Investigating Science

Introduction to Sustainable House Kit Activities

ATSE STELR PROJECT

Name:

Teacher/Class:

www.stelr.org.au

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Activity 1: Sustainable Housing

The Illawarra Flame

In 2013, over 50 students and staff from the University of Wollongong and TAFE Illawarra Institute joined up to form *Team UOW Australia*. Their goal: enter the Solar Decathlon – an international advanced technology home design competition. They won. Watch the two videos below.

Team UOW Illawarra Flame House Animated Walk-through

www.youtube.com/watch?v=Q4P-NrYDGbo

Team UOW Australia's Illawarra Flame House - Video Walkthrough

www.youtube.com/watch?v=kOXFoRZ8y2k

Question 1

What proportion of Australia's carbon dioxide emissions come from people's homes?

Question 2

The Illawarra Flame was oriented to face the sun. It was built in Australia, so what direction was it facing?

Question 2

According to the first video, the original fibro homes were known for their "poor thermal performance." What do you think this means?

Question 4

The Illawarra Flame is "net zero energy." What does this mean?

Question 5

Explain how the thermal wall works.

Activity 2: Insulation

How much difference do the materials that the walls of your house are made out of make in keeping you warm in winter, and cool in summer?

Aim

Test a variety of materials as walls and ceiling in the STELR house model to

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

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

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

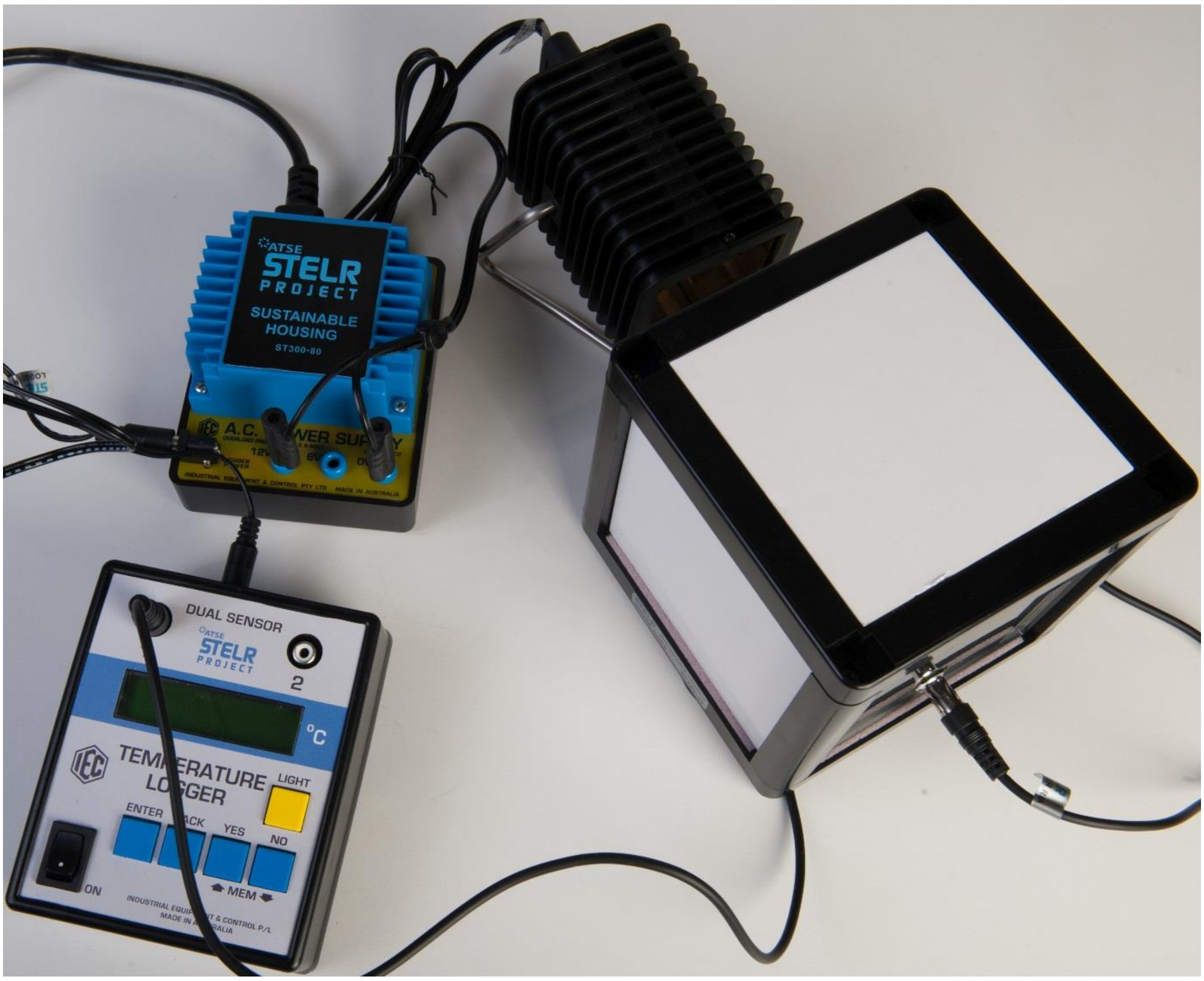

*Figure 1: **The basic equipment set-up***

Material	Temperature	Would the material make a good insulator?

Question 1

Which materials were the best insulators?

Question 2

Why do we need good heat insulators when we build a house?

Question 3

What type of glass would you use for your windows? Explain why.

Question 4

Copper pipes that carry hot water are often wrapped in foam. What benefit would this have in terms of sustainability?

Activity 3: Convection

Does heat distribute evenly when you heat a house? Find out with this experiment, with a model of a two-storey house.

Aim

To investigate whether the temperature at the top of the room in the second storey is cooler, warmer, or the same temperature as at the bottom of the room in the first storey, when the first storey floor is heated.

Equipment

- 2 cube test chambers
- 1 floor heating panel
- 2 temperature sensor panels
- wall frame panel
- heavy paper or cardboard
- 5 insulation panels
- 2 Perspex panels
- power supply
- data logger

Method

Construct a model two-storey building with one cube on top of the other. In the bottom cube:

1. Put the heater in the floor
2. Put a temperature sensor panel in one side with the sensor at the bottom
3. Put two insulation panels and a Perspex panel in the remaining sides
4. Cut the card to fit the wall frame (10 cm x 10 cm) but cut off a corner, to model the gap required for a stairwell. Fit this into the top of the cube.

For the top cube:

1. Put a temperature sensor panel in one side with the sensor at the top
2. Put two insulation panels and a Perspex panel in the remaining sides, and an insulation panel in the top.

Figure 2: Double story set-up without the floor heater

Connect the temperature sensors to the data logger and record the starting temperatures. Connect the floor-heating panel to the power source and turn on. Record temperatures for 10 minutes.

Figure 2: Connecting the floor-heating panel

Hypothesis

Question 1

How do you expect the temperatures to differ at the top and bottom of the model house? Why?

Results

If possible use the data file from the data logger, or manually record your results in the table below.

Time (mins)	0	2	4	6	8	10
Top room temp (°C)						
Bottom room temp (°C						

Discussion

Question 2

What were your results, as per the aim of the experiment?

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Question 3

Do you think that the explanation you gave in your hypothesis, to support your prediction, needs to be changed? Why or why not? If it should be changed, how?

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Activity 4: Thermal mass

Have you ever noticed how, when the sun has gone down after a hot day, brick walls and asphalt or bitumen roads radiate heat? They absorbed the heat from the sun when it was shining on them, retained it, and are now slowly releasing it.

All matter acts like this, absorbing heat that it is exposed to, storing it and slowly releasing it. How much heat a particular material is able to store is called its *thermal mass*:

- a material that stores a lot of heat has a *high* thermal mass
- a material that stores a small amount of heat has a *low* thermal mass

Thermal mass and passive design

By using building materials with different thermal masses, we can design buildings that keep themselves warm or cool, as needed. The following question explores one aspect of this.

Question 1

Look at the two diagrams below, showing a house during the winter, day and night.

1. Explain what you think is happening, and how thermal mass is involved.
2. What would be better to use in this design – material with high or low thermal mass? Why?

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Testing thermal mass of different building materials

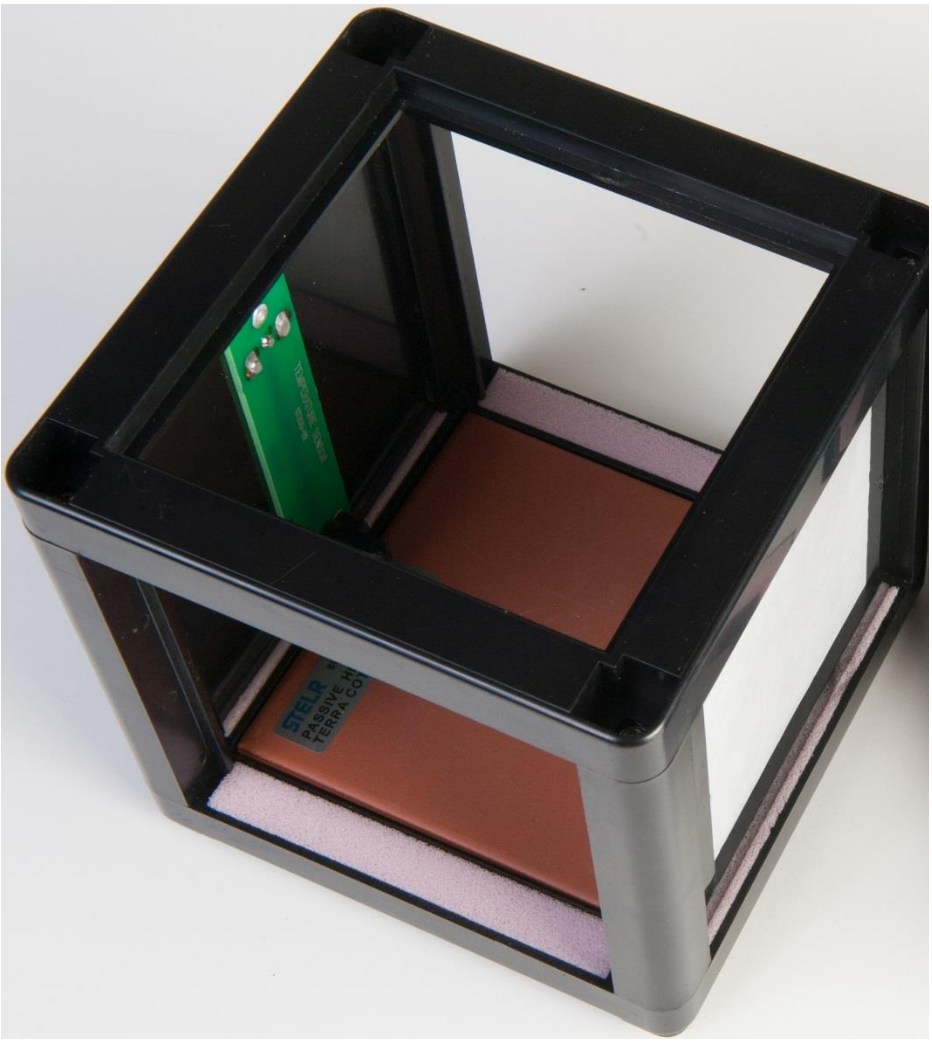
Aim

Test different materials as flooring in the STELR sustainable housing kit to see how their thermal masses affect the temperature in the cube.

Note: You'll probably only have time to test one or two materials, so divide them amongst the class and share your results.

Equipment

- 1 cube test chamber
- 1 Perspex window
- 1 temperature sensor panel
- 3 insulation panels
- power supply
- lamp
- data logger
- test materials: (from the kit) steel, aluminium, terra cotta, chip board, black plastic panel, polystyrene insulation panel. Also test any other materials you can find, for example thick cardboard, using the wall frame panel.



Method

1. Place the temperature sensor in the back wall of the cube with the sensor at the top.
2. Place a Perspex panel on the opposite wall.
3. Put white insulation panels in the remaining two walls and on top.
4. Put the test material into the bottom of the cube as the floor.
5. Connect the temperature sensor to the data logger.
6. Place the lamp 15 cm from the window, angled down to shine on the floor through the Perspex.
7. Turn on the lamp and the data logger at the same time.
8. Record the temperature when you turn on the lamp.
9. Keep the lamp on for 10 minutes, and then turn off. Keep recording the temperature for another 20 minutes.
   The data logger will record the temperature every 2 seconds, but the key recordings are at the start, after 10 minutes, when the lamp is turned off, and then at 20 and 30 minutes.

Hypothesis

Question 2

Order the materials that the class is going to test in order, from the one that will store the most heat to the one that will store the least heat. Give a brief reason why you chose this order.

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Results

Enter the start temperature in the cube, the temperature at 10 minutes – when you turn off the lamp – and then at 20 and 30 minutes, while the cube is cooling.

Swap results with other students to fill in the table.

Material	Start temp (°C)	Temp at 10 mins (°C)	Temp at 20 mins (°C)	Temp at 30 mins (°C)
Steel				
Aluminium				
Terra cotta				
Chip board				
Black plastic				
Polystyrene				
Cardboard				

Use Excel to graph the results.

Discussion

Question 3

Discuss your results, for example:

- How did the different materials behave in the experiment, for example, did they heat up at the same rate?
- Which material was best at storing heat?

Be sure to explain how the data supports your claims.

Question 4

Were the comparisons you made between the different materials justified? In other words, was the experiment a fair test? Could the experiment equipment or method be improved? Could the results be dealt with differently in order to provide a better comparison?

If you want to investigate the use of thermal mass in building further, see www.yourhome.gov.au/passive-design/thermal-mass

Activity 5 - Reflective Paints

The roofs of buildings are large areas that can absorb the Sun's radiation. Some of the radiant energy from the Sun is transformed into heat (thermal) energy. The rest is reflected.

Some paints have been developed to reflect more infrared radiation as a way to control heat absorption.

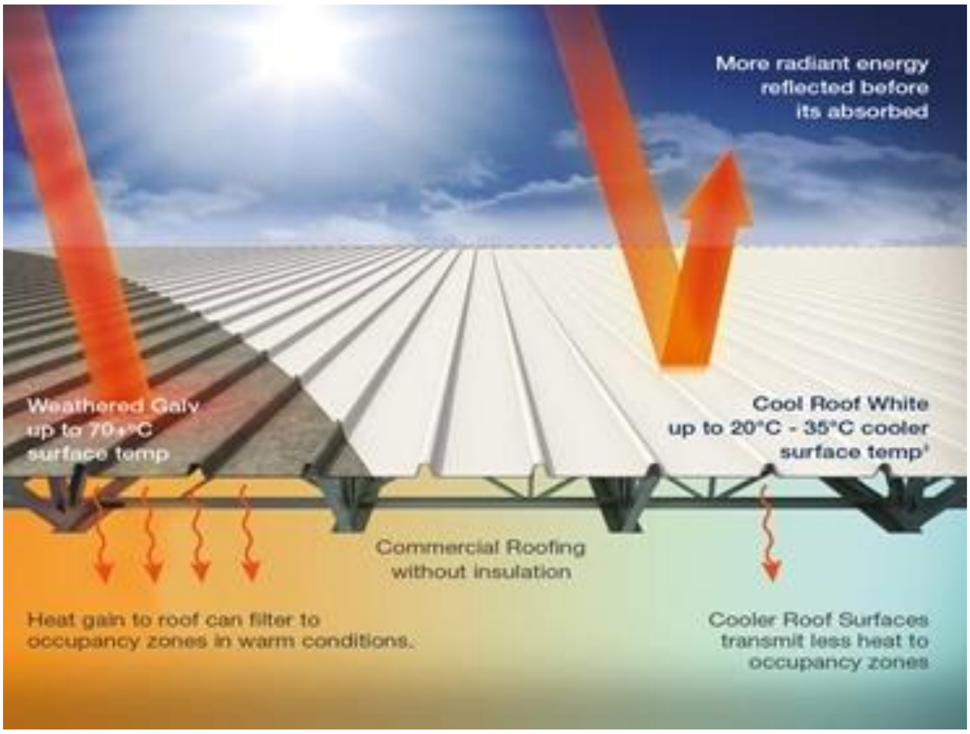
Dulux has developed paints to reflect the Sun's rays before they are absorbed as heat.

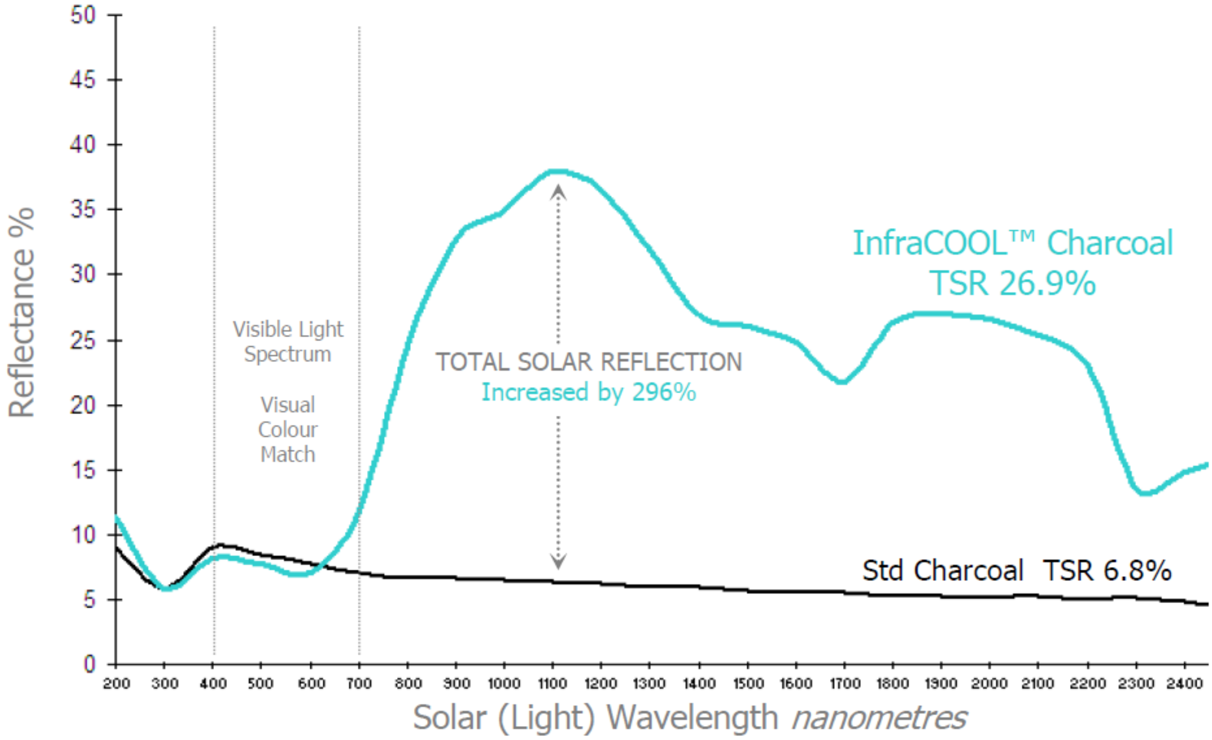
By reflecting more of the Sun's radiation, Dulux paint technology can keep surfaces cooler. This reduces heat build-up in roof spaces that can be conducted into the living spaces of the house.

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

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

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





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

Question 1

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

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Question 2

Which treatment was hottest when exposed to light?

Question 3

How can roof paint make a building more energy efficient?

Activity 6 - Windows

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

What do Windows do?

https://youtu.be/lpCbV95Q4Fg

Question 1

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

House and Window Design and Orientation

www.youtube.com/watch?v=_4_IHSBGUr0

Question 2

Explain cross ventilation. Why is it important?

Question 3

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

Question 4

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

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VIDEO [**Shading Windows**](https://youtu.be/V-ZqeCqqQQM)

https://youtu.be/V-ZqeCqqQQM

Question 5

What can you do to allow winter sun into a room, but keep summer sun out?

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Question 6

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

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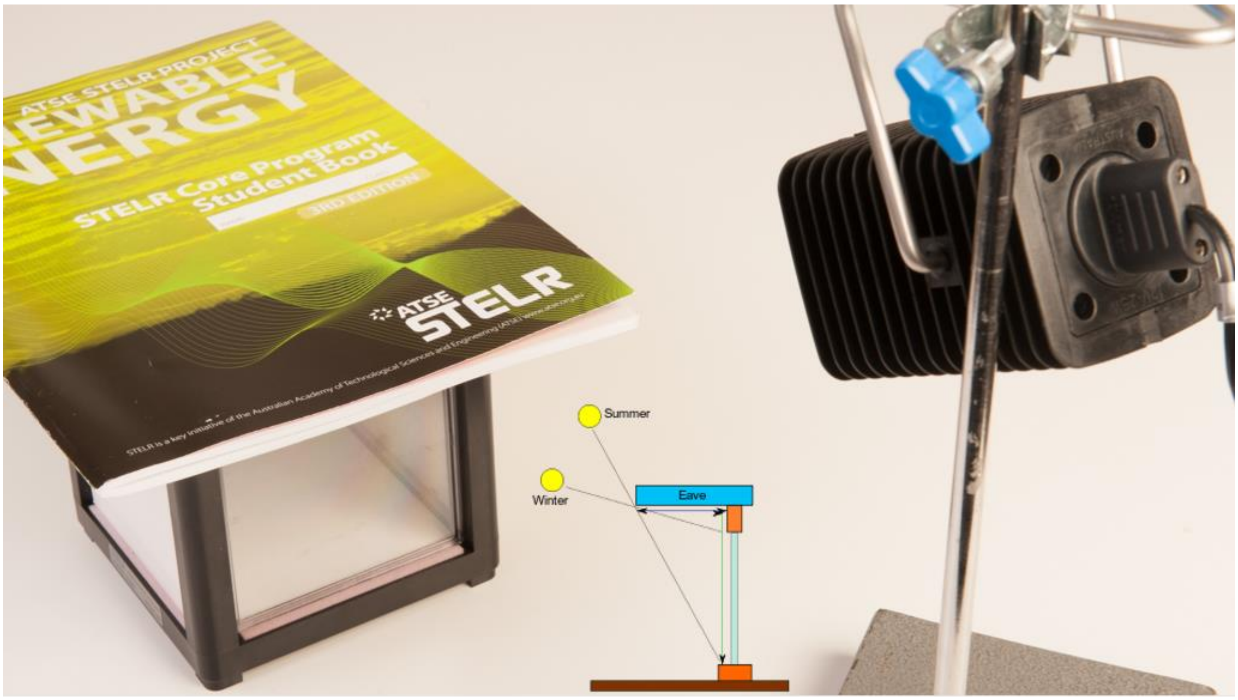
Activity 7 - Summer and Winter Radiation

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

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



Question 1

How will you ensure that your experiment is a fair test?

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Question 2

How does changing the type of glass affect the temperature in your house?

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Results

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

Number	Time	Temperature

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

Number	Time	Temperature

Question 3

Does the temperature in the house rise faster with the lamp at 30° or at 60°? By how much?

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Question 4

On which side of your house would you want windows to capture the most energy from the Sun during winter?

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Question 5

During summer time we need less infrared radiation, as we want our houses cooler. What feature(s) of a house would ensure that?

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Question 6

During winter we want to capture more energy from the Sun to warm up our houses in a natural way rather than with fossil fuel derived energy. What should the orientation of the house be such that it captures a maximum amount of infrared radiation?

Activity 8 - Materials and Radiation

Background information

Light is transmitted through windows. When it hits the surfaces inside the room it is mostly absorbed. Light energy is transformed into thermal energy, increasing the temperature of the room.

Some types of glass have been developed to reflect more light to keep the room cooler.

Low E glass

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

On cold sunny days, low E glass will let short wave infrared radiation into the room.

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

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

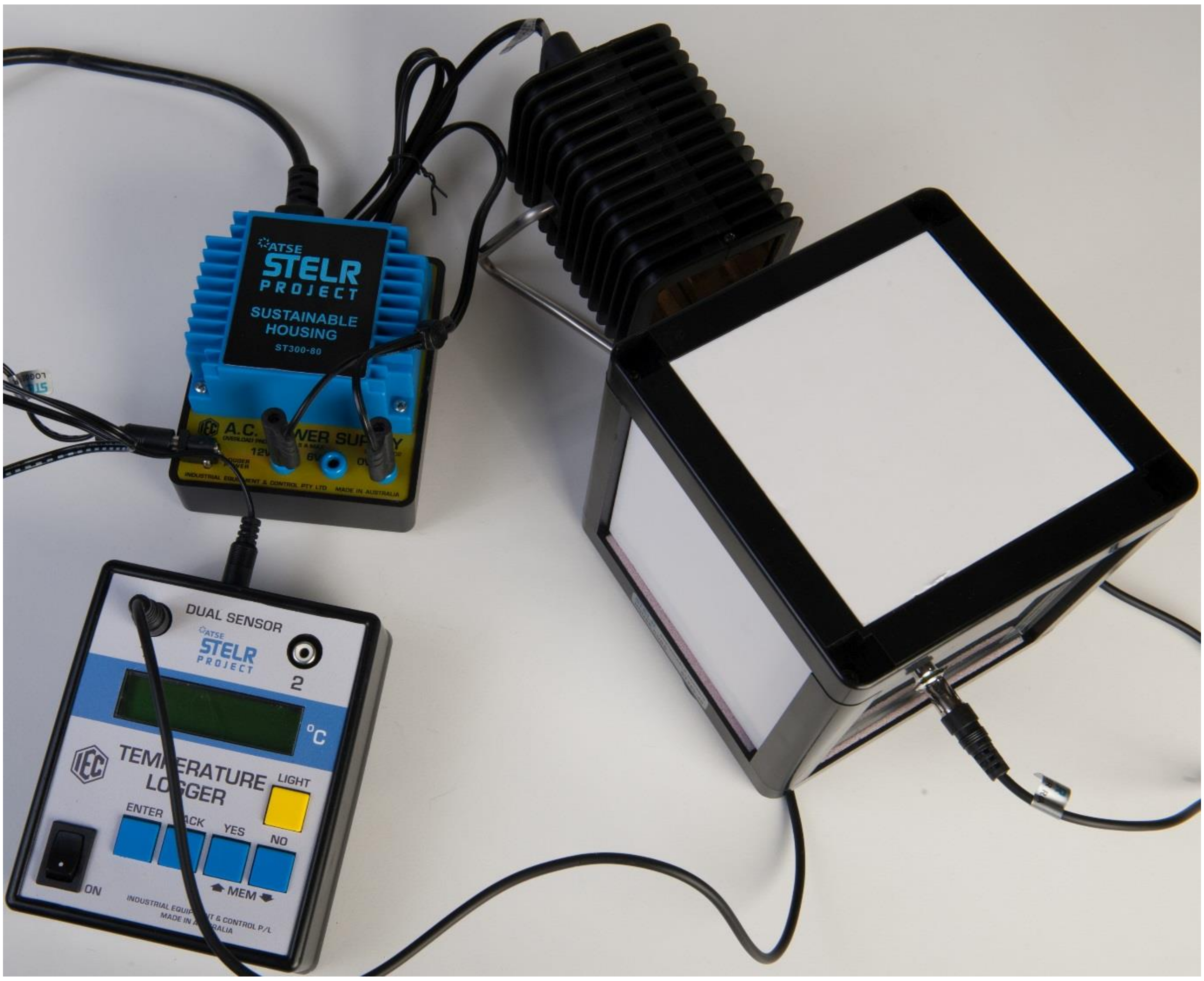
Activity:

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

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

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

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



Results

Material	Temperature

Question 1

How will/did you make sure the comparison between materials was fair?

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Question 2

Which material was the best absorber of radiation?

Question 3

Which materials was the poorest absorber of radiation?

Question 4

Using your results, suggest what materials would be best for the following surfaces in a sustainable house.

- Thermal wall
- Window shades
- Lining of insulation material

Activity 9: Summary of thinking

When you have completed at least two of the eight different activities in the Investigating Science Introduction to Sustainable House Kit Activities, examine the following questions;

Question 1 - Science

a. From your introductory investigation(s), identify at least one inference or generalization you can make about the science of Sustainable Housing.

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b. How might this inference or generalization be further investigated? Write any questions that come to mind that could be used investigated using the Sustainable House Kit.

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Question 2 - Technologies

a. Which commercial products (other than the paint and eglass) could be tested further?

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b. How might the findings of the investigations in the Introductory Activities drive the advancement of new technologies in sustainable housing?

c. Do you have any ideas for unique sustainable housing products or architectural designs that you could make and test using the sustainable house kit? If so record them here.

Question 3 – Values and research

a. Describe an example of how a social, political or ethical agenda might influence research and product development related to sustainable housing? Think both from the point of view of individual preference when building a house, as well as government policy, such as policies related to reducing energy usage per capita.

b. What do you think the economic value of producing ever more efficient sustainable houses is for now and the future? Think in terms of the individual as well as society as a whole.

c. What other value do you think research and advancement of sustainable housing provides for society?

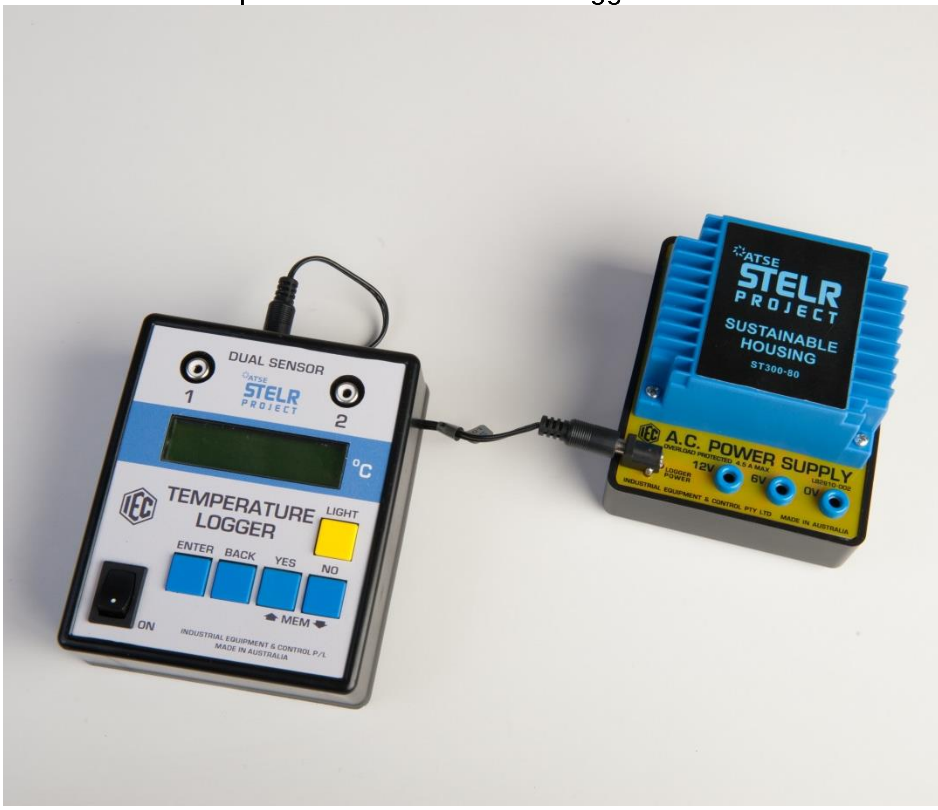
Question 4 – Summing up

Record any personal interests, ideas, thoughts or responses related to the design and science of sustainable housing. For inspiration, imagine you are an architect or a product designer with a mission to help create a more sustainable house, how might you go about designing and testing that house or product…..

Appendix 1: How to use the STELR Sustainable Housing Temperature Logger

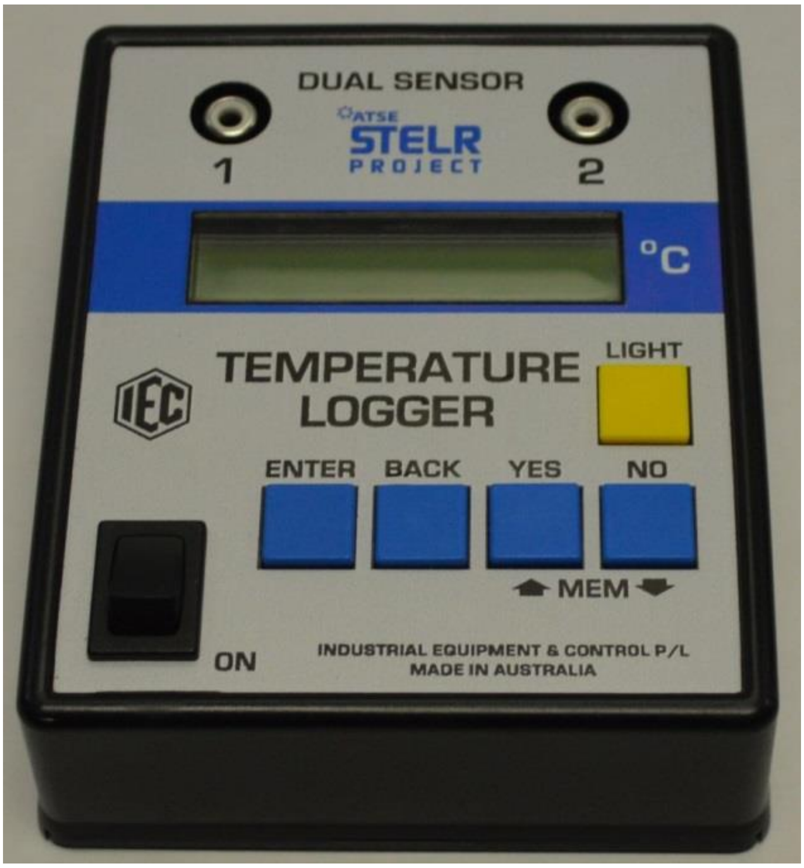
Setting up the temperature logger

1. Connect the power cable to the power socket on the power source Plug the other end of the cable into the power socket of the data logger.



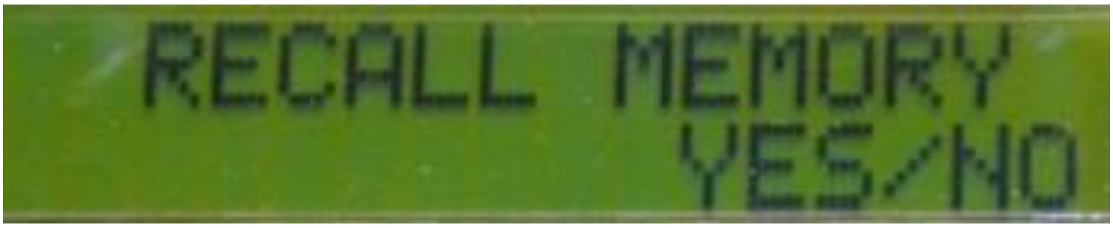
2. Connect the data logger input(s) to a temperature sensor using the long cable(s).

3. Turn on the power supply.
4. Turn on the data logger using the black 'ON' switch.
5. You will be asked 'send data to computer?' Press the 'NO' button



6. You will be asked to ‘Select Memory’. Use the up or down arrow buttons to scroll up and down through the five available memory files. Press the ‘ENTER’ button when you have the file you want.

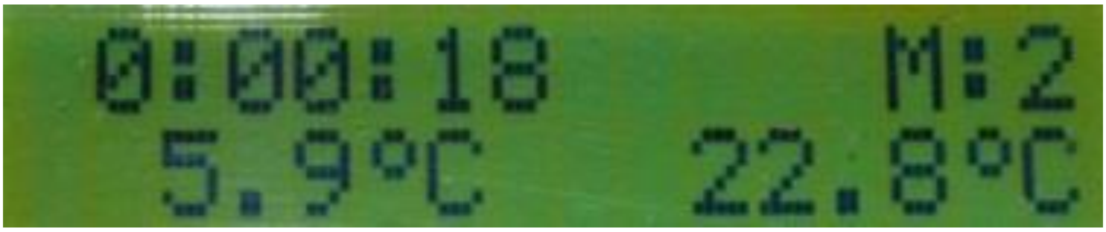
7. You will be asked if you want to recall memory. Press the ‘NO’ button.



8. Next choose the interval for taking readings. Use the up or down arrow buttons to change the interval. You can choose between 1 sec, 3 sec, 15 sec, or 60 sec. Press the ‘ENTER’ button when you have the time interval you want.

9. You will be asked if you want to ‘Overwrite the Memory’. Select ‘YES’ – data will immediately start being recorded to the memory location you selected.

10. Data will be recorded. Time and temperatures will be displayed on the screen.

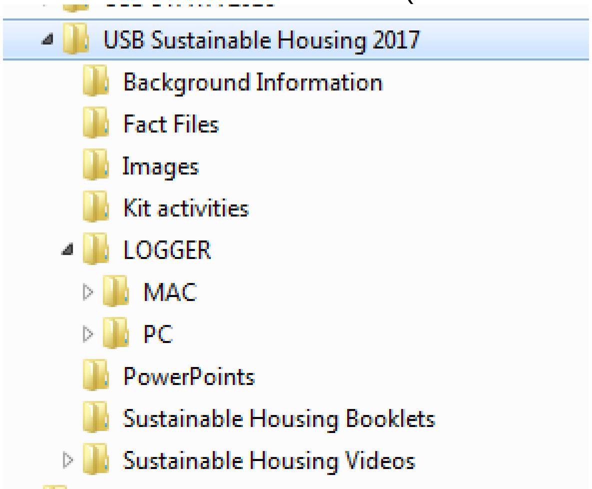


Downloading data from the temperature logger

For PCs

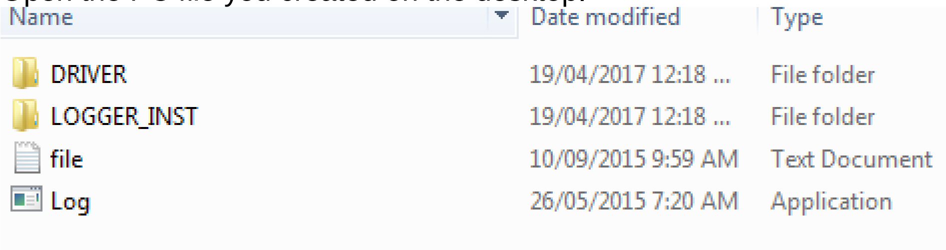
1. Set up a folder called “Sustainable Housing data” on the desktop of your computer.

2. Transfer the files in the PC file (Under LOGGER) on the USB into this folder.



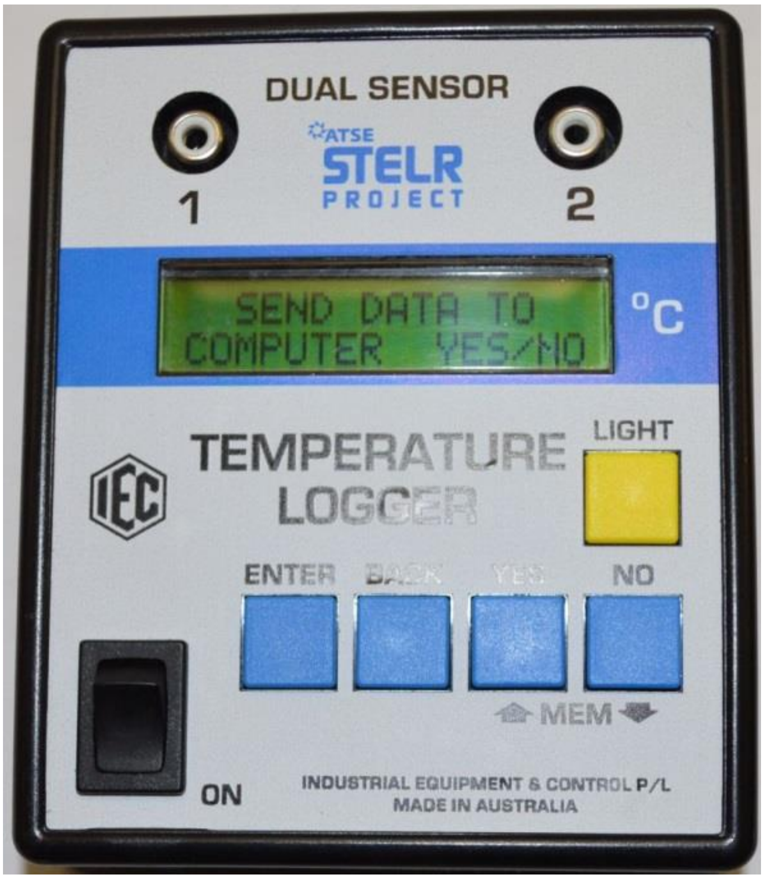
3. Plug the data logger into a USB port on the computer using the cable provided.

4. Open the PC file you created on the desktop.



Double click on the ‘Log’ file.

Turn the logger on.



5. You will be asked ‘Send data to computer?’ - press the ‘YES’ button
6. Five (one for each memory) files will be downloaded to your folder.
7. If you used memory 1, open the file LOG0001.
8. Rename and save this file.
9. Record the start and end temperatures for your investigation.
10. Turn off the data logger to save the battery