LOW CARBON LIVING CRC

Industry Symposium

Using Precinct Information Modelling (PIM) to support carbon management in the built environment

Friday 15 September 2017

LOW CARBON LIVING CRC

Project partners

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Precinct Information Modelling

The PIM vision

Team members: **Jim Plume**, David Marchant, John Mitchell

Precinct Information Modelling

Our purpose is to **lower the carbon emissions of the built environment** while driving the competitive advantage for Australian industry.

Our mission is to engage in **collaborative research** that provides social and technology solutions and policy evidence, to capture community imagination and **facilitate the transition to a lower carbon built environment**.

Urban Modelling

A convergence is rapidly emerging of the historically independent disciplines in the built environment, particularly with the geo-spatial industries

These disciplines now broadly adopt digital technologies

A new integration is possible

multiple vs single buildings

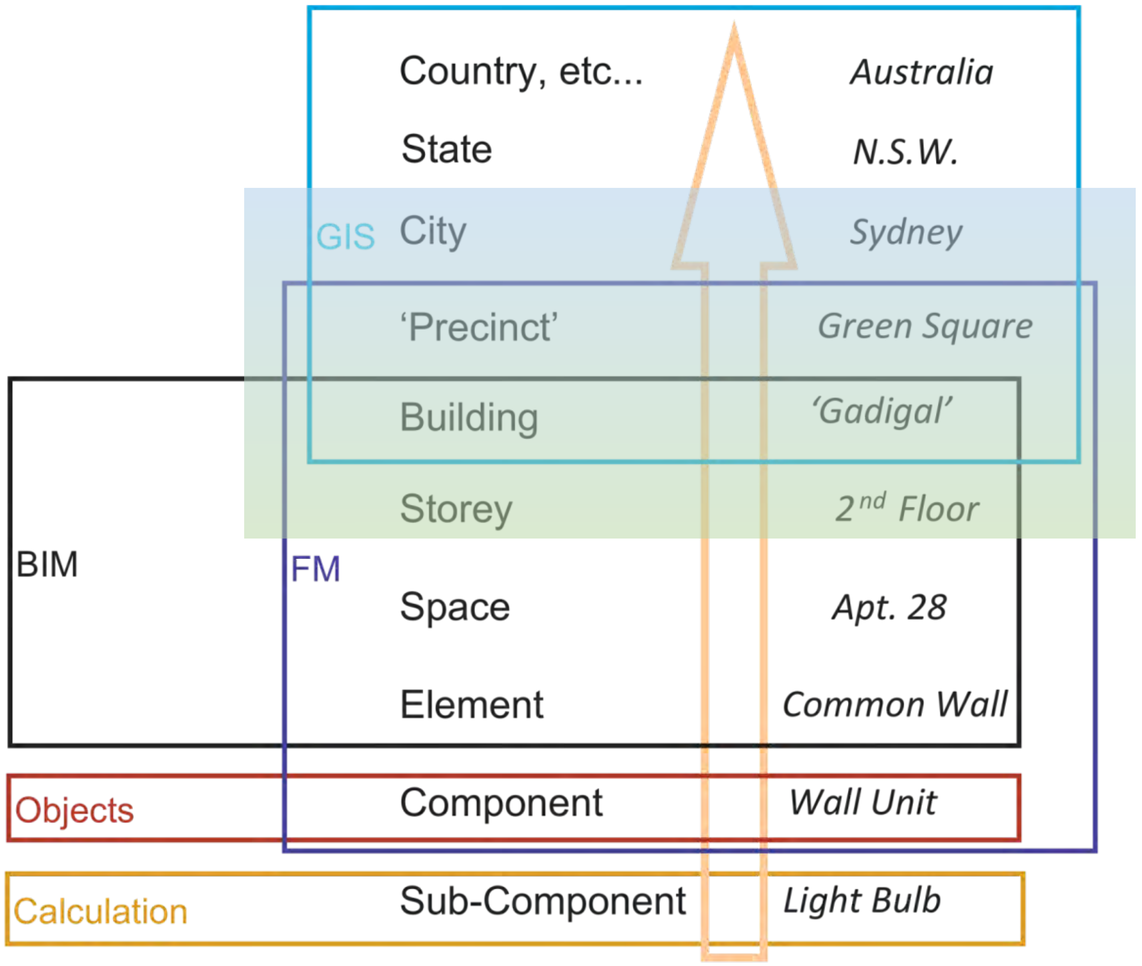
cadastre & terrain (the link between GIS & buildings)

utilities & services

infrastructure - roads bridges, tunnels etc

statistical & social geo-located data

PIM – the Scale of Things



Precinct

Source: UrbanIT, after Andreas Kohlhaas

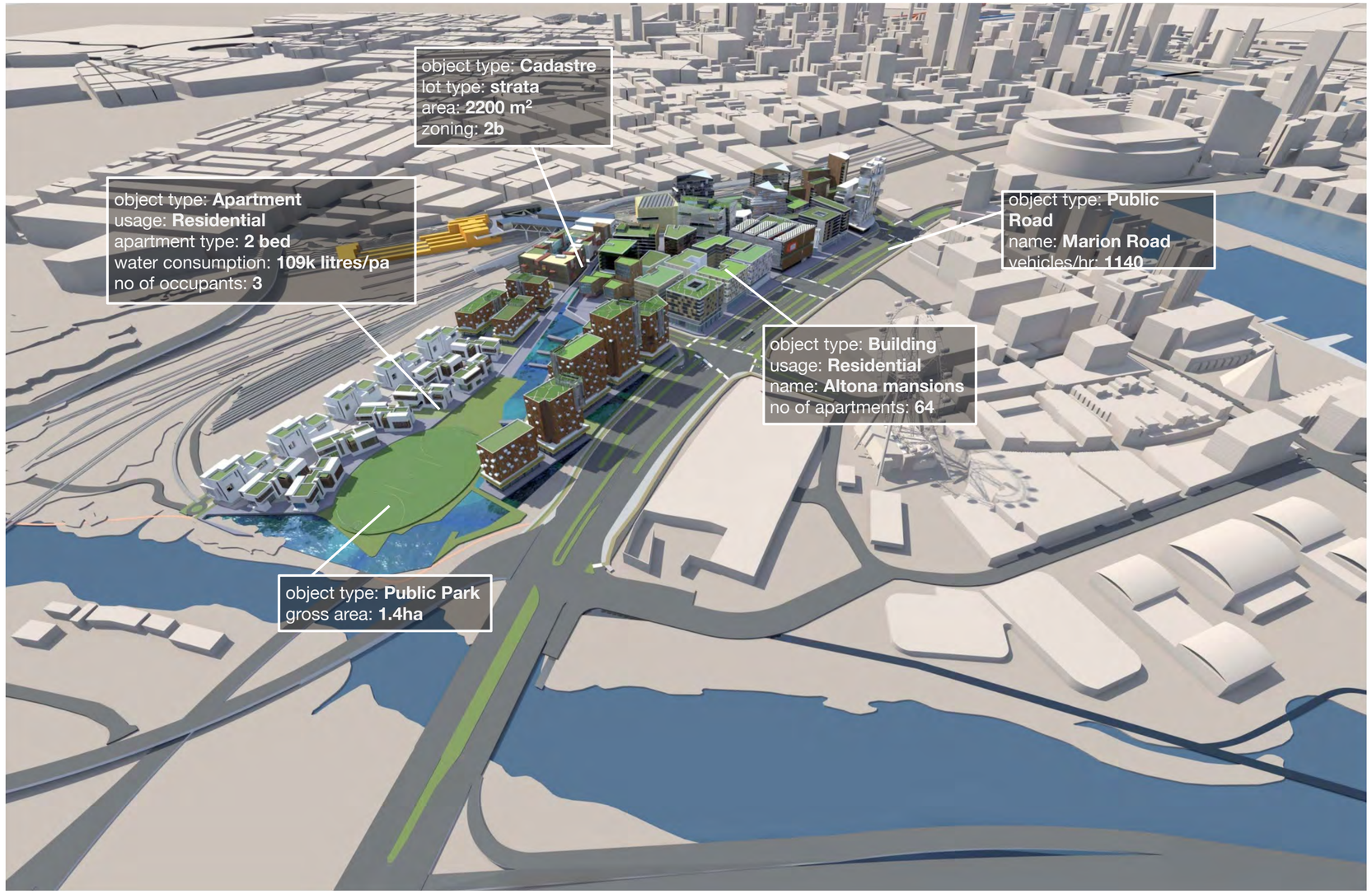
Precinct Information Modelling

interoperability & integrity

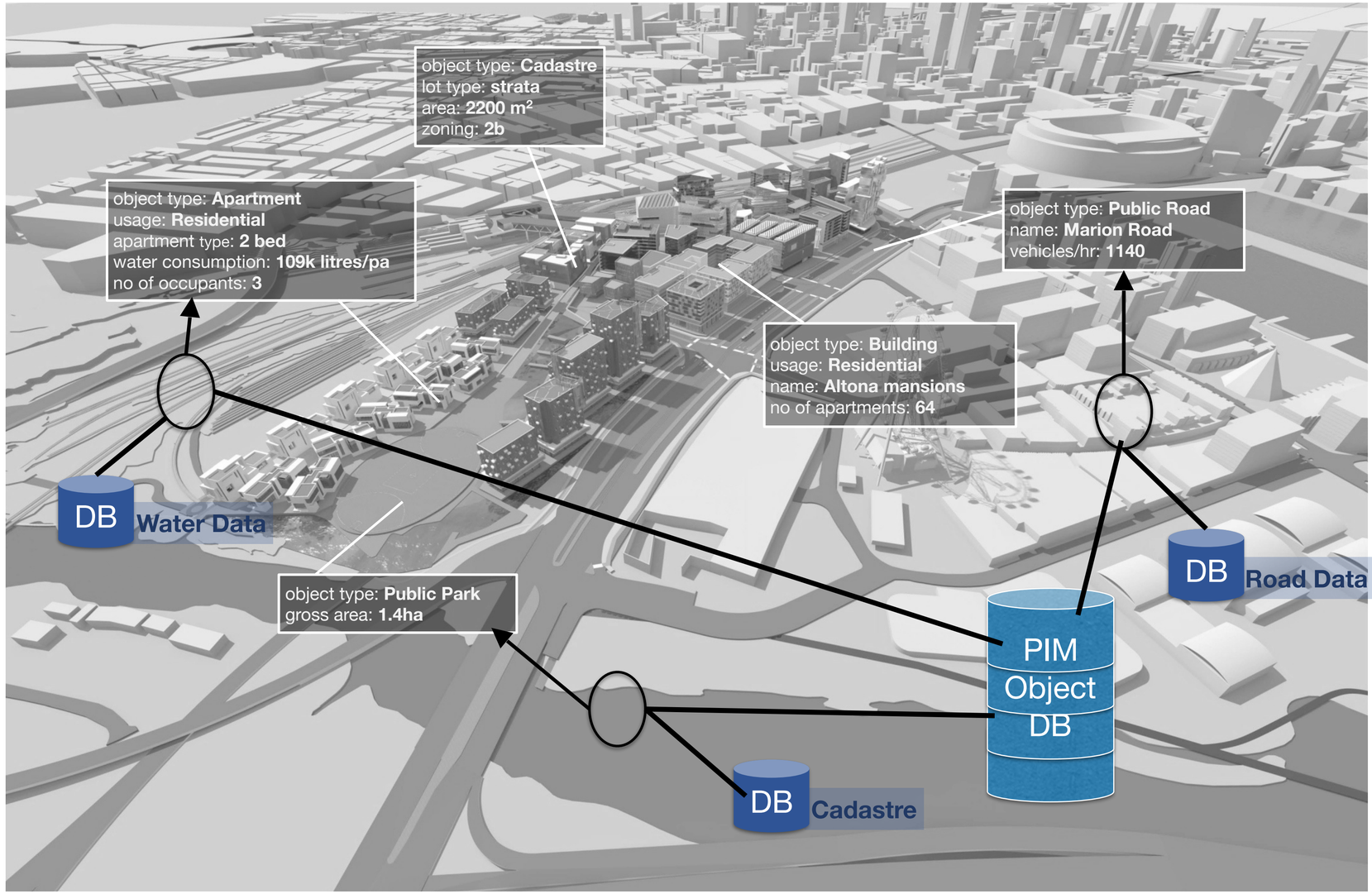
A Precinct Information Model (PIM) is a **comprehensive 3D digital database model** of a Precinct that contains all the Information needed to support planning, design, development, construction, management, operation, use and retro-fitting of urban precincts.

From our perspective as a CRC, the focus is directed towards **minimisation of carbon throughout the precinct life cycle**, supported by a PIM. In a broader context, a PIM could be used for a whole range of other purposes.

Precinct Information Modelling

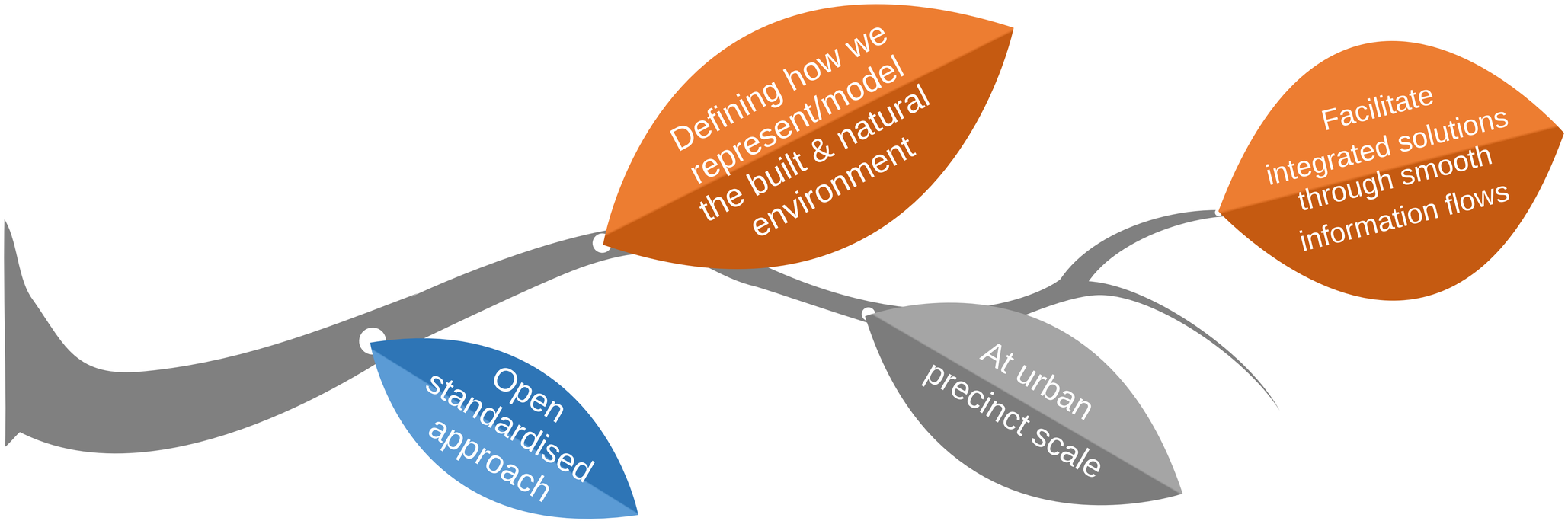


Precinct Information Modelling



PIM Vision for Low Carbon Management

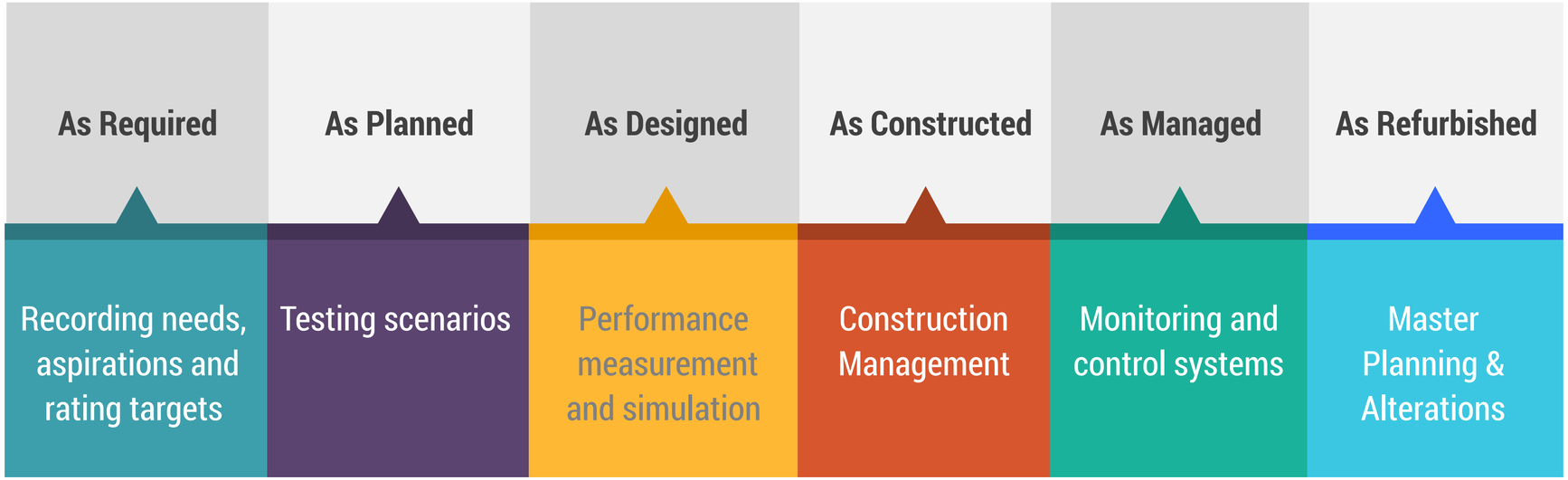
PIM Vision for Low Carbon Management



PIM for Low Carbon Management

Lifecycle Approach

PIM provides a definitive repository of information at all stages in PRECINCT design & management based on open standards



Precinct Model Scope

A precinct is made up of sites that contain one or more built facilities

***Sites* are linked to legal ownership through the cadastre: Need for a 3D cadastre**

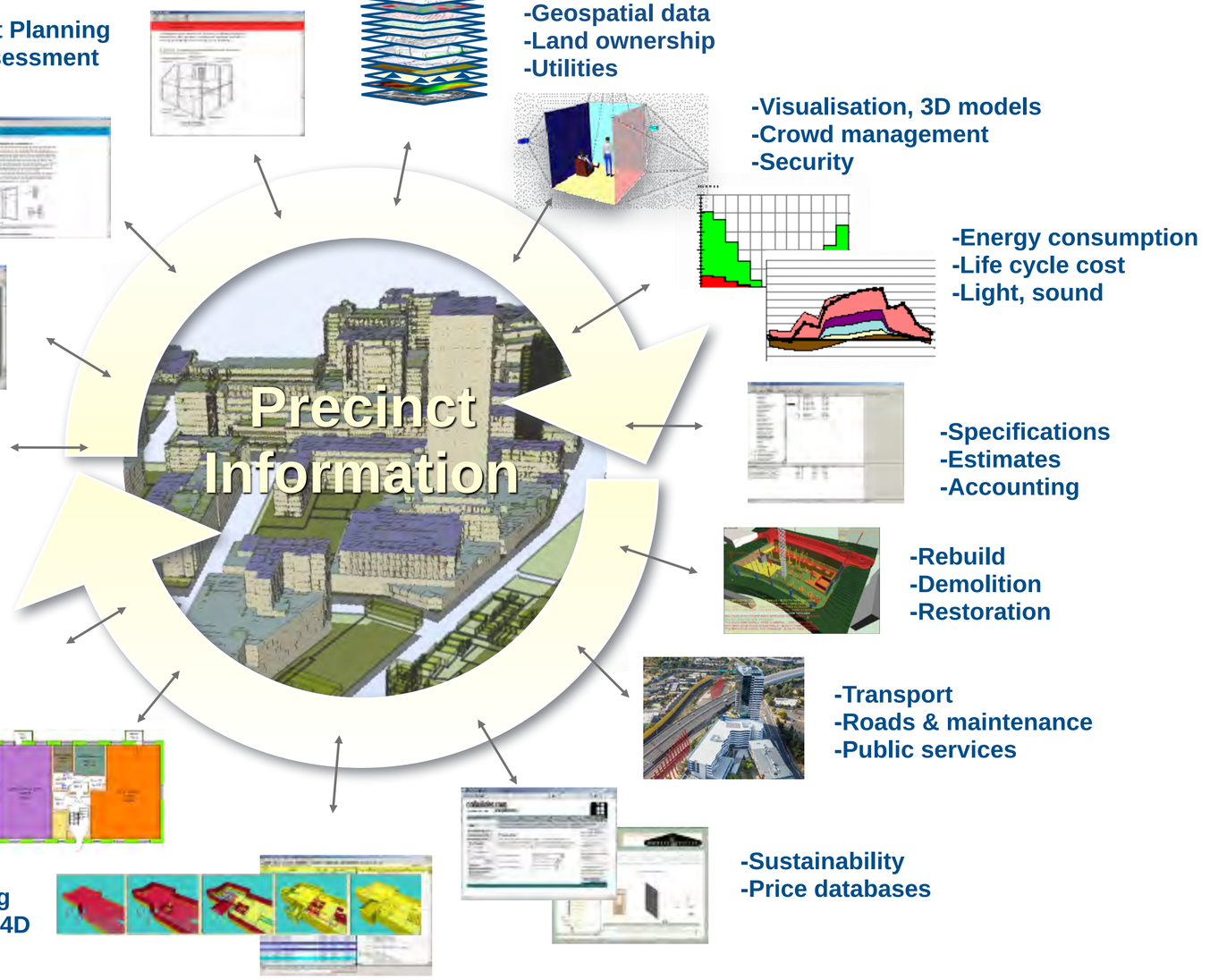
Built facilities include a range of entities:

- ***Buildings***
- ***Civil infrastructure* (roads, railway, bridges, tunnels, etc.)**
- ***Utility infrastructure* (energy, water, waste, network, etc.)**
- ***Open space* (paved, parkland, water features, etc.)**
- ***Structures* (street furniture, shelters, public art, etc.)**

Precincts exist within an urban context:

- ***Administrative zones* (local government, census, demographic, etc.)**
- ***Services* (transport, entertainment, education, health, etc.)**
- ***Ecological* (flora & fauna, protected habitats, fragile communities, etc.)**

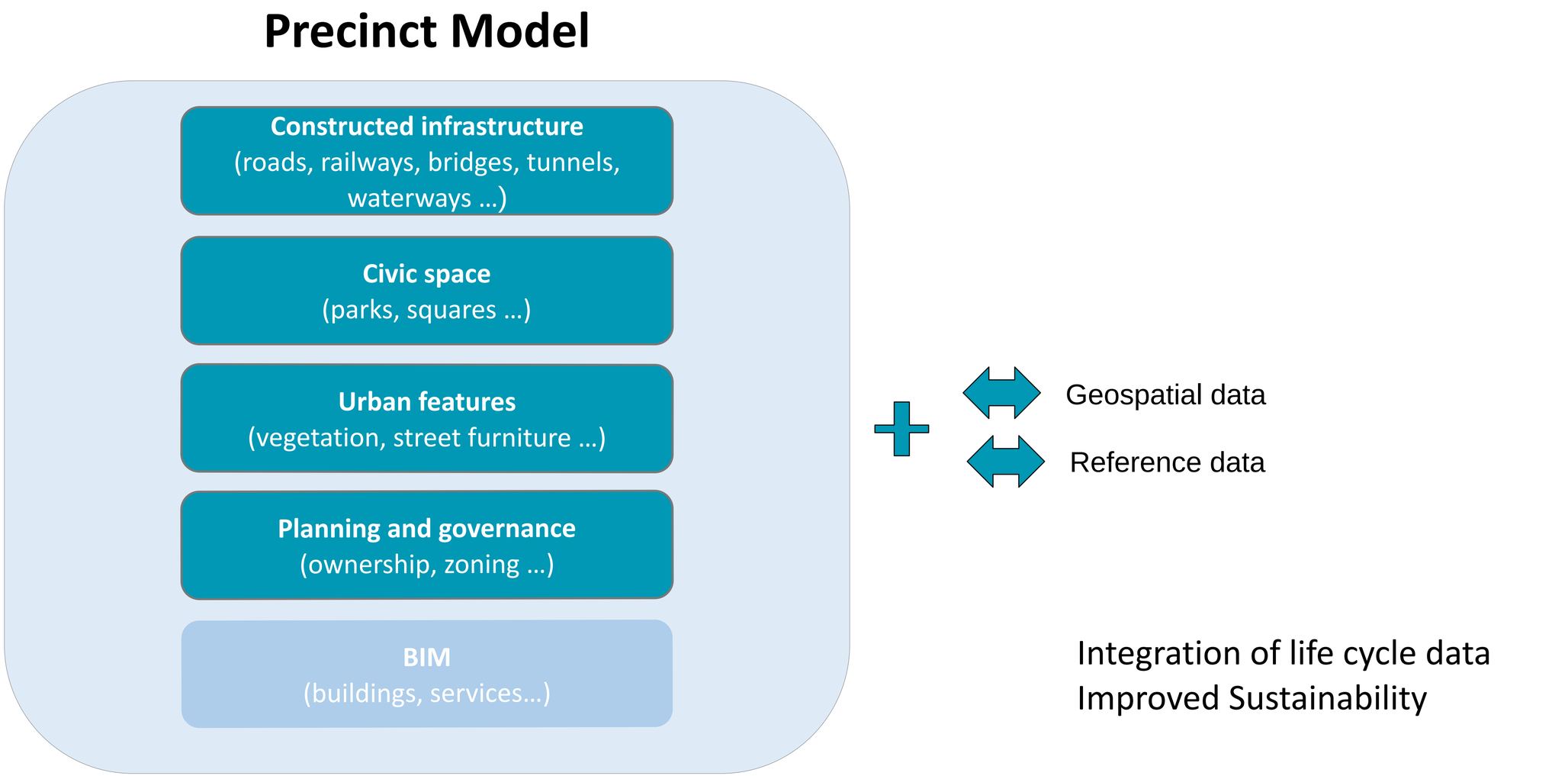
Precinct lifecycle



PIM project objectives

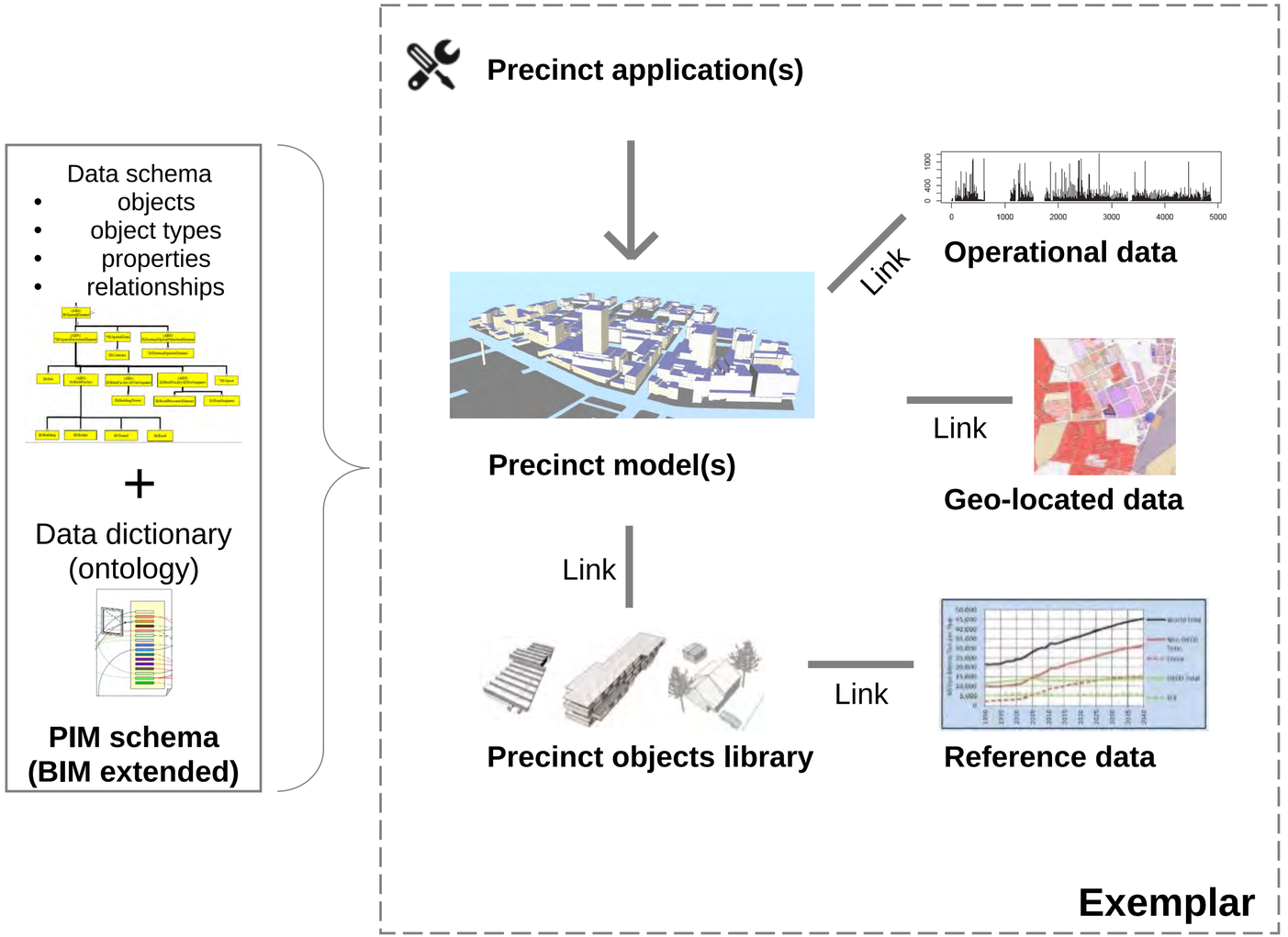
- Develop a shared way of digitally describing a real-world precinct (throughout its entire life cycle)
  - extend the current IFC standard for building information modelling (BIM) beyond building-level
  - detail to address precinct-level objects such as infrastructure, civic spaces, vegetation etc
  - correlate with corresponding geographic information system entities (eg as defined by CityGML)
  - this is a bottom-up approach for precinct information modelling
  - the result is the formal definition of a precinct information modelling data schema (PIM)
- Prototype implementations using PIM schema for other CRC-LCL research projects' precinct data

PIM – Extension to IFC standard



Integration of life cycle data
Improved Sustainability

Precinct Model Components & Structure



The Challenge before the Built Environment Sector

- Collaborative adoption of BIM & GIS technologies
- Requirements for urban level sustainable modelling
  - an integrated built environment object framework supported by government and industry
  - availability of rich product data, which must include LCI - embodied and operational carbon
  - access to national digital data sources of all types
  - improved metrics for performance measurements and benchmarks

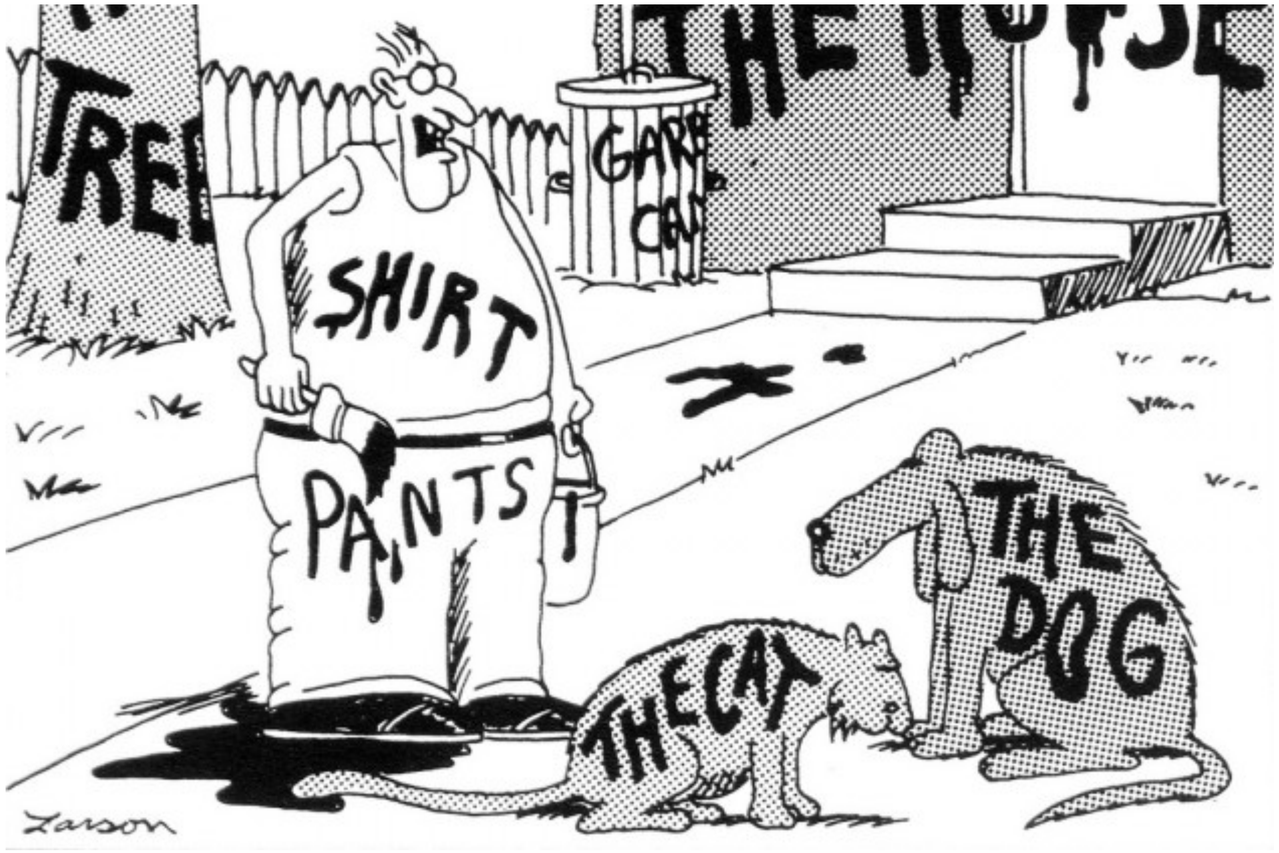
Thank you and Questions

Modelling a precinct

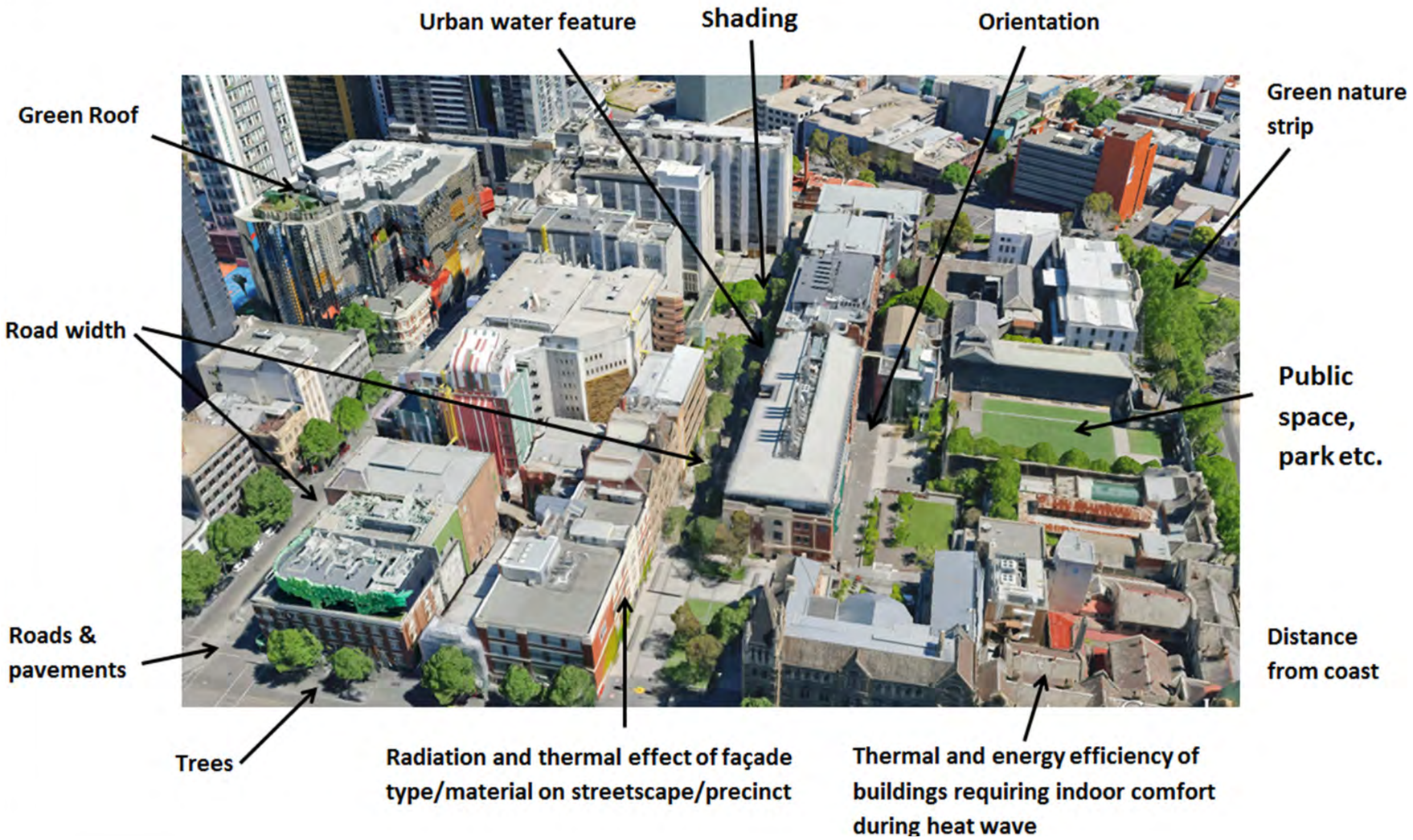
Team members: Jim Plume, **David Marchant**, John Mitchell

A data schema

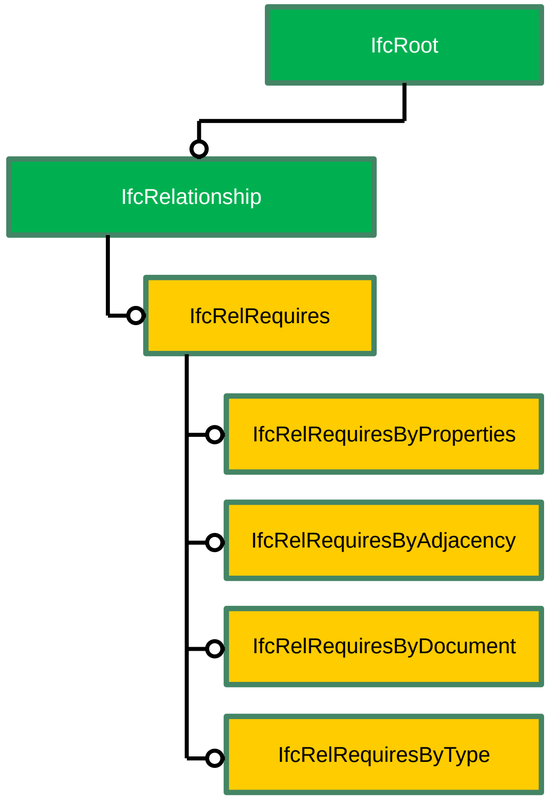
Objects / properties / relationships



Some urban precinct objects and properties



Requirements



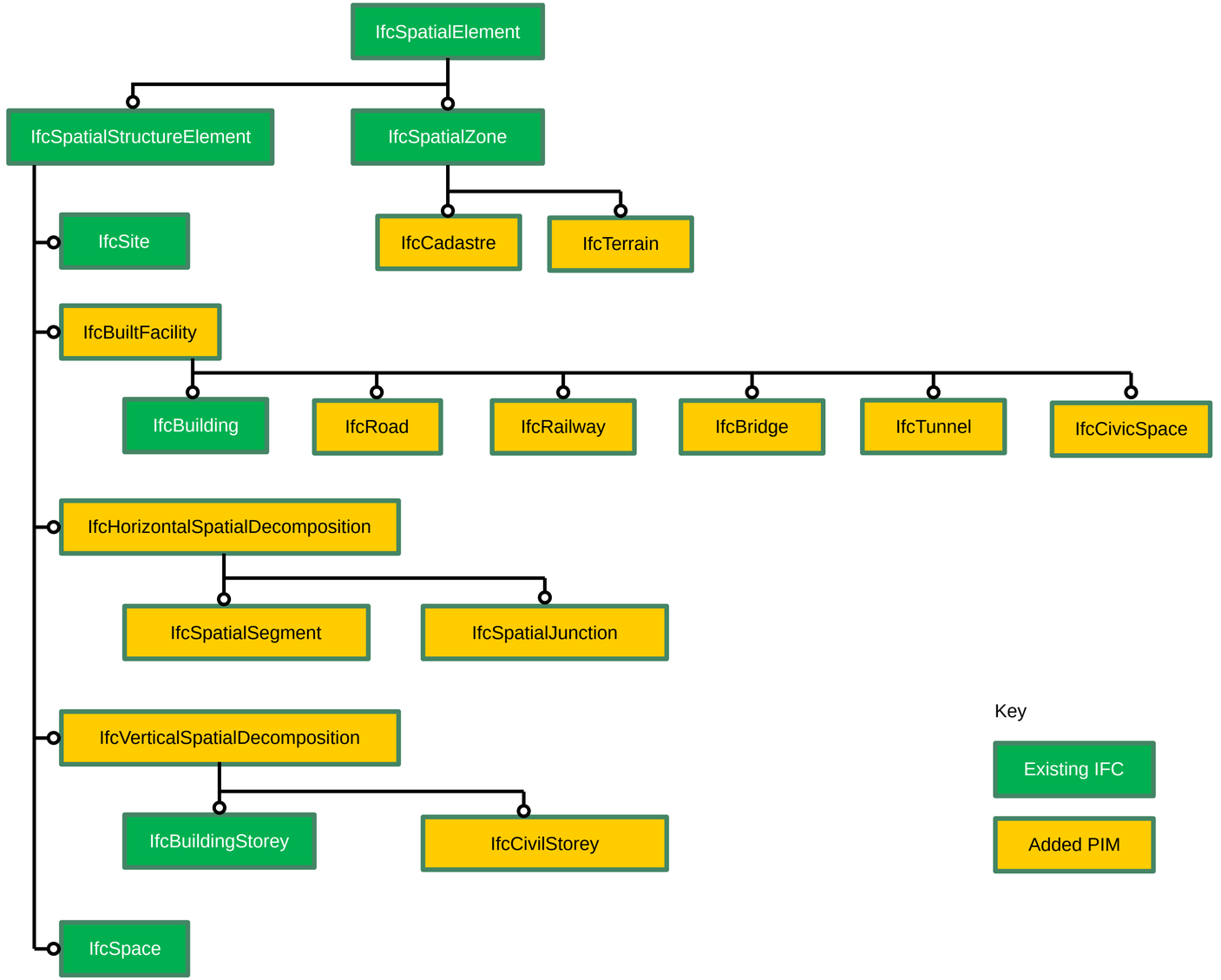
Key

Existing IFC

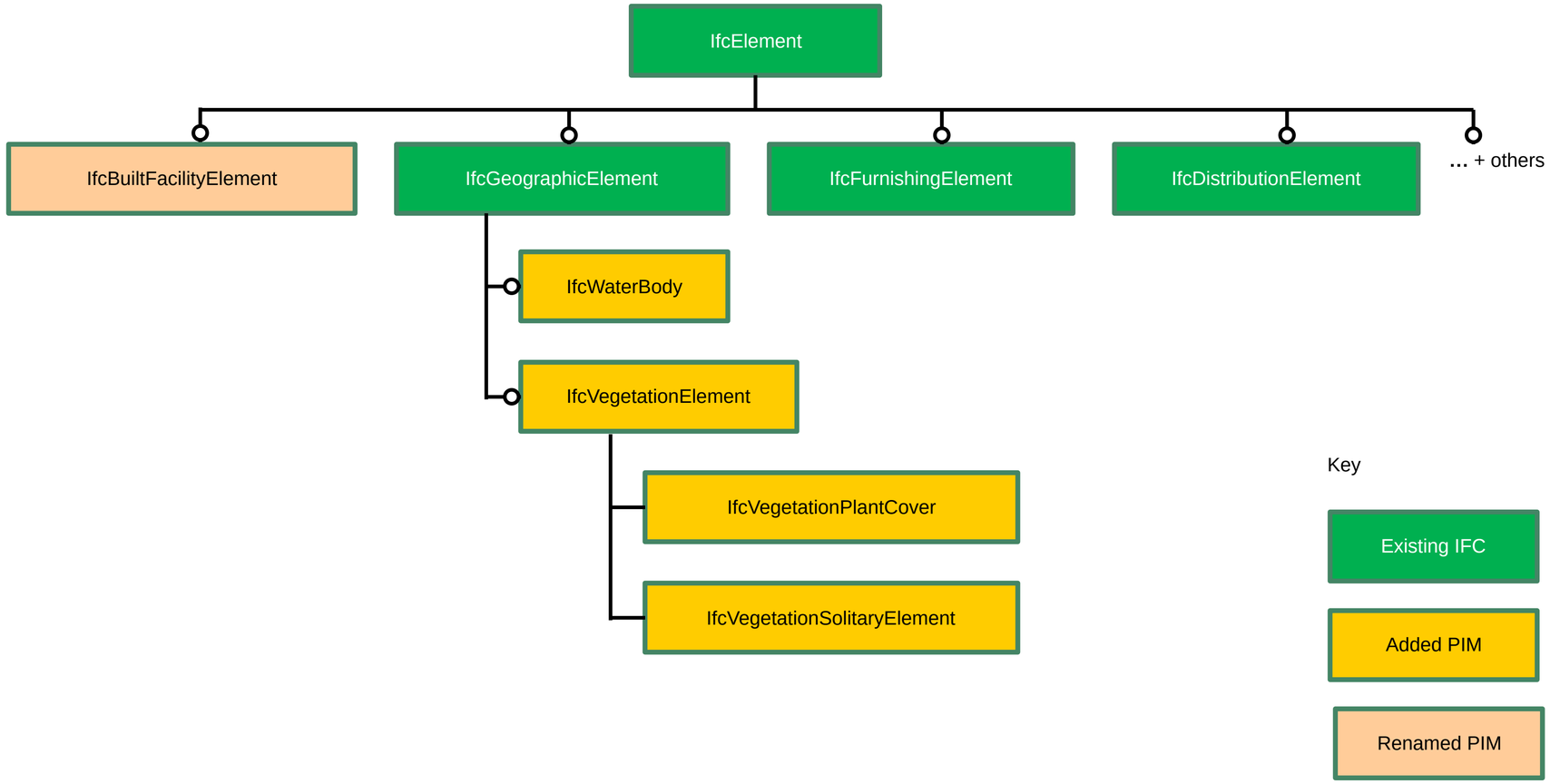
Added PIM

Renamed PIM

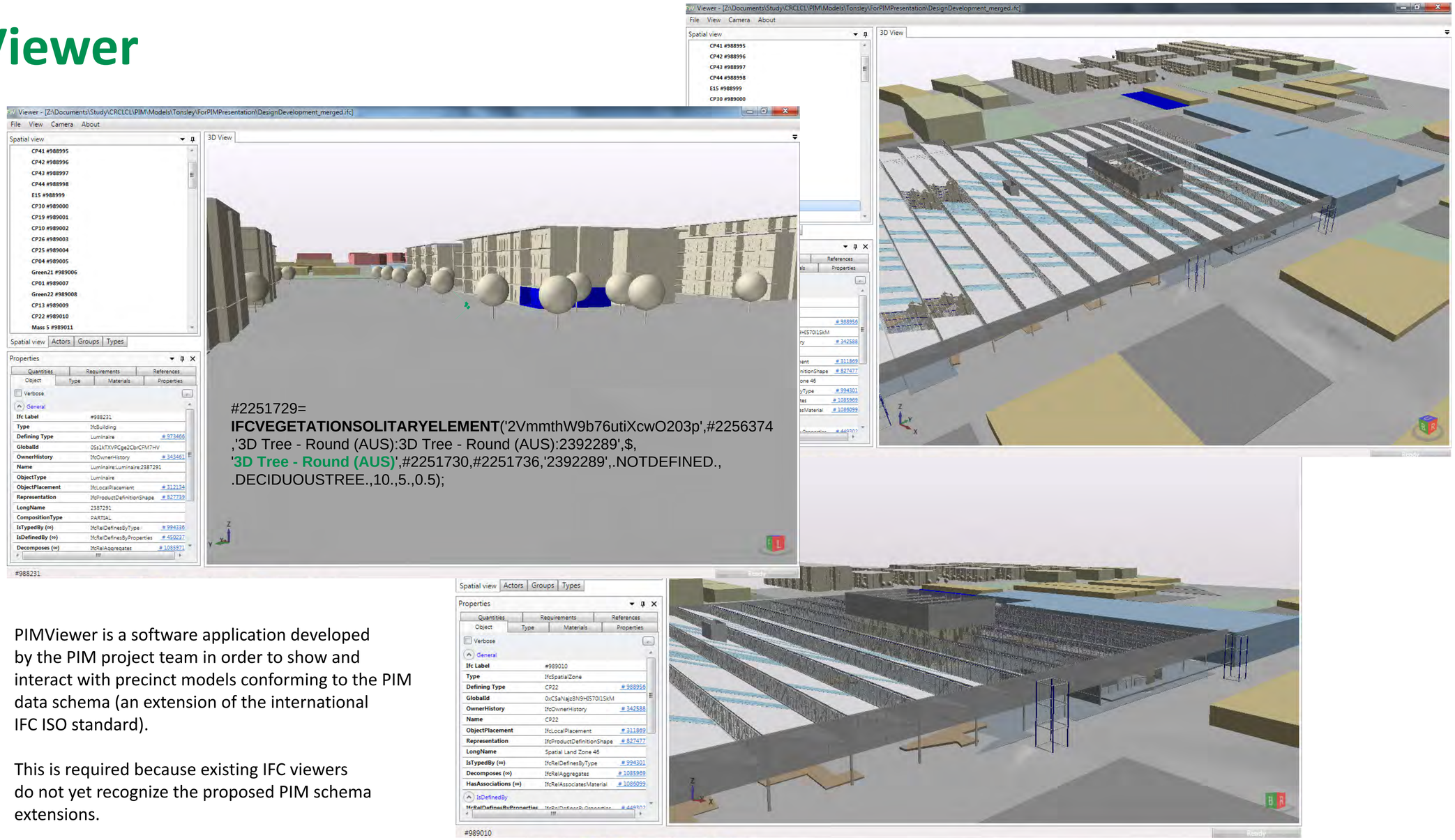
Spatial entities



Physical entities



PIMViewer



PIMViewer is a software application developed by the PIM project team in order to show and interact with precinct models conforming to the PIM data schema (an extension of the international IFC ISO standard).

This is required because existing IFC viewers do not yet recognize the proposed PIM schema extensions.

Modelling Tonsley

Existing context – precinct as a “**site**” or a “**zone**”

#5247= **IFCSITE**('2SfiKR4i17FA9K__FP5vDR',#41,'**Tonsley site**',
$,'',#5246,$,$,.ELEMENT.,
(-34,-55,-43,-29784),
(138,35,59,857176),48074.0000000001,$,#114);

Zonal decomposition

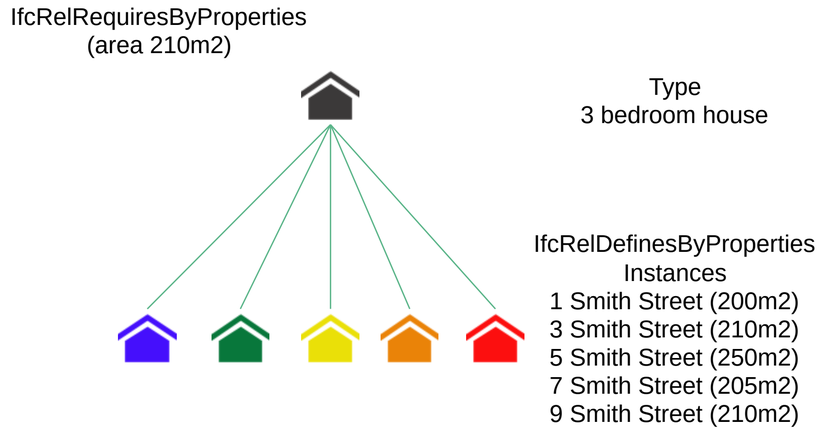
#5247= **IFCSITE**('2SfiKR4i17FA9K__FP5vDR',#41,'**Tonsley site**',
$,'',#5246,$,$,.ELEMENT.,(-34,-55,-43,-29784),(138,35,59,857176),
48074.0000000001,$,#114);

#5267= **IFCRELAGGREGATES**('0dgj_S4hrBmh20mkVIlPkX',#41,$,
$,#5247,(#715,etc));

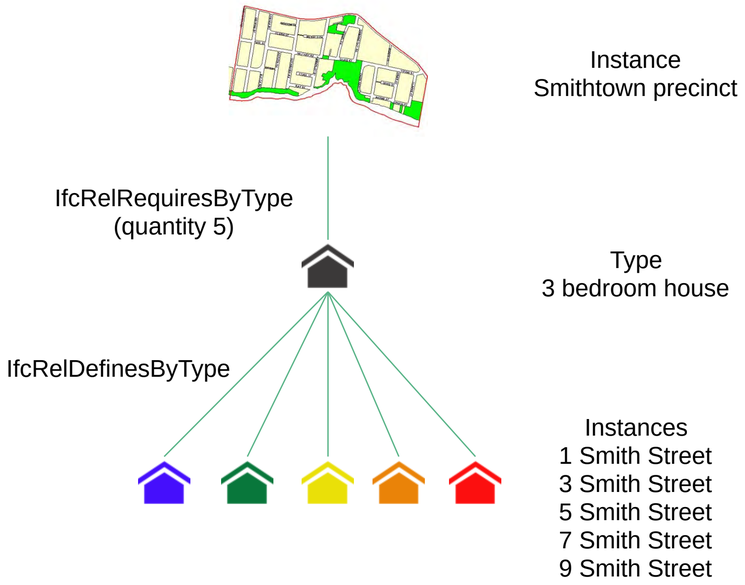
#715= **IFCSPATIALZONE**('1r$uNKeKfEuOdOOlimhZi$',#41,'**Area 9**','',
$,#687,#713,'Area 9',.OCCUPANCY.);

Briefing

- by properties



- by quantity of type



Energy, transport, water, waste - Mosaic resident types

Precinct Name: Tonsley

						2	3	5	6	7	6	9	3		10
					Residential Land Uses										
Development Areas				Residential Code Inputs	Calculated/Lookups								862	1923	
LUTYPE	Built Footprint Area	Building Floors	Gross Floor Area	Residential Type Ref	Mosaic Resident Type	Adults	Residents	Workers	Bedrooms	Bathrooms	PlotSize (m2)	Vehicles	Residences	Population	BinFill Factor
RES	3,051	4	12,204	2	C14	1.24	1.97	0.86	2.09	1.28	145.00	1.19	51	101	0.40
RES	2,307	6	13,843	3	I35	1.53	2.69	0.92	2.15	1.06	130.00	1.08	70	189	0.50
RES	1,567	6	9,401	3	K38	1.18	2.06	0.35	2.35	1.43	130.00	1.34	48	98	0.50
RES	7,578	4	30,312	2	C10	1.42	2.11	1.28	2.25	1.43	145.00	1.23	128	269	0.50
RES	3,397	3	10,192	1	C13	1.27	2.24	1.14	2.17	1.22	151.00	1.36	41	92	0.50
RES	7,075	3	21,226	1	H30	1.53	2.46	1.37	2.85	1.32	151.00	1.43	86	211	0.50
RES	4,527	4	18,106	2	C11	1.88	2.21	1.69	2.73	1.31	145.00	1.20	76	169	0.50
RES	2,498	3	7,494	1	C12	1.17	1.86	1.06	1.76	1.24	151.00	0.96	30	56	0.40
RES	2,916	3	8,749	1	C11	1.88	2.21	1.69	2.73	1.31	151.00	1.20	35	78	0.50
RES	6,946	3	20,837	1	C14	1.24	1.97	0.86	2.09	1.28	151.00	1.19	84	166	0.40
RES	4,523	4	18,093	2	C10	1.42	2.11	1.28	2.25	1.43	145.00	1.23	76	160	0.50
RES	6,193	4	24,772	2	H30	1.53	2.46	1.37	2.85	1.32	145.00	1.43	104	256	0.50
RES	2,604	3	7,813	1	I34	1.45	2.43	0.87	2.11	1.24	151.00	1.06	32	77	0.50

#621= **IFCACTORTYPE**('1IRxSku5X8SOEPYYhtE2W2',#42,'**C11**','**Inner City Aspirations (Lights View)**',$,(#634),$);
#625= IFCPROPERTYSINGLEVALUE('Adults',$,IFCREAL(1.88),$);
#626= IFCPROPERTYSINGLEVALUE('Residents',$,IFCREAL(2.21),$);
#627= IFCPROPERTYSINGLEVALUE('Workers',$,IFCREAL(1.69),$);
#628= IFCPROPERTYSINGLEVALUE('Bedrooms',$,IFCREAL(2.73),$);
#629= IFCPROPERTYSINGLEVALUE('Bathrooms',$,IFCREAL(1.31),$);
#630= IFCPROPERTYSINGLEVALUE('Vehicles',$,IFCREAL(1.2),$);
#631= IFCPROPERTYSINGLEVALUE('PlotSize',$,IFCREAL(151.),$);
#632= IFCPROPERTYSINGLEVALUE('BinFillFactor',$,IFCREAL(0.6),$);
#634= IFCPROPERTYSET('2b4Y6iVIHDNexohdkL2BWx',#42,'PIM_HouseholdType',$,(#625,#626,#627,#628,#629,#630,#631,#632));
#635= IFCRELDEFINESBYPROPERTIES('1IRxSku5X8SOEPYYhtG2W2',#42,$,$,(#621),#634);

Energy, transport, water, waste - residential types

#1000000= **IFCBUILDINGTYPE**('2c6X5iVIJENexohdkL2AWd',#41,'Res_2','**Luminaire**',$,(#1035000),$,$,$);
#1010000= IFCPROPERTYSINGLEVALUE('BuiltFootprintFactor',$,IFCRATIOMEASURE(0.7),$);
#1011000= IFCPROPERTYSINGLEVALUE('ResidenceFootprintArea (m2)',$,IFCAREAMEASURE(140.),$);
#1012000= IFCPROPERTYSINGLEVALUE('Floors',$,IFCINTEGER(1),$);
#1013000= IFCPROPERTYSINGLEVALUE('TotalResidenceFloorArea (m2)',$,IFCAREAMEASURE(145.),$);
#1014000= IFCPROPERTYSINGLEVALUE('Bedrooms',$,IFCINTEGER(2),$);
#1015000= IFCPROPERTYSINGLEVALUE('BedroomArea (m2)',$,IFCRATIOMEASURE(0.22),$);
#1016000= IFCPROPERTYSINGLEVALUE('LivingArea (m2)',$,IFCRATIOMEASURE(0.27),$);
#1017000= IFCPROPERTYSINGLEVALUE('KitchenArea (m2)',$,IFCRATIOMEASURE(0.12),$);
#1018000= IFCPROPERTYSINGLEVALUE('WetArea (m2)',$,IFCRATIOMEASURE(0.06),$);
#1019000= IFCPROPERTYSINGLEVALUE('GreenArea (m2)',$,IFCRATIOMEASURE(0.04),$);
#1020000= IFCPROPERTYSINGLEVALUE('CarparkArea (m2)',$,IFCRATIOMEASURE(0.17),$);
#1021000= IFCPROPERTYSINGLEVALUE('OtherArea (m2)',$,IFCRATIOMEASURE(0.12),$);
#1022000= IFCPROPERTYSINGLEVALUE('RainwaterStorageSize (kL)',$,IFCREAL(1.),$);
#1023000= IFCPROPERTYSINGLEVALUE('ElectricCookingNumber',$,IFCINTEGER(1),$);
#1024000= IFCPROPERTYSINGLEVALUE('ElectricAirConNumber',$,IFCINTEGER(1),$);
#1025000= IFCPROPERTYSINGLEVALUE('ElectricHotWaterNumber',$,IFCINTEGER(1),$);
#1026000= IFCPROPERTYSINGLEVALUE('ElectricWashingMachineNumber',$,IFCINTEGER(1),$);
#1027000= IFCPROPERTYSINGLEVALUE('ElectricClothesDryerNumber',$,IFCINTEGER(1),$);
#1028000= IFCPROPERTYSINGLEVALUE('ElectricRefrigeratorNumber',$,IFCINTEGER(1),$);
#1029000= IFCPROPERTYSINGLEVALUE('PVPanelsPerResidence',$,IFCINTEGER(4),$);
#1030000= IFCPROPERTYSINGLEVALUE('GasCookingNumber',$,IFCINTEGER(0),$);
#1031000= IFCPROPERTYSINGLEVALUE('GasHeatingNumber',$,IFCINTEGER(0),$);
#1032000= IFCPROPERTYSINGLEVALUE('GasHotWaterNumber',$,IFCINTEGER(0),$);
#1033000= IFCPROPERTYSINGLEVALUE('WaterShowerNumber',$,IFCINTEGER(1),$);
#1034000= IFCPROPERTYSINGLEVALUE('WaterToiletNumber',$,IFCINTEGER(1),$);
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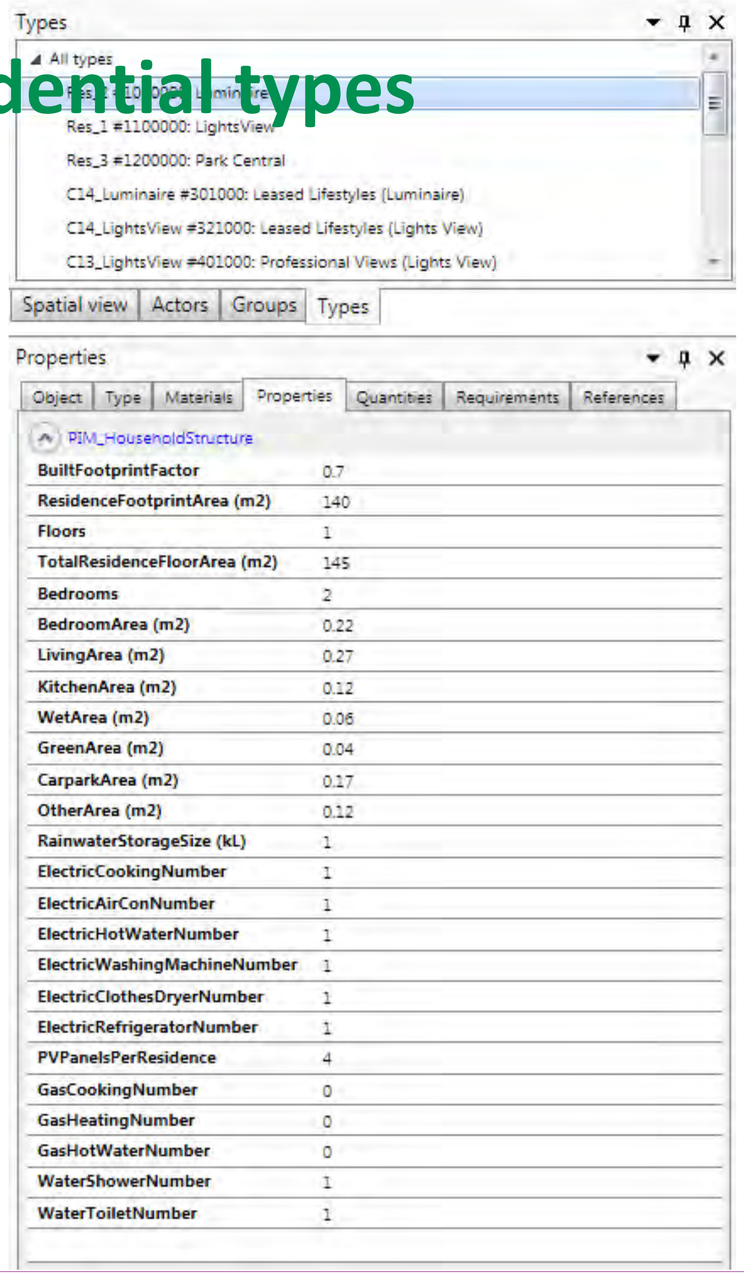
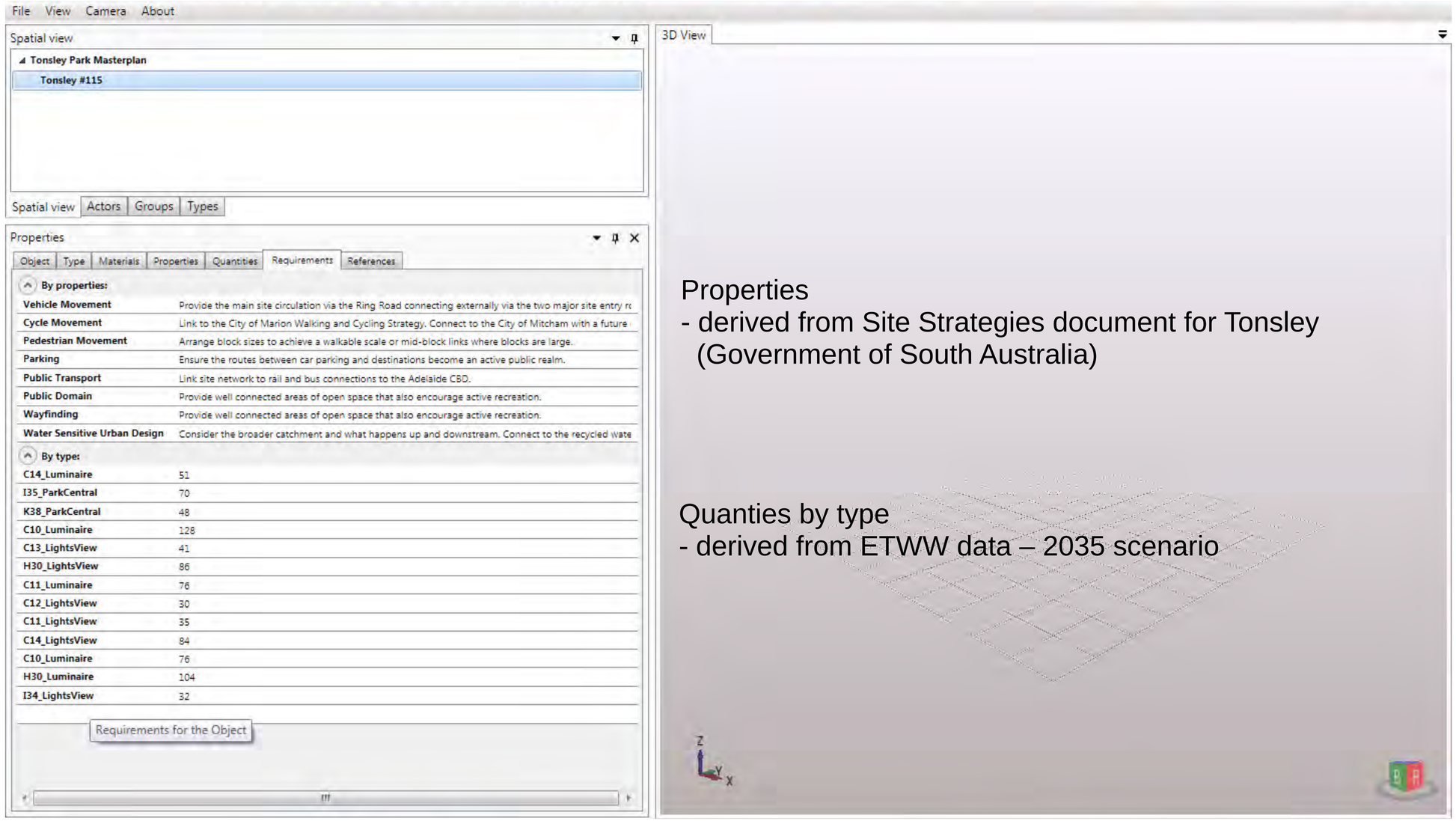


Energy, transport, water, waste - briefing



Properties
- derived from Site Strategies document for Tonsley (Government of South Australia)

Quanties by type
- derived from ETWW data – 2035 scenario

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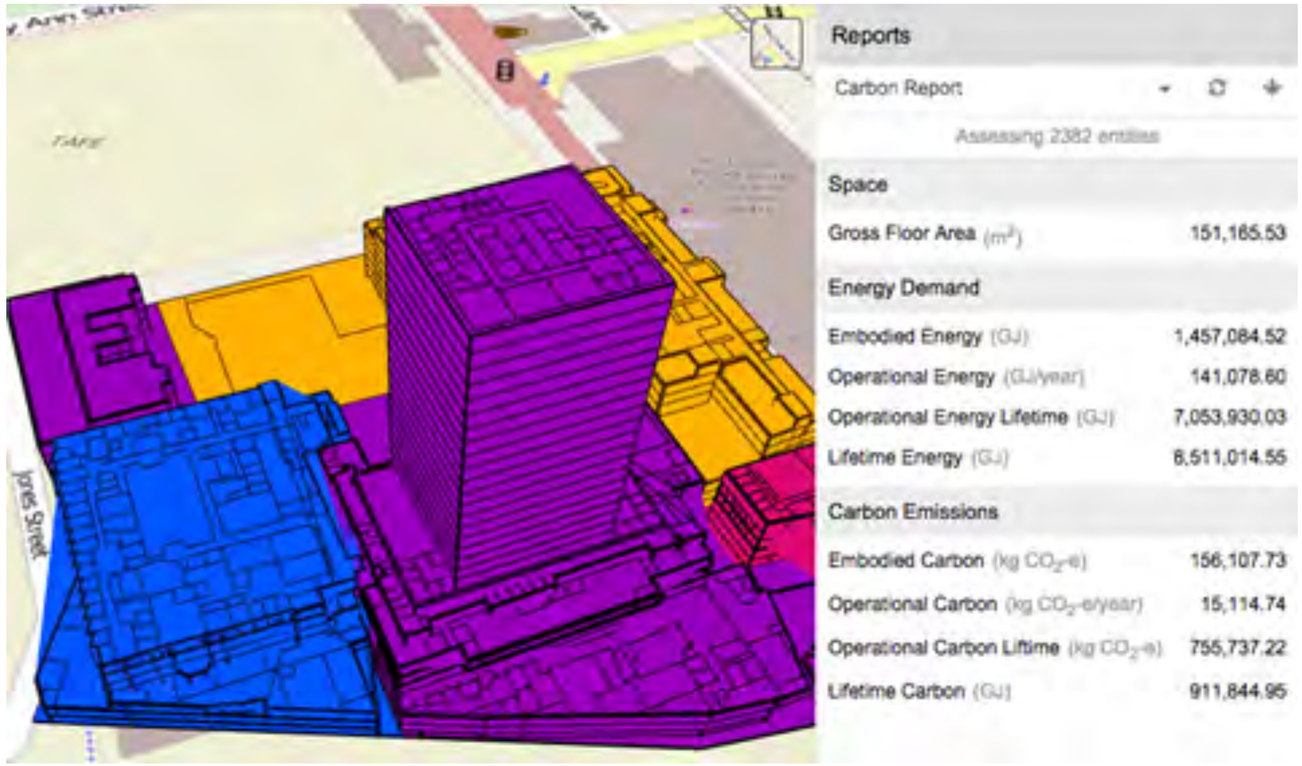
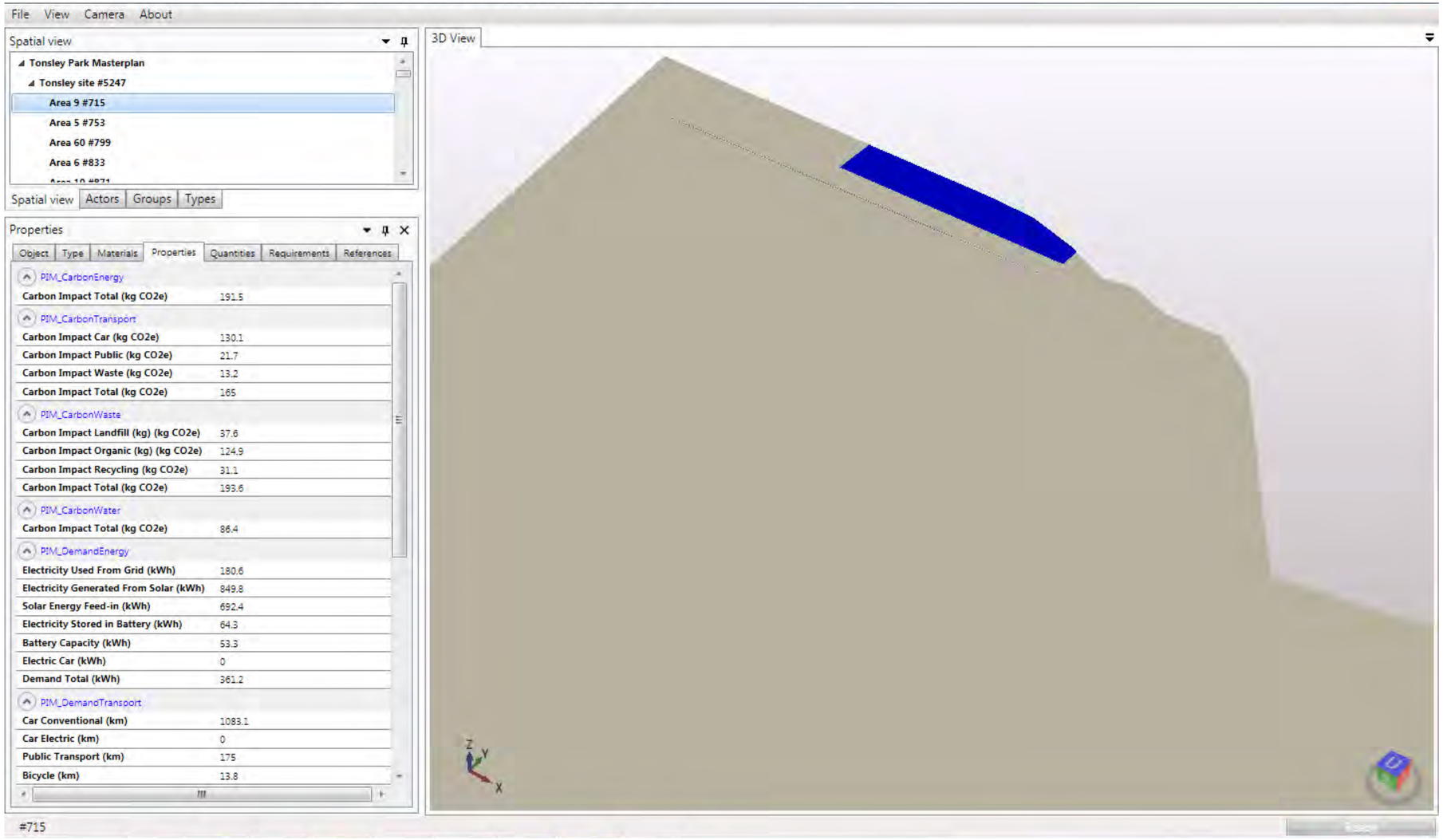
Carbon

Carbon metrics are “measures” so can be stored as a property of an object

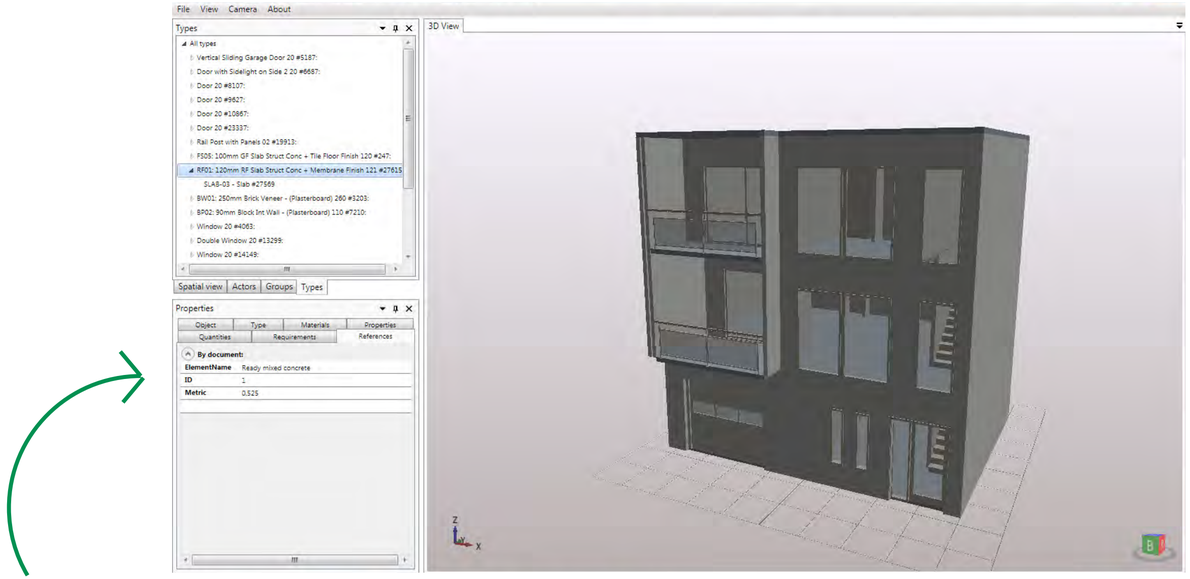
- availability / referencing of base data
- object scale / level of detail applicability



Energy, transport, water, waste – carbon by zone



Integrated carbon metrics – carbon by reference



#27615=IFCSLABTYPE('1BG91Aqglx7bIKPwTeP7e5',#12,'RF01: 120mm RF Slab Struct Conc + Membrane Finish 121',$,$,$,$,'4B40904A-D2AB-FB1E-5494-67A768647A05',$,.FLOOR.);
#27616=IFCRELDEFINESBYTYPE('36BcJm$$UuXt3RQ63i4hrD',#12,$,$,(#27569),#27615);
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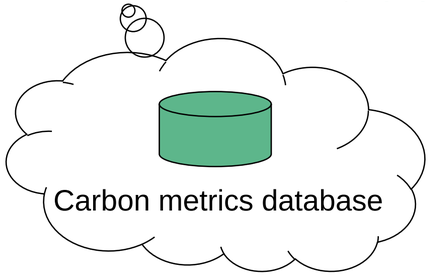
#30001= **IFCDOCUMENTREFERENCE**('**http://portfolio.woodsbagot.com/SpaceApp/Service1.svc/GetCarbonMetric/**','1','ICM',$,$);



A PIM object can reference the prototype carbon metrics database created by the PIM team,
and made available through a custom web service interface.

The appropriate data value is returned and displayed as shown in the following slide.

Integrated carbon metrics – calculations

Precinct model
(multi-scale)

Zonal object type
(quantity)

Built facility object type
(quantity)

Elemental object type
(quantity)

Precinct embodied carbon
=
sum of Object eCO2

ICM reference database

ICM GUID ↑ ↓ eCO2/$

Object eCO2
(quantity * $ factored cost * eCO2/$)

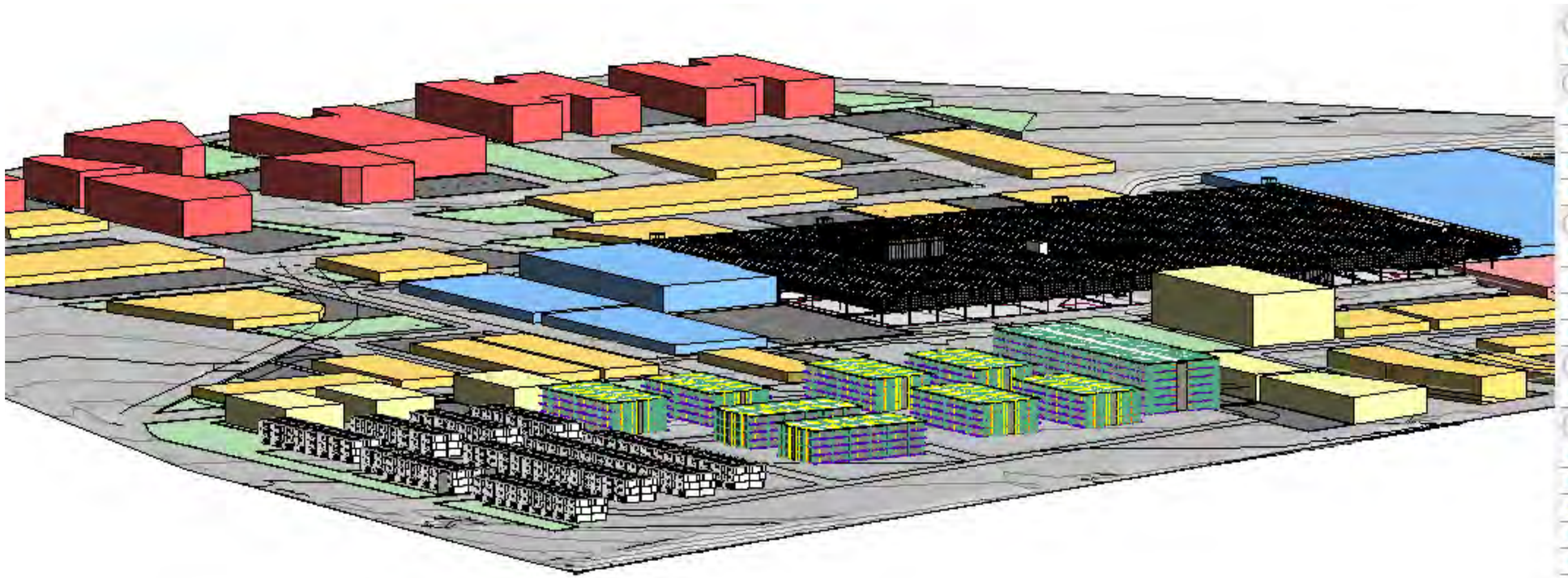
Cost GUID ↓ ↑ $/unit quantity
location factor

Costs reference database

Most carbon data is available at materials level, so need to first quantify at that level, then aggregate to larger scale entities.

Very little averaged entity-level data currently available.

The developed Tonsley Precinct model



PIM_CarbonEnergy	
Carbon Impact Total (kg CO2e)	191.5
PIM_CarbonTransport	
Carbon Impact Car (kg CO2e)	130.1
Carbon Impact Public (kg CO2e)	21.7
Carbon Impact Waste (kg CO2e)	13.2
Carbon Impact Total (kg CO2e)	165
PIM_CarbonWaste	
Carbon Impact Landfill (kg) (kg CO2e)	37.6
Carbon Impact Organic (kg) (kg CO2e)	124.9
Carbon Impact Recycling (kg CO2e)	31.1
Carbon Impact Total (kg CO2e)	193.6
PIM_CarbonWater	
Carbon Impact Total (kg CO2e)	86.4
PIM_DemandEnergy	
Electricity Used From Grid (kWh)	180.6
Electricity Generated From Solar (kWh)	849.8
Solar Energy Feed-in (kWh)	692.4
Electricity Stored in Battery (kWh)	64.3
Battery Capacity (kWh)	53.3
Electric Car (kWh)	0

Thank you and Questions

Precinct planning and assessment

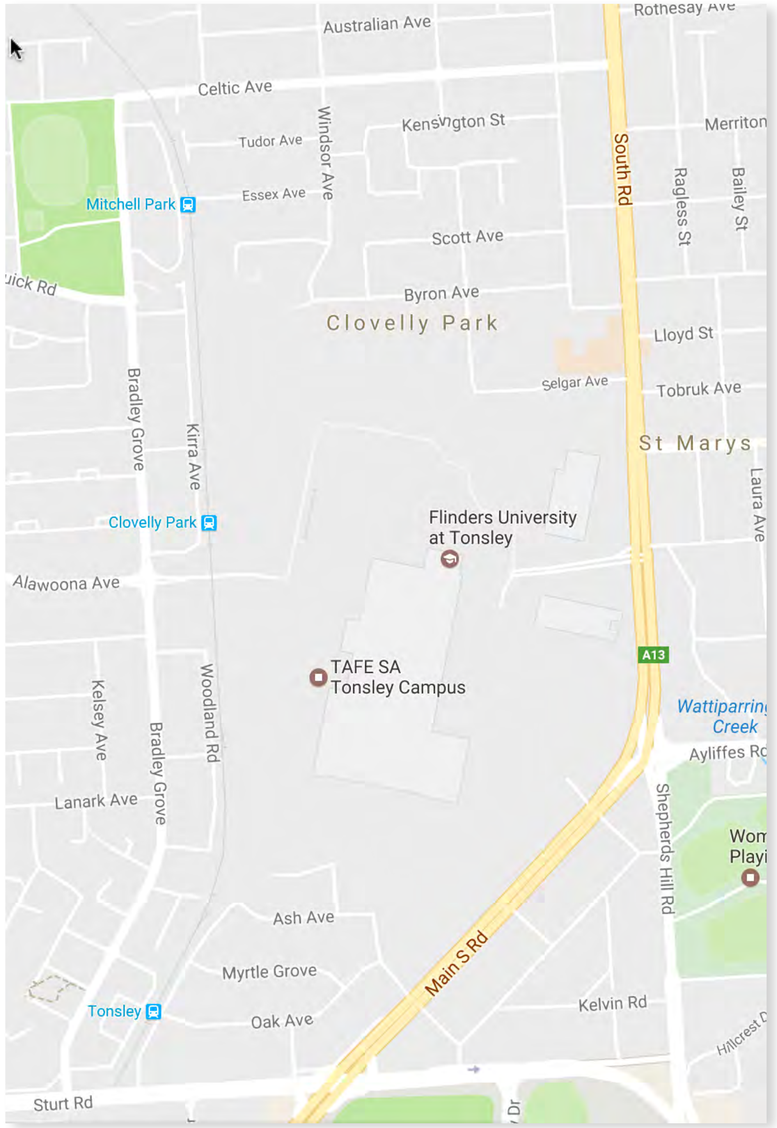
Team members: **Jim Plume**, **David Marchant**, **John Mitchell**

Developing a digital precinct model

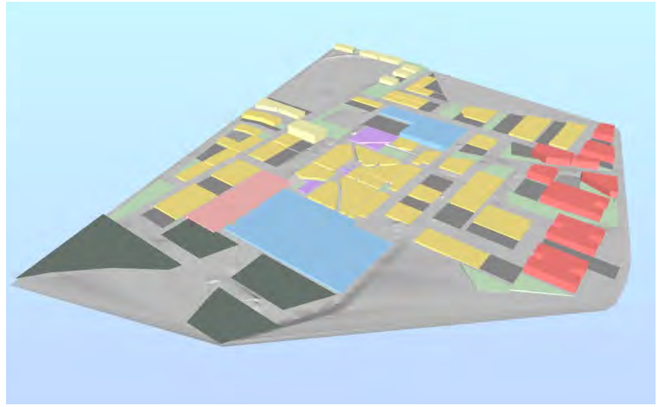
How is a PIM model initiated and developed over its life-cycle?

Issues to consider:

- precinct model typologies
- location and cadastre
- Council Planning systems
- associating C02e & related data

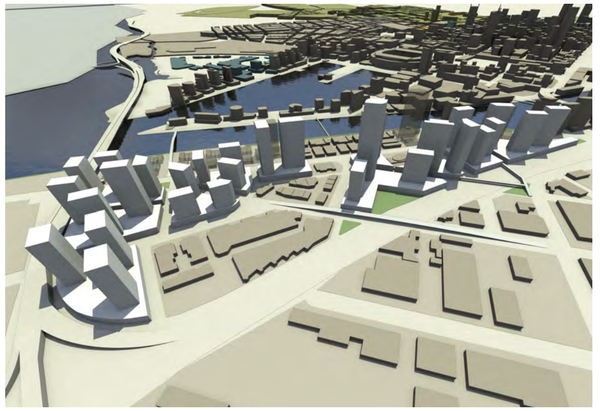


PIM Typologies



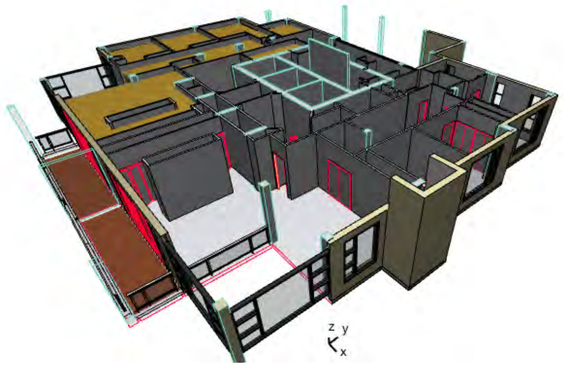
A precinct model at initial concept stage will designate geographic zones or simple volumes and spaces to represent the high level activities in the precinct. Each object has geometric properties (dimensions, volume, area), specified functional usage (residential, commercial, or other use types…

Functional



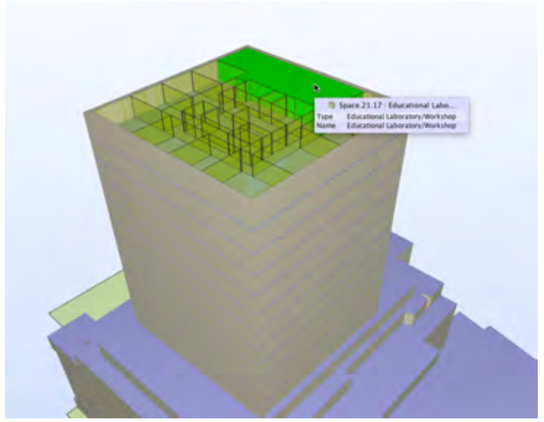
At this level of detail PIM, activities are modelled as 3D forms that are approximations of the scale of development required, and with more attention to the relationships between the objects. Infrastructure elements representing transport and open space are also shown.

Built Facility



At the most detailed level all infrastructure and buildings are authored in BIM tools, with all elements described accurately and with detailed properties of the chosen types or products

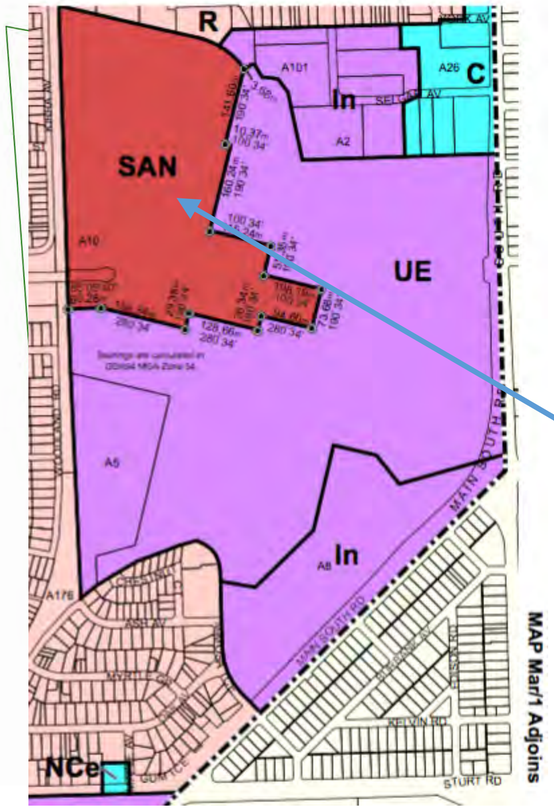
Elemental



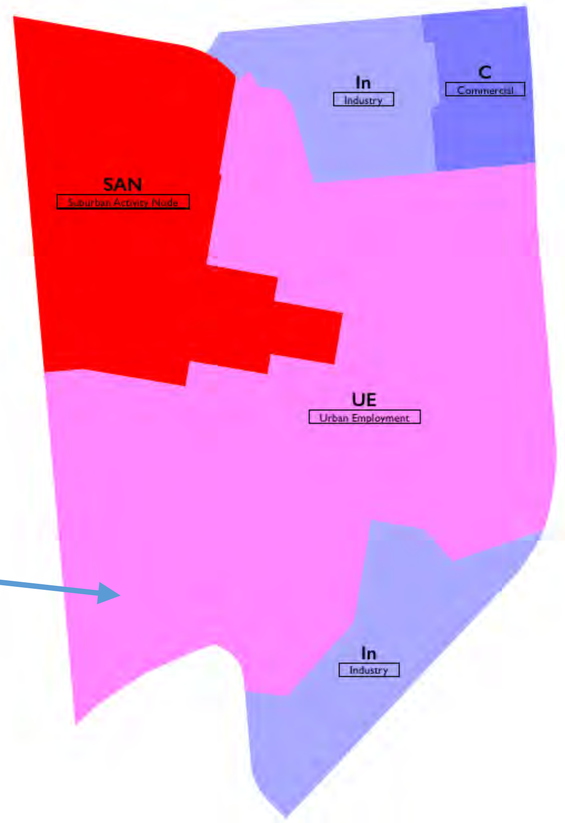
Occupancy focusses on the functions carried out in a precinct by its users. It can address the requirements as a basis for a design (a brief), or it can model the operations of the facility for example in terms of energy consumption or patterns of energy usage by occupancy type.

Occupancy

Tonsley Precinct - planning context



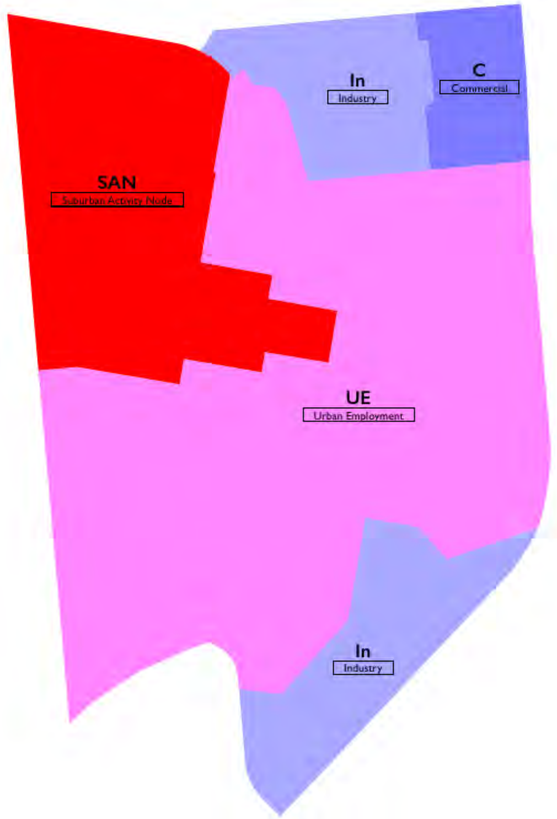
SAPZ Code	SAPZ Permitted Use
CP	Caravan and Tourist Park
C	Commercial
In	Industry
LCe	Local Centre
NCe	Neighbourhood Centre
OS	Open Space
R	Residential
SAN	Suburban Activity Node
UE	Urban Employment

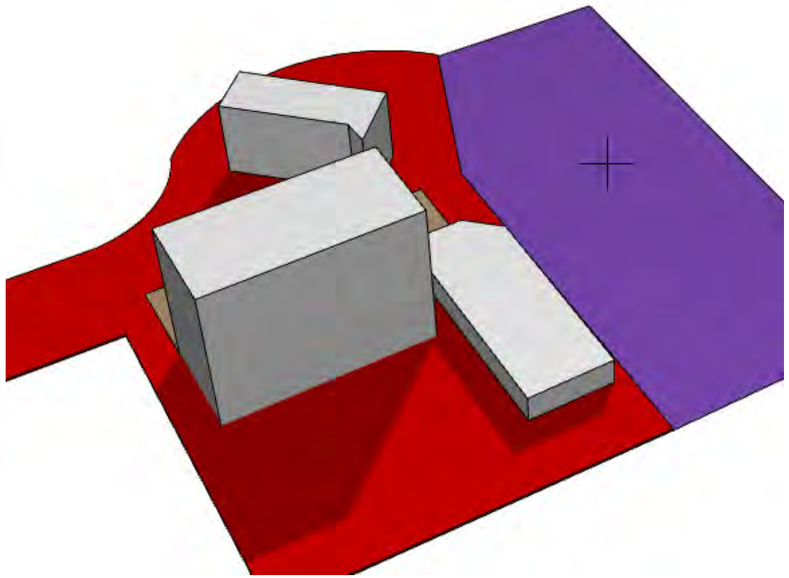


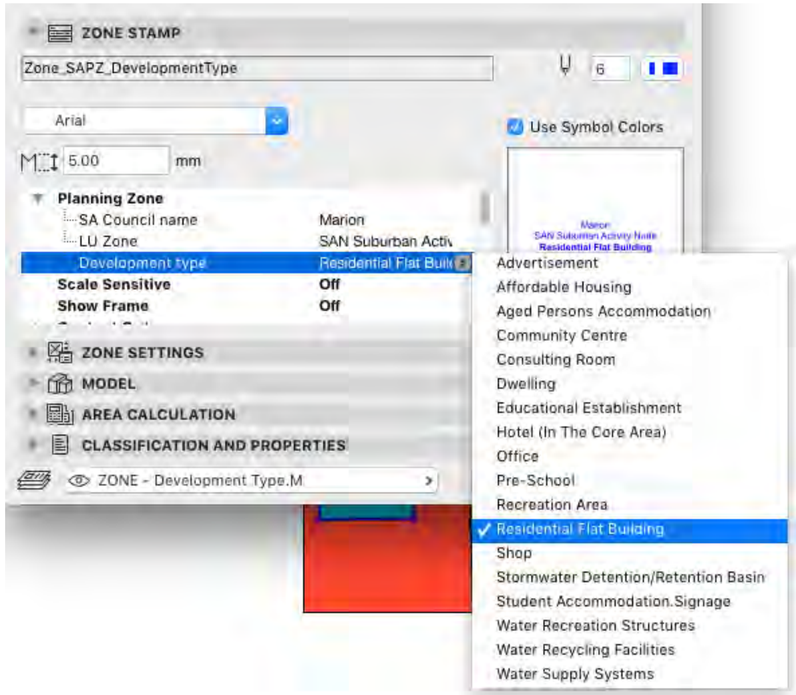
City of Marion planning zones

Planning Zones are modelled as *ifcSpatial Entities*, colour coded for *Permitted Use*, with boundaries taken from the State *cadastre*

Defining Permissible Developments





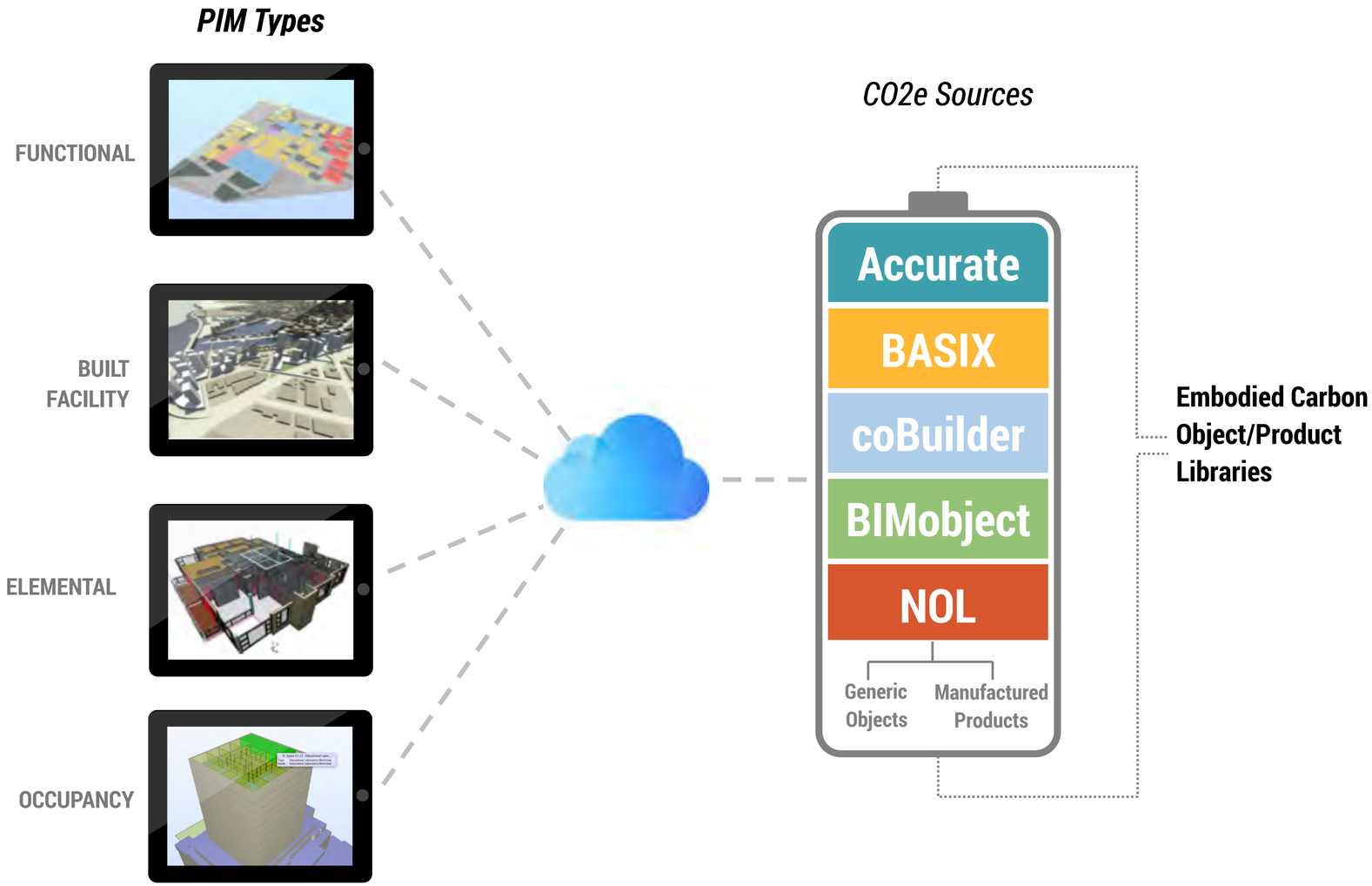


Accessing LCI data repositories

There is *no single solution today* for providing embodied carbon data to support sustainability analysis and modeling in a PIM *or* a BIM environment.

The *Accurate* developments represent the best interim solution, while the industry waits for either the NOL or international BIM and EPD vendors to establish a robust service.

However, global online libraries are becoming a powerful provider of object data and likely to influence developments here in Australasia.



AccuRate Embodied CO2 emissions module

A significant development has been the publishing of the CSIRO *Implementation of Embodied CO2 Module in Accurate*. This has a much larger range of approximately 150 product material definitions (see extract opposite).

This data currently, as far as we can ascertain, is the best dataset for embodied carbon at an elemental and materials scale. Use of this data requires sufficient detail to be identified in a precinct information model in order to apply the metrics at that level, then aggregate.

Materials	Unit	Embodied CO2 (kg CO2 eq./unit)	Comments
Aerated autoclaved concrete block	m3	196.9	Adopt European data from Ecoinvent (2004, autoclaved aerated concrete block, at plant/kg/CH). Assumed raw material are transported within 100km Density is 550 kg/m3 (Hebel, 2009)
Aluminum	m3	35804.8	Employ closed-loop method for recycling allocation (EAA, 2005; ISO 14044, 2006). Assumed 70% recovery rate Assumed mixing as virgin (70%) and scrap aluminum (30%) (Koltun and Tharumarajah, 2006)
Bituminous roof membrane	m3	1012.5	Adopt European data from Ecoinvent (2007, bitumen sealing, polymer EP4 flame retardant, at plant/kg/RER)
Brickwork with extruded clay brick	m3	290.8	Density 1580kg/m3 Standard brick size (110 (W)×230 (L)×76 (H) 3.3kg of clay brick (extruded)
BST lightweight concrete	m3	1332.0	Density 2000kg/m3 (25-30MPa) sourced from Kirkside Products (2009)
Carpet (Nylon)	m3	2337.9	Assumed 50% for cut pile (0.175 g/cm3) and 3 50% for loop pile (0.150 g/cm) • surface pile mass for Nylon BCF carpet (25.2/100mm gauge) is 580g/m2 cut pile and 475 g/m2 loop pile (CIAL, 2009)
Carpet underlay (rubber)	m3	739.5	Rubber underlay Thickness 7.5mm (1.830±55 kg/m2) Sourced from NFA (2009)
Ceramic tile	m3	1920	Adopt European data from Ecoinvent (2003, ceramic tiles, at regional storage/kg/CH) Assumed raw material are transported within 100km
Concrete block 190 dense- weight (not core-filled)	m3	153.9	Adopt Boustead data (UK dense concrete block) Thickness 190mm Density 1101kg/m3

Linking C02e metrics to PIM

A European project led by the industry group **SBAlliance**[1] has been to "... bring together operators of rating and certification tools for sustainable buildings, standard setting organisations, national building research centres as well as key property industry stakeholders and manufacturers of construction products."

The PIM project has adopted this approach which has defined comprehensive IFC properties that can be associated to PIM objects.

Ifc Pset_EnvironmentalImpactIndicators	Data type	Definition
Reference	IfcPropertySingleValue / IfcIdentier	Reference ID for this specified type in this project
FunctionalUnitReference	IfcPropertySingleValue / IfcLabel	Reference to a database or a classification
Unit	IfcPropertySingleValue / IfcText	the unit of the quantity the environmental indicators values are related with.
LifeCyclePhase	IfcPropertyEnumeratedValue / IfcLabel / PEnum_LifeCyclePhase: Production, Transportation, Installation, Usage, Disposal, WholeLifeCycle, UserDefined, NotDefined	the whole life cycle or only a given phase from which environmental data are valid.
ExpectedServiceLife	IfcPropertySingleValue / IfcTimeMeasure	Expected service life in years.
TotalPrimaryEnergyConsumptionPerUnit	IfcPropertySingleValue / IfcEnergyMeasure	Quantity of energy used as defined in ISO21930:2007.
WaterConsumptionPerUnit	IfcPropertySingleValue / IfcVolumeMeasure	Quantity of water used.
HazardousWastePerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of hazardous waste generated
NonHazardousWastePerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of non hazardous waste generated
ClimateChangePerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of greenhouse gases emitted calculated in equivalent CO2
AtmosphericAcidificationPerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of gases responsible for the atmospheric acidification calculated in equivalent SO2
RenewableEnergyConsumptionPerUnit	IfcPropertySingleValue / IfcEnergyMeasure	Quantity of renewable energy used as defined in ISO21930:2007
NonRenewableEnergyConsumptionPerUnit	IfcPropertySingleValue / IfcEnergyMeasure	Quantity of non renewable energy used as defined in ISO21930:2007
ResourceDepletionPerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of resources used calculated in equivalent antimony
InertWastePerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of inert waste generated
RadioactiveWastePerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of radioactive waste generated
StratosphericOzoneLayerDestructionPerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of gases destroying the stratospheric ozone layer calculated in equivalent CFC]R11
PhotochemicalOzoneFormationPerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of gases creating the photochemical ozone calculated in equivalent ethylene
EutrophicationPerUnit	IfcPropertySingleValue / IfcMassMeasure	Quantity of eutrophicating compounds calculated in equivalent PO4

Measuring C02e for all asset types

The adoption of the PIM framework gives a *common foundation* for tool-makers, owners and users to store and access data in the current absence of a consistent, published standard for implementation.

The PIM scoping study recommended the following measures ->

Built Asset Class	Type	Energy	Carbon	Water (by total)	Waste (by total)
Building	Residential (Detached, townhouse, apartment etc.**)	kWh/m^2/ year* (or MJ/m^2/year)	Kg of CO2e/ m^2/year*	kL of potable water/m^2/year	Kg of MSW/m^2/ year Kg of recycled waste/ m^2/year
	Commercial (Office, retail, education, hotel, shopping centre, hospital etc.)	kWh/m^2/year* (or MJ/m^2/year)	Kg of CO2e/m^2/ year*	kL of potable water/m^2/year	Kg of MSW/m^2/year
Transport	Rail	kWh/km of run	Kg of CO2e/km of run		
		Distance of travel (km) Trip number (frequency)			
	Road	kWh/km of run	Kg of CO2e/km of run		
		Distance of travel (km) Trip number (frequency)			
Park	Park/reserve etc	kWh/m^2/year (or MJ/m^2/year)	Kg of CO2e/m^2/ year kg of CO2e/m^2/ year***	kL of potable water/m^2/year	Kg of MSW/m^2/year

* By total and end-use (Heating, cooling, lighting, cooking, electric appliances, and others)
** See **Table 4.1** (see Scoping Study) for more detailed building types
*** Absorbed CO2 by planting

Accessing structured C02e data - bsDD terminology

The buildingSMART Data Dictionary (bSDD) is a library of concepts and the relationships between them. It is used to identify objects in the built environment and their specific properties regardless of language, so that for example “door” means the same thing in New Zealand as it does in Australia or the UK.

The bsDD is proposed as a means to specify detail naming and attribution of PIM object instances that are instantiated using generic PIM entity definitions.


```
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#204= IfcPropertySingleValue(‘Energy Consumption’,$,IfcReal(45.312),#200);
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#214= ifcSIUnit (.CUBIC_METRE.,’kL,’Water/m2/year’);
#216= IfcPropertySingleValue(‘Water Consumption’,$,IfcReal(0.23),#214);
#220= ifcSIUnit (.GRAM.,’kg’,’Waste/m2/year’);
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```
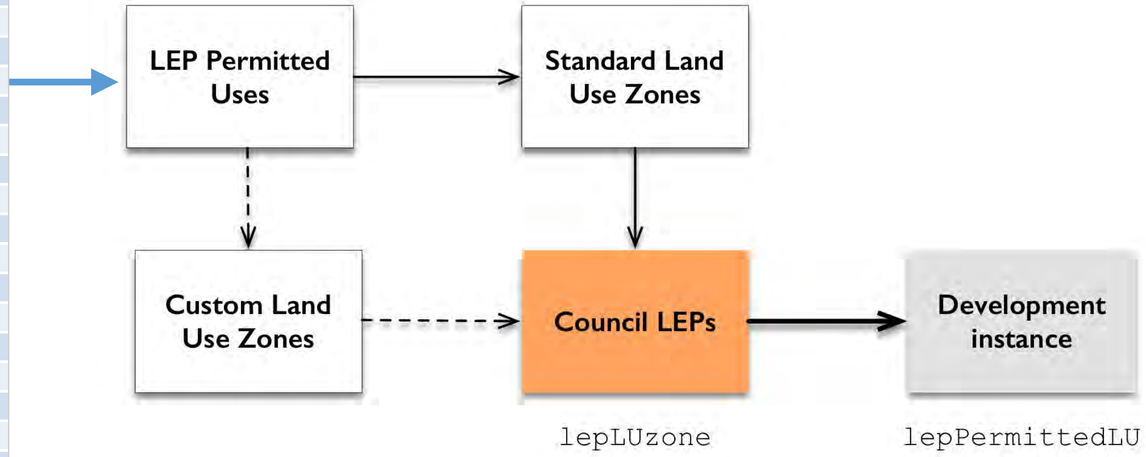

LEP Development Types - simulating the development process

Boarding houses	Function centres
Boat building and repair facilities	Funeral homes
Boat launching ramps	Garden centres
Boat sheds	General industries
Building identification signs	Group homes
Bulky goods premises	Group homes (permanent) or permanent group homes
Business identification signs	Group homes (transitional) or transitional group homes
Business premises	Hardware and building supplies
Camping grounds	Hazardous industries
Car parks	Hazardous storage establishments
Caravan parks	Health consulting rooms
Cellar door premises	Health services facilities
Cemeteries	Heavy industrial storage establishments
Charter and tourism boating facilities	Heavy industries
Child care centres	Helipads
Commercial premises	Heliports
Community facilities	High technology industries
Correctional centres	Highway service centres
Crematoria	Home-based child care
Dairies (pasture-based)	Home businesses
Dairies (restricted)	Home industries
Depots	Home occupations
Dual occupancies	Home occupations (sex services)
Dual occupancies (attached)	Horticulture
Dual occupancies (detached)	Hospitals
Dwelling houses	Hostels
Eco-tourist facilities	Hotel or motel accommodation
Educational establishments	Industrial retail outlets
Electricity generating works	Industrial training facilities
Emergency services facilities	Industries
Information and education facilities	Seniors housing
Intensive livestock agriculture	Service stations
Intensive plant agriculture	Serviced apartments



Improving Facility Development Communication

Planners & Mayors
How can we manage our urban centres and infrastructure more effectively?

State & Local Government
Planning & Compliance

Designers & Builders
PIM supports smarter planning & urban management, but asset development processes are not exploiting this!

Development Planner
PIM, BIM, DE based planning tools

Improving Facility Development Communication

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Development Planner
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Accessing & Sharing PIM Data

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BIM based planning tools

Accessing & Sharing PIM Data

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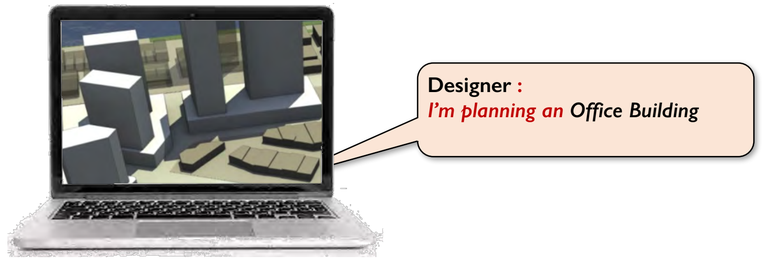
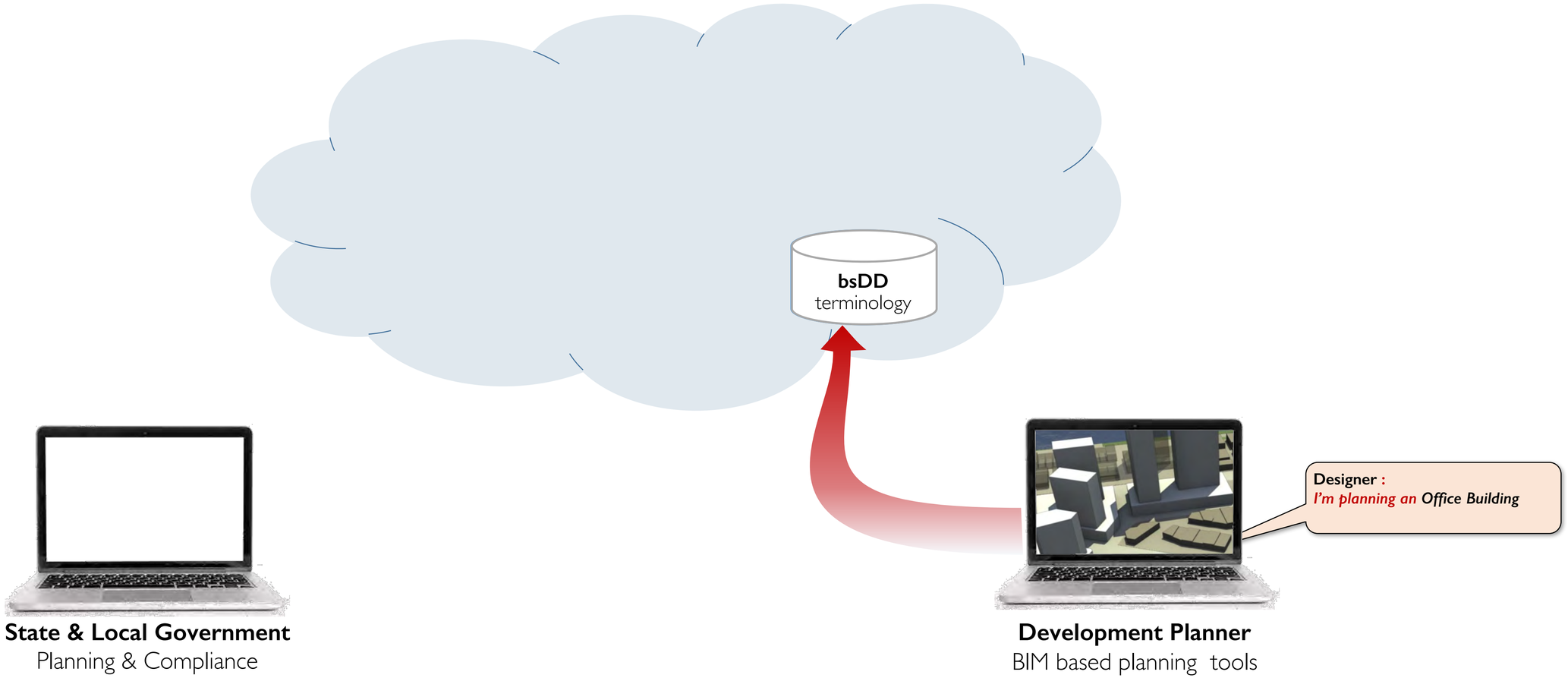


Development Planner
BIM based planning tools

Accessing & Sharing PIM Data



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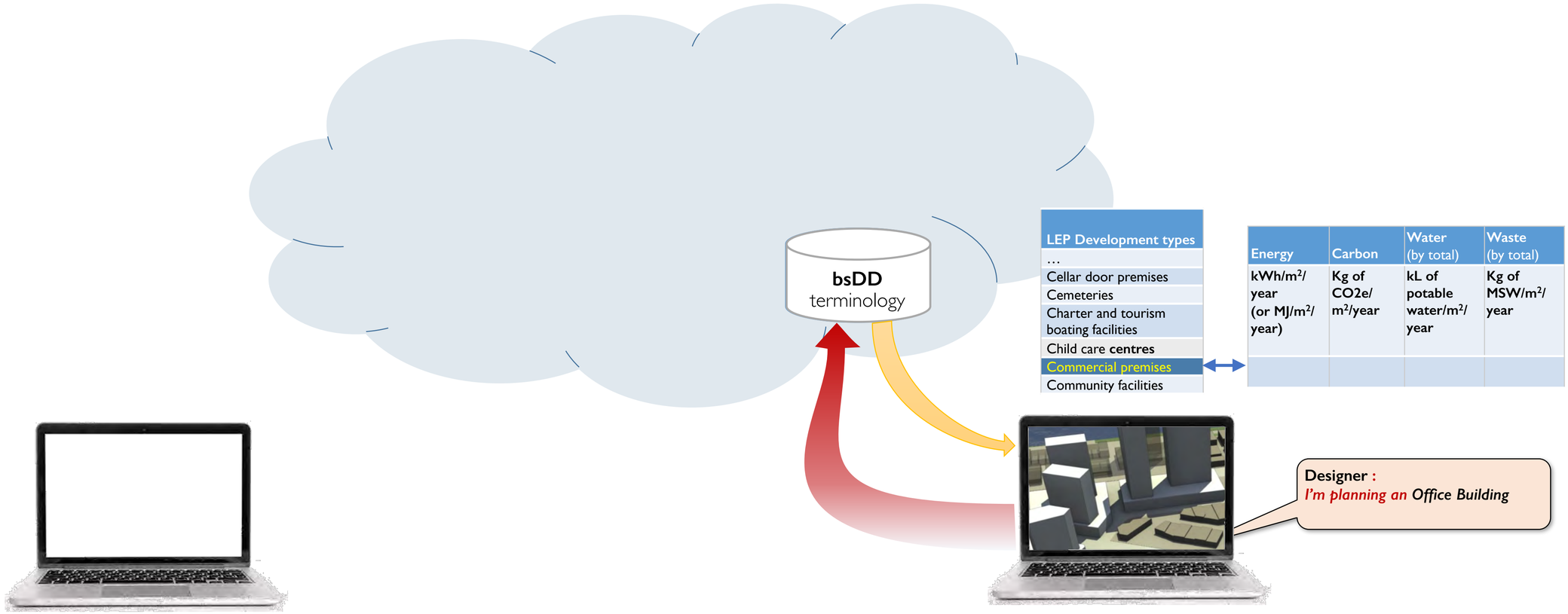

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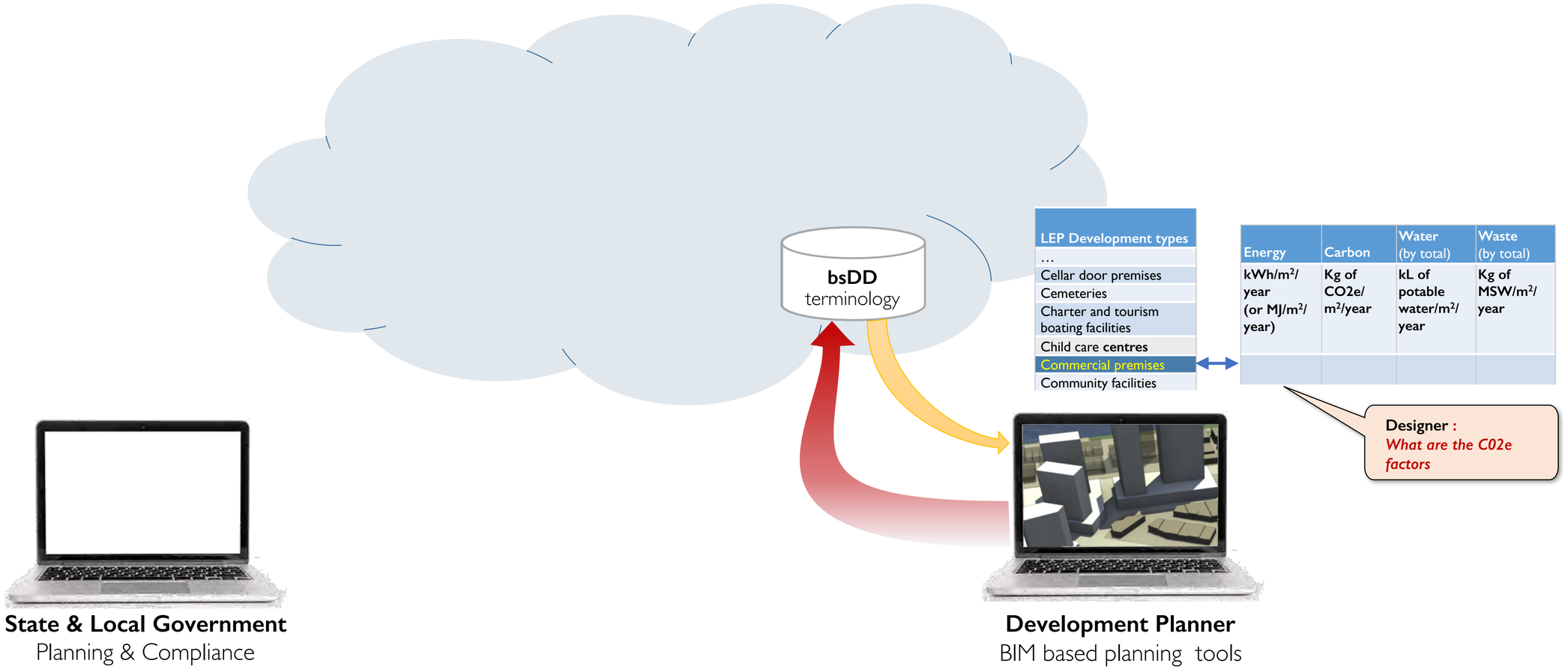

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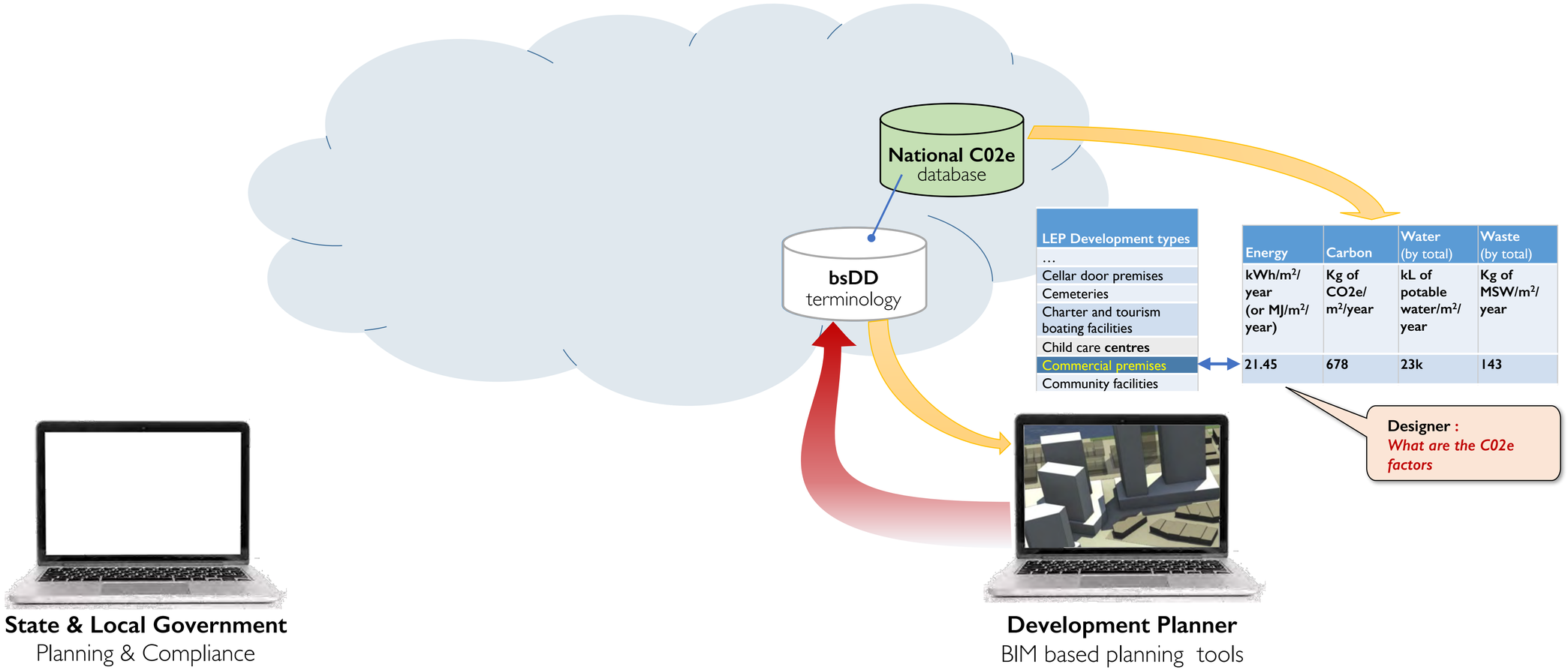

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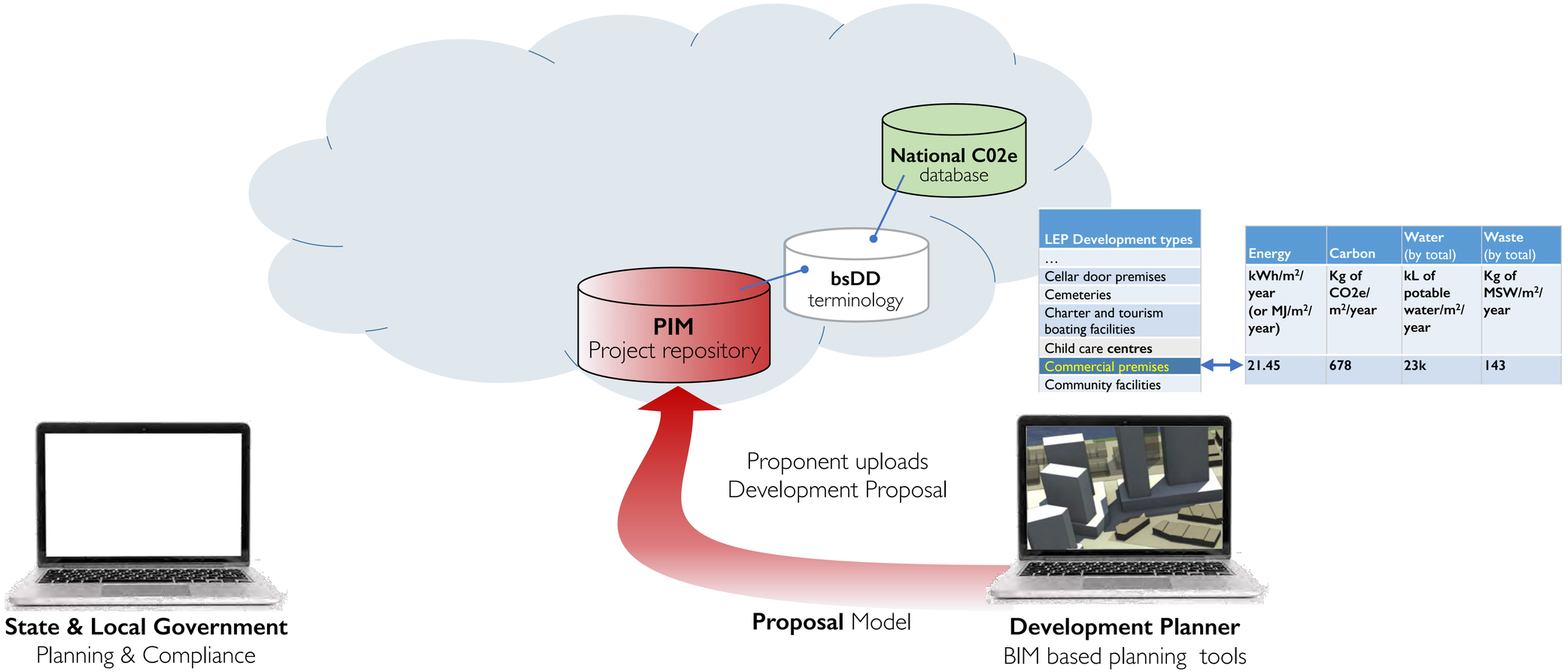

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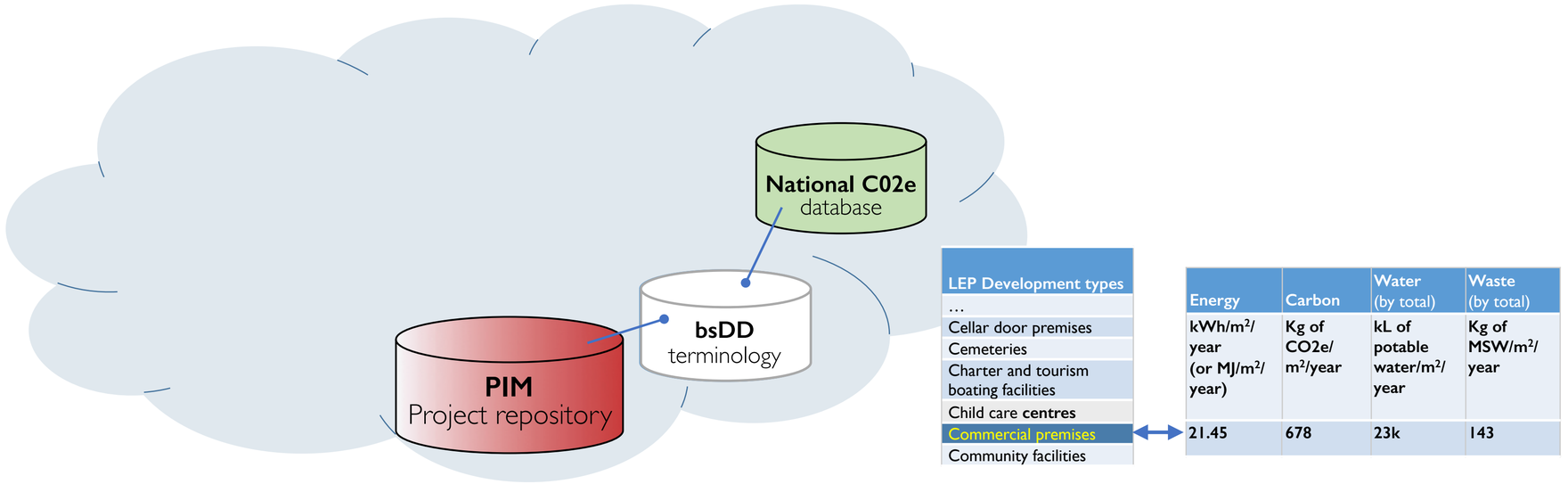

LEP Development types
…
Cellar door premises
Cemeteries
Charter and tourism boating facilities
Child care **centres**
Commercial premises
Community facilities

Energy	Carbon	Water (by total)	Waste (by total)
kWh/m²/ year (or MJ/m²/ year)	Kg of CO2e/ m²/year	kL of potable water/m²/ year	Kg of MSW/m²/ year
21.45	678	23k	143

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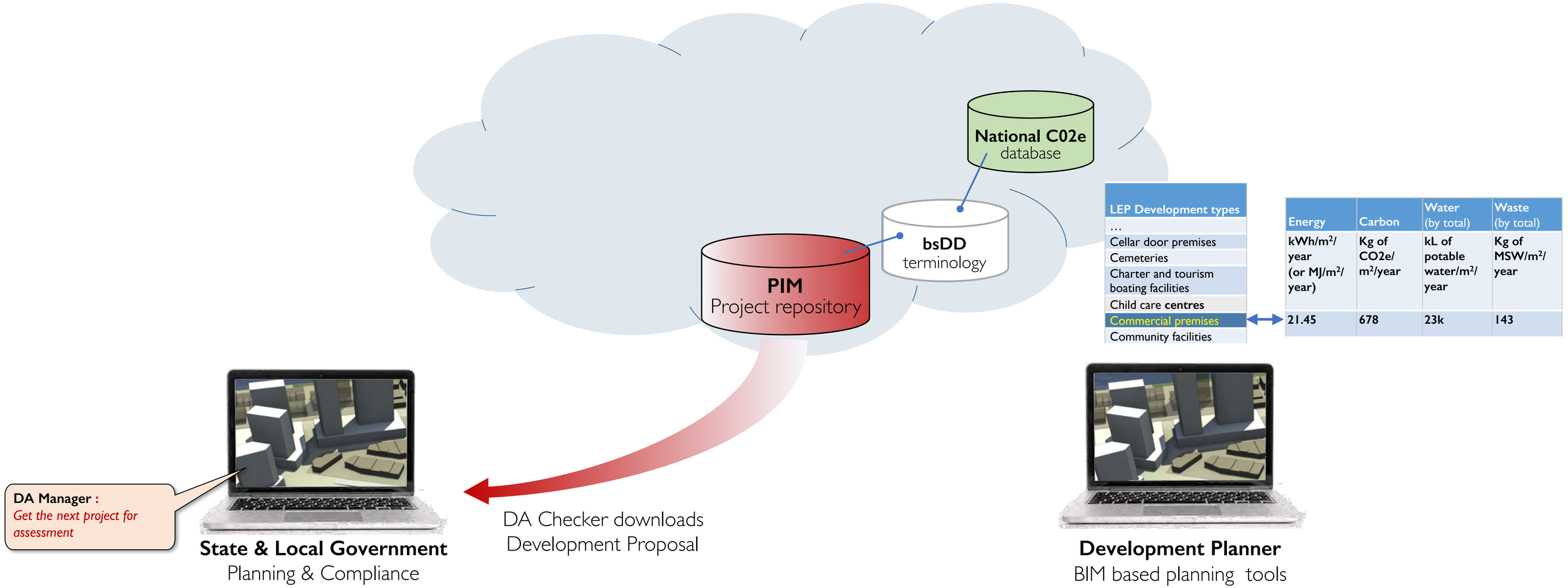
BIM based planning tools

Accessing & Sharing PIM Data



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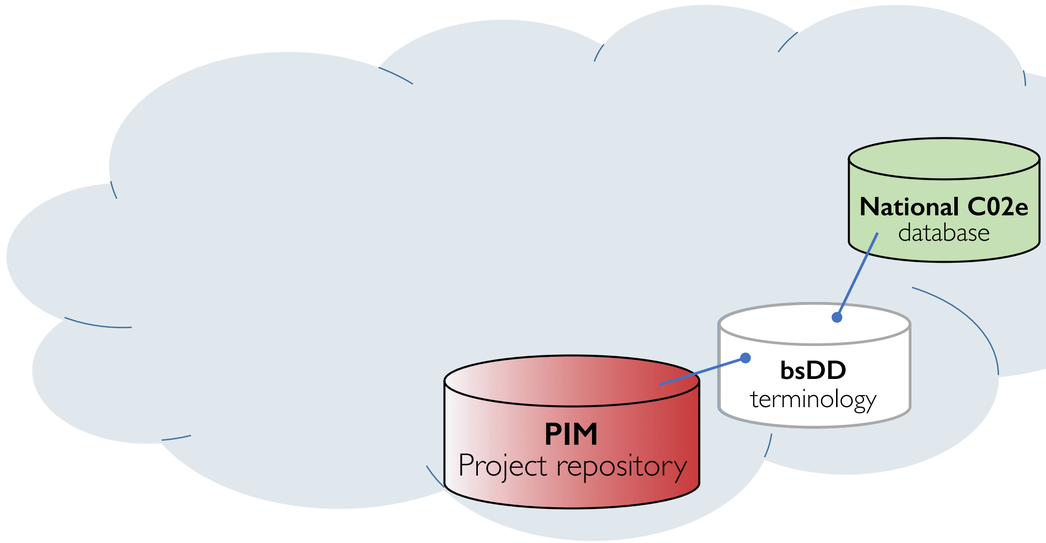

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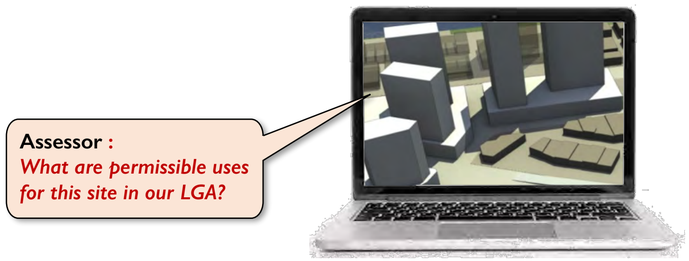
Community facilities				



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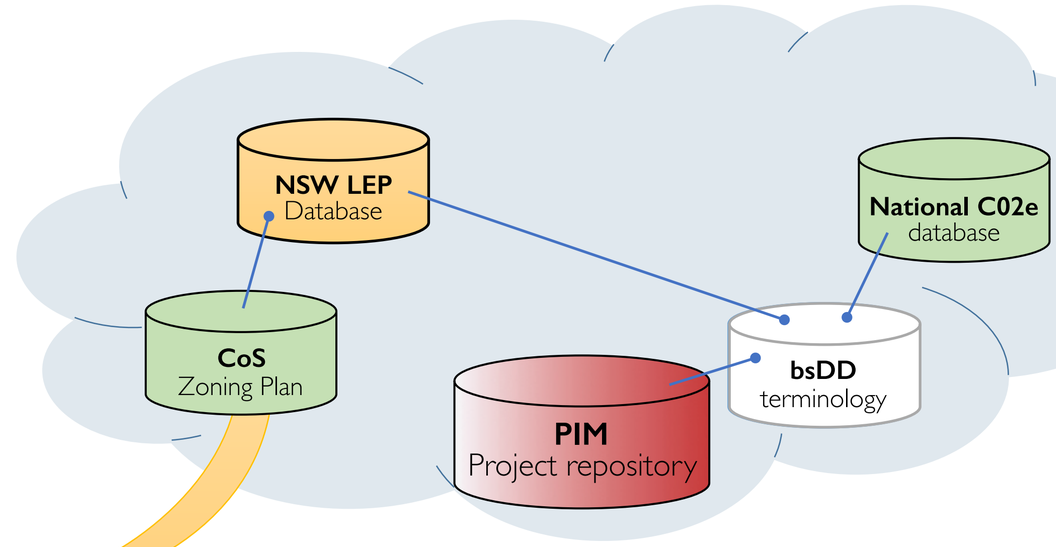
BIM based planning tools

Accessing & Sharing PIM Data

	Zone B4 Mixed Use
1	**Objectives of zone**
	• To provide a mixture of compatible land uses.
	• To integrate suitable business, office, residential, retail and other development…
	• To ensure uses support the viability of centres.
2	**Permitted without consent**
	Home occupations
3	**Permitted with consent**
	Boarding houses; Child care centres; Commercial premises; Community facilities; Educational establishments; Entertainment facilities; …; Any other development not specified in item 2 or 4
4	**Prohibited**
	Extractive industries; Heavy industrial storage establishments; Heavy industries



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Cellar door premises				
Cemeteries				
Charter and tourism boating facilities				
Child care centres				
Commercial premises	21.45	678	23k	143
Community facilities				

Assessor :
What are permissible uses for this site in our LGA?

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BIM based planning tools

Accessing & Sharing PIM Data

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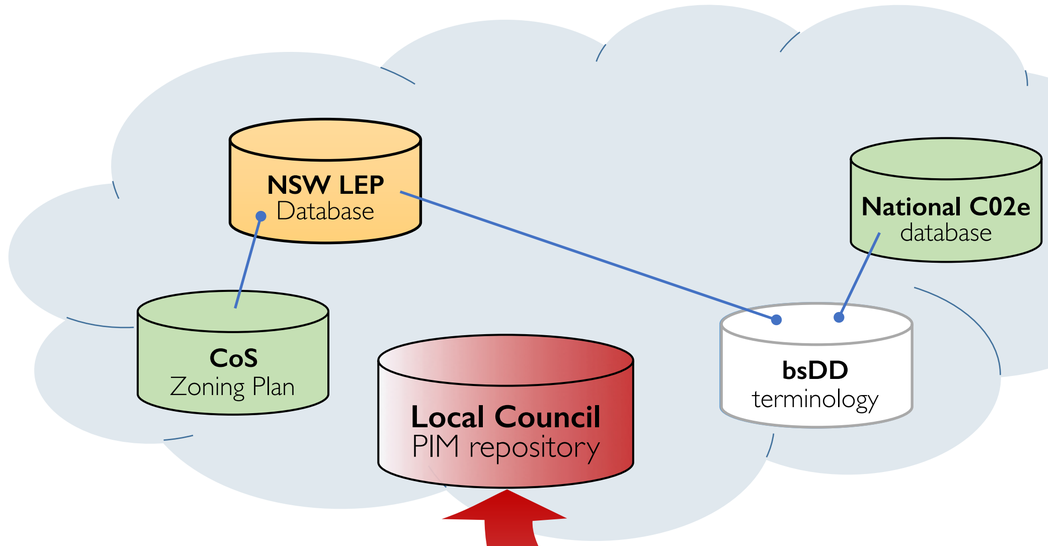

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21.45	678	23k	143

State & Local Government
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Approved Model meets sustainability targets…

Development Planner
BIM based planning tools

Thank you and Questions

Managing precinct information

Team members: Jim Plume, **David Marchant**, **John Mitchell**

PIM information - the perceived benefits

The Scoping Study survey reported the common benefits identified across both government and industry groups were:

- Opportunity to **compare different scenarios**, promoting discussion and highlighting cost/benefits
- Providing **clear performance measures**, leading to a defendable position and a common language that promotes an integrated approach to precinct design
- Leads to more **efficient processes** and incremental improvement of precincts by explicit specification of targets before work proceeds
- Can be used as a **community education** tool.

Managing PIM information - the Role of IDMs

A significant issue for local government, who are the most likely to benefit from PIM repositories, is **collecting, exchanging, importing, exporting and linking data** that will be a continuous task for the many persons and organisations using the model.

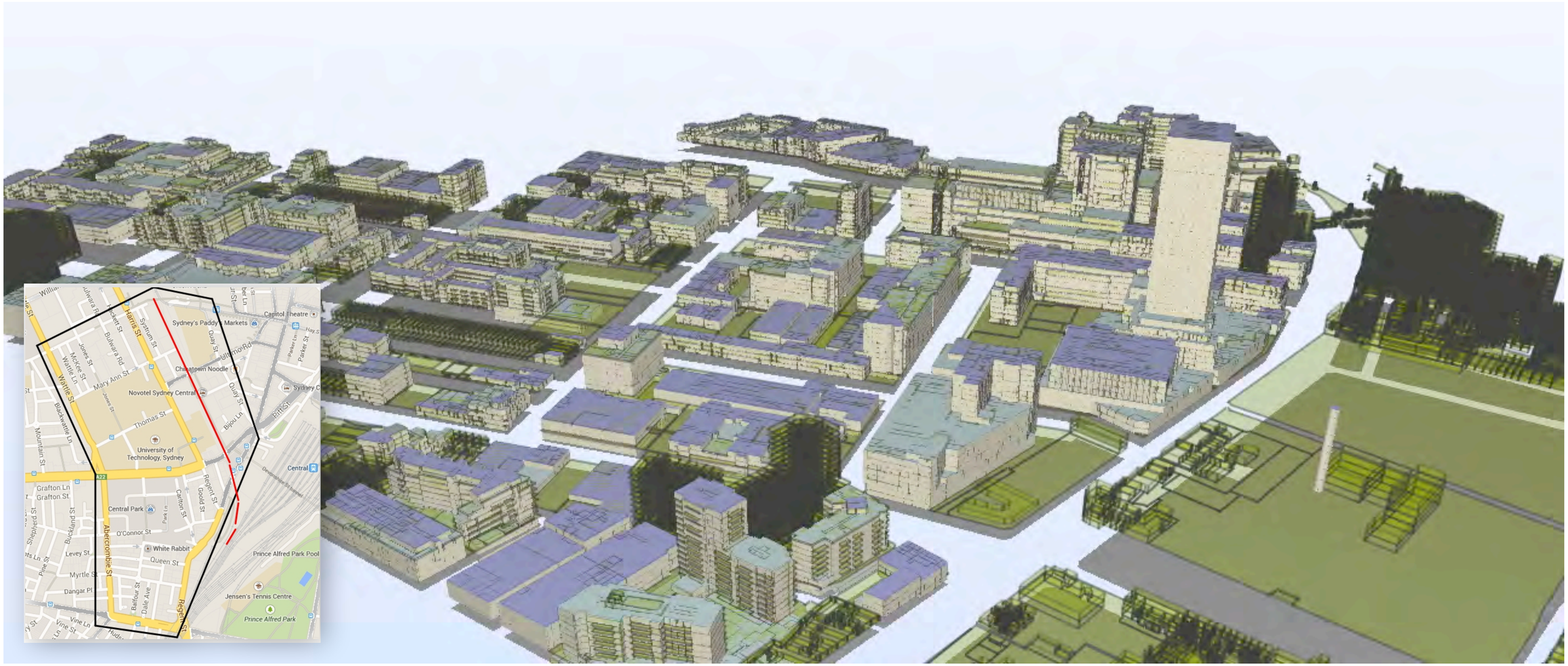
A key challenge in practice is the compatibility of data between the many GIS, PIM, BIM and other software systems in use in Government and industry.

The open standards solution to this issue is the development of IDMs - **Information Delivery Manuals -** which define what information must be contained in a “information exchange”.

We examine one detailed **use case for model location**, and overview some other possibilities that have arisen from the PIM project

- accessing intelligent LEP data
- exchange of cadastral data
- common standards for asset occupancy, activities and business types
- common standards for embodied carbon properties
- common protocol for asset management data
- open protocols for BASIX and ACCURATE assessments
- adopting common protocols for building product, object libraries with emphasis on C02e and environmental data

Broadway Precinct - reusing the City of Sydney FSES



LOW CARBON LIVING CRC

Occupancy - FSES classification of activities & business types

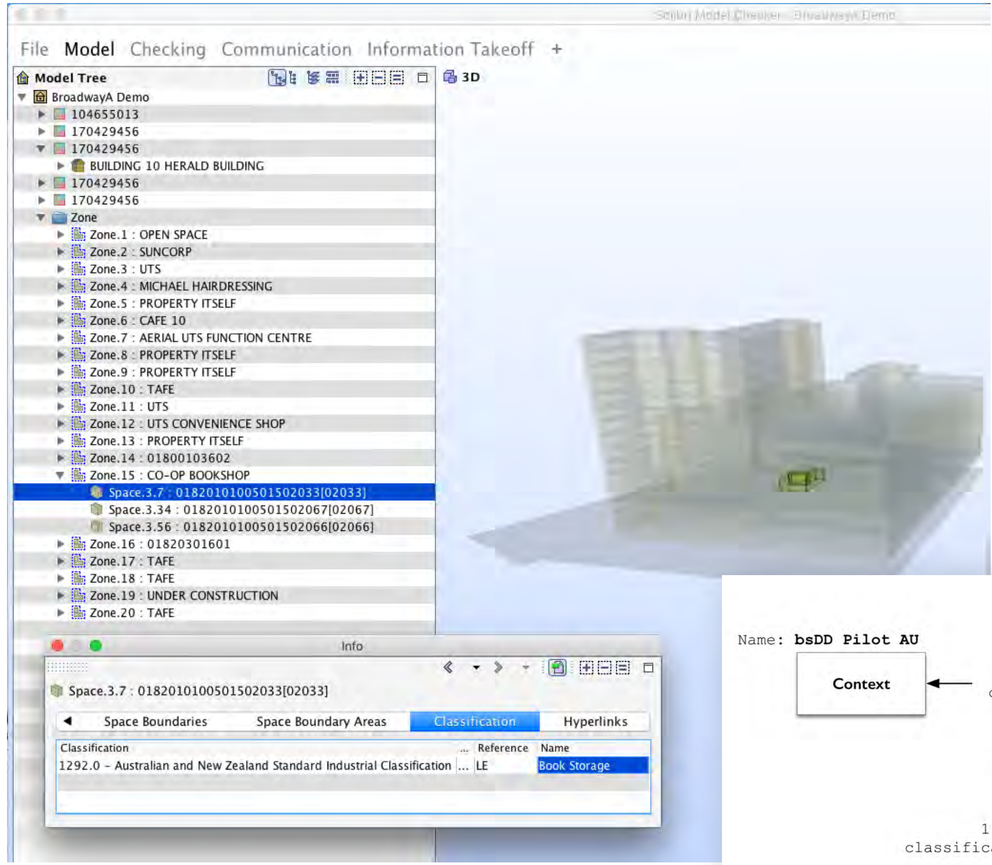
The FSES survey describes all the spaces (rooms) within a building, the type of business organisation and classifies both.

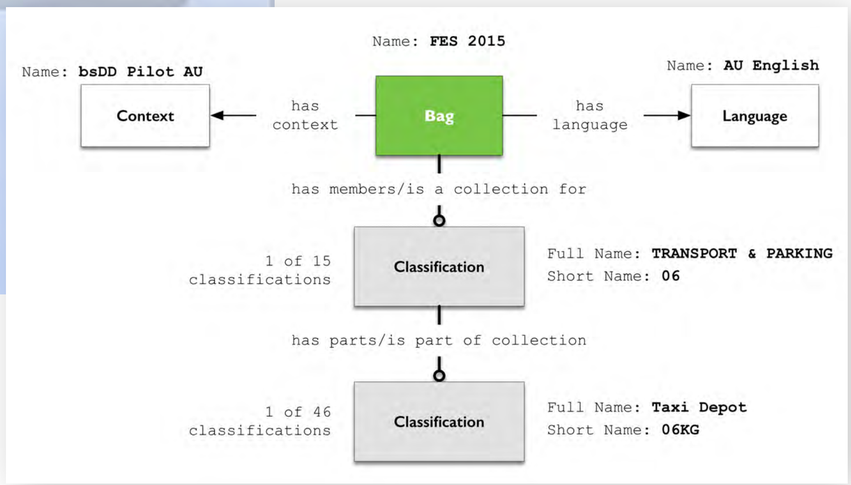
We have used the bsDD to host these ASNZ standard definitions and *encourage its national adoption.*

Associated with those functions are the consumption of energy or aggregated operational carbon impacts that are expended in the carrying out of the function.

Many Precinct Assessment Indicators depend on occupancy data.

The PIM framework includes the concepts described above, linking operational data with occupancy types.





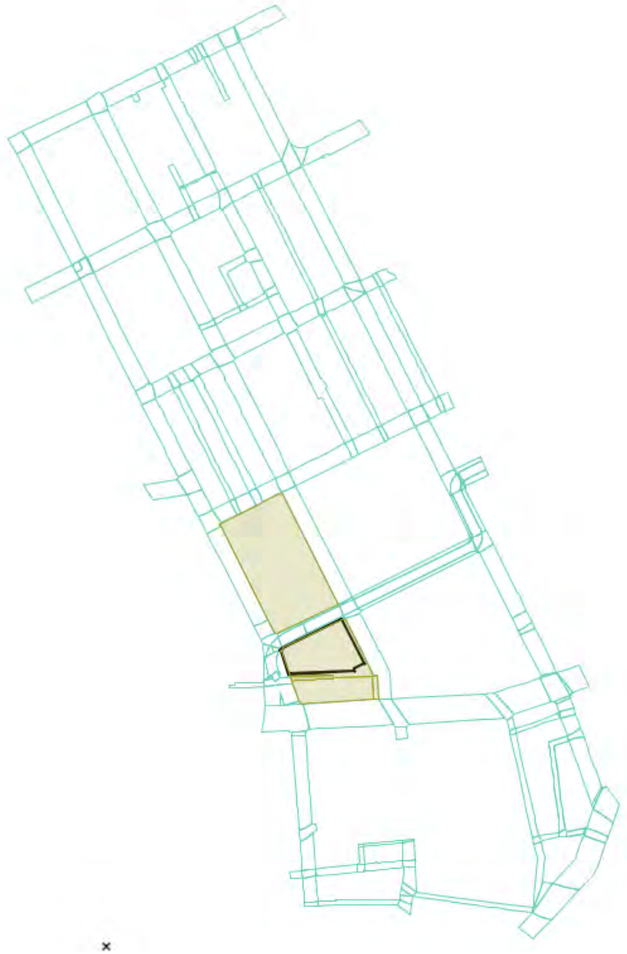
LOW CARBON LIVING CRC

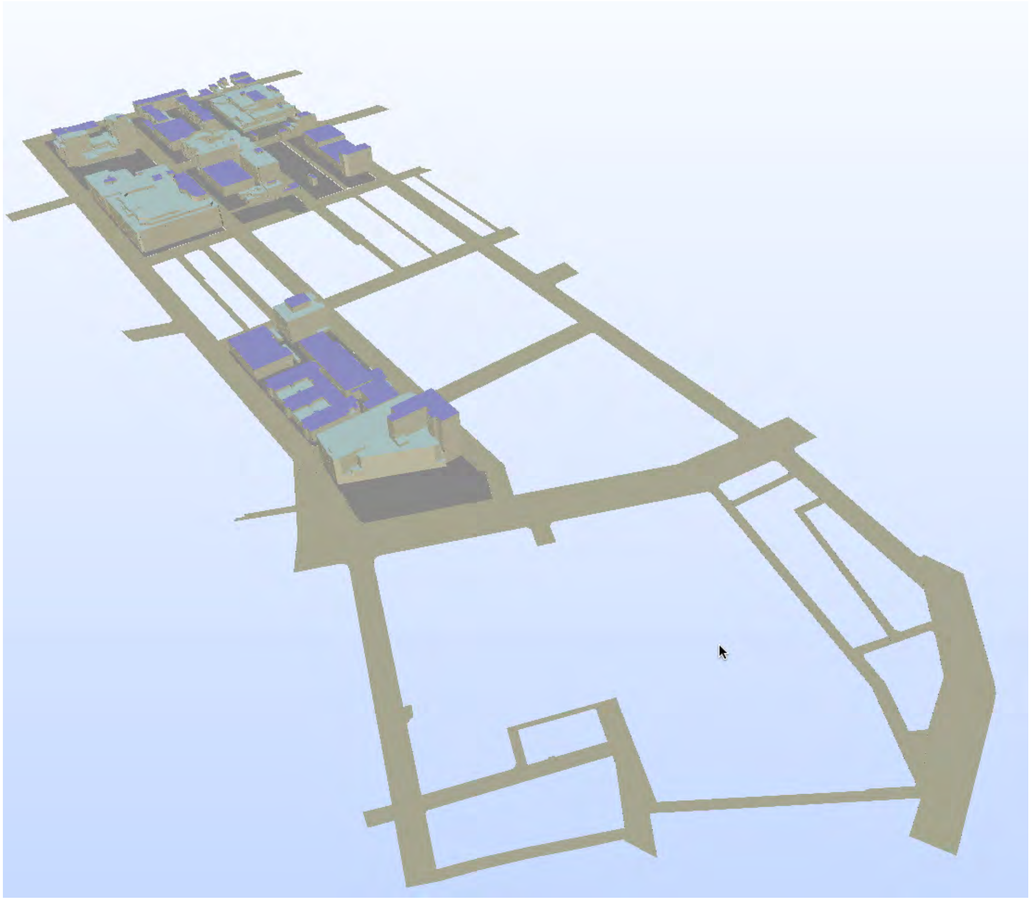
Cadastral data - roads and lots

Cadastral data is literally the foundation of a precinct model.

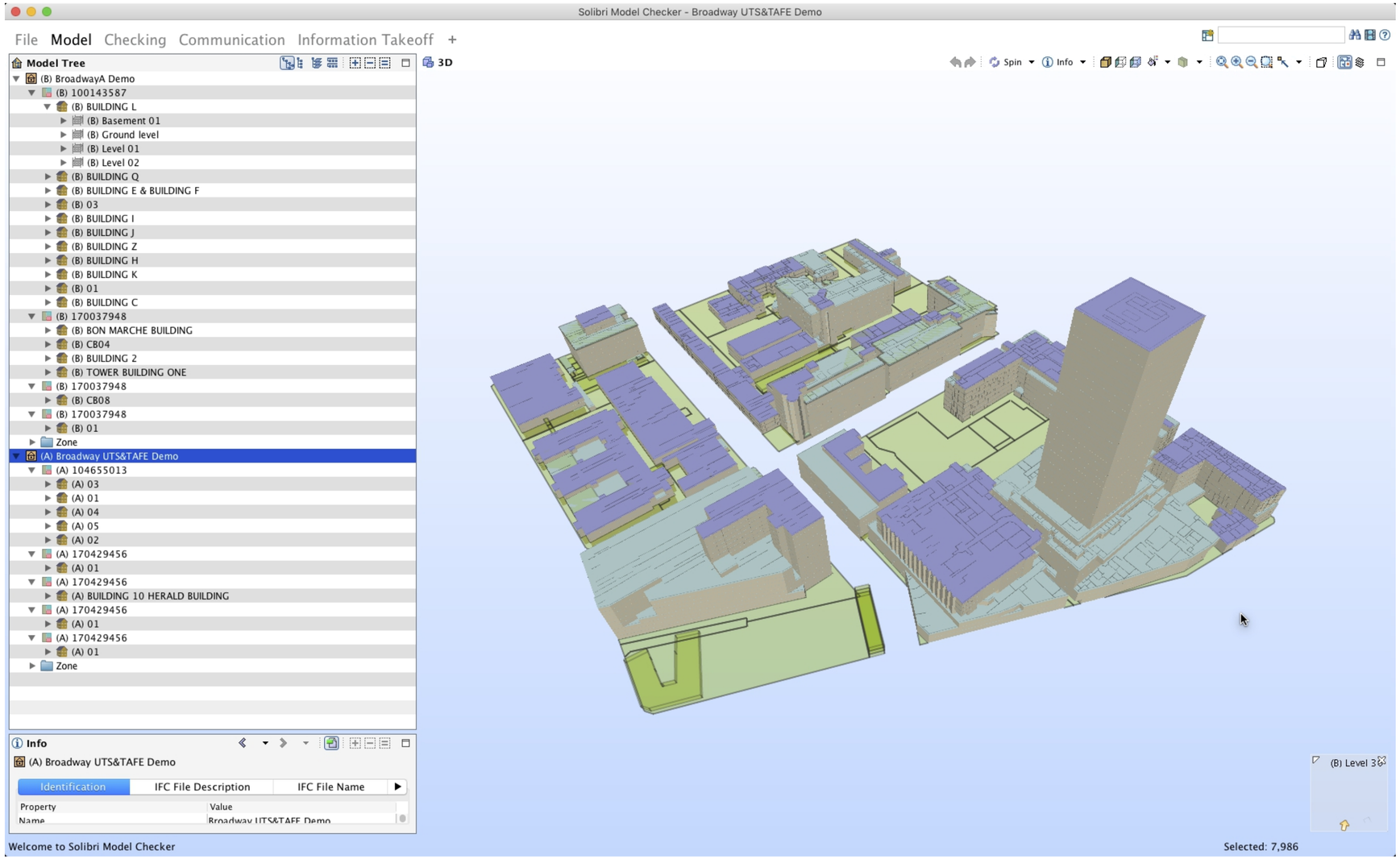
Land ownership, utilities data, geographic data is tied to this land measurement system

Our project has found that getting access to the full range of non-cadastral data is a major challenge (for example for the Empowering Broadway project)





Broadway partial model - working on parts of a PIM



If we need to edit, update this sub-model we must ensure we maintain dimensional accuracy converting from **GIS** (Easting & Northings format) to **ground** (cartesian) coordinates used in PIM authoring tools

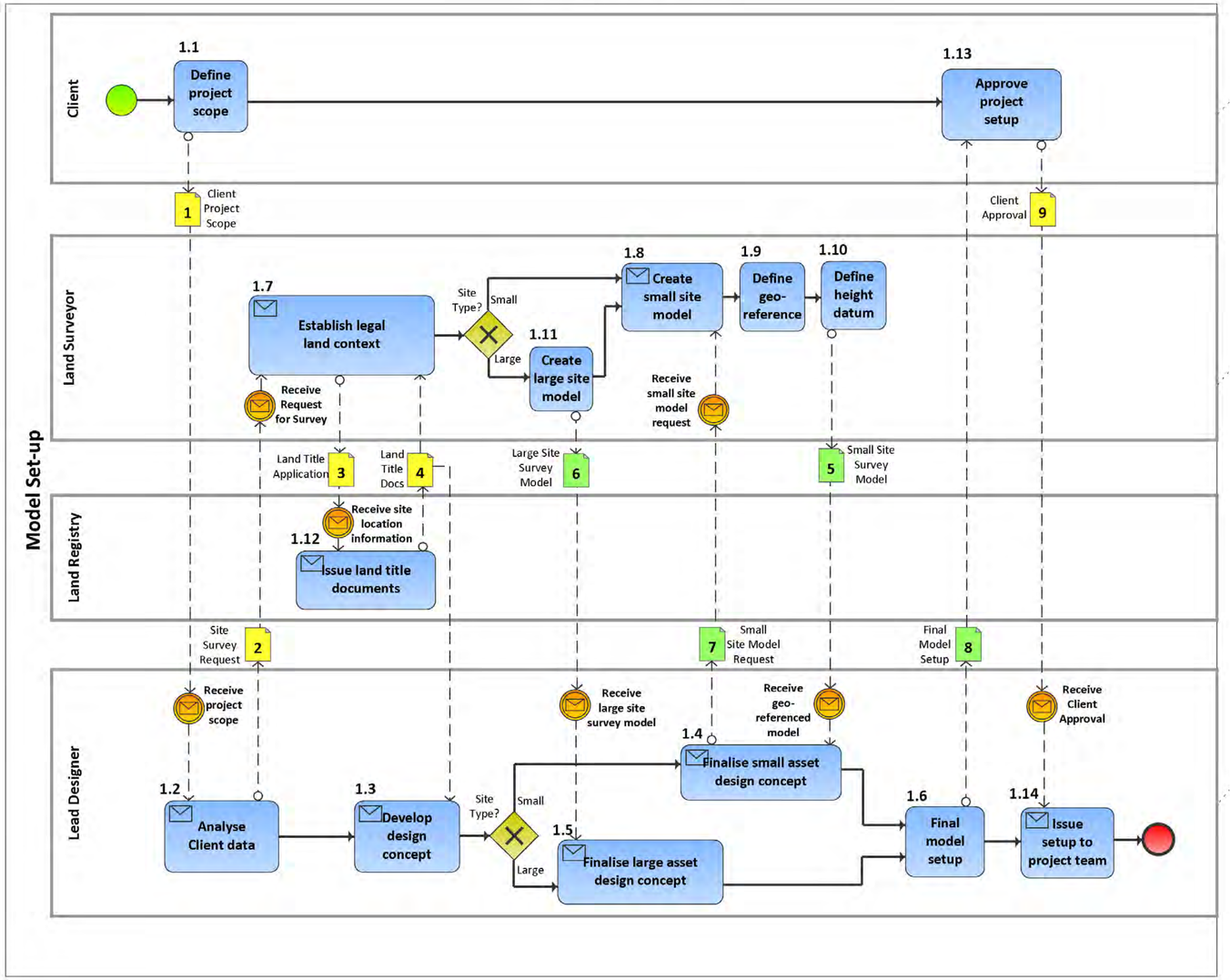
Establishing robust geo-reference - eg for large urban models

The buildingSmart International **IDM** (Information Delivery Manual) defines in the language and perspective of the professional participant what information must be contained in a “model exchange”, in this case **Model Setup**

Four key steps

- specify the problem
- document industry process and workflow
- specify technical solution
- implement & undertake case studies

PIM software inventors can then implement these *globally agreed* technical workflows and improve quality and efficiency



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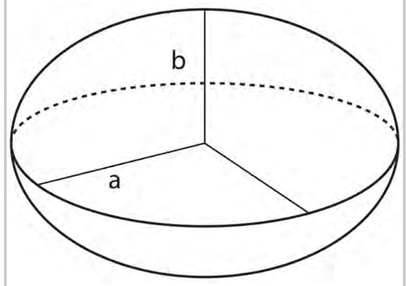
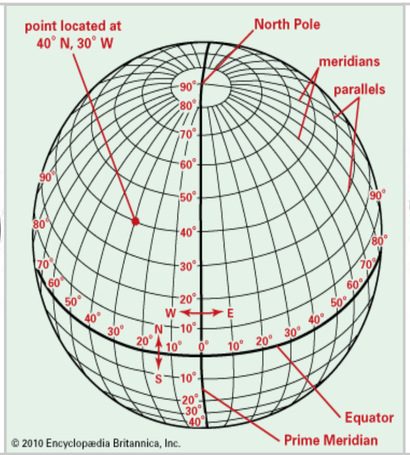
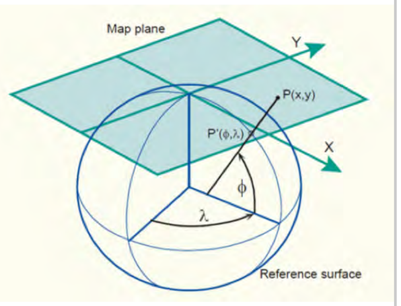
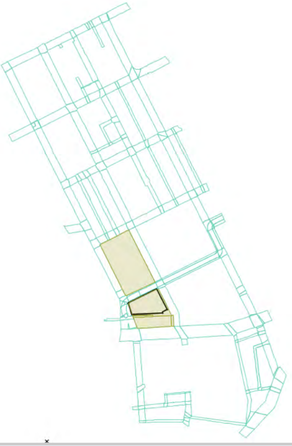
				
Earth as an Ellipsoid	Earth System	Earth's True Shape & its Terrain	A Map 'flat' Projection	A Large Site is over 1km x1km

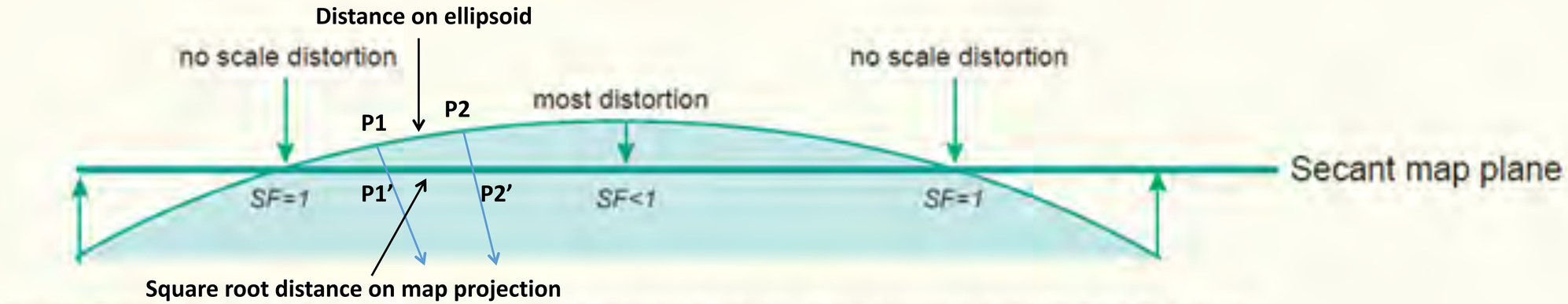
A Map projection enables points on the ellipsoid surface to be mathematically projected onto an imaginary developable surface

When the model extent is greater than 1km x 1km significant errors can occur in conversions from GIS to ground coordinates, especially in linear infrastructure and urban models

Map Coordinates

It is easiest to see that the distance between the two points on the ellipsoid will not be the same as on the map projection by looking at the slice though the ellipse

The distortion is called the **scale factor** and varies from point to point across the slice.



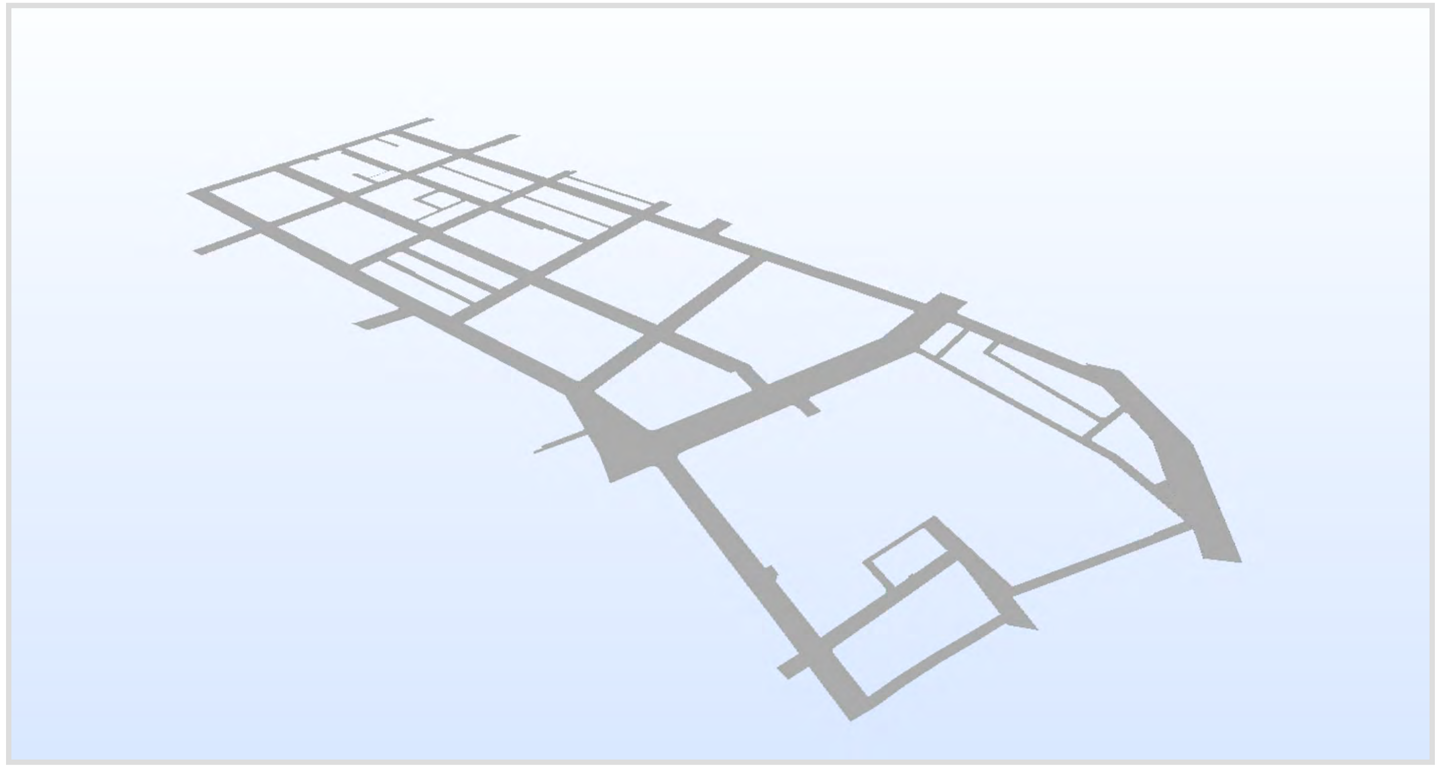
Scale distortions on a secant map surface. Line(s) of intersection are not distorted on the map.

Norwegian Health Facilities Web Portal

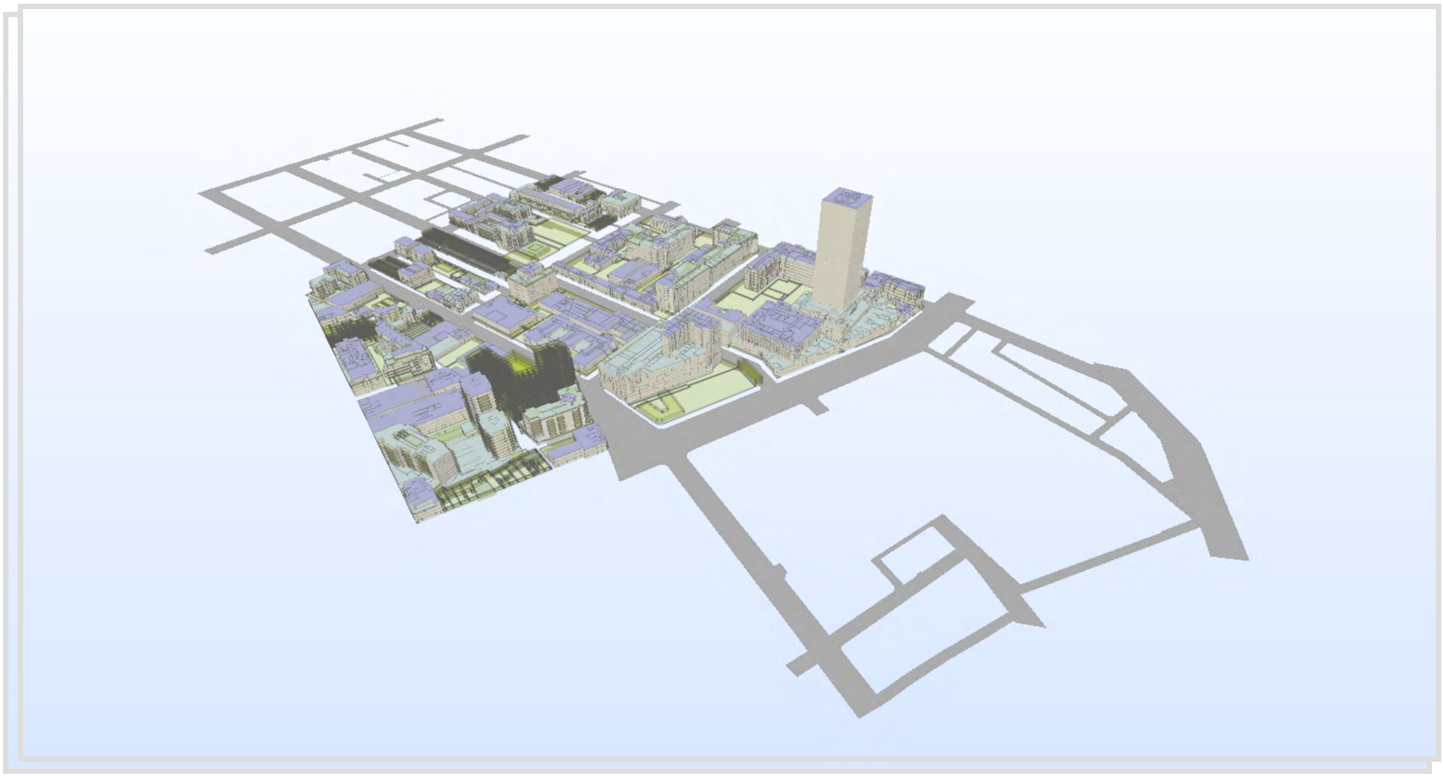
The technical solution is a ***Helmert transformation*** computed from the coordinates of the pairs of GIS and local ground reference points.

An example is a Health Authority's web accessible systems where building information, plans etc are layered onto to a local map.

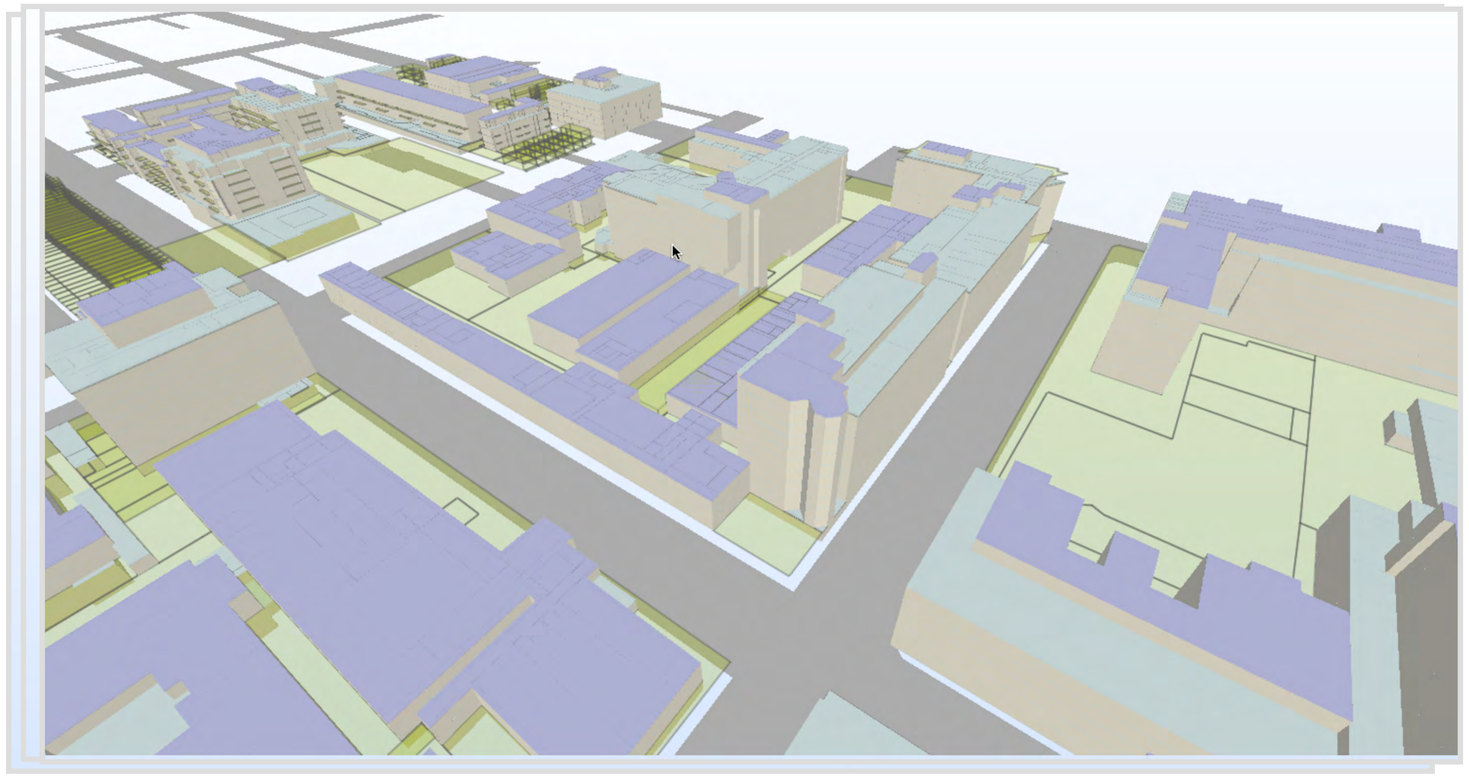
Energy Consumption - focussed building services system data



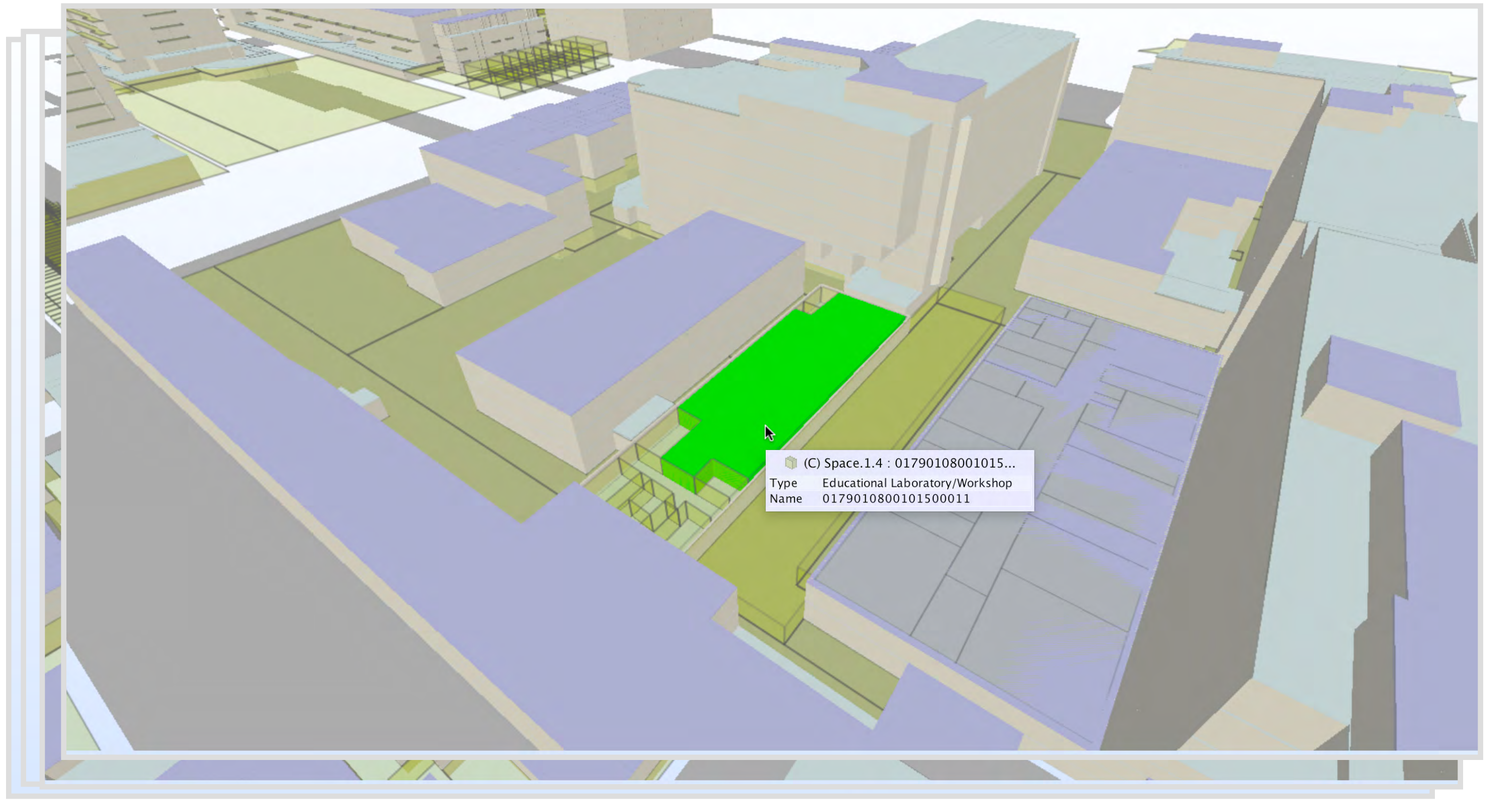
Energy Consumption - focussed building services system data



Energy Consumption - focussed building services system data



Energy Consumption - focussed building services system data



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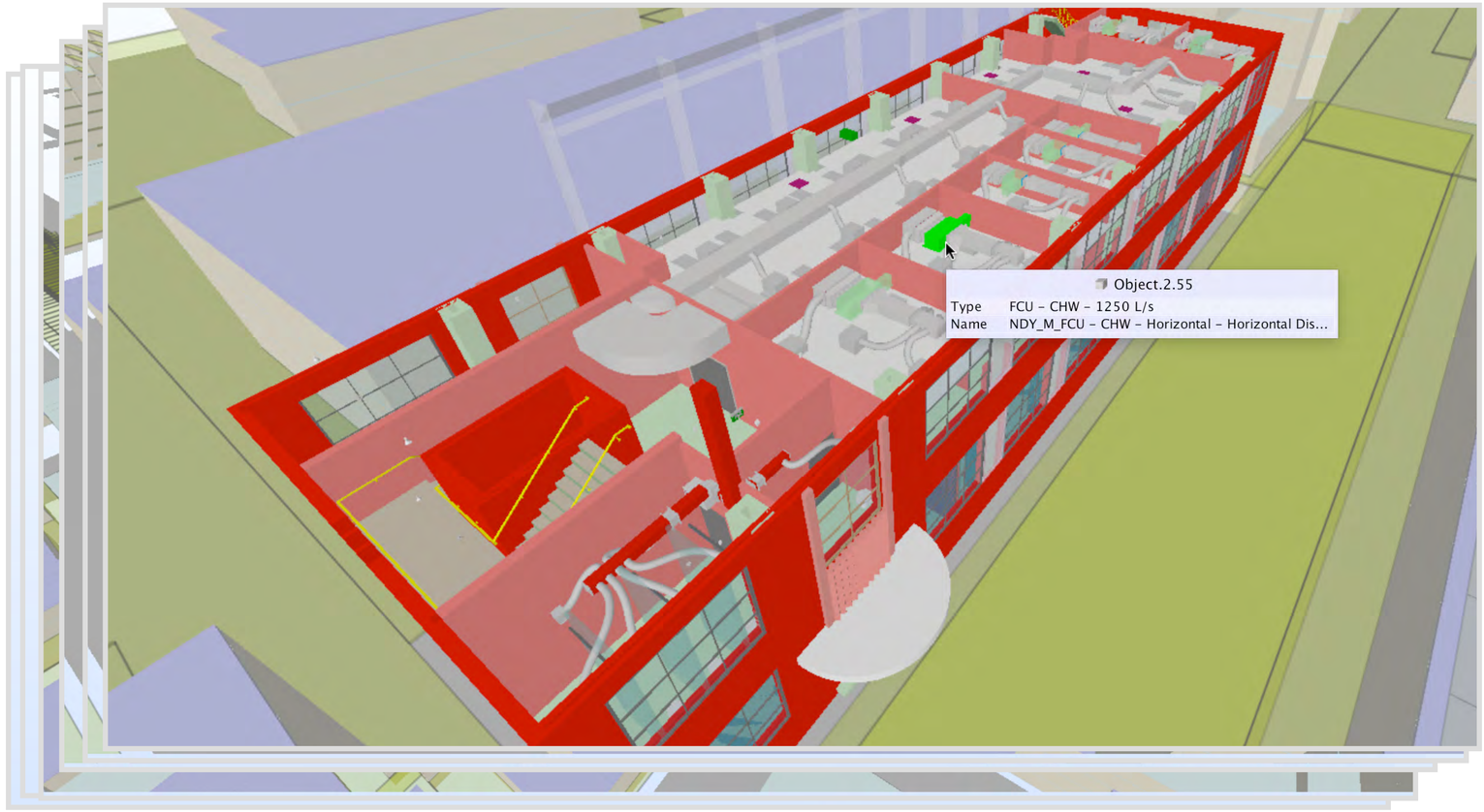
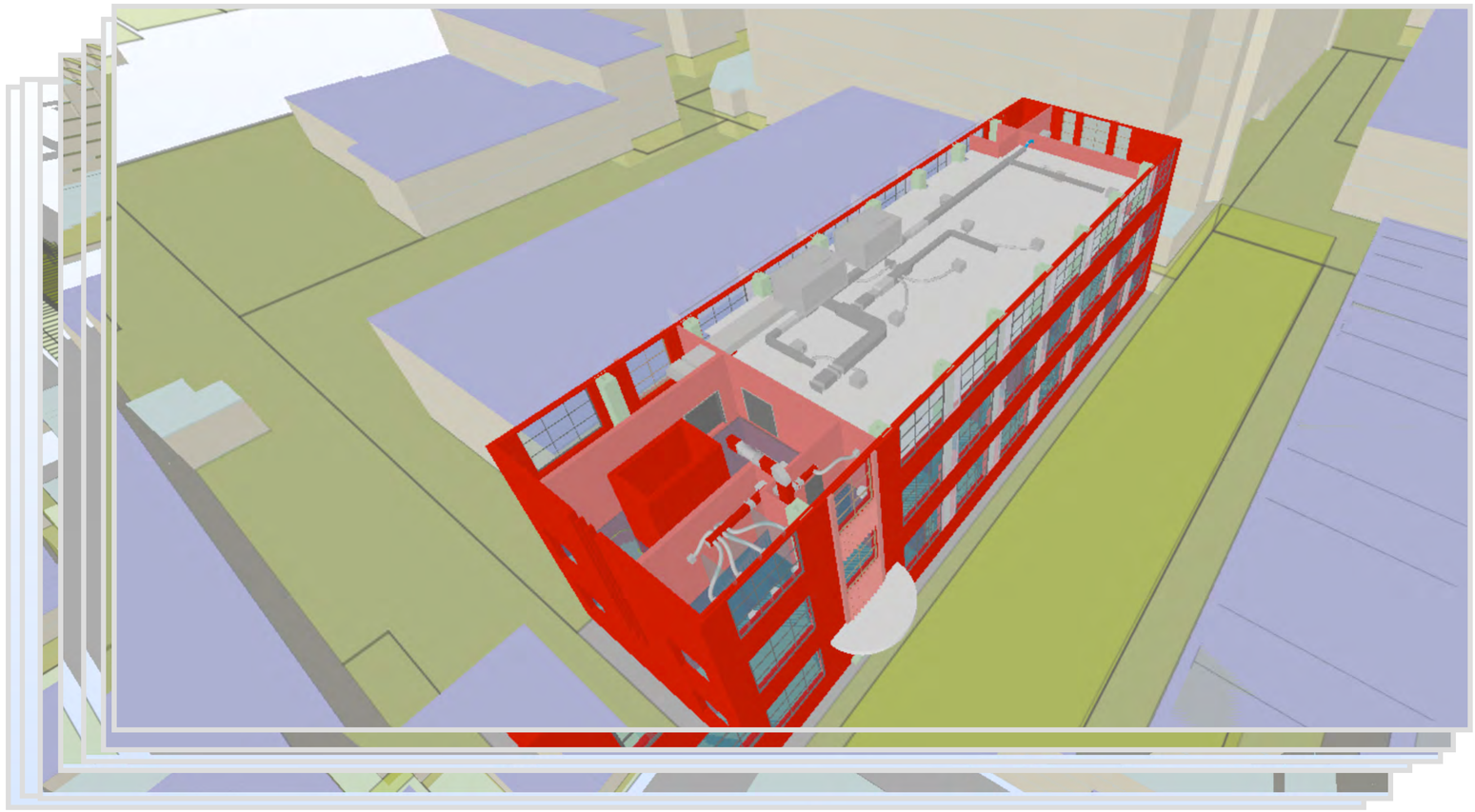
Energy Consumption - focussed building services system data

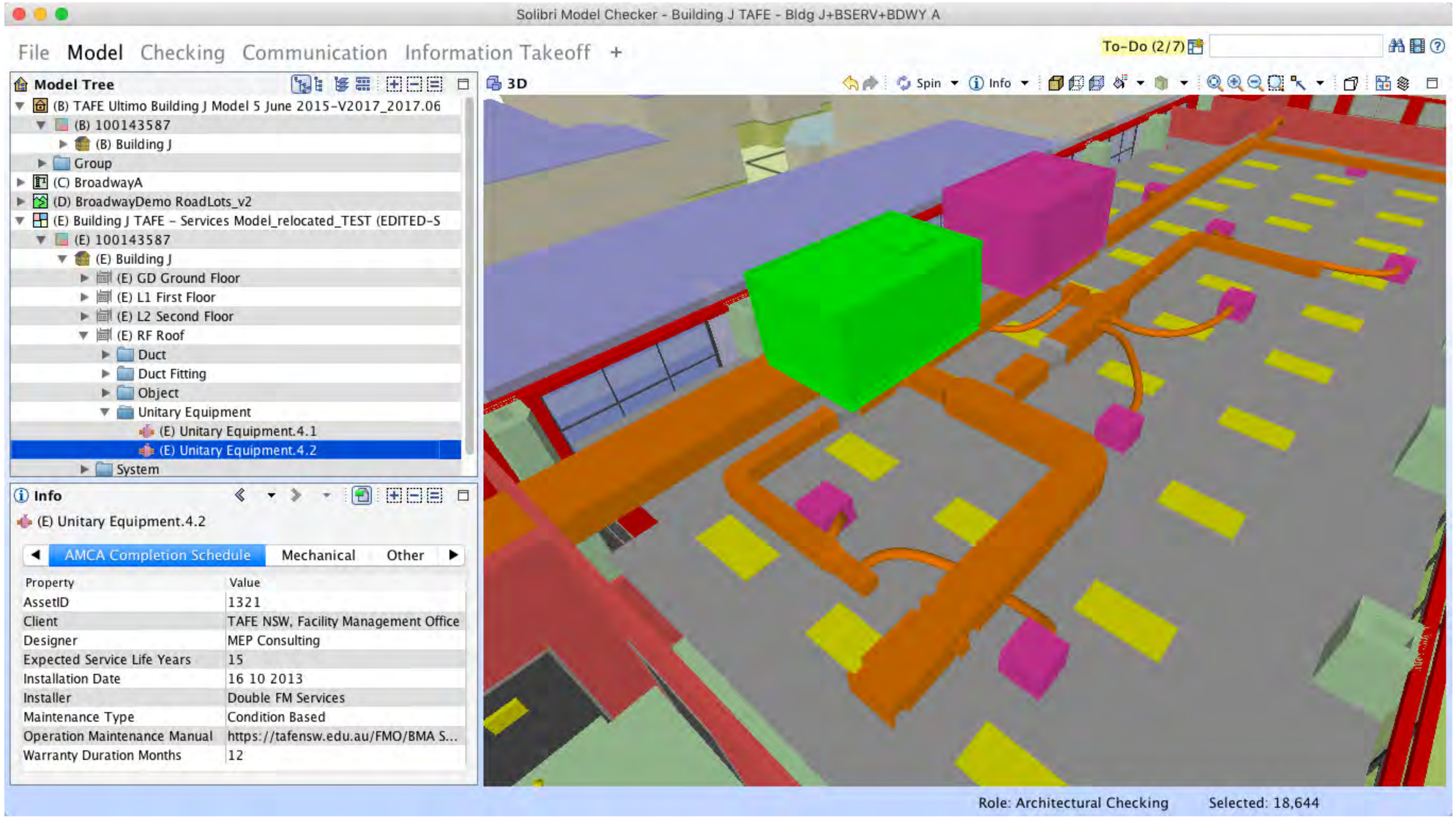
Energy Consumption - focussed building services system data



Energy Consumption - focussed building services system data



Asset Data - linking maintenance & operational data



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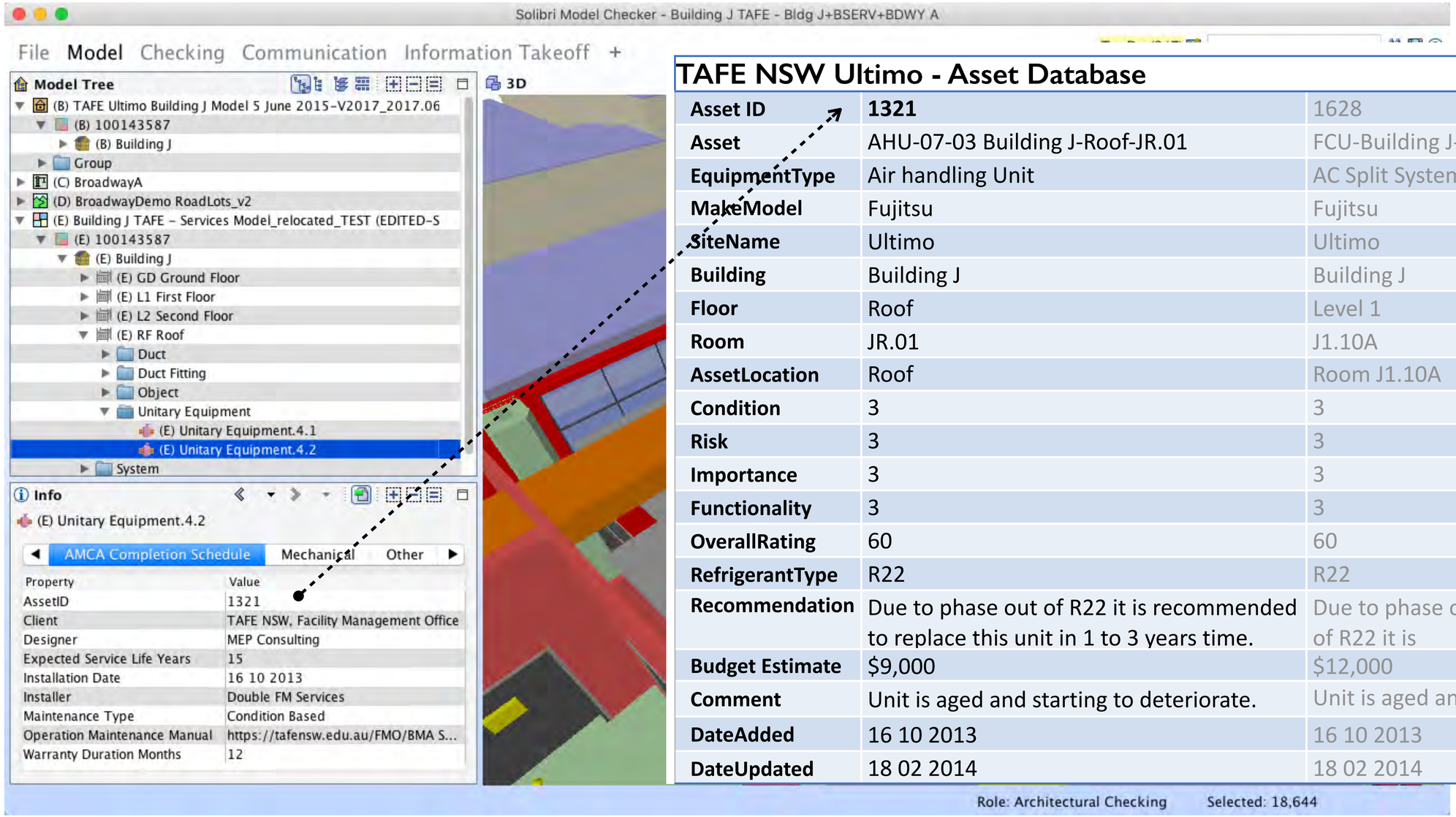
Asset Data - linking maintenance & operational data

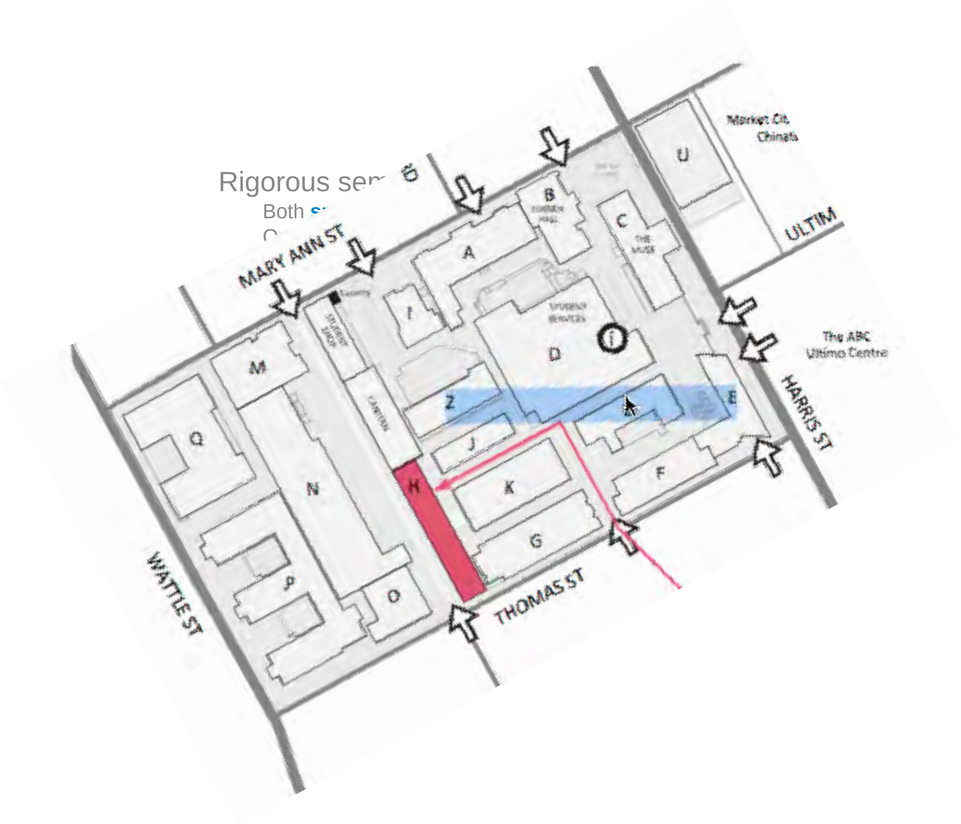


TAFE NSW Ultimo - Asset Database			
Asset ID	**1321**	1628	...
Asset	AHU-07-03 Building J-Roof-JR.01	FCU-Building J-	...
EquipmentType	Air handling Unit	AC Split System	...
MakeModel	Fujitsu	Fujitsu	...
SiteName	Ultimo	Ultimo	...
Building	Building J	Building J	...
Floor	Roof	Level 1	...
Room	JR.01	J1.10A	...
AssetLocation	Roof	Room J1.10A	...
Condition	3	3	...
Risk	3	3	...
Importance	3	3	...
Functionality	3	3	...
OverallRating	60	60	...
RefrigerantType	R22	R22	...
Recommendation	Due to phase out of R22 it is recommended to replace this unit in 1 to 3 years time.	Due to phase out of R22 it is	...
Budget Estimate	$9,000	$12,000	...
Comment	Unit is aged and starting to deteriorate.	Unit is aged and	...
DateAdded	16 10 2013	16 10 2013	...
DateUpdated	18 02 2014	18 02 2014	...

Monitoring Consumption Data (UTS)

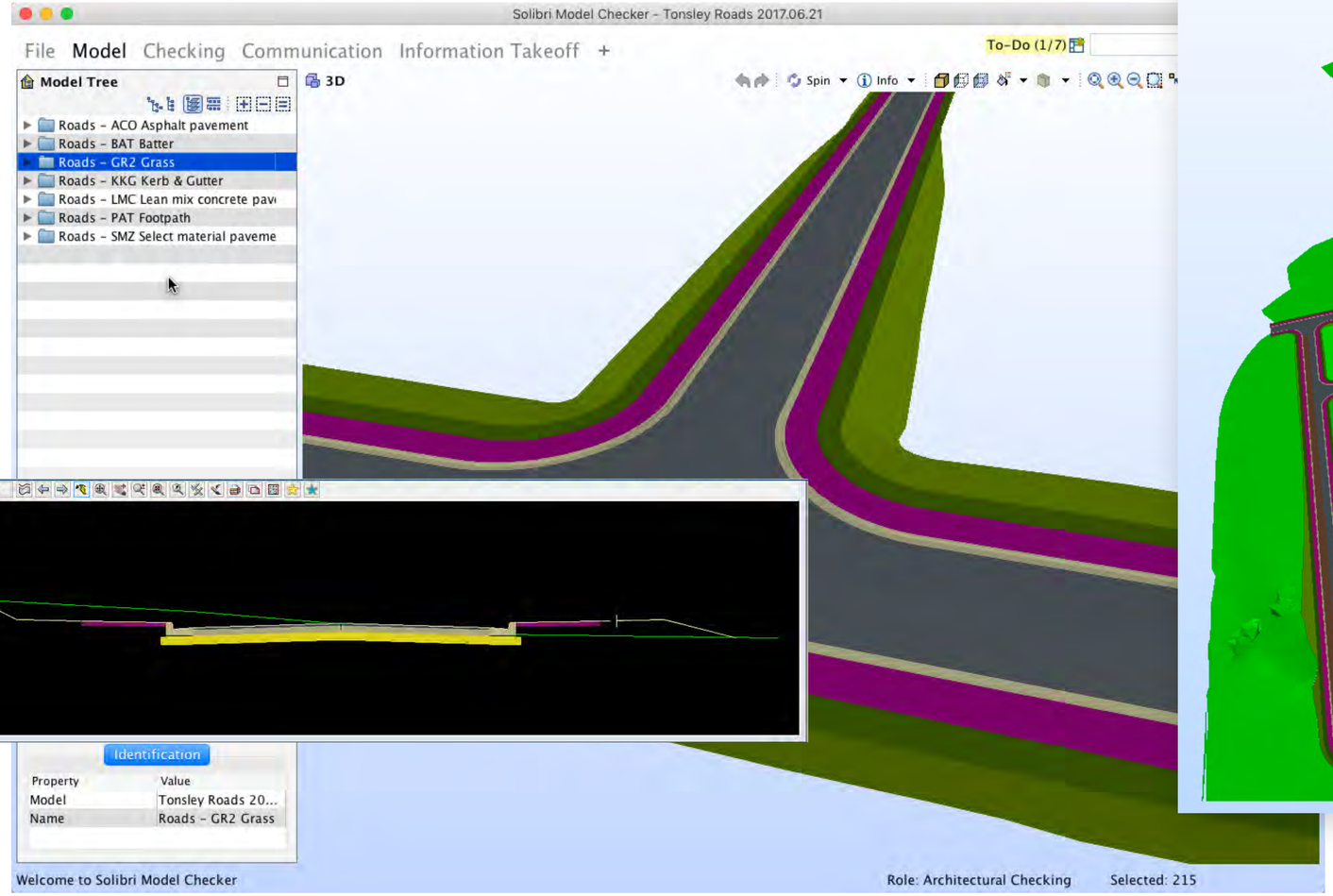
UTS BNo	Building Name	Gross floor area	Usable Floor Area (UFA)	Renew-ables	Sum of Potable	Sum of Potable	kWh	Cost ($)
CB01	Tower, Building 1	62,498	32,102	PV			20,058,097.99	$4,011,619.60
CB02	Building 2	24,063	16,246	PV				
CB03	Bon Marche, Building 3	6,725	4,677	PV				
CB04	Building 4, Science	30,516	21,808	Wind			5,580,498.121	$1,116,099.62
CB05	Haymarket, Building 5	35,515	24,828	Wind			5,851,989.824	$1,170,397.96
CB06	Peter Johnson Building, Building 6	29,605	15,617	Wind, PV			2,620,186.289	$524,037.26
CB07	Building 7 (Faculty of sciecne and graduate school of health building)	20,136	10,610				1,979,620.056	$395,924.01
CB08	Dr Chau Chak Wing Building, Building 8	18,450	10,799				2,355,469.7	$471,093.94
CB09	The Loft	205	188					
CB10	Building 10	44,948	26,732				6,775,657.48	$1,355,131.50
CB11	Building 11 (FEIT Building)	45,583	23,645				7,611,733.866	$1,522,346.77

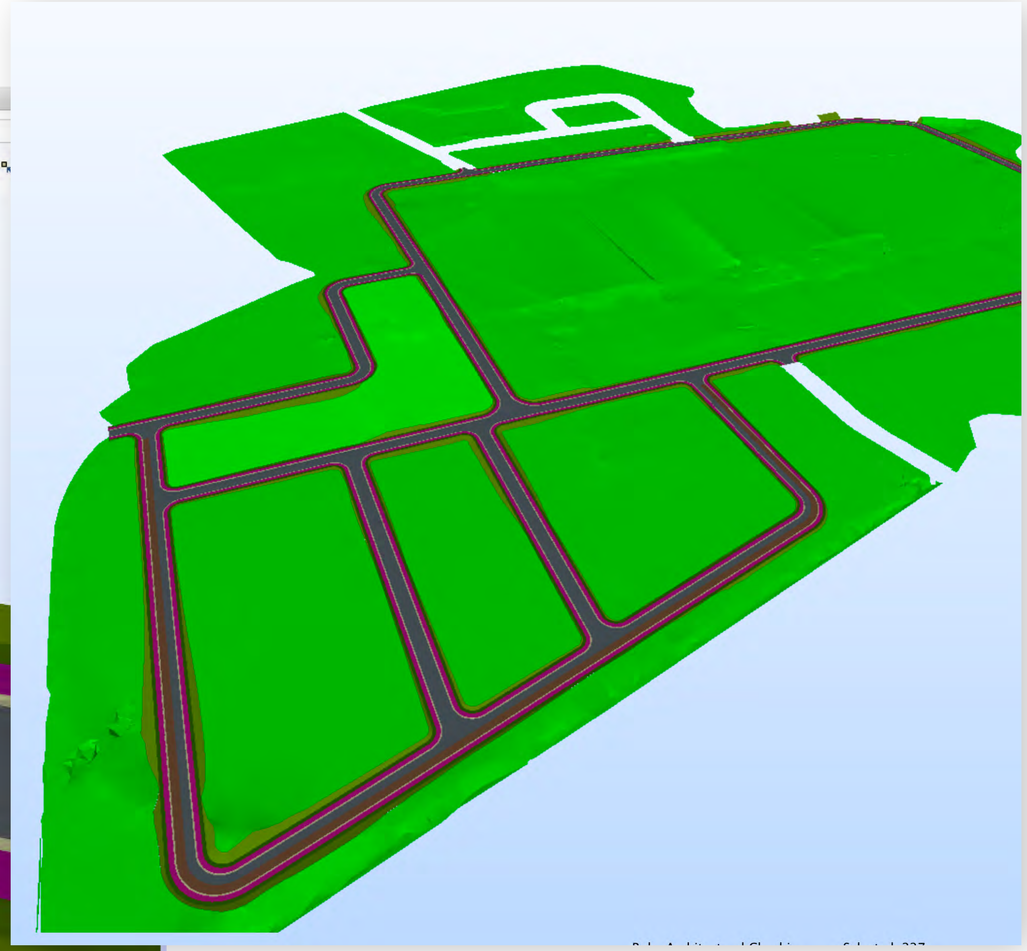
Monitoring Consumption Data (TAFE)



Building	Sum of Gross floor area (GFA)(m2)	Usable Floor Area (UFA)	Renew-ables	Sum of Potable Water Used (L) (per day)	Sum of Potable Water Used (KL) (per annum)	kWh	Cost ($)
A	4,193.11			6,133	2,238.545		
B	1,476.7			2,296	838.04		
C	3,741.78			1,699	620.135		
D	24,660.54			13,862	5,059.63		
E	6,649.05			26,849	9,799.885		
F2	6,152.72			16,039	5,854.235		
G	11,234.84			18,441	6,730.965		
H	5,536.77			20,810	7,595.65		
I	789.96			1,660	605.9		
J	1,344.55				0		
K	3,600.42			4,036	1,473.14		
L	2,606.38			3,457	1,261.805		
M	8,559.69			7,704	2,811.96		
N1	6,622.04			20,123	7,344.895		
O	2,824.37				0		
P	10,571.98				0		
Q	6,073.92			6,287	2,294.755		
W	22,248.25			48,442	17,681.33		
Z	1,461.91			7,964	2,906.86		

Adding Road elements to the site model





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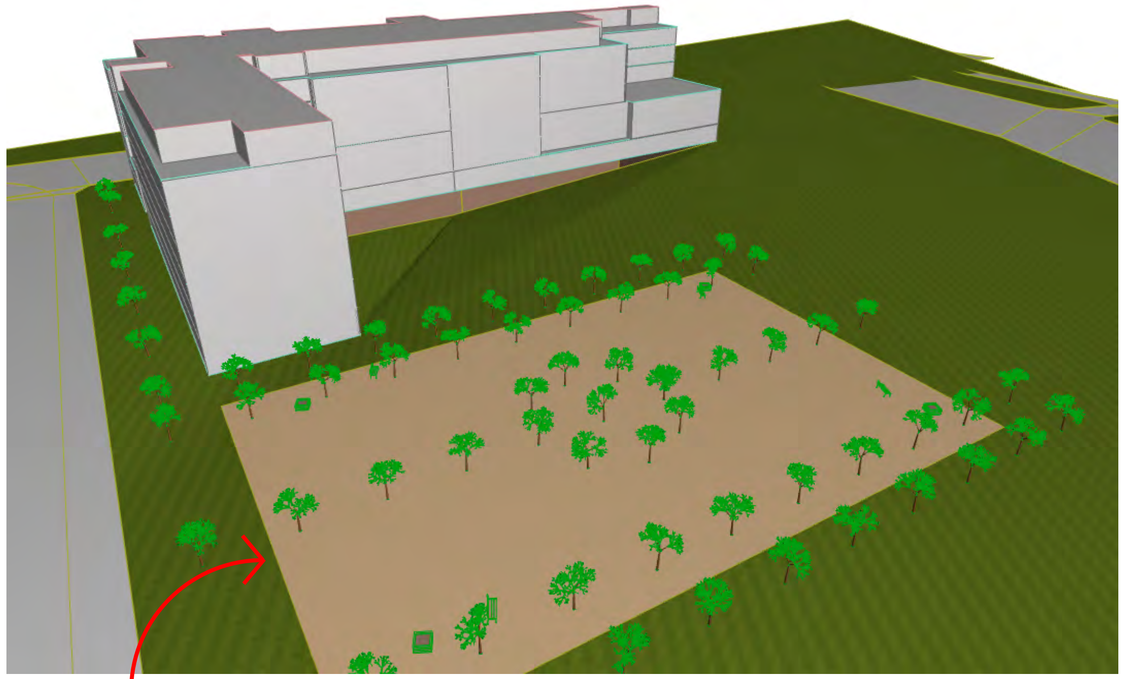
Landscape extensions (3D model view + an excerpt from PIM model file)

Façade and building surfaces

Facility space occupancies, and patterns of usage



Hard and soft landscape elements

Roads and pavements

```
#140682= IFCVEGETATIONPLANTCOVER('3gMArIIBR4IgKFbWYup6_U',#12,'GRASS-01',$,$,#140649,#140679,'EA58AD52-48B6-C44A-A50F-9608B8CC6F9E',$,.GRASS.,0.25);
#140686= IFCMATERIAL('Grass',$,$);
#140687= IFCSTYLEDITEM($,(#140671),$);
#140689= IFCSTYLEDREPRESENTATION(#91,$,$,(#140687));
#140691= IFCMATERIALDEFINITIONREPRESENTATION($,$,(#140689),#140686);
#140703= IFCMATERIALPROPERTIES('AC_Pset_MaterialCustom',$,(#140705,#140706),#140686);
#140705= IFCPROPERTYSINGLEVALUE('EmbodiedEnergy',$,IFCPOSITIVERATIOMEASURE(0.42),$);
#140706= IFCPROPERTYSINGLEVALUE('EmbodiedCarbon',$,IFCPOSITIVERATIOMEASURE(0.022),$);
#140707= IFCRELASSOCIATESMATERIAL('3$KYR4tFmZeGSR9_jbt8HC',#12,$,$,(#140682),#140686);
#140711= IFCVEGETATIONPLANTCOVERTYPE('0Ox3JVIl6pJa3qteecwS0u',#12,'Native Couch',$,$,$,$,'18EC34DF-4AF1-B34E-40F4-DE8A26E9C038',$,.NOTDEFINED.,.GRASS.,0.25);
#140712= IFCRELDEFINESBYTYPE('3cKkGNa$rlhzFIJk886au1',#12,$,$,(#140682),#140711);
```

Summary

The PIM examples have demonstrated

- digital planning frameworks - using City of Marion and City of Sydney data
- extension of asset types for precinct modelling - examples of cadastre, roads, vegetation and civic/urban space
- implementation of terminology and standardised properties for C02e and related environment impact measures
- large model considerations - derived from CoS FSES in GIS format
- methodology for structured data definition, acquisition and access - MVDs
- illustrative example of operational asset data - TAFE Building J
- comprehensive modelling of Tonsley ETWW project data - integrated data repository as backbone for applications

Thank you and Questions

PIM utilisation

Team members: **Jim Plume**, John Mitchell, David Marchant

Three approaches to effective utilisation of PIM

- Integration with existing information modelling standards
- Implementation in commercial software tools
- Opportunities for Australian leadership and innovation

Integration with existing information modelling standards

OGC/bSI Collaboration – Joint Standards development


buildingSMART
International home of openBIM

IFC Infra Overall Architecture Project

Documentation and Guidelines

Authors: André Borrmann (Project Lead), Julian Amann, Tim Chipman, Juha Hyvarinen, Thomas Liebich, Sergej Muhič, Laura Mol, Jim Plume, Paul Scarponcini

Status: FINAL (01/03/2017)

Road

Railways


buildingSMART
International home of openBIM

OGC

Joint OGC / bSI Whitepaper

Agreed Framework for Collaboration

02 May 2017

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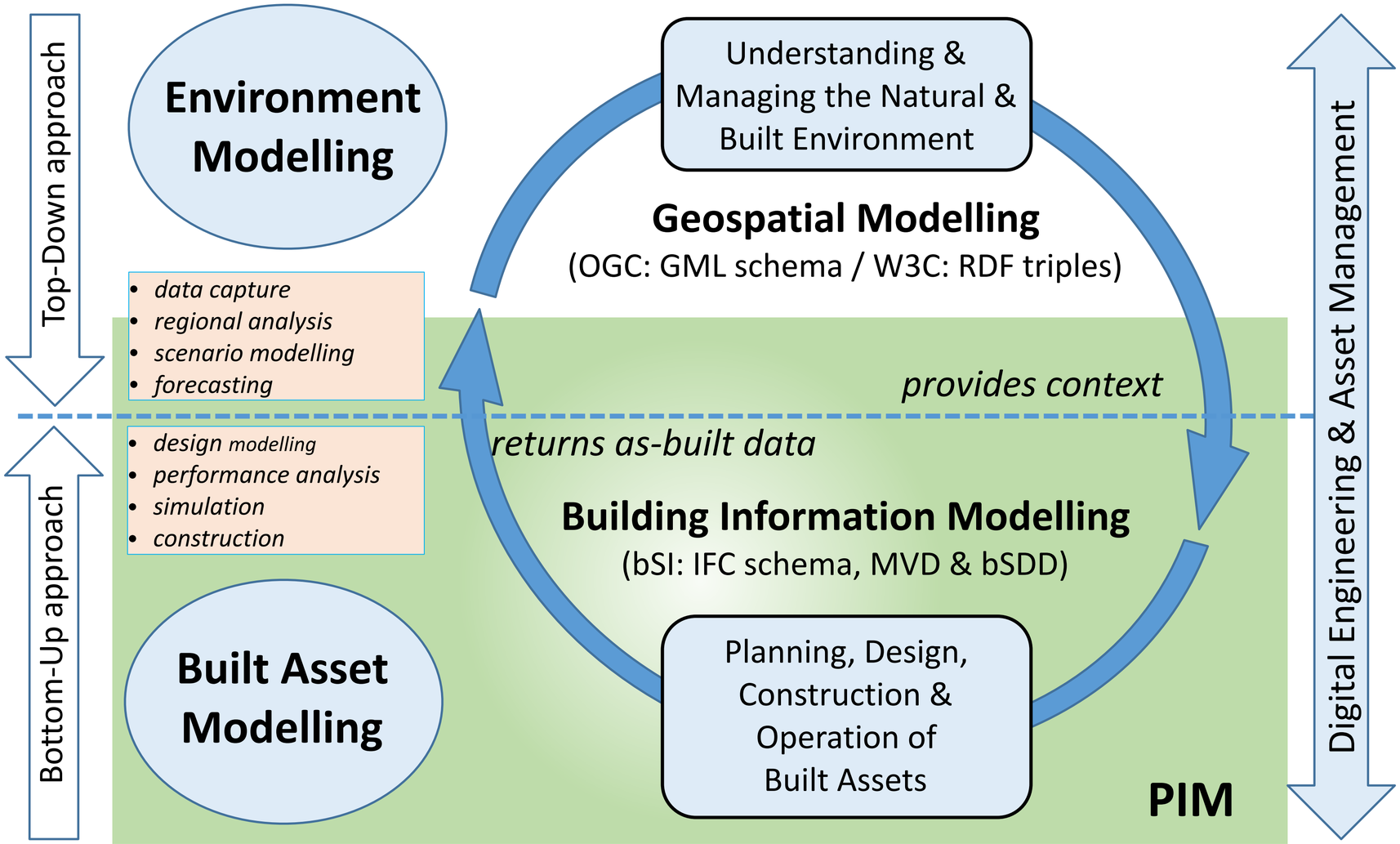
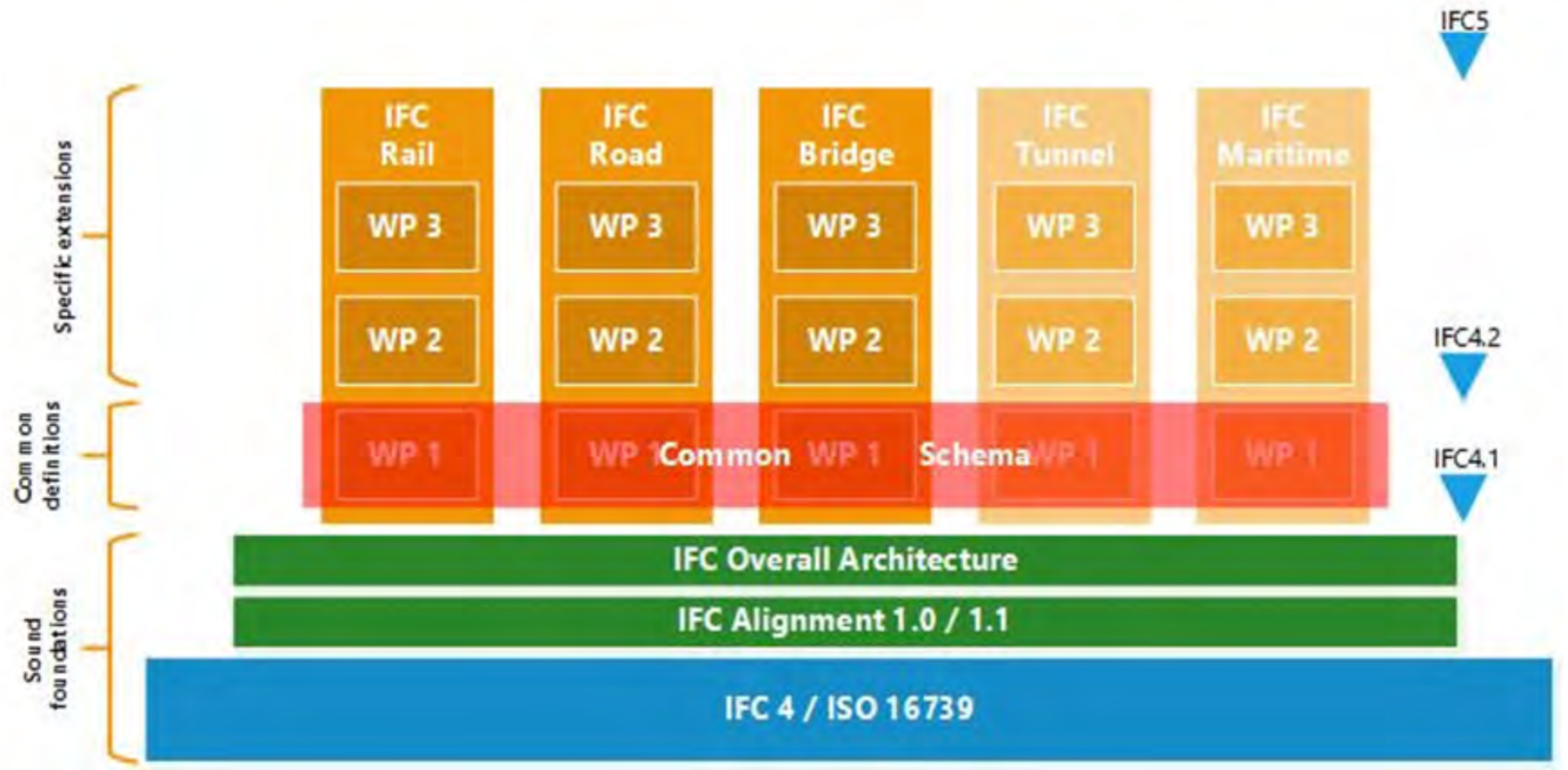
Integration with existing information modelling standards

Integrated Digital Built Environment



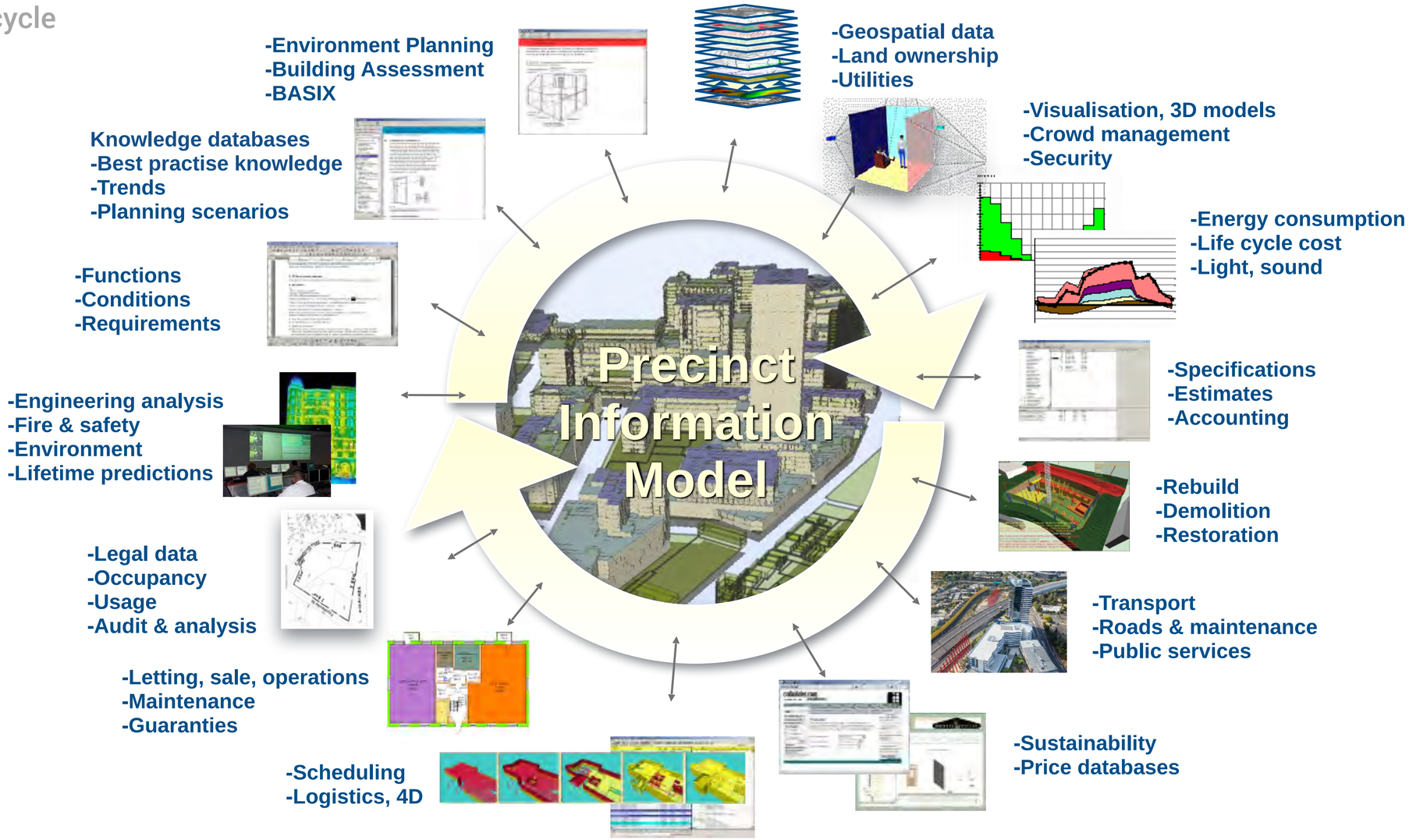
Implementation in commercial software tools

buildingSMART International Standards Development



Implementation in commercial software tools

Precinct lifecycle



Opportunities for Australian leadership and innovation

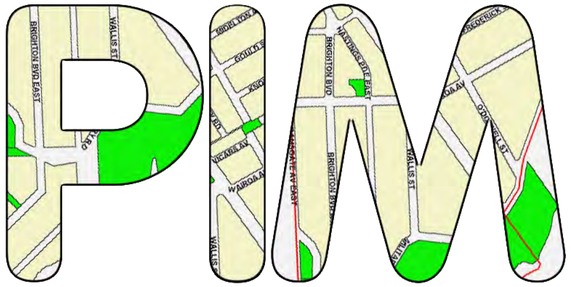
- Identify and implement a national C02e library (PIM granularity)
  - extend AccuRate across broader range of building types
  - support a national approach to product information as the basis for certification, compliance and integrated product data
- Adopt PIM as a backend technology activities such as the following:
  - the use of BIM models to assess DA/BAs
  - implement openBIM for BASIX assessments
  - integrate PIM into the 3D Cadastre initiative in Queensland
  - collaborate with other initiatives e.g. ACT Climate Change Strategy office – precinct-scale initiatives
  - adopt PIM as a data framework for the development of the NCOS

Opportunities for Australian leadership and innovation

- Implement PIM in Australian precinct projects, such as:
  - for new or existing urban centres
  - defence, health care or university facilities
  - precinct developments (greenfield, brownfield or greyfield)
  - major civic/infrastructure developments - eg Darling Harbour, Badgery's Creek Airport…
- Develop an adoption plan based on incremental steps with smaller projects or sub-projects to expand PIM expertise and deliver short term feedback and benefits realisation

Our Collaborators - thanks for your many contributions

Steve **Hillier**	FSES Manager	City of Sydney, AU
Jorulv **Rangnes**	Director	EPM Technology, NO
Lee **Gregory**	Civil Modelling and Geo-referencing	12D Solutions Pty Ltd
Joel **Allsop**	Road modeller	Extra Dimension Solutions, AU
Adrian **McGregor**	Landscape/urban designer	McGregor Coxall, AU
Julian **Carr**	Landscape/urban space modelling	OzCAD Pty Limited, AU
Jiri **Haitenan**	IFC Modelling	Datacubist Oy, FI
Paul **Cusack**	Railway Modelling	Bentley Systems Pty Ltd, AU
Craig **Walker**	Building Services Modelling	NDY Pty Ltd, AU
Tim **Chipman**	IFCdoc Documentation Tool	Constructivity, US
David **Shorter**	Architectural Modelling	MsDesign, AU
Claudio **Benghi**	xBIM developer	University of Northumbria, UK
Tuan **Ngo**	Project Leader	University of Melbourne, AU
Oliver **Lade**	Modeller	University of Melbourne, AU
Brandon **Lim**	Software Developer	University of Melbourne, AU
Tom **Hore**	Architectural Technology	St George TAFE, AU



Thank you

Information Modelling at a Precinct Scale to Manage the Carbon Load of the Built Environment

Jim Plume, David Marchant, John Mitchell

LOW CARBON LIVING CRC

Brookfield MULTIPLEX | BM

UNSW AUSTRALIA

aurecon

AECOM

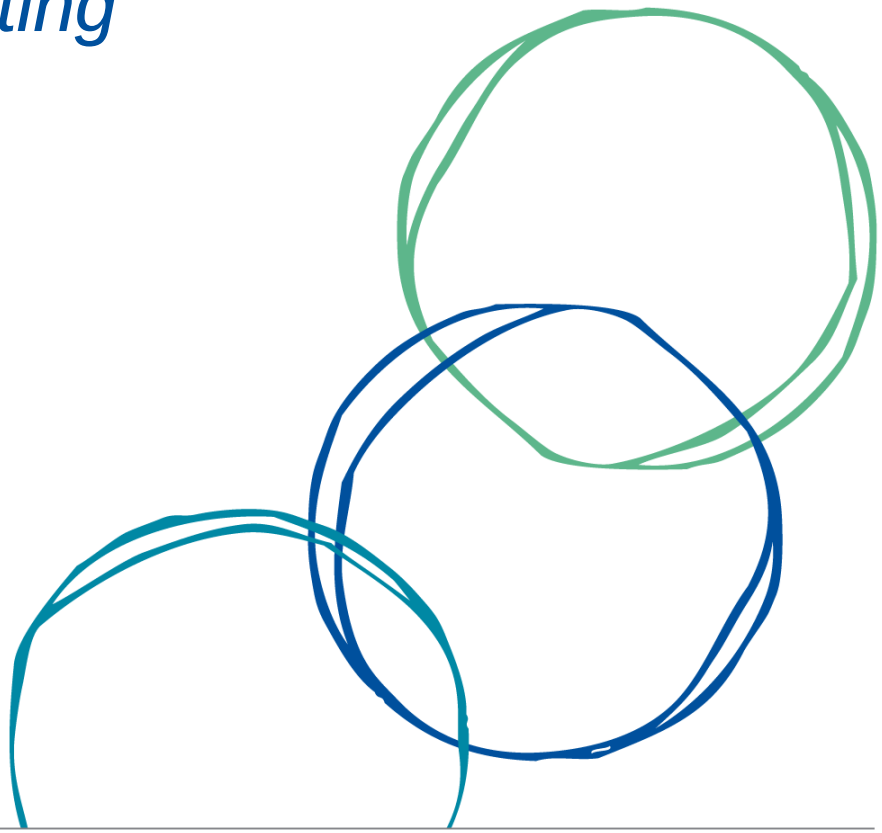
buildingSMART AUSTRALASIA

An Australian Government Initiative

CRC

CRC LCL Research Project 2002:

Integrated Energy Transport Waste and Water Demand Forecasting and Scenario Planning for Precincts.



PIM Industry Symposium,

UNSW, Sydney, Friday 15th September 2017.

Our Research Aims

Original ETWW project proposal:

"…deliver a method and tool for the simultaneous estimation of the demands for **energy** consumption, **travel**, **water** consumption and **waste** disposal facilities by **households** in **residential areas** of **Australian cities**, implemented as a **software tool** for use by planners and developers.

The method will be able to include the **impacts** of voluntary **behaviour change** by households.

This will allow **planners and developers** to assess the **total demands** for energy, transport, waste and water in the planning, design and evaluation of residential developments, including their **carbon impacts**."

Research Focus

- **Integrated** demand and carbon impact assessment,
- Possible to assess not only the **physical structure** of the precinct but also a variations to **resident population** ‘type’,
- Software tool for demand forecasting and scenario evaluation with specific forecast **scenario inclusions**,
- Goes beyond the household to recognise **other land uses, green areas** and precinct-scale **infrastructure**,

Lochiel Park precinct.

Proposed Tonsley precinct masterplan.

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Modelling Domains and Approaches

- **Energy:**
  - Steven Percy (PhD candidate, UniMelb/CSIRO),
  - Demand forecast process combined with battery solar optimisation model.
- **Transport**
  - Nicholas Holyoak (Post-doc, Flinders Uni), Michael Taylor (Em Prof., UniSA) (Rocco Zito, Prof. Flinders Uni), Branko Stazic (PhD candidate, flinders Uni) Ivan Iankov (PhD, UniSA),
  - Macro and 'nano' scale demand representations for internal and external precinct-travel.
- **Water**
  - Michalis Hadjikakou (Post-doc, UNSW),
  - Water demand forecasting model with end use components.
- **Waste**
  - He He (PhD candidate, UniSA),
  - Regression and factor analysis based forecasts of waste production.

Currently, the project's **Final Report*** provides more detail on each of these models and includes case study applications.

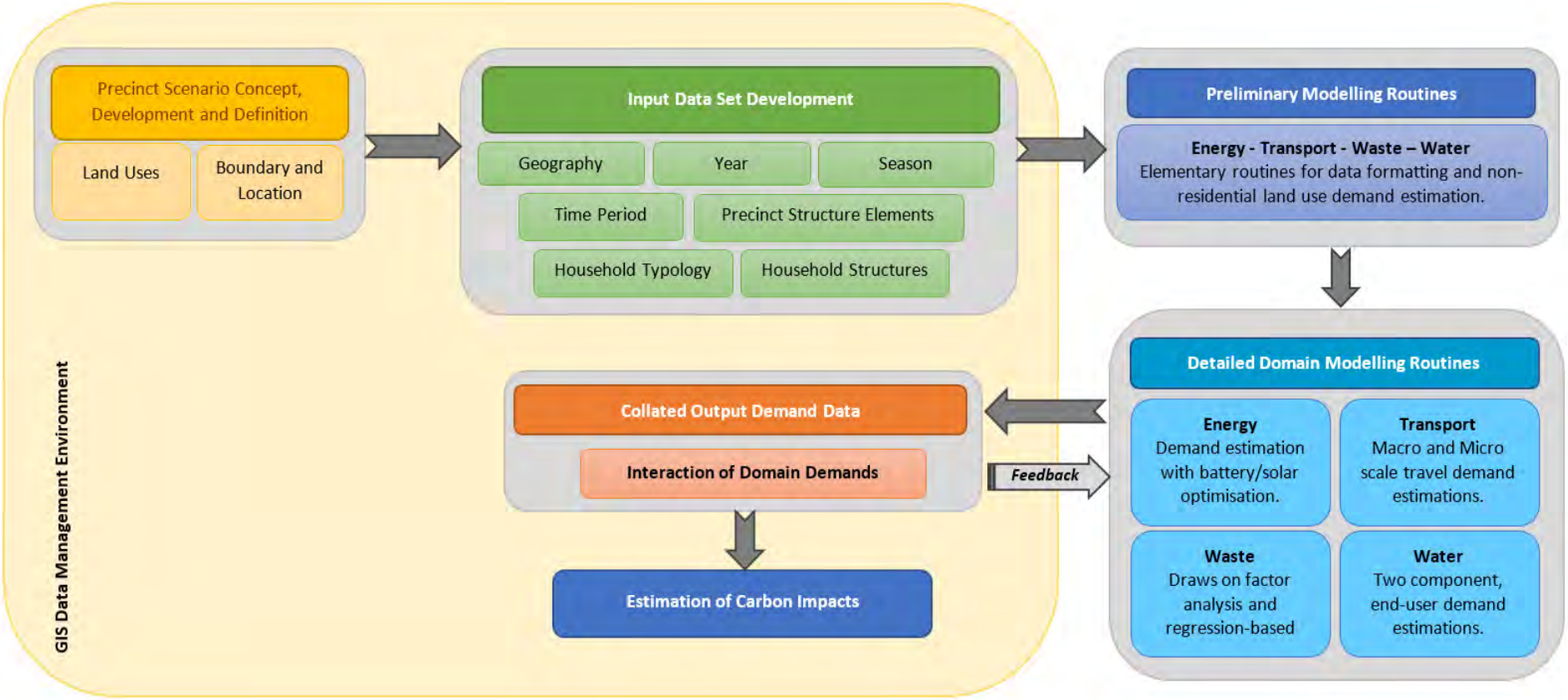
****now available through the CRC website.***

Project Participants

A Forecast Tool For…

- planning agencies,
- infrastructure providers,
- infrastructure operators,
- private developers,
- researchers,
- … and others!

Modelling Approach



Features:

- *GIS assisted precinct definition and output presentation,*
- *A range of behaviour, technology and policy-related options for forecasting scenarios (eg. electric vehicles, solar performance, working from home),*
- *Internal routines and connections to external modelling applications*
- *Interaction of household demands,*
- *Estimation of and carbon impacts, (disaggregated and total precinct).*

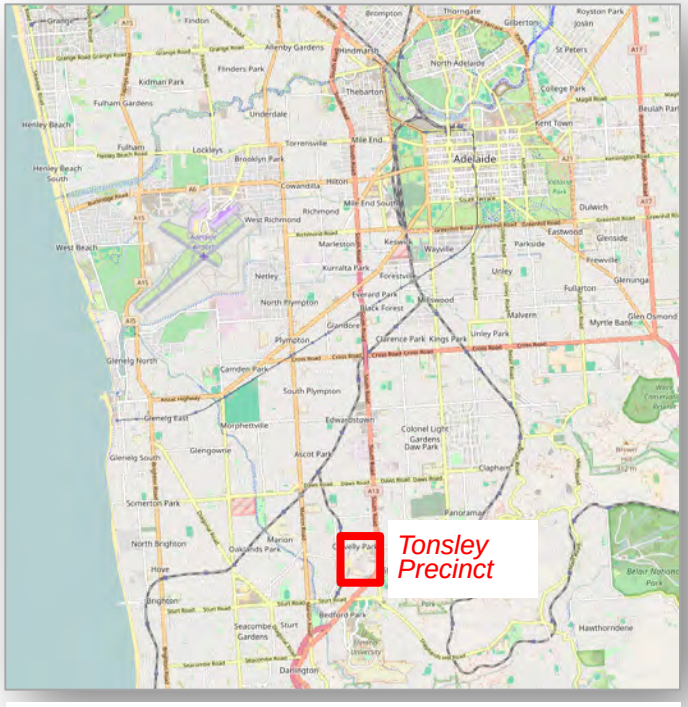
Tonsley: A Case Study Application

Tonsley Forecasts

The Tonsley Precinct:

- Located 11km South-West of Adelaide CBD,
- Mixed use precinct,
- 3 x scenario forecasts
- All scenarios 2035 forecast with 862 households
- All scenarios other land uses (with employment) include

  - ➢ *Commercial,*
  - ➢ *Educational,*
  - ➢ *High Value Industry,*
  - ➢ *Open Space,*
  - ➢ *Car parking,*
  - ➢ *Mixed,*
  - ➢ *Retail,*
  - ➢ *No Designation,*
  - ➢ *Roof space.*

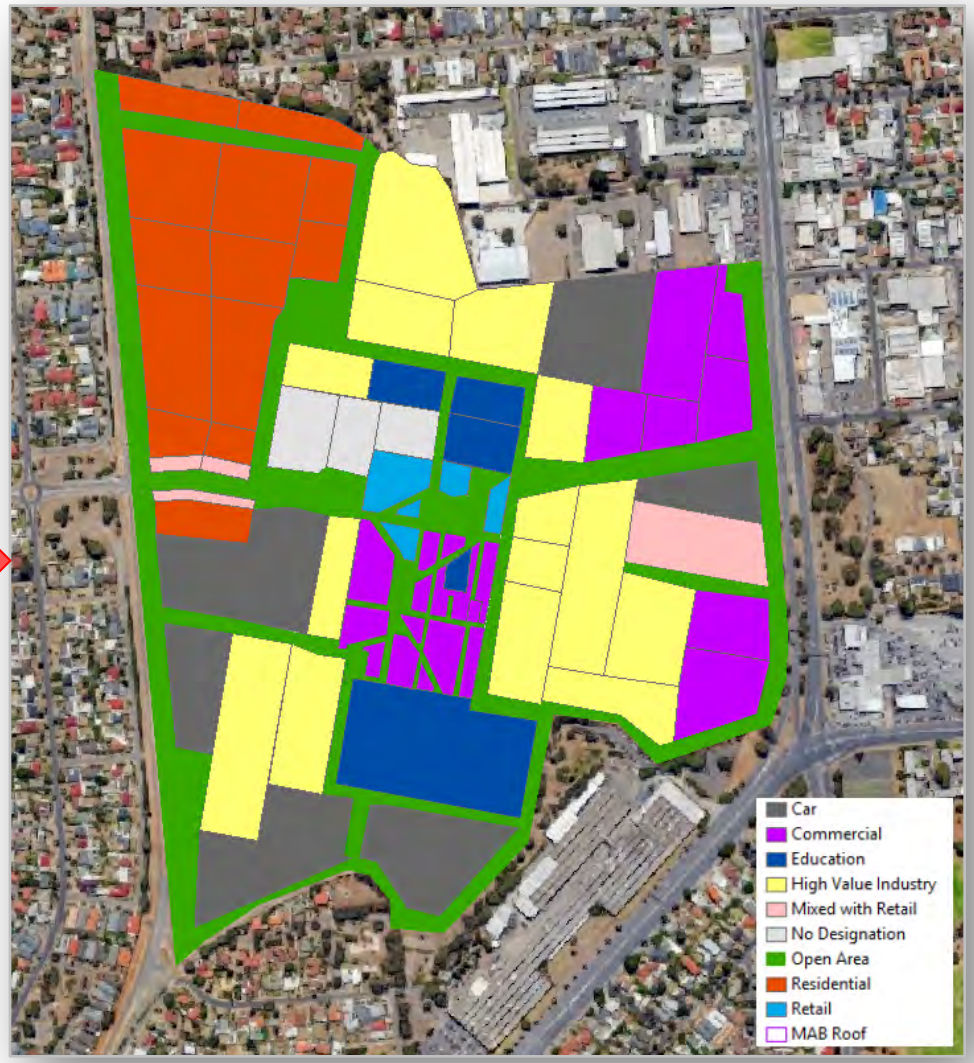


Location of the Tonsley precinct in Adelaide

- Road, cycle/walk networks included with connections to public transport
- Forecast for the month of October,
- Daily (24 hour) demand forecasting,
- Scope 2 (NGGAF) emissions for grid energy supply,
- Utilise current dump/recycling locations.

Tonsley Application

Strategic Precinct Information (Masterplan)



Configuration of Tonsley masterplan in the ETWW Model

LOW CARBON LIVING CRC

Tonsley

3 Forecast Scenarios…

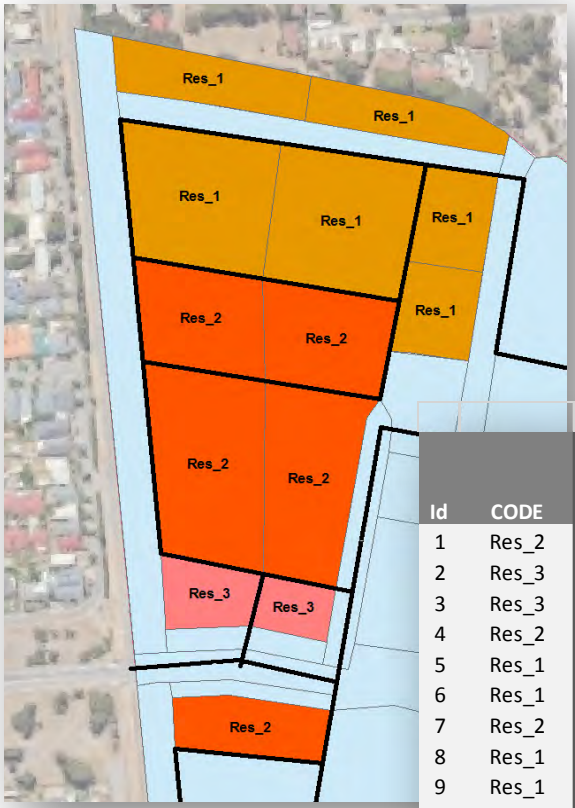
- **Scenario 1**: Baseline condition:
  - *With all residential area populated, and complete build-out of other land uses,*
  - *No scenario options applied.*

- **Scenario 2**: S1 plus inclusions for:
  - *Electric vehicle ownership and use,*
  - *Rainwater tank water use,*
  - *Wastewater recycling,*
  - *Activities from home,*
  - *Water consumption behaviour,*
  - *Energy use behaviour,*
  - *Recycling behaviour,*

- **Scenario 3**: Repeat of Scenario 2 inclusions
  - *with an altered resident population type.*

Tonsley: 3 Scenario Forecasts

Scenario 1, 2 and 3 resident typologies.

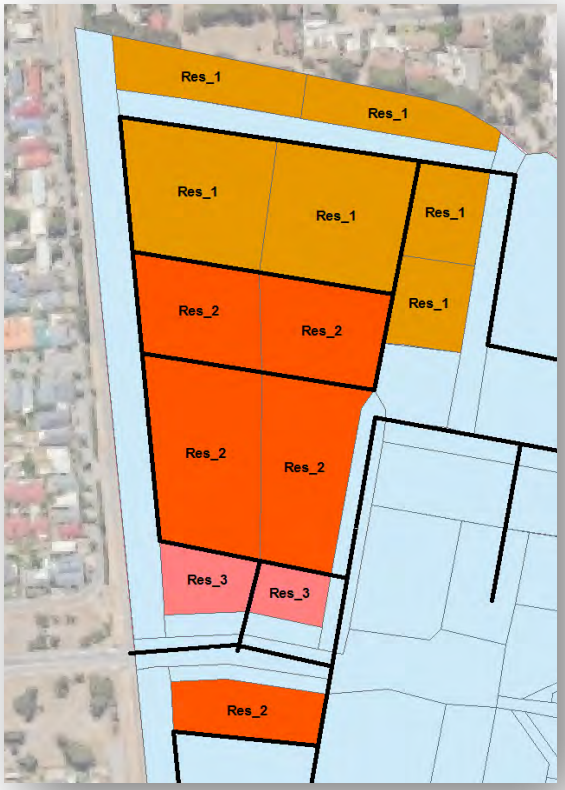


Same resident types

						Scenario 1	Scenario 2	Scenario 3
Id	CODE	Masterplan	Building Floors	Gross Floor Area	Residences	Mosaic Resident Type	Mosaic Resident Type	Mosaic Resident Type
1	Res_2	Residential/Mixed H_Res	4	12,204	51	**C14**	**C14**	**C13**
2	Res_3	Residential/Mixed F_Res	6	13,843	70	**I35**	**I35**	**F22**
3	Res_3	Residential/Mixed G_Res	6	9,401	48	**K38**	**K38**	**F24**
4	Res_2	Residential Central E_1	4	30,312	128	**C10**	**C10**	**A02**
5	Res_1	Residential Transition A_1	3	10,192	41	**C13**	**C13**	**B07**
6	Res_1	Residential Central B_1	3	21,226	86	**H30**	**H30**	**B09**
7	Res_2	Residential Central D_1	4	18,106	76	**C11**	**C11**	**D16**
8	Res_1	Residential Central C_1	3	7,494	30	**C12**	**C12**	**F22**
9	Res_1	Residential Transition A_2	3	8,749	35	**C11**	**C11**	**C11**
10	Res_1	Residential Central B_2	3	20,837	84	**C14**	**C14**	**C11**
11	Res_2	Residential Central D_2	4	18,093	76	**C10**	**C10**	**F21**
12	Res_2	Residential Central E_2	4	24,772	104	**H30**	**H30**	**J37**
13	Res_1	Residential Central C_2	3	7,813	32	**I34**	**I34**	**I34**

Tonsley: 3 Scenario Forecasts

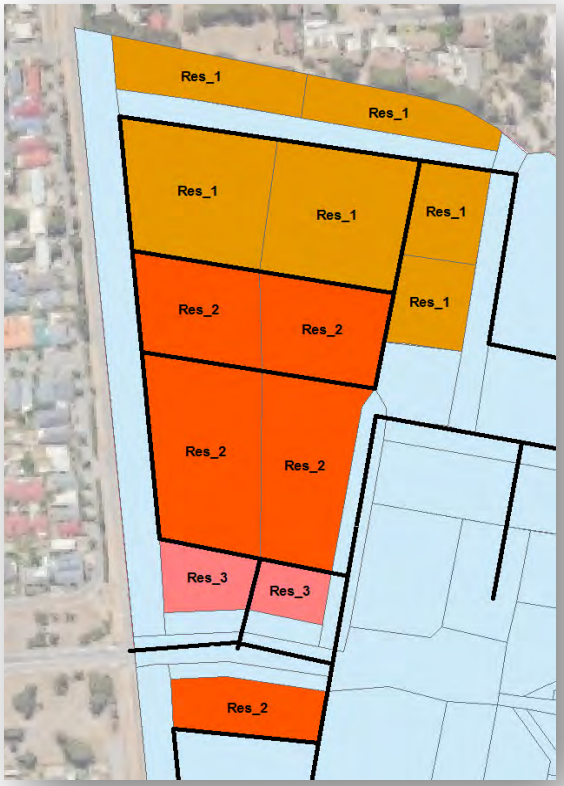
Scenario 1, 2 and 3 household structure types.



Attribute	Residence Type		
Residence Reference Number	**Res_1**	**Res_2**	**Res_3**
Reference Building	LightsView	Luminaire	Park Central
Built Footprint factor	61%	61%	66%
Residence Footprint Area	44.5	140	130
Floors	3	1	1
Total Residence Floor Area	151	145	130
Bedrooms	2	2	2
Bedroom Area	18%	22%	25%
Living Area	28%	27%	30%
Kitchen Area	11%	12%	12%
Wet Area	5%	6%	6%
Green Area	2%	4%	3%
Carpark Area	15%	17%	14%
Other Area	19%	12%	10%
Rainwater storage size	1	1	1
PV panels per residence	4	4	2
Elec - Cooking	1	1	1
Elec - AC	1	1	1
Elec - HotWater	1	1	1
Elec - Washer	1	1	1
Elec - Dryer	1	1	1
Elec - Fridge	1	1	1
Gas - Cooking	0	0	0
Gas - Heating	0	0	0
Gas - HotWater	0	0	0
Water - Showers	1	1	1
Water - Toilets	1	1	1

Tonsley: 3 Scenario Forecasts

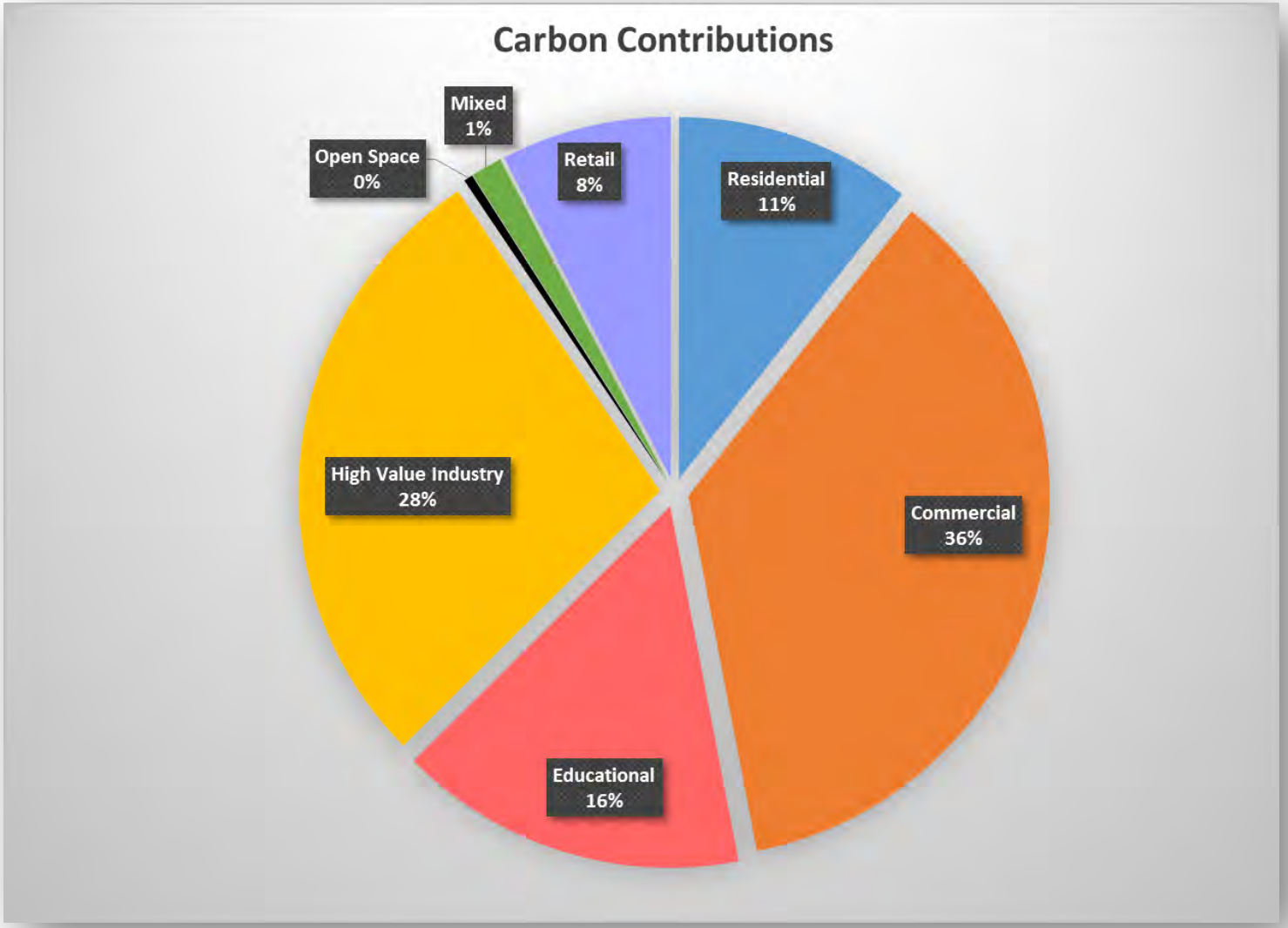
Scenario 2 and 3 included “scenario options”.



	Electric Vehicle			Rainwater Use	Wastewater recycling
Id	EV Type	Trip Purpose	% Travel by EV	% Rainwater Use	% Greywater Recycled
1	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
2	none	none	0%	**20%**	**15%**
3	none	none	0%	**20%**	**15%**
4	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
5	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
6	none	none	0%	**20%**	**15%**
7	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
8	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
9	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
10	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
11	**VW e-Golf**	**Home-Based Work**	**50%**	**20%**	**15%**
12	none	none	0%	**20%**	**15%**
13	none	none	0%	**20%**	**15%**

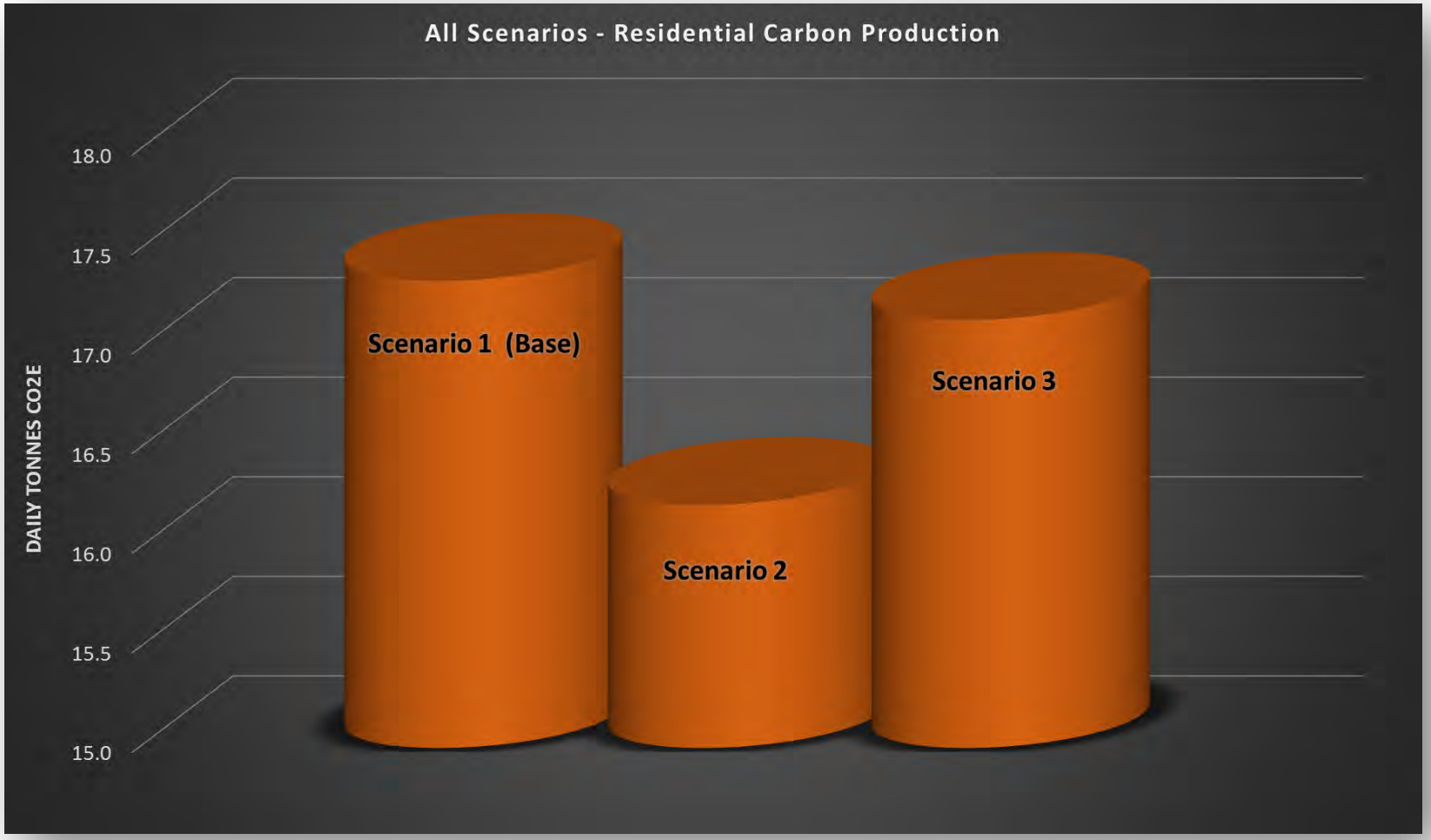
	Activities from home			Water consumption behaviou		Energy use behaviour		Recycling behaviour	
	Activity								
Id	Work	Shopping	Education	% change	increase or decrease	% change	increase or decrease	% change	increase or decrease
1	N	N	**Y**	**17%**	Decrease	0%	-	25%	Increase
2	**Y**	N	N	0%	-	15%	Decrease	20%	Increase
3	**Y**	N	N	0%	-	15%	Decrease	20%	Increase
4	N	N	**Y**	**17%**	Decrease	0%	-	25%	Increase
5	N	N	**Y**	**17%**	Decrease	0%	-	25%	Increase
6	**Y**	N	N	0%	-	15%	Decrease	20%	Increase
7	N	N	N	**17%**	Decrease	0%	-	25%	Increase
8	N	N	N	**17%**	Decrease	0%	-	25%	Increase
9	N	N	N	**17%**	Decrease	0%	-	25%	Increase
10	N	N	N	**17%**	Decrease	0%	-	25%	Increase
11	N	N	N	**17%**	Decrease	0%	-	25%	Increase
12	**Y**	N	N	0%	-	15%	Decrease	20%	Increase
13	**Y**	N	N	0%	-	15%	Decrease	20%	Increase

Tonsley: Carbon Impacts



Tonsley: Carbon Impacts of 3 Scenarios

Daily residential carbon.



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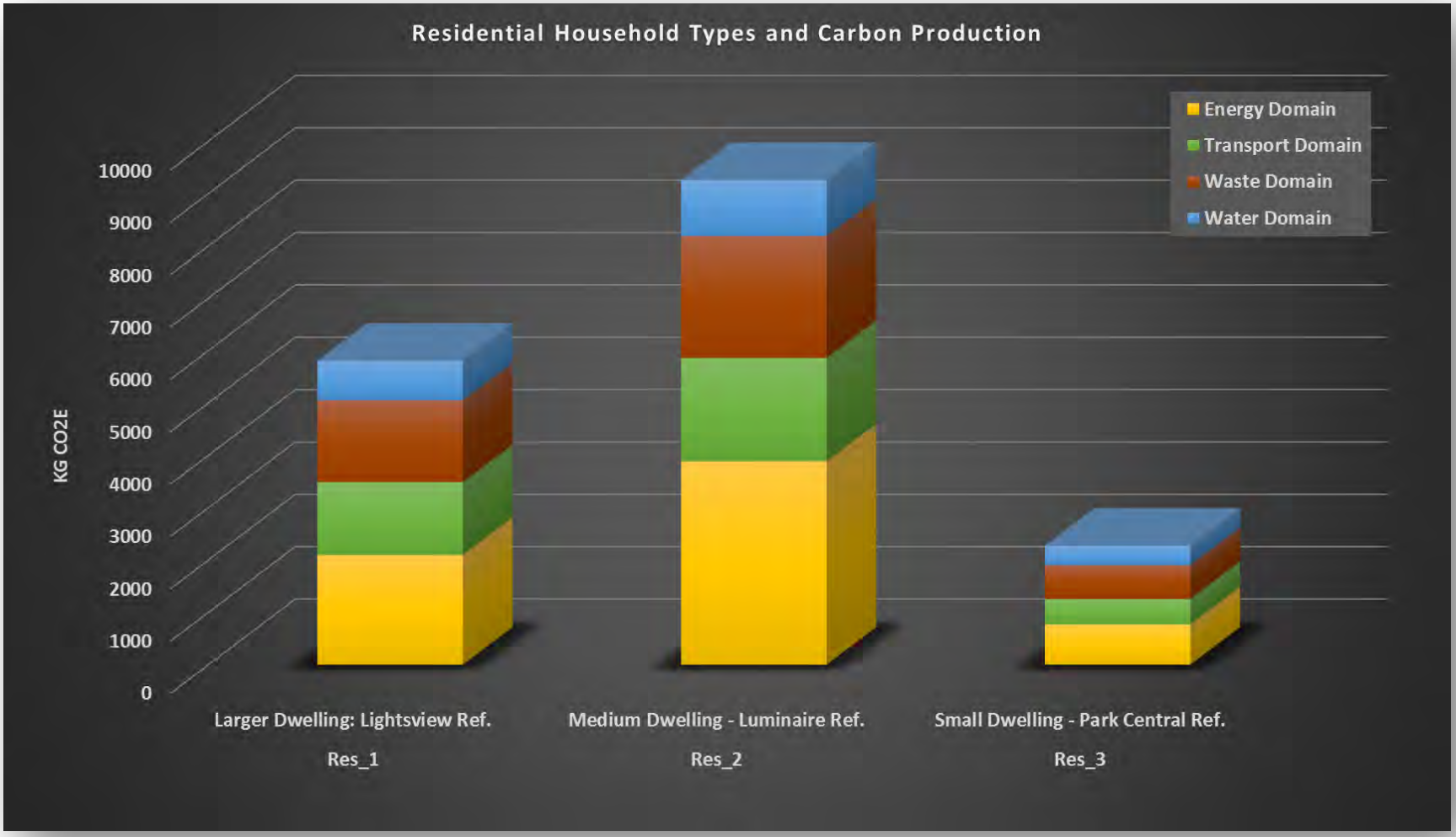
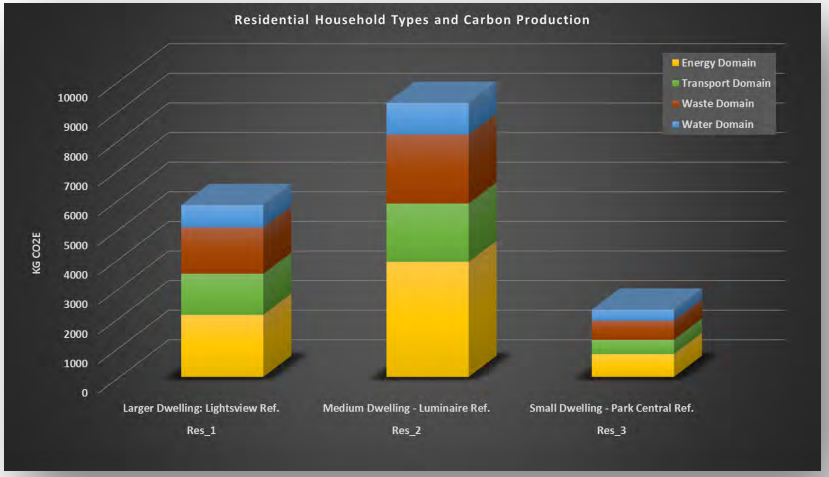
Tonsley: Carbon Impact of Base Scenario

Daily residential carbon by household type and domain.

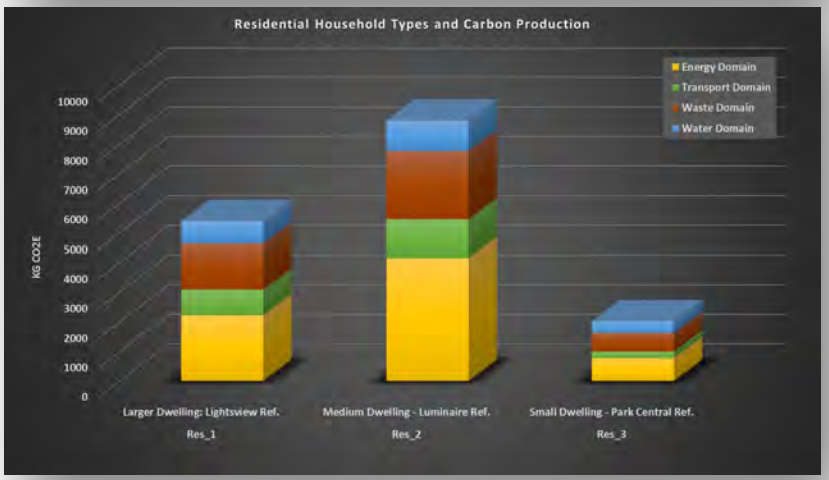


Tonsley: Carbon Impact of 3 Scenarios

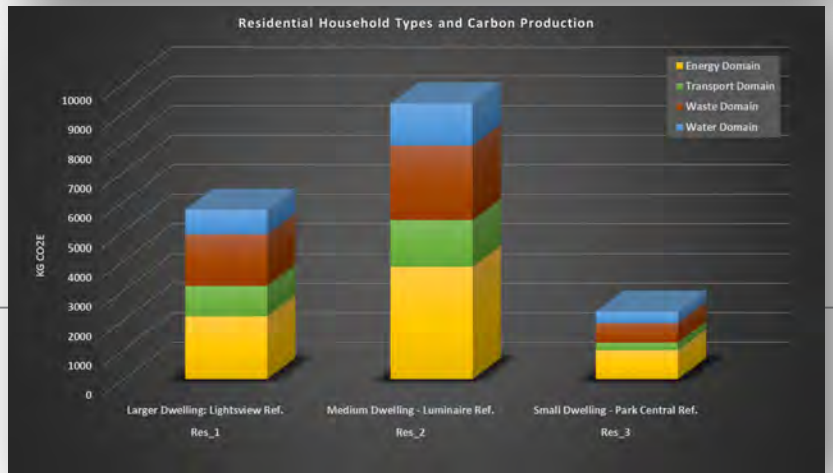
Daily residential carbon by household type and domain.



Scenario 1



Scenario 2

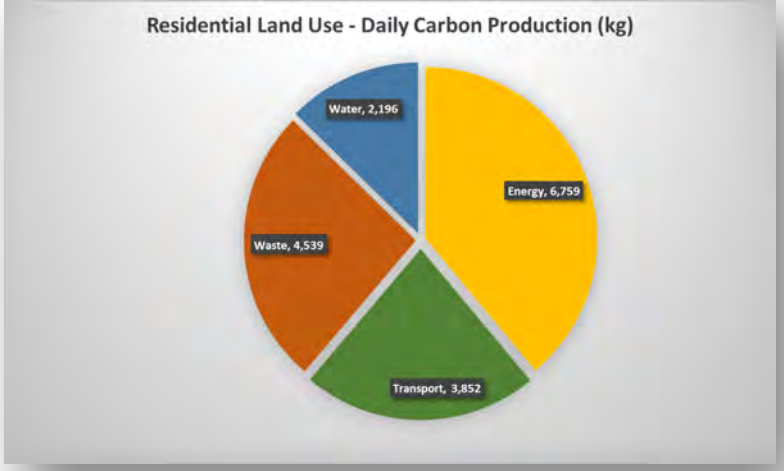


Scenario 3

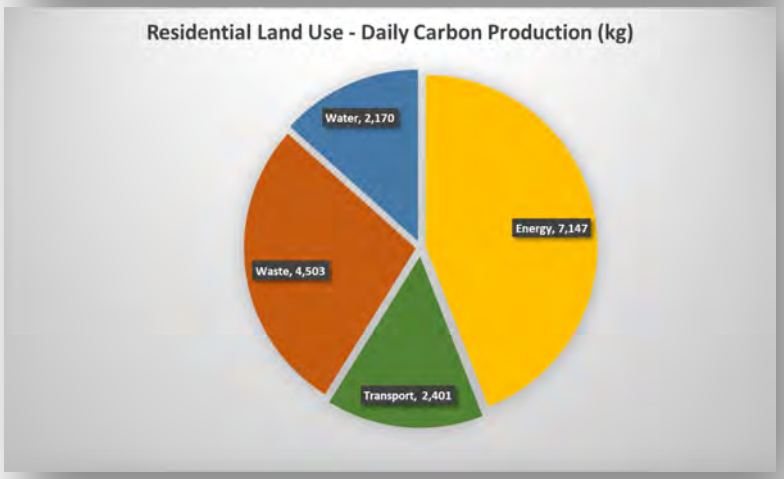
LOW CARBON LIVING CRC

Tonsley: Carbon Impact of 3 Scenarios

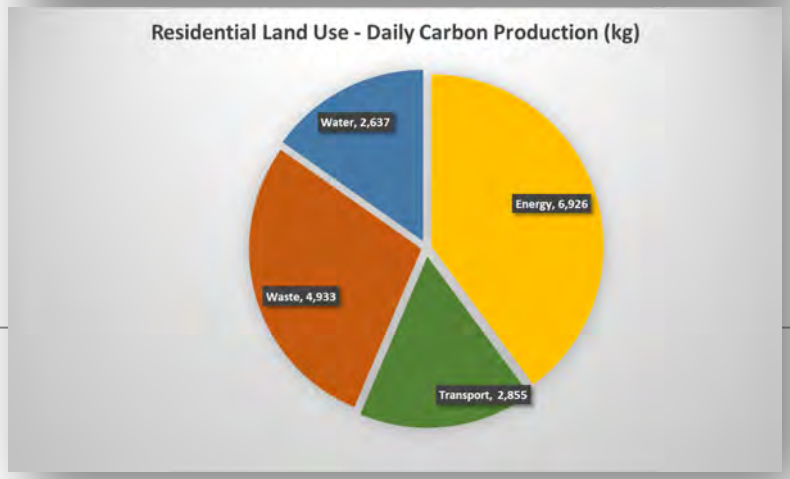
Daily residential carbon by domain.



Scenario 1



Scenario 2

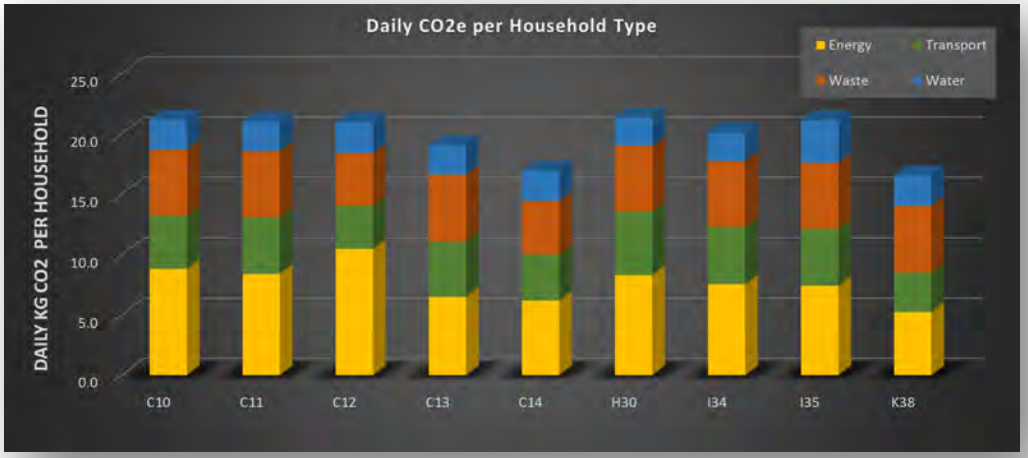


Scenario 3

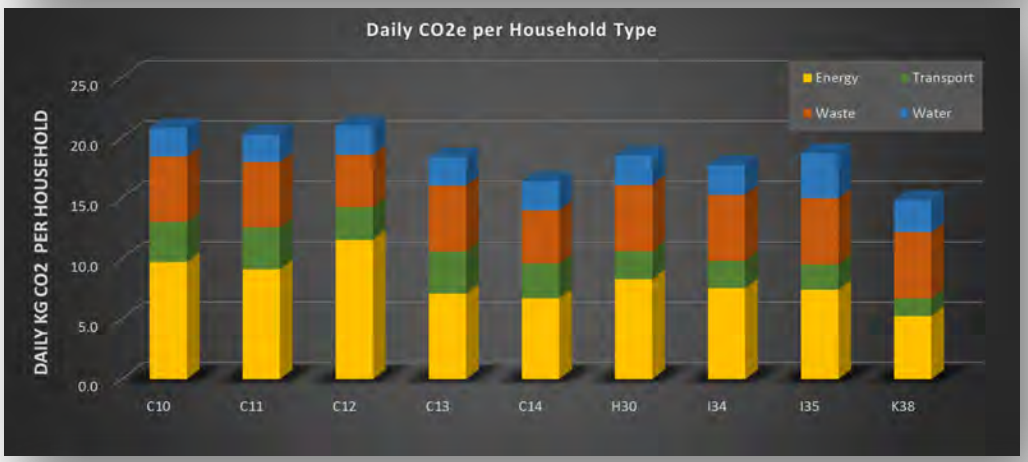
LOW CARBON LIVING CRC

Tonsley: Carbon Impact of 3 Scenarios

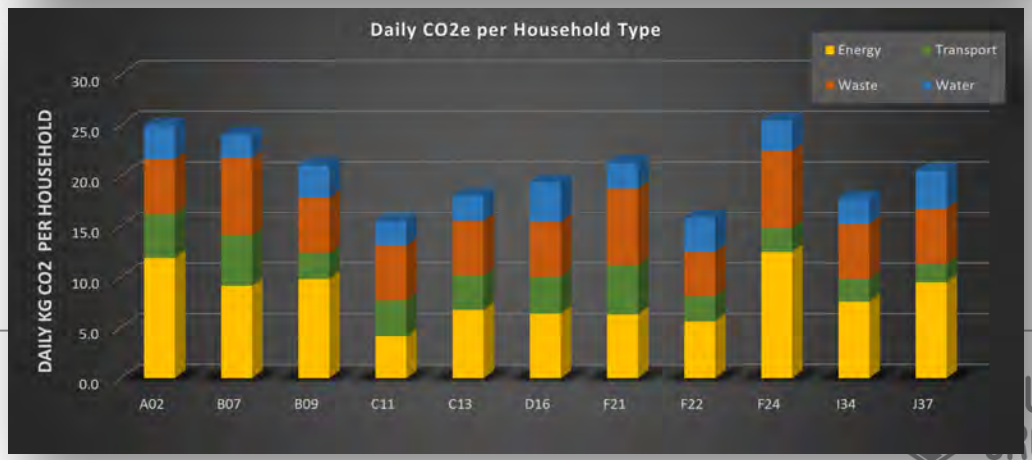
Daily residential carbon by resident type and domain.



Scenario 1



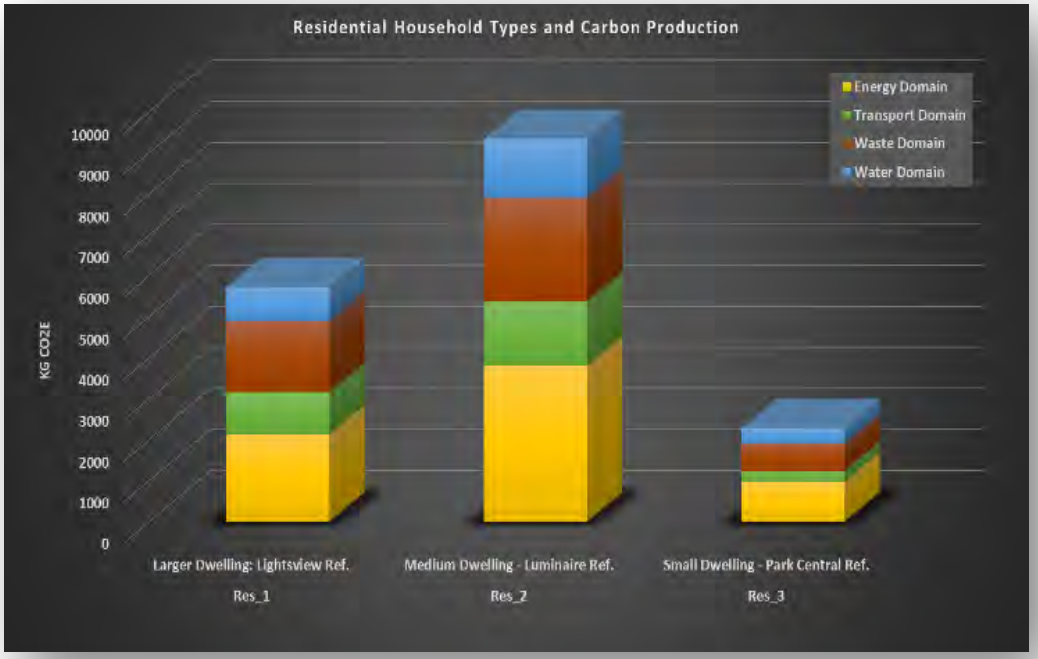
Scenario 2



Scenario 3

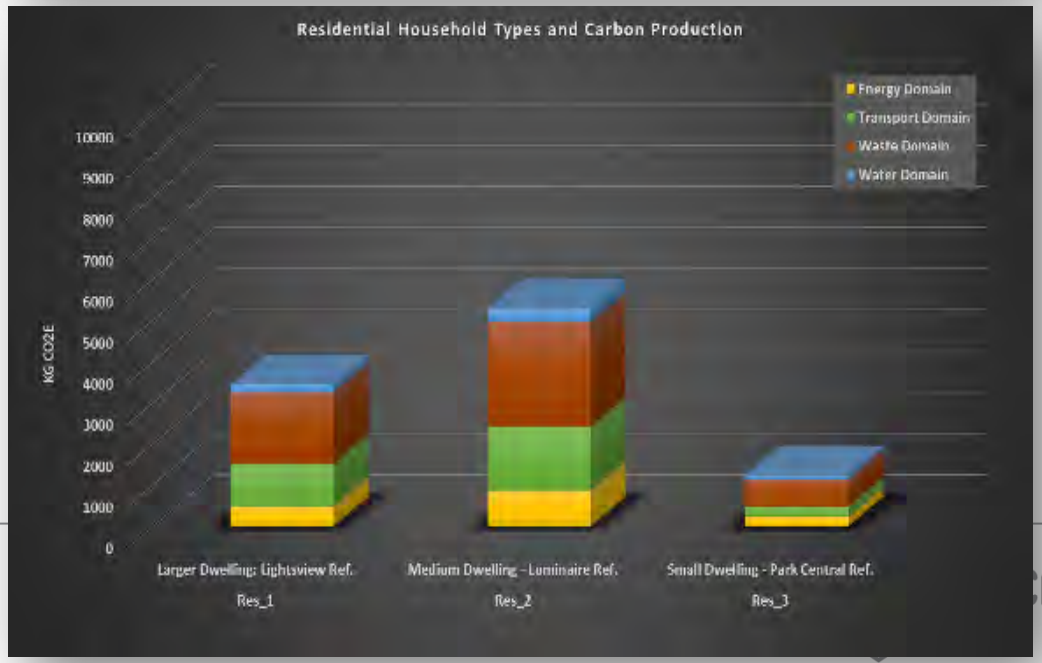
Tonsley: Carbon Impact of Grid Energy

Powering our grid with Tasmanian energy.



Scenario 3 with SA power

0.53 kg CO2/ kWh

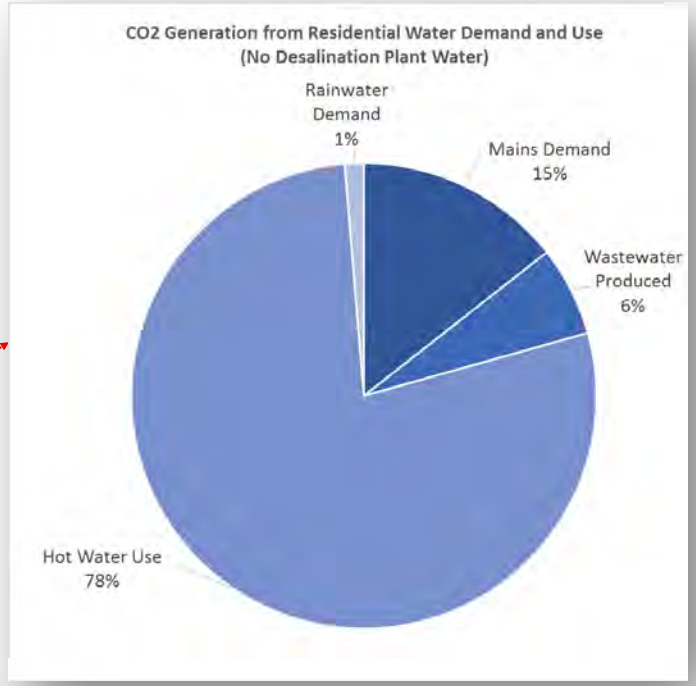


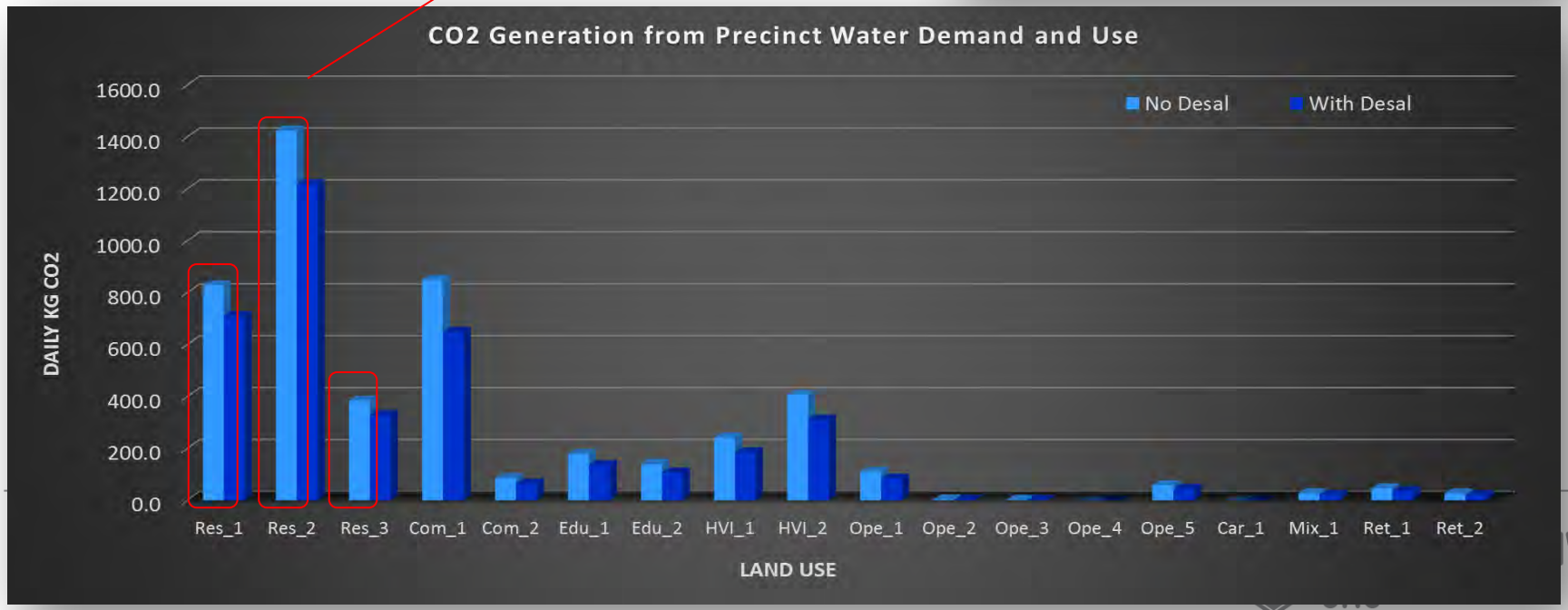
Scenario 3 with Tassie power

0.12 kg CO2/ kWh

Tonsley: Carbon Impact of Desalination Plant Water Supply

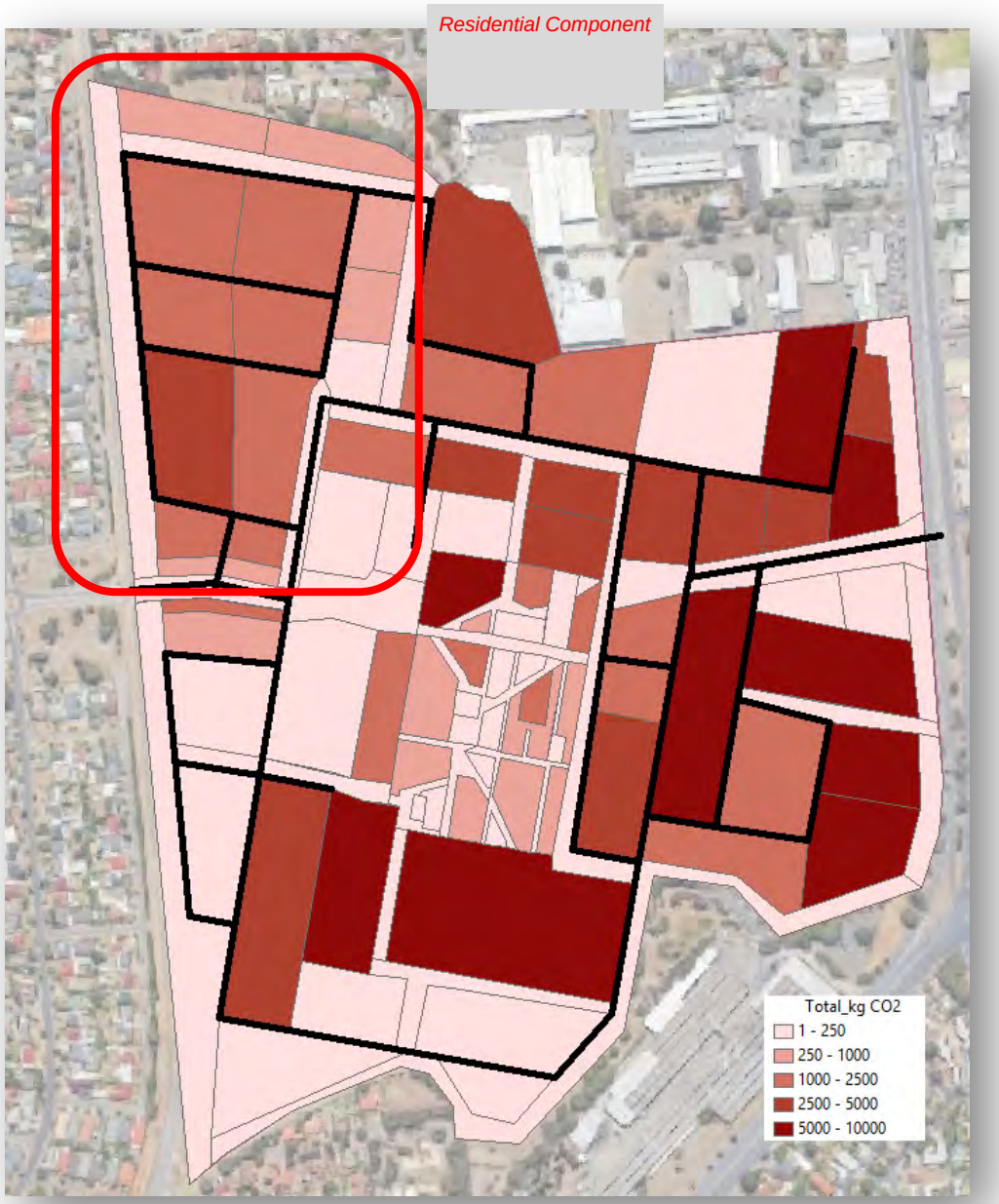
Utilising SA's desal plant to supply water networks …
100% offset with renewables.





Tonsley: Carbon Impact of Scenario 3

Daily carbon for all precinct land uses



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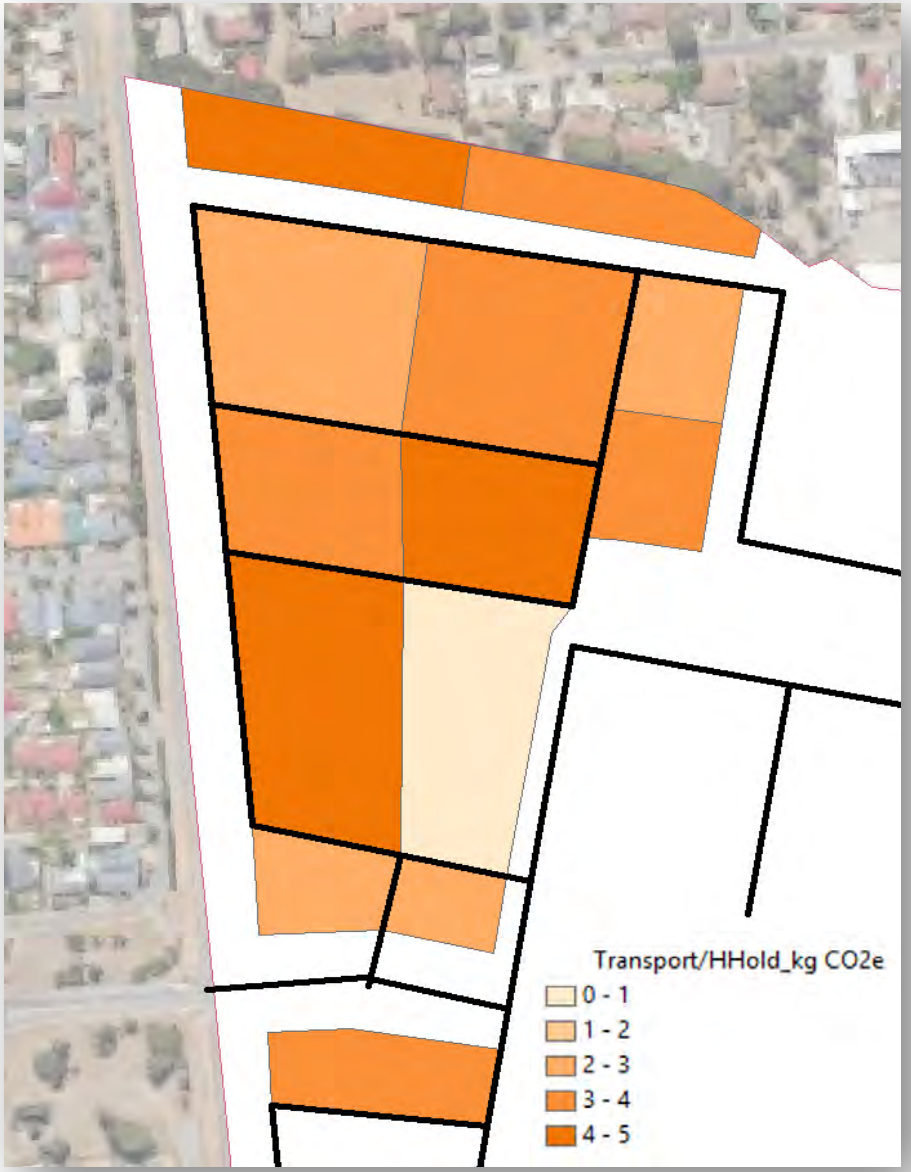
Tonsley: Carbon Impact of Scenario 3

Daily transport domain carbon

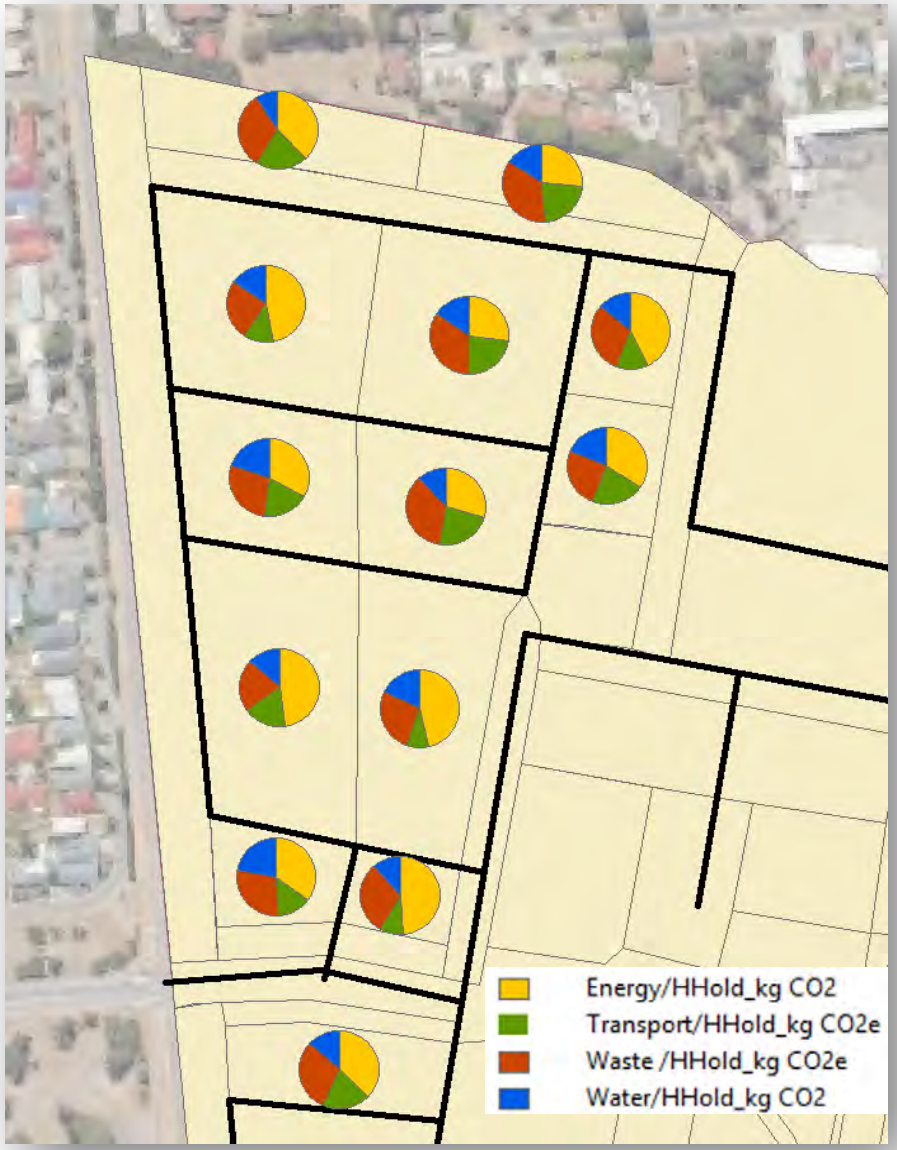
kg per household for the **residential zones only**.



Tonsley: Carbon Impact of Scenario 3

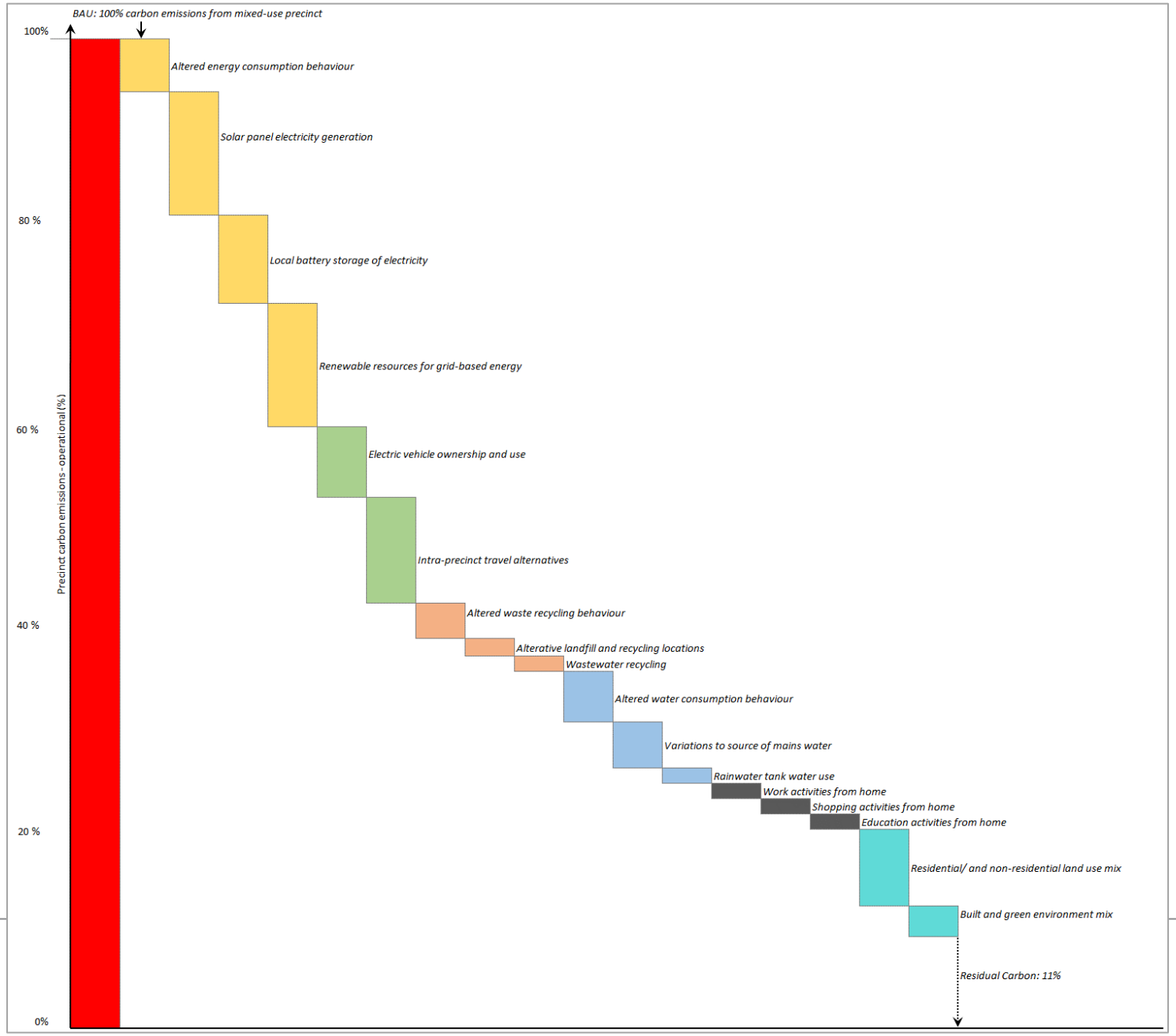
Daily carbon proportions for all domains

Residential zones only.

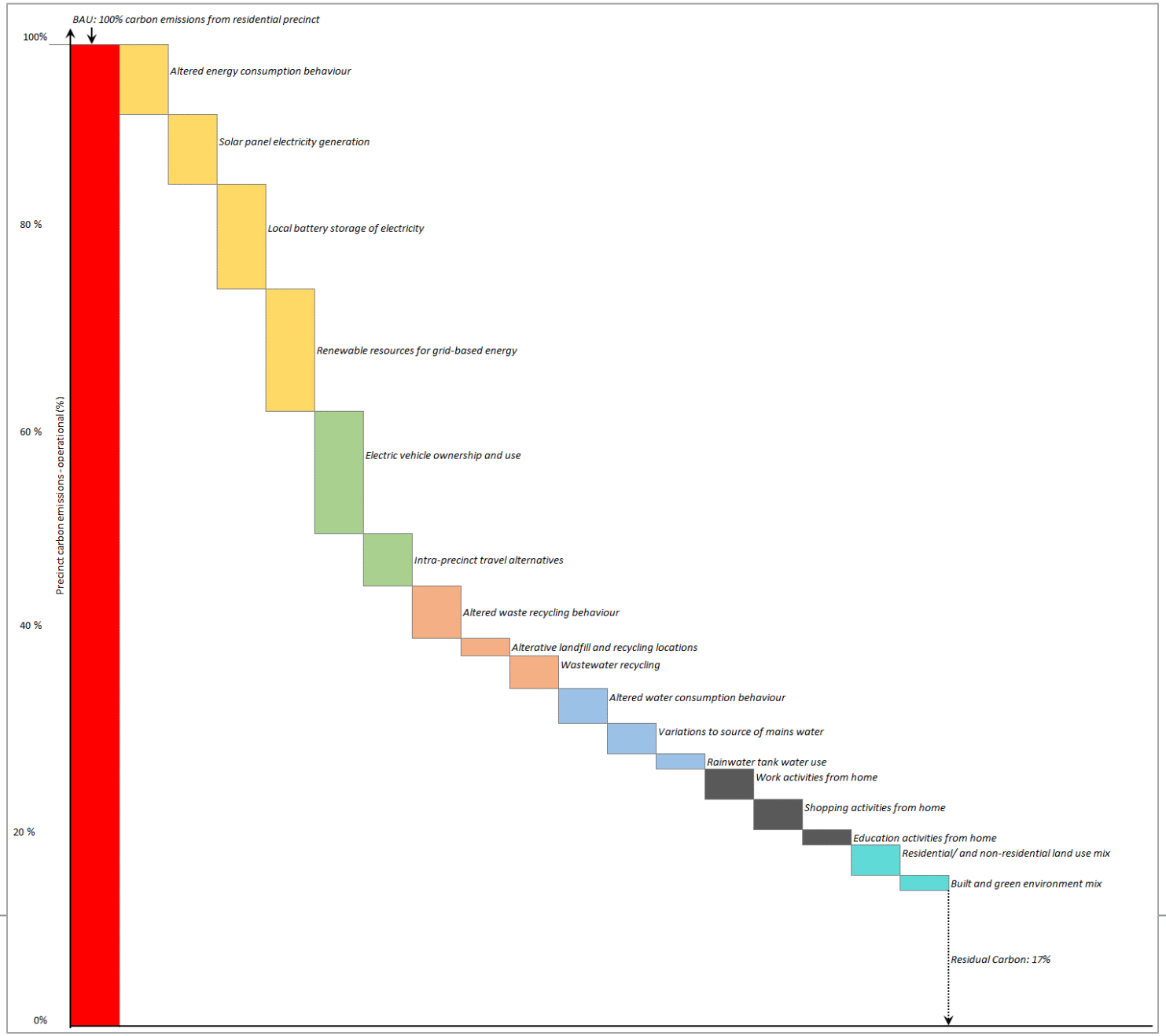


Carbon Reduction Potential in a Precinct

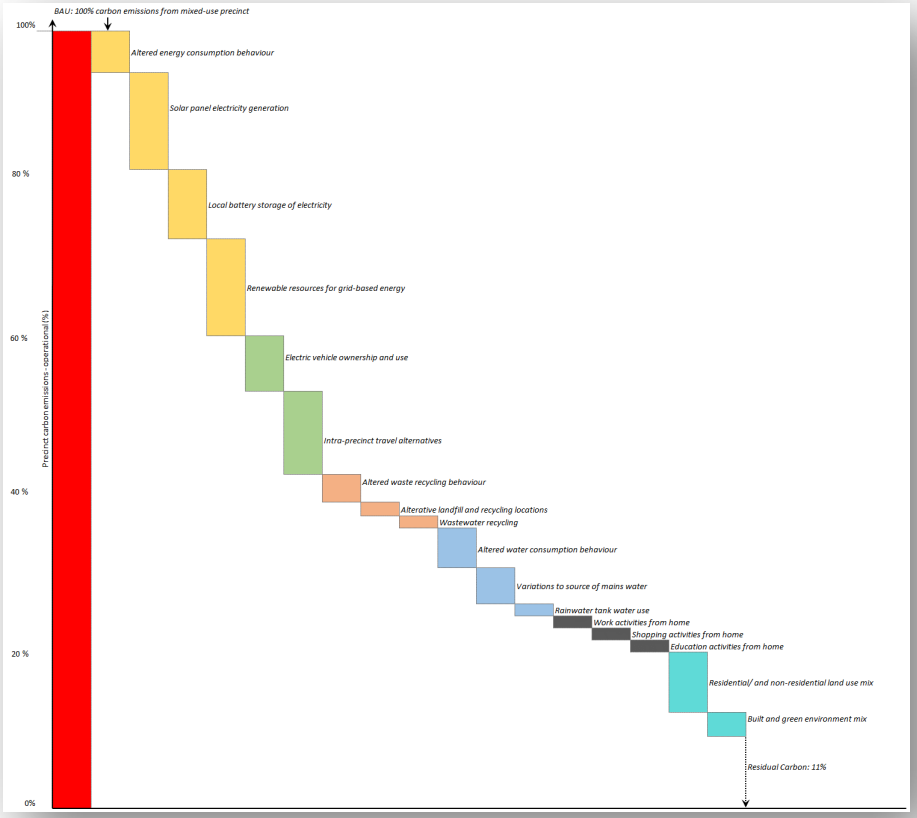
Carbon ‘Staircase’: **Mixed Use** Precinct



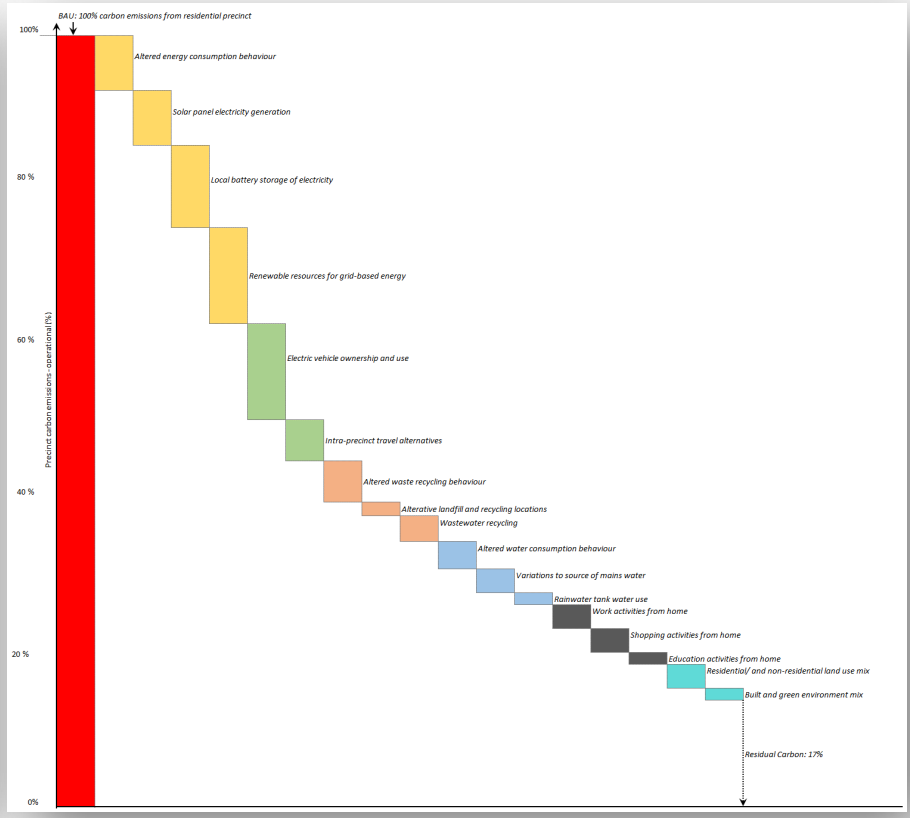
Carbon ‘Staircase’: **Residential** Precinct



Carbon ‘Staircase’ Comparison



Mixed Use



Residential

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Discussion...

Transitioning Broadway

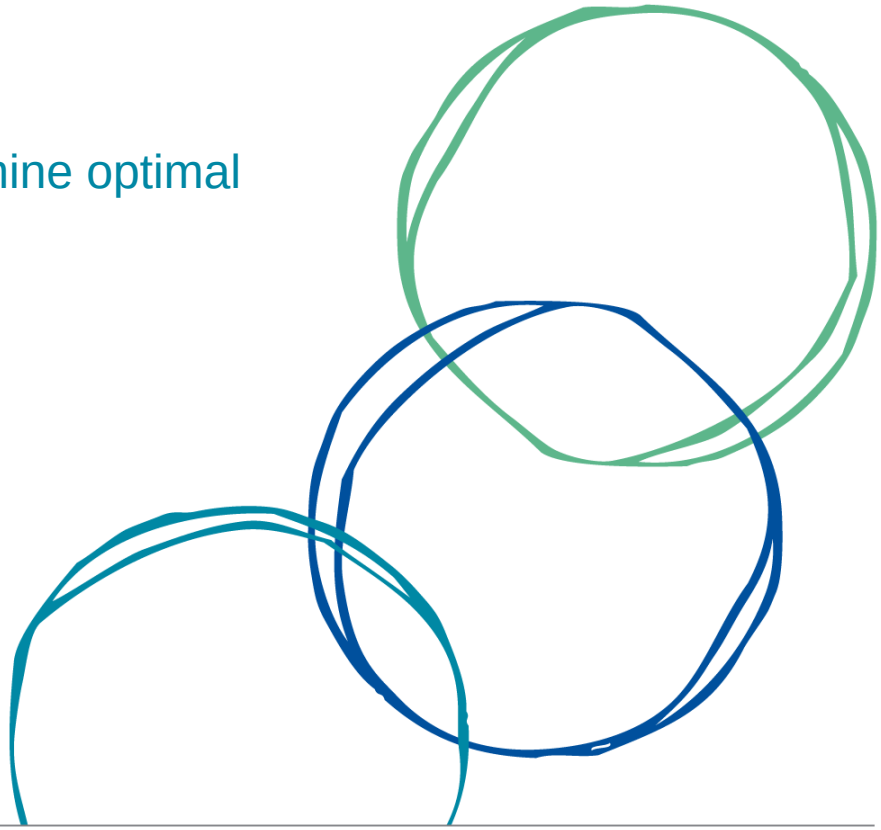
LOW CARBON LIVING CRC

Retrofitting Urban Precincts: The Broadway Example

A multi-stakeholder baseline study to determine optimal pathways to transition

September 2017

Roger Swinbourne - AECOM



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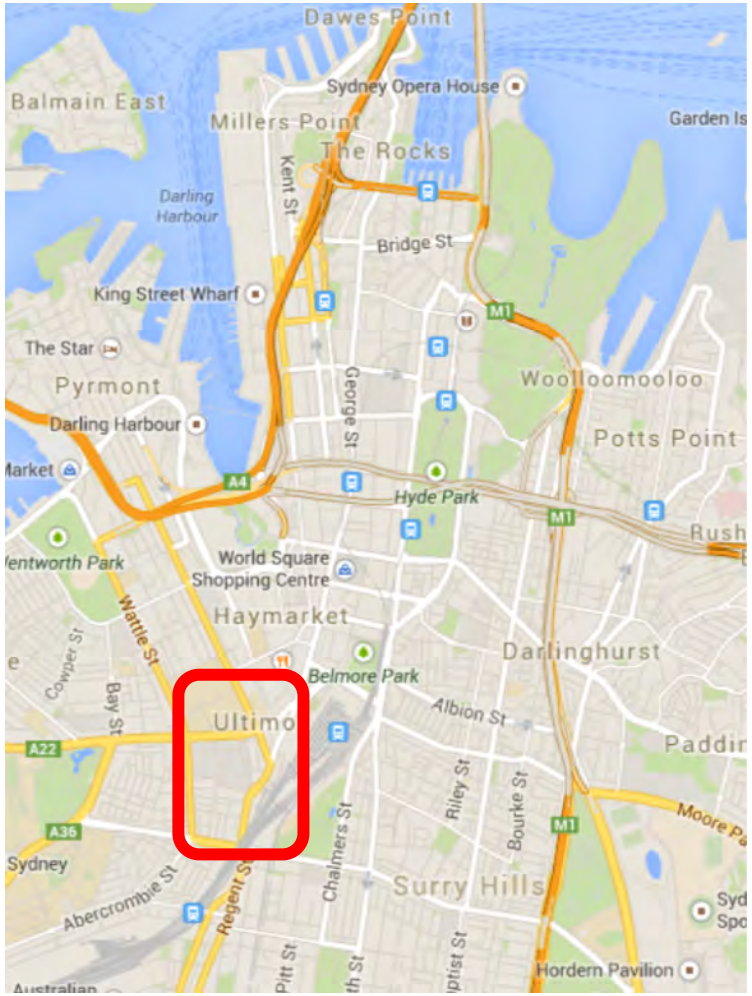
Project Partners

Project – Overview



- Understand **stakeholder motivations and needs**
- Global **best-practice** (governance) and **applicable systems & technologies**
- An appreciation of **precinct typologies**
- Understanding of **key barriers, governance structures and information** required to enable successful transitions

- **Broadway Baseline** – usage and assets.

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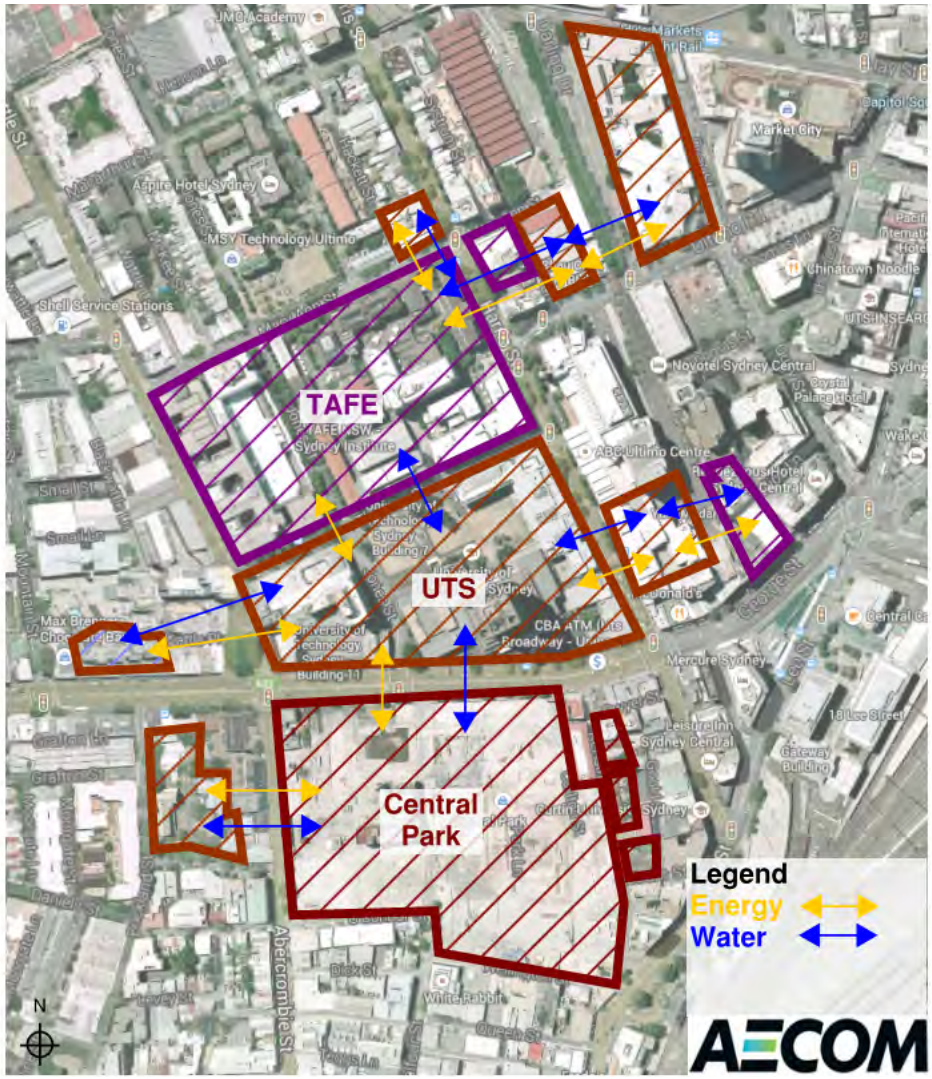
Precinct assets – location and profile



UTS- Ultimo Campus

- 11 Buildings
- Chau Chak (5 Green Star rated) with a 20,000 liter water tank

TAFE – Sydney Institute

- 19 buildings
- 22 kW PVs (72 modules)
- 12 kW (vert. axis wind turbine)
- 60 MWh thermal energy plant

Central Park

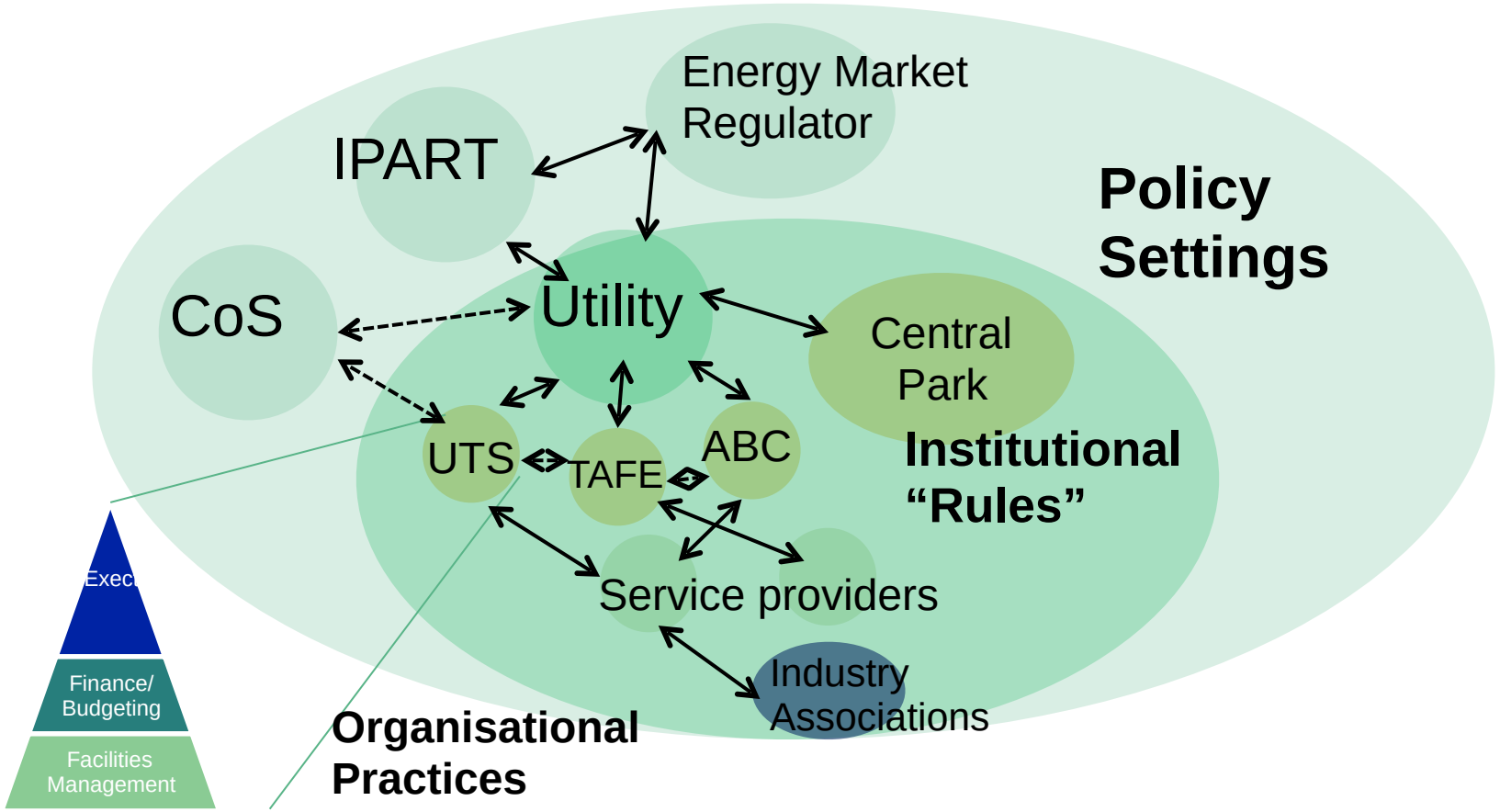
- 30 MW central plant
- 2 MW trigen. system
- 1 Ml black water treatment plant

Local residents: ca. 18,000

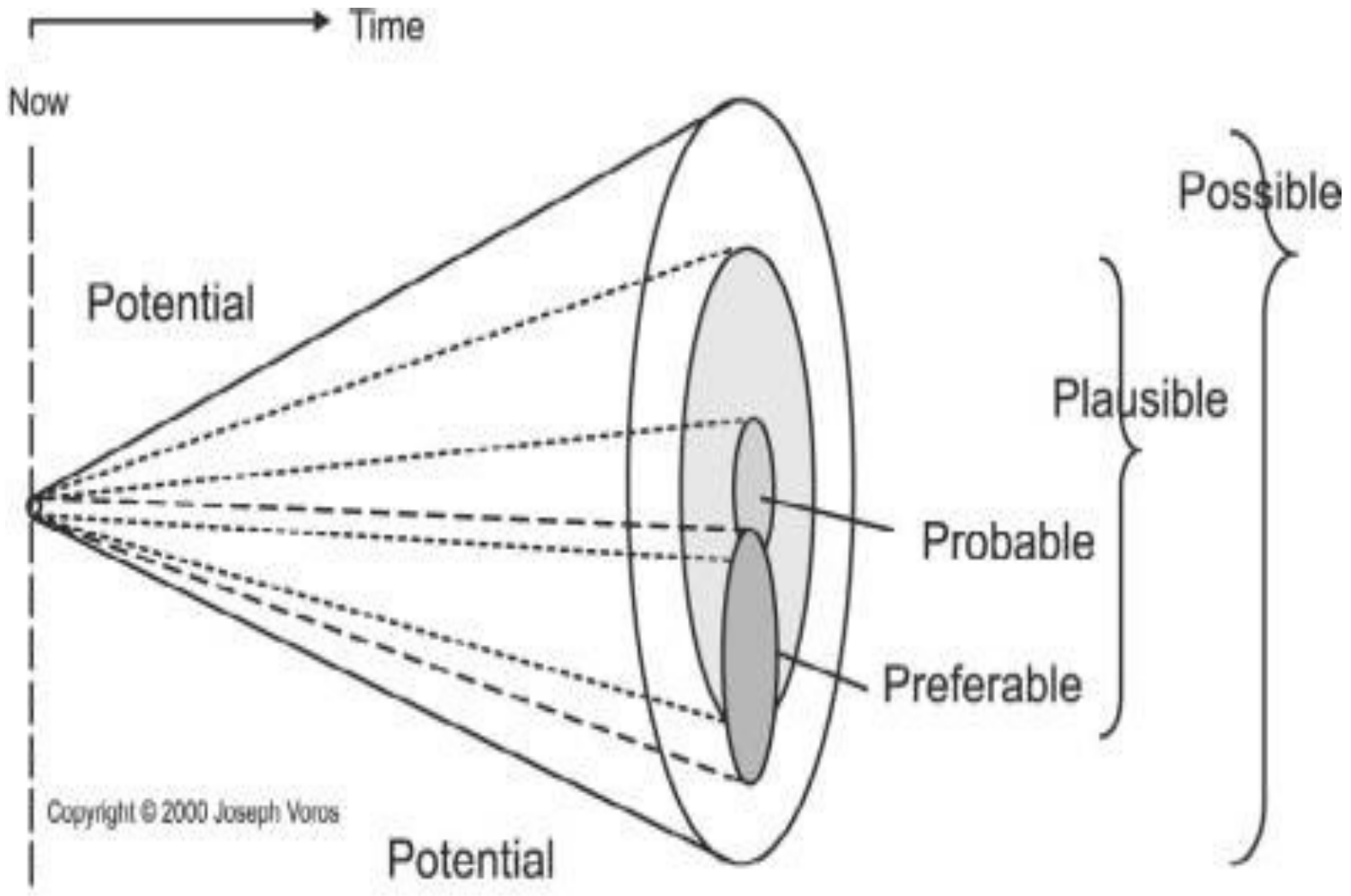
Business workforce: ca. 26,000

Local Students: ca. 50,000

Broadway stakeholder map



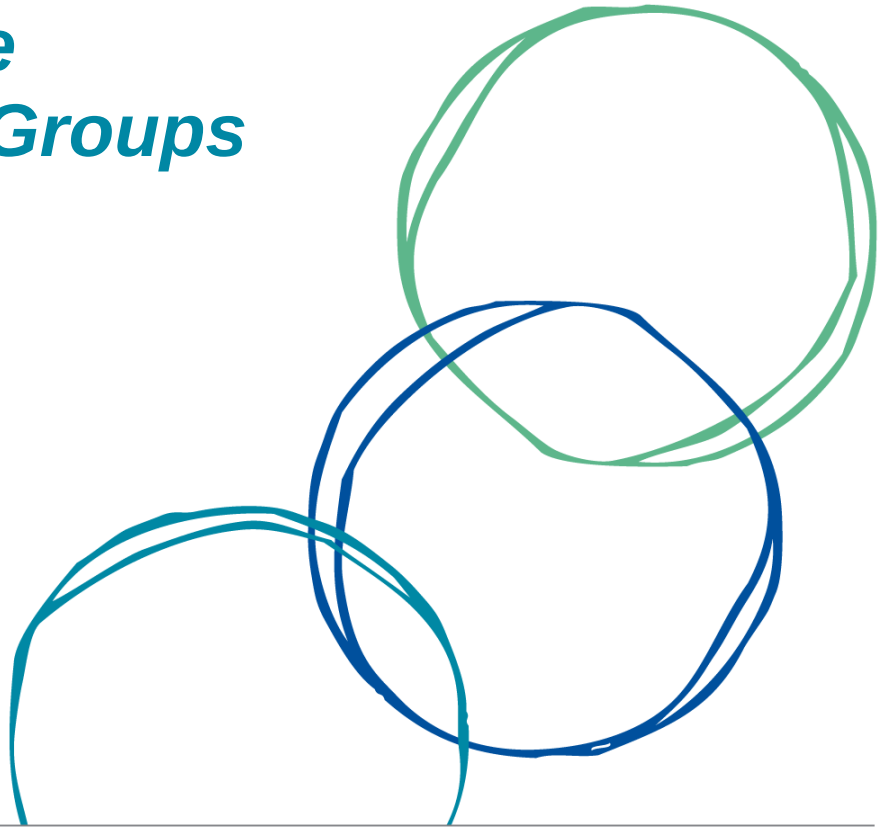
Transitioning to future scenarios



Source: Voros, 2003 adapted from Hancock and Bezold 1994

LOW CARBON LIVING CRC

Governance, Best Practice Precincts, and Transition Groups



AECOM

What is governance?

What is governance?

‘Process’ for making and implementing decisions – especially when the group is too large to make collective decisions.

Includes laws, policy, institutional structures and rules, markets, organisational practice, social norms, language!

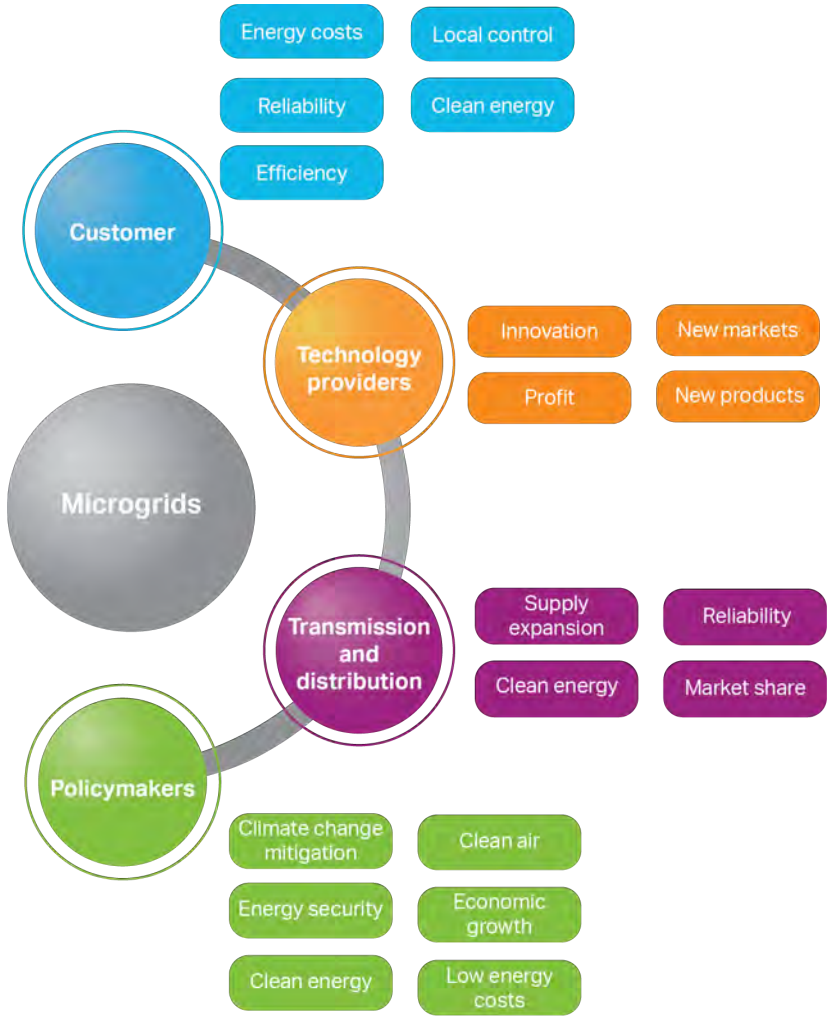
Types of governance

- Traditional forms of governance
  - Hierarchy - strong chains of command, top-down, state regulation
  - Market - self-organizing governance, free transactions between actors
- Network governance
  - Private actors such as business and NGOs increasingly participate in policy making
  - Consist of both formal and informal interactions
  - Key tool for transitions management

Stakeholders

Identifying key stakeholders is a significant element to the implementation of any strategy

- Responsibility
- Influence
- Proximity
- Dependency
- Representation
- Policy and strategic intent



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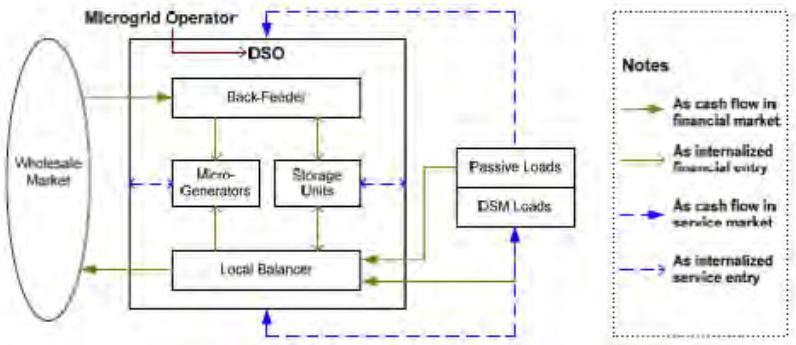
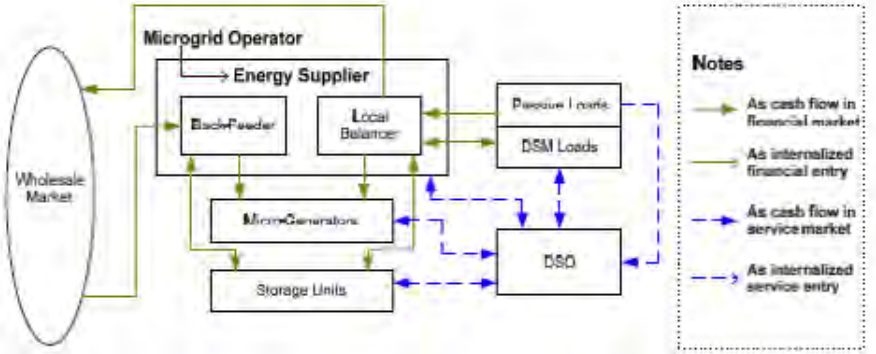
Infrastructure business models

DSO Monopoly



Free Market microgrid



Prosumer Consortium

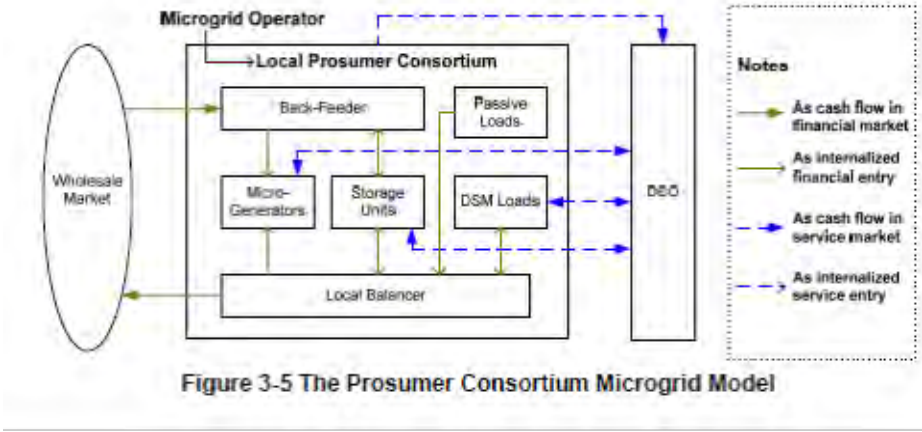
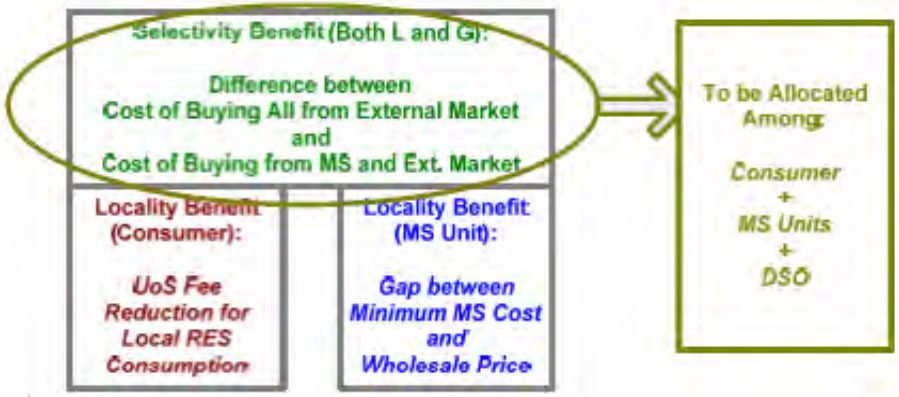


Figure 3-5 The Prosumer Consortium Microgrid Model



Infrastructure business models

- Independent Power Producers - Power Purchase Agreements (PPA) with privately run utilities
- Public private partnerships – Consortium pays for infrastructure and government entity guarantees income stream over long time period.
- Joint Venture Partnerships – Infrastructure manufacturer partially owns infrastructure and recoups investment through lease arrangement.
- Co-operatives – Membership based decision making. Take on the risk and management of the project but they receive a government guaranteed loan
- Community-owned - community are shareholders in a proprietary limited company
- Municipality owned – profit goes to Municipality budget.

Examples of business models

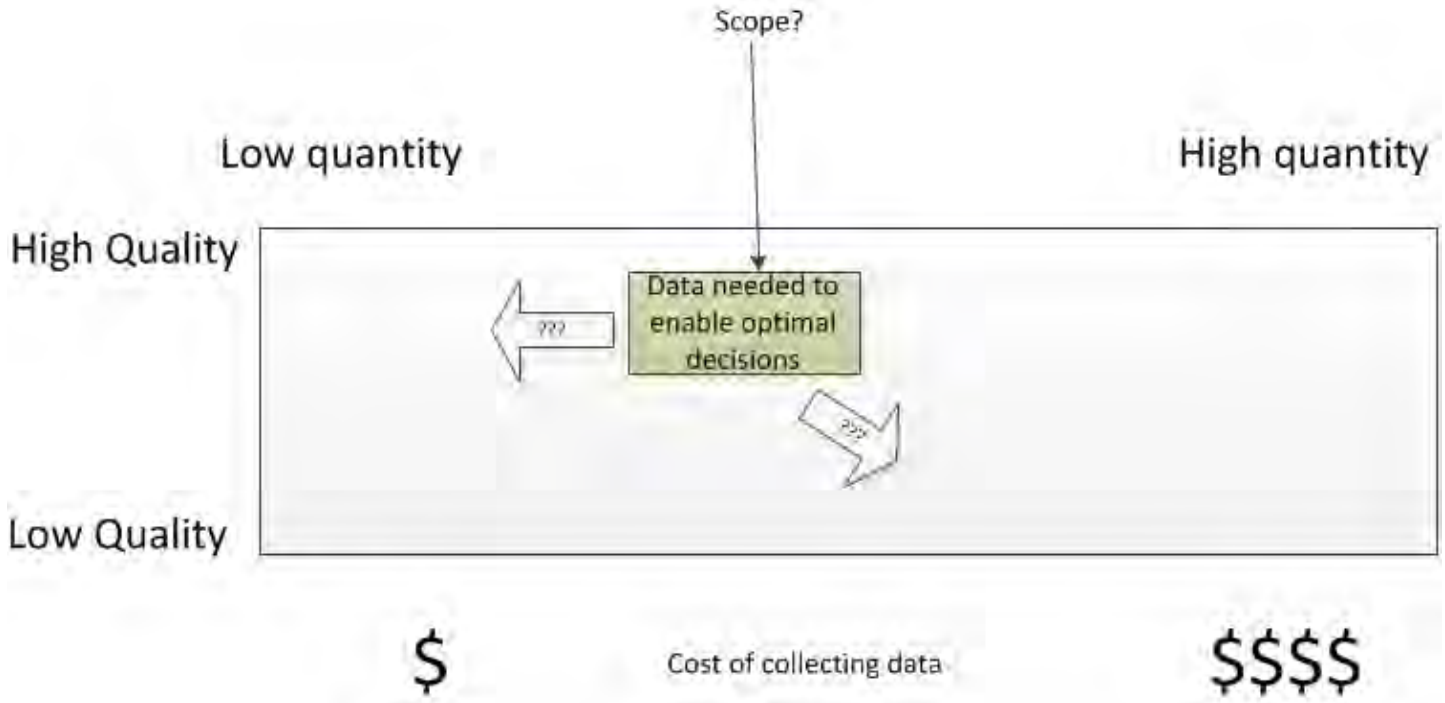
- Energy Service Company or Energy Savings Company (ESCO or ESCo) – Aberdeen Heat and Power Company
- Bulk Precinct Retrofit Model – Living City Block
- Outsourcing facilities management – Outsource management of buildings, Uni of Brighton
- Bulk Purchase Agreement – Bulk PV or Lighting, Portland Bulk PV
- Collective Model – Precinct stakeholder collective organisation, Lloyd EcoDistrict
- Membership Model – shared data and collaboration (PPB)

Business model evaluation

	Business (ownership) Models					
Drivers		Power Purchase Agreement	Internally Owned and Operated	Investment Trusts	Community Ownership	etc…
	Risk Avoidance	✓✓				
	Income Generation					
	Supply Security			??		
	Min return on investment					
	Reduce exposure to energy price flux	✓✓				
	…					

Utility and Asset Data Needs – quality and security

- Level of data determined by *need* – governance structure, stakeholders, risk and finance
- Data needs will need to consider technical data but with reference to governance, ownership, management etc.
- Managing the 80/20 rule – or avoiding analysis paralysis



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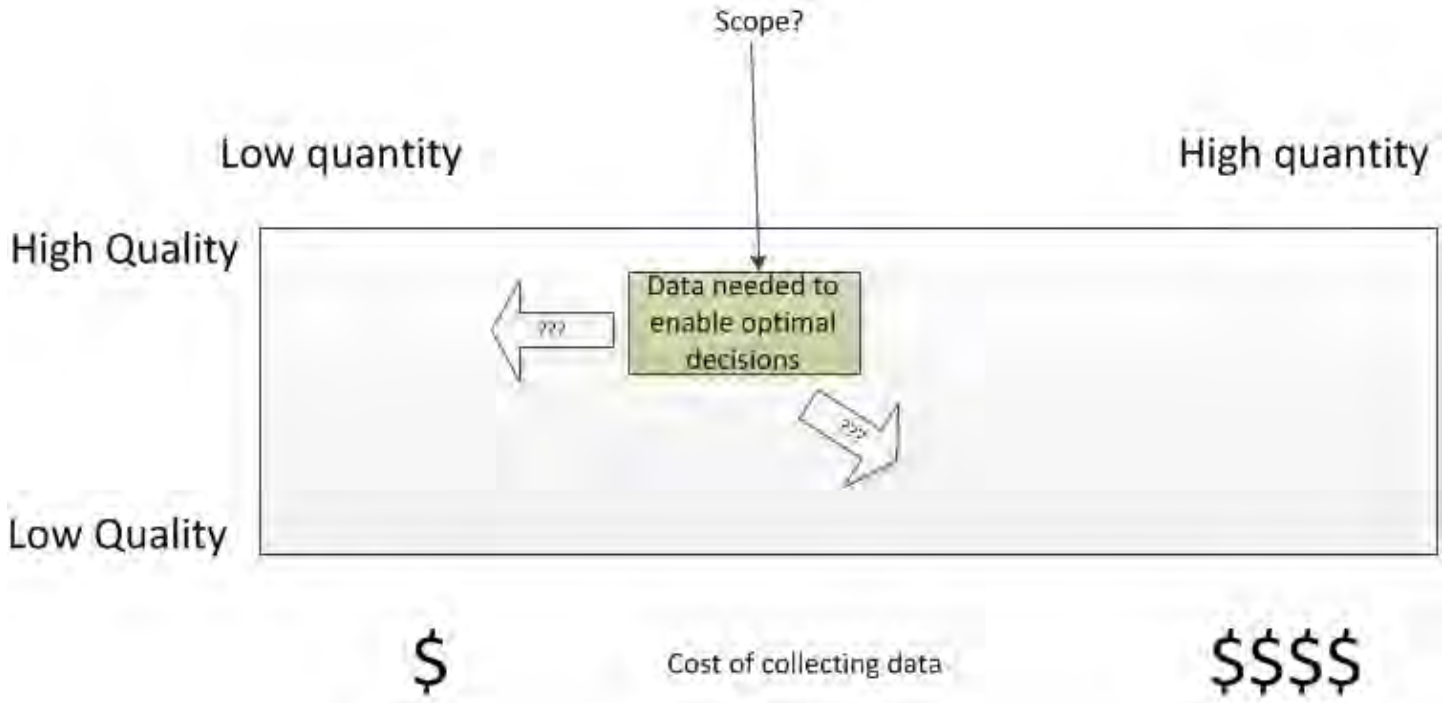

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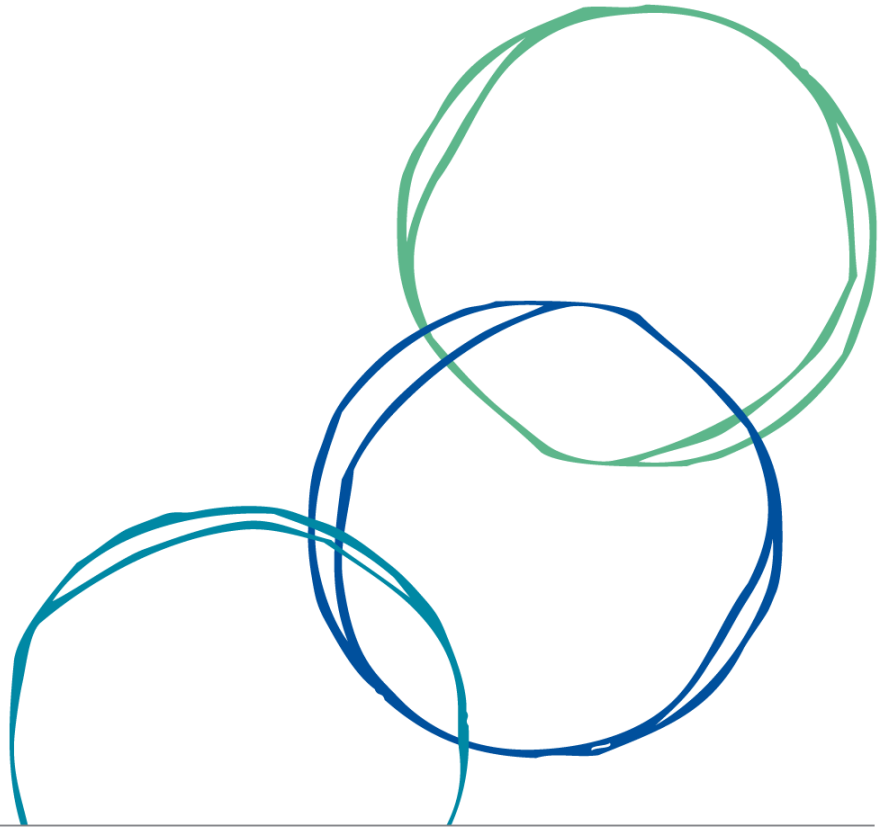
Research outcomes



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Some of the key findings from the research (PIM related)

- Fundamental changes in urban systems required -not just optimisation
  - Institutional frameworks, mind-sets, knowledge and practices
- Cannot be simply planned or directed
  - Engaged and networked transparently (PIM?)
- Complex issues
  - Multiple levels, multiple actors, long-timeframes (PIM?)
- Precinct Governance Issues
  - Ownership of information and ability to influence (PIM?)
- Regulatory and corporate risk frameworks
  - Inhibit efficient management of local infrastructure across property boundaries (PIM?)

Some of the key findings from the research (PIM related)

- Social media and the emergence of the “shared economy”
  - data tools that enable sharing – assets and utility
  - new business models and new regulatory frameworks
  - Governance at precinct scale (PIM?)
- Management of fragmented land ownership
  - Infrastructure, governance and economic models
  - Need for a coordinating network (PIM?)
- Research into microgrids
  - the area of microgrids with regards to precinct migrations is ripe of new research. Management framework (PIM?)

Future research opportunities

- Identifying the emergence of “next generation business models” based on service delivery and reducing inefficiency.
- Development of flexible governance, risk management and economic models for precinct scale.
- Identifying the relationship of the investment implications of driving parallel energy efficiency outcomes with energy supply solutions.
- Investigation into existing regulatory and corporate risk mechanisms and their influence on transition.

Thank you

To find out more, contact:

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