LOW CARBON LIVING CRC

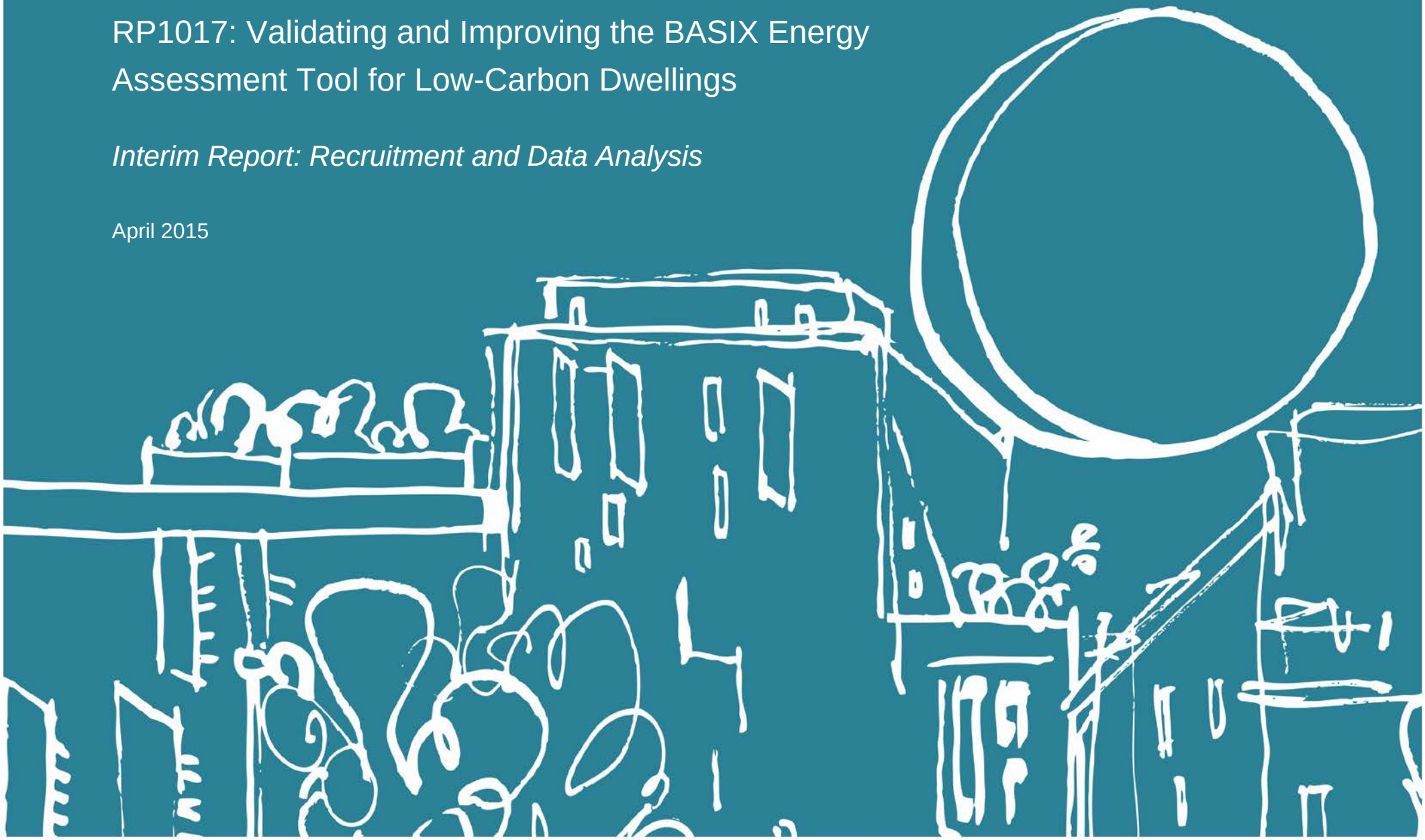
Australian Government
Department of Industry and Science

Business Cooperative Research Centres Programme

RP1017: Validating and Improving the BASIX Energy Assessment Tool for Low-Carbon Dwellings

Interim Report: Recruitment and Data Analysis

April 2015



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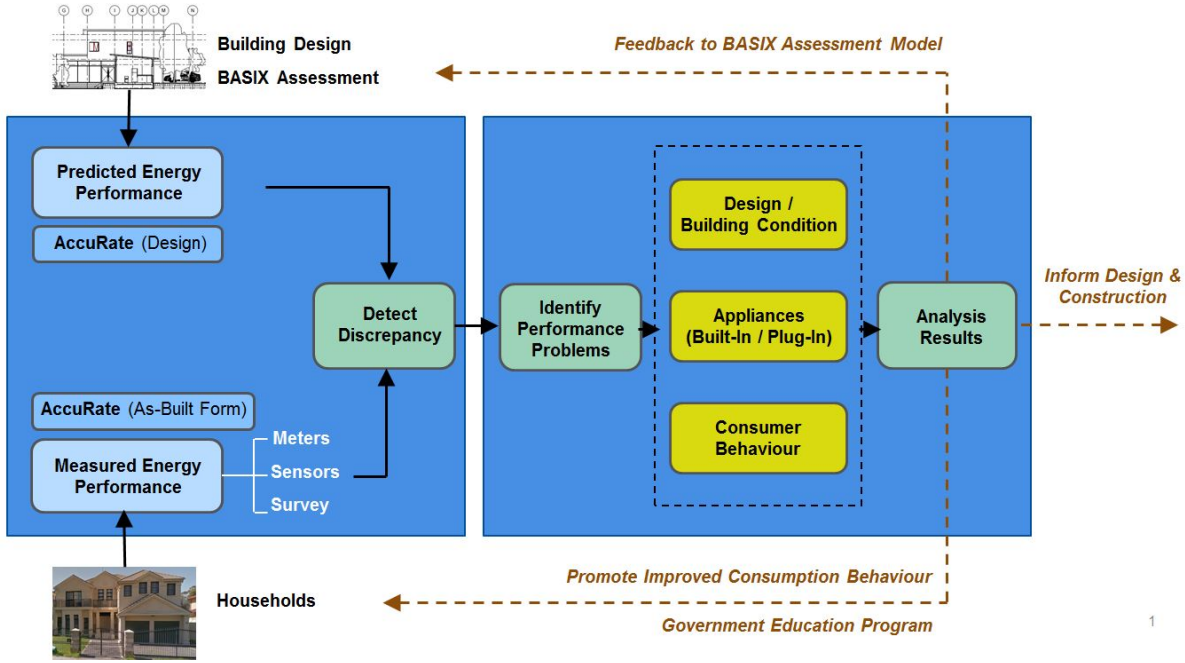
Introduction

The Building Sustainability Index (BASIX) is used to model and regulate energy use and greenhouse gas emissions of all new residential buildings in NSW. More than 140,000 dwellings have been built in NSW under BASIX since it was launched in 2004. This research project will carry out post-occupancy investigations of new residential buildings in NSW. It compares BASIX modelled results to monitoring data in real-life environments for each type of energy use in homes, and identifies performance problems in building condition, appliances and consumer behaviour. The findings of this research will assist to identify areas for improvement of the BASIX assessment models, establish the links between government regulations, design options and post-occupancy behaviour and inform future sustainability strategies and policy.



The activities of this research project include:

1) Recruitment of participants from single dwellings and multi-unit dwellings;
2) Collection of real-time energy performance and behavioural data through metering, sensing and thermal imaging technologies as well as face-to-face interviews;
3) Development of a post-occupancy energy performance assessment model; and
4) Generation of insights to inform future sustainability strategies and decision-making.

The project interim report presents the stage 1 initial research outcomes that consist of:

PART 1: Recruitment and initial data analysis, and

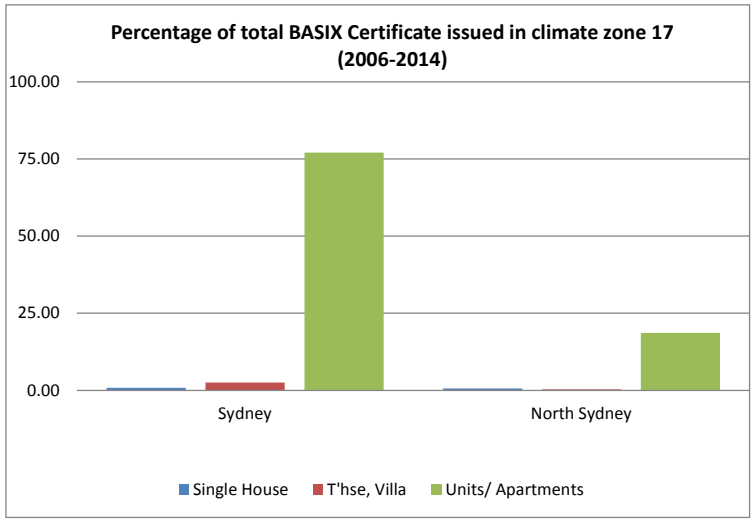
PART 2: Analysis of key variables for data collection at the stage 2.

Part 1 | Recruitment and Initial Data Analysis

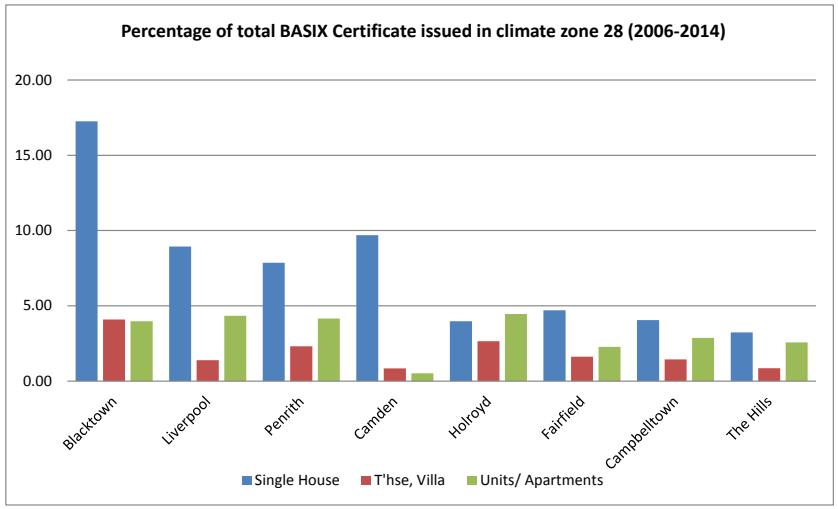
Local Government Area Selection

BASIX dwelling addresses were supplied from the New South Wales Department of Planning and Environment based on Sydney's three NatHERS Climate Zones. A brief analysis of this data (shown in the graphs below) illustrates the Local Government Areas with the largest proportions of BASIX applications categorised into Unit/Apartments, Single Houses and Townhouse/Villas.

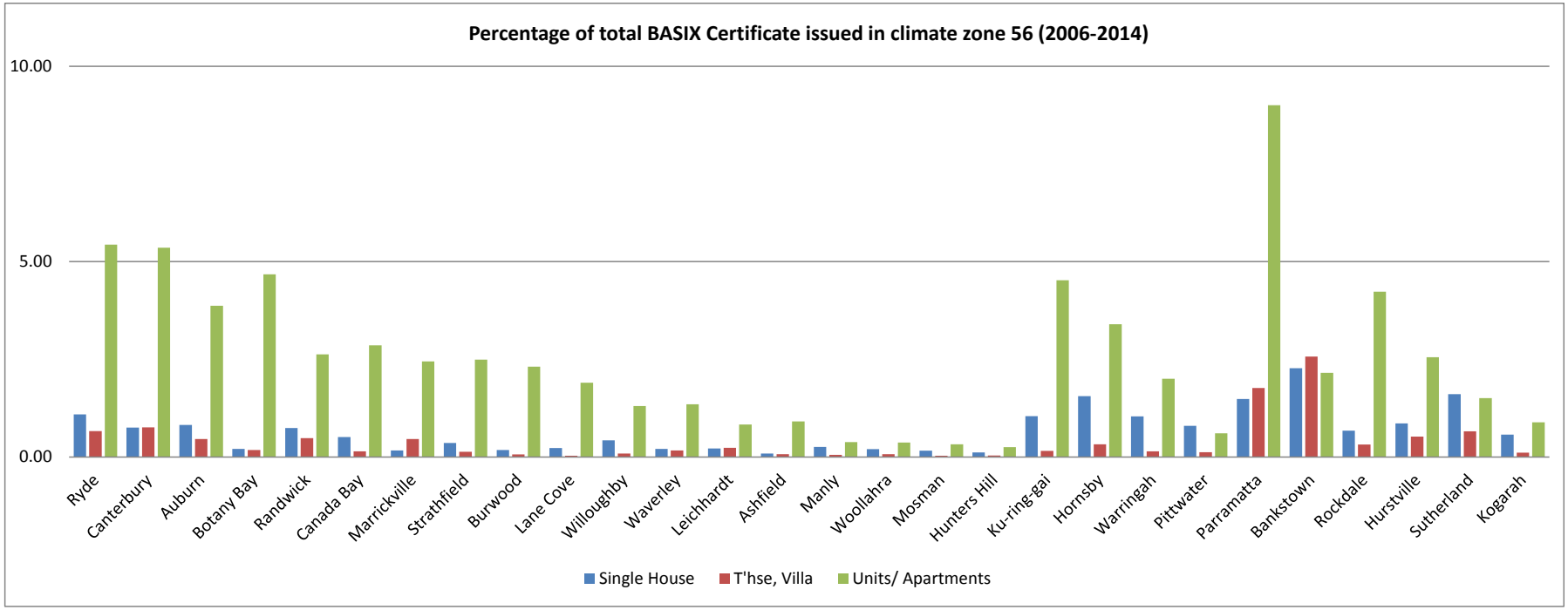
At this stage in the process of recruitment for single dwellings and in order to achieve diversity within the dwellings, Local Government Areas were chosen based on the amount of single dwelling BASIX applications received. Recruitment for units/ apartments will be predominantly carried out in Sydney City Council (Climate Zone 17) once again due to a large proportion of BASIX applications in this area for units/apartments.



77% of BASIX Certificates were issued for Units/Apartments in Sydney City Council (climate zone 17) between 2006 and 2014.



60% of BASIX Certificates were issued for Single Houses in climate zone 28 followed by, 25% for Units/Apartments and, 15% for Townhouse/Villas between 2006 and 2014.The majority of BASIX Certificates were issued in Blacktown, Camden, Liverpool, Penrith and Fairfield Councils.



70% of BASIX Certificates were issued for Unit/Apartments in climate zone 56 followed by, 19% for Single Houses and, 11% for Townhouse/Villas between 2006 and 2014. The majority of BASIX Certificates were issued in **Bankstown, Sutherland, Hornsby, Parramatta** and **Ryde** Councils.

Individual Dwelling Selection

The process of selecting individual dwellings involved verifying addresses supplied from the New South Wales Department of Planning and Environment through a variety of image-based platforms. Bankstown, Blacktown, Camden, Penrith and Parramatta City Councils, along with additional Local Councils, were all selected as suitable for this first stage of recruitment due to a significant number of BASIX Certificates issued. A set amount of dwellings were randomly chosen from each local council based on the year BASIX Certificate was applied for. These addresses then needed to be cross referenced with Google Maps, Street View and SIX Maps (NSW Land and Property Information), in order to verify the existence of a relatively new and/ or renovated dwelling. This process removed any discrepancies in the supplied addresses and facilitated the appropriate selection of individual dwellings based on their location and age.

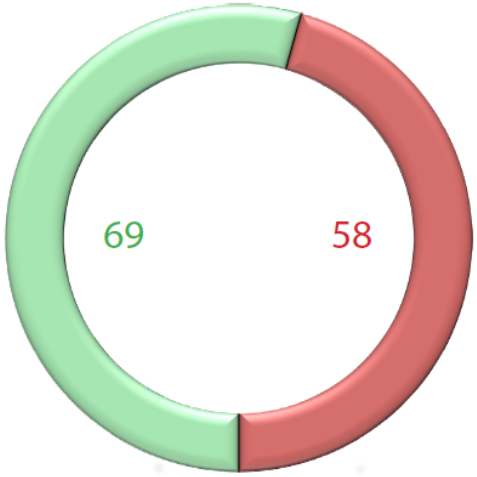
Survey Distribution

The recruitment survey was distributed to BASIX dwellings as either a hardcopy or an online survey. Approximately 1100 formal letters were sent to dwellings within Bankstown, Parramatta, Blacktown, Camden and Penrith City Councils. Additional Local Councils assisted this process through promoting this project via social media, local websites, newspapers and e-newsletters. Home owners could either respond to the survey either by mail or online through the link provided to them. This allowed quick and efficient means of receiving, collating and analysing the data from the survey. Any surveys that were received via mail were then transferred to the online survey so that this data could be clearly presented and analysed. The following section illustrates the survey questions from a total of 128 responses, taken from both the hardcopy and online surveys.

Survey Responses

Are you interested to participate in the next stage survey?

128
Survey Responses

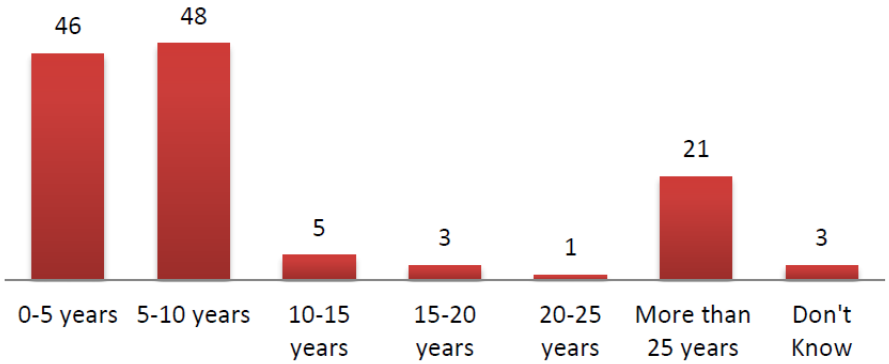


54.33%
are willing to participate in Stage 02, and

45.67%
do not want to participate in Stage 02.

1 did not respond to this question

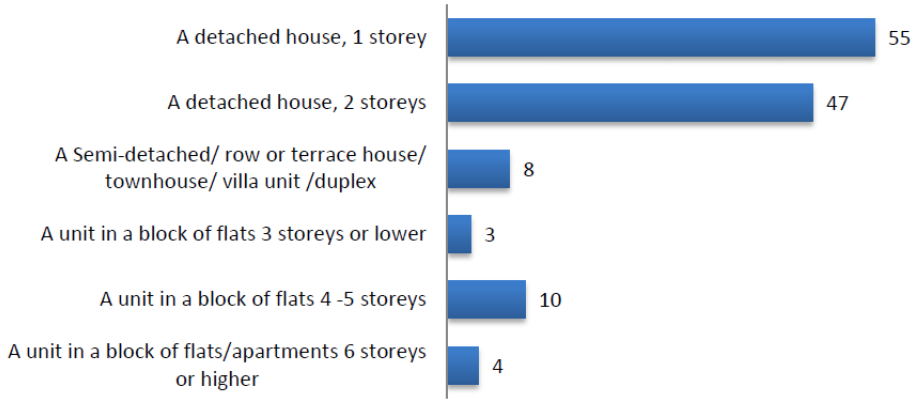
How old is your dwelling? *(Response Total)*



1 did not respond to this question

74.02%
of dwellings are between 0-10 years old.

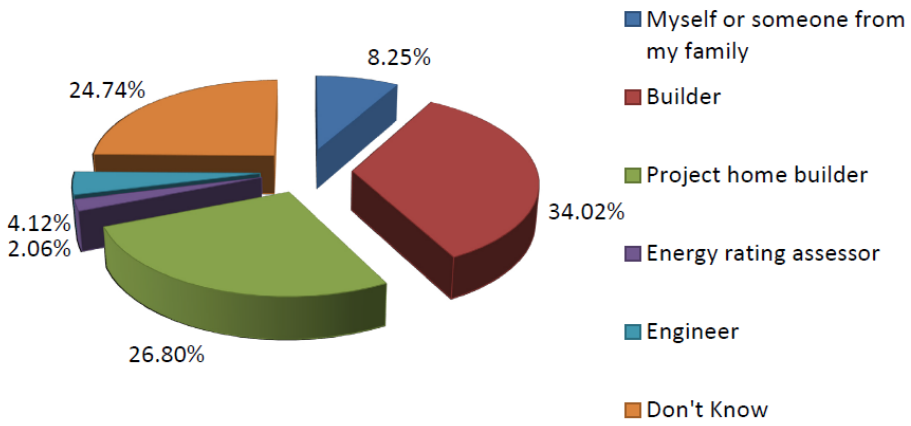
Which of the following best describes where you live?
(Response Total)



1 did not respond to this question

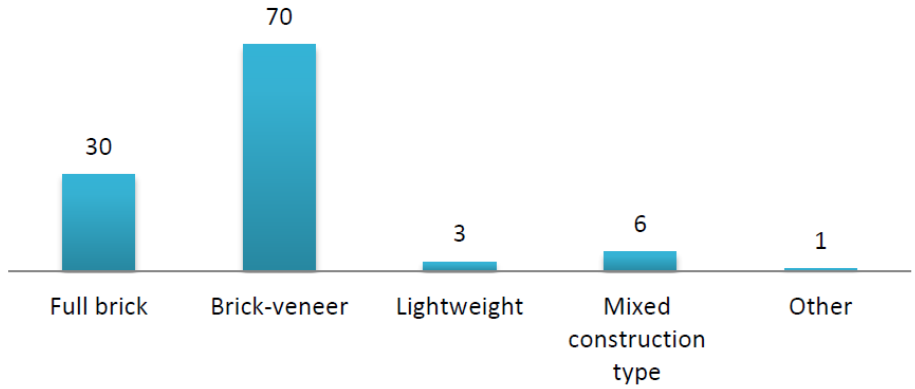
80.31%
of dwellings are detached houses, either 1 or 2 storeys.

If your dwelling was built within last 10 years, do you know who completed the BASIX certificate? *(Response Percentage)*



31 did not respond to this question

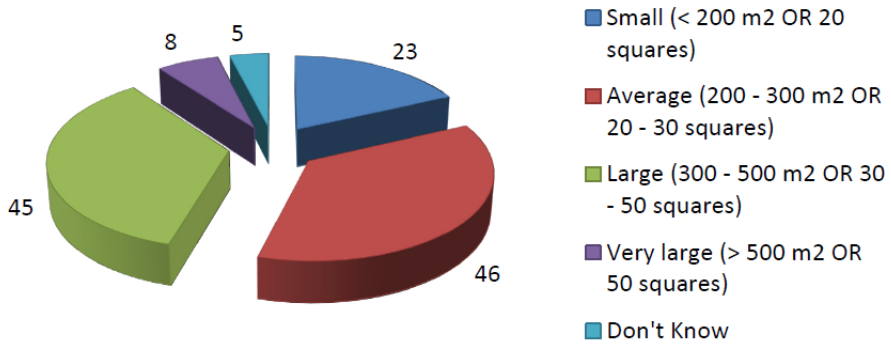
Which of the following best describes the building type of your house? *(Response Total)*



18 did not respond to this question

63.64%
of dwellings employ a brick-veneer construction type.

How large is your dwelling? *(Response Total)*

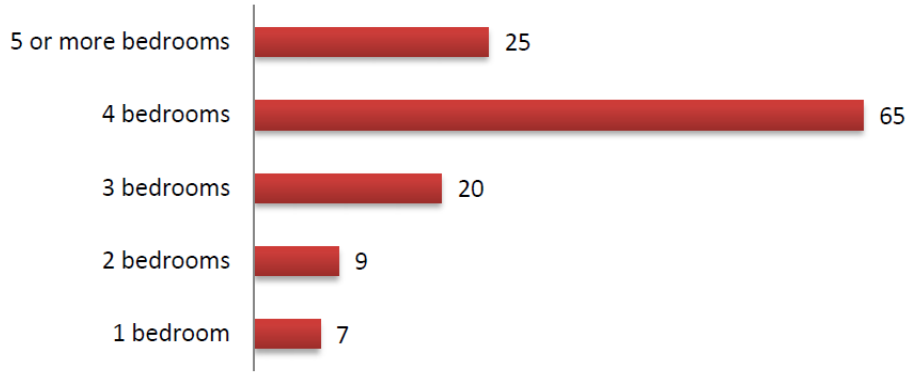


1 did not respond to this question

36.22%
of dwellings are between 200-300 sqm, and

35.43%
of dwellings are between 300-500 sqm.

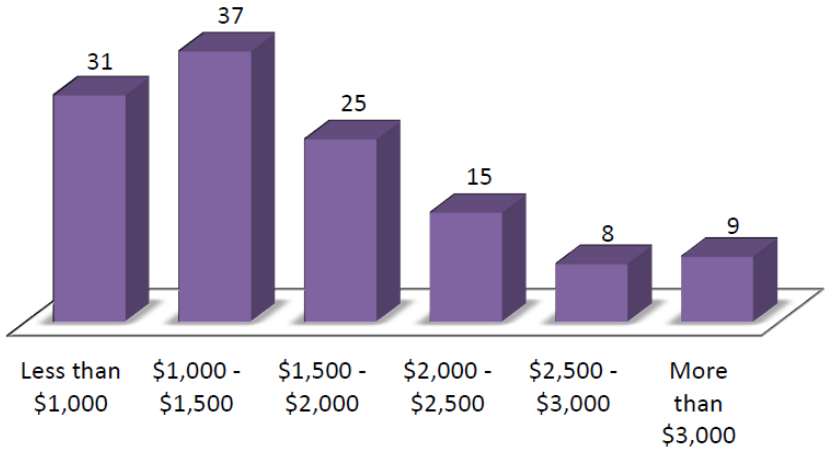
How many bedrooms does your dwelling have?
(Response Total)



2 did not respond to this question

71.43%
of dwellings have 4 or more bedrooms.

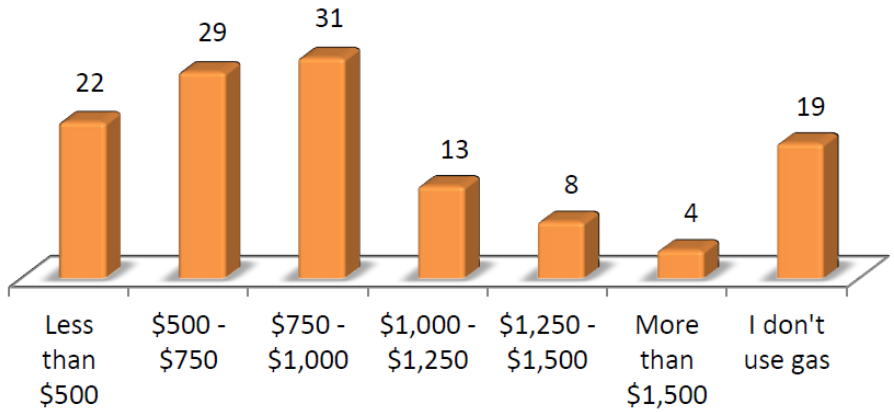
How much did you spend on electricity last year?
(Response Total)



3 did not respond to this question

54.40%
of dwellings spend less than $1500 on electricity each year.

How much did you spend on gas last year? *(Response Total)*

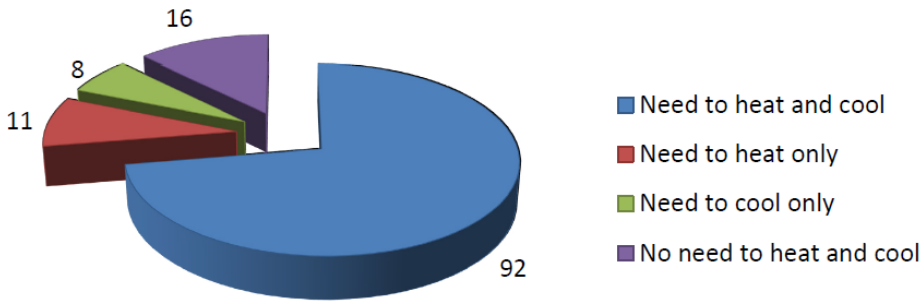


2 did not respond to this question

65.08%
of dwellings spend less than $1000 on gas each year, and

15.08%
of dwellings do not use gas.

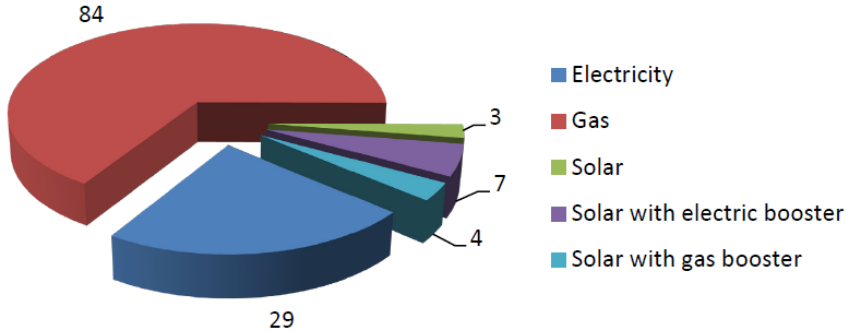
Do you need to heat or cool your home?
(Response Total)



1 did not respond to this question

72.44%
of respondents need to heat and cool their dwellings.

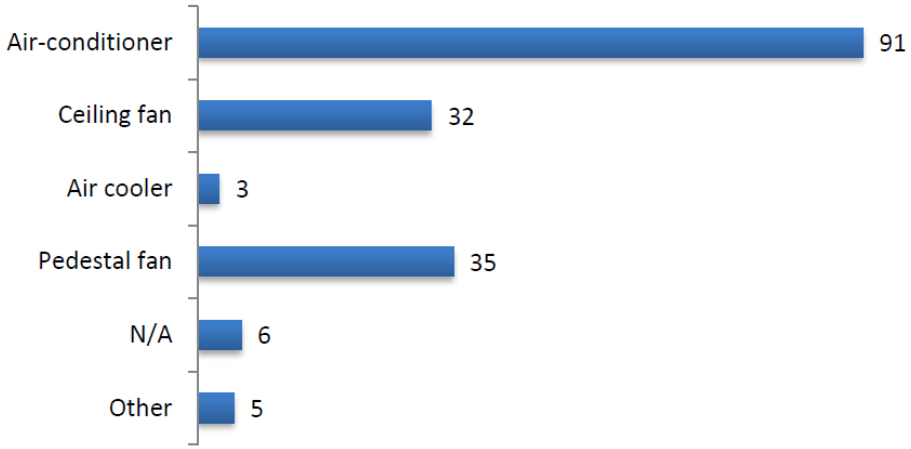
Which of the following best describes the main energy used in your Hot Water System? *(Response Total)*



1 did not respond to this question

66.14%
of dwellings use gas for their hot water system.

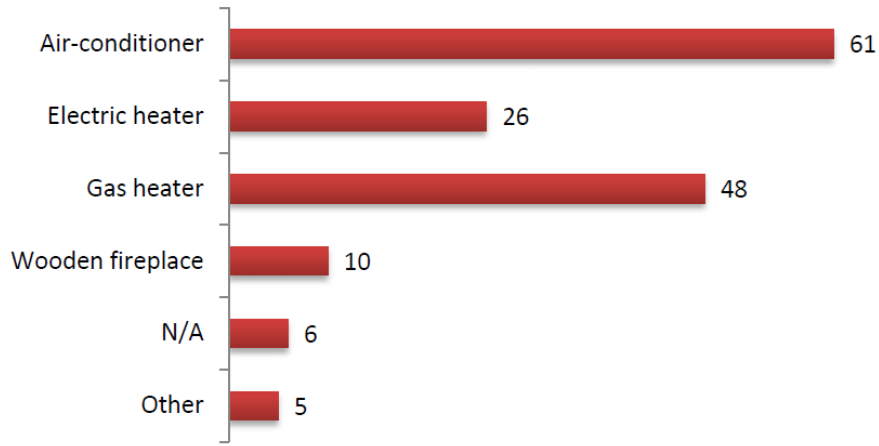
If you need to cool your home, which home appliances do you most often use? *(Response Total)*



2 did not respond to this question - can select more than one if applicable

72.22%
of respondents use an air-conditioner to cool their dwellings.

If you need to heat your home, what do you use most often? *(Response Total)*



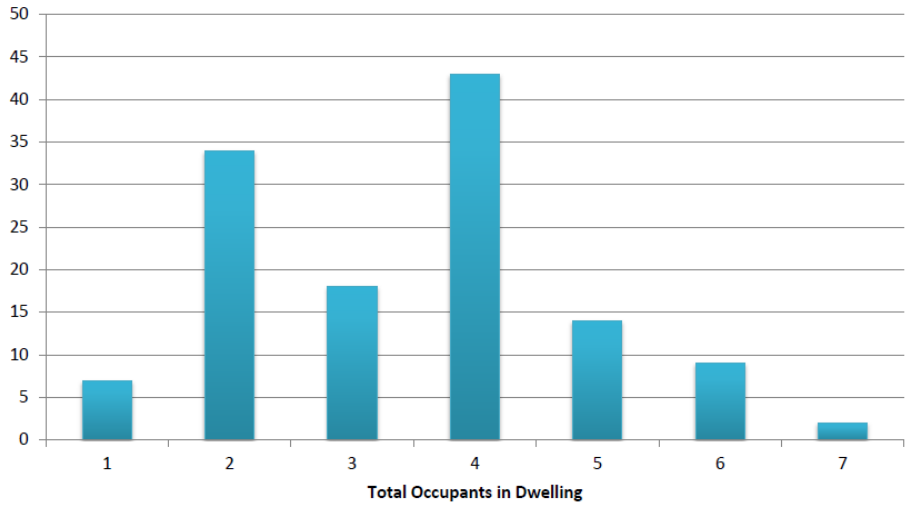
3 did not respond to this question - can select more than one if applicable

48.80%
of respondents use an air-conditioner to heat their dwellings, and

38.40%
of respondents use a gas heater.

Number of people currently living in this dwelling?

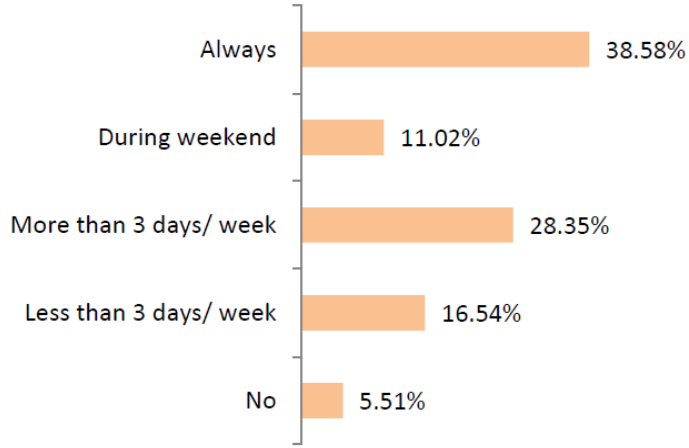
(Response Total)



1 did not respond to this question

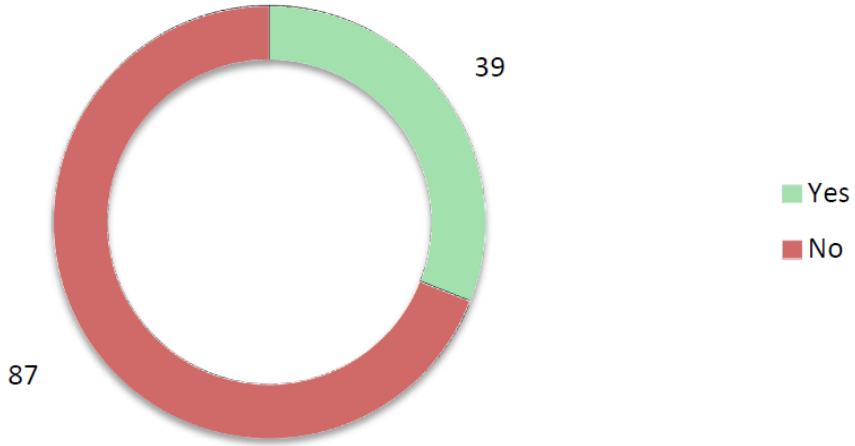
Is someone home during daytime (between 9 AM to 6 PM)?

(Response Percentage)



1 did not respond to this question

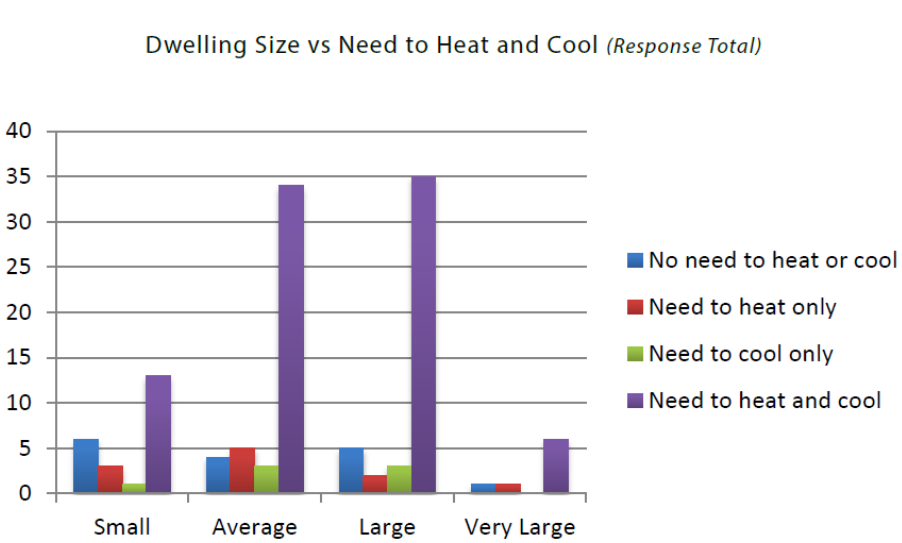
Have you installed solar panels for generating electricity in your dwelling? *(Response Total)*



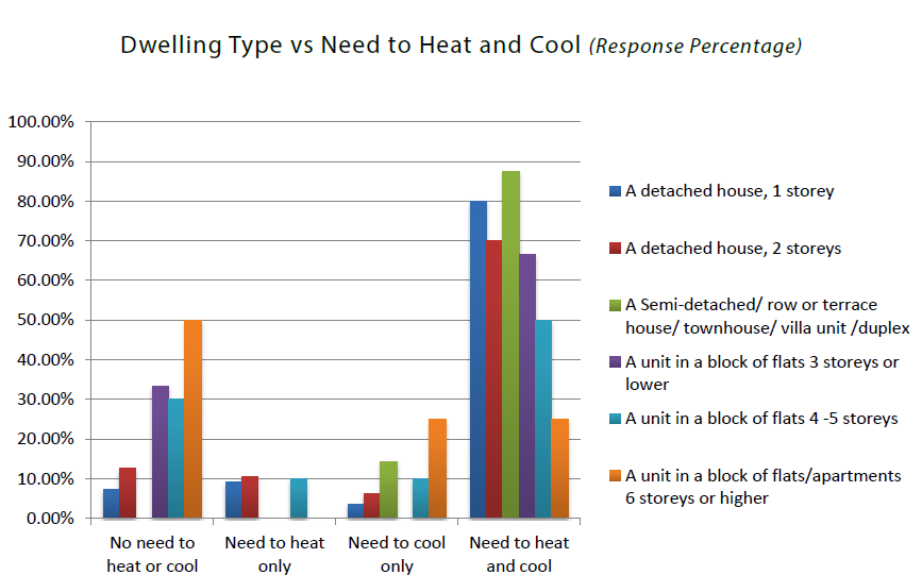
1 did not respond to this question

30.95%
of dwellings have installed solar panels for generating electricity.

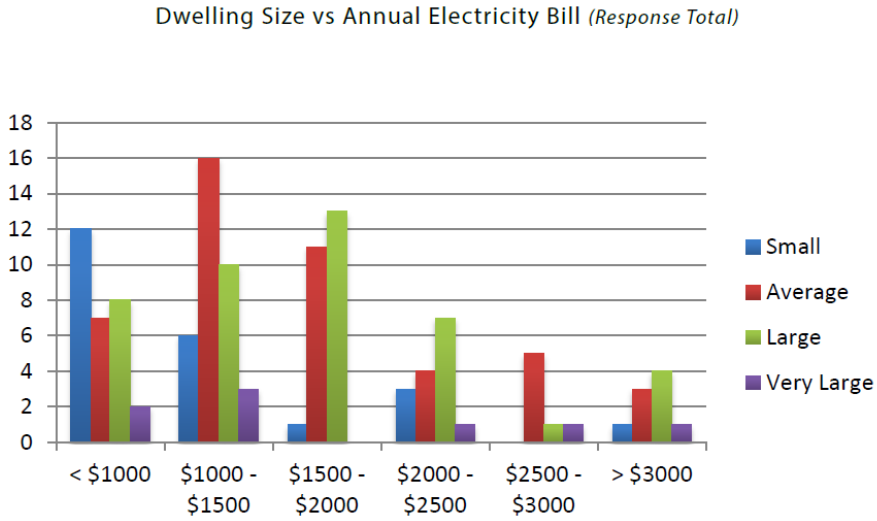
Initial Analysis

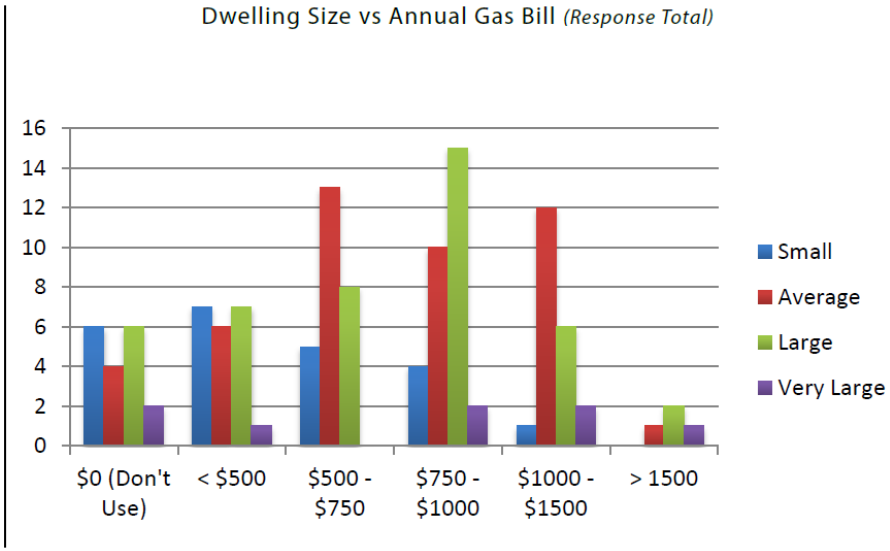


73.91% of average sized dwellings need to heat and cool, and 77.78% of large sized dwellings need to heat and cool.

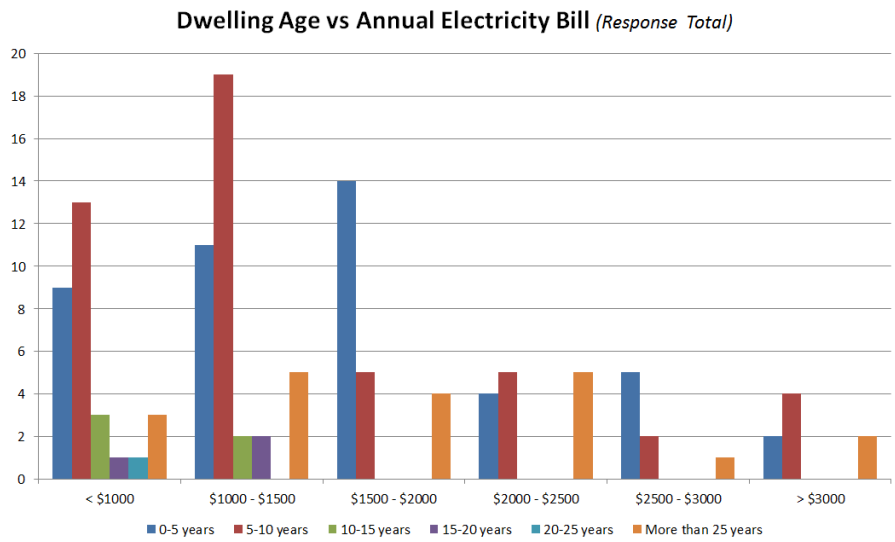


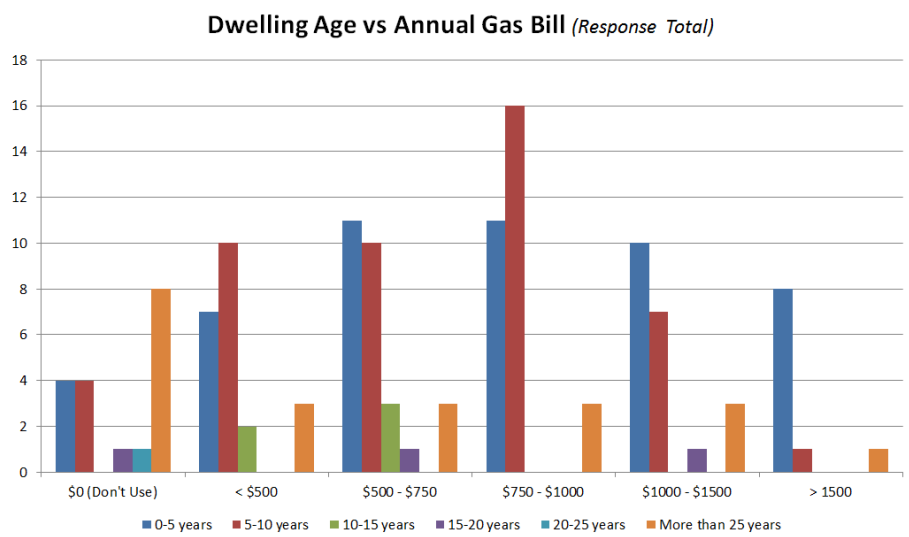
80.00% of detached 1 storey dwellings need to be heated and cooled, and 70.21% of detached 2 storey dwellings need to be heated and cooled.



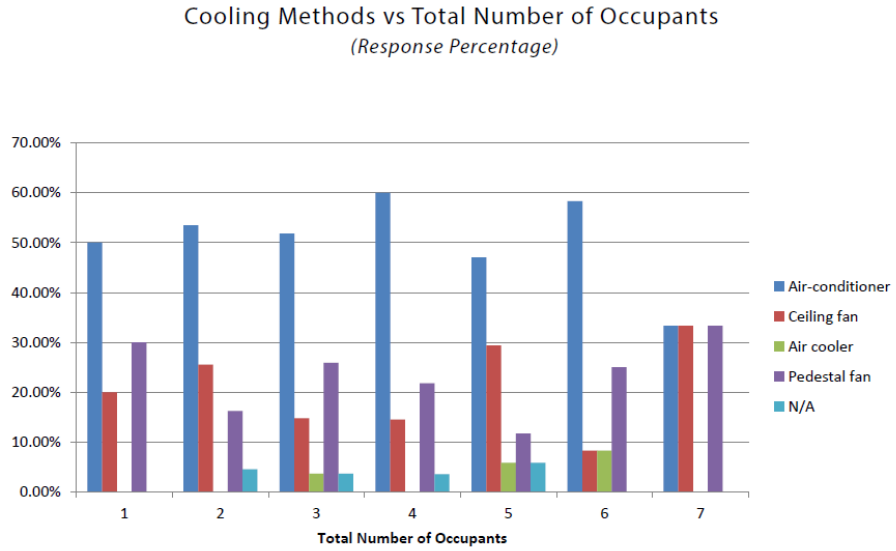


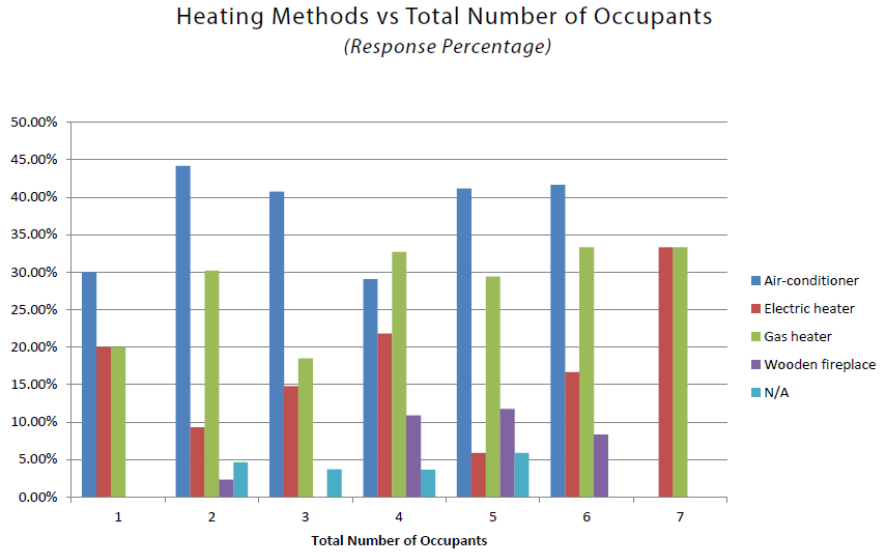
Both of these graphs show generally uniform trends with regards to dwelling sizes and annual gas and electricity bills. However, this reliability and accuracy of this data is limited by the relatively small response group.





When looking at the annual electricity and gas bills in regards to the dwelling age, again there is a generally uniform trend in these graphs. However, at this stage in the recruitment process, only dwellings between ages 0-10 years old are useful as other categories have relatively small response totals.





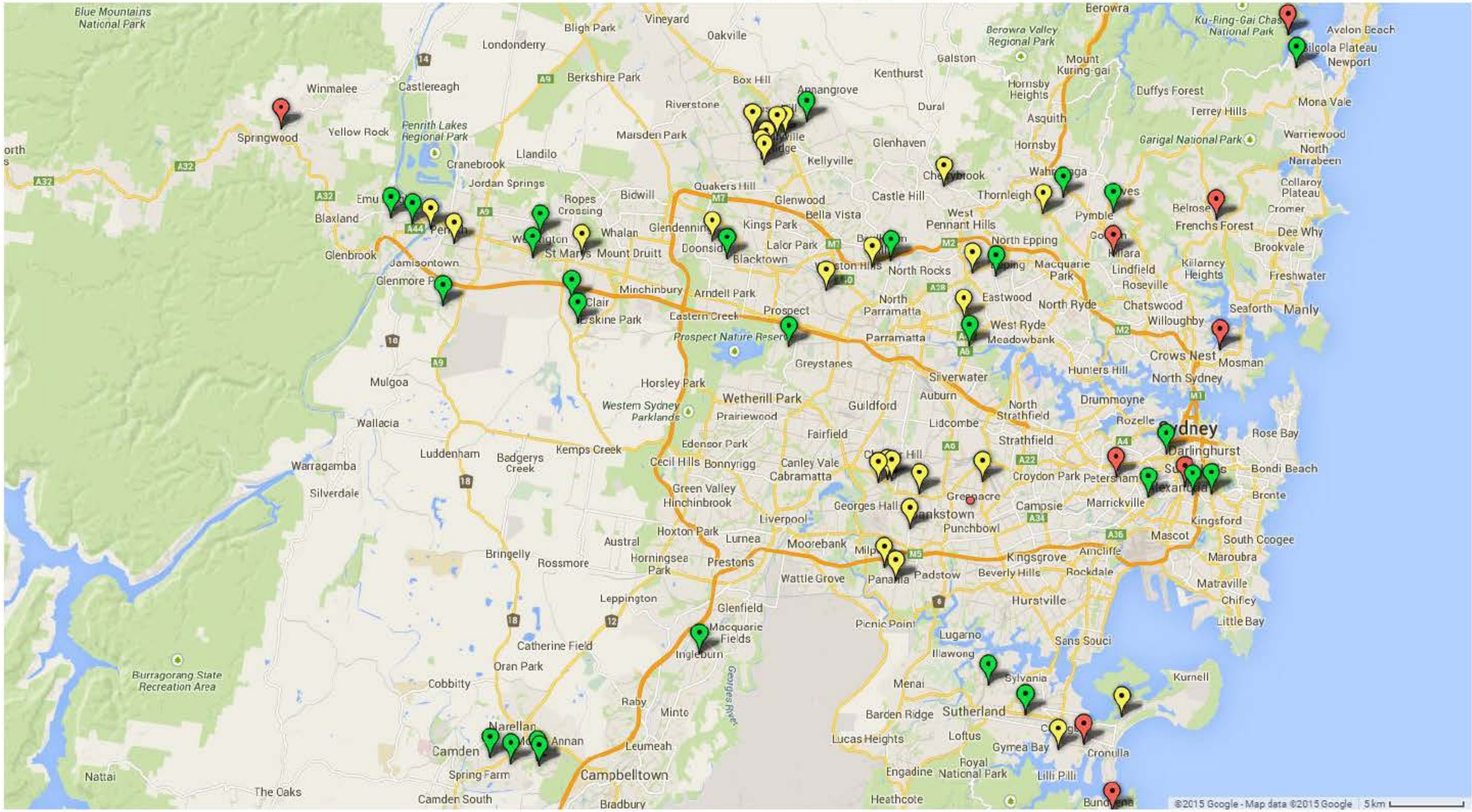
60.00% of dwellings with a total of 4 occupants require air-conditioning, and only 14.55% are using ceiling fans as a method of cooling.

Looking at dwellings with a total of 4 occupants again, 32.73% use gas heaters, and 29.09% use air-conditioners to heat their dwellings.

Confirmed Stage 02 Dwellings vs Dwelling Age

0-5 years - 28 single dwellings.
5-10 years - 23 single dwellings, 3 multi-unit dwellings.
20+ years - 10 single dwellings, 1 multi-unit dwelling.

Map shows 63 out of 65 confirmed dwellings

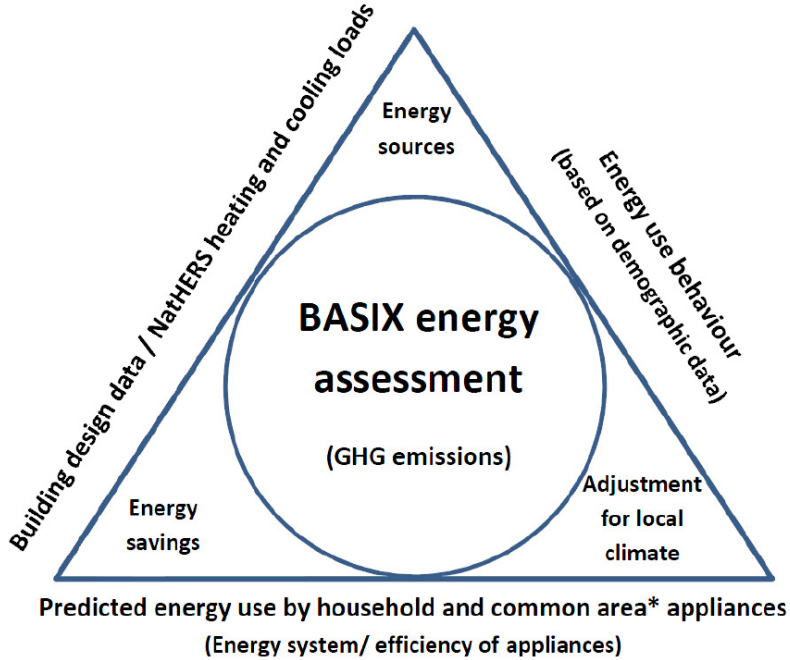


Part 2 | Key Variables for Stage 2 Data Collection

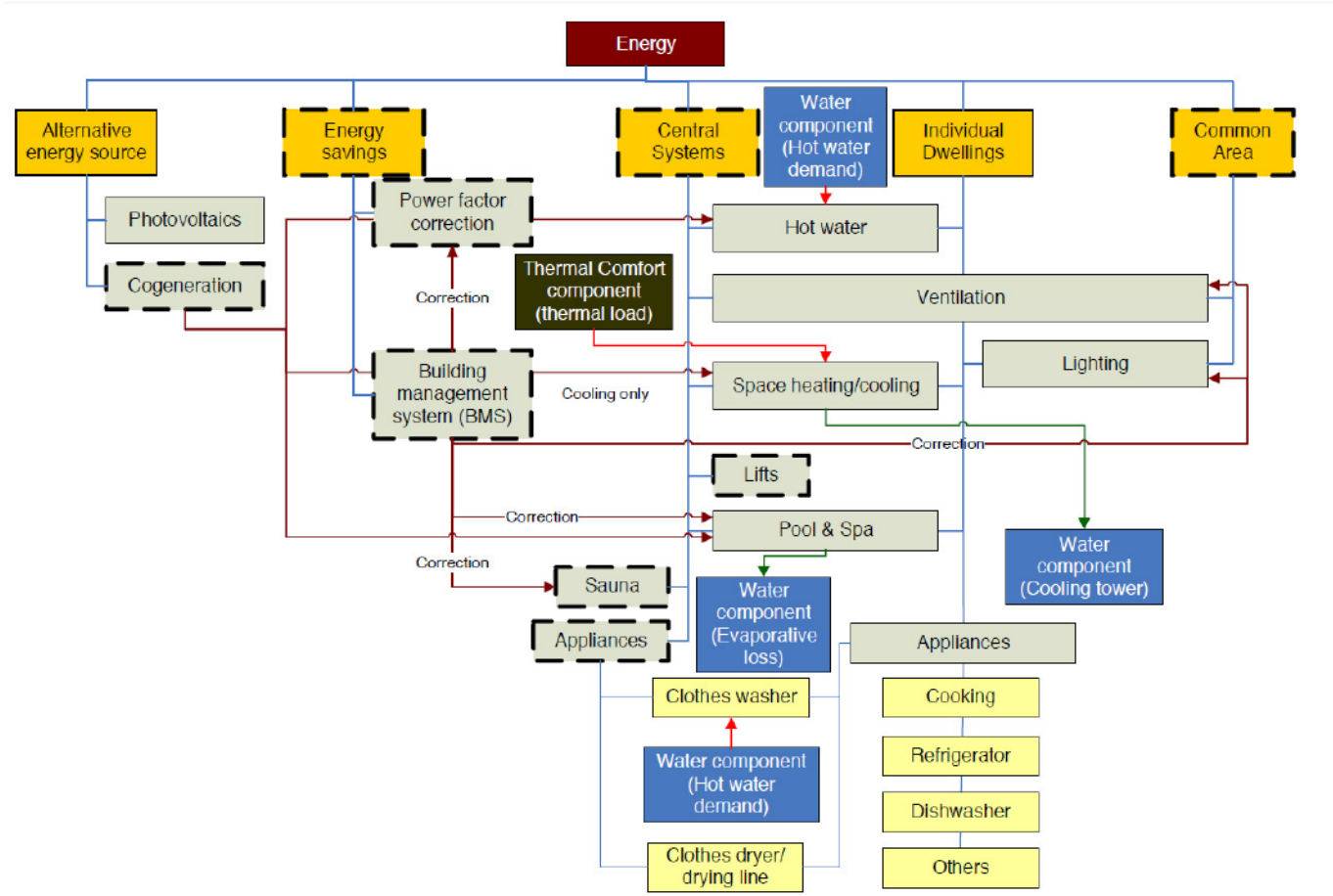
This part of the report briefly explains BASIX energy assessment, outlines key variables, describes the research approach and method of collecting data from a household level. The first section identifies factors considered in the BASIX energy assessment and number of components which contribute in energy consumption and GHG emissions. The second section explains research approach, key variables and methods of data collection for the stage 2 energy performance monitoring.

BASIX Energy Assessment

The BASIX energy assessment tool considers energy used for all activities within a dwelling. Building design data is used to estimate energy required to maintain thermal comfort, if NatHERS accredited thermal performance simulation software is not used. Energy use behaviour/pattern are estimated from demographic data and built-in assumptions within the BASIX energy assessment tool. Predicted energy use by household appliances are determined using user input and inherent assumptions in the assessment tool. Energy system, efficiency of appliaces and energy source are important variables in estimating total energy demand and GHG emission from a dwelling. The BASIX energy assessment tool considers local climate while estimating energy usage for maintaining thermal comfort. For multi-unit apartments, energy savings measures (by using building management systems) contribute in reducing energy consumption for central system and common area. Energy used by central system and common area are calculated separately.



Factors considered in BASIX energy assessment



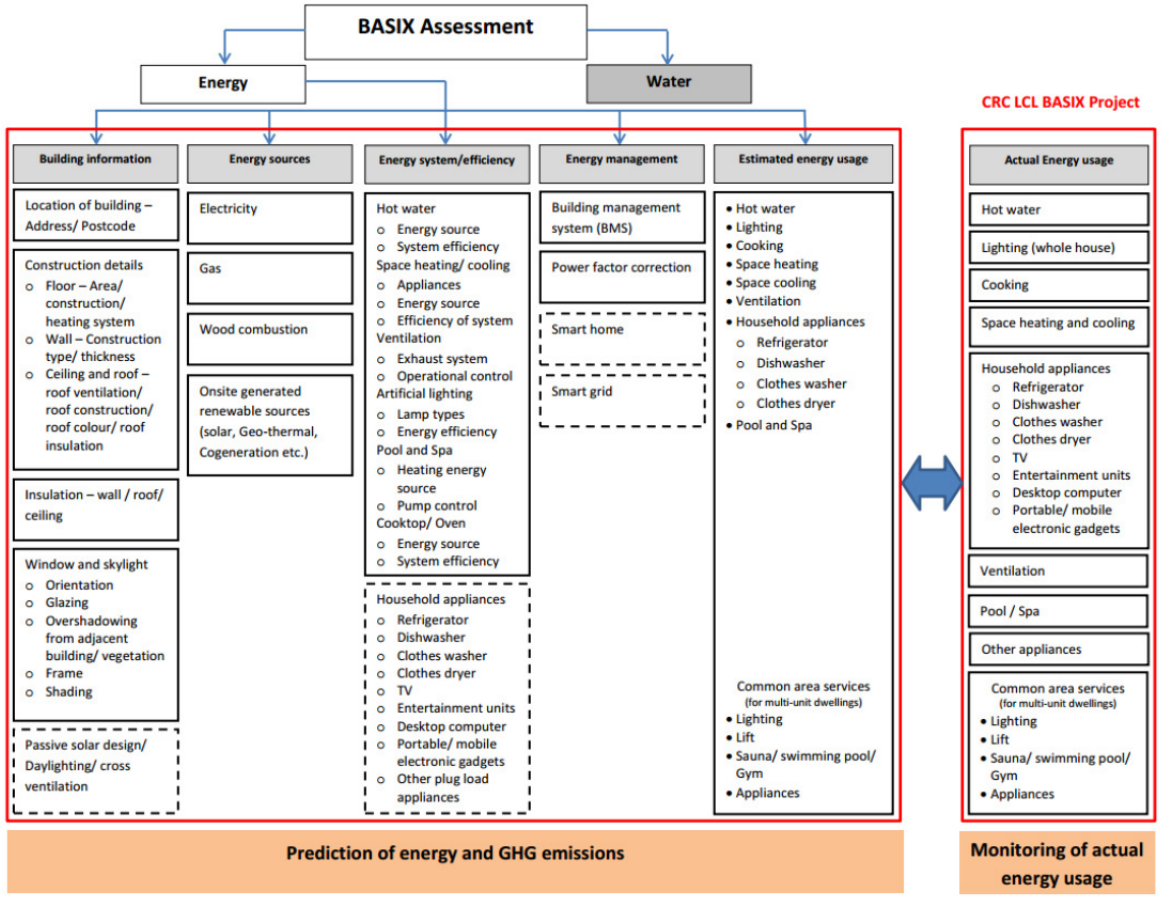
Components contributing in energy consumption and GHG emissions in BASIX energy assessment
(Landreth, Yee et al. 2011)

Although the BASIX certificate reports individual score for water and energy components, and pass or fail for thermal comfort; the energy simulation tool extracts hot water usage data to estimate energy used for heating hot water and thermal comfort data for predicting energy consumption for heating and cooling systems. The model considers common household appliaces such as cooking, refrigerator, dishwasher, clothes washer, clothers dryer to estimate energy usage at dwelling scale. The components that are considered in multi-unit dwellings are in dashed boarders.

We identified key components used in BASIX assessment in order to monitor actual energy usage at individual appliance level.

- Building information is used to determine thermal comfort of the dwelling if Do-It-Yourself (DIY) method is selected. Alternatively, NatHERS accredited building thermal performance simulation software are used to predict heating and cooling loads. Passive solar design techniques, daylight access and provision of cross ventilation can helpto reduce operational energy usage significantly.
- Energy source determines the level of GHG emissions. Electricity emits almost four times more GHG emissions than natural gas to deliver same energy output. Clean and renewable energy sources help offsetting GHG emissions.
- Energy management system help reduce energy wastage by its intelligenet control system. Smart power plugs help reducing standby energy usage and motion sensors lights save significant amount of energy at the household scale. With the advancement of technology, energy management systems are becoming affordable with short payback periods.
- The BASIX simulation engine calculates predicted energy usage for major household appliaces and informs percentage of GHG emissions saved in comparison to the benchmark GHG emissions data.

In this project,, energy meters and plug load monitors are used to record energy usage data in real-time which not only give a profile of energy usage per appliance but also informs behavioural pattern of energy usage.



Key components considered in predicting energy and GHG emissions in BASIX assessment. This project monitors actual energy usage for various activities at appliances level.

Research Approach

This project considers a holistic approach in understanding how people use energy at household scale. Literature review suggests following key components to determine energy usage at household scale:

- Building design (as built)
- Building construction quality and performance
- Actual energy use behaviour
- Possession of household appliances and monitoring of their energy usage

Additionally, climate efficient building design (also known as passive design), smart home/ appliances, energy sources and adaptive behaviour also affect overall energy usage.

Specific Research Questions to Investigate

RQ.1. What is the actual energy consumption and GHG emissions of BASIX compliant new dwellings?

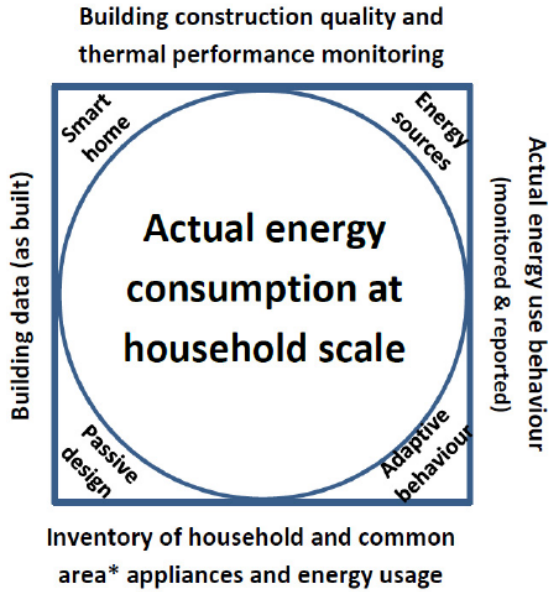
RQ.2. How the design of a dwelling and building construction quality influence energy usage at household scale?

RQ.3. How energy source, system, efficiency and management system influence energy use in the BASIX compliant dwellings?

RQ.4. How energy use behaviour affect energy consumption in the BASIX compliant dwellings?

RQ.5. When and how the occupants of the BASIX compliant dwellings use their heating and cooling systems?

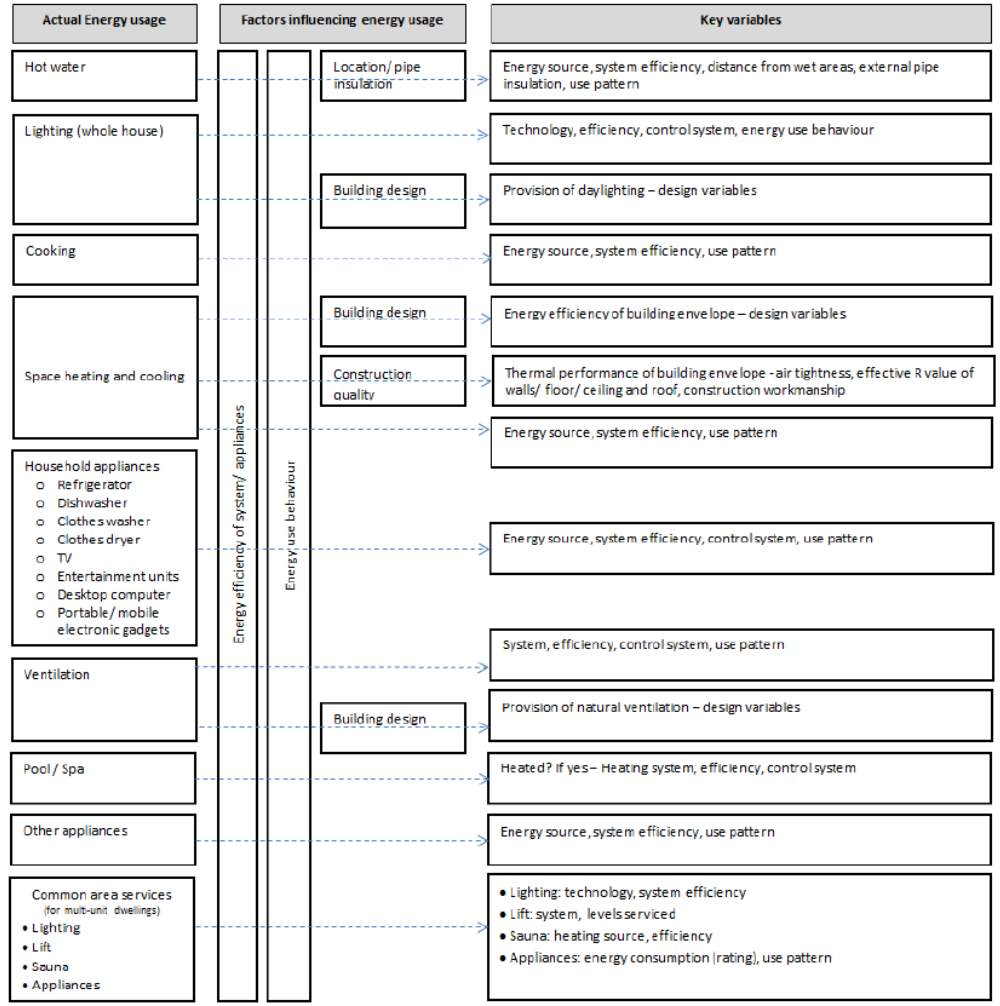
RQ.6. How can the BASIX assessment help to achieve low energy consumption and promote low carbon dwellings?



Factors need to be considered to determine actual energy consumption at household level.

Indentifying Key Variables

We identified key variables for individual appliance level in relationship with factors that influence energy usage such as energy efficiency of system/ appliances, energy use behaviour and design/ construction quality of building. The key variables help to outline measures to reduce energy usage for the specific appliance. For example, key variables for hot water energy usage are energy source, system efficiency of the hot water heating system, layout of wet areas in relation to hot water storage tank, external pipe insulation and hot water use pattern.

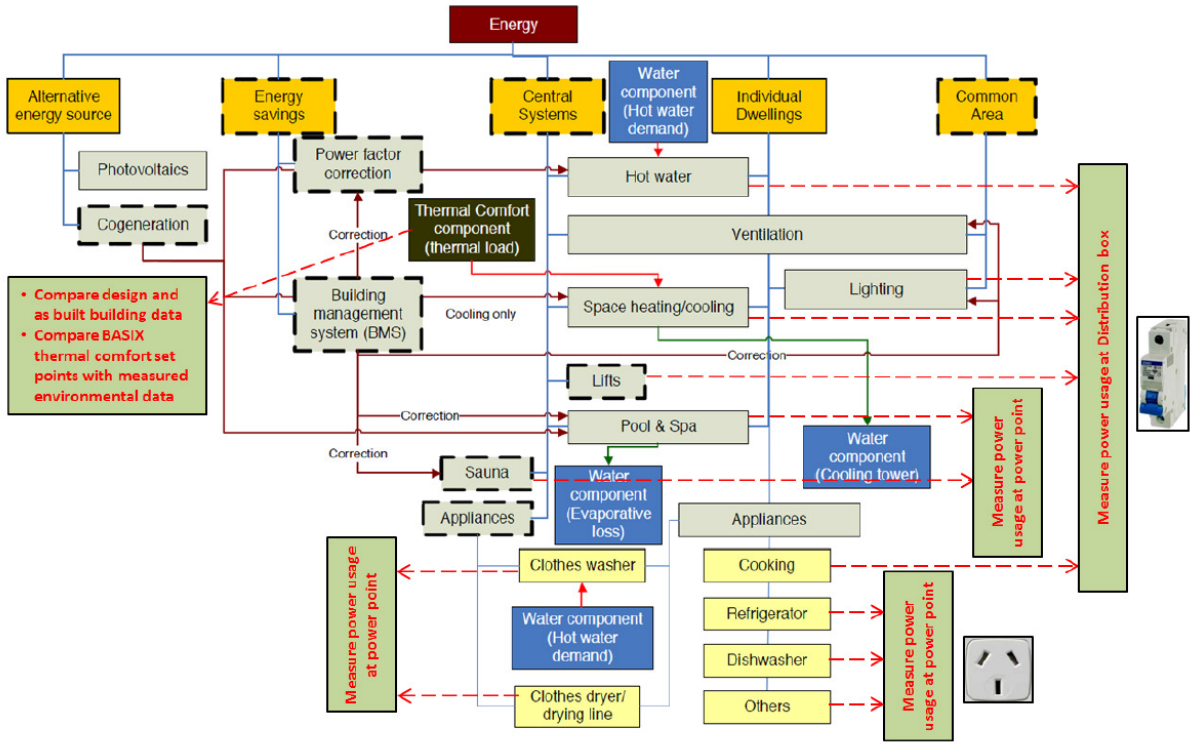


Identification of key variables at individual appliance level in a household.

Data Collection

Energy usage monitoring

Energy consumption data is collected at the distribution board for appliances which draw large power (i.e. more than 2.5 kW) such as air-conditioners, electric hot water system and hot plates. Other small appliances (i.e. draw power less than 2.5 kW) are connected to general power outlets (GPOs). Therefore, it is necessary to measure power usage at the GPOs to understand actual power usage by specific appliances such as refrigerators, clothes washers/ dryers and dishwashers. Building data is useful in understanding and comparing design and construction of the dwelling. Environmental data (i.e. temperature and humidity) collected from living areas is useful in compating thermal performance of dwellings and corresponding used of heating and cooling appliances. It also helps to crossexamine BASIX thermal comfort set points and actual thermal comfort preferences of individual households.



An overview of energy usage and environmental (temperature/ humidity) data collection approach at household level.

Appendix

Stage 01 Survey Request Letter for Houses

Stage 01 Survey Request Letter for Units

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We kindly request you to participate in the study if you are the owner of your dwelling. You can participate by completing this survey form and sending it back to us using enclosed reply post envelop/ by visiting http://www.surveys.unsw.edu.au/f/159434/f6b5/ or by scanning this QR code (using mobile QR reader app) and completing the survey form online.

The survey component of this study has been approved by the Human Research Ethics Committee, UNSW Australia (University of New South Wales). Participation in this study is optional and you can withdraw at any time. All your personal details and answers will be **strictly confidential**. Only sanitised data and combined results will be used to determine common themes and trends. Individual participants will not be identified in any reporting.

This 'Expressions of Interest – Survey' will take approximately 5 minutes to complete. Please select relevant answers by crossing the box ☒

SURVEY PRE-REQUISITES
1. Are you an adult (>18 years old) and the owner of the house/unit/flat/apartment? (This study is limited to the owners of the dwellings) ☐ Yes ☐ No
2. What is the postcode of your home address? _____
3. How old is your dwelling? ☐ 0 – 5 years ☐ 5 – 10 years ☐ 10 – 15 years ☐ 15 – 20 years ☐ 20 – 25 years ☐ More than 25 years ☐ Don't Know

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4. If your dwelling was built within last 10 years, do you know who completed the BASIX certificate?
(BASIX Certificate is one of the requirements of development application (DA) for new dwellings since 2005 in NSW)

☐ Myself or someone from my family ☐ Builder ☐ Project home builder
☐ Energy rating assessor ☐ Engineer ☐ Don't know

5. Which of the following best describe where you live?

☐ A Detached house, 1 storey ☐ A Detached house, 2 or more storeys
☐ A Semi-detached/ row or terrace house/ town house/ villa unit /duplex

6. Do you have a swimming pool?

☐ Yes ☐ No

7. Which of the following best describes the building type of your house?

☐ Full brick ☐ Brick-veneer ☐ Lightweight ☐ Mixed construction type
☐ Other (Please mention) _____

8. How large is your dwelling?

☐ Small (<200 m^2 or 20 Squares) ☐ Average (200-300m^2 or 20-30 Squares)
☐ Large (300-500m^2 or 30 - 50 Squares) ☐ Very Large (>500m^2 or 50 Squares) ☐ Don't Know

9. How many bedrooms does your dwelling have?

☐ 1 bedroom ☐ 2 bedrooms ☐ 3 bedrooms ☐ 4 bedrooms ☐ 5 bedrooms or more

ENERGY USAGE

10. How much did you spend on electricity last year? (please consider the last four quarters)

☐ Less than $1,000 ☐ $1,000- $1,500 ☐ $1,500- $2,000 ☐ $2,000- $2,500 ☐ $2,500 - $3,000
☐ More than $3,000

11. How much did you spend on gas last year? (please consider the last four quarters)

☐ Less than $500 ☐ $500- $750 ☐ $750- $1,000 ☐ $1,000- $1,500 ☐ More than $1,500
☐ I don't use gas

SPACE HEATING/COOLING and HOT WATER SYSTEM

12. Do you need to heat and cool your dwelling?

☐ Need to heat and cool ☐ Need to heat only ☐ Need to cool only ☐ No need to heat and cool

13. If your dwelling needs mechanical cooling, what do you use most often? (Please select more than one option if applicable)

☐ Air-Conditioner ☐ Ceiling fan ☐ Air cooler ☐ Pedestal fan
☐ Other (Please mention)_____

14. If your dwelling needs heating, what do you use most often? (Please select more than one option if applicable)

☐ Air-Conditioner ☐ Electric heater ☐ Gas heater ☐ Wooden fireplace
☐ N/A ☐ Other (Please mention)_____

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15. Which of the following best describes the main energy source used in your dwelling for Hot Water System?

☐ Electric ☐ Gas ☐ Solar ☐ Solar with electric booster

☐ Solar with gas booster ☐ Other (Please mention)_____

ON-SITE ENERGY GENERATION

16. Have you installed solar panels for generating electricity in your dwelling?

☐ Yes ☐ No

DWELLING OCCUPANCY

17. Number of people currently living in this dwelling?

Number of adults: _____ Number of children (Aged 5 – 17 yrs)_____

Number of children (younger than 5 yrs)_____

18. Is someone in your dwelling during daytime (9AM to 6PM)? (Please answer based on your current circumstances)

☐ Always ☐ During weekend ☐ More than 3 days/week ☐ Less than 3 days/week ☐ No

Thank you for taking time to complete this survey and considering involvement in the project "Validating and Improving the NSW BASIX Energy Assessment Tool for Low Carbon Dwellings". Our next stage of data collection involves in-depth questionnaire survey, building inspection and diagnostics using thermal imaging and infiltration testing (air gaps) and monitoring of energy usage/ environmental conditions of your dwelling.
If you choose to participate in the next stage of data collection, we will share the summary of your building performance data with you and you could be one of the lucky winners of $50 gift vouchers.

19. Are you interested to participate in the next stage survey?

☐ Yes ☐ No

If you answered YES to Q 19, our researchers will contact you in 3-6 weeks and arrange a time with one adult representative of the household to answer study questions and to organise dwelling inspection.

Please provide your contact information.

Name: .....

Address: .....

Email:.....

Phone:..... Today's date: .....

If you have any questions, please feel free to contact us. Contact details are listed below:

Dr Lan Ding (Project Leader)
Tel: 9385 5593
Email: Lan.Ding@unsw.edu.au

Dr Anir Kumar Upadhyay (Researcher Fellow)
Tel: 9385 5559
Email: anir.upadhyay@unsw.edu.au

Any person with concerns or complaints about the conduct of a research study can contact Ethics Secretariat, The University of New South Wales, SYDNEY 2052 AUSTRALIA (phone (02) 9385 4234, fax (02) 9385 6222, email humanethics@unsw.edu.au. Any complaint you make will be investigated promptly and you will be informed out the outcome.

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5. Which of the following best describe where you live?

☐ A unit in a block of flats 3 storeys or lower ☐ A unit in a block of flats 4-5 storeys
☐ A unit in a block of flats 6 storeys or higher

6. What services are provided in your apartment block? (Please select that are applicable)

☐ Lift ☐ Swimming pool ☐ Gymnasium ☐ Sauna ☐ N/A

7. How large is your dwelling?

☐ Small (<200 m^2 or 20 Squares) ☐ Average (200-300m^2 or 20-30 Squares)
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