iHBE
Sustainable Built Environment
Conference Series 2016
SBE16 Sydney

Lowering the Carbon Footprint of Buildings and Cities

Scientia Professor Deo Prasad AO
CEO: CRC for Low Carbon Living (base UNSW)

Conference Organisation
UNSW AUSTRALIA | Built Environment
LOW CARBON LIVING CRC

Australian Meteorological Organisation

- This year stands to be the hottest year yet….
  - » SMH – 15th November 2016

GLOBAL PERSPECTIVE

(Global alliance for building and construction, COP22)

Table Building floor area growth to 2050 by region[3]

Billion m2	2015	2030	2050
North America	38.1	47.1	56.9
Western Europe	29.8	34.3	36.9
Eurasia	9.8	13.1	14.9
China	57.2	79.3	84.6
India	15.8	32.1	57.6
Japan and Korea	9.8	10.9	11.1
Southeast Asia	15.6	23.8	32.3
Australia and New Zealand	2.1	2.7	3.4
Latin America and Caribbean	19.3	29.1	43.1
Middle East	8.0	12.7	18.3
Africa	18.0	30.4	56.0
World	**223.4**	**31.54**	**415.2**

Energy use in b… …ruction represents mor… …energy consumption ar… …arter of greenhouse ga… …e.

A growing popu… …in purchasing power in emerg… …countries, means that ene… …increase by 2050, while glo… …ted to double by 2050, driving… …GHG emissions for construction…

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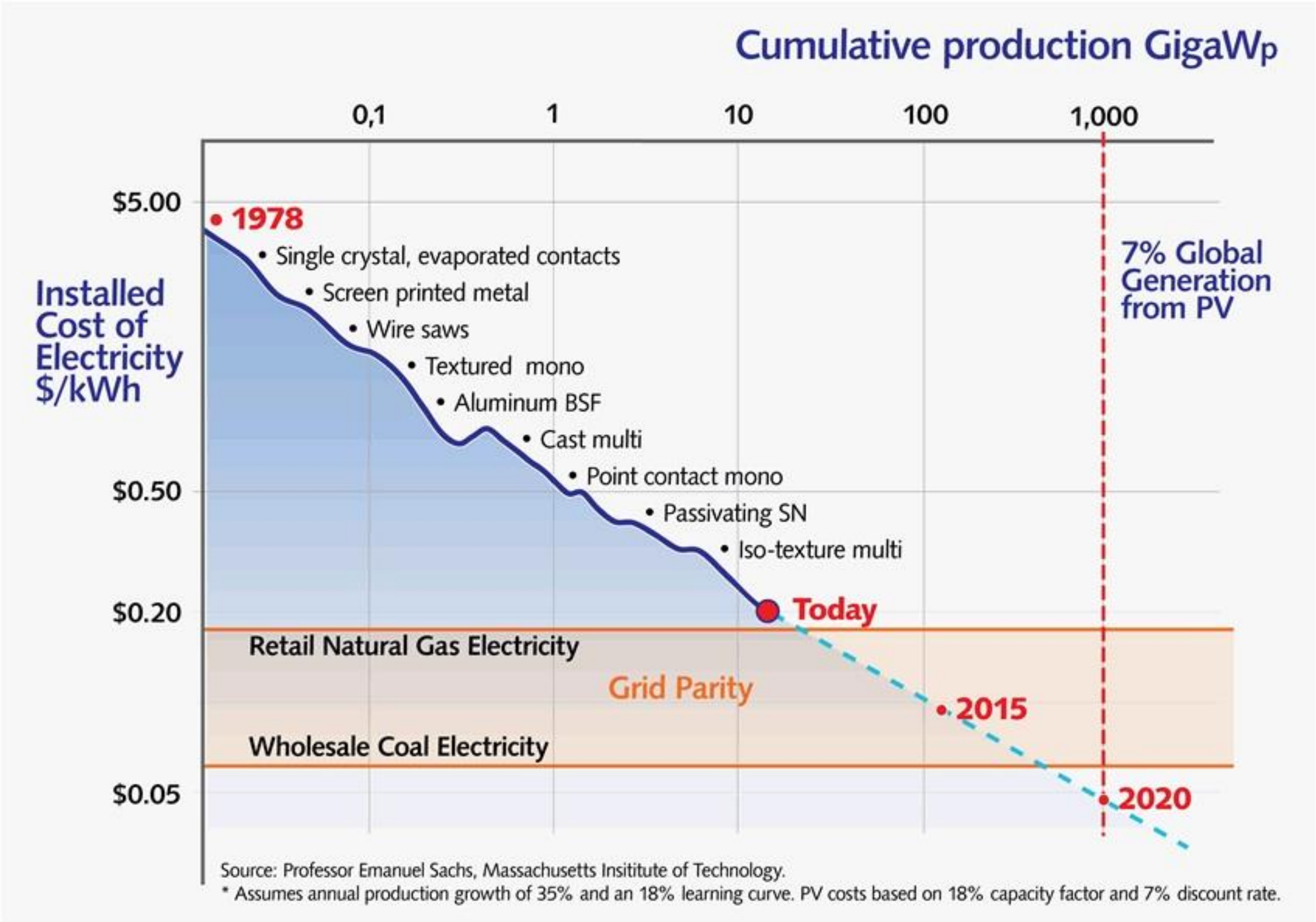
The challenges

- What we already know and have – how best to get it fully deployed?
  - Top down vs Bottom up
  - Policy/regulations / mandatory vs voluntary
  - Education and information at point of need by peer to peer delivery
  - Design, planning innovations – holistic and integrated approaches
  - Social change behaviour issues – people factor
- What research and development and evidences are required???

Challenges….

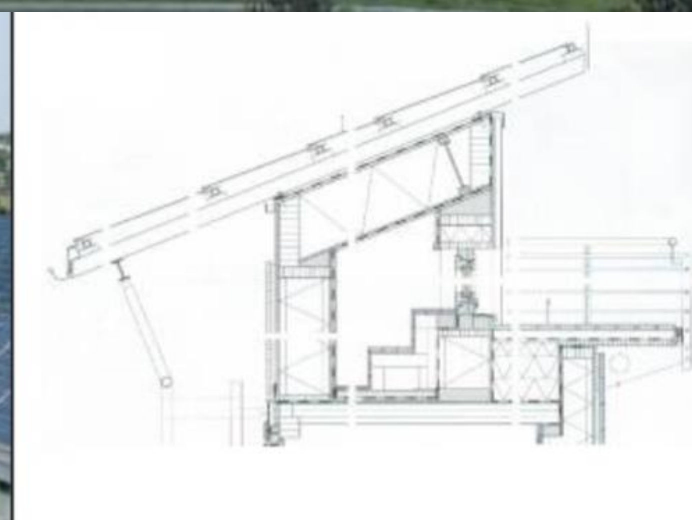
- What we do not know yet and what barriers exist, what technologies, systems and integration knowledge is needed…
  - Need a holistic solution set – including energy efficiency, renewable energy, decarbonising regular supply
  - Need reliable tools, high level expertise base with commitment from stakeholders like developers, owners, designers and consultants to work together
  - Need a life cycle perspective
  - Need to be mindful of business models that support change
  - Need to enable local industry to benefit
  - Need to provide the evidence for design, planning and policy decisions

PV is growing fast and getting cheaper



LIVING

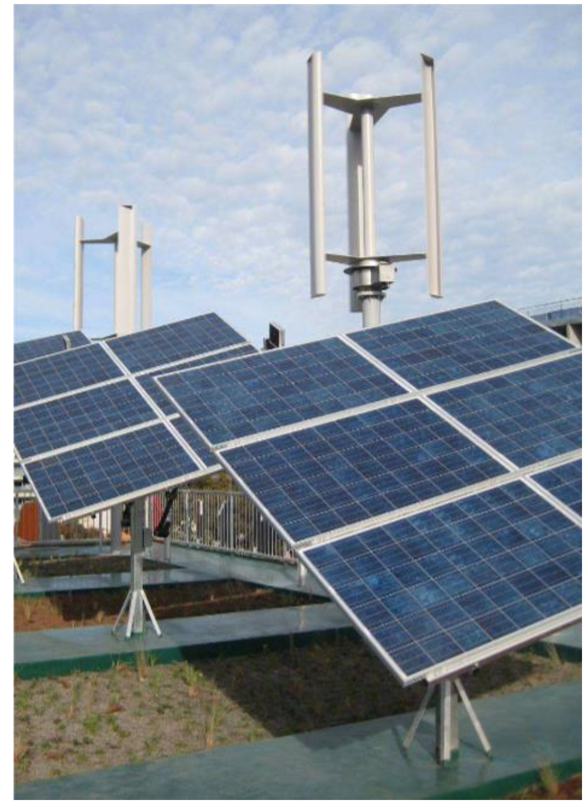
PV Application in Larger Scales: **Freiburg's Solar Siedlung**



The roof top solar panels produce 6,300 kWh/home per year or three times more than each home consumes!

http://www.pvupscale.org/IMG/pdf/Schlierberg.pdf

PV Application in Larger Scales: **Pixel Building, Melbourne**



- **Carbon Neutral;**
- **A special concrete that uses 60 per cent less cement;**
- **A perfect 6 Star Green Star score of 105 points;**
- **Wind turbines and sun-tracking solar panels on the roof.**

http://www.pixelbuilding.com.au

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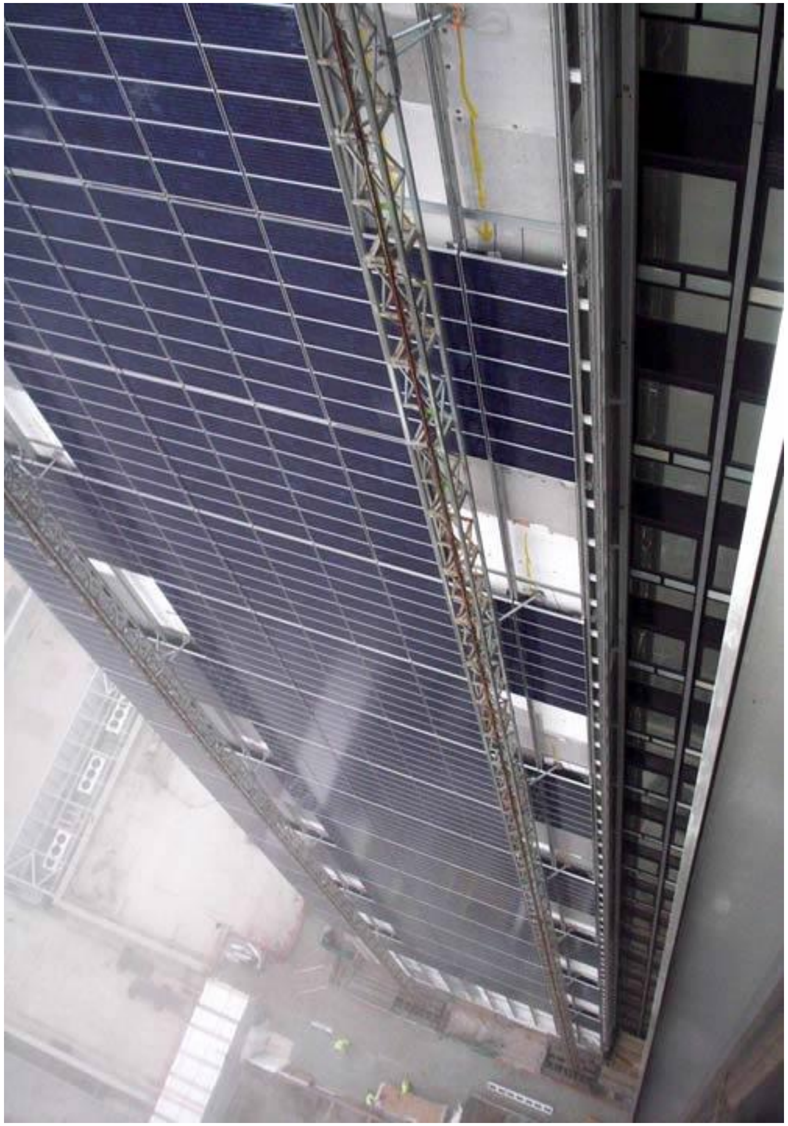
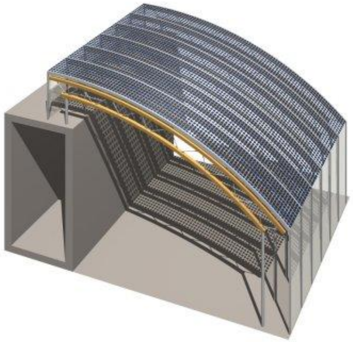


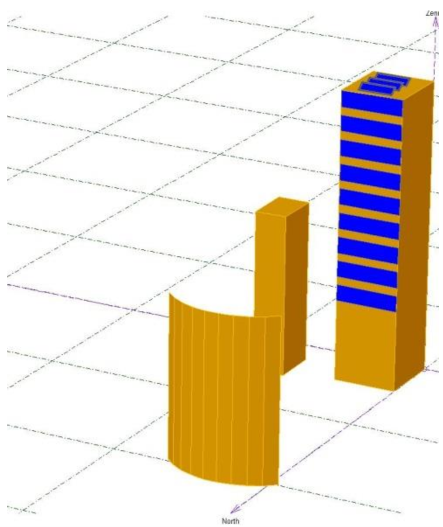
- http://www.metaefficient.com/architecture-and-building/skyscraper-gets-covered-in-7000-solar-panels.html

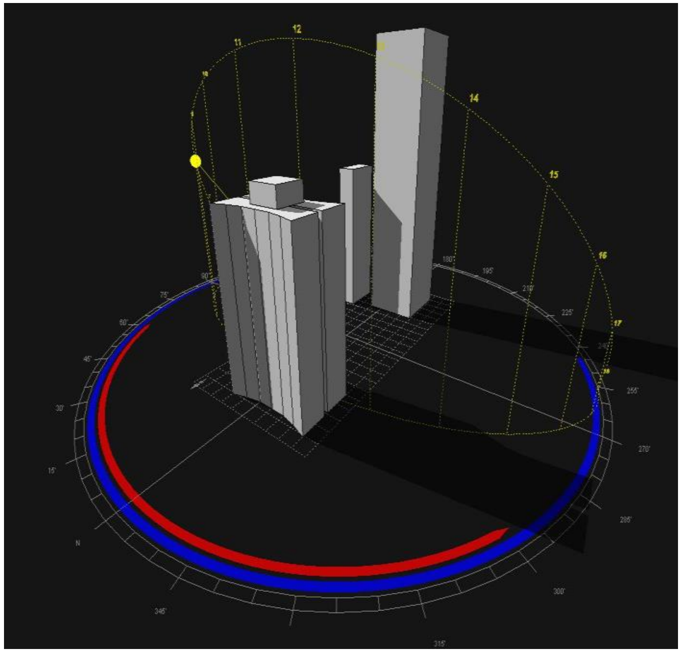
Semi transparent PV



BiPV for Korean Apartments

Drawing on UNSW modelling work andYonsei University understanding of high rise buildingsand sustainable solutions





VCalcul;Simulation variant

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	EOutInv kWh	EffArrR %	EffSysR %
January	187.0	23.00	173.4	167.5	402.4	376.1	3.82	3.57
February	155.0	23.00	154.0	149.1	355.2	332.1	3.80	3.55
March	131.0	21.90	142.2	137.8	333.6	311.5	3.86	3.61
April	92.0	19.10	108.1	104.9	260.9	243.5	3.97	3.71
May	81.0	16.30	109.4	106.2	261.7	244.3	3.94	3.68
June	70.0	13.50	106.2	103.1	252.0	235.2	3.91	3.65
July	79.0	12.40	112.7	109.3	272.2	254.3	3.98	3.72
August	110.0	13.50	146.3	142.4	352.4	329.8	3.97	3.71
September	139.0	15.80	162.7	158.2	388.1	363.1	3.93	3.68
October	182.0	18.00	187.8	182.1	445.3	416.7	3.90	3.65
November	195.0	19.60	183.1	177.0	429.0	401.4	3.86	3.61
December	190.0	21.90	173.6	167.7	405.9	379.3	3.85	3.60
Year	1611.0	18.14	1759.5	1705.2	4158.8	3887.3	3.89	3.64

Legends:
- GlobHor — Horizontal global irradiation
- T Amb — Ambient Temperature
- GlobInc — Global incident in coll. plane
- GlobEff — Effective Global, corr. for IAM and shadings
- EArray — Effective energy at the output of the array
- EOutInv — Available Energy at Inverter Output
- EffArrR — Effic. Eout array / rough area
- EffSysR — Effic. Eout system / rough area

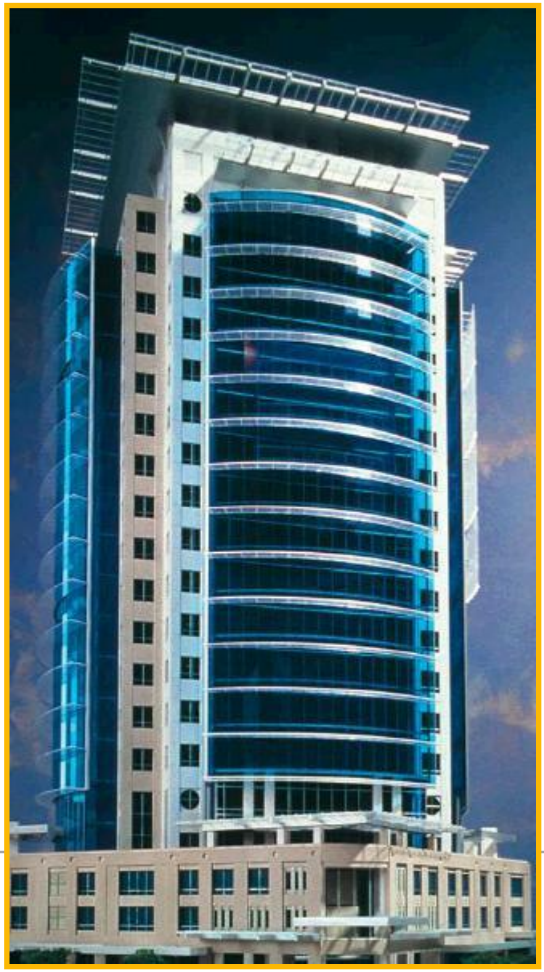
Australian showcase projects in major cities

Kogarah
SYDNEY
160 kWp

QV Markets
MELBOURNE
190 kWp

Melbourne
University
190 kWp

High Rise
BRISBANE
60 kWp



Original 629kWp

Olympic Village
SYDNEY

Additional 72kWp

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POLISHED STONE
$2400-$2800 m²
PHOTOVOLTAICS
$500-$1500 m²
STONE
$800+ m²
GLASS WALL
SYSTEMS
$560-$800 m²
STAINLESS STEEL
$280-$400 m²

PV as part of Building function

221kWp of blessed Vatican PV

T30 Tower, Hunan, China

- By Broad Sustainable Building Group
- 30 storey 5 star hotel
- 9 Richter scale earth-quake resistance
- Assembled on site in 15 days
- Prefabrication technology
- Savings in time, cost and energy
- 5 times more energy efficient than an equivalent building
- Generates fraction of the waste

Source: http://inhabitat.com/200-chinese-workers-erect-a-30-storey-prefabricated-hotel-in-just-15-days-video/t30-hotel-bsb/

- *“With the business case for green commercial buildings now deeply rooted in a growing body of evidence, it should be crystal clear to property investors that there are significant performance gains to be made from competitively pricing green assets, and by the same token, a unique opportunity to be in the driving seat of the current shift to a low-carbon and resource-efficient economy.”*

Paul Clements-Hunt

Head of United Nations Environment Programme Finance Initiative

Our purpose is to enable reduction of carbon emissions of the built environment sector by working collaboratively with industry and governments and engaging with communities. We do this by providing the highest quality end user driven research which also underpins the global competitiveness of the Australian industry.

Our research will deliver social and technological solutions, evidence base for design, planning and policy innovations and once in a generation national capacity build for the sector

WHAT WE DO

We are committed to three integrated research programs for our research activity and projects.

1. Integrated Building Systems

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

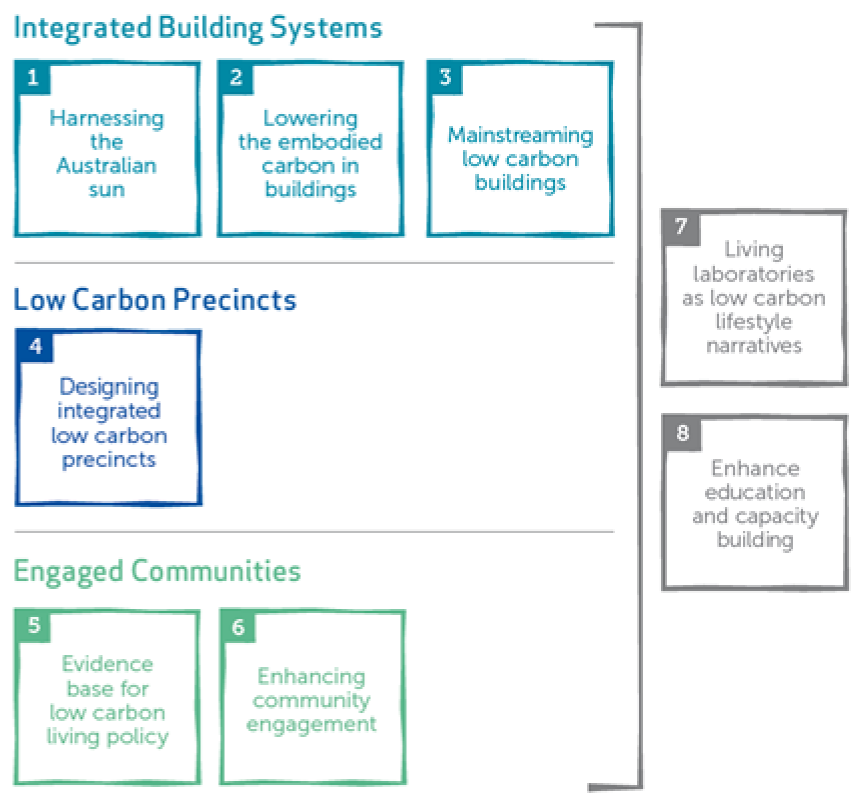
2. Low Carbon Precincts

Creating new planning techniques, models and data for delivering low carbon developments at a precinct scale. Communicating best practice in sustainable city planning through precinct design and assessment tools

3. Engaged Communities

Creating a new community appetite for low carbon living, through strategies for social networking, education and media. Communicating the vision of a prosperous, liveable and sustainable society to business and government through living laboratories and economic modelling

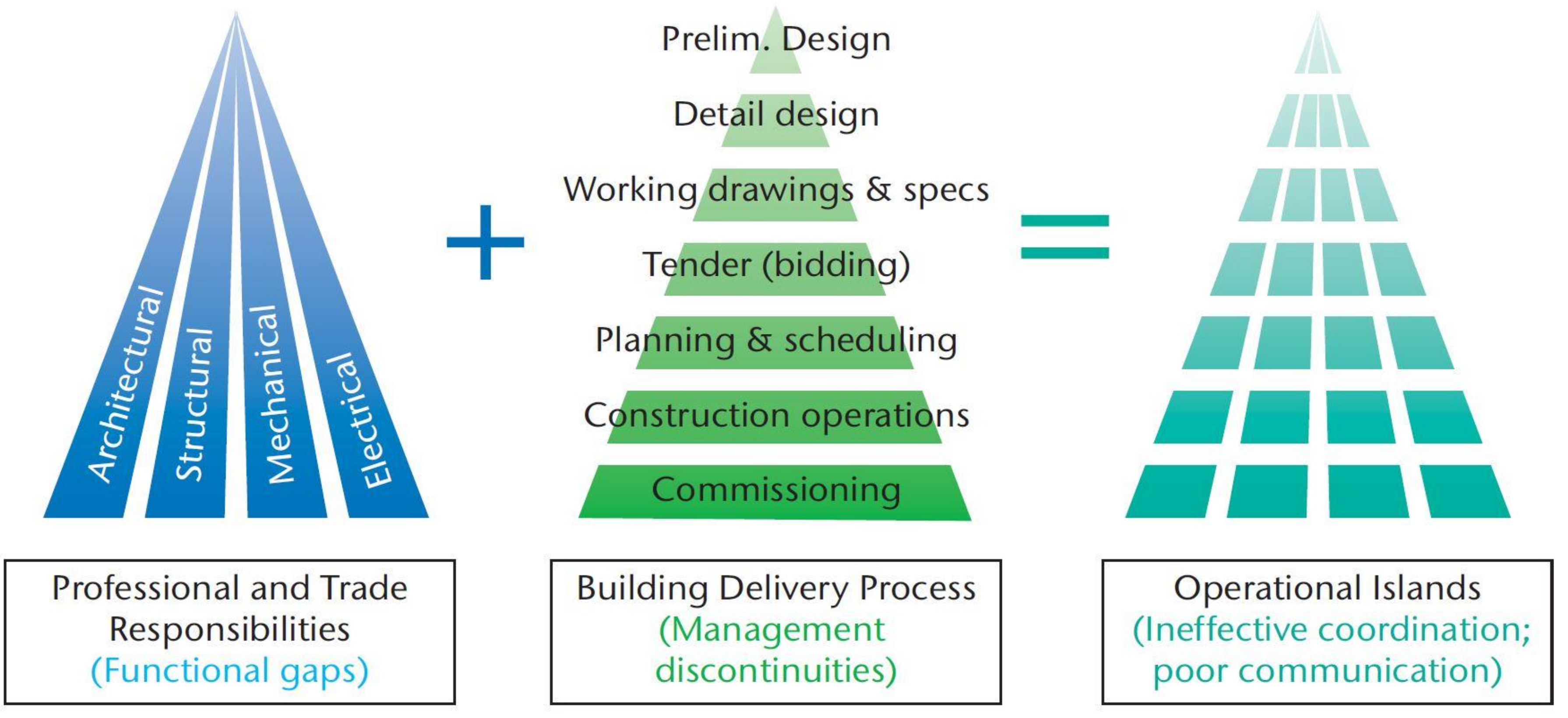
Our projects and activities translate across these eight impact pathways, a journey towards a low carbon economically viable built environment.



How: *Integrating end user response*

Government	*Manufacturing*	*Development*	*Professionals*
NSW Government Office of Environment & Heritage; Government of South Australia; Australian Government Department of Climate Change and Energy Efficiency; City of Melbourne; City of Sydney 2030	CSR; BlueScope Steel	UrbanGrowth NSW; VBA Victorian Building Authority; Brookfield Multiplex Built to outperform.; RenewalSA people partnerships progress; Government of South Australia	AECOM; Consult Australia Business | Engineering | Design; HASSELL; asbec Australian Sustainable Built Environment Council; Australian Institute of Architects
Evidence base for ~$1billion/yr investment in government programs	*Incubating next generation multi-purpose building products*	*Enabling world class low carbon property development*	*Tools for Australia's building design services industry*

........In a fragmented industry



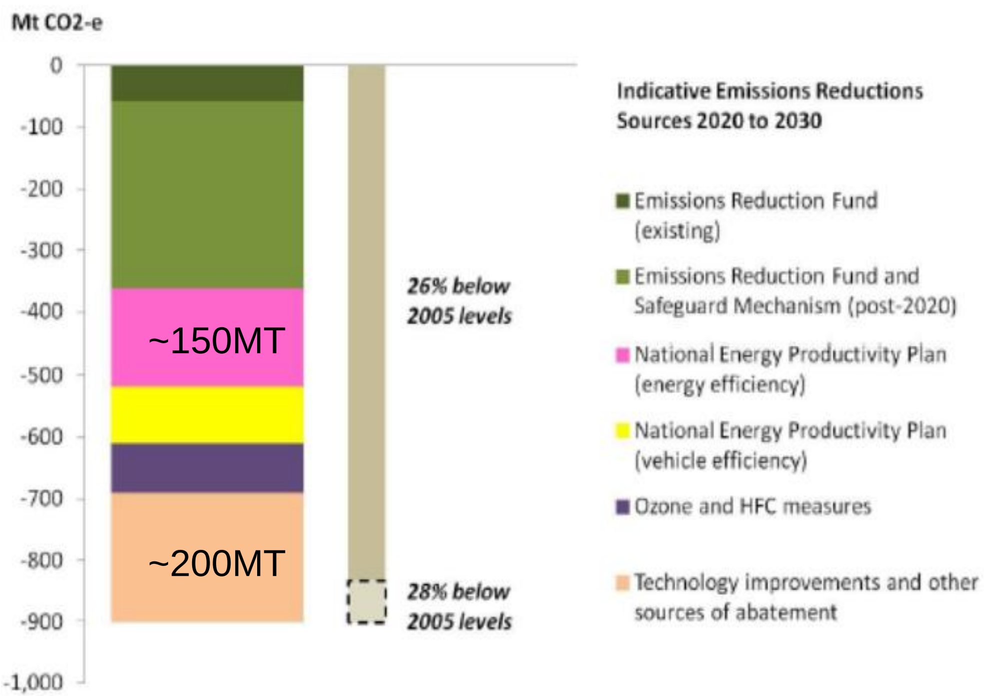
World Business Council for Sustainable Development

A POWERFUL INDUSTRY NETWORK

- ✓ **CRC engages with many thousands of SMEs through industry bodies**
- ✓ **Two way communication: end user advice, vehicle for implementation**
- ✓ **Led by Professor Ken Maher – Gold Medal winning architect and Chair of ASBEC**
- ✓ **Networks at each Node now**

Australia's Post-2020 Emissions Reduction Target: Australia can achieve the 2030 target by improving productivity, reducing costs and through technology

CRCLCL projected estimates of 87-116MT (Ave 102MT) of Carbon Emissions Reductions by 2030 from its current research activities.



Source: Cwth 2030 Carbon Target presentation, 11 Aug 2015

- ***National Energy Productivity Plan (energy efficiency)*** *– Commonwealth target carbon abatement of around 150MT by 2030*.

  The CRCLCL recently wrote to Minister Macfarlane, citing examples of how the CRC's research activities support the actions articulated in the Energy White Paper "Increasing energy productivity to promote growth".

  With around 50% of our projected carbon saving relate to energy efficiency, the CRCLCL might be able to contribute as much as one third towards this source of emission reduction by 2030.

- ***Technology improvements and other sources of abatement*** *– Commonwealth target abatement of about 200MT by 2030*.

  The other half of the CRC's projected carbon reductions are linked to our research activities in technology improvements, recycling and lowering the embodied carbon in building materials.

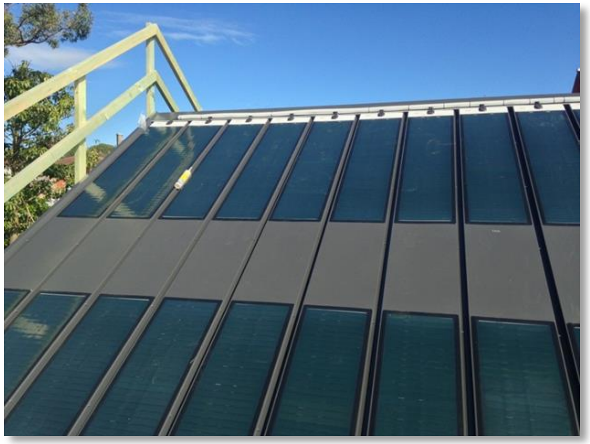
  Therefore the CRCLCL might be able to contribute as much as one quarter towards this source of emission reduction by 2030.

Once in a Generation Capacity Building

- >92 Higher Degree Researchers enrolled
- 9 Million dollars invested in scholarships over the life of the CRC
- Largest ever group of researchers in low carbon field
- Extensive vocational and professional capacity building (HIA, AILA, ISCA +)

RP1001 Air handling solutions, integration approaches and building design considerations for Photovoltaic Thermal (PV-T) roofing

- Determination of appropriate cost-effective solutions for thermal integration.
- Trial the thermal integration of a PV-T system based on the optimised design, as part of a Living Laboratory.
- Development of a methodology to group the building typologies, operational (thermal supply and demand) situations, and macro- and micro- climates.



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BLUESCOPE STEEL
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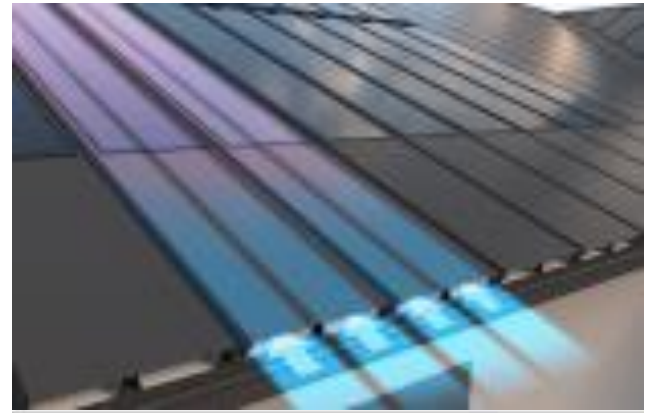
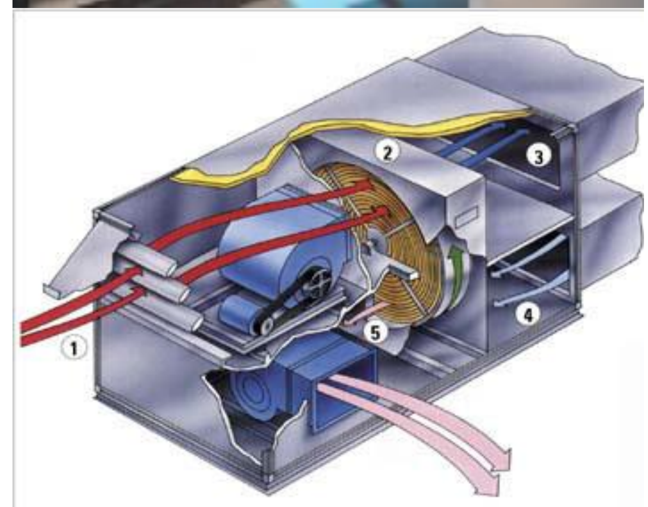
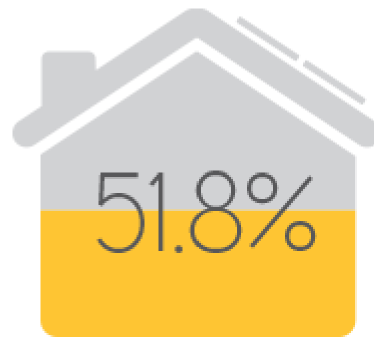
RP1015 - Combining a building integrated PVT system with a low temperature desiccant cooler to drive affordable solar cooling

- The motivation here is that as the price of PV continues to fall, rooftop PV becomes a very cost effective option.
- This project aims to integrate PVT roofing system with desiccant cooling systems.
- BIPV/T cannot produce temperatures high enough to drive an absorption cooling cycle.
- However BIPV/T in many Australian climates can potentially produce thermal energy at a temperature that can drive a low temperature desiccant cycle





UNSW/Solar analytics
PV & Building load prediction algorithms



Ausgrid [2] data from 8000 solar PV systems shows that approximately 51.8% are not performing to capacity

This is a new project that builds on a previous successful project.

Aim now is to improve algorithms for predictions with a view for developing accurate storage models.

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R1014: IMPACT OF ENERGY EFFICIENCY POOL PUMPS ON PEAK DEMAND, ENERGY COSTS AND CARBON REDUCTION

- Variable speed pumping can drastically lower the energy, carbon emissions and peak demand of swimming pool filtering and solar pool heating.

- Experimental results have demonstrated that a solar pool heating system can be operated at lower flow rates and deliver 70% reduction in electricity usage whilst maintaining acceptable pool temperatures.

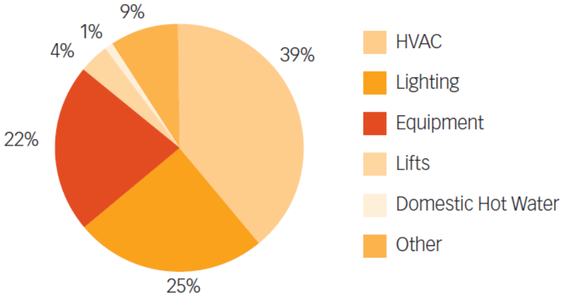
- Approximately 90% of the heated swimming pools in Australia are installed with solar pool heating. This energy efficiency retrofit alone has the potential to save approximately

- **210 GWh of electricity per annum.**
- **150 kilotonnes of carbon emission abatement**
- **$52.5 million dollars of savings per annum**

R1033: Mainstreaming High Performance Commercial Building HVAC

- The overall aim of this project is to investigate how to mainstream high performance Heating Ventilation and Air Conditioning (HVAC) in commercial buildings.
- The project will tackle this issue with three areas of work.
- The first area will tackle the minimum energy requirements of the National Construction code regarding energy consumption metrics for HVAC in commercial buildings.
- The second will investigate the current best practice of HVAC designs in Australian commercial buildings and communicate that to industry to raise standards.
- The third will investigate the 5 largest energy consuming components in a high performance commercial HVAC system and closely examine if there are opportunities for further improving current best practice.

Figure 1: Typical energy consumption breakdown in an office building[1]



The GHG Case for Geopolymer Concrete

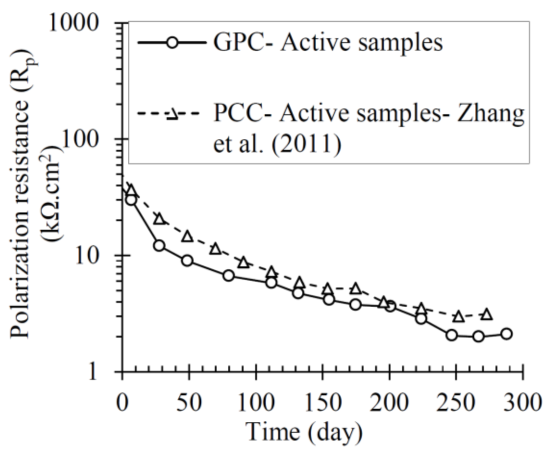
- CO_2 emissions generated by typical concrete mixes using Portland cement as the binder are between 0.29 and 0.32 tonnes of CO_2–e per m^3.
- According to the Australian Bureau of Statistics 2012-13, the current production of pre-mixed concrete is about 27 million m^3 per annum.
- Results in 8 million tonnes of CO_2-e p.a. from the manufacture of pre-mixed concrete.
- Geopolymer alternatives can provide significant carbon reduction compared to OPC concrete.
- For an uptake of 10% geopolymer/concrete replacement, 640 thousand tonnes per annum less carbon will be emitted to the atmosphere per year from Australia alone.

Annual carbon emission savings for various uptake of geopolymer concrete.

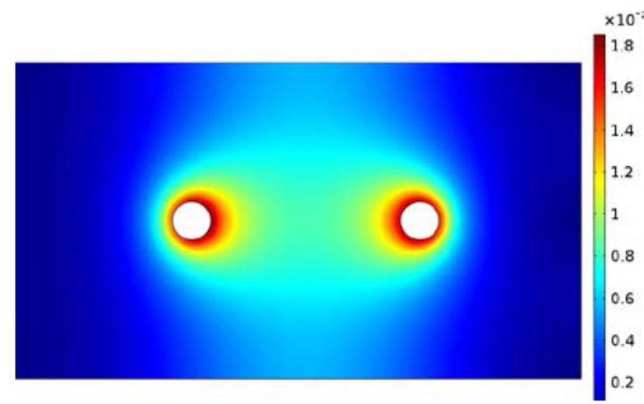
% adoption of geopolymer	Carbon emissions (tonnes) due to pre-mixed concrete manufacture	Carbon emission savings (tonnes) that can be achieved by geopolymer alternative
0%	8,000,000	0
10%	7,360,000	640,000
20%	6,720,000	1,280,000

RP1020: Reducing Barriers for Commercial Adaptation of Construction Materials with Low-Embodied-Carbon

- The major barrier to geopolymer concrete adaptation is the lack of both standard specifications and knowledge related to its durability aspects.
- The project aims to gather field data from GPC real-life constructions to develop greater confidence in GPC use, as well as establish reliable test methods.
- Using the field and laboratory data, as well as numerical analysis, a comprehensive handbook for GPC specification is being developed to be published through Standards Australia.

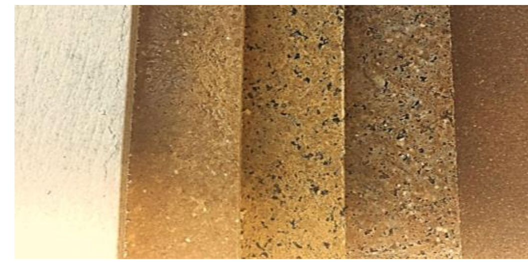


Comparison of the Polarization resistance of geopolymer and OPC concrete samples



Corrosion current density between a corroding reinforcing bars concrete

RP1022 – Investigation of innovative sustainable low carbon products from waste materials for built environments



- Transferring waste materials (wood, plastic and marine waste such as seaweed and seashell) into resources for the developing of a new generation of high performance non-toxic engineered wood-plastic bio-composite for building, furniture and architectural applications.
- This invention will enable re-using of these 85% of the urban wood wastes.
- These products have been specifically designed for disassembly and recycling and the end of their life.
- Also the materials have been designed for a consistent state of non-toxicity for end users regarding chemical and biological Volatile organic compounds (VOCs) for the whole product's lifespan.

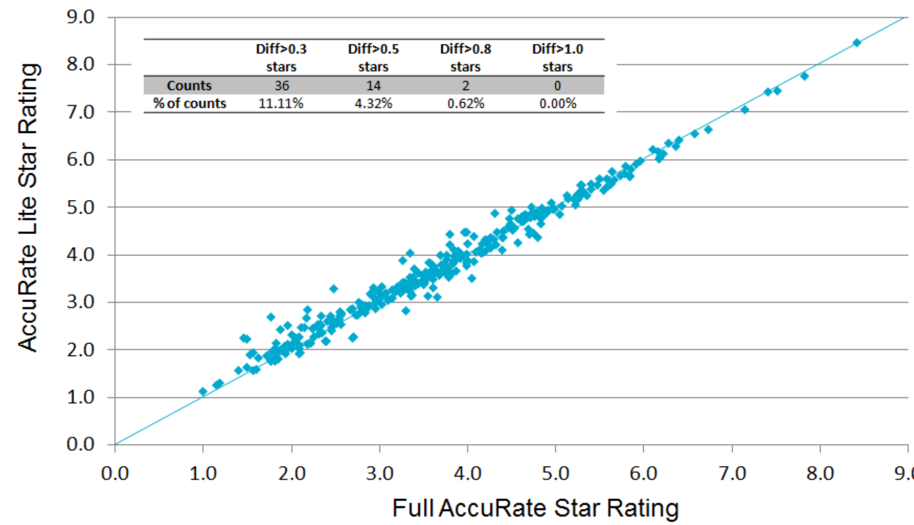
NP4007 – Glass recycling for waste reduction in built environment

- This study has successfully manufactured a high quality artificial construction slabs from waste glass powder filler with high flexural and compression strength as well as low water absorption and moderate density.
- Using these mixtures as raw materials and enhancing different performance of product using bio-wastes instead of synthesis raw materials is unprecedented until now.
- These products have been specifically designed for disassembly and recycling and the end of their life.

Next generation whole of house tool

RP1024: Ref NEPP Measure 5

- Review of user assumptions in NatHERS
- Include appliances, generation and storage
- Simplify data entry
- Validate against measured data
- Investigate compliance



	Diff>0.3 stars	Diff>0.5 stars	Diff>0.8 stars	Diff>1.0 stars
Counts	36	14	2	0
% of counts	11.11%	4.32%	0.62%	0.00%

AusZEH Design
(Lite & Heavy)

Thermal | Embedded Carbon | Hot Water | Lighting | HVAC | Appliances | Occupancy | Generation

Energy Inspection

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RP2007: Integrated Carbon Metrics Project

Project Objectives:

Research Challenge:

One third of global GHG gas emissions are emitted from the building sector. While more work has been done on decreasing direct emissions from the operation of buildings, embodied emissions of construction materials and processes receive little consideration, even through they constitute a significant additional proportion of emissions. Estimating embodied emissions is complicated, and there are uncertainties as there is yet to be developed a universally accepted methodology.

- Enable the analysis of the **carbon fabric of the built environment**
- Build detailed, economy-wide **database** of embodied carbon flows
- Help assess the carbon performance of **precincts by delivering tailored PIM tools**
- Quantitatively evaluate low-carbon **scenarios at PIM and economy-wide level**
- Contribute to the process of defining universal carbon accounting **principles, guidelines and standards** (such as 'low-carbon', 'carbon-neutral', 'zero-carbon', etc.)

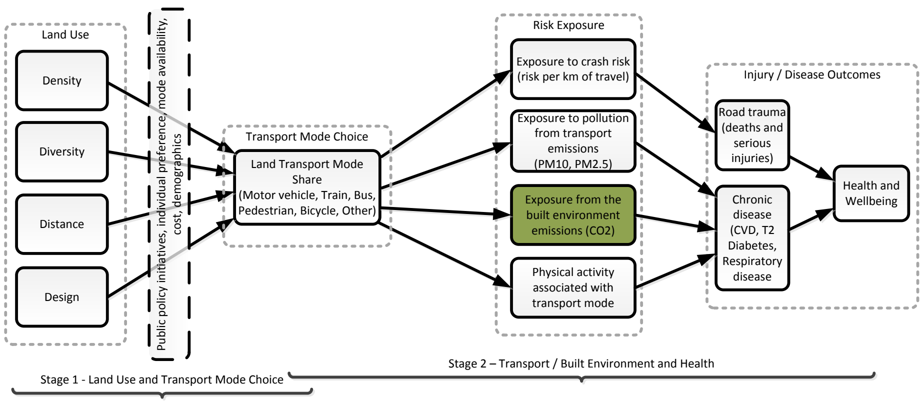
UNSW THE UNIVERSITY OF NEW SOUTH WALES · University of South Australia · THE UNIVERSITY OF MELBOURNE · AECOM · Sydney WATER · LOW CARBON LIVING CRC

Carbon Neutral Adelaide

RP2028 Development and Trial of a Low-Carbon Living Co-Benefits Calculator

Objective;

- Develop a co-benefits calculator suitable for various stakeholders involved in the planning process.(Regulators, Developers, Precinct planners, etc.)
- Linked to key aspects of the built environment
  - Residential density / diversity, Street networks, Green space, Traffic, mode share, etc.

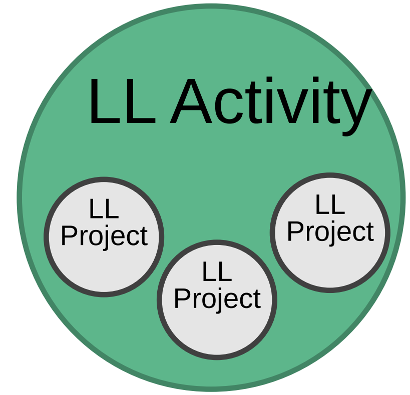


What are the Co – Benefits ?

- Reductions in injuries & deaths associated with transport accidents
- Reductions in chronic disease (CVD, asthma, respiratory disease) associated with built environment
- Reductions in chronic disease (CVD, overweight, diabetes) & increases in health associated with active transport modes (walking, cycling, etc.)
- Improvements in productivity (e.g., reduced travel time, more productive time use) associated with efficient urban land form design
- Overall health, wellbeing, productivity and economic benefit

Community Engagement – Living Laboratories

Living Lab *Activity* Vision



- Stories *well-told* and *massively-communicated* will change public and industry appetite for low carbon living outcomes
  - ✓Assist communities & industry co-create their own desired vision
  - ✓Create social pressure to adopt

RP3009: High Performance Housing – Monitoring, Evaluating & Communicating the Journey

Project Objectives:

- Demonstrate that high performance, zero energy housing is readily available to volume market (Josh's House).
- Illustrate this through real-life case studies from around Australia and generate national media interest (Star Performers).
- Investigate the impact of resident behavior as compared to design in terms of household operational energy use and carbon emissions (10 House Living Labs Study).

Curtin University
University of South Australia
City of Fremantle
JOSH BYRNE & Associates
LOW CARBON LIVING CRC

RP3033: Mainstreaming Low Carbon Housing Precincts – the WGV Living Laboratory

Project Objectives

- Demonstrate that significant reductions in BAU carbon emissions in mainstream precinct-scale residential developments are achievable.
- Identify where the carbon savings are made, including level of cost and complexity of the various strategies and mechanisms deployed.
- Evaluate market interest in the low carbon aspects of the development and how this relates to the level of resident participation with low carbon lifestyle actions.
- Understand the inter-relationships between stakeholders in regards to low carbon aspirations and how these can better align.

Curtin University LANDCORP City of Fremantle JOSH BYRNE & Associates LOW CARBON LIVING CRC

RP3009e1: Mainstreaming High Performance Housing

Project Objectives

- Work with property developers to deliver three HP ZEH display homes around Australia.
- Establish an agreed construction industry position on the construction cost of HP ZEH volume market homes.
- Undertake an assessment of the market potential of HP ZEH homes.
- Foster heightened awareness of the accessibility (cost and capacity) and market interest of HP ZEH features.

Process	Content	Participants

Construction industry engagement principles	• Develop project messaging strategy
	• Identify required cost information and cost generation process
	• Evaluate outcomes and behaviours being asked of the builders
	• Draft incentivization strategy and tender documentation
	• Developer/builder consultation – video diary segment #1 (VD#1)
		• Developers
		  • Marketing team
		  • Procurement team
		• Project team

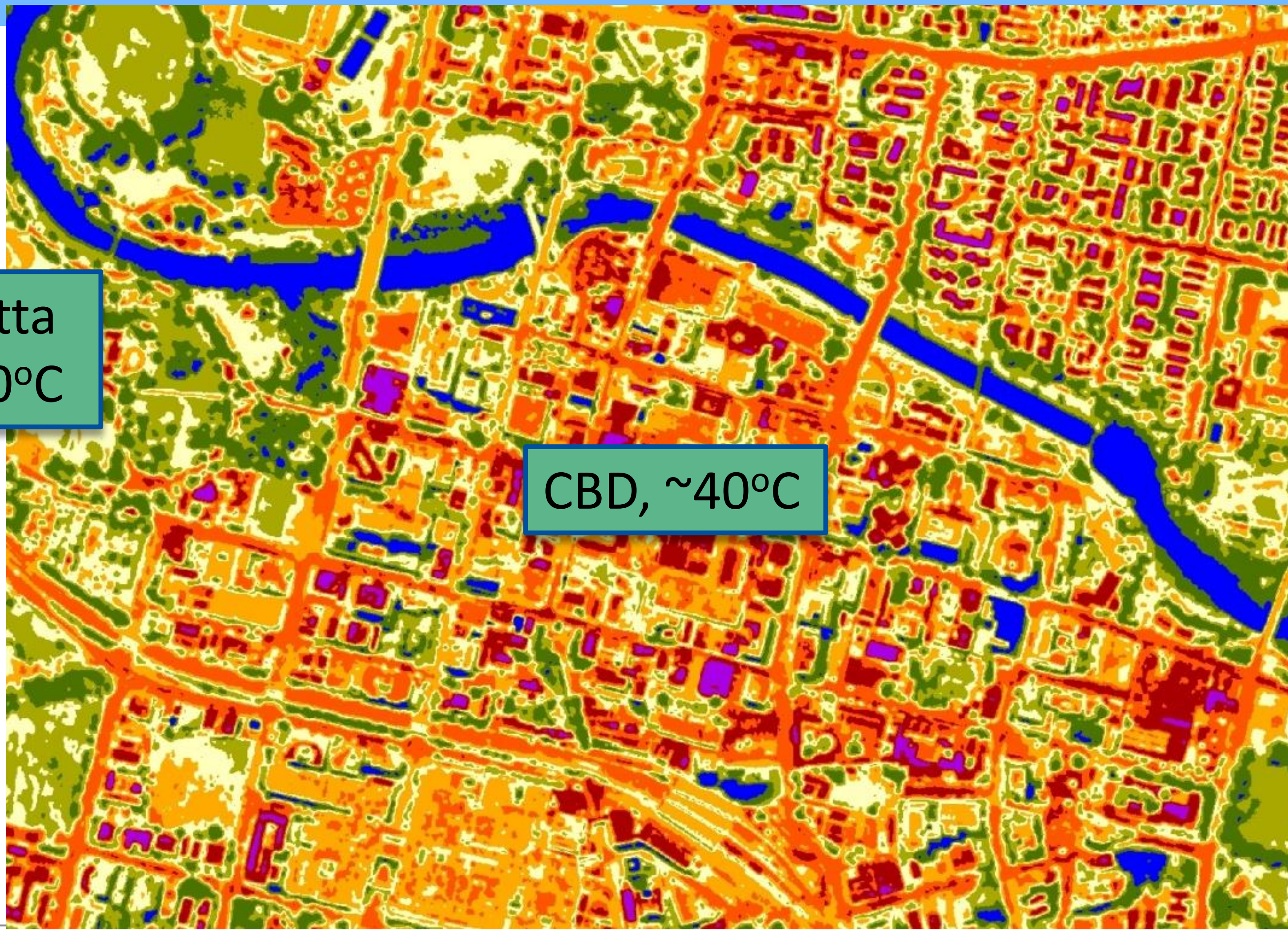
Design options analysis	• Design phase builder procurement
	• Successful builders BAU building analysis (VD#2)
	• Design charrettes and performance enhancement (VD#3)
	• 3D comfort visualisation model animations (VD#4)
	• Public consultation (via sample/focus group) on 3D visualisations (VD#5)
		• Builders
		  • Marketing team
		  • Value engineering team
		• Project team

Construction	• Video interviews with builder post completion of build (VD#6) • Materials inventory	• Subcontractors • Builders value engineers • Project team

Trial period display home marketing	• Survey consumer interest of HP ZEH features (VD#7)
	• Performance monitoring of HP ZEH homes (VD#8)
		• Builders
		  • Direct sales team
		  • Marketing team
		• Project team

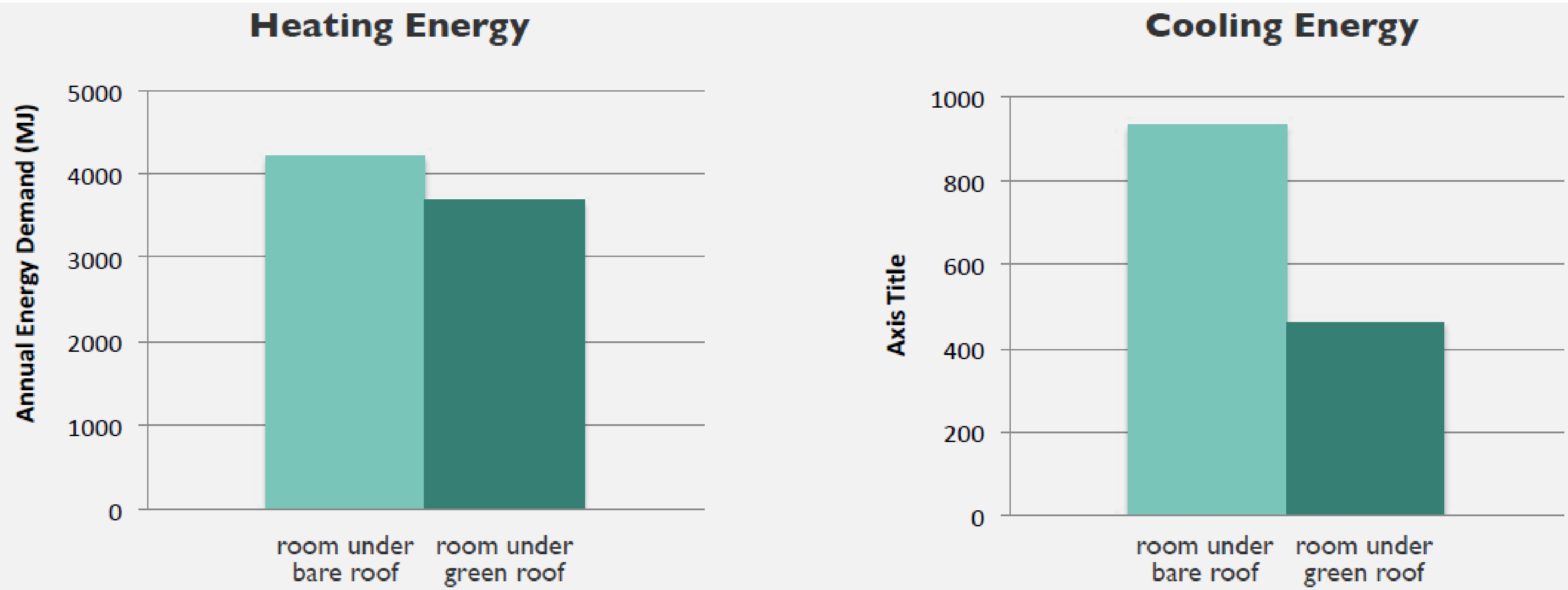
Dissemination	• Stakeholder workshops (VD#9) • Unveiling of ZEH homes to the public and ongoing display home promotion • Video diary collation and online publication	• Project team

Evidence Base for Policy



Parramatta CBD – Day thermal: Source: Parramatta City Counc
Source: http://www.remotesensing.com.au/urbanheat.html

Evidence Base for Policy



Source: Chen and Williams (2009) Green roofs as an adaptation to climate change: modelling the green roof at the Burnley campus, The University of Melbourne, Research Report for CSIRO Climate Adaptation Flagship.

The results of a study on energy demand under a green roof and bare roof in Melbourne.

LOW CARBON LIVING CRC

Greyfields urban regeneration

Lower Carbon

- Reduced travel distances/ accessible amenities
- Better, more accessible public transport
- Lower energy consumption housing forms

HASSELL, 2015

To this

2 x no dwellings/ floor area
2 x public space

This

Financially attractive

- Better utilization of existing infrastructure
- Unlocking underutilized land value.

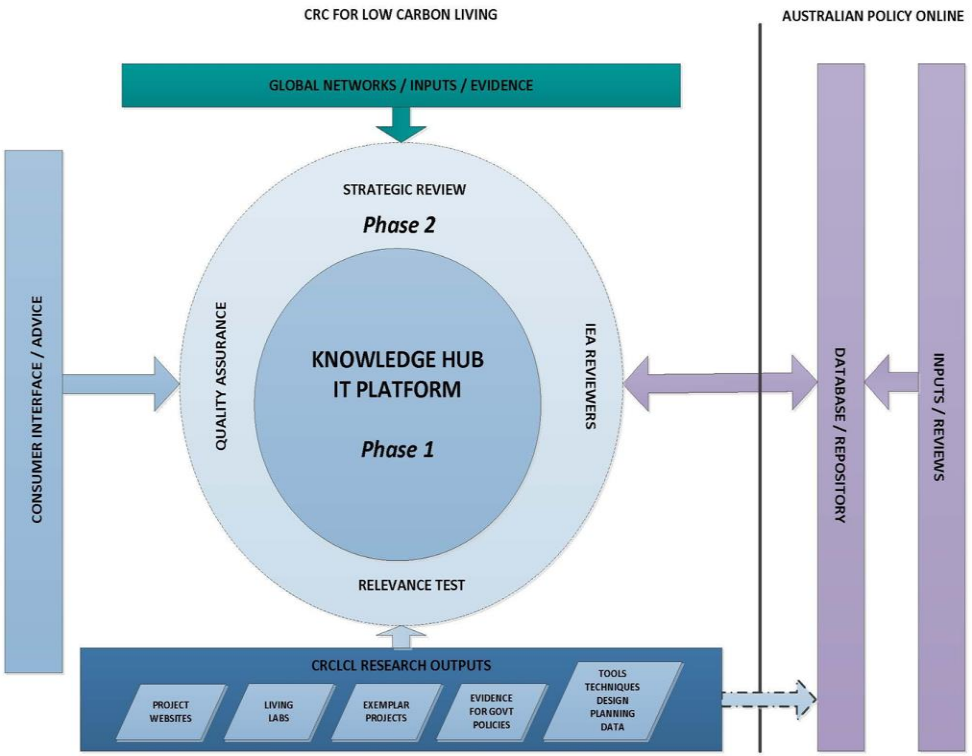
LOW CARBON LIVING CRC

Evidence-Based Decisions & Systematic Reviews (SRs)

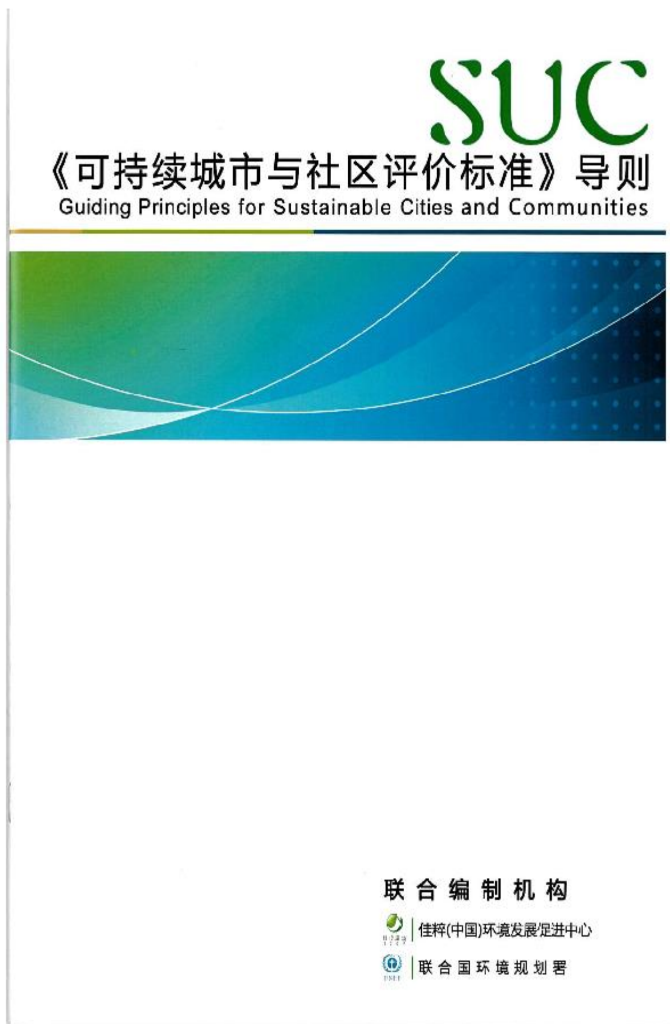
- Cochrane Collaboration: SRs on medical practice & healthcare, started 1993, large worldwide network of 'groups', provides training & support
- Campbell Collaboration: SRs on social interventions, started 2000, partly modelled on Cochrane, smaller network of groups, looking to grow, provides support & training
- Evidence Synthesis International (ESI): worldwide umbrella body (incl. Cochrane and Campbell)

SP0008 Low Carbon Built Environment Knowledge HUB

- Access to the outputs of the CRC
- Provides a collaborative platform for CRC Nodes, and
- Aligns the significant existing Australian and International resources for industry, policy makers, researchers and the public.
- Provides and maintains an evidence base for policy makers and practitioners promoting low carbon living



International Forum on Sustainable Cities and Communities & Press Conference on SUC Guidelines, Beijing, 2015



UNEP

佳粹環境 JCEP

LOW CARBON LIVING CRC

PARTNERS 2015

BLUESCOPE

Brookfield MULTIPLEX BM

Sydney WATER

University of South Australia

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Curtin University

AECOM

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CITY OF SYDNEY 2030

SYDNEY COASTAL COUNCILS

Government of South Australia

SA Water

Ash Development Association of Australia

HASSELL

STANDARDS Australia

CSR

AWA AUSTRALIAN WINDOW ASSOCIATION

City of Greater Geraldton a vibrant future

ISCA Infrastructure Sustainability Council of Australia

Australian Institute of Architects

Australian Government Department of Industry

Australian Government Department of Infrastructure and Regional Development

VBA VICTORIAN BUILDING AUTHORITY

Government of South Australia Department of Environment, Water and Natural Resources

NSW GOVERNMENT Planning & Infrastructure

NSW GOVERNMENT Office of Environment & Heritage

TONGJI UNIVERSITY 1907

BCI MEDIA GROUP

UrbanGrowth NSW

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RenewalSA people partnerships progress

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HIA

MASTER BUILDERS AUSTRALIA

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CONSULT AUSTRALIA

NSERC Smart Net-Zero Energy Buildings Strategic Research Network