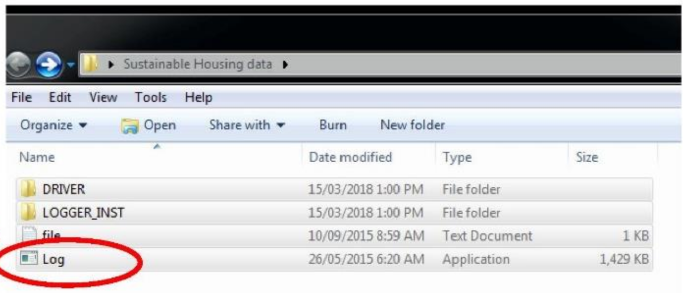
Press the NO button

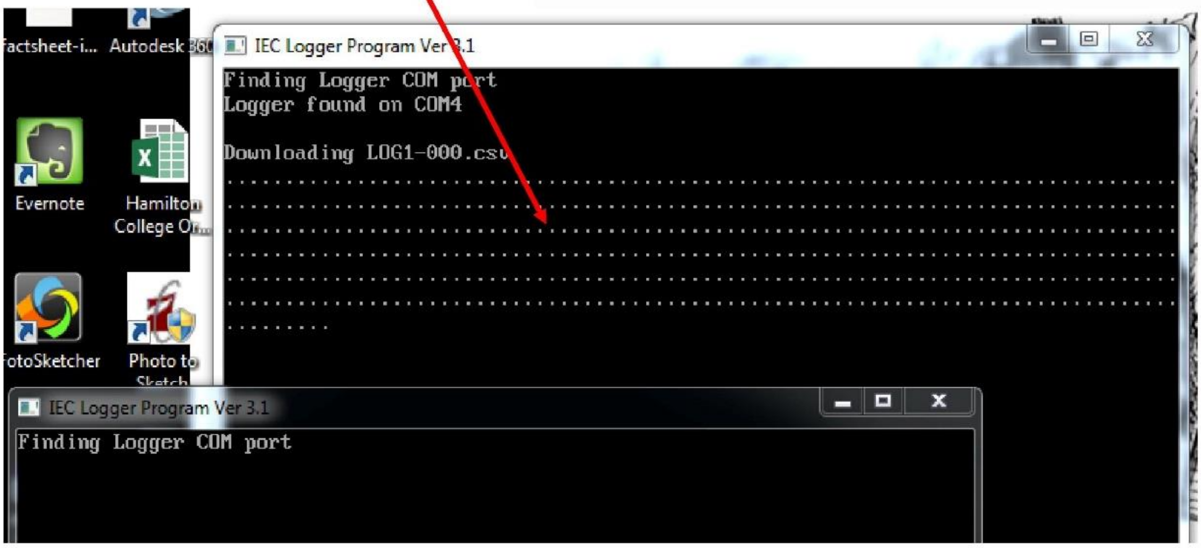
The following message will appear on the Logger screen: WAITING FOR PC EXECUTE LOG.exe

Double click on the 'Log' file **again**.

A second screen will appear. Dots will appear

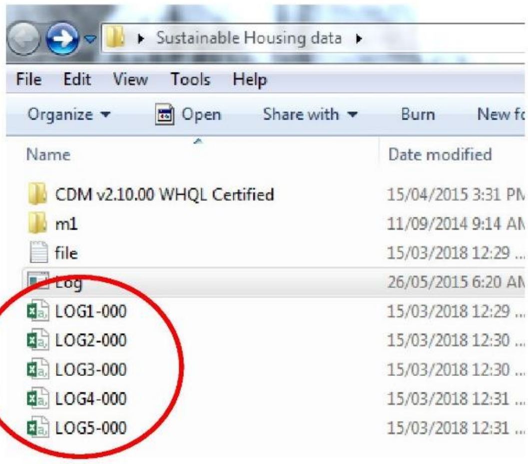
indicating that data is downloading





At the same time a message will appear on the logger screen: DATA TRANSFER IN PROGRESS.

Five Excel files (one for each memory) will be downloaded into your folder on the desktop.



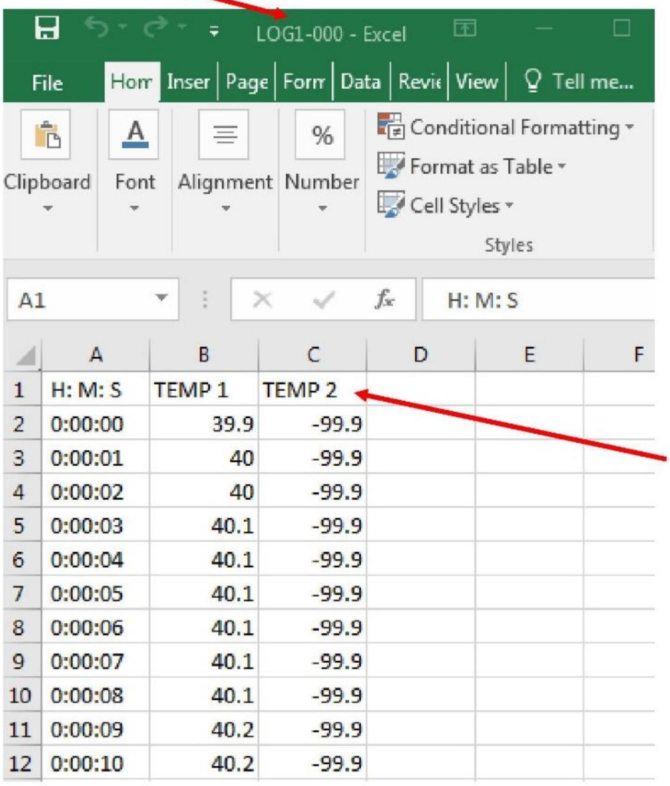
Step 6

Open the appropriate file according to which memory was used. For example , if Memory 1 was used, open LOG*-001.

For the example data shown below:

Memory 1 is shown

Data was logged at one second intervals



Only one temperature probe was used in position 1. Position 2 is showing the default temperature of –99.9C.

Finally

Rename and resave the file to avoid confusion.

Delete any unused Memory files. From your folder.

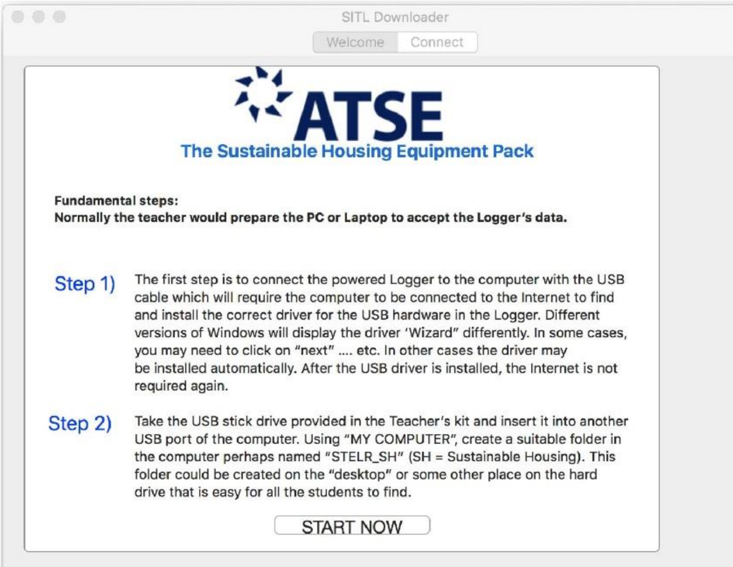
Turn off the temperature logger to save the battery.

How to use the STELR Sustainable Housing Temperature Logger

3. Transferring data from the temperature logger to a Mac

Step 1

Plug the Logger into the USB port. Make sure that the computer is connected to the internet. Open the ATSE Logger reader file. The following screen should be displayed.



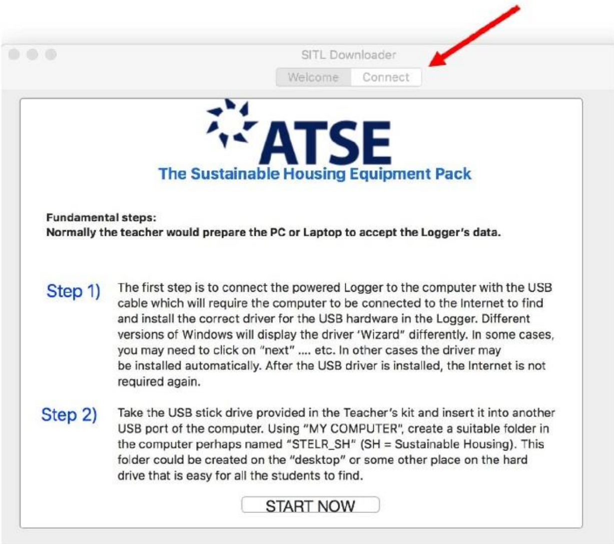
Step 2

Turn the temperature logger on. You will be asked "display or log data?" - press the "No" button.

The following message will appear on the logger screen:
"WAITING FOR PC EXECUTE LOG.exe".

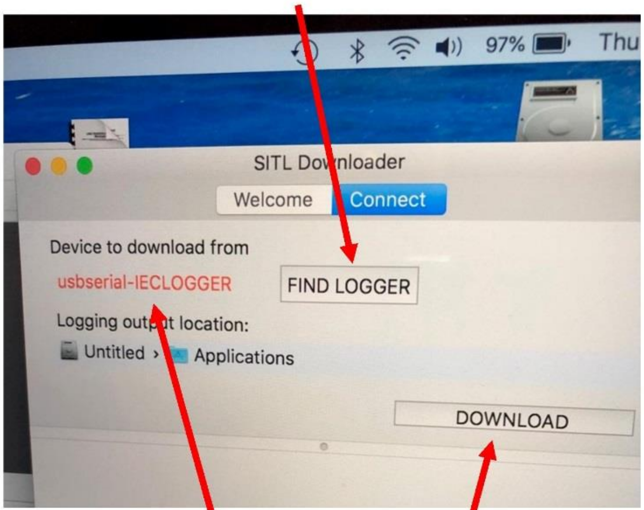
Step 3

Press the connect button at the top of the screen on your computer.



Step 4

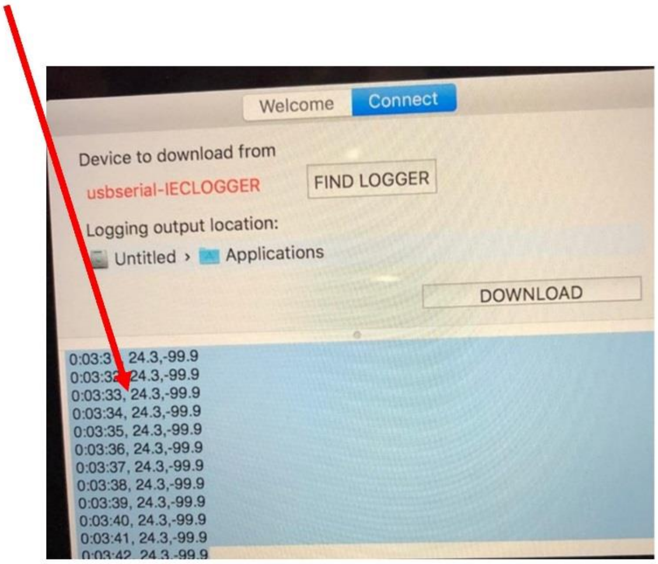
You should then see this screen. Press the FIND LOGGER button



The IECLOGGER name will then be displayed here.

Press the DOWNLOAD button which will start the process of reading data from the logger

The box below should fill with data being outputted from the logger



The data logger may give you three sets of data in one column.

If your logger gives you this:

A1 | H: M: S,TEMP 1,TEMP 2

	A	B	C
1	H: M: S,TEMP 1,TEMP 2		
2	0:00:00, 22.8,-99.9		
3	0:00:01, 22.8,-99.9		
4	0:00:02, 22.8,-99.9		
5	0:00:03, 22.8,-99.9		
6	0:00:04, 22.8,-99.9		
7	0:00:05, 22.8,-99.9		
8	0:00:06, 22.8,-99.9		
9	0:00:07, 22.8,-99.9		

And you want it to look like this:

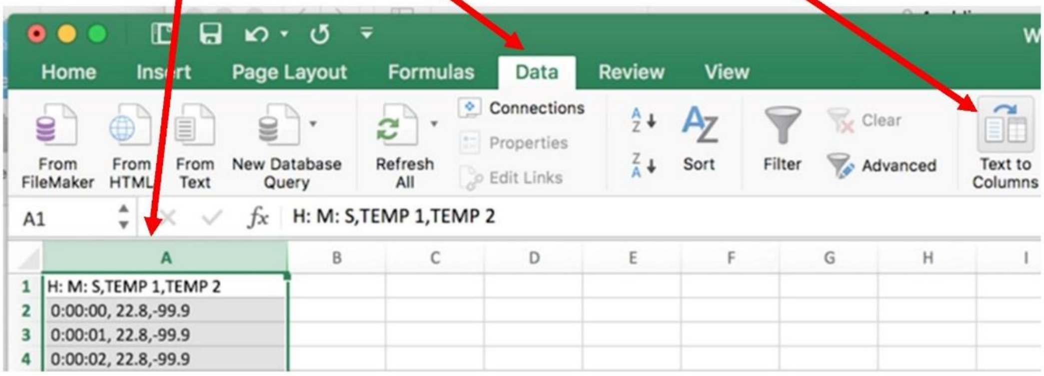
A1 | H: M: S

	A	B	C	D
1	H: M: S	TEMP 1	TEMP 2	
2	0:00:00	22.8	-99.9	
3	0:00:01	22.8	-99.9	
4	0:00:02	22.8	-99.9	
5	0:00:03	22.8	-99.9	
6	0:00:04	22.8	-99.9	
7	0:00:05	22.8	-99.9	
8	0:00:06	22.8	-99.9	
9	0:00:07	22.8	-99.9	
10	0:00:08	22.8	-99.9	
11	0:00:09	22.8	-99.9	

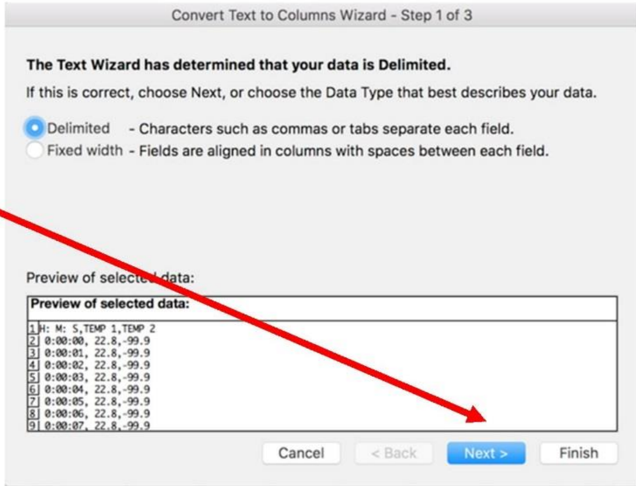
Follow the next step.

Step 5

Select the column of data and then select the data tab, then select Text to Columns

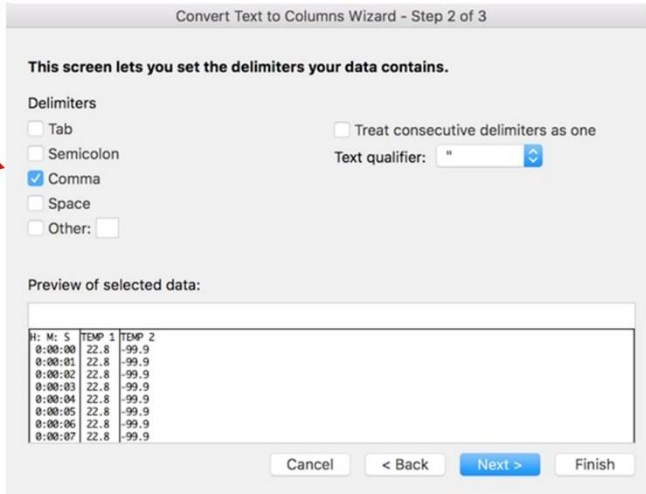


You will see this screen. Press the next button.



You will then see this screen. Select Comma and then press next.

The data should then be in three columns.



APPENDIX 4 ASSESSMENT RUBRICS

The STELR Project is not assessment-driven. However, assessment provides valuable feedback to students and helps teachers track their progress.

Following are three assessment rubrics you can copy and modify. They cover:

4.1 Science inquiry skills
4.2 Group projects
4.3 Peer assessment of presentations

ASSESSMENT RUBRIC – SCIENCE INQUIRY SKILLS

STUDENT NAME: ____ CLASS: __________

Science inquiry skill	Undeveloped	Developing	Proficient	Exemplary
Designing an experiment	The student can: • Develop a testable hypothesis with assistance. • Show some understanding of the variables operating. • With assistance can design simple fair tests and select equipment suited to the purpose.	The student can: • Develop a testable hypothesis with assistance. • Identify some variables with assistance. • Design simple fair tests and select equipment suited to the purpose.	The student can: • Develop a testable hypothesis. • Identify a number of variables and, with assistance, design an experimental investigation a procedure in which these are tested one at a time and repeat trials are conducted. • Select equipment suited to the purpose. • Suggest some ways to reduce risk in the investigation.	The student can: • Develop a testable hypothesis based on prior observations and/or secondary sources. • Design an experimental investigation, including using repeat trials and replicates, independently identifying and controlling variables and selecting equipment suited to the purpose. • Suggest a number of ways to reduce risk in the investigation that show insight into the specific risks involved.
Collection of data	The student can: • With assistance, collect data in a consistent and ethical manner, including using ICT where possible. • Use equipment and materials safely, with assistance and advice.	The student can: • With assistance, collect data in a consistent and ethical manner, including using ICT where possible. • Use a wide range of equipment and materials safely.	The student can: • Collect data in a consistent and ethical manner, including using ICT where possible. • Use a wide range of equipment and materials safely and show consideration of the safety of others.	The student can: • Collect data in a consistent, efficient and ethical manner, including using ICT where possible. • Use a wide range of equipment and materials safely and manage the working environment for the safety of self and others.
Recording and processing data	The student can: • Record some data in provided tables with accuracy. • With assistance, construct graphs with reasonable accuracy.	The student can: • Record data in provided tables accurately. • With assistance, construct graphs with accuracy. • Use simple statistical tools to process and analyse data, with assistance.	The student can: • Select and design tables and graphs for the recording and analysis of **some** data. • Record data in provided tables accurately. • Construct graphs with accuracy. • Use simple statistical tools to process and analyse data with accuracy.	The student can: • Select and design tables and graphs for the recording and analysis of data. • Record data efficiently and accurately. • Construct graphs with accuracy • Use simple statistical tools to process and analyse data with accuracy.

Science inquiry skill	Undeveloped	Developing	Proficient	Exemplary
Analysis and evaluation of data	The student can: • Draw conclusions from observations, evidence and data, and relate this to hypotheses, with assistance. • With assistance, identify sources of error in the investigation method.	The student can: • Draw conclusions from observations, evidence and data, and relate this to hypotheses and scientific concepts, with assistance. • With assistance, Identify sources of error in the investigation method.	The student can: • Draw conclusions from observations, evidence and data, and relate this to hypotheses and scientific concepts. • Identify sources of error in the investigation method and suggest specific improvements that would reduce error.	The student can: • Draw conclusions or explain interactions from observations, evidence and data, and relate this to hypotheses and scientific concepts. • Identify sources of error in the investigation method and suggest specific improvements that would reduce error. •Critique reports of investigations noting any flaws in design or inconsistencies of data.
Communication of findings	The student can: • With assistance, communicate findings using scientific language and meaningful representations and make evidence-based arguments.	The student can: • Communicate findings using scientific language with a fair degree of accuracy and using some meaningful representations. • With assistance, make evidence-based arguments.	The student can: • Communicate findings using scientific language with a good degree of accuracy and fluency, and using meaningful representations. • Make evidence-based arguments.	The student can: • Communicate findings using scientific language with a high degree of fluency and accuracy, and using meaningful representations and make evidence-based arguments.

Overall evaluation with comment/evidence:

Teacher's signature: ____

Date: __________________________

ASSESSMENT RUBRIC – GROUP PROJECTS

STUDENT NAME: ____ CLASS: __________

NAMES OF GROUP MEMBERS: ____

RENEWABLE ENERGY RESOURCE INVESTIGATED: ______________________________

Aspect	Undeveloped	Developing	Proficient	Exemplary
The science and technology behind the energy resource	The group: • Showed little evidence of suitable research. • Displayed a limited understanding of the science and technology behind their chosen renewable energy resource.	The group: • Researched this aspect to some degree. • Displayed some understanding of the science and technology behind their chosen renewable energy resource.	The group : • Researched this aspect to a reasonable depth. •Displayed a good understanding of the science and technology behind their chosen renewable energy resource and communicated this with clarity.	The group: • Researched this aspect in depth. • Displayed a thorough understanding of the science and technology behind their chosen renewable energy resource and communicated this in a logical way with clarity and fluency, including an explanation of unfamiliar terms.
The benefits and problems associated with the energy resource, and community views	The group: • Showed little evidence of suitable research. • Presented conclusions that were based on insufficient evidence and analysis.	The group : • Researched this aspect to some degree. • Applied some critical thinking skills to draw their conclusions.	The group: • Researched this aspect to a reasonable depth. • Presented some evidence-based arguments and applied some critical thinking skills to draw their conclusions.	The group : • Researched this aspect in depth. • Presented evidence-based arguments and applied well-developed critical thinking skills to draw their conclusions.
The uses of the energy resource and its likely future	The group: • Showed little evidence of suitable research. • Presented conclusions that were based on insufficient evidence and analysis.	The group : • Researched this aspect to some degree. • Applied some critical thinking skills to draw their conclusions.	The group: • Researched this aspect to a reasonable depth. • Presented some evidence-based arguments and applied some critical thinking skills to draw their conclusions.	The group : • Researched this aspect in depth. • Presented evidence-based arguments and applied well-developed critical thinking skills to draw their conclusions.

Aspect	Undeveloped	Developing	Proficient	Exemplary
Presentation of findings	The group: • Presented some findings using a small number of visual aids. • Showed some understanding of their subject. • Was sometimes audible and sometimes established eye contact with their audience.	The group : • Showed some evidence of preparing for their presentation. • Presented their findings using some visual aids. • Showed some understanding of their subject and were able to answer some questions. • Was generally audible and generally established eye contact with their audience.	The group: • Prepared well for their presentation. • Presented their findings in an engaging way, making use of a range of visual and other communication aids. • Showed good understanding of their subject and were able to answer questions clearly. • Was audible, established eye contact with their audience and involved their audience.	The group: • Prepared thoroughly for their presentation. • Presented their findings in a creative and engaging way, making full use of a range of visual and other communication aids. • Showed a thorough understanding of their subject, answering questions confidently. • Was clearly audible, established good eye contact with their audience and involved their audience to a great degree.
Student contribution to group	The student: • Co-operated with the group most of the time. • Contributed to most aspects of the project.	The student : • Co-operated well with the group. • Contributed to all aspects of the project.	The student: • Co-operated very well with the group and showed well-developed time management skills. • Contributed well to all aspects of the project.	The student: • Co-operated well with the group and showed initiative and well-developed leadership and time management skills. • Contributed fully to all aspects of the project.

Comment:

____

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Teacher’s signature: ____

Date: ______________________

STUDENT ASSESSMENT OF GROUP PRESENTATIONS

NAMES OF GROUP MEMBERS: ____

____

Criterion	Needs improvement	Satisfactory	Very good	Excellent
Voice projection	Most of the group spoke too softly and/ or too quickly.	It was difficult to hear parts of the presentation.	Most of the group's voices were clear and able to be heard.	All the group's voices were clear and projected well.
Engagement with the audience	Most of the group members did not seem confident or enthusiastic or aware of their audience.	Some of the group members did not seem confident or enthusiastic or very aware of their audience.	Most group members appeared confident and enthusiastic and maintained good eye contact with the audience. They made a good effort to interest and involve all the audience.	All group members were confident, lively and enthusiastic and maintained good eye contact with the audience. They made a real effort to interest and involve all the audience.
Response to questions from the audience	The group members did not encourage the audience to ask questions, and found it difficult to answer questions.	The group members did not encourage the audience to ask questions, but answered most questions quite clearly.	The group members encouraged the audience to ask questions, and answered most questions clearly and confidently.	The group members encouraged the audience to ask questions, and answered the questions clearly and confidently.
Use of different communication aids to the presentation	The group used some visual aids in their presentation, but these were sometimes difficult to see or needed more work to be beneficial.	The group used some communication aids in their presentation, but these needed more work to be beneficial.	The group used some well-prepared communication aids to help make their presentation interesting and clear.	The group used a good variety of well-prepared communication aids. Their presentation was interesting, clear and very creative.
Knowledge of material	The group needed to provide a lot more information.	The group provided some interesting relevant facts but needed to explain them more clearly.	The group provided a number of interesting relevant facts and explained the ideas and terms well.	The group provided many interesting relevant facts and explained the ideas and terms very clearly.
Logical development of material	The group tended to jump around with their presentation, making it difficult to follow. Some of the content did not appear to be relevant.	The group needed to organise their material into a more logical order and to give a more balanced coverage of the different aspects. Some of the content did not appear to be relevant.	The group presented the material in quite a logical and balanced way. All or most of the content was relevant to their topic.	The group presented the materials in a very logical , balanced way. All the content was relevant to their topic.

Signed: ____________________________________

Print name: _________________________________

VIDEO PROFILES OF WOMEN IN STEM CAREERS AND ENTREPRENEURSHIP

View them all at www.stelr.org.au/WomenInSTEM

#WomeninSTEM #BeAChangemaker #DoSTEMMakeChange

STELR

An initiative of the Australian Academy of Technology and Engineering

This project received grant funding from the Australian Government

The Australian Power Insititute (API) proudly supports science, technology, engineering and maths education in Schools.

ENGINEERING THE FUTURE

Engineers in the Energy Industry help to:

- Provide the "bridge" between science & community
- Take up climate change challenges
- Address technological challenges
- Transition to a renewables future
- Implement energy efficiency initiatives
- Continue providing essential service to community
- Raise living standards & tackle poverty in developing countries.

ABOUT API

The API is a not for profit organisation established by the energy industry companies in Australia to facilitate the provision of tomorrow's technical leaders equipped to deliver Australia's energy future through initiatives such as:

- API Bursary Program to support students at university study engineering and technology courses
- Support for programs to encourage young female students to study STEM and pursue engineering and technology careers.

API SOLAR CAR CHALLENGE

As API is committed to improving STEM education, API provides part funding for STELR, which is an initiative of The Australian Academy of Technological Sciences & Engineering (ATSE). API supports this program by providing class sets of re-usable model solar car kits to over 250 schools Australia wide using the Science and Technology Education Leveraging Relevance (STELR) Renewable Energy Module.

API also encourages involvement between university undergraduate engineering students by sending an API Bursary Holder to a participating high school to deliver a presentation about careers related to the renewable energy and power industry. During these visit the young undergraduate engineers also assist with solar car construction, judge the cars, and award prizes. The API, the high school teachers and students consider the Solar Car Challenge a great program to be invlolved in!

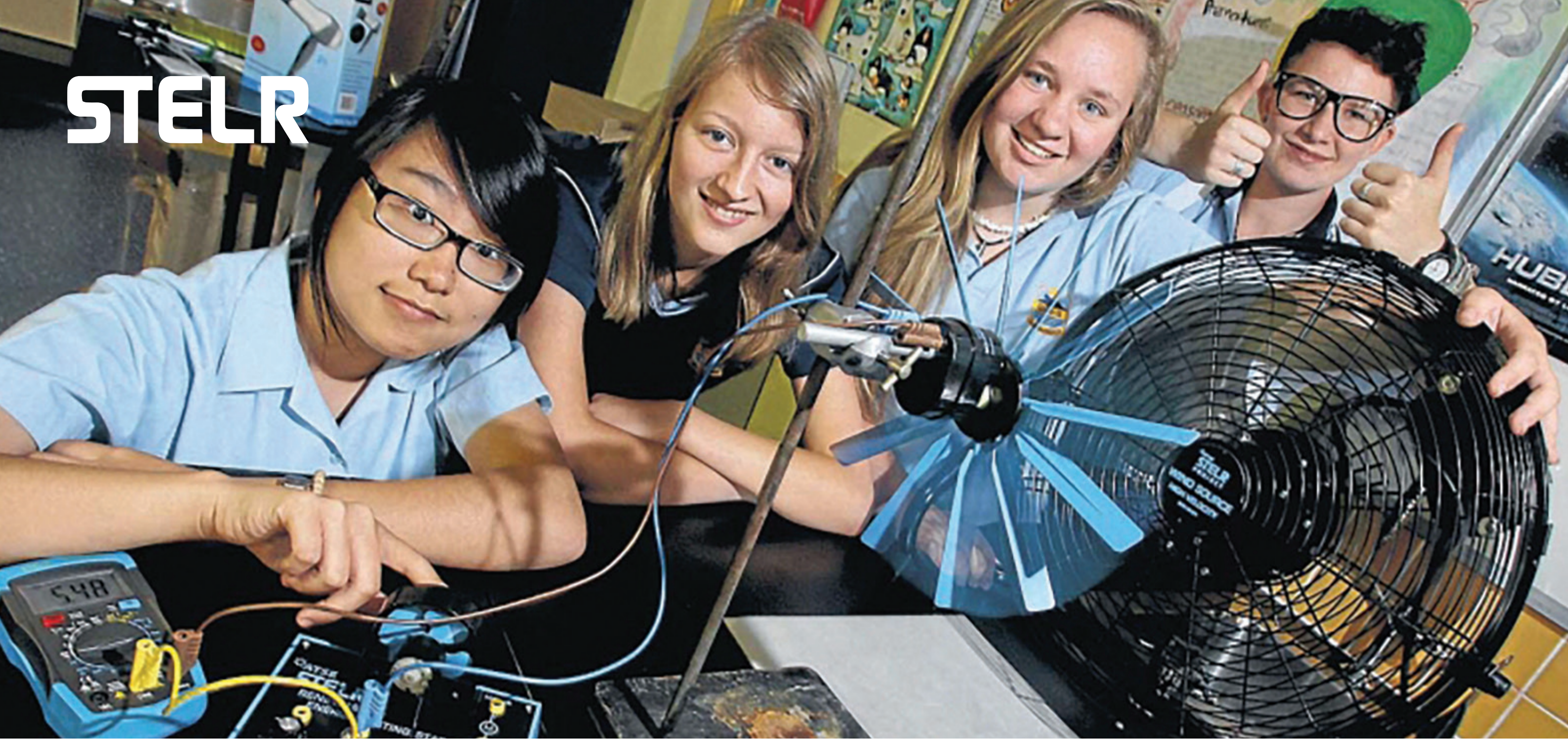
API BURSARY PROGRAM

As The API is constantly working to support the education and professional development of engineers & technologists in the energy industry across Australia, API offers scholarships to engineering & technology students with an interest in areas of engineering relevant to the electric power industry. The bursaries provide financial assistance over 4 years plus the opportunity where available for paid employment with member companies during the univeristy summer vacations.

Applications open February-May 2020 via API website.

CONTACT US

www.api.edu.au   info@api.edu.au



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Sustainable Housing
Teacher Resource