# Integrated Carbon Metrics (ICM)

LOW CARBON LIVING CRC

UNSW AUSTRALIA

SUSTAINABILITY ASSESSMENT PROGRAM

AECOM

THE UNIVERSITY OF MELBOURNE

BLUESCOPE

Sydney WATER

University of South Australia

aurecon

CRCLCL/ISCA Forumm Tuesday 23 February 2016

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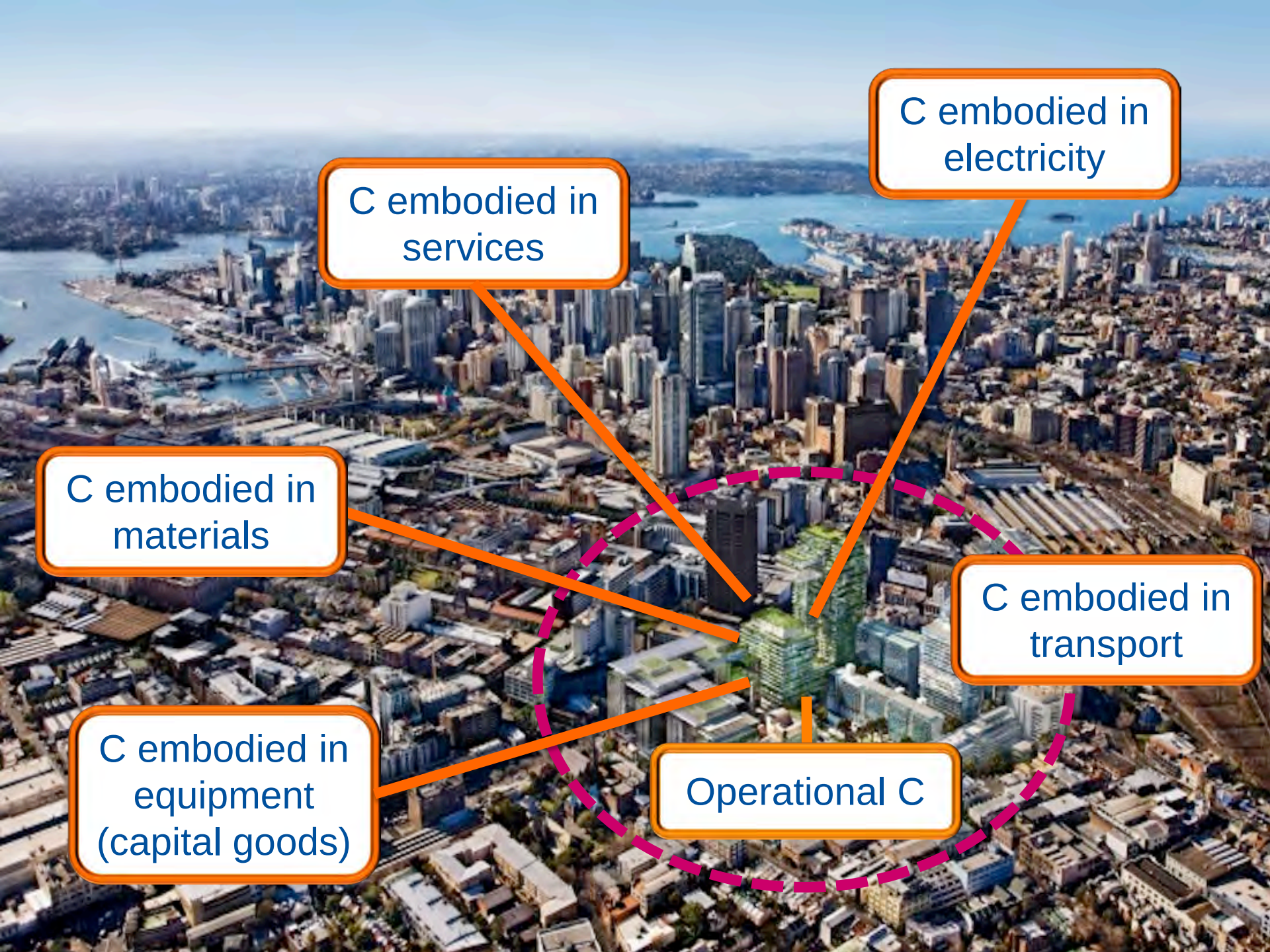
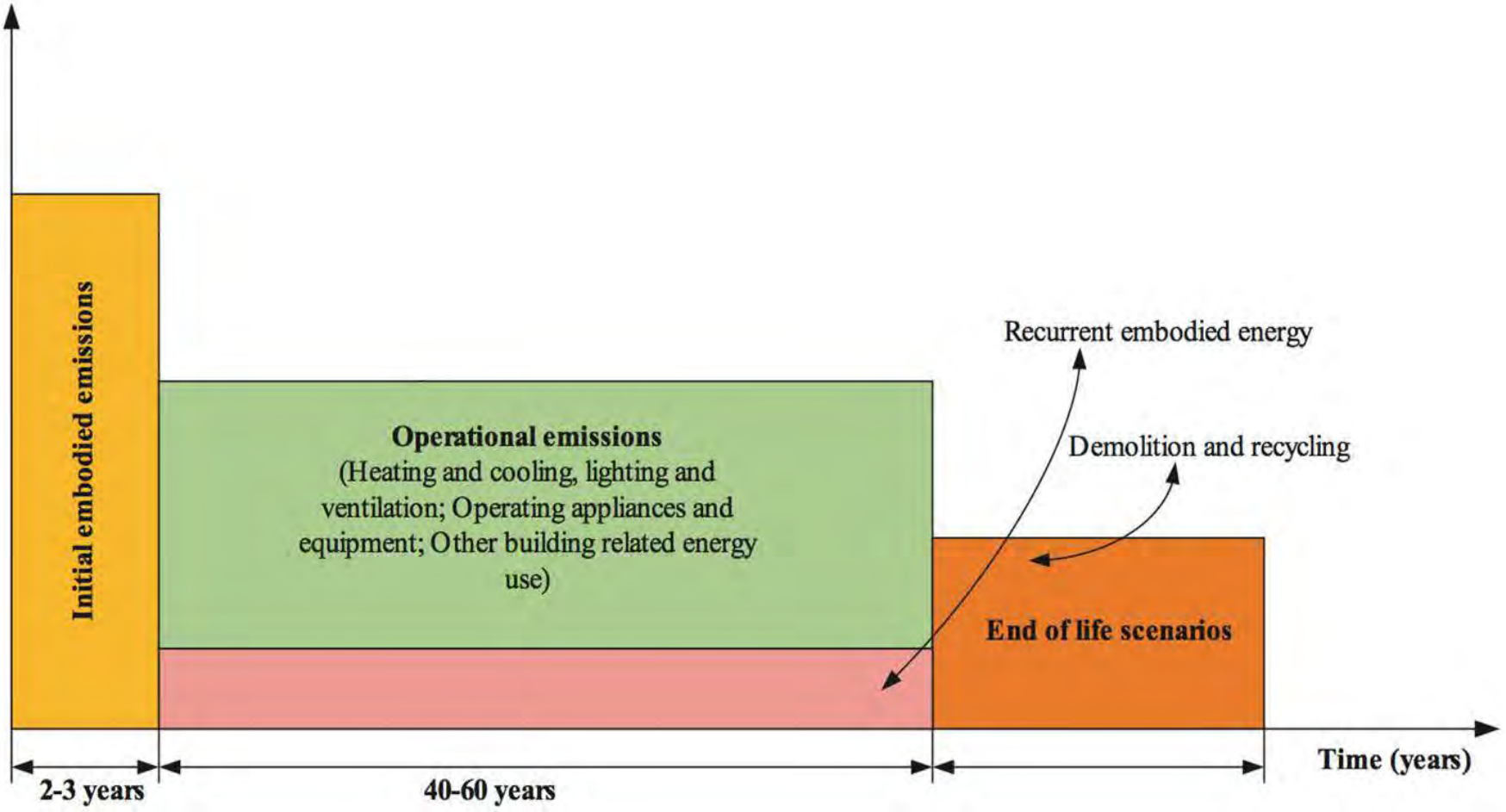
# Integrated Carbon Metrics – Project Goals

- Enable the analysis of the '**carbon fabric' of the built environment**
- Provide **data** and **tools** to
- Assess the carbon performance of **precincts, projects, sectors** and **cities**
- Quantitatively evaluate low-carbon **scenarios**
- **Cooperate** between researchers, industry, local and state authorities

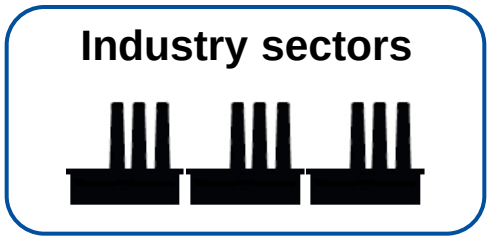

C embodied in electricity
C embodied in services
C embodied in materials
C embodied in transport
C embodied in equipment (capital goods)
Operational C

# Life cycle carbon emissions (of a building)

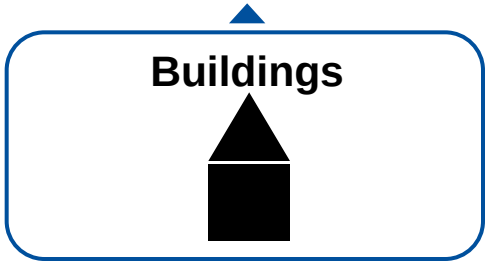


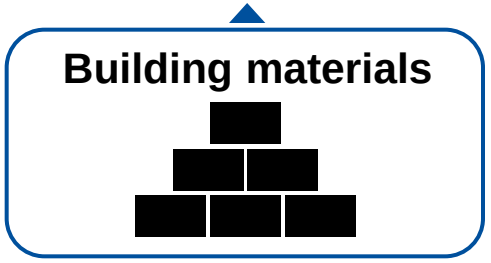

Reference: Ibn-Mohammed et al. (2013) Operational vs. embodied emissions in buildings — A review of current trends. *Energy and Buildings*, 66(0), 232-245. http://www.sciencedirect.com/science/article/pii/S0378778813004143

# Levels of Carbon Emissions and ICM Tools








Hybrid LCA Database

Life cycle cost and carbon analysis

Product Explorer

Precinct Carbon App

PIM Scenario Model

Sector Carbon Map

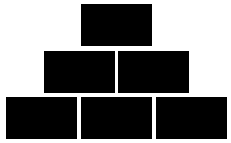
# Levels of Carbon Emissions and ICM Tools

**Industry sectors**

**Precinct, city**

**Buildings**

**Building materials**



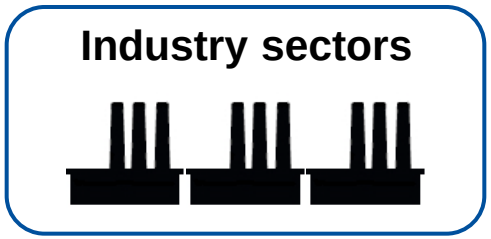
**Hybrid LCA Database**

Examples for Building Materials and Elements:

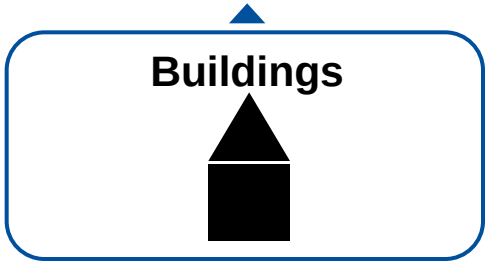
kg $CO_2e$ / $
(or kg, $m^2$ etc.)

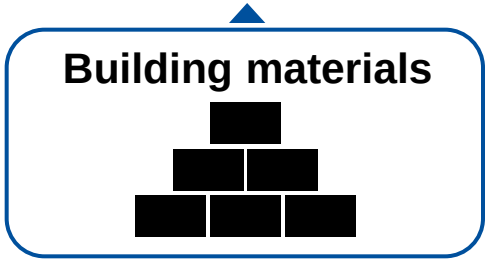
- Gravel
- Doors, wooden
- Plywood
- Glued laminated lumber
- Plastic pipes
- Clay bricks
- Ready mixed concrete and mortar
- Alloy steel flat-rolled products
- Iron or steel rails, rail fastenings or other rail accessories
- Cast iron tubes, pipes and hollow profiles
- Aluminium roofing and guttering
- Iron or steel window-frames
- Nails, tacks, staples, spiked cramps, studs, spikes & pins

# Levels of Carbon Emissions and ICM Tools








Hybrid LCA Database

**Product Explorer**

Life Cycle Optimi-sation Model

Precinct Carbon App

PIM Scenario Model

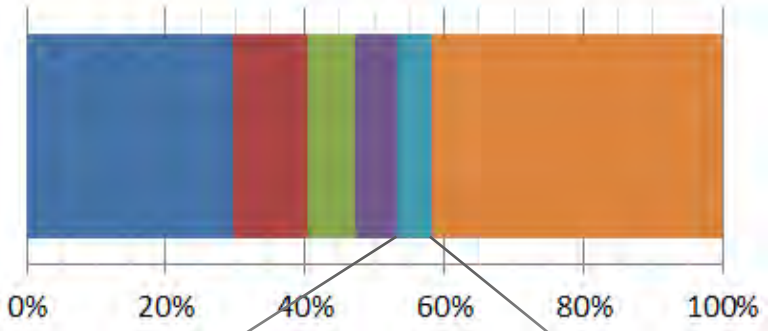
City Carbon Map

# ICM Tool > Product Explorer

**Select sector:** 'Plywood'

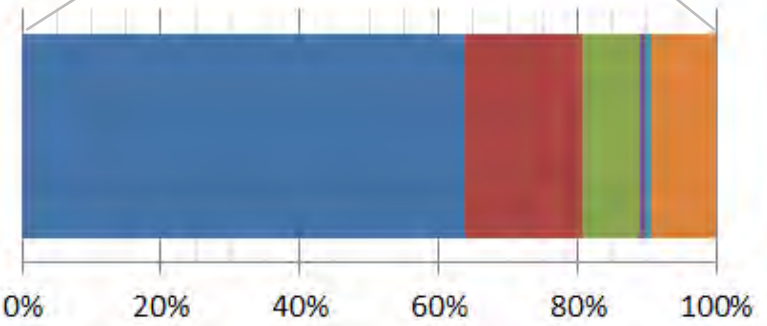
**Major contributors to the footprint of the 'Plywood' sector (kg/yr):**

| | |
|---|---|
| 1 | 'Electricity generation' |
| 2 | 'Other wooden builders joinery and carpentry' |
| 3 | 'Other wood product manufacturing' |
| 4 | 'Particle board (incl laminated) and similar board of wood or ot |
| 5 | 'Road transport' |
| 6 | Other |
| | TOTAL |



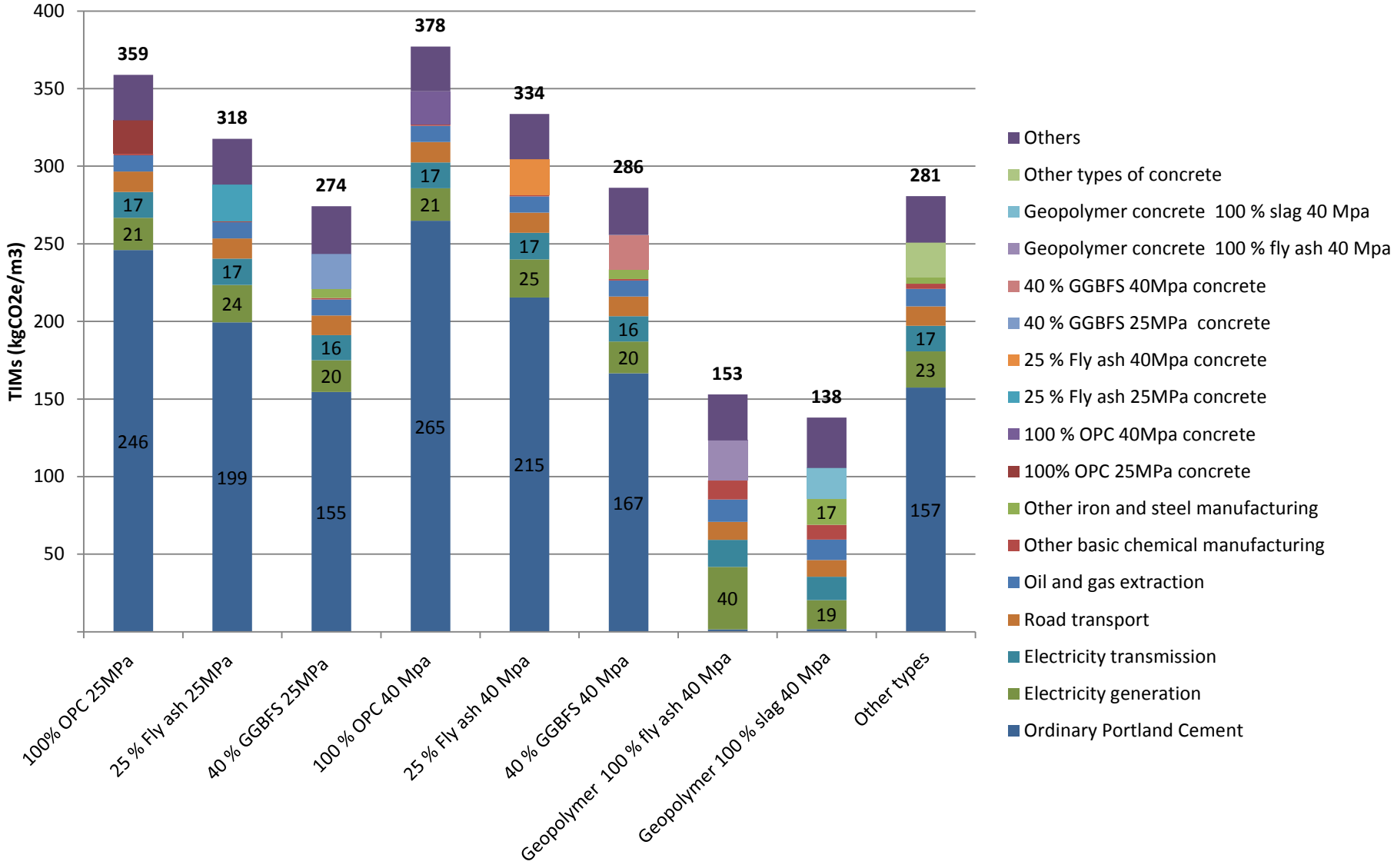

**Major contributors to the footprint of the 'Road transport' sector (kg/yr):**

| | |
|---|---|
| 1 | 'Road transport' |
| 2 | 'Electricity generation' |
| 3 | 'Oil and gas extraction' |
| 4 | 'Other petroleum and coal product manufacturing' |
| 5 | 'Postal and courier pick-up and delivery service' |
| 6 | Other |
| | TOTAL |



# Case study on cement and concrete

# Decomposition of life-cycle GHG emissions for types of concrete

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# IS Materials Calculator – based on LCA

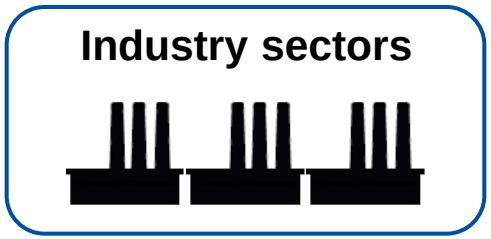
**Infrastructure Sustainability Materials Calculator**
Version 1.1

Release date: 20/02/2015
Original release date: 20/02/2015
Level Achieved: 2

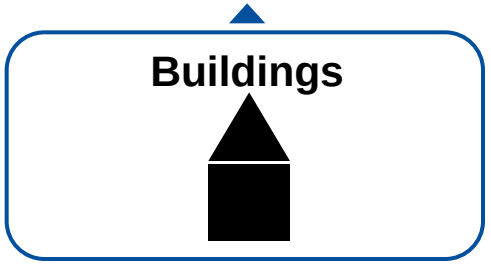
| | Base Case | GHG (tCO2-e) | Ecopoints | Actual Case | GHG (tCO2-e) | Ecopoints | Reductions | GHG (tCO2-e) | | Ecopoints | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total** | | **5,454** | **7,957** | | **3,793** | **5,668** | | **1,661** | **30%** | **2,289** | **29%** |
| 1 Component type: | Wastewater Treatment | | | Wastewater Treatment | | | | | | | |
| Sub-component type: | Municipal Sewage works | 3,584 | 5,253 | Municipal Sewage works | 2,730 | 4,092 | | 854 | 24% | 1,161 | 22% |
| capacity of treatment f | 1,825,000 m3/yr Detail | | | 1,825,000 m3/yr Detail | | | | | | | |

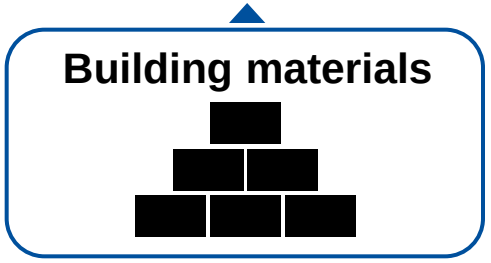
| **Component 1:** | | | GHG (tCO2-e) | Ecopoints | |
|---|---|---|---|---|---|
| Component: | Wastewater Treatment | | **2,730** | **4,092** | **Total** |
| Sub-component: | Municipal Sewage works | | | | |
| capacity of treatment facil | 1,825,000 | m3/yr | **0.00150** | **0.00224** | **per m3/yr of wastewater treated** |
| | 0 | | | | |
| **Asphalts** | | | | | |
| Select **Asphalt 1:** | Hot Mix Asphalt | | | | |
| Amount | - | tonnes | - | - | |
| Transport mode | None, On-Site | | | | |
| Transport distance | 0 | km | - | - | |
| **Concretes** | | | | | |
| Select **Concrete 1:** | Concrete Strength Grade 20 Mpa 30% SCM | | | | |
| Amount | 1,125 | tonnes | **104** | **111** | |
| Transport mode | Rigid Truck | | | | |
| Transport distance | 0.2 | km | **0** | **0** | |
| Select **Concrete 2**: | Concrete Strength Grade 32 Mpa 20% SCM | | | | |
| Amount | 280 | tonnes | **36** | **38** | |
| Transport mode | Rigid Truck | | | | |
| Transport distance | 0.2 | km | **0** | **0** | |

# Levels of Carbon Emissions and ICM Tools





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Life Cycle Optimi-sation Model

Product Explorer

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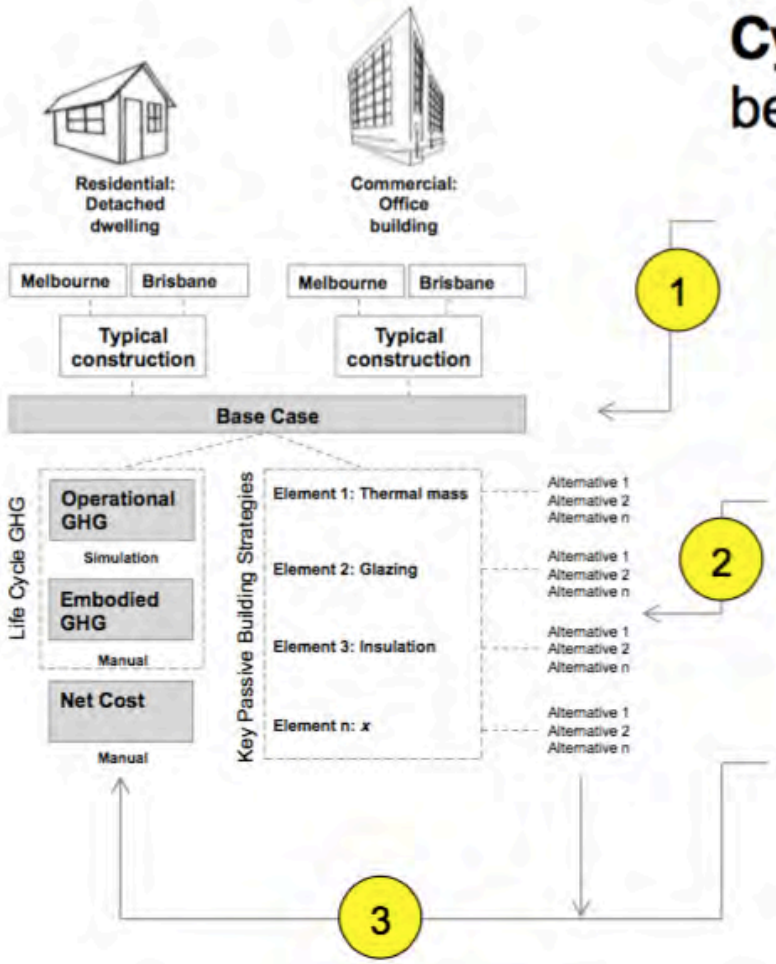
PIM Scenario Model

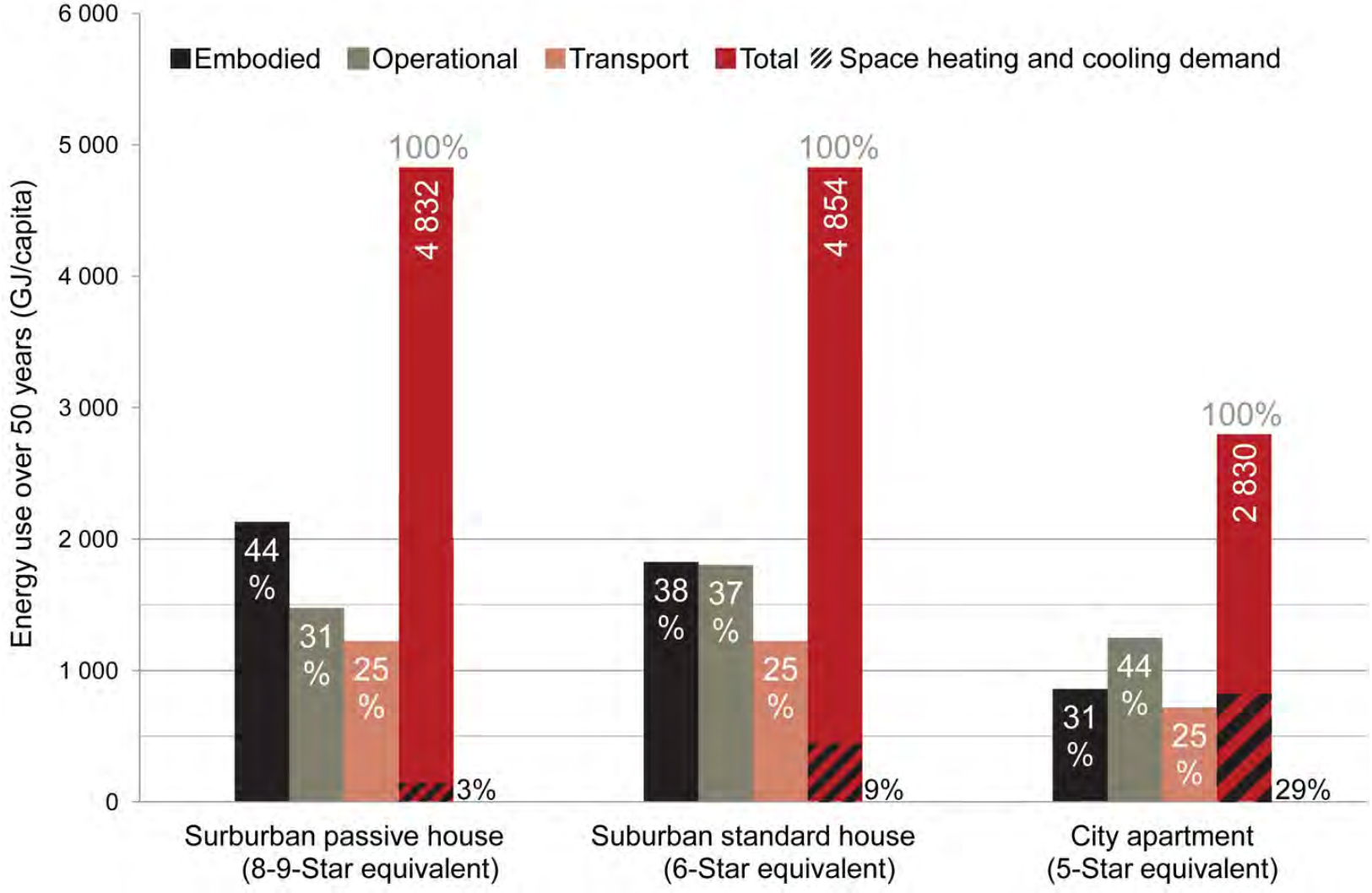
City Carbon Map




# This framework, called the **Life Cycle Optimisation Model**, will be achieved by:

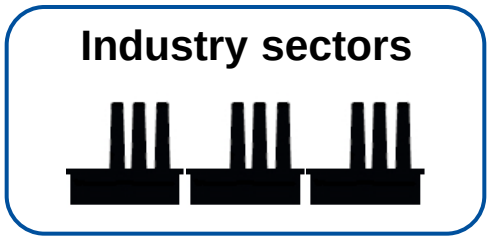
- Determining the base case life cycle GHG emissions and net cost of 2 typical Australian building typologies in 2 different climate zones
- Identifying the key passive building elements (and their alternatives) used to lower operational GHG emissions in these buildings.
- Determining the implications on the life cycle GHG emissions and net cost of using these alternative elements.

# Embodied vs operational energy

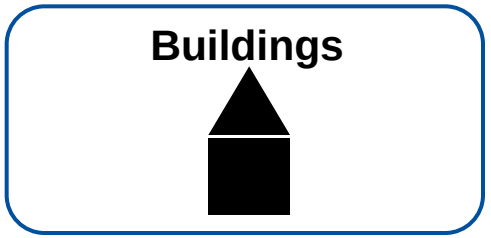


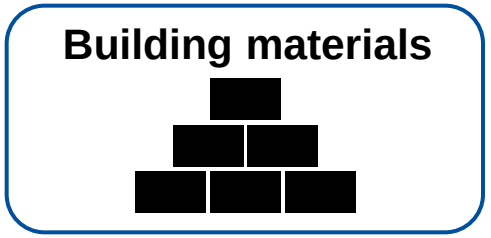

Stephan, A., Crawford, R. H. and de Myttenaere, K. (2013) A comprehensive assessment of the life cycle energy demand of passive houses. *Applied Energy*, **112**(0), 23-34. http://www.sciencedirect.com/science/article/pii/S0306261913004996

# Levels of Carbon Emissions and ICM Tools





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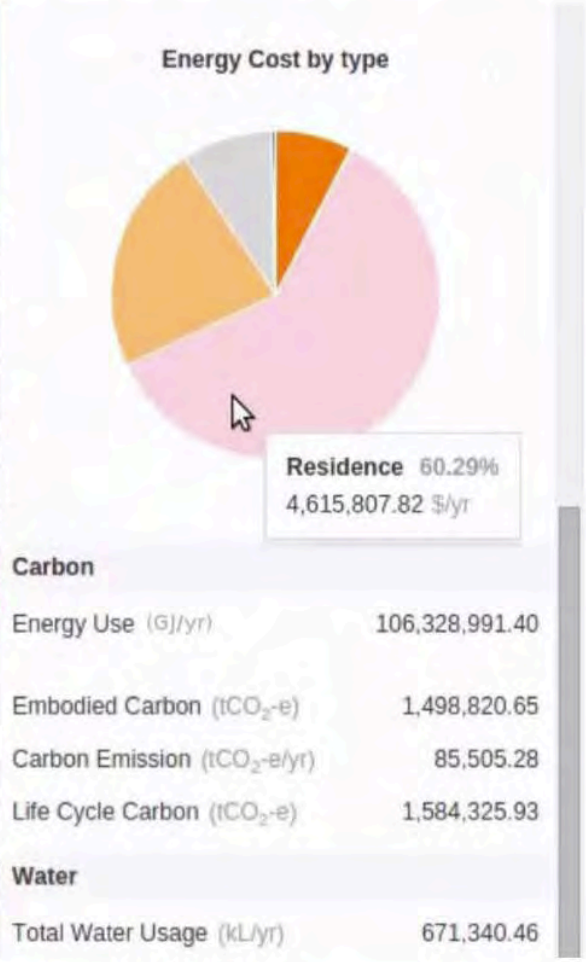
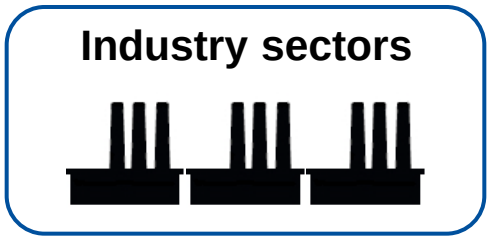
# Outputs from Precinct Carbon App

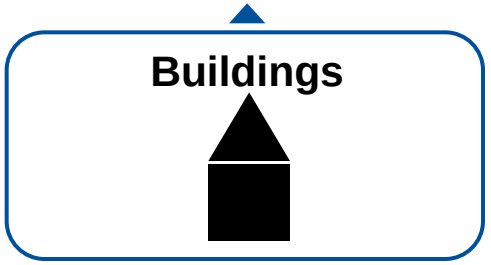


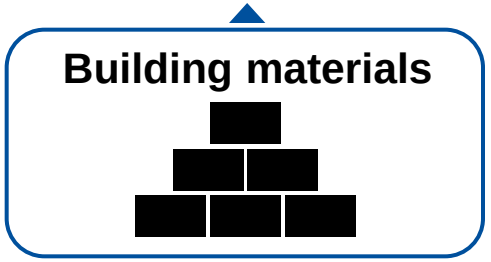

*The results of a precinct assessment of Fisherman's Bend.*

# Levels of Carbon Emissions and ICM Tools





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Life Cycle Optimi-sation Model

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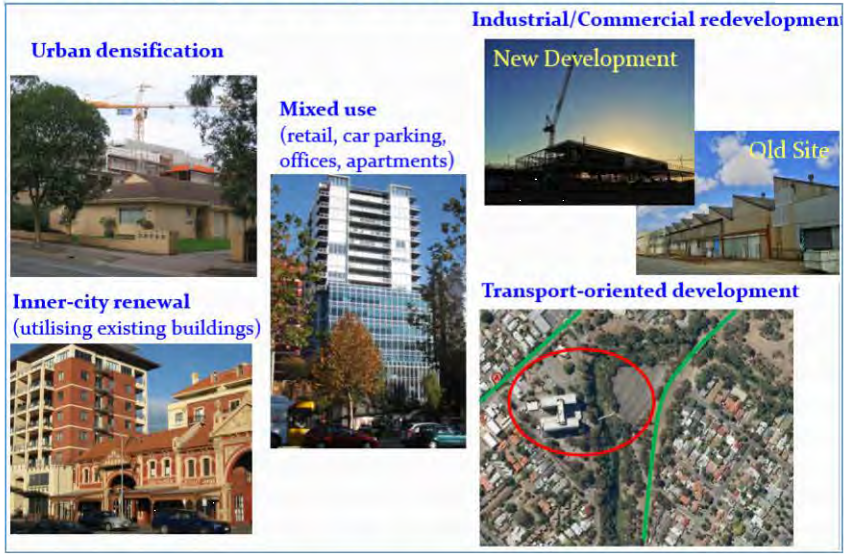
**PIM Scenario Model**

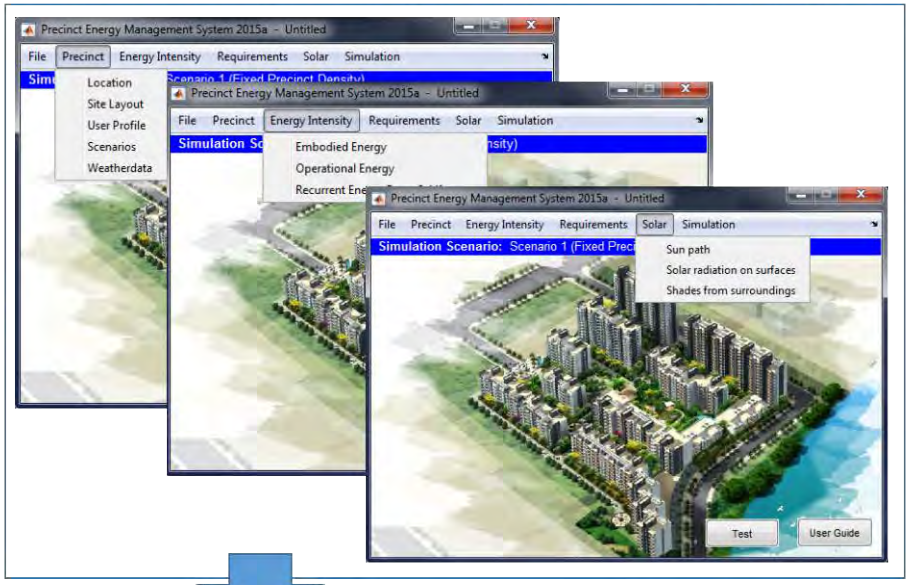
Sector Carbon Map

# Precinct Information Modelling - Scenarios

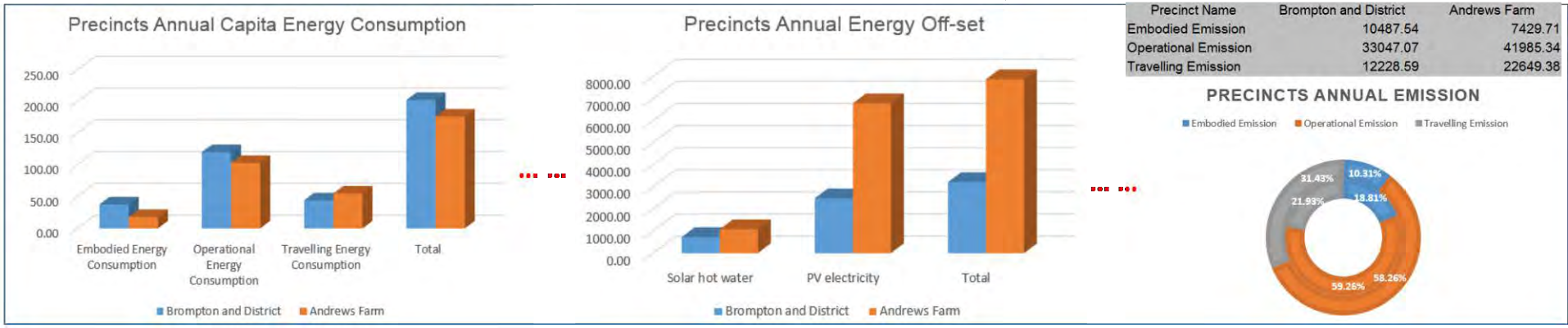
## Precinct (Re)Development Scenarios & Data




## Precinct Life-cycle Energy & Emission Modelling Tool




## Precinct Scenario Analysis and Planning




| Precinct Name | Brompton and District | Andrews Farm |
|---|---|---|
| Embodied Emission | 10487.54 | 7429.71 |
| Operational Emission | 33047.07 | 41985.34 |
| Travelling Emission | 12228.59 | 22649.38 |

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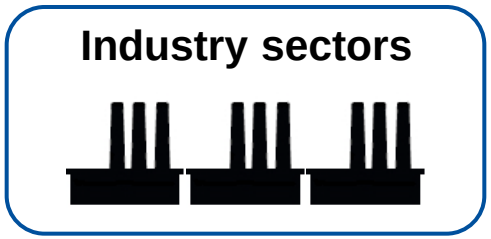
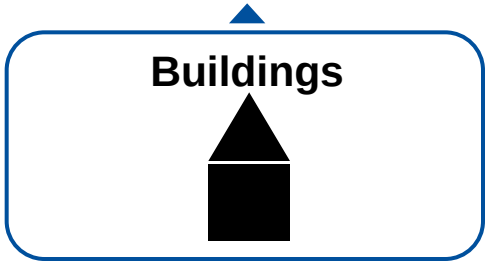
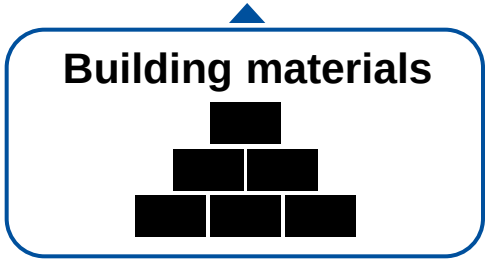
# Levels of Carbon Emissions and ICM Tools





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# Industry sector 'carbon map' of direct and embodied emissions

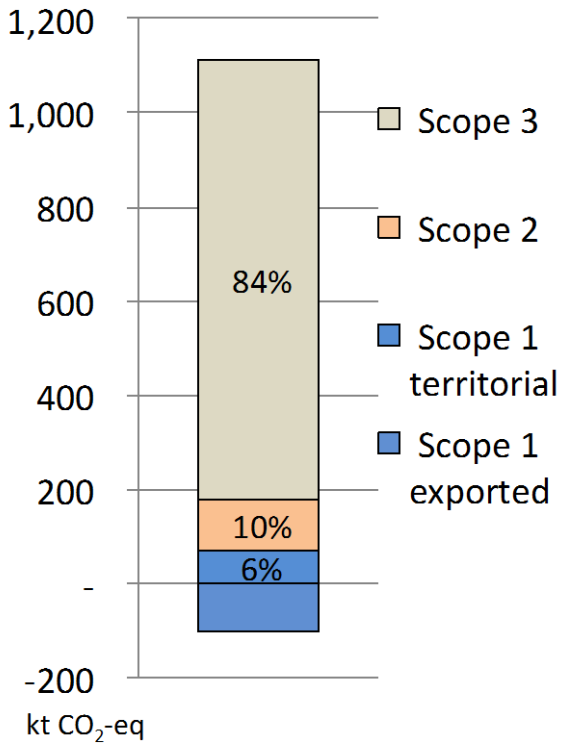
Total annual GHG emissions in kt CO2-eq (excl. HH)

| Products (destination) > / Industries (origin) v | Residential building construction | Non-residential building construction | Road and bridge construction | Non-building construction nec | **Total emissions embodied in construction activities per year** |
|---|---|---|---|---|---|
| Agriculture, Food & Fibre | 783 | 2,199 | 218 | 901 | **4,101** |
| Mining | 2,550 | 2,191 | 795 | 3,190 | **8,725** |
| Material manufacturing | 3,147 | 2,090 | 657 | 2,115 | **8,009** |
| Cement & concrete | 454 | 330 | 112 | 339 | **1,235** |
| Metal production | 1,365 | 1,036 | 344 | 952 | **3,696** |
| Equipment manufacturing | 838 | 808 | 291 | 866 | **2,804** |
| Electricity | 4,277 | 3,951 | 1,405 | 16,925 | **26,558** |
| Gas & water supply, waste | 1,959 | 1,388 | 467 | 1,962 | **5,776** |
| Residential building construction | 822 | 190 | 13 | 49 | **1,074** |
| Non-residential building construction | 208 | 466 | 27 | 32 | **733** |
| Road and bridge construction | 15 | 32 | 73 | 129 | **249** |
| Repair and maintenance - road and bridge | 2 | 4 | 9 | 16 | **31** |
| Non-building construction nec | 49 | 107 | 243 | 429 | **828** |
| Repair and maintenance - non-bldg constr. | 2 | 4 | 9 | 16 | **31** |
| Trade & transport services | 2,994 | 2,262 | 759 | 3,049 | **9,063** |
| Public services | 16 | 14 | 5 | 14 | **49** |
| Business services | 606 | 529 | 187 | 565 | **1,887** |
| **Total Carbon Footprint** | **20,087** | **17,602** | **5,613** | **31,547** | **74,849** |
| | **4.8%** | **4.2%** | **1.4%** | **7.6%** | **18% of all industry emissions** |

# Integrated C Metrics for Adelaide: "City Carbon Map"

**Carbon Map of the City of Adelaide**

| ORIGIN: Emissions from industries | kt CO2e per year | DESTINATION: Emissions embodied in products | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Agri-culture | Goods | Energy | Food | Construc-tion | Elec-tricity | Waste | Trans-port | Services |
| Agriculture | Adelaide City | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Goods | Adelaide City | 0 | 12 | 0 | 1 | 4 | 0 | 0 | 0 | 5 |
| Energy | Adelaide City | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 2 |
| Food | Adelaide City | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 |
| Construction | Adelaide City | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 1 |
| Electricity | Adelaide City | 0 | 3 | 0 | 5 | 20 | 38 | 1 | 1 | 21 |
| Waste | Adelaide City | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 |
| Transport | Adelaide City | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 4 | 3 |
| Services | Adelaide City | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 11 |
| Agriculture | Rest of World | 7 | 14 | 0 | 7 | 30 | 0 | 0 | 3 | 4 |
| Goods | Rest of World | 0 | 145 | 0 | 3 | 76 | 0 | 1 | 13 | 14 |
| Energy | Rest of World | 0 | 50 | 0 | 1 | 32 | 0 | 0 | 5 | 6 |
| Food | Rest of World | 0 | 1 | 0 | 1 | 3 | 0 | 0 | 0 | 0 |
| Construction | Rest of World | 0 | 2 | 0 | 0 | 53 | 0 | 0 | 1 | 1 |
| Electricity | Rest of World | 0 | 75 | 0 | 3 | 177 | 1 | 1 | 20 | 10 |
| Waste | Rest of World | 0 | 4 | 0 | 0 | 15 | 0 | 2 | 1 | 0 |
| Transport | Rest of World | 0 | 20 | 0 | 2 | 33 | 0 | 0 | 75 | 8 |
| Services | Rest of World | 0 | 6 | 0 | 0 | 17 | 0 | 0 | 3 | 1 |




Total carbon footprint of Adelaide City:
1.1 Mt $CO_2e$

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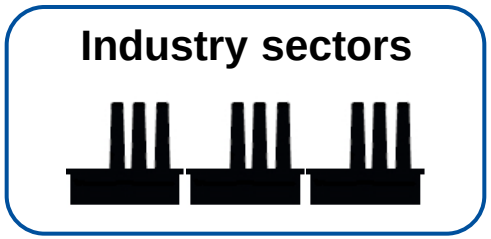
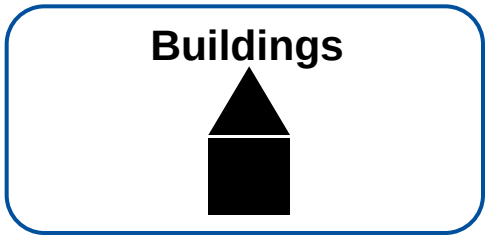
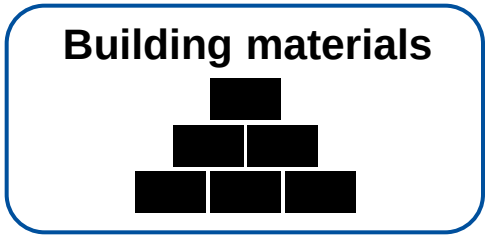
# Suite of ICM Tools as output





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Click-b4u-build portal

# ICM Tools for Infrastructure Planning – THANK YOU

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