LOW CARBON LIVING CRC

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

Workshop 5 - Research Development and Scenario Specification.

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Introduction

Forecasting for integrated demands and carbon impacts of a precinct in the ETWW (energy, transport, waste and water) domains will allow for the assessment of policy scenarios for low carbon futures. This CRC for Low Carbon living project has investigated gaps, synergies, alternative approaches and required research directions to achieve its goals. The aim is to seek the development of integrated tools for demand forecasting and scenario evaluation covering ETWW with identified commonalities in data requirements and model formulation. It has developed an integrated framework for demand forecasting that is in the process of being fully developed and implemented. A method for including the impacts of household behaviour change in demand forecasting is a major component of the framework. In this way overall carbon impacts of urban developments or redevelopments can be assessed effectively and efficiently. As a result of facilitated national workshops to date, researchers, project partners and industry interests have explored initial project issues, and established an approach for integrated ETWW demand forecasting and model specification, development and integration.

The following report presents the outcomes of a fifth workshop associated with this project, held at Flinders University's Tonsley Campus on Thursday 20th August 2015. Workshop 5 has provided key researchers and interested partied the opportunity to present updates of recent research progress and current research status and discuss issues related to data specification, collection and use across domains, forecast application including the development of a foundation model and scenario application and future directions for the research. This report presents the key outcomes of the workshop, summarising discussions during workshop sessions with conclusions and a synthesis of these outcomes presented for the next stages of the research progress.

Current project parner organisations, key personnel and domain researchers associated with the ETWW project are presented in the following project organisational chart.

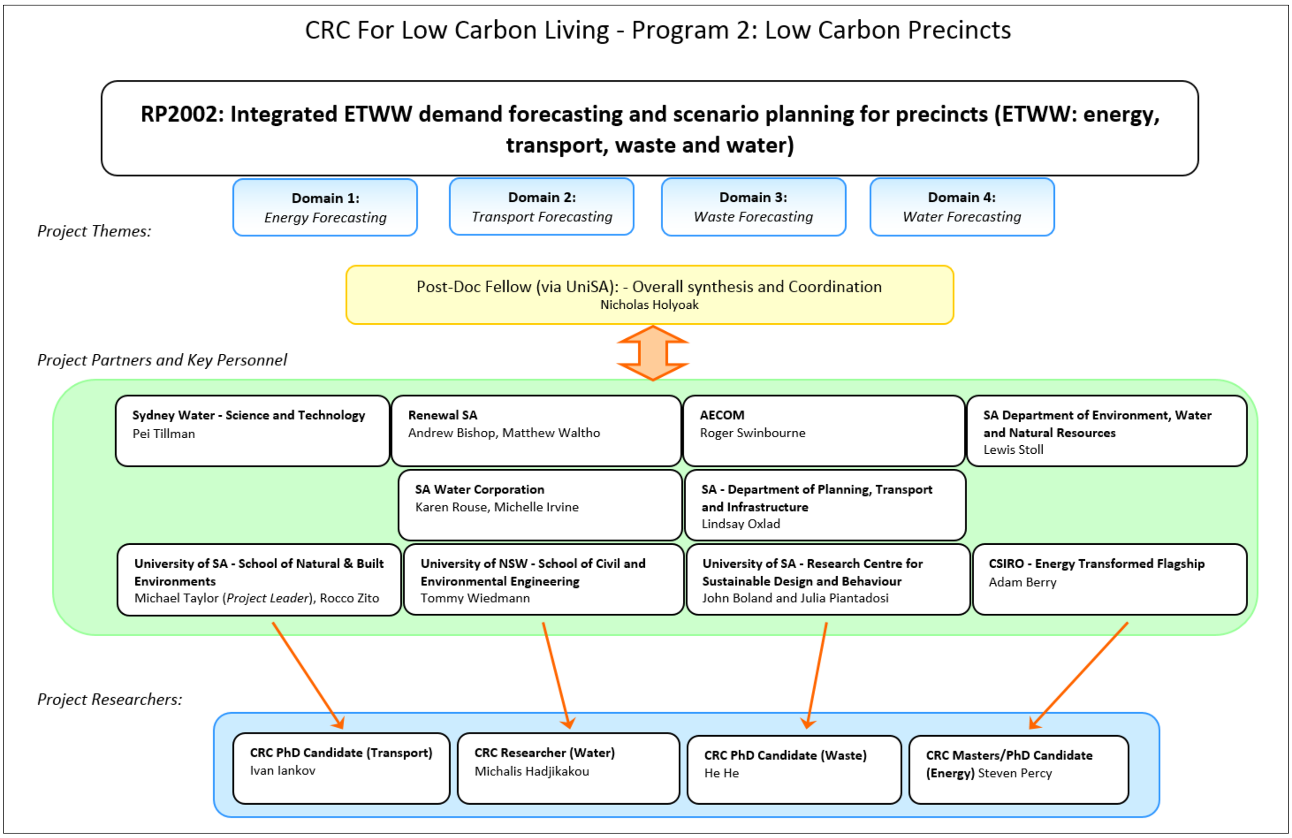


Figure 1: ETWW project organisational chart.

A snapshot of current research status.

The ETWW project forecasting framework identified in project workshop 3 (Figure 2) established the direction for much of the research effort with a particular emphasis (to date) on population profiling, forecast modelling and scenario definition components.

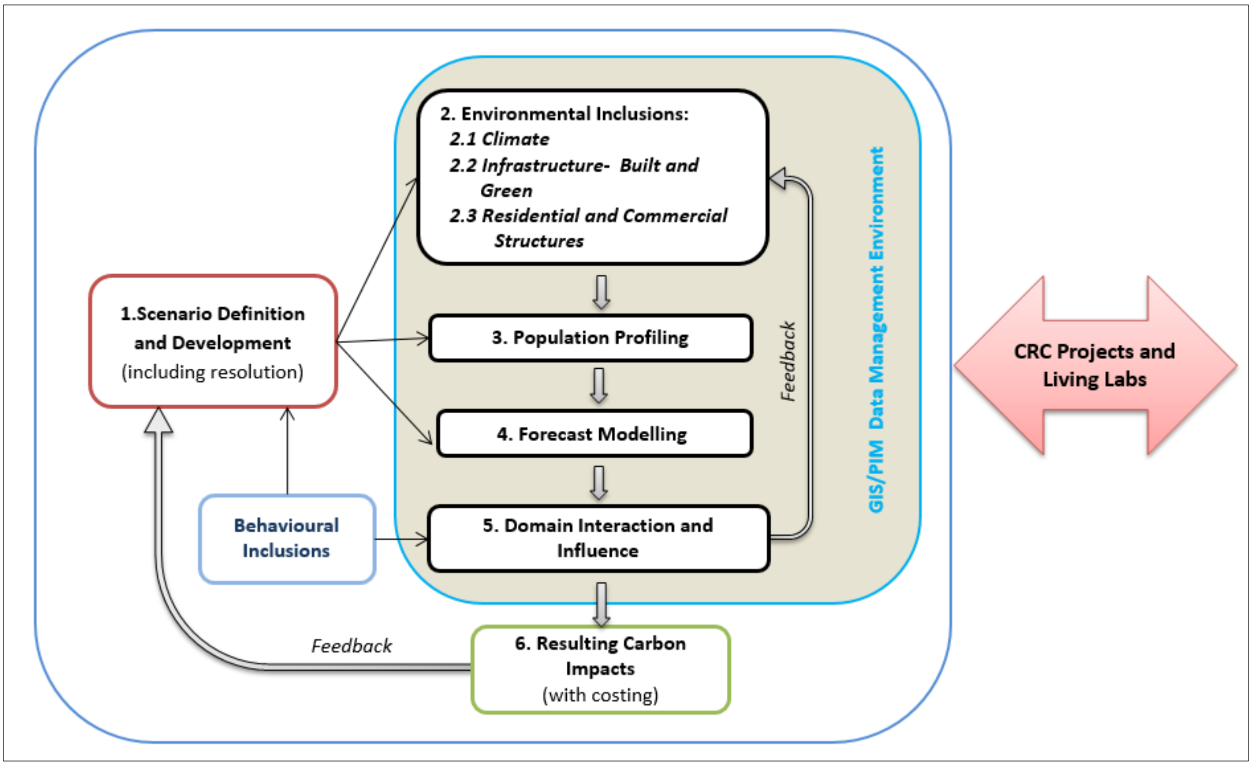


Figure 2: ETWW project forecasting framework [Source: ETWW Project Workshop 3 Report]

Precinct inputs to the forecasting process have been identified according to domain, with a common focus on the household characteristics, including resident profiles and household structure with specific technology and appliance options. The model also recognises other land uses but forecasting approaches are simplified for these. A range of domain-specific outputs are identified that again focus mainly on the on the household and in general terms, include forecasts for:

- energy consumption and production,
- water consumption and capture,
- transport demand,
- waste production.

Workshops 3 and 4 have provided a range of domain integration opportunities through application scenarios and forecasting interactions from both a technology and behavioral basis. Three examples of this are:

- Electric Vehicle use by the household: energy and transport domain interaction,
- Pumping of locally collected water at the household: water and energy domain interaction,
- Working-from-home or telecommuting behavior: all domains interaction.

Application scenarios will offer the opportunity to validate the forecasting abilities against current datasets and to apply industry-led recommendations for scenario forecasts. Current forecast scenarios include:

- Lochiel Park Precinct: Utilising existing data resources to replicate current situation with an expansion of the development to previous masterplan recommendations and incorporation of interactions between all domain forecasts.
- Tonsley Precinct: Utilising current masterplan information (along with additional estimations) as a base for demand forecasting
- Bowden Precinct: As with Tonsley, utilise current masterplan information as a base for demand forecasting with incorporation of data on current precinct development stages.
- Best Case Precinct: Apply our best-case scenario estimations (ie greatest potential carbon reduction) to either/both of the above locations. The 4 domain scenarios can result in 4 'best case' scenarios, targeted to each domain.

Databases and models.

A number of databases and modelling applications have been developed and acquired for research development, significant to the ETWW project as a whole and applicable across domains and others domain-research specific. Many of the following datasets have potential for relevance to other CRC projects, especially in Program 2.

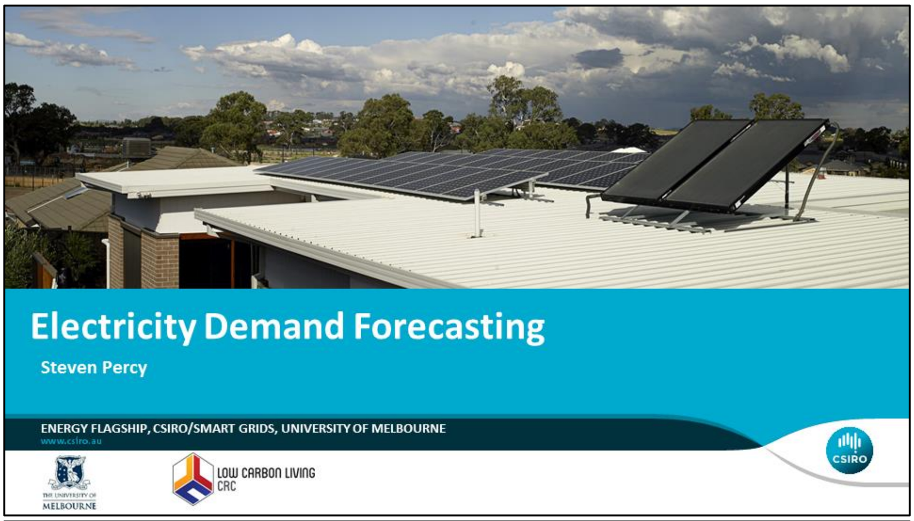
- The ‘Mosaic’ dataset of 5,000 individual household ‘typology’ profiles,
- The Lochiel Park household performance datasets on energy, water and household profiles. Access agreement reached with Renewal SA however ethics approval is still in progress,
- The ‘Thornthwaite Index’ model for climate forecast information,
- A copy of the fully-functional Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM),
- ‘Infraworks360’ modelling environment for intra-precinct scale transport model development,
- Historic meteorological data for study locations,
- Various ABS mapping and datasets,
- Flinders at Tonsley Building Information Model (BIM) suite,
- Household energy and water datasets from AGL, Sydney Water and SA Water. Confidentiality issues associated with address information delaying the acquisition of these.
- Ongoing development of datasets from survey activity, in particular for the waste domain.
- Smart cities smart grid (SCSG) datasets,
- Online survey data for ETWW project parameters.

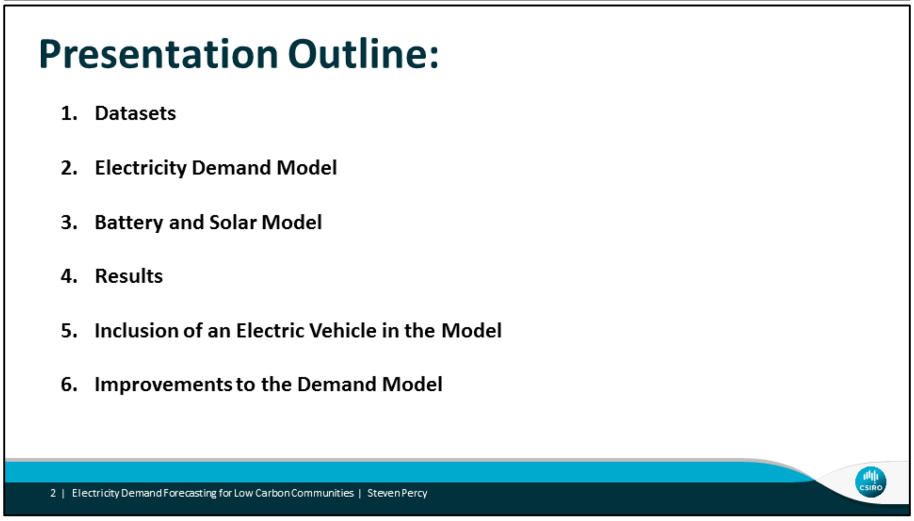
Researchers involved in the domain forecasting processes are a combination of PhD/Masters students and post-doc qualification. Current research status and presentations on research issues as identified by domain researchers are provided in the following section of this report.

Presentation 1: Electricity Demand Forecasting, Steven Percy.

Current research in the energy domain involves the implementation of an Adaptive Boost Regression Tree algorithm to forecast electricity demand at 1 hour intervals and applied linear programing to model the impact of solar and battery systems on residential demand, capturing divisions of energy costs to reduce emissions. The model allocates an optimum system capacity and control operation for each home in the precinct with implementation of a demand model that applies three large demand datasets and Mosaic codes to predict residential electricity demand.

Steven's presentation made to the workshop is provided as follows.





Datasets for Machine learning

- **Smart Grid Smart Cities Customer Apps Dataset**
  - Contains 30 minute interval load profile data for **7112 customers** distributed between Newcastle, Lake Macquarie, Upper Hunter Non-metro and Sydney
- **Residential Building Energy Efficiency Standards Repository**
  - Containing 30 minute sub metered load profile data for **209 customers** with data with an equal distributed between Brisbane, Melbourne and Adelaide.
- **(New) AGL Smart Meter Data**
  - 1200 homes in Melbourne, Sydney and Adelaide with attached Mosaic code, customers without solar, customers with continuity of service since the last census and gas usage data.

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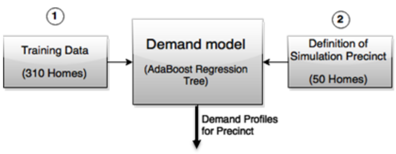
1) Demand Model:



Data selection:

- Within Newcastle.
- No solar PV installed.
- A complete set of survey responses.

Static	Temporal
Air conditioning type	Outside humidity
Running a pool pump	Outside temperature
Gas installed and uses	Week of the year
Number of refrigerators	Weekend indicator
Running a pool pump	
Social Demographics: age bracket of adults, number of occupants, number of children, Income bracket, and renting	

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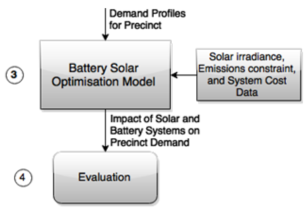
2) Solar Battery Model - Linear Program



- Inputs: demand profile, solar irradiance and Cost data.
- Outputs: optimum system capacities, power flow, cost of energy, cost of infrastructure, and emissions.

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Solar Battery Model - Linear Program

Minimise: $Cost_{Total} = \text{Cost}_{PV} + Cost_{Bat} + Cost_{Imp} - Cost_{Exp}$

s.t

$$B_{Lev}(h) = B_{Lev}(h-1) - B_{Gen}(h) + \eta \cdot B_{Rech}(h)$$

$$\text{D}(h) + B_{\text{Rech}}(h) + G_{\text{Exp}}(h) = \text{P}(h) + B_{Gen}(h) + G_{Imp}(h)$$

$$E = \frac{860\sum_{h=1}^{n} G_{Imp}(h)}{\sum_{h=1}^{n} D(h)}$$

$$G_{imp}(h) \le M \cdot \alpha(h)$$

$$G_{Exp}(h) \le M \cdot (1 - \alpha(h))$$

$$Cost_{PV} = \text{I}_{PV} \cdot \text{S}_{Cap}$$

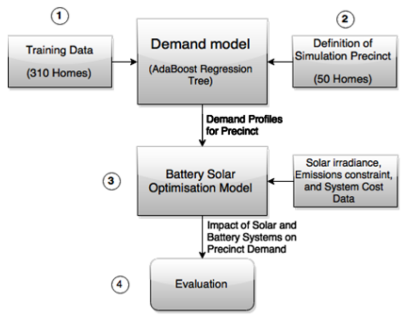
$$Cost_{Bat} = \text{I}_{Bat} \cdot B_{Cap}$$

$$Cost_{Exp} = R \cdot \sum_{h=1}^{n} G_{Exp}(h) \cdot e$$

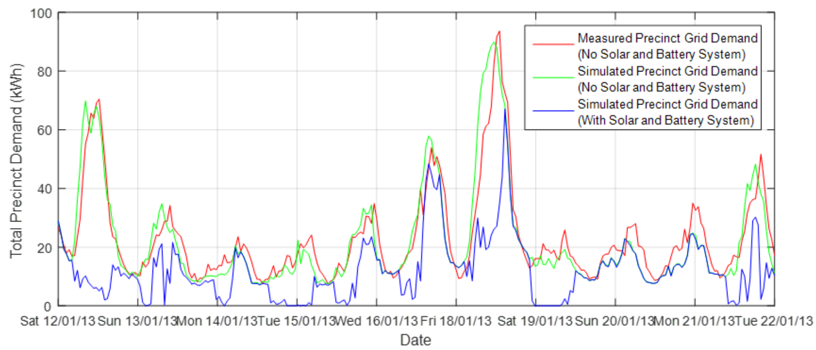
$$Cost_{Imp} = \text{R} \cdot \sum_{h=1}^{n} G_{Imp}(h) \cdot T(h) + 365 \cdot R \cdot I_{con}$$

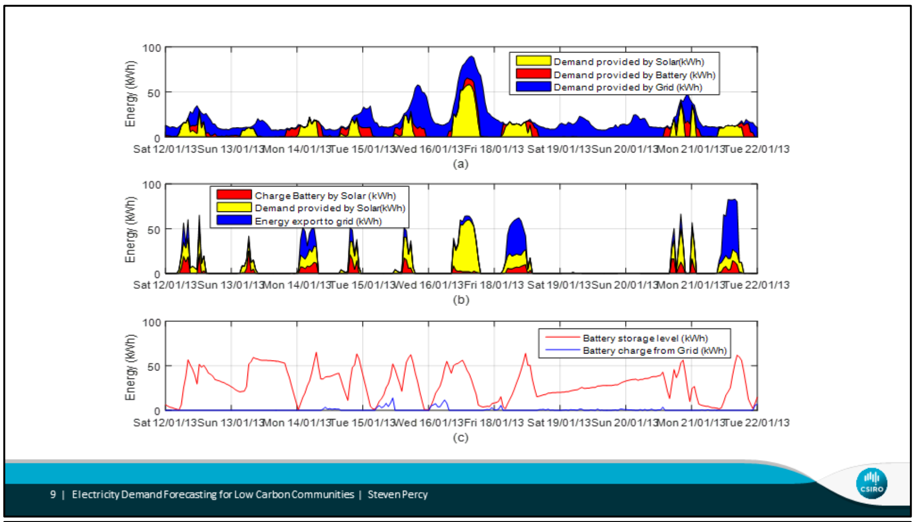
For all hours h=1-8760

Combined model



Demand profile:




Demand provided by Solar(kWh)
Demand provided by Battery (kWh)
Demand provided by Grid (kWh)
Energy (kWh)
Sat 12/01/13 Sun 13/01/13 Mon 14/01/13 Tue 15/01/13 Wed 16/01/13 Fri 18/01/13 Sat 19/01/13 Sun 20/01/13 Mon 21/01/13 Tue 22/01/13
(a)
Charge Battery by Solar (kWh)
Demand provided by Solar(kWh)
Energy export to grid (kWh)
(b)
Battery storage level (kWh)
Battery charge from Grid (kWh)
(c)
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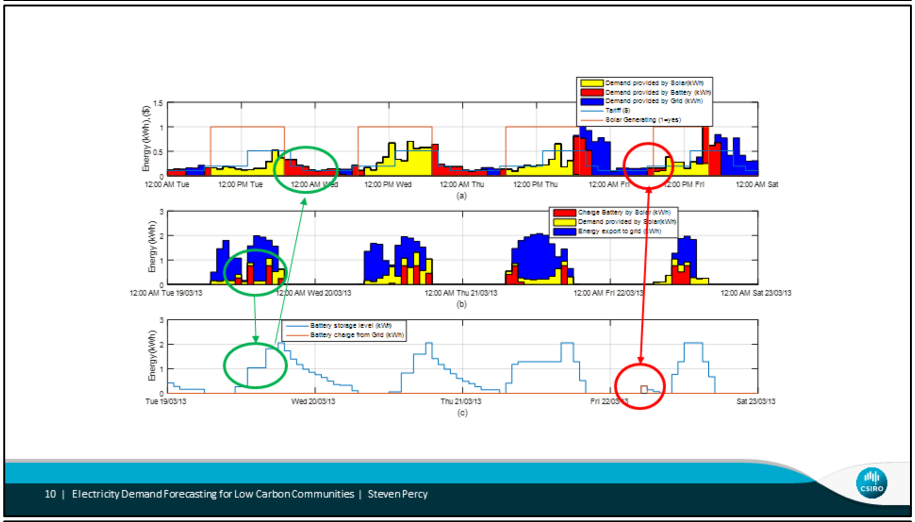
Energy (kWh), ($)
12:00 AM Tue 12:00 PM Tue 12:00 AM Wed 12:00 PM Wed 12:00 AM Thu 12:00 PM Thu 12:00 AM Fri 12:00 PM Fri 12:00 AM Sat
(a)
Energy (kWh)
12:00 AM Tue 19/03/13 12:00 AM Wed 20/03/13 12:00 AM Thu 21/03/13 12:00 AM Fri 22/03/13 12:00 AM Sat 23/03/13
(b)
Tue 19/03/13 Wed 20/03/13 Thu 21/03/13 Sat 23/03/13
(c)
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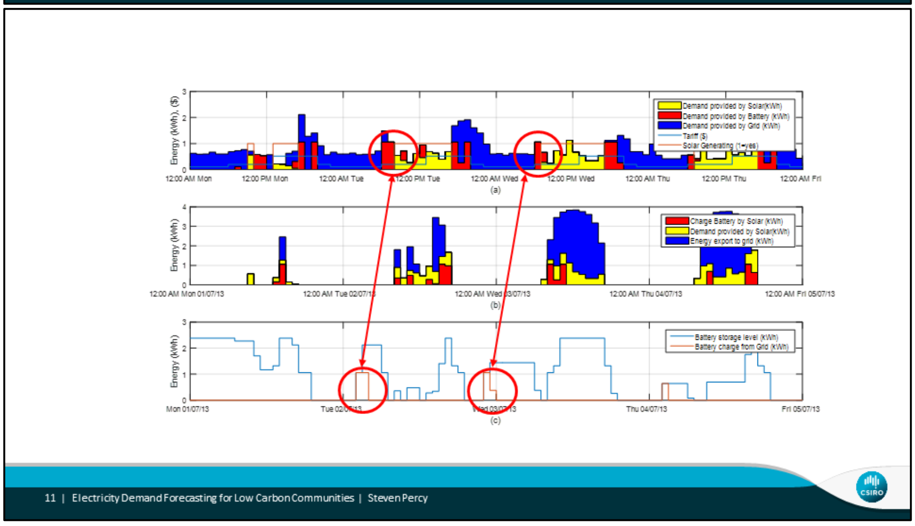
CSIRO


Energy (kWh), ($)
12:00 AM Mon 12:00 PM Mon 12:00 AM Tue 12:00 PM Tue 12:00 AM Wed 12:00 PM Wed 12:00 AM Thu 12:00 PM Thu 12:00 AM Fri
(a)
Energy (kWh)
12:00 AM Mon 01/07/13 12:00 AM Thu 04/07/13 12:00 AM Fri 05/07/13
(b)
Mon 01/07/13 Thu 04/07/13 Fri 05/07/13
(c)
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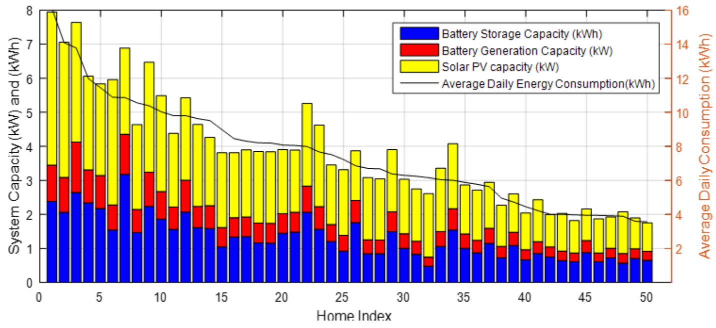
System Capacity 50% reduction in Emissions:



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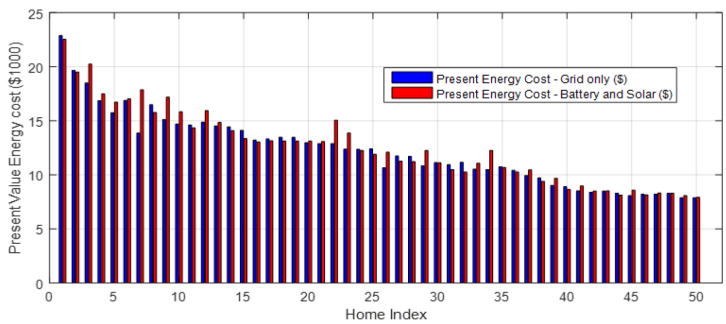
Cost Comparison 50% reduction in Emissions :



- 2.6% cost increase to reduce emissions by 50%

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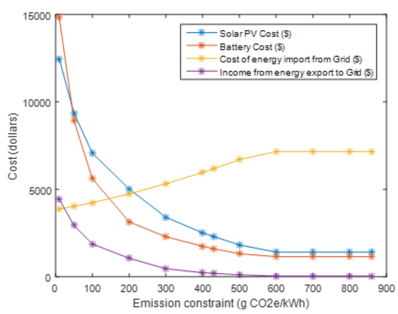
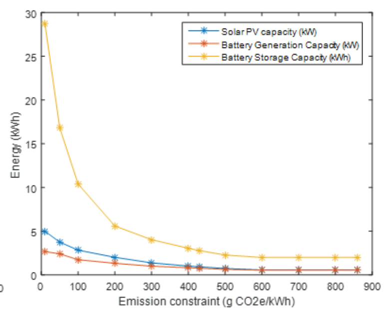
Cost and Capacity Against Emissions Limit





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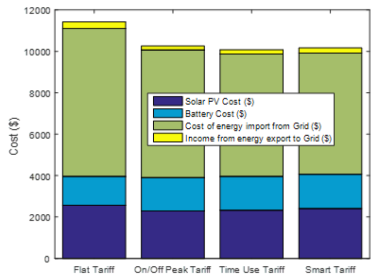

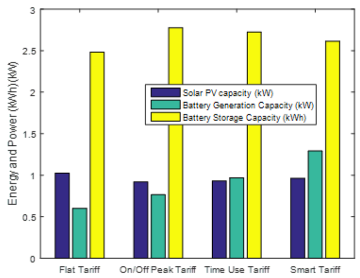

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Implementing an Electric Vehicle in this model

$$B_{Lev}(h) = B_{Lev}(h-1) - B_{Gen}(h) + \eta \cdot B_{Rech}(h)$$

New Constraint

7am

$$V_{Lev}(h) = V_{Lev}(h-1) - V_{Gen}(h) + \eta \cdot V_{Rech}(h) \quad + \quad V_{Lev}(7,31 \ldots 8743) > E(7,31 \ldots 8743)$$

Where *E is the Energy required in the car battery.*

$$D(h) + B_{Rech}(h) + G_{Exp}(h) = P(h) + B_{Gen}(h) + G_{Imp}(h)$$

New Constraint

$$D(h) + B_{Rech}(h) + V_{Rech}(h) * AtHome(h) + G_{Exp}(h) = P(h) + B_{Gen}(h) + V_{Gen}(h) * AtHome(h) + G_{Imp}(h)$$

Where *AtHome(h)* is a parameter = 1 at hour h if the car is Plugged in, and 0 otherwise.

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Improvements to the Demand Model

1. Allocate Mosaic Codes to The SGSC and RBEES datasets (complete).
2. Segment data based on the Mosaic Group (Complete).
3. Generate new features based on profile, i.e. high, med or low energy usage (in progress).
4. Train the learning algorithm on each data subset.
5. Validate models.
6. Combine with Solar-Battery Model.

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SGSC FEATURE NAME:			
AIRCON_TYPE_CD_Ducted	CONTROLLED_LOAD_CNT	HAS_GAS	NUM_CHILDREN_0_10
AIRCON_TYPE_CD_Other	CONTROL_GROUP_FLAG	HAS_GAS_COOKING	NUM_CHILDREN_11_17
AIRCON_TYPE_CD_SplitSystem	DRYER_USAGE_CD	HAS_GAS_HEATING	NUM_OCCUPANTS
ASSRTD_CLIMATE_ZONE_CD	DWELLING_TYPE_CD_SemiDetached	HAS_GAS_HOT_WATER	NUM_OCCUPANTS_70PLUS
ASSRTD_CLIMATE_ZONE_DESC_Mild_temperate	DWELLING_TYPE_CD_SeparateHouse	HAS_GAS_OTHER_APPLIANCE	NUM_REFRIGERATORS
ASSRTD_CLIMATE_ZONE_DESC_Warm_temperate	DWELLING_TYPE_CD_Unit	HAS_GENERATION	NUM_ROOMS_HEATED
ASSRTD_DWELLING_TYPE_CD	GENERAL_SUPPLY_CNT	HAS_INTERNET_ACCESS	OTHER_LOAD_CNT
ASSRTD_ELECTRICITY_USE_GRP_CD	GROSS_SOLAR_CNT	HAS_POOLPUMP	
ASSRTD_GAS_USAGE_GROUP_CD	POSTCODE	HAS_SOLAR	REDUCING_CONSUMPTION_CD
ASSRTD_HHOLD_INCOME_GROUP_CD	IS_RENTING	HHOLD_INCOME_GROUP_CD	HAS_AIRCON
CID_AMP	NET_SOLAR_CNT	IS_HOME_DURING_DAYTIME	HAS_CHILDREN

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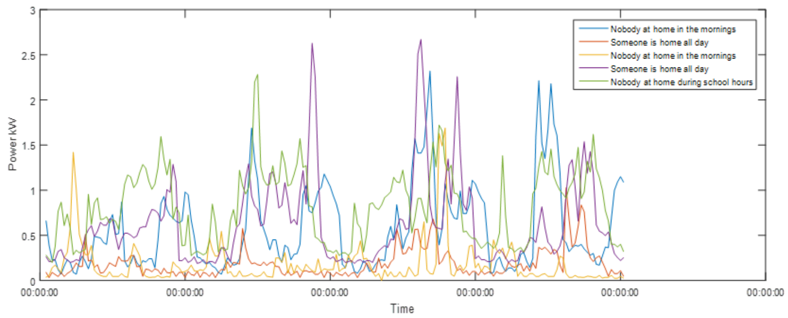
Occupancy and Load profile



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Modelling Outline

- Appling machine learning to forecast electricity demand for homes based off a small set of input parameters.
- Implement a second stage model to consider the impact of solar and battery systems on electricity demand.
- Evaluate a precinct, quantify costs and $CO_{2\,e}$ emissions.

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Summary of outcomes

1. Development of energy demand models using machine learning and applying an unprecedented amount of data spread over the east coast of Australia.
2. Capture the interactions between ETWW demand domains.
3. Provide a refined demand forecast capturing things that are unique about low carbon precincts.
4. Test this on real world case studies.

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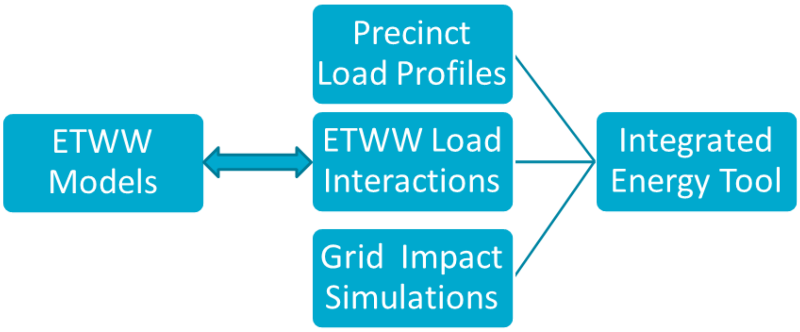
The Energy Tool



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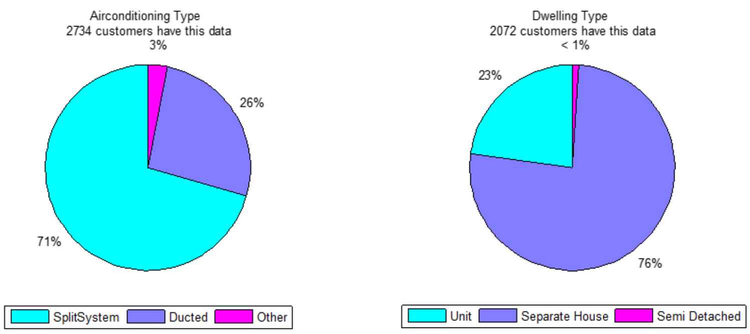
Smart Grid Smart Cities Data



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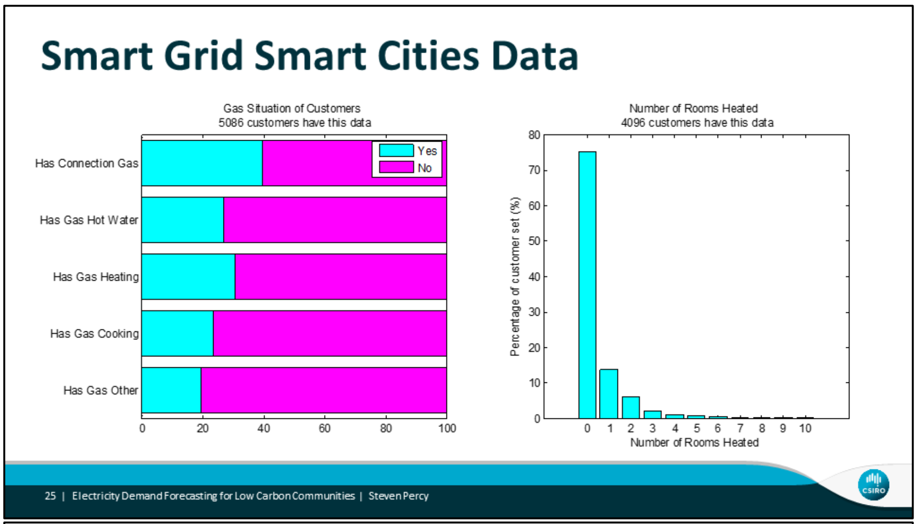
Smart Grid Smart Cities Data
Gas Situation of Customers
5086 customers have this data
Has Connection Gas
Has Gas Hot Water
Has Gas Heating
Has Gas Cooking
Has Gas Other
Yes
No
Number of Rooms Heated
4096 customers have this data
Percentage of customer set (%)
Number of Rooms Heated
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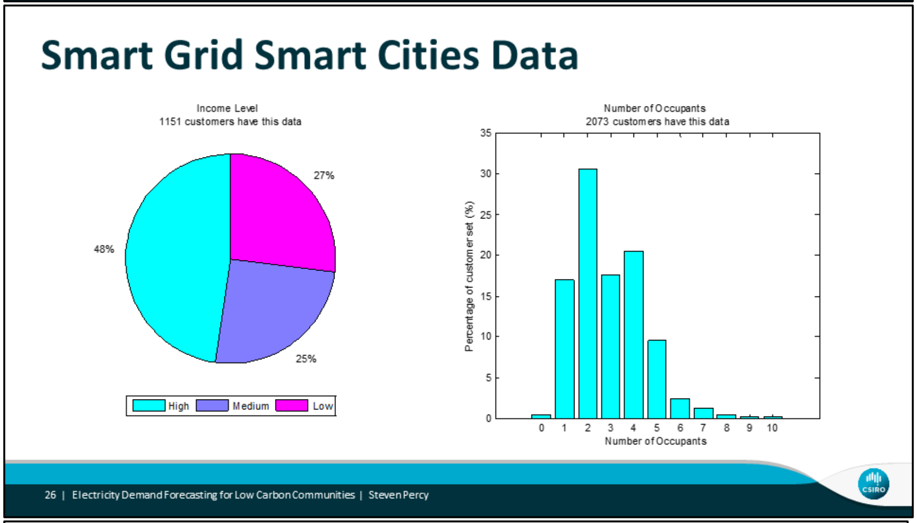
Smart Grid Smart Cities Data
Income Level
1151 customers have this data
27%
48%
25%
High
Medium
Low
Number of Occupants
2073 customers have this data
Percentage of customer set (%)
Number of Occupants
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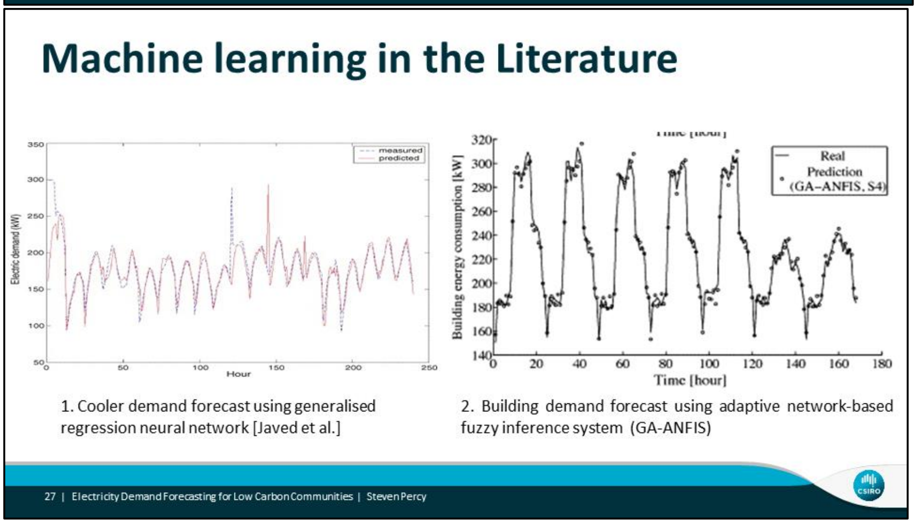
Machine learning in the Literature
measured
predicted
Electric demand (kW)
Hour
Building energy consumption [kW]
Real
Prediction
(GA–ANFIS, S4)
Time [hour]
1. Cooler demand forecast using generalised regression neural network [Javed et al.]
2. Building demand forecast using adaptive network-based fuzzy inference system (GA-ANFIS)
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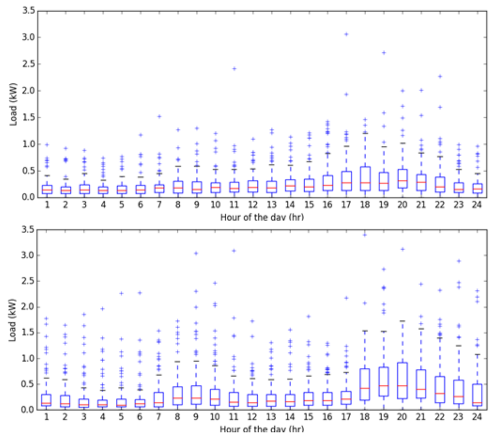
Summer

Winter



Literature - Demand Modelling Approaches

From : Torriti 'A review of time use models of residential electricity demand'

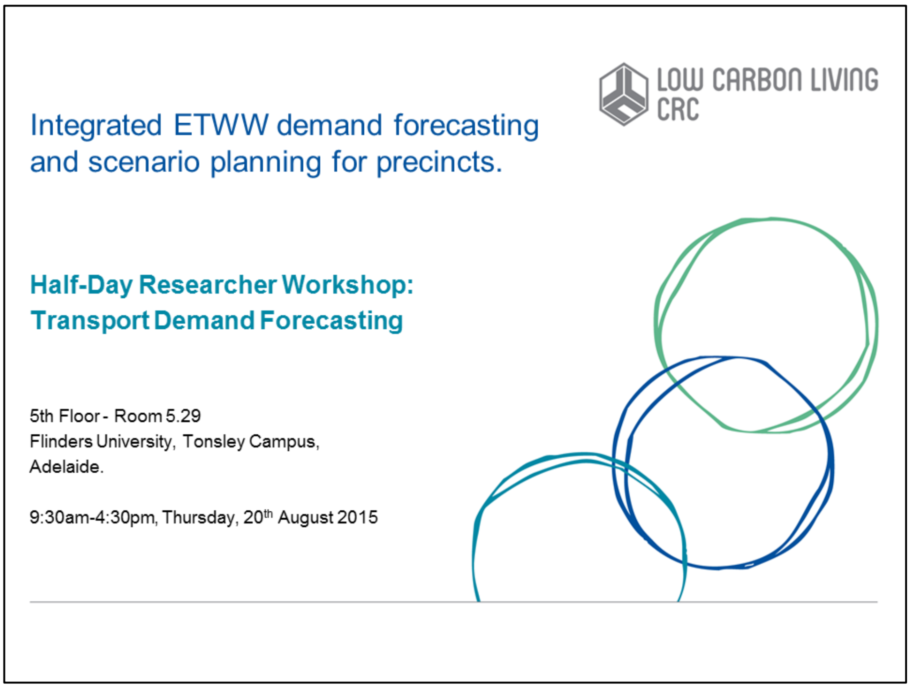
Top-down approach: treats the residential sector as an energy sink and does not distinguish energy consumption due to individual end-users or precincts.

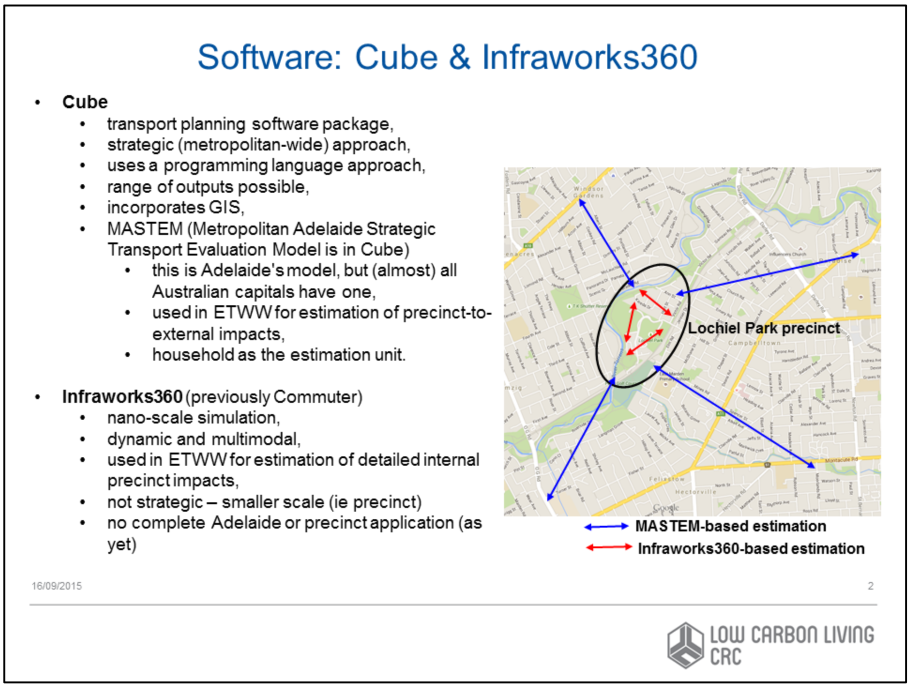
The bottom-up approach: looks at details of the energy consumption of individual end-uses, individual houses, or groups of houses. Profiles can be aggregated together to represent a precinct or city.

Presentation 2a: Transport Demand Forecasting, Nick Holyoak.

Current research in the transport demand forecasting domain involves establishing forecasting procedures in the Metropolitan Adelaide Strategic Transport Model (MASTEM) established for strategic-level precinct-to-external demands. Intra-precinct demand in the Commuter software is under development, with the incorporation of household types and behaviour through Mosaic and datasets also under development.

Nicholas's presentation made to the workshop is provided as follows.





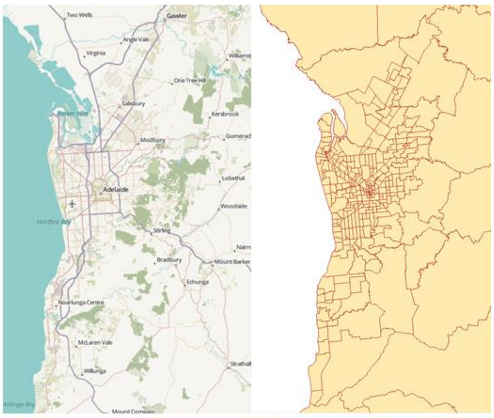
Metropolitan **A**delaide **S**trategic **T**ransport **E**valuation **M**odel

Adelaide-based transport demand forecasting.

All capitals have a similar forecast tool.

Provides us with:

- 283 Traffic Analysis Zones (TAZ),
- Trips by…
  - purpose,
  - household type,
  - mode,
  - period (AM, PM, daily),
- On-road trips (private car, bus, freight),
- Rail trips,
- Non-motorised demand estimates also.



Adelaide metro region included in MASTEM as a network and the TAZ configuration used for forecasting.

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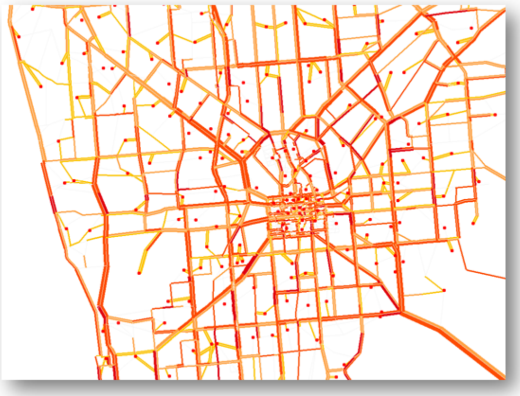
MASTEM: AM Peak

- Across ***all metro Adelaide*** forecasting for 2016, focussing on private vehicle use…
  - 2-hour AM peak period
  - Assigned Trips = 300,597
  - Total VKT = 2,762,794 km
  - Ave. Trip Length = 9.2 km
  - Total VHT = 88,953 hrs
  - Ave. Trip Time = 16.2 min
  - Ave Speed = 37.0 km/hr

  - Total Fuel Used = 269,622 litres
  - Total Energy = 2,426,601 kWh
  - Total CO_2 = 632,440 kg



Example of MASTEM mapping output – link width indicates flow volume and colour indicates congestion.

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Inclusions

Lochiel Park in MASTEM Process:

- Define the precinct within the existing zone structure – new precint-based Traffic Analysis Zone (pTAZ) split from existing MASTEM TAZ.
- Re-run the model allows us to utilise the full functions of the model…
  - vehicle ownership,
  - household type definition,
  - mode choice,
  - road network definitions,
  - congestion effects,
  - etc
- From the pTAZ travel forecasts we can estimate emissions for scenarios – and create a basis for comparison between scenarios, ie. the change in emissions.

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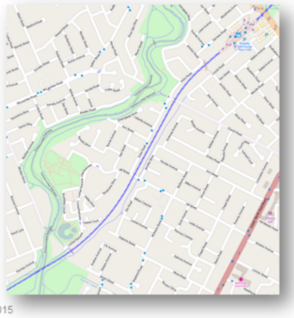
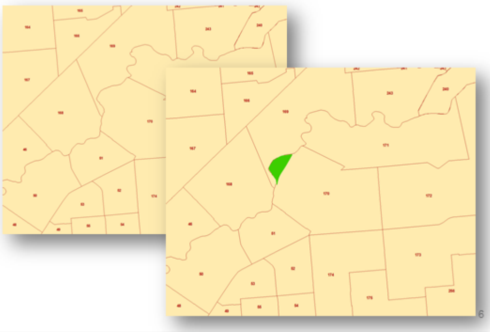
MASTEM: pTAZ

Lochiel Park Precinct:

- Total area: 444,276.56 m²
- Residential only , Households: 106 houses
- Mosaic Types: 3 [10xB05, 36xC13, 60xD16]
- Local road network,
- Major PT interchange 1.3km North-East of LP
- pTAZ 'cut' from larger MASTEM TAZ#170 representing a zone within the suburb of Campbelltown





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LOW CARBON LIVING CRC

Lochiel Park pTAZ in MASTEM

Representing Lochiel Park in MASTEM

pTAZ Attribute	2026 Base
Total Households	106
Total Population	263
Persons/household	2.48
Workers/household	0.98
Dependants/household	1.50
Cars/household (conventional)	1.53
Cars/household (electric)	0
Service industry jobs	0
Manufacturing industry jobs	0
Technical industry jobs	0
Transport industry jobs	0
Retail industry jobs	0
Education industry jobs	0
Entertainment industry jobs	0
Other industry jobs	0
Primary school enrolments	0
Secondary school enrolments	0
Tertiary enrolments	0

2026 Scenario

- Sees the introduction of electric vehicles to all households in Lochiel Park,
- Ave of 1.53 cars per household now split into 1.03 conventional and 0.5 electric vehicles
- Other scenarios could incorporate telecommuting or teleshopping, increase in bike or walking behaviour, changes in land-use mix, etc. etc.

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LOW CARBON LIVING CRC

Representing Forecasting Results

Lochiel Park in MASTEM

- Representing the transport demand and the assigned transport demand.

Desire Line diagram of Lochiel Park Car demand.

Select Link analysis for Lochiel Park car demand assigned to the transport network.

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LOW CARBON LIVING CRC

Representing Forecasting Results

Lochiel Park in MASTEM

- Base condition and the EV scenario forecast results:

Trips	82.9
VKT	808.6 km
VHT	26 hrs
Total Fuel Used	78.9 litres
Total Energy	710.2 kWh
Total CO2	185.1 kg
Ave Speed	33.5 km/hr

Base 2026 conditions

Trips	55.1
VKT	519.5 km
VHT	18 hrs
Total Fuel Used	52.2 litres
Total Energy	469.7 kWh
Total CO2	122.4 kg
Ave Speed	33.4 km/hr

EV Scenario 2026 conditions

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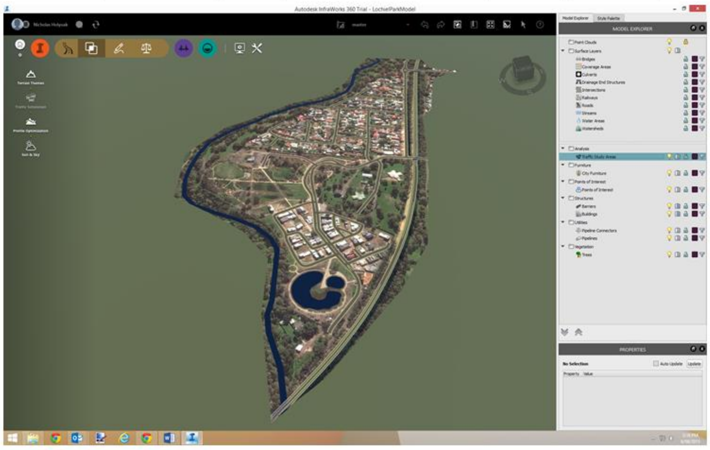
LOW CARBON LIVING CRC

Within the Precinct.

- Infraworks360 provides the opportunity to forecast detailed transport activity within the precinct.



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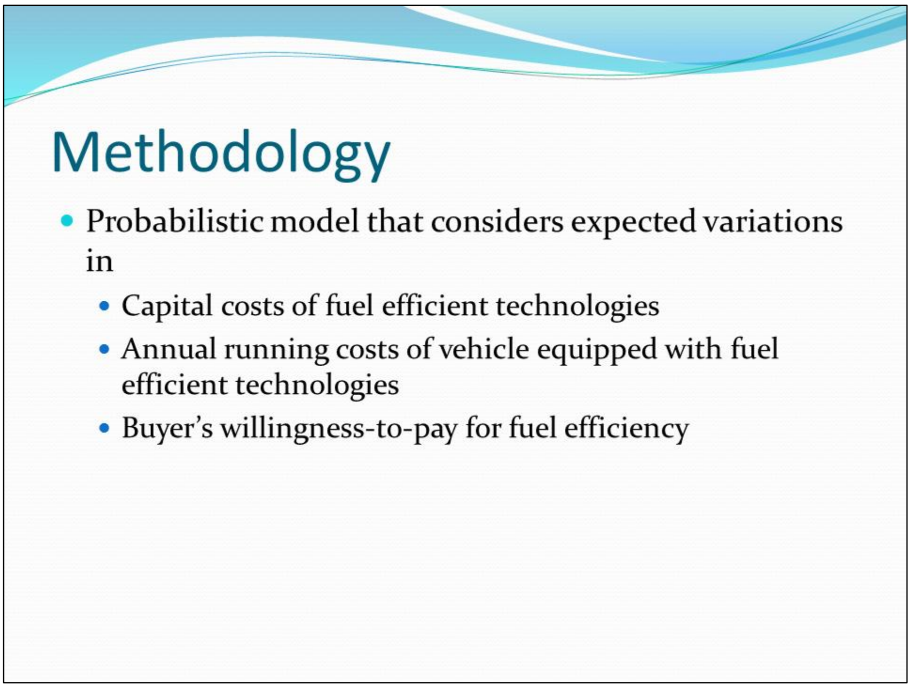
LOW CARBON LIVING CRC

Presentation 2b: Market Uptake of Fuel Efficient Technologies, Ivan Iankov.

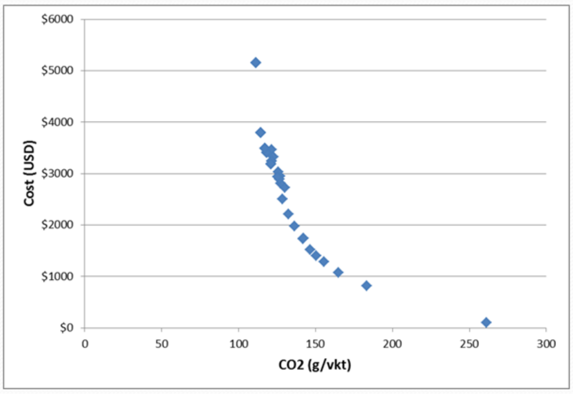
Current research in the transport emission forecasting domain involves the development of generic emission rates for light vehicle traffic loads that are highly applicable to Australian conditions. The emission rates are user friendly and can be used in long term forecasting studies. A sound and robust statistical methodology is used for predicting the expected variance of the emission rates and they are reported as confidence intervals. The user of the emission rates can assess risk when forecasting road transport greenhouse gas emissions. Research has also determined the uptake of fuel efficient technologies, including Hybrid electric vehicle (HEV), Plug-in hybrid electric vehicle (PHEV), Battery electric vehicle (BEV), Fuel cell vehicle (FCV) in the future light vehicle fleet.

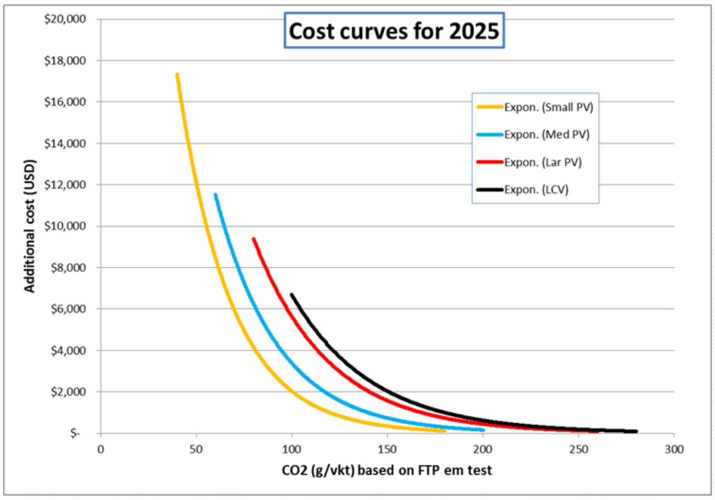
Ivan's presentation made to the workshop is provided as follows.



Capital cost

- US EPA and NHTSA Regulatory Impact Analysis for CAFÉ standards 2010-2016 and 2017-2025
  - Comprehensive literature review, extensive consultations with car manufacturers, analysis is broken down to "bolts and nuts", considering learning curve, economies of scale
- AEA Ricardo publications
  - Predictions for costs and effectiveness of ICE, PHEV, EV
- CE Delft
  - Trends for vehicle fuel efficiency
- UBA – German environmental agency
  - Cost curves for reduction of vehicle CO_2 emission rates
- Argonne National laboratory
  - Simulation analysis of fuel efficient technologies
- King's review
  - Broad summary of potentials for reducing vehicle CO_2 emission rates
- MIT, ANL
  - Trends in battery technologies

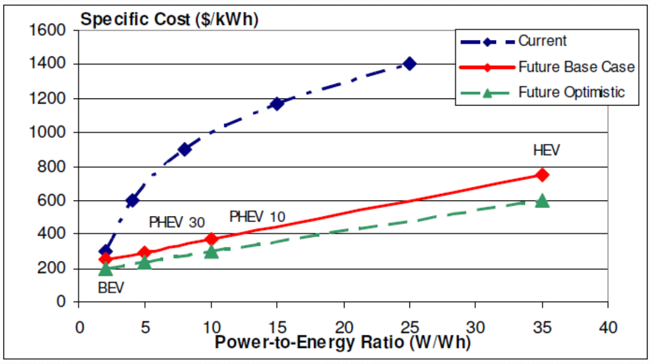


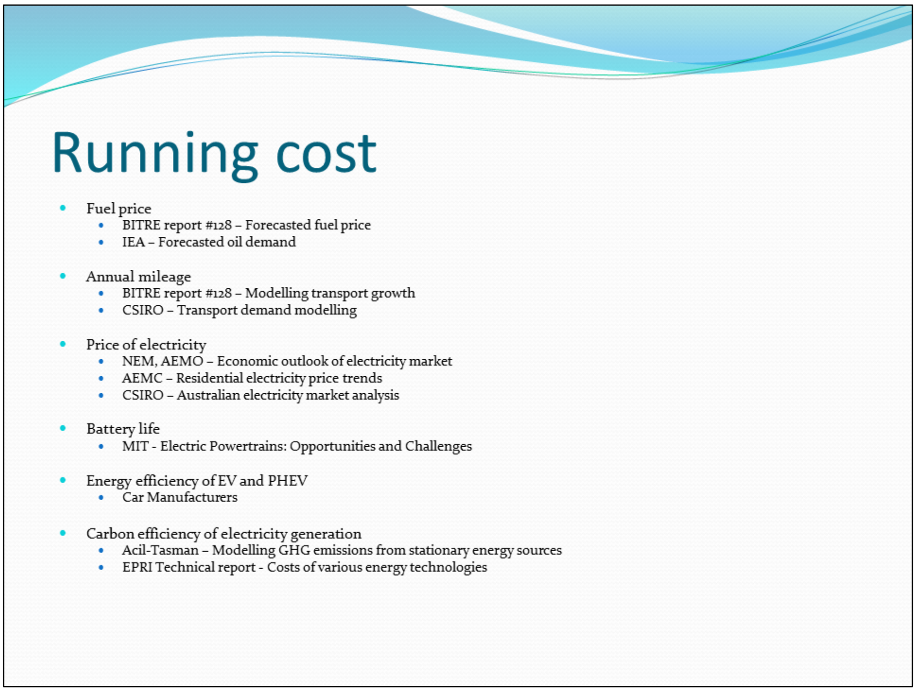


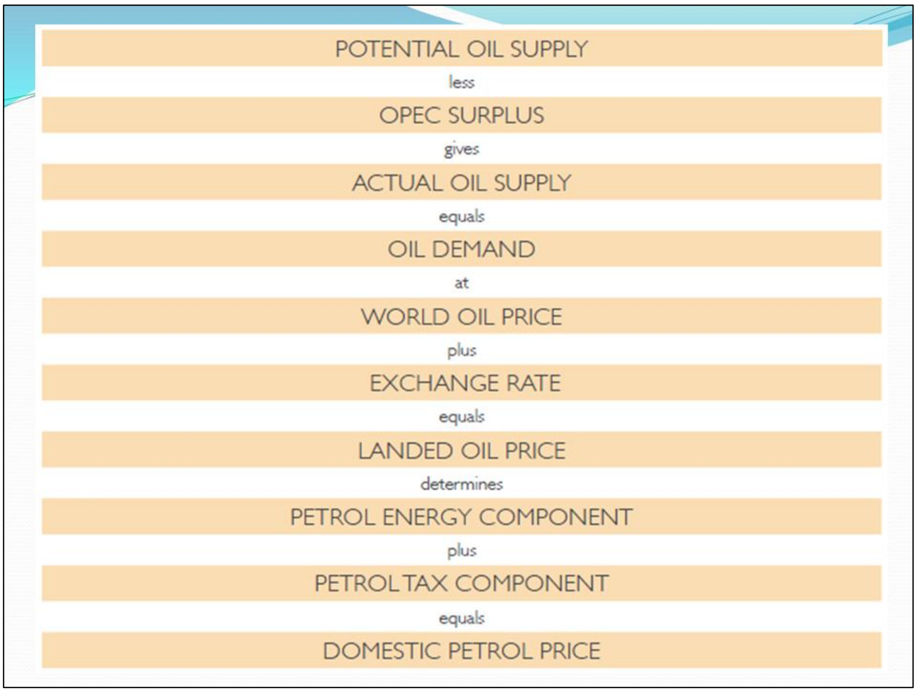
Battery technologies (MIT, ANL)

Energy (kWh)	~Range (Mi)	Specific Energy (Wh/kg) 100	120	150	200	300
2	0 (HEV)	20	17	13	10	7
5	10	50	42	33	25	17
10	30	100	83	67	50	33
20	60	200	167	133	100	67
30	100	300	250	200	150	100
50	200	500	417	333	250	167

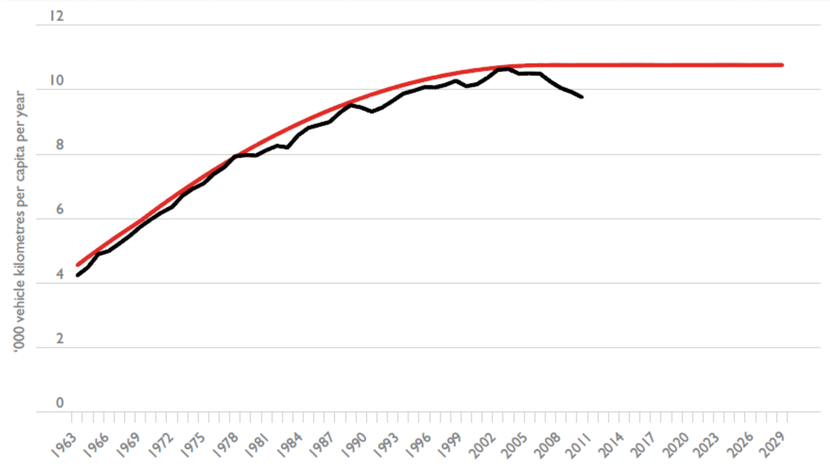
Battery Weight (kg)




Running cost
Fuel price
BITRE report #128 – Forecasted fuel price
IEA – Forecasted oil demand
Annual mileage
BITRE report #128 – Modelling transport growth
CSIRO – Transport demand modelling
Price of electricity
NEM, AEMO – Economic outlook of electricity market
AEMC – Residential electricity price trends
CSIRO – Australian electricity market analysis
Battery life
MIT - Electric Powertrains: Opportunities and Challenges
Energy efficiency of EV and PHEV
Car Manufacturers
Carbon efficiency of electricity generation
Acil-Tasman – Modelling GHG emissions from stationary energy sources
EPRI Technical report - Costs of various energy technologies


POTENTIAL OIL SUPPLY
less
OPEC SURPLUS
gives
ACTUAL OIL SUPPLY
equals
OIL DEMAND
at
WORLD OIL PRICE
plus
EXCHANGE RATE
equals
LANDED OIL PRICE
determines
PETROL ENERGY COMPONENT
plus
PETROL TAX COMPONENT
equals
DOMESTIC PETROL PRICE

Annual mileage per person



Willingness-to-Pay

- Choice models, hedonic models, price regression
  - US EPA – Comprehensive literature review
  - David L. Green – Oak Ridge National Laboratory
  - Hensher et al
  - …
- Findings
  - Widely varying, inconsistent estimates
  - Consumer should make decision about very uncertain future

Strategy

- Consider range of cost when predicting share of technology
  - 25th, 50th, 75th percentiles of capital cost of each alternative
  - 25th, 50th, 75th percentiles of running cost of each alternative
- Divide population of buyers into groups depending on their willingness-to pay

Assumptions

- Capital costs are independent of running costs
- Strong positive linear relation between capital costs of ICE alternatives
  - E.g. if it is assumed that a capital cost of ICE alternative is equal to its 25th percentile, then capital costs of all ICE alternatives are equal to their 25th percentiles
- Strong positive linear relation between capital costs of PHEV and EV alternatives
- Capital costs of ICE alternatives are relatively independent from the capital costs of PHEV and EV alternatives
- Strong positive linear relation between running costs of ICE alternatives
- Strong positive linear relation between running costs of PHEV and EV alternatives
- Moderate to strong positive linear relation between the running costs of ICE alternatives and running costs of PHEV and EV alternatives

Probabilistic model

- 81 scenarios that can occur during forecasting period
- Determine the outcome for each scenario
  - the outcome shows the shares of technologies in new vehicle fleet
  - the share is determined by comparing willingness-to-pay to ratio of marginal capital cost to marginal running cost
- Weight the outcome from each scenario according to its probability
- Derive the shares of technologies in new vehicle fleet and the expected variances of these shares

Results

- 2016-2020, Small PV

	ICE1	ICE2	ICE3
P(Tech)	65.0%	18.8%	16.3%
WtW em rate	193	178	156

Weighted avg em rate for new vehicle fleet					
Type of emission rate	Mean	St Dev	Confidence level	Lower limit	Upper limit
WtT	24	0.76	0.05	23	26
TtW	160	5.06	0.05	150	170
WtW	184	5.81	0.05	173	196

Results

- 2021-2025, Small PV

	ICE1	ICE2	ICE3	ICE4	ICE5	ICE6	ICE7	ICE8
P(Tech)	0.6%	3.1%	10.9%	12.8%	31.3%	27.5%	13.4%	0.3%
WtW em rate	219	207	196	184	173	161	150	138

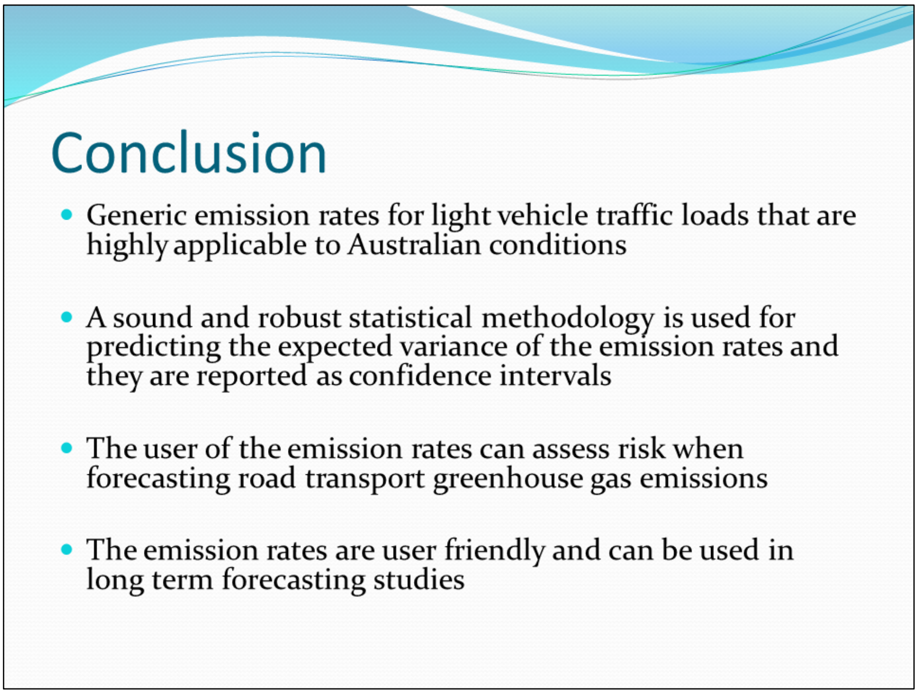
Weighted avg em rate for new vehicle fleet					
Type of emission rate	Mean	St Dev	Confidence level	Lower limit	Upper limit
WtT	22	0.85	0.05	21	24
TtW	149	5.66	0.05	138	160
WtW	171	6.51	0.05	159	184

Results

- 2026-2030, Small PV

	ICE1	ICE2	ICE3	ICE4	ICE5	ICE6	PHEV
P(Tech)	16.3%	20.0%	29.1%	22.1%	11.4%	0.9%	0.2%
WtW em rate	184	173	161	150	138	127	160

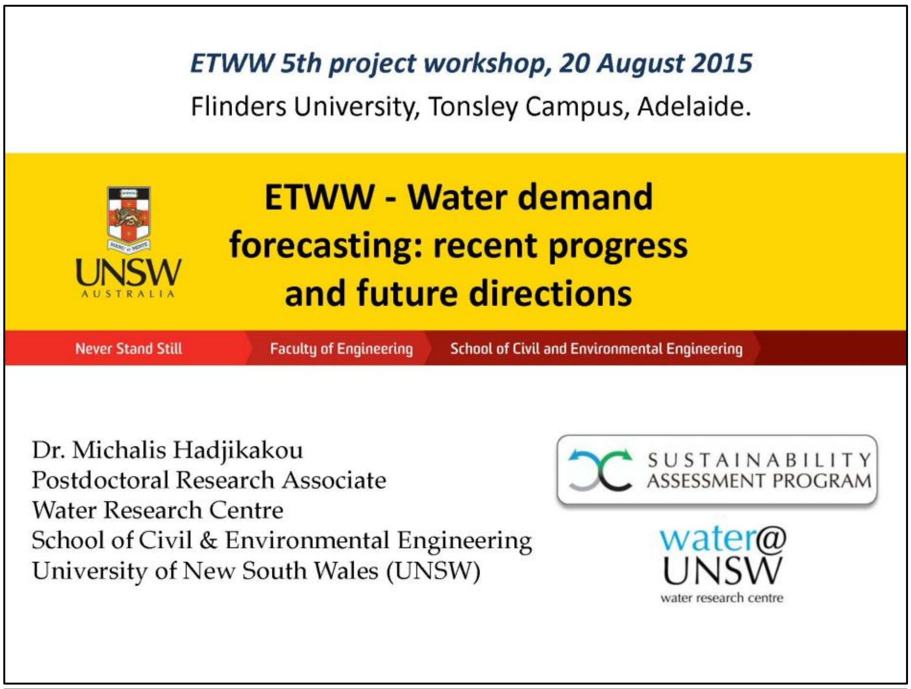
Weighted avg em rate for new vehicle fleet					
Type of emission rate	Mean	St Dev	Confidence level	Lower limit	Upper limit
WtT	21	3.06	0.05	15	27
TtW	140	7.03	0.05	126	154
WtW	162	7.29	0.05	147	176

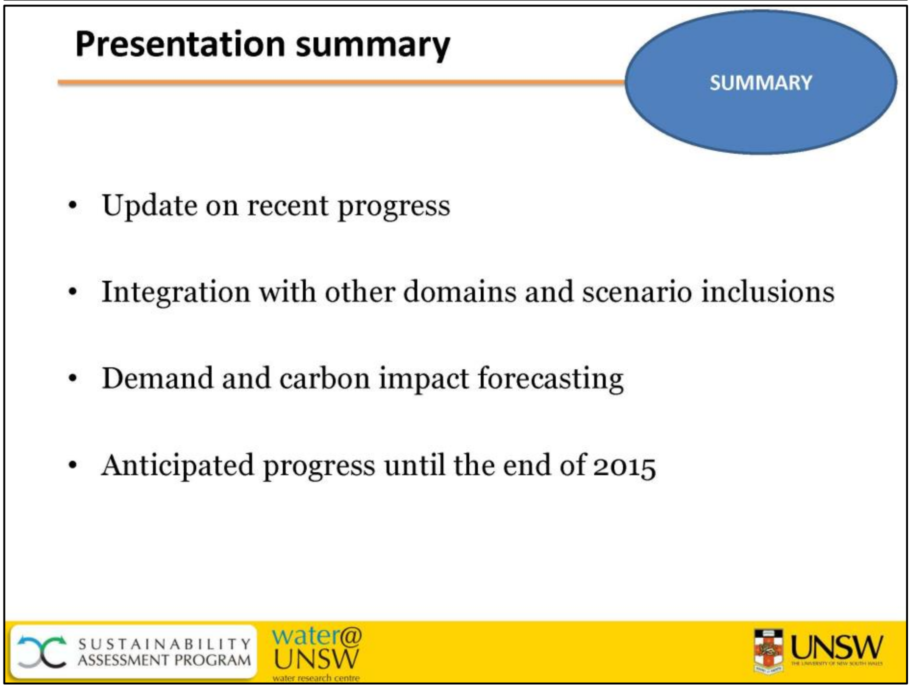

Conclusion
Generic emission rates for light vehicle traffic loads that are highly applicable to Australian conditions
A sound and robust statistical methodology is used for predicting the expected variance of the emission rates and they are reported as confidence intervals
The user of the emission rates can assess risk when forecasting road transport greenhouse gas emissions
The emission rates are user friendly and can be used in long term forecasting studies

Presentation 3: ETWW - Water Demand Forecasting: Recent Progress and Future Directions, Michalis Hadjikakou.

Current research in the water demand forecasting domain involves setting up a two component water demand forecasting model with end use component. Mosaic data socioeconomic characteristics are currently used to estimate likely water demand based on empirical relationships established from previous Australian studies. Ongoing work on model calibration (subject to data from Sydney Water, SA Water and Lochiel Park) and forecasting under future water supply and energy scenarios (in development).

Michalis's presentation made to the workshop is provided as follows.

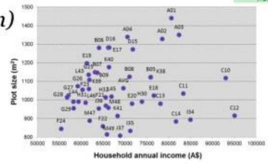




Recent progress – increased model flexibility

- Mosaic variables potentially relevant to water:
  - **Household size** ✓
  - **Plot size** ✓
  - *Dwelling structure/type*
  - *Demographics (age, gender, number of children)*
  - ***Income*** ✓
  - *Education*
  - *Climate and seasonality*
  - *Water rates and charges*

	Age	Adults	Persons	Income	Bedrooms	Bathrooms	Plot size	Vehicles	Children
Age	1.00	-0.11	-0.54	-0.10	-0.10	-0.84	0.30	-0.24	-0.56
Adults		1.00	0.73	-0.41	-0.25	0.36	0.59	0.46	-0.42
Persons			1.00	-0.40	-0.23	0.73	0.34	0.40	0.32
Income				1.00	0.66	-0.01	-0.05	0.11	0.04
Bedrooms					1.00	0.17	0.25	0.52	0.04
Bathrooms						1.00	0.03	0.44	0.47
Plot size							1.00	0.70	-0.37
Vehicles								1.00	-0.11
Children									1.00



- Currently using different relationship coefficients from the literature (for Sydney and Adelaide) but will also calculate my own (pending data requests from Sydney Water and SA Water)

Users of the tool are therefore given the option of choosing which coefficients/relationships they consider most reliable!

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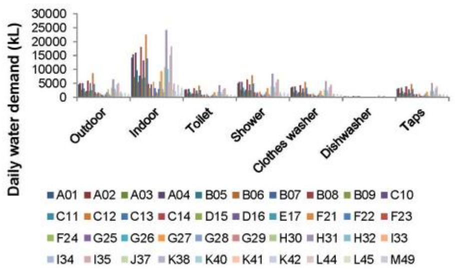
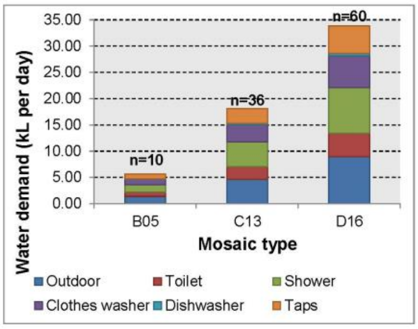
Recent progress – Synthetic precinct results

- NSW, SA and Lochiel Park
- Presently only based on empirical relationships in the literature

NSW



Lochiel Park



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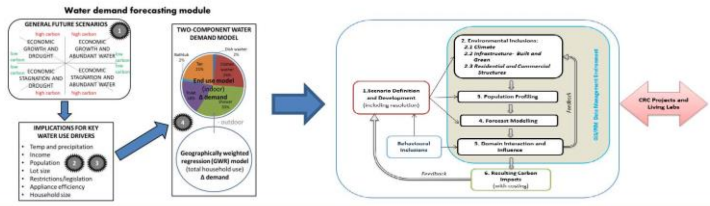
Recent progress – updated workflow

1. R script reads in any Mosaic data file for any precinct
2. Calculates Mosaic type composition in any given precinct
3. Use any chosen relationship to relate any of our available variables to indoor and outdoor water demand
4. End use breakdown based on previous Australian studies
5. Estimates carbon emissions based on present water and electricity supply mix.
6. Uses future population, future water and energy supply mix along with future climate to project water demand and associated carbon emissions
7. Allows assumptions about appliance efficiency and/or human behaviour



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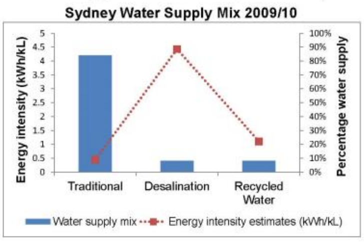
Integration and scenario inclusions

- Water clearly interacts very closely with energy, **water-energy nexus literature** (Kenway et al. 2011)
- End use component to be linked to energy estimates (two-way consistencty)



- Scenarios
  - Population
  - Climate
  - Behaviours
  - Appliances
  - Water supply mix
  - Electricity/energy mix
- Existing empirical relationships will be assumed for future scenario considerations (e.g each Mosaic type will behave in the same way in the future).
- Need to discuss behavioural changes and their likely impacts…

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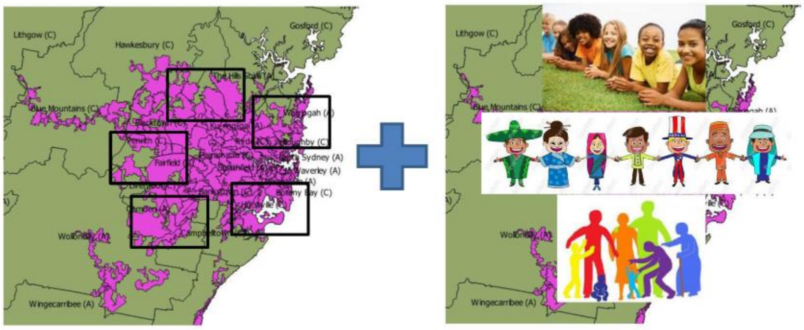
Model integration – remaining issues

- Remaining data – I propose multi-purpose sampling



- Mosaic areas which are of interest to as many domains as possible

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Anticipated progress until the end of 2015

- Current and future water demand and carbon estimates for precincts on the basis of Mosaic data – **including results**
- Option of choosing linear model according to city and/or prior knowledge of water demand variability
- Option of choosing city electricity mix and other types of carbon-related modifications
- Flexible model prototype to be improved/fine-tuned in 2016 following feedback from industry partners and PSC
- Adding cost estimates using information supplied by Sydney Water and SA Water

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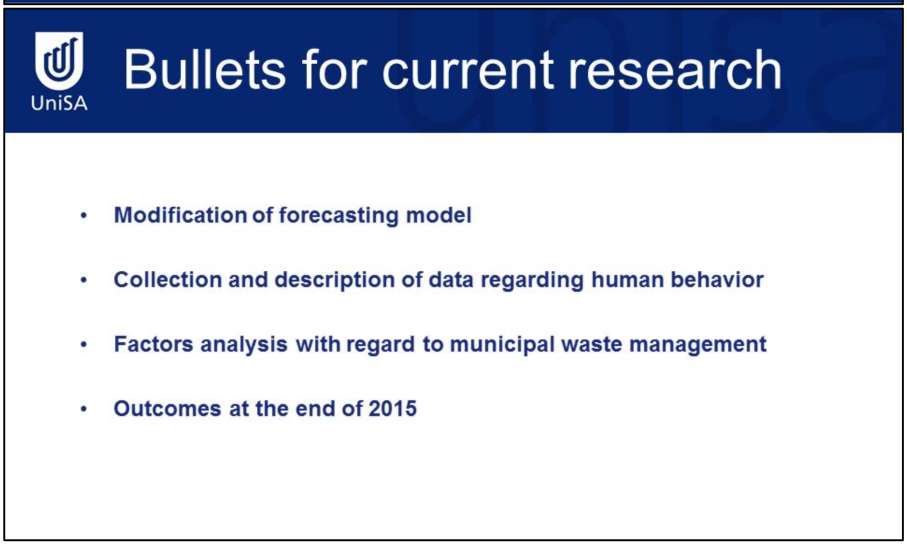
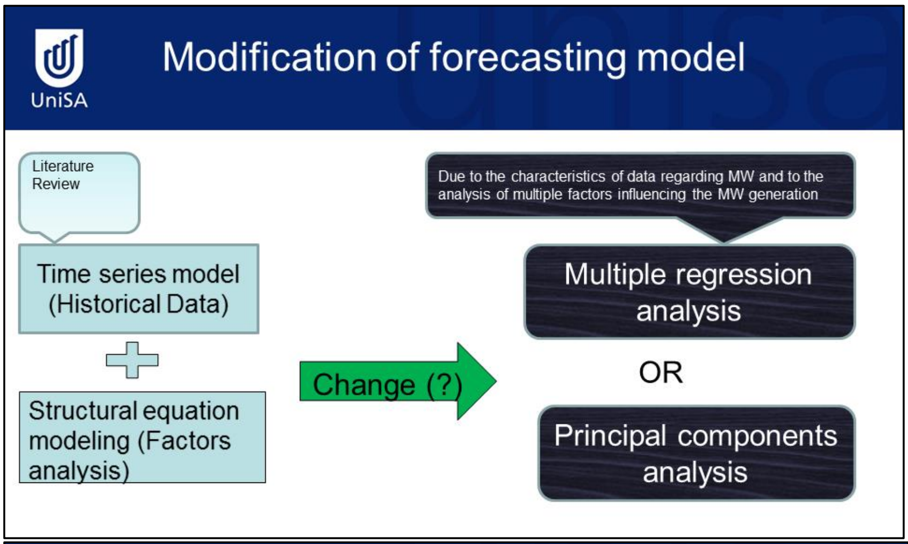
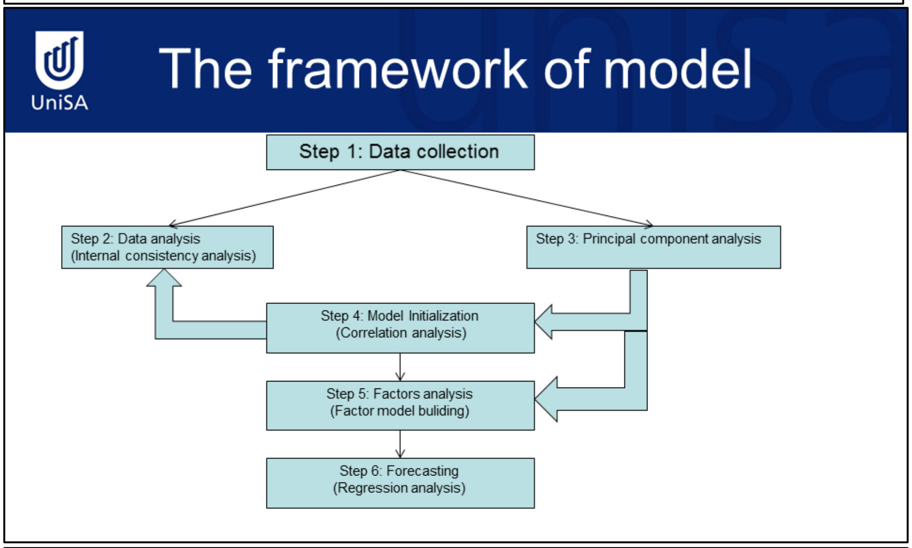
Presentation 4: Current Research Process Regarding the Waste Domain, He He

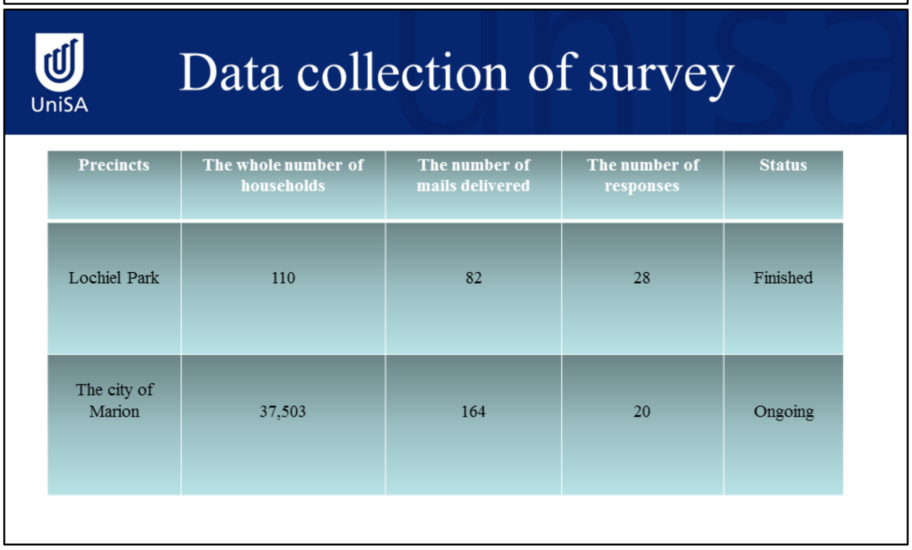
Current research in the waste production forecasting domain involves applying a time series model and multivariable linear regression model in terms of the characteristics of data in order to forecast the municipal waste generation. The information of human behavior at the Lochiel Park had been collected, and the work at the city of Marion is ongoing and factors based on the information from the Lochiel Park are analyzed to show how factors influence the municipal waste generation, and the research of connecting human behavior with associated quantity of municipal waste generation is carried out.

He He's presentation made to the workshop is provided as follows.





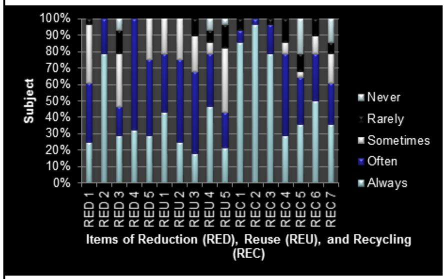


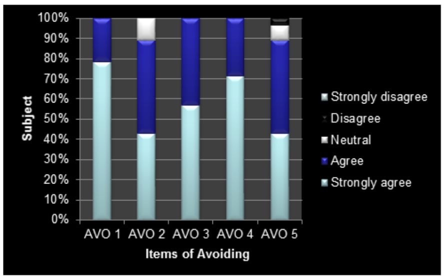


Precincts	The whole number of households	The number of mails delivered	The number of responses	Status
Lochiel Park	110	82	28	Finished
The city of Marion	37,503	164	20	Ongoing

Basic analysis and description of data at Lochiel Park

UniSA





Basic analysis and description of data at Lochiel Park

UniSA

Descriptive Statistics of Income Weekly and Education Degree

	N	Minimum	Maximum	Mean	Std. Deviation
Income Weekly($)	28	.00	6.00	4.8214	1.67892
The highest educatin degree	28	1.00	5.00	3.6429	1.31133
Valid N (listwise)	28				

Descriptive Statistics of Responds about Global environment issues

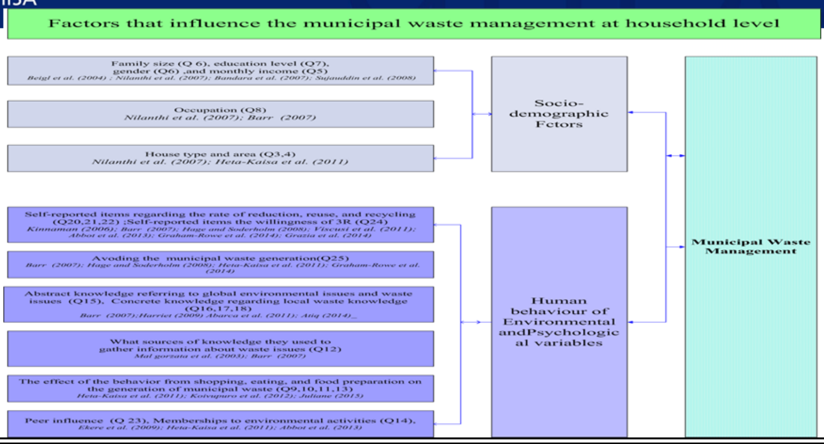
	N	Minimum	Maximum	Mean	Std. Deviation
Global warming	28	1.00	3.00	1.6071	.62889
Ozone layer depletion	28	1.00	3.00	1.6429	.55872
Desertification	28	1.00	3.00	1.6429	.62148
Water pollution	28	1.00	3.00	1.4286	.57275
The pollution of general waste	28	1.00	3.00	1.3571	.55872
Valid N (listwise)	28				

Data collection of quantity

UniSA

Source	Region	Time	Waste stream model
The city of Marion Council	The city of Marion	From June 2006 to December 2014	Material stream (more details)
Zero waste SA	Central Eastern (Adelaide City, Adelaide Hills, Burnside, Campbelltown, Norwood Payneham & St Peters, Prospect, Unley, Walkerville)	From July 2010 to June 2013	Material stream

Factors analysis



Factors analysis

Test of Homogeneity of Variances

Buy product with as little packaging as possilbe

Levene Statistic	df1	df2	Sig.
.042	2	25	.959

ANOVA

Buy product with as little packaging as possilbe

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.761	2	3.880	7.858	.002
Within Groups	12.346	25	.494		
Total	20.107	27			

Buy product with as little packaging as possilbe

Student-Newman-Keuls[a,b]

Global warming	N	Subset for alpha = 0.05
		1
Extremely	13	1.62
Neutral	2	2.50
Moderately	13	2.69
Sig.		.071

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.588.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Outcomes at the end of 2015

- Determine which forecasting model is better for the research;
- More data about the research is collected;
- Factors analysis is finished.

Foundation Model

At the end of 2015 the project is looking toward assembling and integrate domain reseach at that point in time with the development of a foundation version of the forecasting framework. It is envisaged that this will occur in a prototype format and as a spreadsheet assembly of significant modelling components such as common inputs, assumptions, select processes and demand forecasting outputs. The foundation model will provide a common resource for domains to interact through integration. Application therefore requires a fondation model scenario, with Lochiel Park having been chosen for this task.

Lochiel Park Precinct Scenario

The Lochiel Park precinct site will form the basis for a forecast scenario with potentially two stages, that being for the application years of 2015 and for 2035. Land uses for these years will be:

- 2015: 103 households as current,
- 2035: 256 households at the same proportions of Mosaic types as in the 2015 year or with new proportions and the addition of simple land uses, eg. small retail and/or education site.

All domains will apply the identified household Mosaic typologies including and basic household resident characteristics. The combined and interactions forecast for the 2035 forecast only are:

- Electric Vehicles: energy and transport,
- Waste Disposal: waste and transport and energy,
- Energy from renewables / energy use in the supply of water: water and energy,
- Another inclusion may be on behaviour change, such as work-from-home behavior that will influence all domains (ie. spending he day in the precinct rather than at the work location).

Application of the foundation version of the model to the Lochiel Park scenario will in-turn produce damnd forecasts for subsequent carbon impact estiamtions.