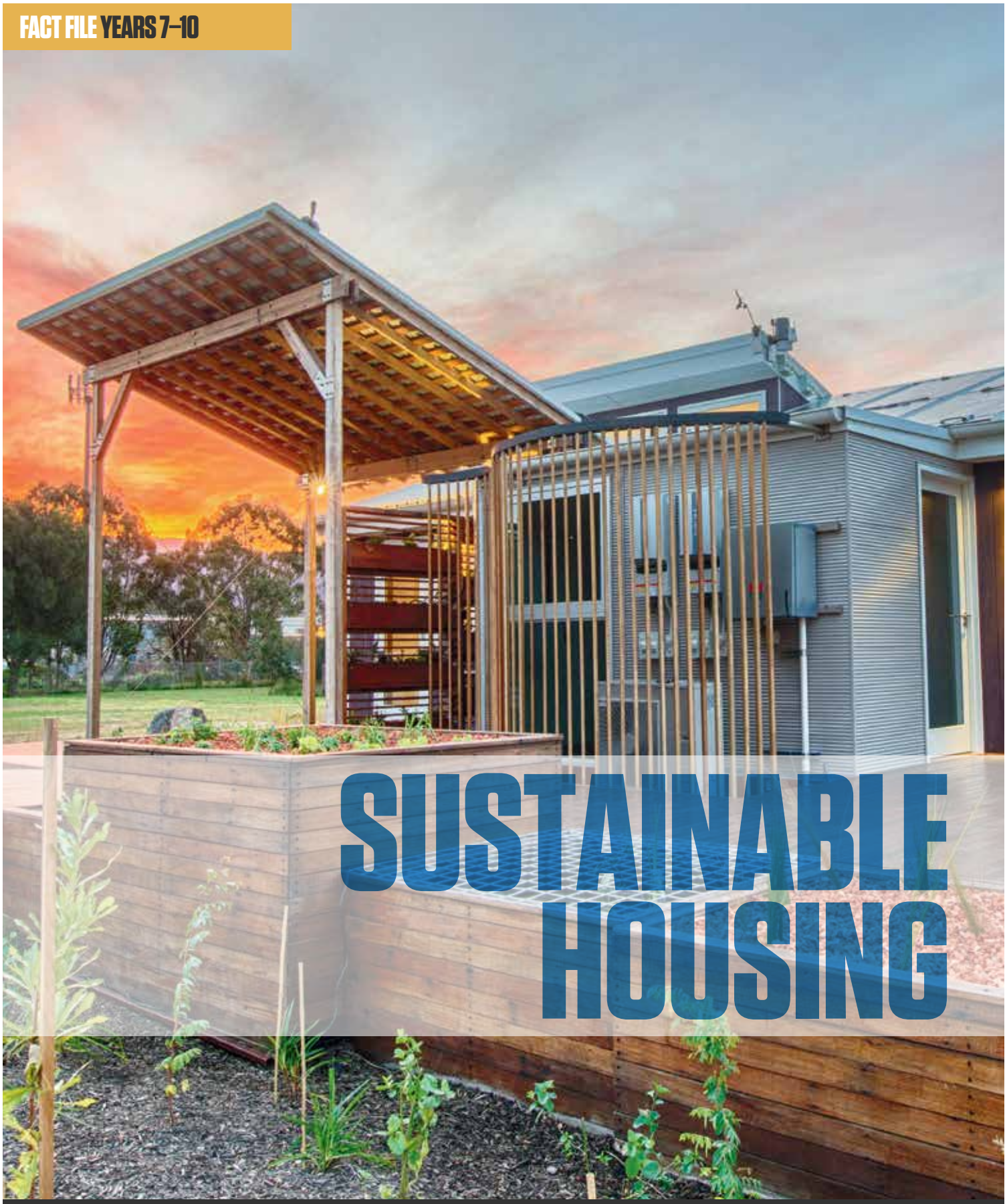
FACT FILE YEARS 7–10



SUSTAINABLE HOUSING

ATSE STELR

RETROFITTING RESIDENTIAL LIVING

GREEN SKYSCRAPERS

University of Wollongong Australia
Southern Cross University
Charles Darwin University

WHAT MAKES A BUILDING SUSTAINABLE?

CONSERVING ENERGY

For a building to be sustainable, it must use resources like water and energy efficiently. There are plenty of design features that can save energy, like natural ventilation, and north-facing windows to maximise natural light. Insulation and double or triple glazed windows can also keep buildings cooler in summer and warmer in winter. Energy-saving features cut back on the consumption of fossil fuels to create power for heating and light.

BUILDING MATERIALS

Choosing the right green building materials can make a building more comfortable as well as energy efficient. These green materials include renewable, non-toxic plant materials like straw and mud brick, timber from forests that are certified as 'sustainably managed', recycled materials, and other products that are non-toxic, reusable and renewable.

WATER EFFICIENCY

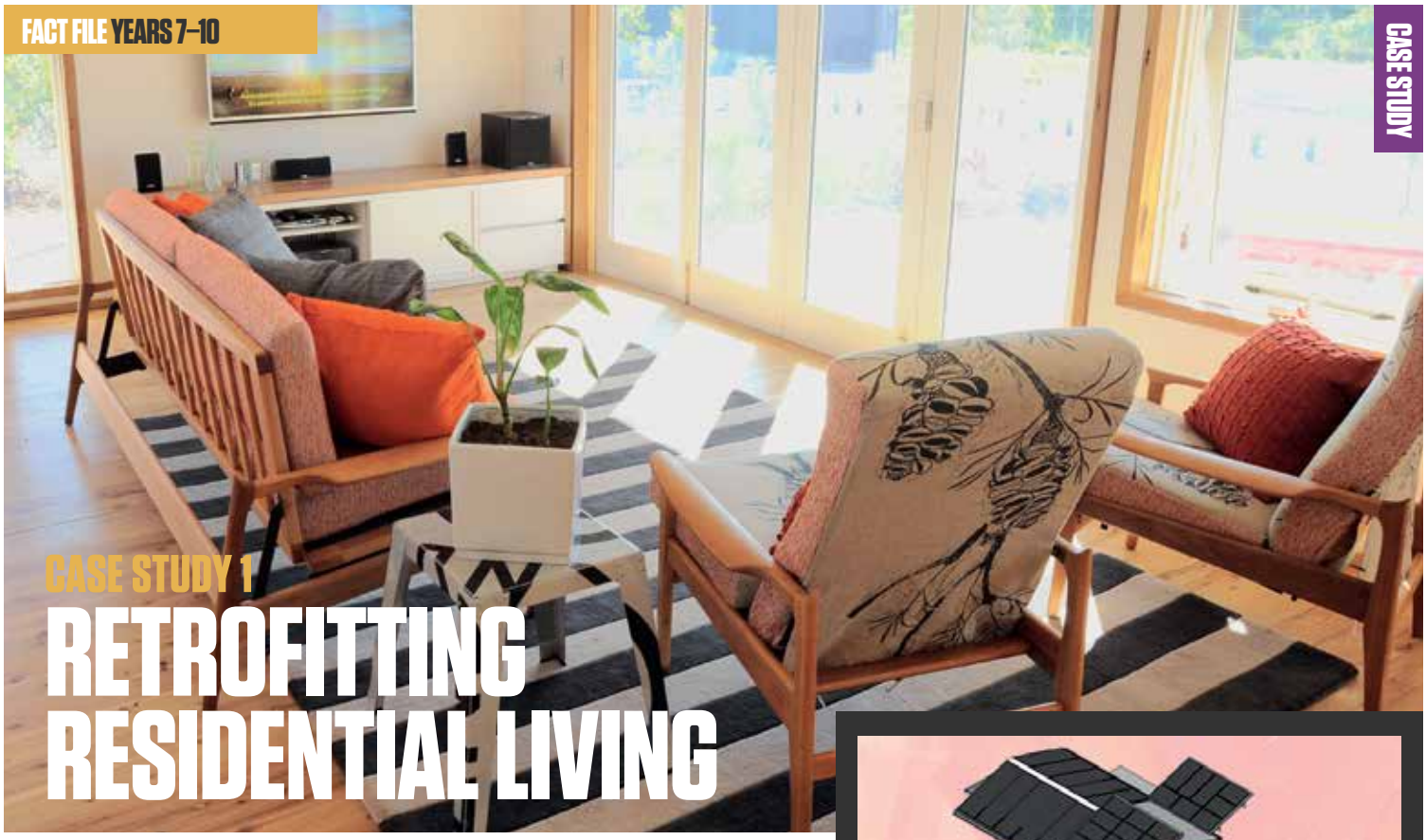
Water efficiency is another important feature of sustainable houses. Rainwater tanks, for example, can capture water and repurpose it for flushing toilets or watering gardens. Choosing water-efficient whitegoods like dishwashers, washing machines, showers, taps and toilets can save water and money. One way to identify whitegoods that use less water is to look at their energy star rating. Products with higher star ratings can save households thousands of litres of water per year.

RENEWABLE ENERGY

Renewable energy is the energy produced by wind, waves or sunshine. Houses can utilise the energy from the sun through solar photovoltaic panels on the roof. One and a half million Australian homes now have solar panels on their roofs. Renewable energy is set to boom as prices come down for efficient energy storage batteries, which allow homes to store the energy created during sunshine hours for peak, non-daylight hours.

COMMUNITY INVOLVEMENT

Developing countries such as Cambodia, Tanzania, India and Brazil need low-cost, sustainable buildings that provide adequate, safe shelter. Community development group RAW Impact is a non-profit, volunteer organisation working in Cambodia that helps local communities build waterproof homes with good sanitation and ventilation using renewable and recycled materials. Projects like these can make a huge impact on people's lives, and have a long-lasting effect as locals are involved in the building and manufactuirng process.



CASE STUDY 1

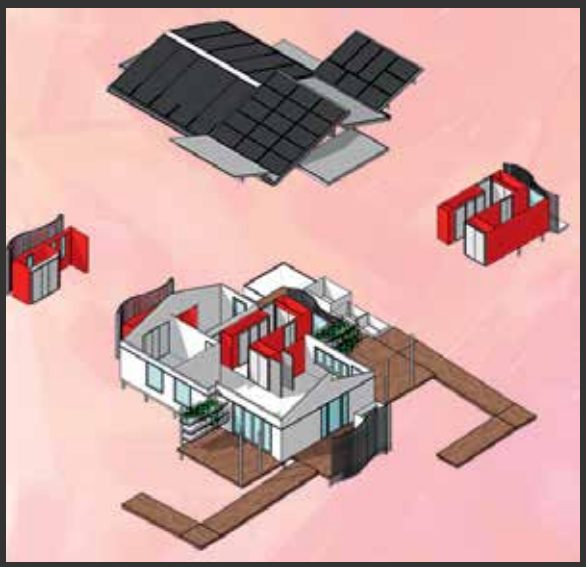
RETROFITTING RESIDENTIAL LIVING

SUSTAINABLE DESIGN IS OFTEN ASSOCIATED WITH NEW BUILDINGS. Retrofitting is when existing buildings are redesigned and renovated in order to be more sustainable in their structure and use. Existing buildings are by far the most energy intensive sectors of the built environment, simply because they represent most of the buildings in use today. It can be cheaper to retrofit a house to improve its carbon footprint rather than demolish an existing building and build a new sustainable house on the same site.

The University of Wollongong and TAFE Illawarra Institute redesigned and retrofitted a typical fibro house so that it was more sustainable for their entry in the Solar Decathlon China 2013 competition. The team designed a fibro house that was similar to existing fibro houses often seen in Australia but one that had net-zero energy consumption and that could be taken apart in modular sections.

The Illawarra Flame House was built and assembled on the University of Wollongong campus over three months and displayed in April 2013 before being disassembled and shipped to China for reassembly within a fortnight for the judging process. The team walked away with the highest score in the competition's history. There were 10 criteria for judging the sustainability of the house and the retrofitting efforts: architecture, market appeal, engineering, communications, solar application, thermal comfort, hot water, appliances, home entertainment and energy balance.

As Australia's aged population is growing – with a quarter of the population estimated to be 65 or older by 2050 – the retrofit of the Illawarra Flame House was tailored towards people nearing retirement and looking to downsize. With about 8 million existing fibro homes in Australia that make up nearly 13% of the country's carbon emissions, being able to retrofit such properties would make a huge impact. "Going forward, if we want to reduce those, we need to retrofit those existing homes," says Lloyd Niccol, the Project Manager for Team UOW.



- The project recycled over 2 km of hardwood from other fibro houses.
- The house is designed to face the sun with bifold doors and windows and solar panels on the roof that can be oriented towards the sun. The eaves and shading were designed to maximise the incoming solar radiation during winter and minimise it during summer.
- The house is also designed to be net-zero energy, producing more energy than it consumes, allowing it to be fed back to the grid.
- A thermal wall is included in the house to allow the sun to warm up the house during winter but not during summer.
- The house also includes an aquaponics system, a composting system and two green walls on the north and south decks with recycled hardwood and a cascading watering system allowing for minimal water use in gardening. The species used are all Australian natives.

> "Currently we have about 8 million existing fibro homes in Australia – they make up nearly 13% of our carbon emissions. Going forward, if we want to reduce those, we need to retrofit those existing homes." – Llyod Niccol, Project Manager, Team UOW

CASE STUDY 2

GREEN SKYSCRAPERS

ENERGY IS OFTEN THE NUMBER ONE DESIGN DRIVER OF GREEN SKYSCRAPERS. Architects, structural engineers and sustainable engineering companies can use many environmentally friendly solutions to cut back on the vast amounts of energy typically used by skyscrapers for lighting, heating and cooling systems. They are designed to take advantage of weather conditions like wind and sunshine to conserve energy, and to capture rainfall to cut back on water use. These measures can make their buildings partly or fully carbon-neutral. Typically, green skyscrapers are an unusual shape, to capture power from the sun and improve ventilation and light, and cut down on air-conditioning and artificial lighting.

One outstanding design for a green skyscraper is the Pertamina Energy Tower in Jakarta, Indonesia, on which construction began in 2014. It is 500 metres high and does not require power from fossil fuel sources because it creates its own energy by harvesting sun, wind and geothermal energy. Efficient use of energy was the principal focus of architectural firm Skidmore, Owings and Merrill (SOM), which designed Pertamina.

When completed in 2020, the Pertamina Energy Tower will be the tallest building in Jakarta, and it will be the workplace for 20,000 employees – yet it will consume zero energy. The definition of a zero energy building is that it consumes less, or equals the amount of, renewable energy that is created by the building.

The Pertamina Energy Tower has been designed in the shape of a beacon with a tapered, rounded top with a wind funnel to take advantage of the increased wind speeds at the upper floors to generate energy.

The design director at SOM, Scott Duncan, says the Pertamina Energy Tower's curved shape was devised with Jakarta's proximity to the equator in mind. It is designed to align with the path of the sun and cut down on solar heat gain throughout the year. The east and west notches will have a specially designed facade with vertical fins to counteract the low-angle east and west sun. The north and south facades will have horizontal shading.

The building will be set on green parkland and the complex will include an auditorium for performing arts and an exhibition pavilion, plus an energy plant. A covered walkway that provides protection from sun and rain will be covered with solar photovoltaic panels to generate power.

> "The Pertamina Energy Tower's curved shape is designed with Jakarta's proximity to the equator in mind."

SOME OF THE PERTAMINA ENERGY TOWER'S ENVIRONMENTAL FEATURES

- Porous walls that act like a sponge will absorb and recycle run-off water for use in the building as greywater for flushing toilets. Any leftover water will go back into the ground to refill the water table.
- Air flow beneath the ancillary buildings will be improved by raising the floor, which can be very useful during monsoon floods.
- Wind turbines at the top of the building will harvest the prevailing winds and tropical typhoons.
- Bulk of the energy generation will come from a geothermal system tapping into the thermal resource that is created by the active volcanoes in the area.
- Sunshades will save energy by reducing the need for artificial lighting. They will also protect the building from the harsh Indonesian sun.
- A curved facade has been designed to help stop the building heating up, reducing the need for air-conditioning.
- A skin of solar panels will harvest power for the building.
- Double and triple skins of glass will act as buffers for excess heat.

PROFILE 1

REBUILDING SCHOOLS

Inspecting damaged schools in Vanuatu

HAMISH BANKS, A STRUCTURAL ENGINEER WITH consulting firm Arup in Adelaide, works on improving buildings in countries like Timor-Leste and Vanuatu. "I really love having a job where I can use my skills to make a positive impact on people's lives," he says. "Working as an engineer, you get to see the outcomes of your work in a really clear and practical way."

In 2015, Hamish travelled with Arup to Vanuatu after the island nation was devastated by Cyclone Pam. Winds of up to 300km/h demolished vital infrastructure, including many schools across Vanuatu's southern islands. As part of a World Bank program to rebuild Vanuatu's schools, Hamish and his team carried out a diagnostic study to look at the performance of school buildings after the cyclone. This involved undertaking detailed inspections of buildings to identify the critical failure points, such as how the roofs were strapped to the walls and how walls were connected to the foundations. They also interviewed school principals and government staff to understand how their schools were constructed and maintained.

Prior to working in Vanuatu, Hamish spent 18 months with Engineers Without Borders in Timor-Leste, assisting local staff to develop low cost building products, including stabilised earth bricks, made by mixing clay and cement.

Hamish went to Mount Barker Waldorf School in the Adelaide Hills, where he was encouraged to use his hands in a broad study across academic, artistic and practical activities. He studied maths, physics and chemistry in a bridging course at Flinders University for one year after high school to prepare for his Bachelor of Engineering (Civil & Structural) at Adelaide University. Hamish says being comfortable with mathematics is really important for engineering. "Maths is an important tool which can help to break down a large, seemingly impossible problem, into smaller, manageable pieces."

Ultimately, Hamish recommends that students at school follow their passions. "My advice for students is to pursue what you love, because it means when you go to work, you're going to be happy."

Training staff in Timor-Leste in materials research and house construction

> "Working as an engineer, you get to see the outcomes of your work in a really clear and practical way."

PROFILE 2

BUILDING SUSTAINABLE HOMES

JASON HOPKINS, A QUALIFIED CARPENTER AND BUILDER, FINDS his job building sustainable homes in regional NSW truly rewarding. "I like making energy efficient homes at an affordable price," he says. Jason was inspired by green energy efficient homes in European countries, including Germany, Iceland and the UK, that use high-rating insulation to keep their heating needs low. He tracked down company Green Homes Australia (GHA), which builds similar homes to the European standards but tailors them to the Australian climate, and asked for an apprenticeship.

"I knew there was a big future market in this," explains Jason. "Handing the keys over to families and hearing back from them, just so they can tell you how well their house is performing, is a wonderful feeling."

During his apprenticeship with GHA he learned valuable skills, like how to draught-proof a home and calculate the correct eave length relative to the window height to maximise natural heat progression so that there is shade in summer and full sun in winter.

Studying maths has proved to be very useful for Jason. "I use maths every single day, to work out roof pitch and make sure the frames are perfectly square, and for material orders, payments and salaries."

He says if he didn't calculate the size of holes accurately, he would lose money before he even started. "Without using maths correctly every day, I would be throwing money out the window."

He also works with digital tools. "My iPad has become one of my most important tools, from taking photos and uploading them straight away into our ordering software, to checking emails, updating job logs and scheduling.

"Also, once you get into the office you're on a computer using estimating software, doing research, quoting work and drawing plans," he says.

Jason says you should work hard at whatever path you choose. "Listen and learn as much as you can from others. If you follow what really interests you, you'll enjoy your work and make loads of money doing it!"

Name: Jason Hopkins

Job title: (Franchise owner/ builder)

Who do you work for? Green Homes Australia (GHA)
www.greenhomesaustralia.com.au

"This is me in the button up shirt, with our clients Gabe and Brad Miller-McMillan and their three children, and my project manager Brendan Finn on the right. We just handed them the keys to their beautiful new family home." – *Jason Hopkins*

> "Without using maths correctly every day, I would be throwing money out the window."

TOOLKIT

GENERAL CAPABILITIES

Literacy

Use all you have learnt in the case studies and profiles to respond to the following:

COMPREHENDING

1. What does 'sustainable' mean?
2. What features make a building sustainable?
3. Why do we need sustainable buildings?
4. What is a 'zero energy' building?
5. How can your choice of whitegoods cut down on energy and water usage?
6. What natural phenomena are renewable energies produced by?

COMPOSING

Annotate the image [on the right] to describe and promote the features and benefits of sustainable buildings.

Numeracy

Jason Hopkins in Profile 2 describes how studying maths at school helped him succeed in his job. List the ways Jason uses maths in his job.

_____

_____

_____

_____

TAKE THE SUSTAINABLE HOUSING WATER CHALLENGE!

In this activity, your challenge is to build a house that catches as much rain as possible with its roof when 500ml of water is poured over it with a watering can. You will have points taken off for the materials you use to build the house, and points rewarded for the amount of water it catches. You will need to calculate the best way to win the challenge. Look at the features of the sustainable homes in the case studies you give you some ideas to get started.

RULES:

1. The house must be no more than 20cm in width, height and depth.
2. The water must be collected from the roof and channelled into two 250ml plastic containers inside (under the roof so water can't be poured directly into the containers) and on opposite sides of the house.
3. One point is taken off for each item used.
4. One point is given for each ml of water in each of the 250ml plastic containers.
5. Water is poured over each house in a large basin so the water can be collected and recycled.

WHAT YOU CAN USE:

• 2 x 250ml plastic containers • 1 x large basin • A4 sheets of paper • paddle pop sticks • 10 x 10cm pieces of foil • paper clips • 10 x 10cm pieces of plastic food wrap • 5cm of tape • 10 x 10cm sheets of baking paper • rubber bands • straws • toothpicks • 10cm string

YOUR SCORE SHEET

POINTS SPENT	POINTS EARNED
Add these up as you build...	ml of water in container 1
	ml of water in container 2
Total number of points =	
Points earned – points spend =	

At the end of the activity, evaluate the water collecting efficiency of a variety of designs, including yours and some of your class members.

Who caught the most rainwater? Which features appeared to be the most successful at catching water, and why? What recommendations would you give to anyone wanting to build a water-efficient house?

RISK ANALYSIS
Consult your teacher to complete a risk analysis for this investigation.

HAZARD	PRECAUTION	CONSEQUENCE

Digital Technologies

Use digital design software, like AutoCAD Architecture, Google SketchUp or Minecraft, to build a model sustainable house. Include the environmental features described in the What makes a building sustainable? article on p2, the Illawarra Flame House in Case Study 1, or the Green Skyscrapers in Case Study 2.

When you have finished, provide a brief evaluation of the suitability of the software for this engineering project. How was it useful? Which environmental features could you include? What were the limitations of the software? Which environmental features couldn't you include?

Critical and Creative Thinking

Case study 1 describes how students at the University of Wollongong and TAFE Illawarra Institute have become experts at retrofitting houses to make them more sustainable. Should you and your family invest money in making your house more sustainable? Complete the template provided to carry out a SWOT analysis to weigh up the advantages and disadvantages of specific changes. One example is given in each area of the analysis. For more information on SWOT analysis visit: **http://bit.ly/2bBA4IA**

	POSITIVES	NEGATIVES
Internal forces	**Strength** Adding solar panels or a mini wind turbine will increase the sale value of the house, which we will benefit from in the future.	**Weakness** Not sure what we are buying. Will we be able to find the most efficient solar panels?
External forces	**Opportunity** Less carbon will enter the atmosphere as we won't be burning as much fossil fuel for our energy needs.	**Threat** The price of solar panels might drop next year.

Once you have written your ideas in the SWOT analysis, decide whether or not you should recommend that your family make certain changes to live more sustainably.

Personal and Social Thinking

Design and build your own sustainable building. Before you start, consider the following questions:

1. What kind of building will it be, and who will it be for?
2. Which sustainable materials will you use to construct the building, and which materials will you use inside?
3. How much of the house will use recycled materials? Where will you source these materials from?
4. Will you need to use metal? Why do you think metal was used as a material for the sustainable house on page 6?
5. How will you use the immediate surrounding environment?
6. What features have other builders included in their sustainable buildings?

As you build your model, photograph or video-document each stage to show the various sustainable features.

When you have finished reflect on the following things.

ALL THE DIFFERENT SKILLS YOU USED TO:
- design your model;
- work independently;
- persevere and overcome challenges;
- show initiative.

THE SOCIAL BENEFITS OF YOUR PROJECT, SUCH AS:
- how others will benefit from your project;
- how you negotiated help when needed;
- how you communicated the features of your project to others.

Ethical Thinking

Which organisations or groups of individuals should be driving the move to more sustainable buildings? Write your initial thoughts.

In order to respond to the question in detail consider approach of several different focus groups including:

- Governments
- Individual home owners
- Architects
- Builders like Jason Hopkins
- Futurists
- Environmental activists
- Renewable energy companies that build technologies like solar panels and home wind turbines
- Media, e.g. *Better Homes and Gardens*, TV
- Innovators like Lorna Pitt and Mike Hill at WestWyck

Break up into groups representing the various interest groups. Research their goals for a more sustainable future (with a focus on the building industry) and the work they already do to promote sustainable buildings. Present your findings to the class.

At the end of the presentations, readdress where society's responsibility should be for the move towards a more sustainable future through the habitation of more buildings with sustainable features. What did your class decide?

Intercultural Understanding

Watch the video above [**http://bit.ly/2ccMEjV**]

1. What are the Australian students doing to help the villagers in Cambodia – think beyond the obvious in order to explore as many different possibilities that you can think of. Think on your own first before sharing ideas with the rest of the class.

2. What sort of knowledge would the Australian students need before embarking on a project like this? Again, think broadly across a range of categories such as the social, geographical (climate, terrain, natural resources), political, scientific, and planning knowledge they would need.

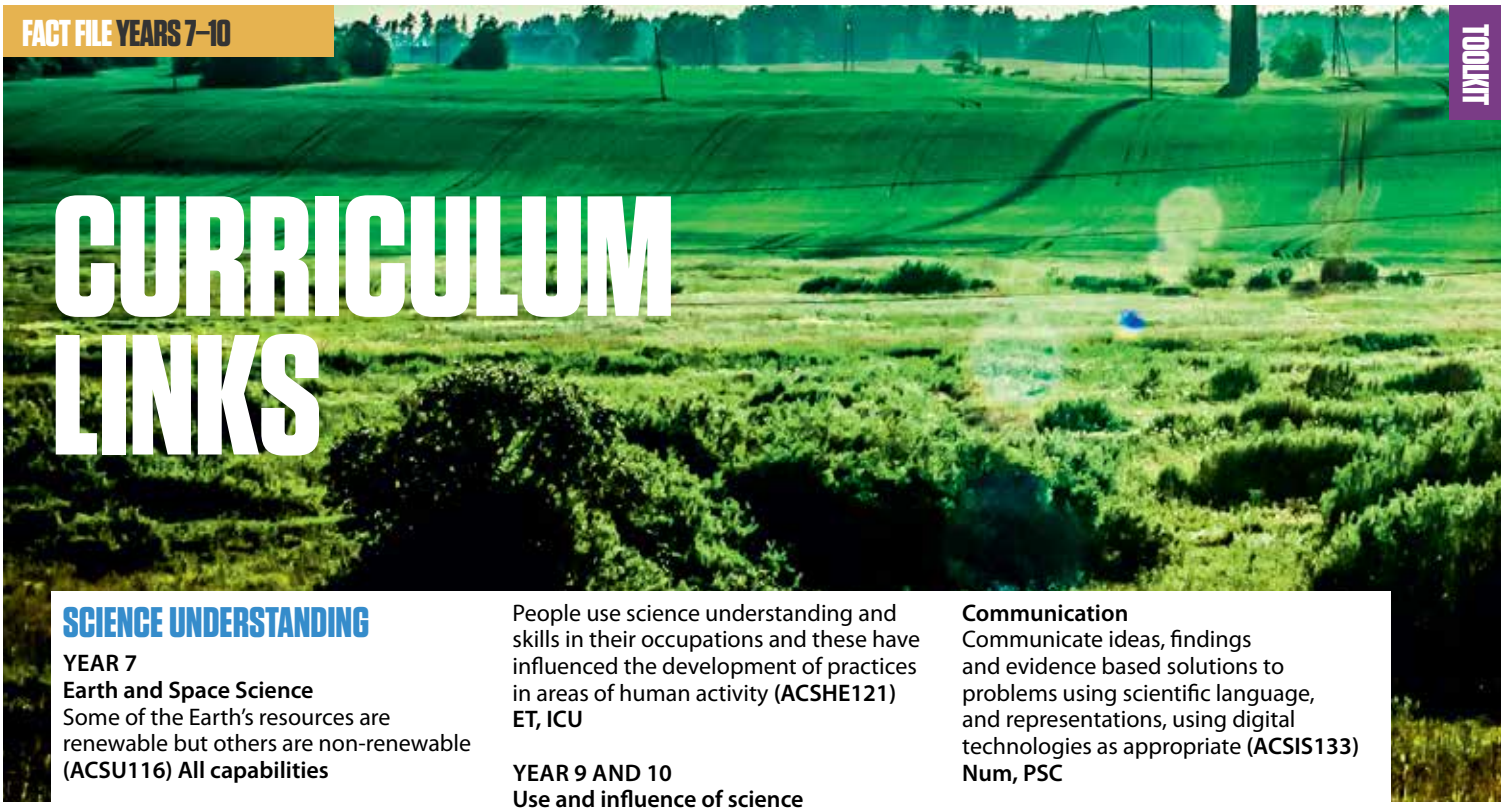
3. Why do you think the University students want to help the Cambodian village? What are they getting out of this project?

4. Why do you think the Cambodians can't build their own sustainable houses? Should they be able to? Will they be able to in the future?

5. Should the University students in the video also be responsible for passing on their skills and knowledge of the construction of sustainable buildings?

Useful links

- AutoCAD architecture (FREE for students)
  www.autodesk.com/products/autocad-architecture/overview
- Google SketchUp (choose the FREE 'Make' version with excellent tutorial videos for first time users)
  www.sketchup.com/
- SWOT analysis
  rapidbi.com/swot-analysis-for-schools-and-education/
- The Australian Trade Commission Green Building
  www.austrade.gov.au/greenbuildings/
- Australian Government's Guide to Sustainable Homes
  www.yourhome.gov.au/



CURRICULUM LINKS

SCIENCE UNDERSTANDING

YEAR 7
Earth and Space Science
Some of the Earth's resources are renewable but others are non-renewable **(ACSU116) All capabilities**

YEAR 8
Physical Sciences
Energy appears in different forms, including movement, heat and potential energy, and energy transformations and transfers cause change within systems **(ACSSU155) Lit, DT, CCT, PSC, ET, ICU**

YEAR 9
Biological Sciences
Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems **(ACSSU176) All capabilities**

YEAR 10
Physical Sciences
Energy conservation in a system can be explained by describing energy transfers and transformations **(ACSSU190) DT, CCT, PSC, ET, ICU**

Earth and Space Science
Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere **(ACSSU189) Lit, Num, DT, PSC, ET, ICU**

SCIENCE AS A HUMAN ENDEAVOUR

YEAR 7 AND 8
Nature and development of science
Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures **(ACSHE223) ET, ICU**

Use and influence of science
Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations **(ACSHE120) All capabilities**

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity **(ACSHE121) ET, ICU**

YEAR 9 AND 10
Use and influence of science
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 **(ACSHE160) ET, ICU**

Values and needs of contemporary society can influence the focus of scientific research **(ACSHE228) ET, ICU**

SCIENCE INQUIRY SKILLS

YEAR 7 AND 8
Planning and conducting
Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed **(ACSIS125) Num**

Measure and control variables, select equipment appropriate to the task and collect data with accuracy **(ACSIS126) Num**

Processing and analysing data and information
Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate **(ACSIS129) Lit, Num**

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence **(ACSIS130) Lit, Num, ET**

Evaluating
Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements **(ACSIS131) Num**

Communication
Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate **(ACSIS133) Num, PSC**

Year 9 and 10
Planning and conducting
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 **(ACSIS165) Num**

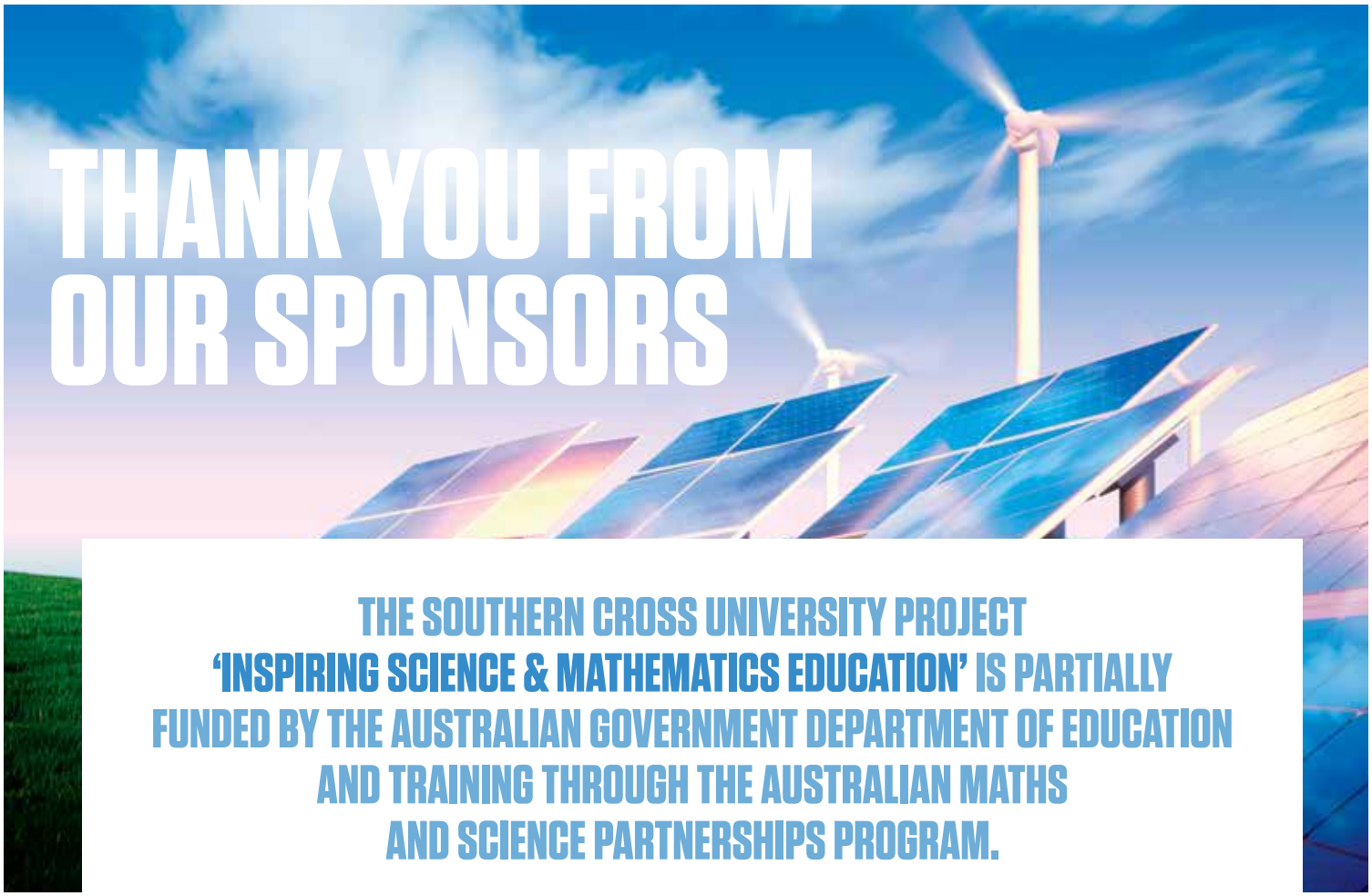
Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately **(ACSIS166) Num**

Processing and analysing data and information
Use knowledge of scientific concepts to draw conclusions that are consistent with evidence **(ACSIS170) Lit, Num**

Evaluating
Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS171) Num**

Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems **(ACSIS172) Num**

Communicating
Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations **(ACSIS174) Lit**



THANK YOU FROM OUR SPONSORS

THE SOUTHERN CROSS UNIVERSITY PROJECT
'INSPIRING SCIENCE & MATHEMATICS EDUCATION' IS PARTIALLY
FUNDED BY THE AUSTRALIAN GOVERNMENT DEPARTMENT OF EDUCATION
AND TRAINING THROUGH THE AUSTRALIAN MATHS
AND SCIENCE PARTNERSHIPS PROGRAM.

Charles Darwin UNIVERSITY
Innovation in Education

CSR

ARUP

Dulux
Acra·Tex

Cochlear®

Southern Cross University

UNIVERSITY OF WOLLONGONG AUSTRALIA

Viridian
New World Glass

Stile

ORICA