



LOW CARBON LIVING  
CRC

EXIT AND HIGHLIGHTS REPORT 2012—2019

# Seven-Year Contribution to Australia's Built Environment Sector





LOW CARBON LIVING  
CRC

**From 2012–2019  
the CRC for  
Low Carbon Living  
was Australia's  
leading research  
and innovation hub  
dedicated to driving  
the nation's built  
environment sector  
towards a globally  
competitive low  
carbon future**

**The CRC for  
Low Carbon Living  
expects to exceed all  
of its founding goals  
in carbon emissions  
reduction, national  
economic benefit,  
education, planning  
and policy**



LOW CARBON LIVING  
CRC

## FOUNDING GOALS

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**10Mt**

CO<sub>2</sub>e cumulative savings delivered by 2020

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**\$684 million**

in economic benefit delivered to Australia by 2027

Benefit cost ratio of 2.9:1

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**88 higher degree research students graduated**

with skills in the low carbon built environment sector

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**Provide a high quality evidence base for low carbon planning & policy**

## ACHIEVEMENTS

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**12.8Mt**

CO<sub>2</sub>e cumulative savings by 2020 & over 100Mt by 2027

Independently verified by UNSW Sydney

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**\$1.116 billion**

in economic benefit to Australia by 2027

Benefit cost ratio of 9.5:1

Independently verified by PwC

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**52 graduated**

plus 41 expected to graduate by 2020

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**Delivered research, tools and evidence to improve planning & policy**



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# We thank all of our participants for their contribution to meeting our goals



Australian Government  
Department of Industry,  
Innovation and Science



Australian Government  
Department of Infrastructure  
and Regional Development



Imagine it.  
Delivered.



Infrastructure  
Sustainability  
Council of Australia



VICTORIAN  
BUILDING  
AUTHORITY



raising the standard





1 Shelley Street, Sydney by  
CRC for Low Carbon Living  
partner Multiplex

**“The CRC for Low Carbon Living has driven significant change in Australia’s built environment sector by delivering quality research which has been translated into real-world benefits and uptake by government, industry and the community”**



**The Hon Robert Hill AC**  
CRC for Low Carbon Living  
Chair, Board of Directors

# PROGRAMS

The CRC for Low Carbon Living's research projects were organised under three programs which set out a strategy for achieving a low carbon, economically viable built environment.

## 1. INTEGRATED BUILDING SYSTEMS

Developing new low-embodied-carbon products and services, and finding ways to communicate best practice design through rating tools, standards and display homes.



## 2. LOW CARBON PRECINCTS

Creating planning techniques and data for delivering low carbon developments at a precinct level. Communicating best practice in sustainable city planning through exemplar precinct developments and tools.



## 3. ENGAGED COMMUNITIES

Capturing a new community appetite for low carbon living. Through research, communicating to business and government the vision of a prosperous, liveable and sustainable society.





**SCIENTIA PROFESSOR  
DEO PRASAD AO**  
CRC for Low Carbon Living  
Chief Executive Officer

# EXECUTIVE SUMMARY

Seven years ago, the CRC for Low Carbon Living opened its doors with a deep commitment to helping the built environment sector reduce its carbon footprint while enabling it to become globally competitive through collaborative research that delivers world-leading innovations.

At the time, we were faced with many challenges including a disparate sector with limited appetite for research and innovation.

Thankfully, much has changed in recent years and now both the sector and industry have evolved to realise the critical need for carbon reduction at all levels of the built environment including cities, precincts, individual buildings, products and technologies. This is vital if we are to keep our cities, and the industry that supports them, environmentally competitive into the future.

Firstly, we would like to sincerely thank all of our participants whose individual collaborations and contributions have been the lifeblood of the CRC, allowing us to deliver impact at various levels of Australia's built environment sector.

Many of the exemplary projects featured in this, our Exit Report, are testament to our commitment

to mainstreaming our research. They include: ClimateClever, a national education program that started in Perth schools; Low Carbon Living Australia, which has helped 80 tourism businesses lower their carbon emissions; and commercial applications of our low carbon geopolymer concrete, which are being trialled by NSW Ports and the City of Sydney.

We have contributed to policy reform in a number of areas including our collaboration with the Australian Sustainable Built Environment Council on the *Built to Perform* report which proved changes to the National Construction Code could improve energy efficiency in Australian buildings by up to 56%. The research helped inform a major report by the COAG Energy Council.

It is particularly gratifying that many of our projects naturally intersected with each other, resulting in increased industry impact. Our Urban Heat Mitigation projects, led by world-class experts, culminated in an authoritative new body of Australian research on the critical subject of how to cool our cities. Likewise, our sustainable homes projects resulted in significant collaborations with councils, government developers, real estate agents, volume builders and home buyers.

Looking back at the trajectory of the Centre, we're proud of how far we've come. We started with 27 projects in our first year; this has grown to 150 projects that are delivering real impact to the built environment. Seven years ago we had only two Living Labs; now we have residents, researchers and industry working collaboratively in 16 homes and precincts across Australia to test low carbon living technologies in real-world settings. We enrolled 104 higher degree research students, creating a generation of Australian researchers and built environment practitioners who will continue our work by translating great ideas into better cities.

Finally, our work will continue through our six Nodes of Excellence established in Australian universities, and the BuiltBetter knowledge hub, a website established by the Centre, will collate low carbon built environment research for ongoing use in the sector.

We hope you enjoy reading this showcase of the last seven years of the Centre's research in this, our final report.

Scientia Professor Deo Prasad AO



# SNAPSHOT

## FOUNDING GOAL

**\$684 million**

in economic benefit delivered by 2027 at a benefit cost ratio of 2.9:1



## ACHIEVEMENT

**\$1.116bn**

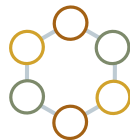
in economic benefit by 2027 at a benefit cost ratio of 9.5:1  
Independently verified by PwC

## Research Outputs



### Builtbetter knowledge hub

One-stop-shop for low carbon built environment research products



### 6 Research Nodes of Excellence

at Australian Universities



### 150 Projects

involving 70+ research, industry and government partners



### 16 Living Labs

across Australia



### 11 Low Carbon Living Guides



### 820+ Publications, papers & reports



### 20 Modelling & forecasting tools



### Energy Efficiency Node

established for the NSW Office of Environment & Heritage—seven major projects initiated



### Decarbonising the Built Environment

published by Palgrave Macmillan

# 2012-2019

## FOUNDING GOAL

**10Mt**

CO<sub>2</sub>e cumulative savings delivered by 2020



## ACHIEVEMENT

**12.8Mt**

CO<sub>2</sub>e cumulative savings by 2020 & over 100Mt by 2027

Independently verified by UNSW Sydney

## Education & Training



**\$8million**

Invested in scholarships



**104**

HDR scholarships awarded

52 completed  
41 due to complete in 2020



**67**

Researchers and students trained to be industry-ready



**6**

Professional Development courses produced

## Media & Outreach



**200+**

Nationwide events



**2000+**

Media mentions



**350%**

Increase in media mentions

2019 (final year) compared with 2018



**Towards Zero Carbon**

video series released



# RESEARCH HIGHLIGHTS & CASE STUDIES

1

ENERGY  
EFFICIENT  
BUILDINGS

2

BETTER HOMES





# 3 BETTER PRECINCTS



# 4 BETTER COMMUNITIES



# 5 BETTER POLICY





# ENERGY EFFICIENT BUILDINGS

Electricity is Australia's largest source of greenhouse gas emissions. The CRC for Low Carbon Living worked with major industry and research partners including Solar Analytics, BlueScope and CSIRO to ensure commercial and residential buildings minimise their energy use and carbon footprint



Tyree Energy Technologies  
Building, Sydney  
Photo: Andrew Chung  
Courtesy of FJMT Studio



### **PUTTING SOLAR COOLING TO THE TEST**

At UNSW Sydney, researchers from the Centre worked with BlueScope, CSIRO and UNSW to put solar photovoltaic (PV) cooling to the test, using a prototype solar desiccant air conditioning unit. Desiccant cooling systems use water as a refrigerant in direct contact with air, in a combination of evaporation and dehumidification using the desiccant, water absorbing material.

The prototype at the campus's Tyree Energy Technologies Building is unique because it uses low-temperature air in a building integrated photovoltaics system, providing air to regenerate the desiccant when in cooling mode. In other systems, this heat would usually be supplied at higher temperatures via a more powerful heat source, at greater expense. With the recent significant fall in PV prices, it was a good time to test such a system.

The Tyree system also uses indirect evaporating cooling technology where two air streams are separated by a heat transfer surface; dry one side, where only air is cooling, and wet on the other where



## SOLAR COOLING

The prototype at UNSW's Tyree Energy Technologies Building can provide 100% fresh air ventilation, heating, dehumidification and cooling



**The Centre developed a world-first technical standard for calculating the energy consumption of alternative heating, cooling and ventilation systems**

both air and water are cooling. Overall, the results were positive. They showed that the prototype unit can provide 100% fresh air ventilation, heating, dehumidification and cooling, however more research is required for long-term commercial viability. The system's key innovation is its capacity to function effectively across a range of temperatures.

### **CHEAPER POWER FOR ALL**

Dr Jemma Green's PhD research with the Centre was the catalyst for the launch of Australia's successful international energy-sharing company Power Ledger. The Power Ledger platform uses real-time data from existing smart meters to enable electricity trading between buyer and seller using low cost technology. The company's founding goal is the democratisation of power, a philosophy that captured Sir Richard Branson's attention when he named Power Ledger the winner of his 2018 Extreme Tech Challenge.

The company recently partnered with US-based Silicon Valley Power to encourage electric vehicle owners to charge their cars from solar during the day in return for carbon credits via blockchain. In Japan, Power Ledger is being used by the country's privately-owned power utility, KEPCO, to support a Virtual Power Plant in Osaka.

Dr Green's formative research with the Centre used blockchain technology to monitor how residents in Perth could share and trade electricity from shared solar power and battery storage technology. The research was conducted at WGV, a residential development in Fremantle, Western Australia, and one of the Centre's 16 Living Labs. Dr Green ultimately disrupted the dominant way of thinking by advancing a model of shared ownership of renewable energy assets between developers, owners, tenants, strata bodies and utilities.

The Power Ledger platform is now being used at Gen Y Demonstration House at WGV, a sustainable and affordable housing product for young buyers. Gen Y was developed in partnership with LandCorp and Synergy, and each apartment is expected to use 70% less water than a typical Perth home and 60% less grid energy.

"The Centre really backed me with this zany idea to build an ecovillage in an applied research project and it's really through their support that this project came to life," Dr Green said. The model enabled greater uptake of solar PV and energy storage within medium density housing establishments across Australia, reducing energy costs and carbon emissions.

"I'm enormously grateful for the risk the Centre took by investing in me. At Power Ledger we're a group of passionate experts in blockchain and technology and with the scaling and commercialisation, we hope to make a big difference to achieving the Paris climate goals."

In 2017 the Australian Government awarded the City of Fremantle an \$8m Smart Cities and Suburbs Program grant which will use the Power Ledger platform to trial the use of blockchain-powered distributed energy and water systems. In 2019 Dr Green and the Centre were awarded an Excellence in Innovation Award by the Cooperative Research Centres Association for their pioneering research.

### **WORLD-FIRST TECHNICAL STANDARD FOR LOW-ENERGY TECHNOLOGIES**

The Centre developed a world-first technical standard for calculating the energy consumption of alternative heating, cooling and ventilation products and systems. These emerging systems have so far been largely overlooked in emissions reduction schemes. Developed by a team from the Centre led by CSIRO Research Scientist, Dr Mark Goldsworthy, the new Australian Standard AS 5389 enables the performance of space heating, cooling devices and ventilator systems to be evaluated in different climate zones. Unlike conventional energy-hungry air conditioners and heating systems, these low-energy technologies harness combinations of solar thermal energy, desiccant dehumidification and evaporative cooling to maintain comfort, with potentially significant energy savings.

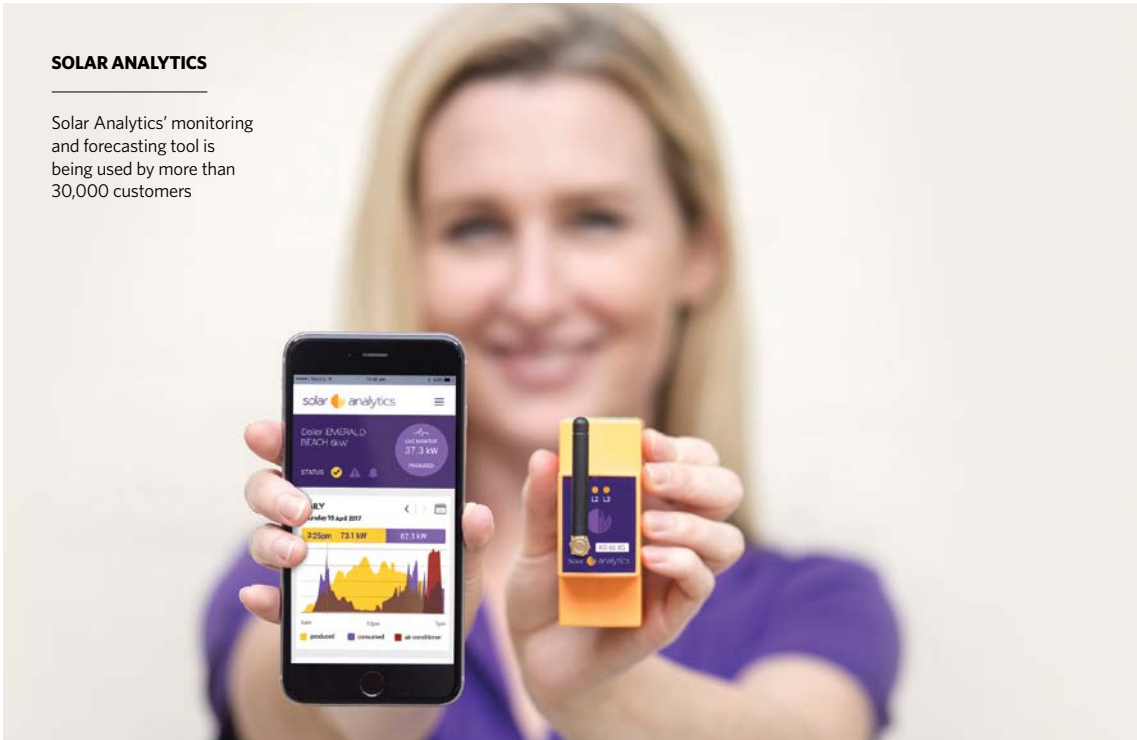
Emerging technologies covered under AS 5389 include (i) a new photovoltaic/thermal solar roofing module, developed by BlueScope, and (ii) a new thermostatically controlled home ventilation product developed by CSR Edmonds. AS 5389 will enable emissions savings to be reliably calculated, so low-energy heating and cooling devices and evaporative cooling systems could become eligible for 'white certificates' issued by state government energy saving schemes. The certificates represent verified emissions savings and can be sold as carbon offsets to electricity retailers. The Centre's role in developing the new standard was critical, said Dr Goldsworthy.

"Standards are time-consuming to deliver and require industry cooperation," said Dr Goldsworthy. "To have an independent entity like the Centre champion it for the common good of the entire industry gives the standard great authority."



## SOLAR ANALYTICS

Solar Analytics' monitoring and forecasting tool is being used by more than 30,000 customers



### SMART FORECASTING AND ENERGY ANALYSIS SAVE MONEY

A new electricity-load forecasting tool was devised by the Centre, potentially saving money for Australia's 1 million households with rooftop solar and electric water heating.

The new tool, Cluster-Classify-Forecast (CCF), has 20% lower forecast errors than existing state-of-the-art forecast models. The Centre's researchers, in partnership with Australia's largest independent solar monitoring company, Solar Analytics, also tested CCF within a hot water heating control tool called Smart Switch Control (SSC). This tool used the CCF forecast to redirect excessive rooftop solar generation to heat water, rather than sending it to the grid.

Solar Analytics' monitoring and forecasting tool is being used by more than 30,000 customers, about 1.5% of the market. The company hopes to increase this share to 15% by 2027. The simulation showed higher accuracy load forecasts improved SSC's performance by reducing the amount of electricity brought from the grid, and improved the self-consumption rate of rooftop solar generation. The SSC tool, combined with CCF forecasts, reduced electricity

brought from the grid for heating water by 15% on average, cutting power bills by 5% annually. Compared with readily available alternative electric hot water heating control technologies, such as simple timers and diverters, SSC also offered a shorter pay-back time. SSC provides benefits to network companies and utilities too, because it can reduce daytime solar export rates by more than 20%. This can significantly help alleviate voltage and frequency-related problems in certain regions with high rooftop solar penetration rates, while protecting consumers from solar curtailment and size-limitation regulations that are being discussed by the network and utilities.

### MONITORING HOUSEHOLD ENERGY USE

The largest share of a household's energy consumption is used on heating and cooling. In response to this, researchers from the Centre developed an innovative tool to visualise indoor thermal comfort and household energy and water use which is currently being trialled in 20 Sydney households. VIHEW collects data using meters, sensors and state-of-the-art cloud computing technology which delivers user-friendly information through an interactive dashboard directly to householders. A significant

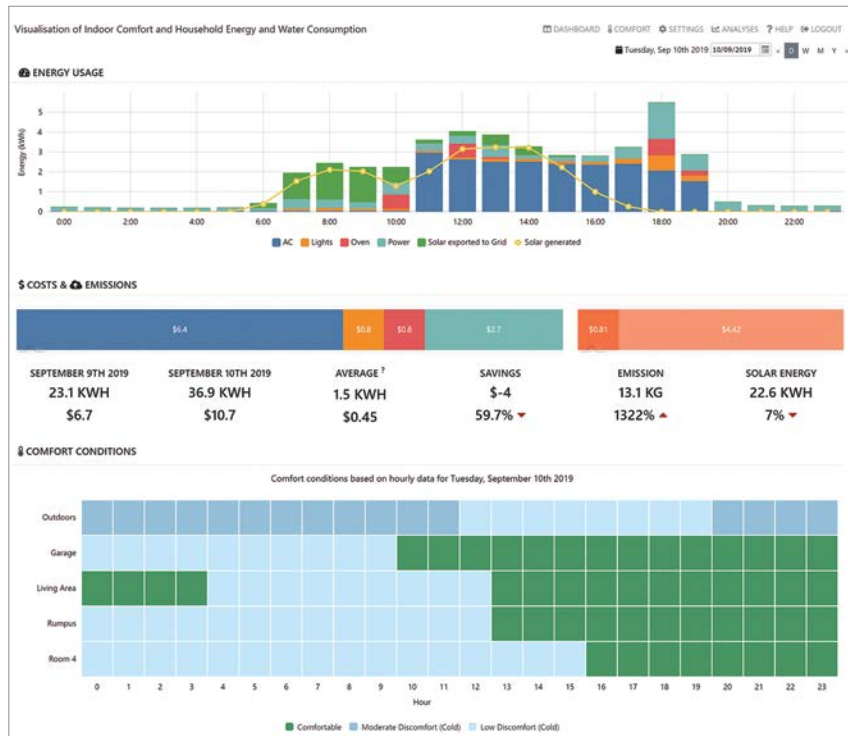


**Researchers at the Centre worked with Solar Analytics to develop sophisticated forecasting algorithms, enhancing a widely used monitoring tool that directs excess solar energy to heating water, rather than to the grid**



### AWARD WINNER

VIHEW won the Data as an Enabler category of the 2019 Smart Cities Committee for Sydney Award. A significant innovation of the tool is its personalised approach, presenting simple graphics to illustrate indoor thermal comfort conditions.



innovation of VIHEW is its personalised approach, presenting indoor thermal comfort conditions via house floor plans, and using simple graphics to illustrate indoor thermal comfort conditions. These are cross referenced with air-conditioning energy consumption to highlight issues associated with the building envelope or a household's thermal preference. The tool can also be used remotely to adjust home temperatures in preparation for a resident's arrival or to shut down appliances that haven't been switched off.

"VIHEW displays energy consumption from lighting, plug loads, air conditioning, water heating and pool pump and solar energy generation, while encouraging households to use energy efficient appliances and change their behaviour," said lead researcher Dr Anir Upadhyay, UNSW Sydney.

VIHEW also provides energy performance and total greenhouse gas emissions of buildings post occupancy and compares it with benchmark data such as BASIX in NSW. The information generated could inform government policy and influence development of a targeted energy efficiency program. Utility companies may also benefit from the household scale energy/water demand and water leakages information. VIHEW won the Data as an Enabler category of the 2019 Smart Cities Committee for Sydney Award.

### **'COOL' ROOFS CHEAPER FOR COMMERCIAL BUILDINGS**

'Cool' roofing materials or coatings could generate larger savings than expected for commercial buildings, such as shopping centres, according to the Centre's research. Until now, the benefits from cool roofs have been significantly underestimated in building performance simulations using ambient temperatures.

A team of researchers from the Centre, led by Senior Professor Paul Cooper, Director of the University of Wollongong's Sustainable Building Research Centre, developed a new empirical model that can accurately quantify changes in electricity and gas use in large buildings, if conventional roofs are swapped for cool roofs.

The Centre worked closely with BlueScope, Australia's largest manufacturer of commercial and residential metal roofing, to develop a model to help manufacturers of cool-roofing materials make reliable claims about their products, and designers and developers to make informed choices. The new model incorporates variations in temperature in the layer of



**"Cool roofs might be slightly more expensive but they can save both money and emissions in the operation of a building"**

**SENIOR PROFESSOR  
PAUL COOPER**

Node Leader,  
University of Wollongong

air just above a roof that is sucked into roof-mounted heating, ventilation and air conditioning units (HVAC).

Experiments conducted on the roofs of three large NSW shopping centres, with footprints ranging from 16,000 sq metres to 76,000 sq metres, found this 'near-roof' layer of air was typically warmer than the ambient temperature, reducing the efficiency of rooftop cooling equipment, and increasing electricity demand and costs. Conversely, this warmer air reduced the amount of gas used for heating. By contrast 'cool roofs' remain much closer to ambient temperatures than conventional roofs, increasing the cooling saving of HVAC equipment, whilst also creating a typically smaller additional heating penalty.

The experimental data enabled the model to be developed incorporating this near-roof zone. Using seven different Australian climate scenarios, the team simulated electricity and gas use for a large shopping centre with rooftop HVAC, comparing a metal-coated steel roof with a cool roof.

"Cool roofs might be slightly more expensive but they can save both money and emissions in the operation of a building," said Professor Cooper.





### **SAVINGS FOR COMMERCIAL BUILDINGS**

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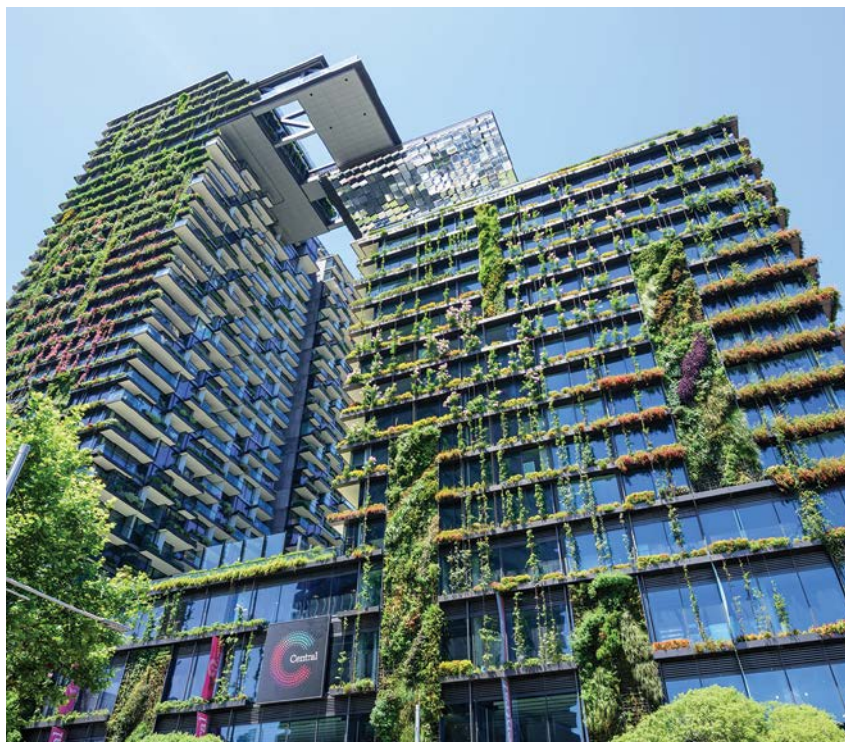
The Centre conducted experiments on the roofs of three large shopping centres  
Photo: iStock



### **SHOPPING CENTRE COOLING**

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Sydney's Central Park Mall incorporates green infrastructure for cooling  
Photo: DensityXDesign





The Centre has worked with  
BlueScope on a number of  
cool roof projects

COLORBOND® Coolmax® steel,  
Stockland, Hervey Bay, QLD

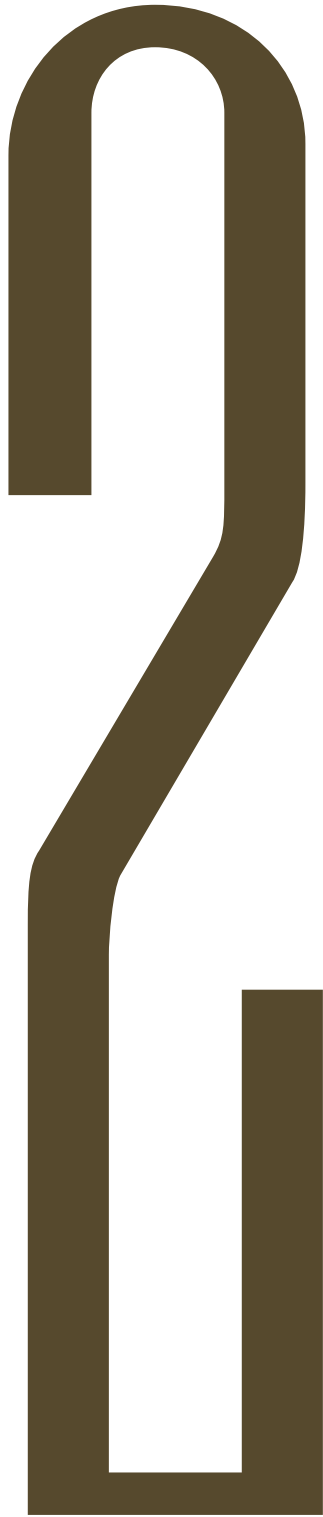
COLORBOND®, COOLMAX®, the BlueScope brand are registered trade marks of BlueScope  
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**"The Centre was responsive and versatile, producing data and insights that underpinned a range of important technical decisions and commercial directions"**



**Mark Eckermann**  
Product Innovation Manager,  
BlueScope



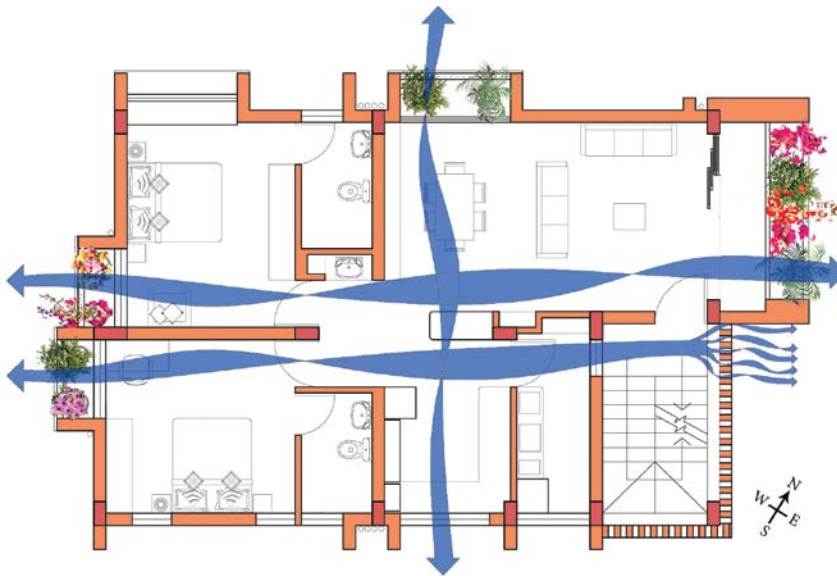
# BETTER HOMES

Australia will need 197,000 more homes a year to deal with rapid population growth. The CRC for Low Carbon Living engaged with social housing providers, real estate agents and home owners to demonstrate the benefits of adopting sustainable housing options





Apartment in Bowden, one  
of the Centre's Living Labs  
Photo: Renewal SA



### LIVEABILITY REAL ESTATE FRAMEWORK

The Liveability Real Estate Framework was developed in collaboration with the design, construction and assessment industries to cover key building structure elements; floor plan and layout; energy and water-saving inclusions and energy ratings; and building orientation and location

Photo:  
LIWO Design and Build Pvt. Ltd.

### THE PRICE OF LIVEABILITY

Granite benchtops and European appliances won't tell you much about a property's comfort or energy efficiency but a new framework for assessing "liveability" will.

The Banksia-Award winning Liveability Real Estate Framework helps vendors and landlords unlock the 'liveability' value in their properties by assisting prospective buyers and tenants identify running costs and comfort. The framework provides an incentive for owners to invest in features such as solar panels and double-glazing, and to orient new homes to maximise sunlight and shade.

Sydney consultancy Weldonco, which developed the Liveability Real Estate Framework with the CSIRO, are rolling out the tool with support from the Centre. The first online course for real estate agents run by the CSIRO is due to begin in late 2019.

The framework identifies The 17 Things or Liveability Features that can reduce the costs of running a home. It was developed in collaboration with the design, construction and assessment industries to cover key building structure elements; floor plan and layout;

energy and water-saving inclusions and energy ratings; and building orientation and location.

Once qualified, real estate agents can use the Liveability Features icon to highlight a property listing marketed by a trained sales agent or property manager who understands and recognises a home's liveability potential.

To date, more than 700 agents have been trained by Weldonco and LJ Hooker.

The Liveability Framework could also be used to help real estate agents explain energy ratings such as those being investigated in the Centre's EnergyFit Homes project. Filling a gap in the market, EnergyFit has built a business case for a national voluntary disclosure system to measure, benchmark and communicate information about the energy performance of existing homes.

The project, undertaken by the CSIRO and Common Capital, found 90% of consumers, building professionals and trades people supported providing energy efficiency information at the point of sale or lease.

# RENOVATE OR REBUILD?

## LIVEABILITY FRAMEWORK

- + This [Real Estate Framework](#) identified The 17 Things that reduce home-running costs
- + Incentivised real estate agents to rate liveability
- + LJ Hooker and Weldonco train 700 Liveability Real Estate Specialists
- + TAFE Sydney delivered Liveability training online

## ENERGYFIT HOMES PROJECT

- + Recommended a national energy rating system to increase market uptake of energy efficient homes at point of sale and lease
- + Rating system could save \$733m in annual household bills
- + Results showed 92% of housing consumers want energy efficiency and sustainable renovation planning and advice

## MY RENOVATION PLANNER

- + One-stop shop website created to offer consumers sustainable renovation planning and advice
- + Trained consultants educated renovators on the best energy and design choices for their home

## MEDIA INFORMS RENOVATIONS

- + Collaboration between the Centre and Sustainability Victoria analysed how home renovators use mainstream and social media to learn about low carbon home renovation options
- + Social media analysis showed consumers respond to the words 'liveability' and 'sustainability'
- + TV shows like *The Block* were found to be highly effective renovation trend influencers



700 Liveability Real Estate Specialists have been trained through the Framework



How can home owners be encouraged towards more sustainable building and renovation options? A number of projects at the Centre used consumer behaviour analysis to better understand and amplify audience reach

### ▶ **RENOVATE OR REBUILD SERIES PRODUCED**

- ✦ Social research confirmed 'top down' approach is failing to shift consumers towards sustainable housing choices
- ✦ Previous research informs development of YouTube lifestyle series *Renovate or Rebuild* to accelerate uptake of Net Zero Energy Housing
- ✦ The lifestyle series was launched with the Office of Environment and Heritage (now Department of Planning, Industry and Environment) featuring former contestants from *The Block*
- ✦ The series was viewed more than 6,000 times in the first five months
- ✦ 77% of viewers clicked through to supporting [website](#)
- ✦ Channel 9 Life confirmed interest in broadcasting an eight-episode series to a 2.8 million audience. Filming to commence mid-2020 subject to industry support

**"Our goal is to demystify the process of building or renovating an energy efficient home by communicating it in an engaging and entertaining format"**

**DR JOSH BYRNE**  
Curtin University Project Leader  
and *Renovate or Rebuild* presenter



# RENOVATE OR REBUILD

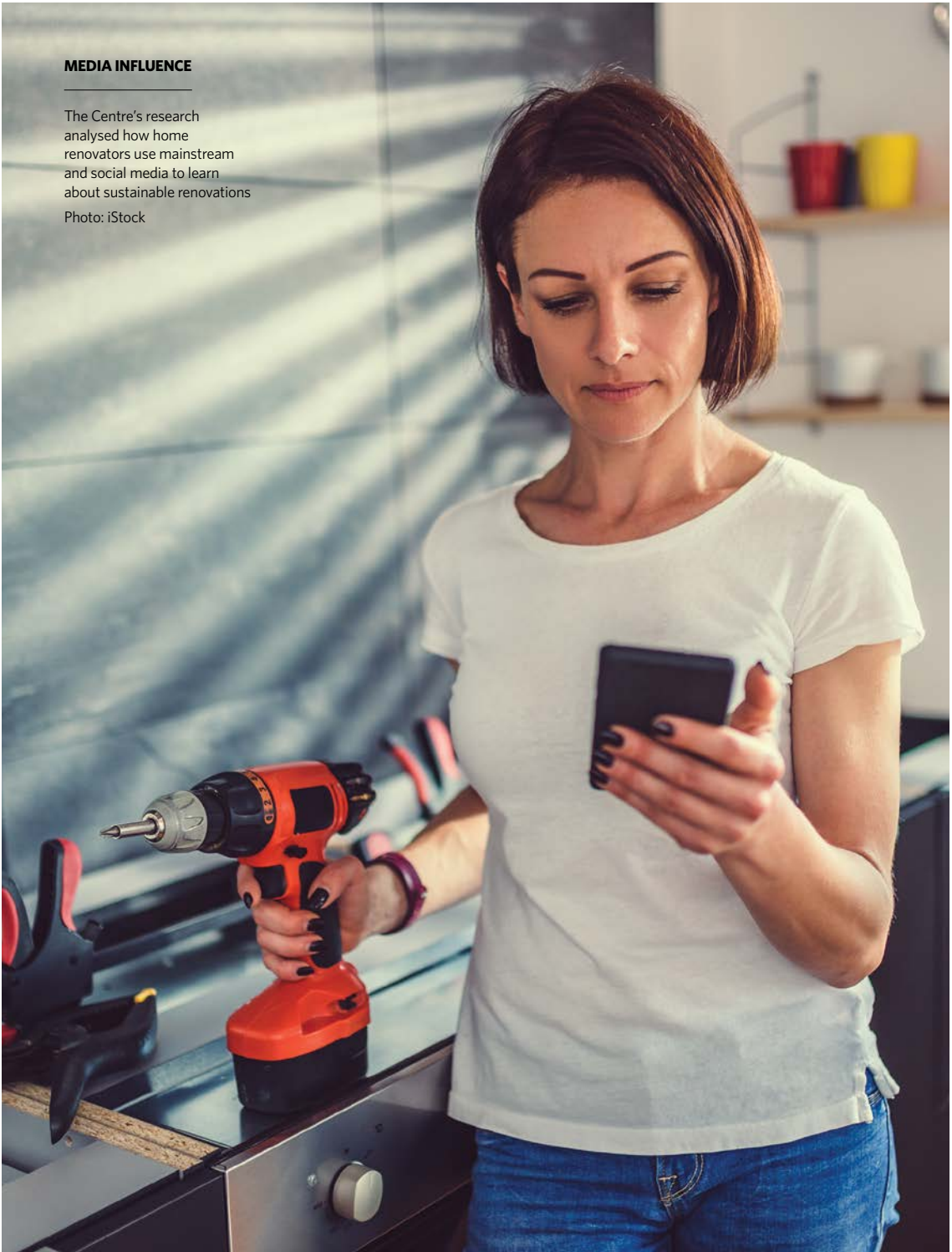
ONE FAMILY | TWO TEAMS | ONE BIG DECISION



## **MEDIA INFLUENCE**

The Centre's research analysed how home renovators use mainstream and social media to learn about sustainable renovations

Photo: iStock





## SUSTAINABLE RENOVATION

*Myrenovationplanner* addresses consumer demand for trustworthy renovation products and services

## SUSTAINABLE RENOVATIONS MADE EASY

It may seem counterintuitive, but to drive sustainable home renovations, it's a good idea to drop terms such as 'eco' and 'green' from the sales pitch. Most renovators want to improve the sustainability of their homes but their plans often fall by the wayside because they become overwhelmed by the renovation itself. What they really need is help with the hard part — finding the right tradespeople and products at the right time and right price.

The Centre tapped into what we already know about how consumers behave to create a business model and web-based tool, *myrenovationplanner*, for the \$33bn-a-year Australian home renovation market. Renovators can use *myrenovationplanner* to plan and cost their renovations, room by room, connect with accredited local tradespeople and products, and access professional consultants.

Many consumers think sustainable housing will cost them more money, and they don't know much about what it involves beyond adding solar panels to the roof. This tool helps them make the best decisions and devise a building timetable to help them save money

and build a sustainable home. It also ensures renovators understand the best energy and design choices for their home, which materials are low carbon, and can connect them to trained consultants.

The new tool was developed by consultants the Blue Tribe Company in partnership with CSIRO and the NSW Office of Environment and Heritage, with input from the housing industry and other stakeholders. It will be run as a stand-alone private venture by Blue Tribe following the end of the Centre's funding period.

The tool addresses consumer demand for trustworthy renovation information and services. The project highlights the value of collaboration between policy-makers, researchers and the private sector, and the benefits of harnessing a 'start-up' business model.

## SOCIAL MEDIA INFORMS LOW CARBON RENOVATIONS

Home renovation does less damage to the environment than demolishing a house and then building a new one. There are plenty of ways to cut the carbon associated with Australia's 8 million existing houses but many home owners don't include these when they renovate their homes. So an innovative research project between the Centre and Sustainability Victoria analysed how home renovators might use mainstream and social media to learn more about the process.

"The potential of incorporating simple energy efficiency measures when renovating homes isn't being realised," said project leader Professor Kath Hulse from the Swinburne University of Technology. "Media can be very persuasive in terms of informing, educating and entertaining, and giving home renovators access to alternative options," she said.

TV formats like *The Block* are highly effective when it comes to influencing sustainable renovation trends. "Language is important. People don't talk about 'low carbon living', they talk about 'home' and 'renovation'; these are the words that have the most traction," said Professor Hulse.

Analysis has shown that Twitter posts by celebrities, not-for-profit organisations and media about home renovation can be more influential than those made by governments, the renovation industry, or retailers.

Analysis conducted as part of the research found that renovators responded to words such as 'liveability' and 'sustainability', while public Twitter conversations using #solar and #sustainability were more influential than terms such as #greenenergy and #lowcarbon.



# MAINSTREAMING

For seven years, the Centre has worked with partner LandCorp and industry collaborators to build and monitor low carbon houses, precincts and display homes to inspire, engage and educate

2012

Dr Josh Byrne documented the construction and performance of his Net Zero Energy Home (NZEH), the first of the Centre's Living Labs

**2013** Josh's House website launched offering access to real-time energy, water and comfort data

PhD student Christine Eon followed the efforts of 10 Perth households for two years in reducing their energy and water use. *Living Labs* video series released

Josh's House website receives 240,000 visits since 2012

6000 visitors attended Josh's House since the inaugural home open event in 2013

**2014** Josh reported saving \$1,200 annually on electricity with the home producing more energy than is consumed

*Star Performers* video series released exploring how to deliver high performing homes in Australian climates

## NET ZERO ENERGY HOME



**PARTNERS** ..... Curtin University, Josh Byrne & Associates, LandCorp, University of South Australia .....

# LOW CARBON HOMES

2019

LandCorp established Fremantle's WGV residential precinct one of the Centre's 16 Living Labs

Residents saved up to \$1,200 a year in utility bills compared to a typical Perth home

2017 *Density by Design* video series released and featured on Sky News

2017 Volume builders SJD Homes and Stockland recruited to build display NZEH in Queensland and Victoria

Research proved NZEH's cost only 6-11% more than a comparable home

180 residents committed to decrease CO<sub>2</sub>e by 60%

State-of-the-art performance monitoring implemented

PhD students Jessica Breadsell and Tanya Babaeff studied resident experience and community participation

House performance showed 88% annual energy savings in NZEHs

*Net Zero Energy Homes* video series launched

Melbourne NZEH kick-starts Victoria's \$2.18m energy efficiency pilot program. Launched by Hon. Lily D'Ambrosi, Minister for Energy, Environment and Climate Change

NZEH case studies used in Housing Industry Australia CPD courses

Dr Josh Byrne invited to produce Master Builders Association podcast series

## PRECINCT-SCALE DEVELOPMENT



WHITE GUM VALLEY LIVING LAB

## MAINSTREAMING NET ZERO ENERGY HOMES



ZERO NET ENERGY DISPLAY HOME BUILT

City of Fremantle, Curtin University, Josh Byrne & Associates, LandCorp

CSIRO, Curtin University, Innovation House, Josh Byrne & Associates Mirvac, Parklea, Rawson Group, Riverview Projects, SJD Homes, Stockland, South East Councils Climate Change Alliance, Sustainability Victoria, Terrace



## LOW-INCOME HOUSING

### TENANTS HEALTH SUFFERS IN SOCIAL HOUSING

The health and comfort of more than 800,000 Australians who live in social housing is at risk because of inadequate housing and rising energy prices. Living on tight household budgets, many residents restrict their energy use, exposing themselves to severe heat stress during Australia's increasingly hot summers, and to indoor winter temperatures below those the World Health Organisation considers safe.

A project at the Centre led by University of Wollongong Senior Professor, Paul Cooper, investigated the potential energy efficiency, comfort and health benefits of a range of upgrades implemented in NSW's existing social housing stock. Retrofits included wall insulation, double glazing, heat pump hot water systems, PV panels, reverse cycle air conditioning, ceiling fans, and draught proofing.

The Centre partnered with the NSW Office of Environment and Heritage, the NSW Land and Housing Corporation, and a number of housing providers including Evolve Housing, Housing Plus, Housing Trust, and the Aboriginal Housing Office.

The researchers created a 'living laboratory', tracking the performance of three different retrofit programs for social housing stock in Port Kembla, Western Sydney and in NSW's central and north-west regions. The effectiveness of the upgrades was evaluated considering changes in internal temperatures, energy consumption and the tenant's experience of the works.

*A [Guide to Implementing Low Carbon Retrofits for Social Housing](#) was developed from this project.*

The guide is an evidence-based, easy-to-use reference for social housing asset managers and those involved in property upgrades. The guide provides concise information on how to improve energy efficiency, and outlines some key retrofit opportunities for social housing stock.

The benefits of improving energy efficiency across Australia's social housing sector would be significant, and the centralised management of social housing can help to facilitate the retrofitting of large numbers of homes in a short timeframe. This project has provided insights into some of the opportunities and challenges for realising energy efficiency improvements in this sector.

**Living on tight household budgets, many social housing residents restrict their energy use, exposing themselves to severe heat stress in summer and cold indoor temperatures in winter**

### ENERGY EFFICIENCY FOR LOW INCOME HOUSEHOLDS

Low-income families suffer disproportionately from rising energy costs and lack of access to energy efficient housing and appliances. In 2015-2016 alone, energy supply was disconnected to more than 160,000 Australians who failed to pay their bills on time.

Researchers at the Centre have worked with regulators, community housing providers and landlords to work out how the NSW Government could improve energy efficiency uptake. Researcher Dr Edgar Liu said their conclusions will hopefully spur federal and state governments to invest in best-practice energy efficiency for all new social housing, and upgrade existing public and community housing. The NSW Office of Environment and Heritage (NSW OEH) is reviewing the findings with a view to broadening access to the government's Home Energy Action Program (HEAP).

"HEAP is important to many social housing providers because it helps them provide energy efficient features to vulnerable clients," said Dr Liu. "But the reach is limited by strict funding rules and complicated application and management processes. Relaxing

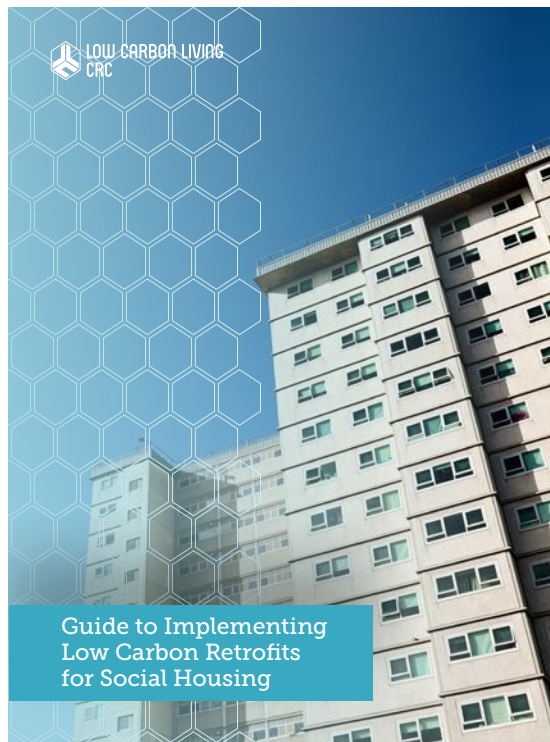


these processes would allow smaller, specialist providers to get involved.”

Work done by the Centre, the Salvation Army, NSW OEH, and the Council of the Ageing, found that an increasing number of Australians live in rental accommodation poorly served by energy efficiency. These households find it hard to access information about energy efficiency, and often don't understand information from energy retailers about support and financial assistance. They also believe 'green' energy is too expensive.

Policymakers and service providers across four states made the following recommendations: extend minimal energy efficiency standards for new builds to existing homes; design energy bills so that energy consumption and efficiency is easy to understand; offer higher tax incentives to landlords to improve energy efficiency in their properties, and give tenants greater rights to modify rental premises.

The Centre's researchers were invited to present their findings at two Australian Government Senate enquiries on the future impacts of climate change on housing, buildings and infrastructure, and improving energy efficiency in rental properties.







The Science Place, James Cook University, Townsville, Queensland, by CRC for Low Carbon Living partner HASSELL

Photo: Andrew Rankin

**“A sustainable future depends on changing our attitude to the built environment. Applied research, like that delivered by the CRC, with real impact on policy and practice, is essential to bringing about that change”**



**Professor  
Ken Maher AO**

President, Australian  
Sustainable Built  
Environment Council  
and HASSELL Fellow

75



# BETTER PRECINCTS

The CRC for Low Carbon Living has developed carbon assessment tools to assess and manage emissions, waste and recycling at every level of precinct development helping policymakers and governments build healthier more sustainable precincts

## PRECINCT TOOLS

### MINIMISING EMBODIED CARBON IN THE BUILT ENVIRONMENT

The construction, operation and maintenance of Australian buildings accounts for 25% of emissions, so it's vital that we can predict the embodied carbon in large buildings and precincts before they are built.

Centre researchers developed a carbon life-cycle inventory database called [Integrated Carbon Metrics](#) (ICM) to quantify the embodied carbon emissions for construction-related materials and processes, including emissions from the production of building materials and the construction of buildings and precincts. This project also led to the development of the Embodied Carbon Explorer tool and a Precinct Carbon Assessment tool to help designers, manufacturers, planners and developers calculate embodied carbon emissions during the planning stage.

Working with data provided by partner Multiplex, Centre researchers also developed a Carbon Value Engineering framework that expanded the industry-standard practice of 'value engineering' to include embodied carbon in cost consideration. Estimates of carbon savings increased markedly when the value engineering techniques were applied earlier in the construction cycle; carbon savings of up to 36% could be obtained with a concrete frame and up to 56% with a more innovative whole timber frame. These equated with cost savings of up to \$127 a sq metre, which represents a potential 10% reduction in capital costs, a huge figure in the context of the building industry.

The project led to carbon footprint analysis expert and ICM project leader, Associate Professor Tommy Wiedmann, contributing to an international report by the C40 Cities Climate Leadership Group. It revealed that cities have a 60% larger carbon footprint than was previously estimated.

### RENEWABLE ENERGY FOR BIG POWER USERS

Switching to renewable energy can help medium to large-scale organisations and businesses reduce emissions and costs, by avoiding high and often volatile wholesale electricity prices in the National Energy Market. But the shift can be more complicated than it sounds. One common option is to use a Renewable Power Purchase Agreement (PPA) to meet a percentage or the totality of the load demand using power drawn from utility-scale renewable energy

## The application of 'value engineering' to carbon can result in a 10% reduction in capital costs—a huge figure in the context of the building industry

plants. This can be brokered through an energy retailer that will also provide the residual power, or 'firming' power, via the electricity grid.

Making a financial case for adopting renewable energy can be a complex exercise, in part because of the various parties involved, and due to the risks associated, which are currently not well understood by the industry. So, drawing on previous research, the Centre has released a set of [Renewable PPA Tools](#) to make the process easier. The tools help large to small energy users, consumers, buyers' groups and local government model Renewable PPAs under varying conditions, so they can assess the financial benefits and risks, and the likelihood of an agreement meeting emissions reduction and financial goals.

The tools help users create cash-flow models using four customised Microsoft Excel workbooks. They can also be used to monitor the returns of existing PPAs to ensure consumers are getting value for money. The tools' release coincides with increasing demand for large-scale renewable power deals, driven by power price increases and emissions reduction goals. Many major Australian retail chains are purchasing renewable power from large-scale solar and wind farms.

# INTEGRATED CARBON METRICS PROJECT

Tools to reduce Australia's embodied carbon emissions



**11%**  
of Australia's  
embodied carbon  
emissions are from:



**BUILDING MATERIALS**

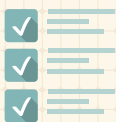


**BUILDING MATERIAL PRODUCTION**



**BUILDING MATERIAL TRANSPORT**

This project has the potential to reduce emissions by using:



A new knowledge base to help architects, designers, planners, engineers & builders to manage project carbon outcomes



A new predictive tool for policy-makers and government to help meet their carbon emission reduction targets for buildings and precincts



Identifying new research areas to further innovate in carbon savings

## PROJECT TEAM

### RESEARCH PARTNERS



University of NSW  
University of Melbourne  
University of South Australia  
CSIRO

### INDUSTRY PARTNERS



AECOM  
Aurecon  
BlueScope  
Sydney Water

### RESEARCHERS





## NEW TOOL TAKES ON URBAN HEAT

As Australian cities heat up, the Centre has assisted local governments and planners with the innovative [Microclimate and Urban Heat Island Mitigation Decision-Support Tool](#). It brings together scientific models, case studies and guidelines to help government and built environment professionals plan top heat mitigation strategies and effects for their city.

The 3D platform helps users visualise development alternatives and ‘see’ the effects of various heat mitigation techniques including the addition of trees and water features or cool roofs and pavements.

Project leader, Associate Professor Lan Ding said the tool provides better scenario analysis to address heat, inform future urban policy, and help develop assessment and planning practices to mitigate urban overheating, improve outdoor thermal comfort and protect the health of the vulnerable. “This tool is unique because it integrates scientific models with a range of mitigation techniques to provide urban heat island mitigation analysis across both urban and building scales, such as urban form, parks, greenery, waterways and cool roofs,” she said.

More than 60 stakeholders in Australia, UK, USA and India have trialed the tool which has also been used across various projects in Sydney including the Green Square Town Centre redevelopment by Landcom and City of Sydney, Parramatta Civic Link redevelopment by Parramatta City Council, and Macarthur Heights greenfield development by Landcom and Campbelltown City Council.

After considerable international interest plans are in place to adapt the tool for a global market. This will allow a comparative analysis of urban heat mitigation to be undertaken in countries including the UK and USA. Quzhou City in China, part of UNEP’s SUC Guidelines, will also be used as an international case study.

## GREENING SUBURBAN TRANSPORT

Transport is Australia’s second largest and most rapidly increasing source of greenhouse gas pollution after electricity. A national team of researchers from the Centre developed a suite of integrated tools to estimate the carbon savings that could result from the introduction of faster and more affordable transport options.



**A national team of researchers developed a suite of integrated tools to estimate the carbon savings that could result from the introduction of faster and more affordable transport options**

Working within the 'Avoid-Shift-Share-Improve' (ASSI) policy framework for low carbon mobility developed at Swinburne University, the project investigated travel demand and shifts in travel behaviour, supply and decision support for infrastructure investment. The study surveyed residents in six Adelaide suburbs to determine their travel preferences. Of those living in the three more distant suburbs, 40% were willing to use public transport at interchanges if they were well connected by shuttle services, and were even willing to pay an extra \$2.50 to catch a shuttle.

The project developed three tools to assess the impacts of low carbon transport solutions: a calculator for modelling the impacts of precinct shared use transport solutions (PSUMC), tools for modelling the impacts of shared Autonomous Mobility-on-Demand services, and agent-based tools for modelling transport mode choice (ABM-TMC).

The tools were applied to the ASSI framework, providing a resource for transport planners to manage the ongoing challenge of moving growing populations around increasingly congested cities.

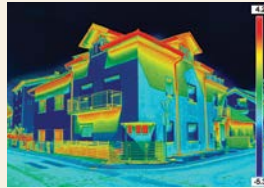


# URBAN HEAT ISLANDS

## 2013

### CITY COMPARISON

First major project compared UHI in Sydney, Melbourne and Adelaide



↑  
Thermal imaging

### PARTNERS

AECOM, BlueScope, Campbelltown City Council, City of Parramatta, City of Sydney, Greater Sydney Commission, HASSELL, Inner West Council, Landcom, NSW OEH, NSW Spatial Services, PSMA Australia, SSROC, Stockland, Swinburne University of Technology, Sydney Water, Waverley Council, WSROC, UNSW Sydney

## 2017

### COOLING CITIES

*Cooling Western Sydney* report with Sydney Water revealed water features could reduce heatwave mortality rates by up to 50%

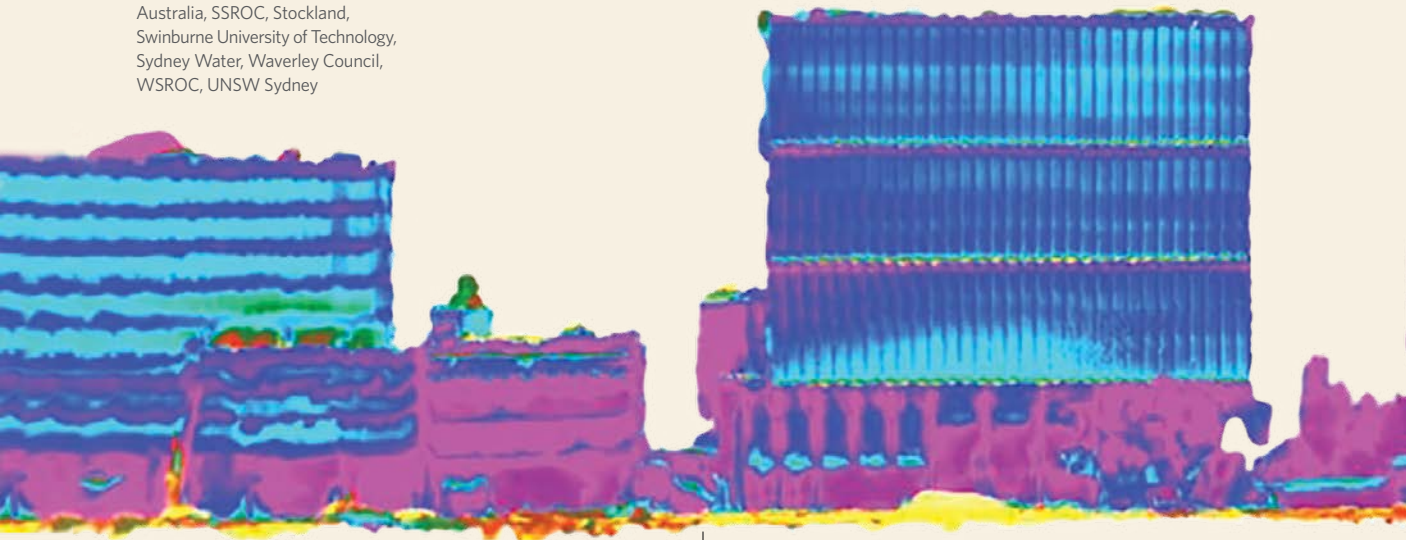
Australia's first *Guide to Urban Cooling Strategies* launched detailing UHI mitigation options for Australia's major cities



## 2018

### SYDNEY'S 'THIRD CITY'

The Centre partnered with the Greater Sydney Commission to undertake complex modelling for the South Creek area near the new airport



As global temperatures rise, cities need more innovative technologies to ensure cool and healthy conditions for residents. Over the past seven years the Centre's world-class experts have partnered with numerous councils to develop an authoritative body of research on how to minimise the Urban Heat Island (UHI) effect in Australian cities

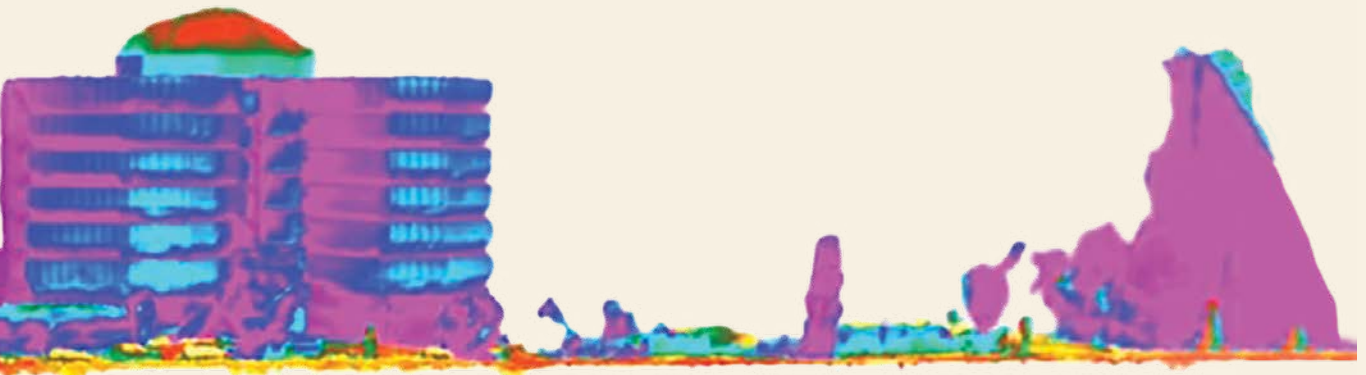
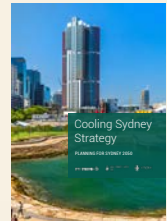
# 2019

- *Cooling Cities* video released showcasing the Centre's research
- New research funded by City of Parramatta revealed temperatures in Western Sydney can be reduced by 2°C
- Four PhD students completed research in various aspects of urban heat resilience

- *Urban Heat Island Mitigation Decision-Support Tool* 3D platform launched providing online scenario analysis for Sydney planners and built environment specialists
- *Cooling Sydney Strategy* launched with City of Sydney outlining temperature rises by 2050 and solutions
- Using UNSW Energy Bus plus drones and thermal imaging researchers captured real-time UHI data



- ↑ Urban Heat Island Mitigation 3D Tool
- UNSW Energy Bus team capture UHI data
- ↓ City of Parramatta thermal imaging





### **WASTEWATER**

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Data was collected from more than 244 wastewater treatment plants nation-wide to manage plant energy use and optimisation



### **COMMUNITY COMPOSTING**

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Many people living in homes with gardens can compost but it can be more challenging for apartment dwellers and business owners. Solutions range from community worm farms to high-tech '24 hour in-vessel systems' that begin the composting process and reduce the volume of food waste by up to 90%. Researchers found taking part in community composting encouraged people to create less waste, develop stronger community connections and take an interest in other environmental issues



## WASTE AND RECYCLING

### HARNESSING THE FULL VALUE OF FOOD WASTE

Most people know that as a nation, we generate a huge amount of food waste: one in every five bags of groceries, or about \$20bn a year is wasted. But few of us know the full cost of sending so much food to landfill. Food waste in Australian landfill generates methane and other emissions equivalent to running more than 1.6 million cars all year. It also locks up a potentially valuable resource. Directed to composting systems, food waste returns carbon to depleted agricultural soils and reduces demand for water, fertilisers, herbicides and pesticides.

The Centre worked with urban communities to develop manageable composting systems of every scale, including a system for the kitchens used by reality TV show *Masterchef*.

The three-year project, led by Dr Vivienne Waller of Swinburne University, piloted a range of urban composting strategies for sites in Melbourne, ranging from high-rise apartment blocks to a luxury city hotel, and large and small city businesses.

The project's findings were communicated through a national Urban Composting Symposium hosted by Craig Reucassel of the ABC's *War on Waste*, and via stories in the media, which sparked numerous public inquiries. Swinburne University PhD student Alex Jaimes Castillo invented a small in-vessel composter for the home that is expected to fill a gap in the home composting market.

### EFFICIENT WASTEWATER TREATMENT

Wastewater treatment is among the most energy-intensive industrial processes conducted in Australian cities, but a tool developed by researchers at the Centre is helping Australian water utilities cut their electricity use, costs and emissions. Developed in collaboration with the Water Services Association of Australia (WSAA), the new Benchmarking Energy and Carbon tool is expected to help the water industry cut energy use and associated emissions from wastewater treatment processing by about 22,500 tonnes of CO<sub>2</sub> per year from 2020, the equivalent of taking some 5,000 cars off the road annually.

The tool provides the wastewater industry with evidence-based energy benchmarks for various processes and plant types via an online energy performance data visualisation dashboard.

**The Centre's research is helping the water industry cut emissions from wastewater treatment processing by about 22,500 tonnes of CO<sub>2</sub> a year from 2020**

Treatment plant operators can check plant energy use against comparable industry benchmarks (national and international), alerting them to inefficiencies and informing optimisation efforts. The dashboard includes energy performance data collected from more than 244 wastewater treatment plants nation-wide.

The rich data resource was previously locked away in inaccessible industry reports, said project leader, Dr Michael Short, from the University of South Australia's Future Industries Institute.

The tool will be available for use by WSAA's 80 member organisations, which collectively provide water supply and wastewater treatment services to more than 20 million people, covering more than 80% of water and wastewater services in Australia. It is expected to be especially useful for smaller utilities that may not have sufficient resources to invest in their own energy management personnel or tools. WSAA will continue to maintain and update the new tool in line with ongoing energy benchmarking efforts.

## Residual biosolids from wastewater treatment plants could be a valuable resource for enriching agricultural soil



### WASTE NOT, WANT NOT

Acceptance for the use of recycled waste products within the global community has grown in recent years, due in part to recycled waste's inexpensiveness, low carbon demands and potential as an effective product in a variety of applications. Despite this, adoption of these products remains low in Australia. As a result, wastewater treatment plants have long disposed of 'biosolids' in landfill, squandering a potentially valuable resource for enriching agricultural soil.

With about 50kg of solid waste a year produced by every person on earth, governments are now encouraging a shift towards biosolids resource recovery.

The Centre partnered with Sydney Water, UNSW Sydney, SUEZ, Hunter Water, SA Water and the University of SA to develop an evidence-based framework for realising the benefits of biosolids. This includes reducing the carbon footprint of processing, improving energy efficiency and providing new strategies to promote community acceptance of recycled human waste.

Regarding industrial environmental impacts, odour remains the dominant cause for complaints.

Researchers from the Centre designed evidence-based methods to address this issue, including how improved processing, removing water from solids and on-site 'digestion' of solid waste could reduce odours. The project also developed an online tool that allows people to report odours and make complaints. Researchers found that one-on-one engagement with complainants proved more effective than using blanket tools, such as leaflets delivered to households.

Odour abatement strategies are often expensive so more effective processing and better community engagement promises to reduce costs and help drive community acceptance of biosolids reuse. The project also generated evidence-based projections of potential energy and costs savings in areas such as better plant digestors and reduced fertiliser costs for farmers. The project also identified potential annual savings of \$3m a year across Sydney Water's network.



## INNOVATION IN ACTION

Scientia Professor Veena Sahajwalla at UNSW's SMaRT Centre with glass benchtop examples



### WASTE TO BENCHTOPS

In Australia, almost 800,000 tonnes of waste glass requires disposal every year, while in Europe approximately 1.5 million tonnes of waste glass is generated annually from building demolition and renovation. To help solve this problem, researchers at the Centre investigated using recycled glass to manufacture benchtops. The product is similar to engineered stone, but is 100% sustainable.

In the long term, the product represents a significant advance in reducing carbon during the production of building materials as it minimises raw materials extraction, transport and production costs.

Working with UNSW's SMaRT Centre, researchers have initiated partnerships with local waste management facilities to provide materials and a commercial hot-press has been installed at Terrazzo Australia Marble so that the benchtops can be prototyped and manufactured.

The manufacturing process will be co-located across two sites; Terrazzo Australia Marble and UNSW Sydney. Terrazzo Australia Marble, which has downstream processing equipment and established

distribution networks, is a key industry partner. SMaRT will leverage these assets to reduce the friction in getting products to market. Terrazzo Australia Marble is well connected to freight routes which will enable waste material delivery and product export across Australia and globally.

UNSW Sydney has been nominated as one of the waste material testing and preparation sites. This is due to its proximity to researchers and testing equipment. SMaRT at UNSW Sydney will form part of the material supply chain to provide quality assurances to the materials and the products. The patented material blends will be trialled at SMaRT Centre to remain agile to market demands and waste material quality, before being introduced into production at Terrazzo Australia Marble.

"Instead of turning waste glass back into more glass, we can envisage safely harnessing complex, difficult and even toxic waste streams to produce previously unimaginable new value-added green materials and resources, instead of shipping our waste offshore," said project leader, Scientia Professor Veena Sahajwalla from UNSW's SMaRT Centre.

4

# BETTER COMMUNITIES

Many CRC for Low Carbon Living projects encouraged the community to engage with low carbon living by establishing low carbon services, including carbon assessment in the education and tourism sectors

# LOW CARBON TOURISM

Tourism represents around 5% of Australia's carbon emissions. The Centre's tourism program was started with the Blue Mountains World Heritage Institute and has now launched nationally, bringing Australian communities and businesses together to collectively lower carbon emissions



## 2014

- Pilot began in Blue Mountains: Thirty local businesses committed to reducing carbon using the auditing system developed by the Centre
- Gold, Silver and Bronze public rating system introduced to incentivise business owners and consumers

## 2016

- Low Carbon Living Blue Mountains program launched with 80 businesses onboard
- Website offered free Carbon Calculator and tailored reports to businesses, individuals and householders

## 2018

- Low Carbon Living Australia (LCLA) national program launched
- Southern Highlands and Far North QLD joined
- EcoTourism Australia became a partner
- EcoBiz sponsors LCLA to support 15 businesses in Far North QLD
- LCLA partnered with Pangolin Associates to sell verified carbon credits
- 160 low carbon calculator audits completed
- Discussions with South Australian Government to extend LCLA to Kangaroo Island

### ↑ ESCARPMENT GROUP LUXURY ESCAPES

Saved 33% on energy and electricity



### SCENIC WORLD BLUE MOUNTAINS

Installed 100kW of solar panels saving 120 tonnes of CO<sub>2</sub>



Businesses reduce their annual carbon emissions by 19% on average after two years participating in the LCLA program



### PARTNERS

BMCC, BMWI, Curtin University, NSW OEH, UNSW Sydney





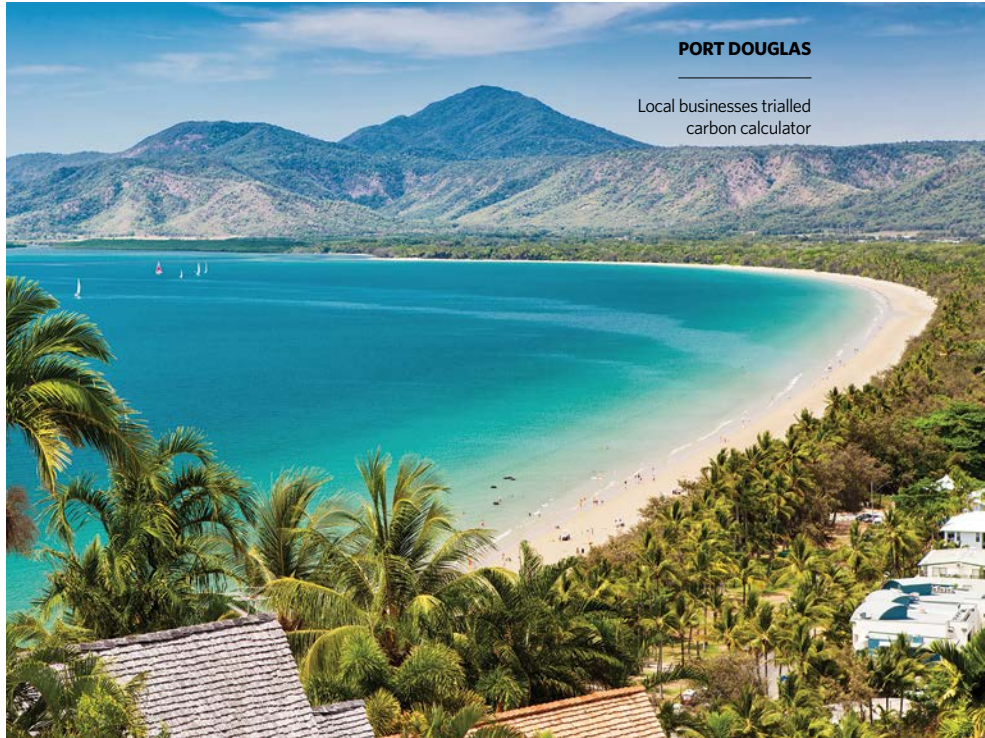
**“The Centre did a deep measure of Scenic World’s carbon footprint. It helped us focus our business strategy and work towards really minimising our environmental impact”**

**ANTHEA HAMMON**  
Project partner and Scenic World’s Managing Director



**“Everyone needs to be involved, especially from the hospitality industry, in reducing their carbon footprint”**

**ADAM HOLMES**  
Hotel Operations Manager,  
Escarpment Group



**PORT DOUGLAS**

Local businesses trialled carbon calculator



**"Australia needs a cost-effective, nationally coordinated effort to empower schools to lower carbon and costs, rather than relying on the government"**

**DR VANESSA RAULAND**

Project Leader and  
Founder & CEO ClimateClever



Dr Rauland at Neerigan Brook Primary School, Armadale, WA

Photo: Sam Proctor



# CLIMATE CLEVER

The national ClimateClever education program has worked with 45 Australian schools to deliver 20% reduction in CO<sub>2</sub>

## 2014

- Opportunity identified by the Centre for Australia's 10,000 schools to reduce carbon emissions
- Scoping study of existing carbon-related programs
- Workshops and interviews with 20 teachers and school staff in Perth

## 2015

- Discussions with City of Fremantle about pilot program for schools
- Program launch featured on SBS News in lead-up to Paris UN Climate Talks

## 2016

- Carbon Schools Pilot Program launched with City of Fremantle, City of Cockburn and City of Melville
- 15 Perth schools and 8,729 students joined program
- PhD student Portia Odell began impact of program research

## 2017

- 20% reduction of CO<sub>2</sub> achieved
- On average schools saved \$16 per student on utility bills

## 2018

- ClimateClever initiative launched nationally
- 30 schools joined pilot
- ClimateClever named finalist in UN World Summit Awards
- New partnership with Horizon Power and schools in Broome

## 2019

- Over 45 schools in ClimateClever Program
- 7 Local Governments subsidised schools
- ClimateClever received \$250K investment from private charitable trust
- Received \$350k from Lotterywest to fund Home app for households in financial hardship
- Business and community versions of app released

### PARTNERS

City of Fremantle,  
Curtin University



# BETTER POLICY

With the aim to have a significant impact on government policy, the CRC for Low Carbon Living delivered quality research as an evidence base for reform



## HIGH PERFORMING HOMES SAVE DOLLARS

In partnership with the Australian Sustainable Built Environment Council (ASBEC), the Centre developed a substantive body of research to help Australian governments initiate more sustainable building practices into the future. *The Bottom Line* report showed Australians could save up to \$150 a household on energy bills each year if standards were tightened in the Building Code.

“Sustainable homes require less energy to heat and cool, enhance occupant health and comfort and are more resilient to climate and weather extremes. They can also be a driver for economic growth,” said Suzanne Toumbourou, ASBEC’s Executive Director.

The following *Built to Perform* report, developed with ClimateWorks Australia, built on the research by demonstrating that energy standards in Australia’s National Construction Code must be urgently upgraded for new buildings to be fit for a zero carbon future. The report, which offered recommendations for almost every Australian state, was considered by the COAG Energy Council when establishing a Trajectory for Low Energy Buildings.

“Buildings contribute to around a quarter of Australia’s emissions and over half of the country’s electricity, through their operation alone. The work of the Centre has provided us with a solid foundation of knowledge on which to build our net zero-ready future. From materials and technical processes to evidence-based policy frameworks, the Centre has forged partnerships across a broad range of industry, government and academic stakeholders that can embed this vital knowledge and deliver this future together,” Toumbourou said.

## IMPROVING BUILDING ENERGY ASSESSMENT

Residential energy consumption represents about 25% of global energy consumption, and 17% of carbon emissions. Home energy rating tools such as BASIX and NatHERS, which aim to help Australians achieve improved energy efficiency, aren’t as effective as they could be, according to our research. The research showed BASIX-compliant buildings in NSW did produce fewer emissions but there were discrepancies between actual energy consumption and estimated consumption.

Project leader Associate Professor Lan Ding, said the discrepancies occurred in heating, cooling, lighting, and domestic appliances. “We found that BASIX underestimated space heating loads by 38% and



## AUSTRALIANS CHOOSE ENERGY EFFICIENT HOMES

The Centre has led numerous research projects on consumer preferences and engagement, construction industry practices and building technologies, which led to the *Growing the Market for Sustainable Homes* roadmap, produced in collaboration with ASBEC. It revealed two-thirds of Australian home buyers prefer energy efficient homes when given a choice but significant barriers prevent them from turning that desire into reality. Preliminary economic modelling found that accelerating Australia’s transition to sustainable housing would deliver more than half a billion dollars of extra investment in the construction industry by 2030.

cooling by 53%,” she said. “It also overestimated lighting energy consumption by 247% and combined plug loads by 110%.”

Researchers also found the building design and materials of BASIX-compliant dwellings contributed to higher energy consumption when it came to space cooling and heating. “Around 71% of BASIX-compliant dwellings with higher space heating or cooling energy than the estimate had brick-veneer and 23% were built using external masonry with an internal plasterboard lining,” said Professor Ding.

The research does not provide the detailed data needed to update the BASIX assessment models, but it highlighted the discrepancies between BASIX estimation and the actual energy performance of BASIX-compliant dwellings for future improvement. These findings form the basis for a review of the computational engines that underly BASIX and NatHERS, the national house energy rating scheme. Both these tools are closely embedded in the construction process nationally so the potential impact is large. The research was a collaborative effort between the NSW Department of Planning, Industry and Environment, City of Sydney and the Commonwealth Department of Industry.



**Accelerating Australia's transition to sustainable housing would create more than 7,000 new jobs and save households \$600m on energy bills**



# LOW CARBON CONCRETE

The Centre has developed a provisional patent on an innovative low carbon concrete embodying 50% less carbon emissions than traditional concrete. The geopolymer concrete has been used in world-first trials with NSW Ports and the City of Sydney

## BARRIERS & TESTING

- ✦ The Centre identified barriers to the commercial uptake of geopolymer concrete including lack of standards and durability testing
- ✦ Long-term performance of geopolymer concrete tested at four trial-sites across Australia. Tests included carbonation, chloride entry, reinforcement corrosion and acid attack

2014



Geopolymer concrete trial in Sydney

**“Projects like the Centre’s geopolymer trial can result in new products that make a real difference in slashing carbon emissions”**

**CLOVER MOORE**  
Lord Mayor of Sydney



Pouring of geopolymer concrete for ocean barricades, Port Kembla NSW



### PILOT STUDY

Carbon reduction potential revealed through manufacturing synthetic aggregates from fly ash

2015

### NSW PORTS

- + Commercial company produced batch of 18-tonne geopolymers concrete coastal protection units
- + Partnership with NSW Ports (Port Kembla Harbour) for world-first trial of geopolymers concrete in coastal barricades. Density of geopolymers concrete makes it ideal for extreme maritime conditions
- + Units monitored for stability and integrity providing a valuable product benchmark

### SYDNEY WATER

The Centre partnered with Sydney Water to assess geopolymers concrete performance at North Head WasteWater Treatment Plant (Sydney)

2018

### CITY OF SYDNEY

- + Partnership with City of Sydney to deliver world-first geopolymers concrete trial on an inner city road
- + Nine sensors installed to monitor performance over three years
- + Trial generated 100 media mentions and Channel 9 News TV coverage

2019

OUTCOMES



**“With the Centre we’ve created a product that didn’t exist before and in only three years made it commercially viable”**

#### PROFESSOR STEPHEN FOSTER

Project Leader and Head of Civil and Environmental Engineering, UNSW Sydney



The Centre’s geopolymers concrete handbook for engineers under review by Standards Australia (due out late 2020)

Patent for a lightweight geopolymers aggregate formula transferred to Swinburne University

#### PARTNERS

Australasian Slag Association, Ash Development Association of Australia, AECOM, Sydney Water, UNSW; Swinburne University of Technology, Standards Australia, AECOM, NSW Ports, Independent Cement and Lime, Australian Steel Mill Services



# LIVING LABS

The CRC for Low Carbon Living collaborated with more than 20 partners across 16 residential and commercial Living Labs to test low carbon concepts, technology and practices in real-life settings





 **HOPE** ST

GEN Y HOUSE, WGV LIVING LAB, PERTH WA

Photo: Robert Frith, Acorn Photo



## WGV

### Sustainable residential development

Committed to reducing water use by 70% and grid energy by 60%



Residents report annual savings of \$1,200 on energy and water bills



WGV

Dr Josh Byrne leads an industry tour

## WGV

Collaboration with City of Fremantle, Curtin University, Josh Byrne & Associates and LandCorp



# LIVING LABS PERTH



**EAST VILLAGE**

Collaboration with City of Fremantle, Curtin University and LandCorp

**“Without this partnership between WGV and the Centre we wouldn’t have access to quality PhD research which enables us to monitor the outcomes and targets we set”**

**WARREN PHILLIPS**  
Senior Development Manager,  
LandCorp



WGV

Community bore and non-drinking water supply scheme

**EAST VILLAGE**

100% renewable energy development informed by WGV research

Potential for residents to save up to 50% on electricity costs



All 36 homes fitted with Power Ledger’s blockchain enabled technology



Onsite data-visualisation hub monitors energy and water trading for all Perth Living Labs





## LOCHIEL PARK GREEN VILLAGE

106 homes



250 residents



7.5 star NatHERS rating



64% energy consumption reduction per home



74% greenhouse gas emissions reduction per home



### LOCHIEL PARK

Collaboration with AECOM, Aurecon, Brookfield Multiplex, Green Building Council of Australia, HASSELL, Renewal SA, SA Water, University of South Australia



### BOWDEN

Collaboration with Renewal SA, University of South Australia, SA Department for Environment and Water



**“The Centre helped us gather valuable data for the Green Building Council of Australia to adjust the Green Star Communities rating tool’s greenhouse gas emissions credits”**

#### ANDREW BISHOP

Senior Project Manager, Renewal SA



# LIVING LABS ADELAIDE



### BROADWAY PRECINCT

The Centre used this precinct, incorporating education, retail, residential and commercial buildings, as a case study for how to enable low carbon energy and water transitions in Australia's growing cities

Photo: Katherine Lu

**“Research from the CRC’s Broadway project was applied to major infrastructure and development projects, including the Sydney Metro, where it had a material impact on design decisions and the carbon footprint”**

**ROGER SWINBOURNE**  
Project Leader and consultant



# LIVING LABS SYDNEY

The “learn by doing” Labs will continue being monitored by their partner universities after the Centre’s completion, ensuring the ongoing collection of essential data to inform future housing





Burnley Living Roof,  
University of Melbourne,  
by CRC for Low Carbon  
Living partner HASSELL  
Photo: Peter Bennetts



**"The Centre should be commended on their commitment to living labs as a vehicle to ensure research is tailored to end user applications, as well as their dedication to ensuring community education and outreach is integral to all research activity"**



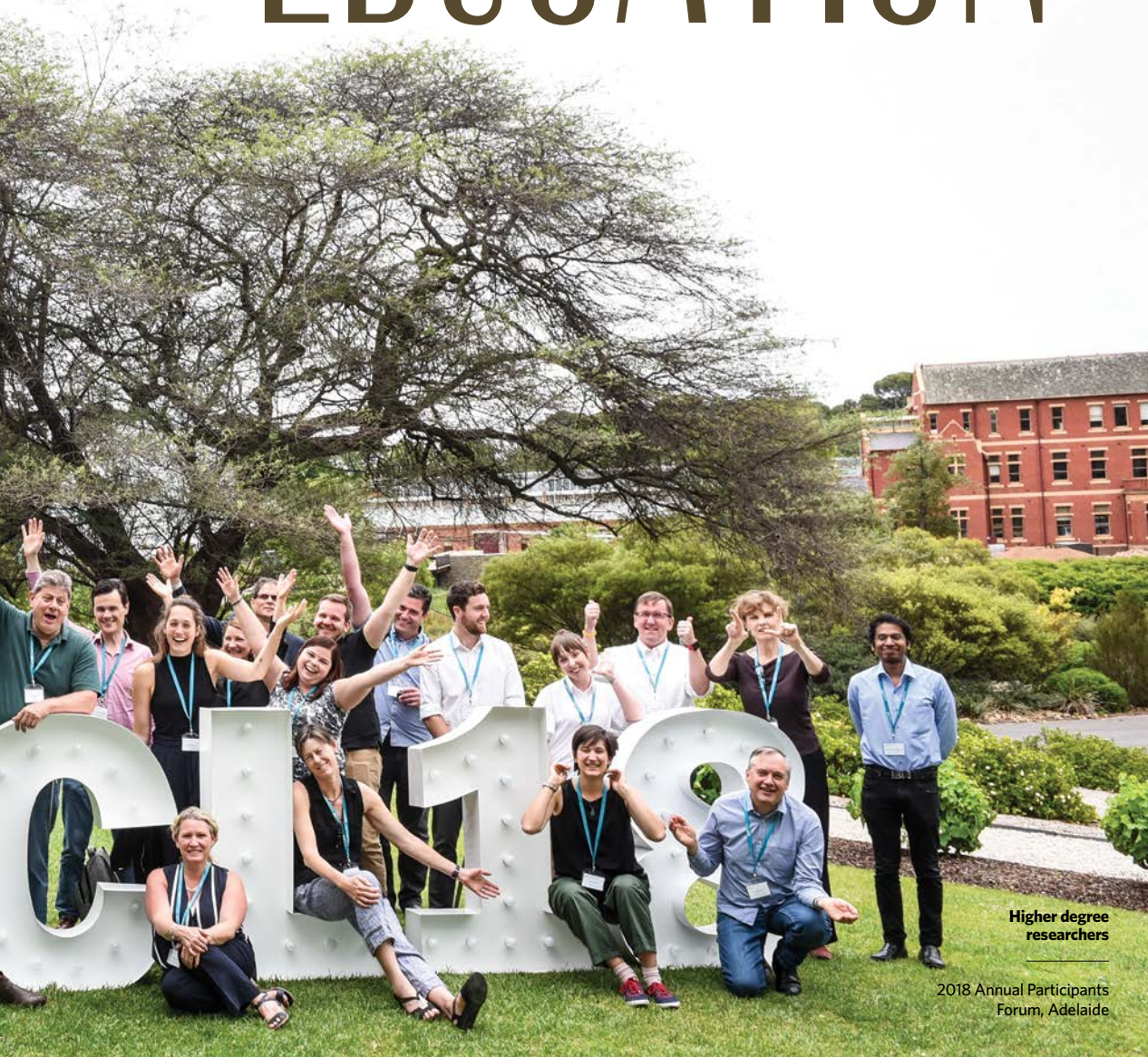
**Megan Antcliff**  
Deputy Chief Executive,  
Department for Trade,  
Tourism and Investment,  
South Australia







# EDUCATION



**Higher degree  
researchers**

2018 Annual Participants  
Forum, Adelaide

# HIGH INTENSITY IMPACT TRAINING

To help HDR students and early career researchers develop a pathway to using their research, the Centre developed a three-day experiential High Intensity Impact Training course. Two researchers from the Curtin University Node of Excellence described how the program helped them distil their research for an industry audience

## **LIO HEBERT**

Lio was 'caught off guard' when he was confronted with perhaps the most challenging question possible about his PhD research: if he had to make money out of his knowledge, how would he do it?

The Perth-based engineer had put his consulting business on hold while he pursued his PhD research looking at ways to improve the integration of renewable energy into the electricity grid by using a private microgrid of connected businesses and industries. Lio said the Centre's High Intensity Impact Training program 'shook him' into taking a step back and asking himself some important questions.

"The training challenged us to ask ourselves why we are studying, who we are studying for and what our research will do to make the world a better place.

"And it asked these questions in a very concrete way, including challenging us to work out how we could make money by, say, turning our research into a business. The High Intensity Impact Training made me realise I had knowledge beyond my immediate project that could be used to solve problems in different industries like water and gas."



**Lio Hebert**

CRC Association  
Early Career  
Researchers  
Showcase finalist

As a result of his High Intensity Impact Training Lio was selected as a finalist in the 2019 Early Career Researchers Showcase at the CRC Association Conference where he presented his research to 200 attendees.

## **JESSICA BREADSELL**

When PhD student Jessica Breadsell left semi-rural WA to study science at university in Perth, her modest ambition was to convince a sceptical father that climate change is human induced.

Her early quest to inform her father stoked Jessica's interest in how everyday human practices can drive, or frustrate, the uptake of low carbon innovations. A decade on, with her PhD near completion and her father long onboard, Jessica's research at Curtin University will help stakeholders such as LandCorp, the West Australian Government's land and development agency, better engage with householders as it seeks to 'green' its housing developments.

Jessica doubts she would have made the jump without the Centre's targeted High Intensity Impact Training, a bespoke program designed to build the skills researchers need to use their findings to achieve real-world change.





“I would never have had the confidence to think about using my knowledge for consulting before taking part in the High Intensity Impact Training,” she said.

Jessica’s PhD research focused on LandCorp’s WGV development, a sustainable mixed housing development in Perth and one of the Centre’s 16 Living Labs to evaluate all aspects of low carbon living, including how residents engage with the environmental technologies and precinct design.

“The High Intensity Impact Training really pushed us out of our comfort zones to think about how to apply our knowledge to other situations.”

After completing the High Intensity Impact Training, Jessica presented to 150 attendees at the 2018 CRC for Low Carbon Living Annual Participants Forum, winning the HDR Pitch Competition.



**Jessica Breadsell**

HDR Pitch  
Competition  
winner



# CAPACITY BUILDING

The successful education and development of the next generation of researchers and built environment specialists was central to the Centre's legacy. The Centre exceeded its founding goals in terms of student enrolments and delivered once in a generation capacity building to the built environment sector



**\$8m**

**INVESTED**  
in scholarships



**104**

**HDRs**  
**ENROLLED**

11 discontinued  
52 completed  
41 completing in 2020



**44**

**PHDs**  
completed

**8**

**MASTERS**  
completed



## POSTGRADUATE EMPLOYMENT



**6**

**PROFESSIONAL DEVELOPMENT**  
**COURSES** developed for industry



## TAFE COLLABORATION

Carbon Reduction website  
delivered with TAFE NSW

**3**

online courses

**25**

student completions



## HIGH INTENSITY

### IMPACT TRAINING

**67**

researchers  
completed training  
to develop pathways  
to utilisation

**97%**

satisfaction rate



**WINNER OF RICHARD BRANSON'S EXTREME TECH CHALLENGE 2018**

Dr Green with Sir Richard Branson at his Necker Island resort



**GRADUATE SUCCESS**

**DR JEMMA GREEN**, Power Ledger co-founder

"The idea for Power Ledger came from my PhD research project with the CRC for Low Carbon Living where I discovered blockchain. The CRC for Low Carbon Living really backed me with this zany idea to build an ecovillage in an applied research project and it's through their support that this project came to life," said Dr Green.

**INDUSTRY AND RESEARCH BERKELEY ENGAGEMENT**

Dr Fan's PhD with the Centre set him up for his role at Tsinghua Berkeley Shenzhen Institute



**DR HUA FAN**, Director of Technology Transfer, Tsinghua Berkeley Shenzhen Institute

"The foundation for my career in technology transfer was set by my PhD with the CRC for Low Carbon Living. It granted me a rare opportunity to engage with industry and research at the same time so I could understand the significant relationship between both sectors," said Dr Fan.

**“The Centre really embarked on a national interest in terms of saving people and the planet by showing there are many different ways communities can reduce their carbon footprint”**



**Dean Brown AO**  
Former Premier of  
South Australia



# LEGACY & IMPACT

The research innovations and significant achievements enabled by the CRC for Low Carbon Living will continue to influence the built environment sector well beyond the Centre's completion



## BUILTBETTER KNOWLEDGE HUB

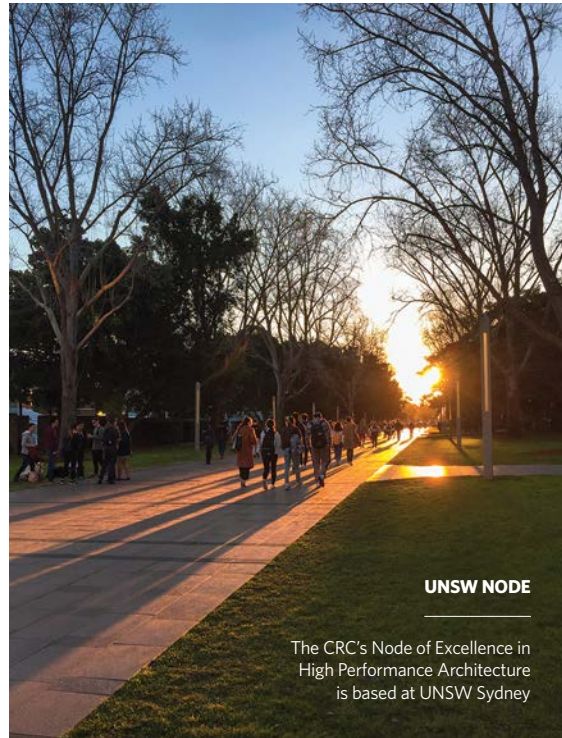
Created as an ongoing legacy resource for the built environment sector, the [Builtbetter website](#) provides government, industry, researchers and students with easy access to best practice information, tools and academic publications. The website offers a public-facing home for the Centre's research as well as a platform for collaborative activity in the built environment.



## NODES OF EXCELLENCE

Six [Nodes of Excellence](#) established to deliver end-user-driven research, vocational training and HDR supervision. Each Node will continue to provide high-quality education and training. The collaborative networks will prioritise best practice while raising awareness and uptake of low carbon practices in the broader community.

1. Curtin University
2. Swinburne University of Technology
3. University of South Australia
4. University of New South Wales
5. University of Melbourne
6. University of Wollongong



### UNSW NODE

The CRC's Node of Excellence in High Performance Architecture is based at UNSW Sydney



↑  
**7 YEARS OF RESEARCH PUBLISHED**

Palgrave MacMillan publication showcasing the Centre's research

→  
**LOW CARBON GUIDES**

Suite of practical guides published to offer built environment professionals and consumers accessible low carbon advice



**PUBLICATIONS**

836 publications contributed by all Centre researchers

18 books / book chapters

214 conference papers

226 articles

378 end user reports



**MEDIA OUTPUT**

*Towards Zero Carbon*  
 11-episode video series showcasing high impact research



**INTERNATIONAL IMPACT**

- + Developed *UNEP Guidelines for Sustainable Cities and Communities and Greening Universities Toolkit*
- + Partnerships with KTH Royal Institute of Technology, Sweden, Tongji University, China and Concordia University, Canada
- + Only Australian member of the Global Building and Construction Alliance



**AWARDS**

**2019 Australian Institute of Architects Leadership in Sustainability Prize**

Leadership in Sustainability Prize

**2019 CRC Association Excellence in Innovation Award**

Excellence in Innovation Award

**2019 Committee for Sydney Smart City Award**

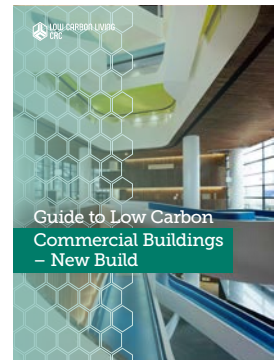
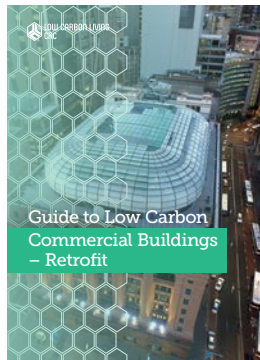
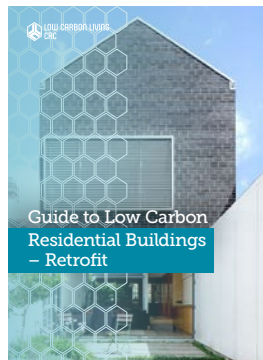
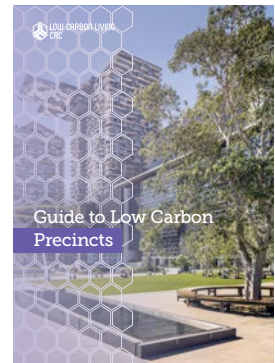
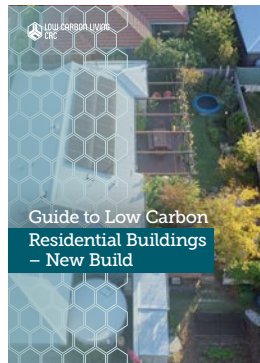
Smart City Award

**2019 Banksia Sustainability Awards**

Finalist, NFP & NGO category

**2018 NSW Green Globe Award**

Highly Commended, Built Environment category



# FINANCIAL OVERVIEW

## 2012-2019

The Centre maintained a healthy financial position throughout its life. The financial statements for the CRC for Low Carbon Living Ltd have been independently audited by HLB Mann Judd (NSW) Pty Ltd and submitted to ASIC, ACNC and the Commonwealth CRC Programme. Copies of the Annual Financial Reports for all periods are available on request.

The Centre ended FY7 on 30 June, 2019 with a planned cash balance intended to cover all of the Centre's costs for the remaining period until the wind-up of the company. After the Centre has met its final reporting commitments to the Commonwealth the company intends to close and deregister in November 2019.

The remaining cash balance at 1 July 2019 is entirely attributable to partner contributions and other income, as all Commonwealth grant funds were fully expended prior to the end of the final reporting period. Any residual funds remaining after meeting reporting and wind-up costs will be allocated to Board-approved Node activities that align with the Centre's mission.



## RESOURCES RECEIVED

Total cash and in-kind contributions by partners & government 2012-19

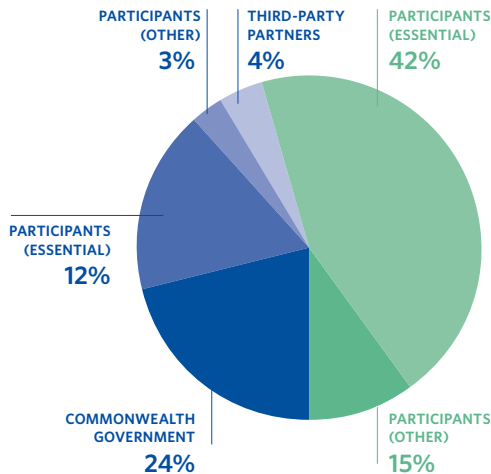
**\$116.95M**

### CASH

**TOTAL: \$49.68M**

From two sources:

1. CRC participants (Essential, Other & third-party partners) (\$21.68m)
2. Commonwealth Government (\$28m)



### IN-KIND

**TOTAL: \$67.27M**

Includes time provided by participant employees (equivalent to 214 full-time researchers valued at \$61.48m) and other non-staff resources such as facilities, equipment and materials (\$5.79m)

## RESOURCES APPLIED

Resources applied across the three research program areas in 2012-19

**\$116M**

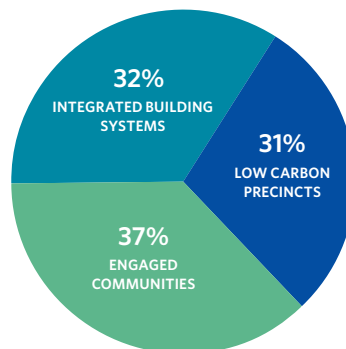
**IN-KIND APPLIED \$67.27M**

**CASH APPLIED \$48.73M**

This includes proportions of expenditure on:

Governance and administration	\$11.17m (23%)
Education (scholarships)	\$8.00m (16%)
Research	\$26.99m (56%)
Utilisation	\$2.57m (5%)

No capital purchases made.





CRC for Low Carbon Living's final  
Annual Participants Forum 2018



CRC for Low Carbon Living Ltd

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Australian Government  
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Innovation and Science

**Business**  
Cooperative Research  
Centres Program