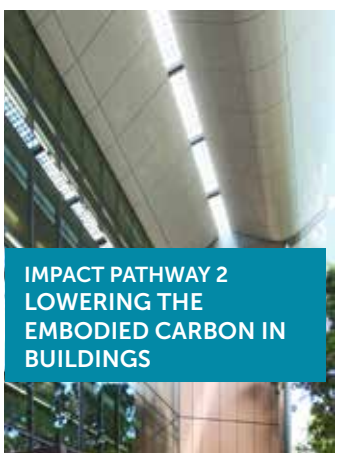
IMPACT PATHWAYS

IMPACT PATHWAYS REPRESENT SPECIFIC AREAS OF IMPACT THAT CRCLCL EXPECTS TO HAVE IN TRANSFORMING THE LOW CARBON BUILT ENVIRONMENT.

OUR PROJECTS AND ACTIVITIES TRANSLATE ACROSS EIGHT IMPACT PATHWAYS, WHICH ARE LINKED TO OUR THREE INTEGRATED RESEARCH PROGRAMS; INTEGRATED BUILDING SYSTEMS, LOW CARBON PRECINCTS AND ENGAGED COMMUNITIES.

IMPACT PATHWAY 1
HARNESSING THE AUSTRALIAN SUN



IMPACT PATHWAY 2
LOWERING THE EMBODIED CARBON IN BUILDINGS

IMPACT PATHWAY 3
MAINSTREAMING LOW CARBON BUILDINGS

IMPACT PATHWAY 4
DESIGNING INTEGRATED LOW CARBON PRECINCTS

IMPACT PATHWAY 5
EVIDENCE BASE FOR LOW CARBON LIVING POLICY

IMPACT PATHWAY 6
ENHANCING COMMUNITY ENGAGEMENT

IMPACT PATHWAY 7
LIVING LABORATORIES AS LOW CARBON LIFESTYLE NARRATIVES

IMPACT PATHWAY 8
ENHANCED EDUCATION AND CAPACITY BUILDING

IMPACT PATHWAY 1 HARNESSING THE AUSTRALIAN SUN

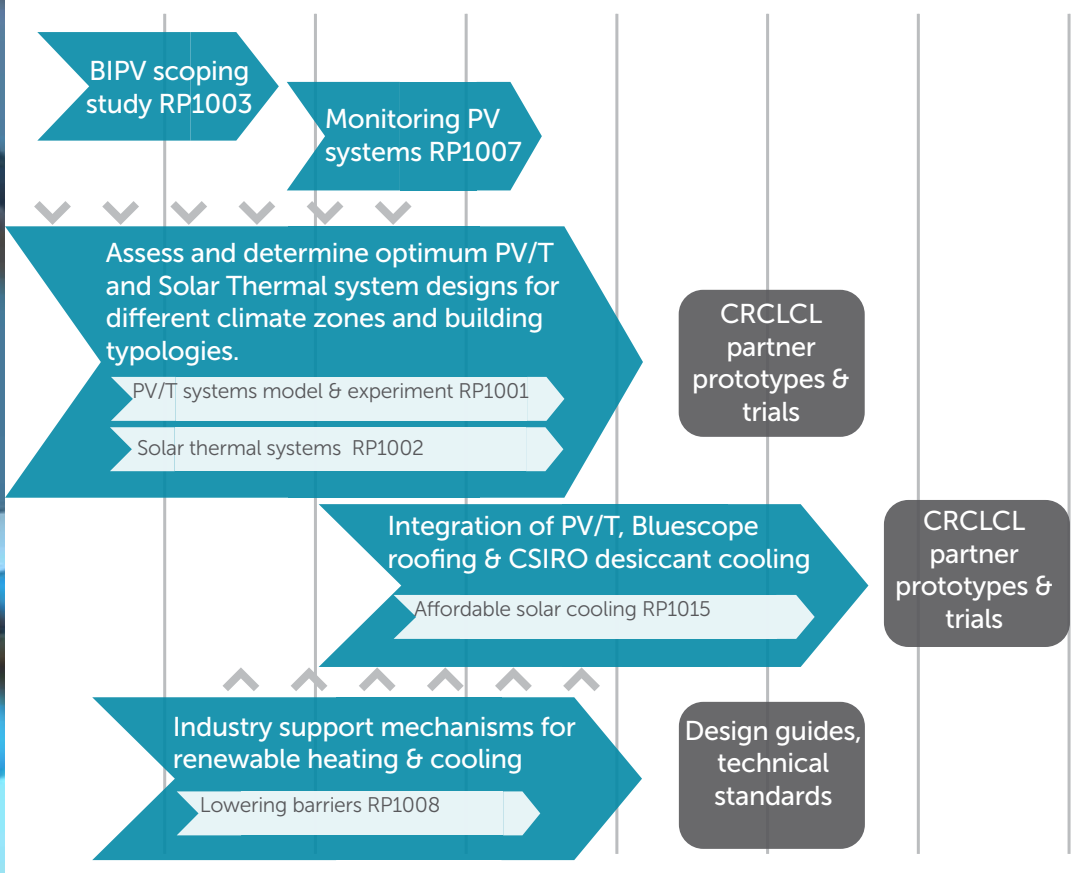
Make active solar roofing products the default solution for buildings. There is enough sun landing on our roofs to power our cities. Instead of being exploited, it is currently just overheating buildings and causing large air-conditioning loads.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC

IMPACT PATHWAY 1 Harnessing the Australian sun

Activity 1.1: Integrated photovoltaic (PV) and solar thermal technologies for buildings



Usage 1.01 Commercialisation of building integrated solar technologies: Commercialise technologies developed by the CRCLCL with industry partners. Adoption of these product solutions by design professionals, households and developers in new and retrofitted commercial and residential buildings.

LOW CARBON LIVING CRC

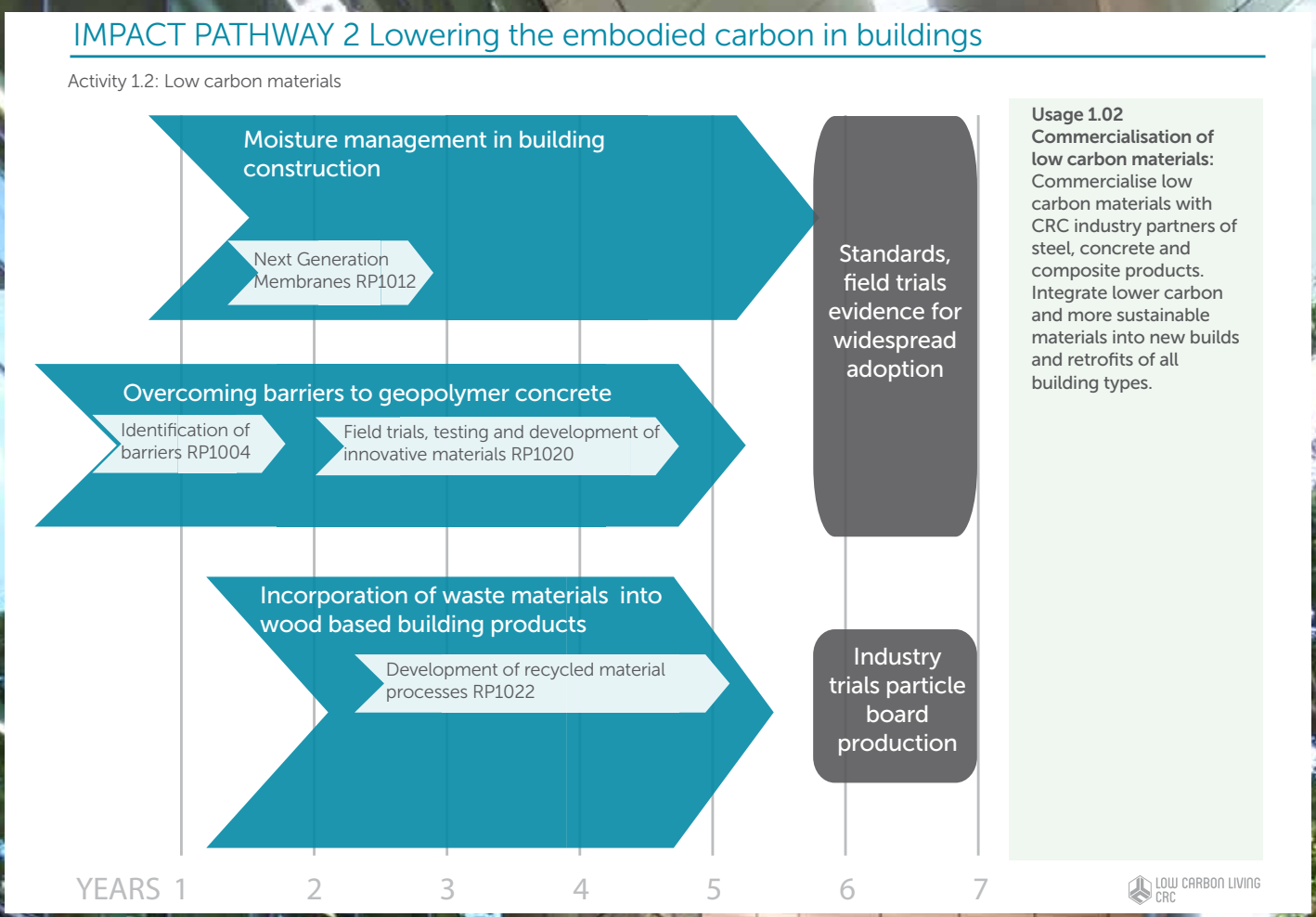
PARTNERS	End users BlueScope, CSR, Standards Australia, NSW OEH, Suntech (Solar Analytics), AECOM	Research UNSW, UniSA, CSIRO
BARRIERS	• Cost effectiveness. Products must be cost effective to attract mainstream market share and to motivate policy makers. • Lack of technology • Market awareness and desirability. Building owners must know about the product and feel that it gives them benefit.	
RESEARCH OVERVIEW	• New technology for utilising the heat output, generating additional revenue and increasing cost effectiveness • Stories and data, from showcase prototype demonstrations of the PV/T rooftop system • Energy end-use measurement data that identifies typical building energy usage patterns and can be used to validate savings projections • Technical Standards to simplify and realistically estimate carbon savings enabling performance based incentives via policy interventions.	
SUCCESS CRITERIA	• When active solar roofing products, produced by our industry partners (eg Bluescope), have become the default solution for buildings. • New buildings utilise intelligent fresh air ventilation (eg CSR Odyssey), roof cavity heat management and minimum R5 ceiling insulation	
BENEFITS	• 1.3 MT $CO_2^{-e/yr}$ in 2020 through PV power generation capacity, and saved energy in building heating and cooling. • Demonstrable evidence of change in i) Government policy, ii) Industry capability, iii) Community attitudes	
KEY MILESTONES	• Piloting, prototyping and field testing • Large scale trials • Full scale commercial production	
CRCLCL MILESTONES	Research Milestones R1.1 Integrated photovoltaic (PV) and solar thermal activities for buildings	Utilisation Milestones U1.1 Commercialisation of building integrated solar technologies

IMPACT PATHWAY 2 LOWERING THE EMBODIED CARBON IN BUILDINGS

Increase the use of low carbon materials as significant energy and carbon is embodied in conventional building materials. Our research aims to mainstream low carbon materials by providing the industry with independent research into the material properties, evidence from field trials and updating of the associated standards. This will allow greater confidence and hence greater uptake by industry.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC



PARTNERS	**End users** Australasian (iron and steel) Slag Association, Ash Development Association of Australia, AECOM, Sydney Water, CSR, Standards Australia	**Research** UNSW, Swinburne
BARRIERS	• Current technical standards do not provide adequate recognition of low carbon materials. Insufficient awareness of material properties and durability. This limits the number of entities specifying low carbon materials. • Improvements in material properties mean that in many instances less material can be used than is currently required by the Australian Standards. Lowering material volumes is another pathway to lower embodied carbon in buildings.	
RESEARCH OVERVIEW	• Provide evidence from laboratory testing and field trials, to enable market growth of low carbon materials such as geopolymer concrete products, recycled timber products and hybrid material systems (e.g. timber/steel). • Development and publishing of new standards specific to low carbon materials that include performance requirements • Studies investigating the durability and field performance of low carbon materials • Show case demonstration(s) of building(s) using low carbon materials	
SUCCESS CRITERIA	• Low carbon materials and material systems become a mainstream solution (10% of demand) for Australian buildings and infrastructure. • Design engineers and the construction industry will specify the use of low carbon materials and systems.	
BENEFITS	• Replacement of 10% of current building materials sales with low carbon materials will achieve 1.1 MT $CO_2^{-e/yr}$ in 2020 • $125m economic benefit	
KEY MILESTONES	• Identification and reporting on barriers • Piloting, prototyping and field testing • Full scale commercial production (2019)	
CRCLCL MILESTONES	**Research Milestones** R1.2 Low carbon materials	**Utilisation Milestones** U1.2 Commercialisation of low carbon materials

IMPACT PATHWAY 3 MAINSTREAMING LOW CARBON BUILDINGS

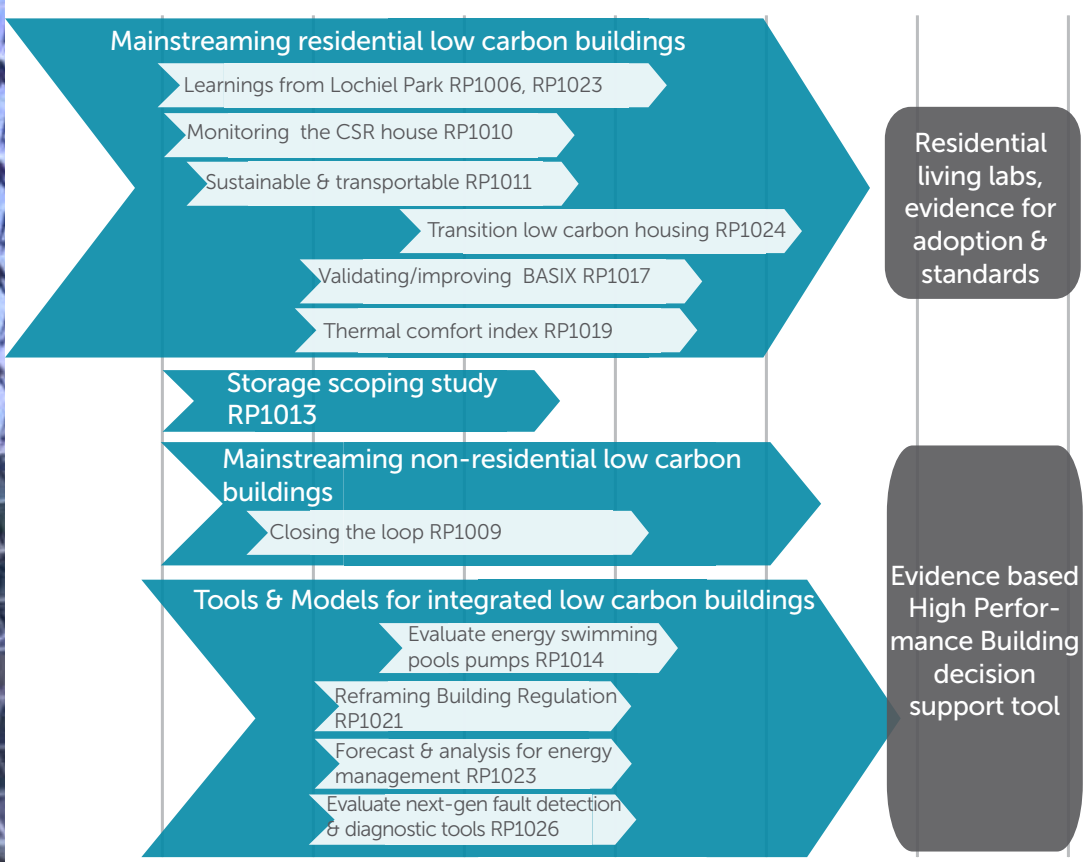
Facilitate mainstream low carbon building/purchasing/leasing behaviour by community through an integrated approach to design, development and operation. A number of low energy/carbon buildings have been constructed in Australia. Our research seeks to critically examine designs and actual performance of new and existing buildings, and provide the necessary evidence and confidence to industry as to what does and does not produce low carbon outcomes.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC

IMPACT PATHWAY 3 Mainstreaming low carbon buildings

Activity 1.3: Integrated Design, Showcase, Ratings and Standards



Usage 1.03 Integrated Design Innovation:
Design professionals and developers will utilise the research generated by the CRC in order to integrate cost effective low carbon design solutions into new build and retrofits of commercial, industrial and residential buildings.

LOW CARBON LIVING CRC

PARTNERS

End users
CSR, Nova Deko, Commonwealth Department of Industry, SA Government, Ausgrid, NSW OEH, Ametalin, Brookfield Multiplex, HASSELL, AECOM

Research
UniSA, UNSW, CSIRO, UniMelb, Curtin, UniSA

BARRIERS

- Low consumer interest: Energy and greenhouse gas emissions savings are weak motivators in many segments of the built environment.
- Low consumer knowledge: Many cost effective energy savings opportunities exist but are not known
- Lack of information at the point of acquisition/leasing
- Low building sector buy-in: Complying with worst practice vs striving for best practice.
- Low uptake of sustainable design in transportable buildings: Typical designs for the Australian market focuses on low cost, highly glazed, poorly insulated designs which perform very poorly from an energy perspective.

RESEARCH OVERVIEW

- Develop new high impact proxy-indicators for energy efficiency that have more motivational pull for consumers.
- Energy end-use cost effectiveness knowledge: produce detailed cost and performance data, and co-benefits analysis, demonstrating the triple bottom line effectiveness of low carbon designs in providing comfort, cost savings and carbon reduction.
- Modelling studies to explore low carbon designs and integration of new products / knowledge generated by other CRC projects – eg PVT rooftops.
- Prototype and field testing: Building of low carbon designs and carry out field testing in order to demonstrate the potential of these designs.
- Education and training: develop and deliver curricula relating to energy efficiency and low/zero energy buildings

SUCCESS CRITERIA

- Compelling proxy indicators are being routinely used to motivate low carbon building/purchasing/leasing behaviour.
- A CRC partner is operating a household rating scheme that real estate agents incorporate in their sales and/or leasing promotional material.
- Zero carbon, affordable, modular and/or transportable buildings are mainstream offerings in the market place.

BENEFITS

- Achieve 1.5 MT CO_2-e/yr in 2020 through residential energy efficiency renovations, government energy efficiency renovations and transportable buildings
- $65m economic benefit

KEY MILESTONES

- Showcasing of low carbon designs through Living Laboratories
- Complete rating framework/tools for low carbon buildings
- Mainstreaming of low carbon designs by CRC partners

CRCLCL MILESTONES

Research Milestones
R1.3 Integrated design, showcase, ratings and standards

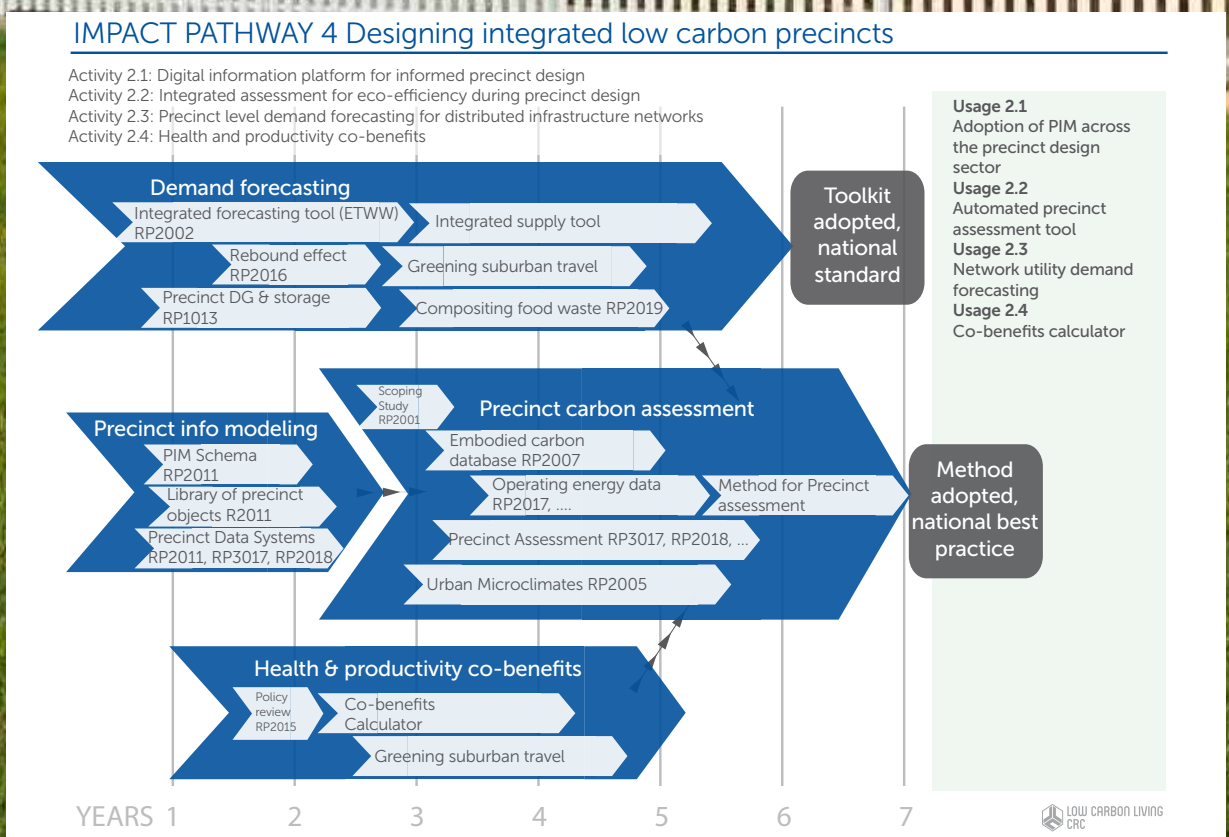
Utilisation Milestones
U1.3 Integrated design innovation

IMPACT PATHWAY 4 DESIGNING INTEGRATED LOW CARBON PRECINCTS

Cities and their residents are the big carbon emitters in Australia. Carbon mitigation of more than 50% is possible for households who can combine energy efficient housing with low carbon travel solutions. This requires the design of low carbon neighbourhoods – the building blocks of cities – that can support low carbon living. The capacity to support low carbon living needs to be embodied in the design of Australia's built environments. Such direct action requires recognition and consequently, assessment. Precinct design and assessment tools are currently in their infancy and lack the necessary functionality, underpinning data, scientific validation and broad government and industry acceptance to deliver the evidence of resilient, low carbon precincts fundamental to the sustainability of our 21st century cities.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC



BARRIERS

- General industry procedures are based on building to standards and not beyond; There is currently a lack of accepted carbon performance targets, benchmarks and standards generally in Australia and its built environment in particular
- Absence of suitably validated precinct design assessment and rating tools and demonstrable market benefits linked to carbon savings
- Absence of concerted pressure from consumers for better design and material selection

RESEARCH OVERVIEW

- Planning and design tools for measuring, modelling and assessing the carbon impact and co-benefits of precincts and their infrastructure
- Criteria, information capture and rating tools for assessing the carbon performance of scenarios and designs at the precinct scale
- Showcase precinct demonstrations through scientific validation with identification of best practice low carbon performance
- Co-benefit calculators that enable quantification of non-carbon benefits in low carbon precincts, in particular human health and productivity benefits

SUCCESS CRITERIA

- Demonstrable evidence of change in i) Government policy, ii) Industry capability, iii) Community attitudes: for example:
- Governments are assessing the energy/carbon performance of new property developments at the design stage
- Agreed carbon performance targets are required by a national statutory authority (such as ABCB or equivalent)
- CRC partners in three tiers of government, NGOs (eg. ABCB, GBCA) and the property development industry adopt the precinct planning and design assessment method developed by Program 2
- Property developments have defined carbon performance targets, and policies and practices are implemented to motivate developers to play their part

BENEFITS

- 4.2 MT $CO_2^{-e/yr}$ will be achieved by 2020 through CO_2 reductions of the order of 80% in new low carbon precinct development projects

KEY MILESTONES

- Understanding of the range of tools, calculators, methods and attitudes
- Development of a performance information model - PIM
- Development of a range of decision support tools for precinct design and assessment that include PIM
- Adoption of PIM and developed tools as industry standards
- Adoption of the precinct design and assessment method as national best practice

CRCLCL MILESTONES

Research Milestones

R2.1 Digital information platform for informed precinct design
R2.2Integrated assessment of eco-efficiency during precinct design
R2.3 Precinct level demand forecasting for distributed infrastructure networks
R2.4 Health and productivity co-benefits

Utilisation Milestones

U2.1 Adoption of PIM across the precinct design sector
U2.2 Automated precinct assessment tool
U2.3 Network utility demand forecasting
U2.4 Co-benefits calculator

IMPACT PATHWAY 5 EVIDENCE BASE FOR LOW CARBON LIVING POLICY

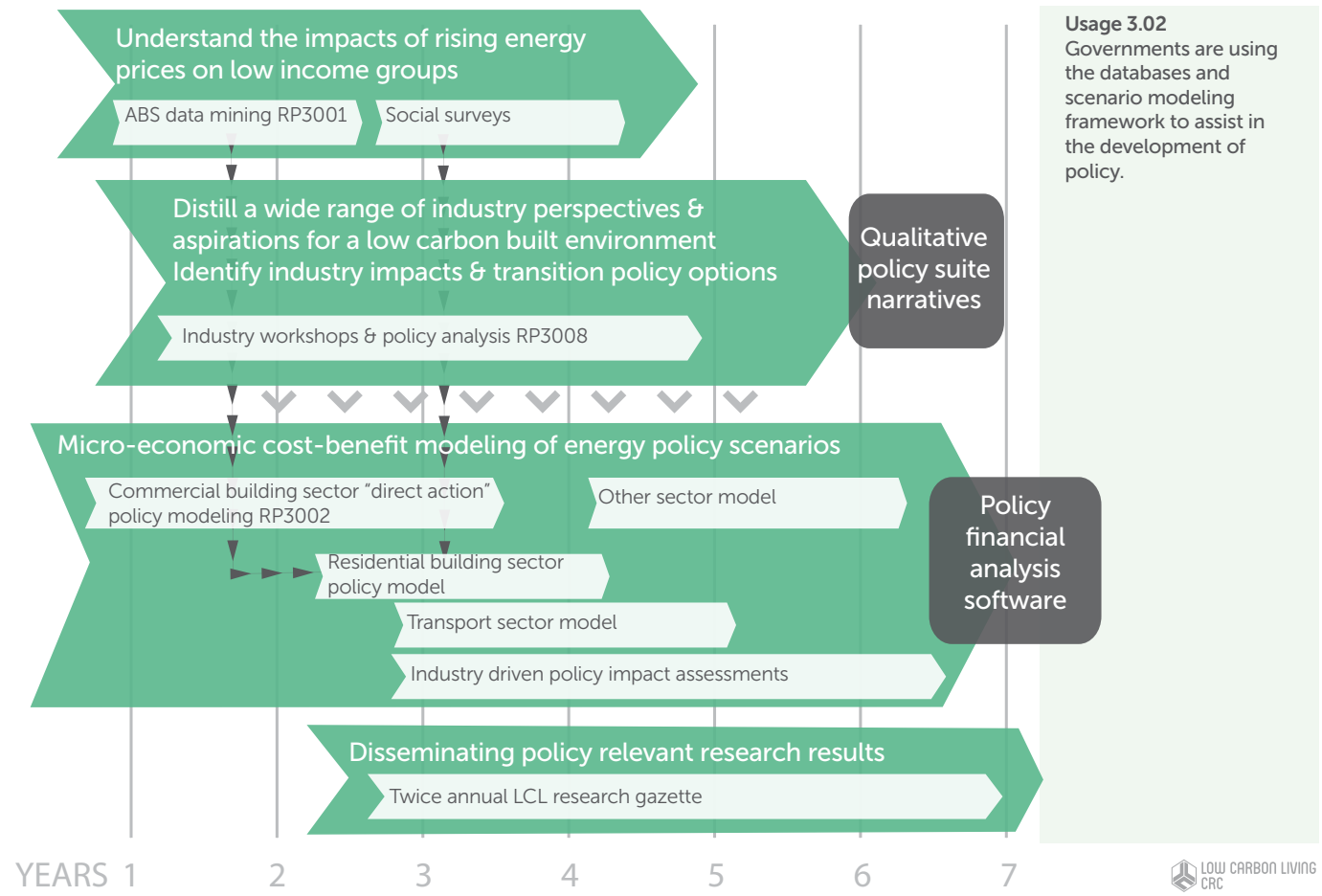
Working with all levels of Government to understand the benefits of possible low carbon policy actions. Government will implement carbon mitigation policy actions when they are confident that these can be implemented in partnership with industry, and with high triple bottom line return for Australia.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC

IMPACT PATHWAY 5 Evidence base for low carbon living policy

Activity 3.1: Transition Scenarios and Affordability



Usage 3.02
Governments are using the databases and scenario modeling framework to assist in the development of policy.

LOW CARBON LIVING CRC

PARTNERS	**End users** Federal Government, State Governments, Energy Utilities, Industry Associations (eg GBCA)	**Research** CSIRO, UniMelb, UNSW, Swinburne
BARRIERS	• Lack of consensus amongst community and industry regarding desirable policy directions for low carbon urban development. • Lack of quantitative analysis capability and evidence base for predicting policy impact with any credibility.	
RESEARCH OVERVIEW	• A quantitative policy modelling tool that predicts CO_2 savings and costs resulting from policy interventions. • Qualitative visioning and analysis of transition pathways. • Surveys of potential energy poverty impacts on low income households.	
SUCCESS CRITERIA	• One or more CO_2 reduction policies/programs have been implemented by the CRC's government partners • CRC has facilitated deep engagement between Government partners, industry and community stakeholders through future visioning workshops and policy modelling	
BENEFITS	• Demonstrable evidence of Government policies implemented with the assistance of CRC research outcomes • CO_2 reductions (quantity and source will depend on the policy interventions under development by the respective parties). 0.5MtCO_2 pa • $115m economic benefit	
KEY MILESTONES	• Establish national building stock and demographic data sets, and a standard analysis framework • Low carbon living research gazette launched and regularly published • Annual industry barriers and intervention workshop established • Industry and government panel established to commission scenario investigations • Additional subsectors added to modelling framework • Policy scenarios modelled on behalf of CRC participants	
CRCLCL MILESTONES	**Research Milestones** R3.1 Transition scenarios and affordability: develop a forecasting model	**Utilisation Milestones** U3.2 Governments at all levels will use the databases, social psychological tools and scenario modelling framework.

IMPACT PATHWAY 6 ENHANCING COMMUNITY ENGAGEMENT

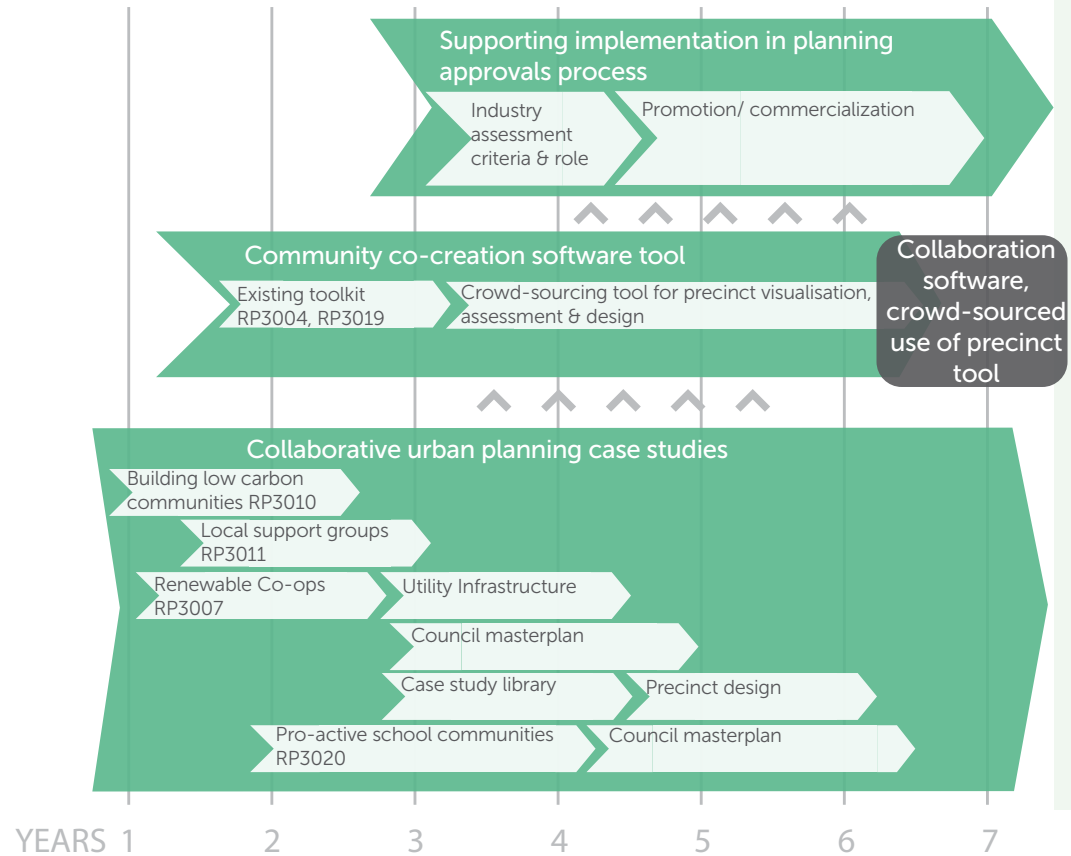
Achieve productive collaboration between developers and communities that stimulates demand for low carbon precinct infrastructure and services. CRC research will develop community engagement/ consultation processes and standards that enable a rich dialogue about community aspirations for low carbon living.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC

IMPACT PATHWAY 6 Enhancing community engagement

Activity 3.2: Drivers and Barriers to Community Engagement



Usage 3.04
Councils, precinct developers & utility service providers are cost-effectively negotiating and incorporating local knowledge into low carbon precincts and infrastructure.

LOW CARBON LIVING CRC

PARTNERS	**End users** City Councils, Water and Energy Utilities, Government Land Owners, Brookfield Multiplex, State Governments **Research** Curtin, UniSA, UniMelb, UNSW, Swinburne
BARRIERS	• Lack of community input to development plans with resulting reduction in low carbon living aspirations • Lack of certainty for developers and opposition from vexatious minorities • Lack of low carbon living knowledge and capability in the community to positively influence the precinct design and approvals process
RESEARCH OVERVIEW	• Visualisation (using CRC design and planning tools) and other engagement tools that enrich community understanding of the likely implications of a low carbon living LDP • Governance and participation tools to facilitate dialogue between development proponents and the community • Showcase piloting of community engagement processes to demonstrate workability and the nature and extent of beneficial outcomes.
SUCCESS CRITERIA	• Local government adopts development plans embracing co-created low carbon living - that also gets widespread community approval • Local government offers streamlined LCL planning approval processes which reduce development approval time • Sufficient pressure created across local government jurisdictions to generate a wave of change (towards low carbon requirements and approvals)
BENEFITS	• Demonstrable evidence of change in i) Government policy, ii) Community participation practices, iii) Widespread cultural acceptance of low carbon living practices • CO_2 emission savings will be achieved through increased market pull and adoption of program 2 precinct CO_2 reduction solutions. 0.8MtCO_2pa • $12m economic benefit
KEY MILESTONES	• Analysis of case study community participation processes • Community engagement tool developed and implemented in precinct design
CRCLCL MILESTONES	**Research Milestones** R3.2 Drivers and barriers to community engagement: develop community engagement and social psychological behaviour change **Utilisation Milestones** U3.4 Local councils and other community agencies adapt and deploy the case study community engagement models.

IMPACT PATHWAY 7
LIVING LABORATORIES AS LOW CARBON LIFESTYLE NARRATIVES

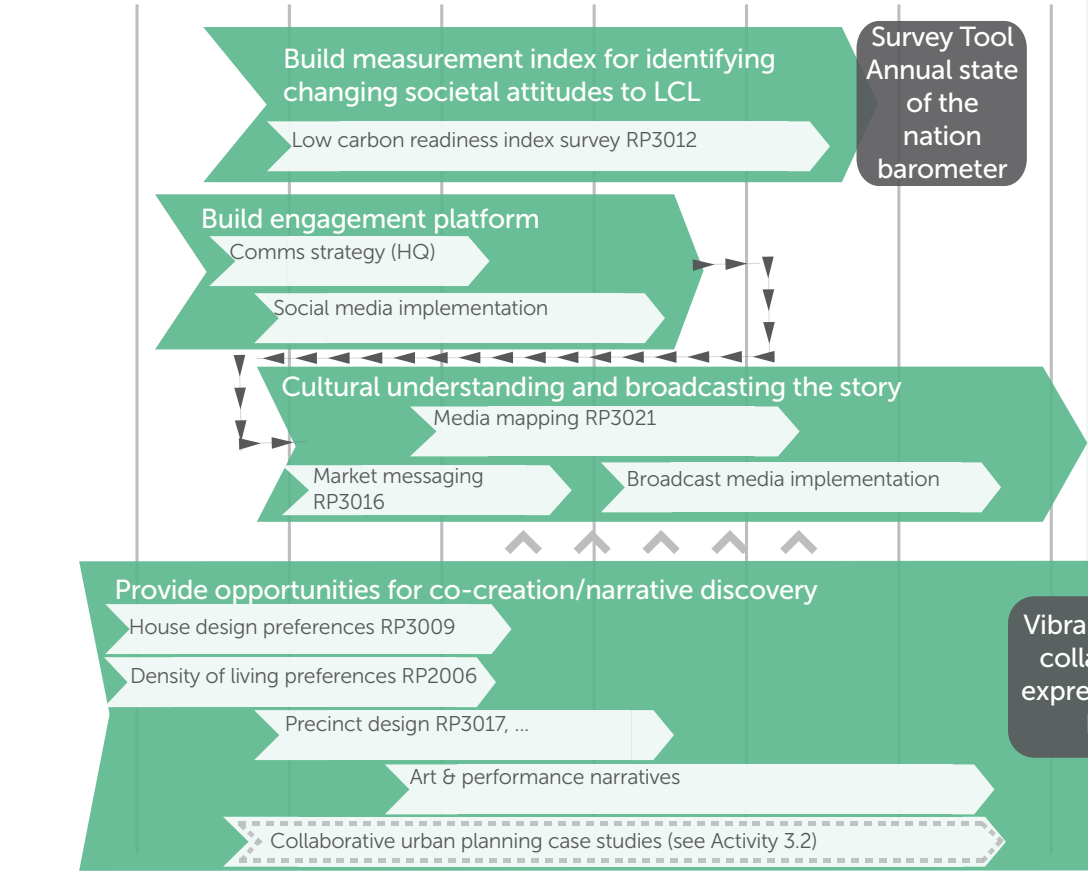
Living Laboratories will create demand for low carbon living. Australians will adopt low carbon living when they have positive experiences of the lifestyle benefits of sustainable living and when they see others adopting and talking about low carbon living.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC

IMPACT PATHWAY 7 Living Laboratories as low carbon lifestyle narratives

Activity 3.3: Living Laboratories



Usage 3.01
Communities, households and businesses are identifying and adopting low carbon living lifestyles (with associated products, services and infrastructure).

LOW CARBON LIVING CRC

PARTNERS	End users Australian Public, Social media, Broadcast media, Product Manufacturers (eg CSR, Bluescope)	Research Swinburne, CSIRO, Curtin; UNSW; UniSA
BARRIERS	• Lack of belief in the appetite for low carbon living amongst product and service suppliers and the Australian property development industry • Inability to communicate the distinctive benefits of low carbon solutions and lifestyles, in a manner that appeals to the public	
RESEARCH OVERVIEW	• Showcasing low carbon living • Stories, data and media content that articulate cultural understanding of low carbon living • Local and national attitudinal surveys • Developing new low carbon living solutions through Co-creation tools and workshops • Engagement of the Australian public and business communities in debate on an Australian response to carbon reduction in the built environment, through articles and online media. • In-depth understandings of how varying community groups relate to and will adopt low carbon lifestyles.	
SUCCESS CRITERIA	• Measured positive change in attitudes to low carbon living behaviour in the living laboratory communities • Media content providers and free to air broadcasters creating and broadcasting low carbon lifestyle programming • Social media actively engaged in co-creating low carbon lifestyle narratives.	
BENEFITS	• Mandate for increased policy action from government at all levels • CO_2 emission savings will be achieved through increased market pull and accelerated adoption of program 1 and 2 CO_2 mitigation solutions. 0.1MtCO_2pa	
KEY MILESTONES	• Develop Living Laboratory model • Establish around 10 Living Laboratories • Survey tool for measuring changing attitudes to low carbon living • Creative content • Two way (social media) communication platform for community engagement	
CRCLCL MILESTONES	Research Milestones R3.3 Living Laboratories	Utilisation Milestones U3.1 Communities, households and businesses use program outputs

IMPACT PATHWAY 8 ENHANCED EDUCATION AND CAPACITY BUILDING

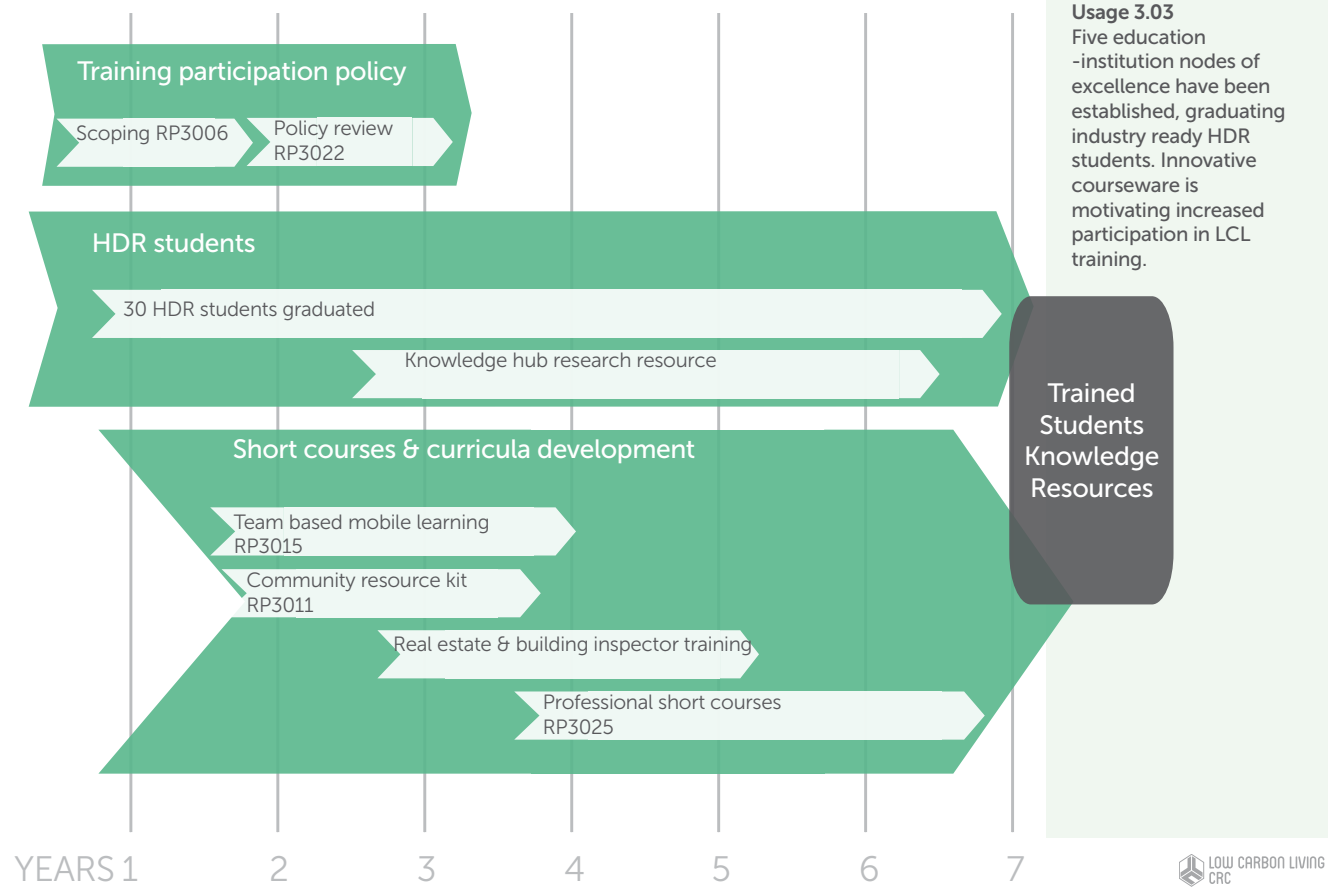
The legacy of CRCLCL Is dependent on the successful education and development of the next generation of researchers, built environment specialists and communities. Inspiring people involved in the program and affected by its results is a key opportunity that will be addressed through education, research and training.

IMPACT PATHWAYS 2015

LOW CARBON LIVING CRC

IMPACT PATHWAY 8 Enhanced education and capacity building

Activity 3.4: Education Training and Capacity Building



Usage 3.03
Five education -institution nodes of excellence have been established, graduating industry ready HDR students. Innovative courseware is motivating increased participation in LCL training.

LOW CARBON LIVING CRC

PARTNERS	End users TAFE, Swinburne, UNSW, UniSA, Curtin, UniMelb	Research TAFE, Swinburne, UNSW, UniSA, Curtin, UniMelb
BARRIERS	• Alignment of research requirements with PhD candidate interests • Lack of long term funding commitment from educational institutes for ongoing centres of excellence	
RESEARCH OVERVIEW	• Offering of 88 PhD scholarships over the life of the CRC • Creation and delivery of a suite of education and training programs • Development of a platform for dissemination of research findings	
SUCCESS CRITERIA	• 88 PhD scholarships successfully delivered by 2019 • Nodes of research excellence are established as a CRCLCL legacy in 5 Universities	
BENEFITS	• Increased participation in low carbon training • Shifts in i) Industry Capability and ii) Community attitudes and cultural practices are indirectly influenced through this activity • CO_2 benefits s are indirectly achieved through this activity. 0.5MtCO_2pa	
KEY MILESTONES	• Target post-graduate students involvement - including scholarship targets • Professional development programs instituted	
CRCLCL MILESTONES	Research Milestones R1.4 Education R2.5 Education	Utilisation Milestones U3.3 Educational institutions and professional associations in Australia and Asia Pacific will use the research output.

A NATIONAL RESEARCH & INNOVATION HUB FOR THE BUILT ENVIROMENT

LOW CARBON LIVING CRC

An Australian Government initiative

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