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Typology of Representative Dwelling Designs for Technical and Policy Purposes in Australia

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Abstract: *Despite the importance of representative building designs for energy efficiency policy, to date there has been no serious attempt in Australia to develop a robust evidence-driven approach to this issue. This research project has developed a range of representative new dwelling designs through a hybrid approach of combining statistical and qualitative data sources. The recent residential building stock (2010-2012) in Australia was statistically analysed by reference to actual rating data records held by the Association of Building Sustainability Assessors. A survey of volume builders' typical building plans, together with spatial analysis of new construction regions across Australia, were combined with the statistical analysis to inform the production of representative concept floor plans and associated dwelling descriptions. A comprehensive new residential building typology is presented with clear categories of 'typical' dwelling structures grouped under various building types, number of storeys, number of bedrooms and the form of the building plans.*

Keywords: Residential building, energy performance, building typology, energy efficiency policy

Introduction

Building-related greenhouse gas emission policy in Australia has directed attention to improving the energy efficiency of building fabric in new construction. Energy efficiency provisions for housing were introduced in the Building Code of Australia to achieve a nominal level of energy efficiency approaching a rating of 4 stars in 2003, 5 stars in 2006 and 6 stars in 2010, based on the Nationwide House Energy Rating Scheme [1].

The potential for further energy efficiency improvements and emissions reductions from the residential sector is well established [2]. Strategies for improving building energy efficiency are an important consideration of government policy, which includes setting goals and pathways to zero-energy or zero carbon buildings [3, 4, 5].

In 2005, the Australian residential sector accounted for approximately 13% of the country's total GHG emissions [6]. Improving energy efficiency in residential buildings would contribute significantly to GHG emission reductions by the building sector. Australia has currently committed to meeting a long term target of a 60% reduction of GHG emissions by 2050 based on 2000 levels, as well as to reduce GHG emissions by 5-15% below 2000 levels by 2020 [3].

Development of a sound methodology to analyse the energy performance of building stock by classifying existing buildings by typology and then modelling the energy use of 'representative' buildings is an effective way to inform policy and improve energy performance in residential building stock was being proven in a number of similar overseas initiatives [7, 8]. The TABULA Project has developed residential building typologies for 13 European countries, with each national typology consisting of a classification scheme that groups buildings according to their size, age and associated parameters. A set of 'representative' buildings represents the different classes of building types [9]. These building typologies are used for energy performance assessment of national building stocks.

In Australia, research has been carried out to investigate the cost savings through residential building redesign to achieve required building energy standards using a range of common dwelling types sourced from major property construction companies [10]. Foliente et al. [11] has proposed a bottom-up modelling approach to systematically assess the energy use of the building stock was proposed and demonstrated in a case study of office buildings in the state of NSW. The specific building stock energy use was categorised by building type, end-use and spatial distribution.

Methodology

A set of dwelling designs that represent the national new building stock is developed for technical and policy purposes, by analysing and surveying existing literature, building stock databases and relevant documentation. The set of dwelling designs represent commonly occurring, characteristics of a particular type of building, based on a statistical analysis of large existing databases for appropriate levels of grouping. Descriptions of these representative building designs are provided so that they can be modelled with the Nationwide House Energy Rating Scheme (NatHERS) software.

A review of building typologies in literature and reports was undertaken to guide the development of a typology for the representative dwelling designs. ABSA Certificate Manager Database, ABS and other relevant databases, including sales building data, state-based Valuer General Data, were assessed for their usefulness in establishing statistically valid samples of new residential building stock (between 2010 and 2012), for developing representative dwelling designs.

Research on Representative Dwelling Designs

Data from the ABSA and ABS databases has been extensively analysed. Data on new residential building stock were categorised by various building types/dwelling structures (e.g. single storey detached), building sizes (e.g. dwelling less than 150 square metres), BCA climatic zones (e.g. zone 6-mild temperate), and selected design features that affect building energy and environmental performance (e.g. 600mm roof eave). These categorised data were subsequently cleansed for outliers to improve the quality of the data.

Typical floor plans and building forms for different types and sizes of dwelling were developed from common residential building designs supplied by major building developers in Australia. More than 60 dwelling designs were obtained from ten major residential developers and private residential owners. These common dwelling designs cover the various

States and Territory and some have been constructed from plans provided by the private owners.

Survey questions pertaining to the high-selling and typical examples of new homes (with the initial formulated typical floor plans) are sent to the selected major building developers for feedback and comments.

The formulated typical building plans for separate houses, attached houses and apartments are further refined through sensitivity analysis to determine the effect of selected design factors (e.g. eave width) on building energy performance.

Spatial analysis techniques are also used to study the correlation between the building typology descriptive information and building locations to identify the influence of climatic conditions toward building design features.

Development of Representative Dwelling Designs

The building typology and common building floor plans were combined to produce a set of sixteen national 'representative' dwelling designs.

The specifications of the 'representative' dwellings can be modified to achieve the minimum star rating standard required in a particular State or Territory. When modelled in NatHERS, the representative dwellings have a star rating equal to, or slightly higher, than the minimum standard.

Design parameters investigated in the development of the set of representative dwellings includes conditioned and unconditioned floor area, external wall area, window area and orientation, eave width and offset, window size, window U-value and solar heat gain coefficient, roof colour and insulation, building materials R-value, and building layout.

ABS Data Analysis

An analysis of ABS data indicates approximately 98% (8.4 million) of Australians live in private self-contained dwellings. Of these, 79% live in separate (detached) houses, 11% in flats, units or apartments, and 10% in semi-detached, row or terrace houses or townhouses. Typically, separate houses have 3 or 4 bedrooms; semi-detached houses have 2 or 3 bedrooms, and flats, units or apartments have 1 or 2 bedrooms. In 2009-10, 78% Australian households live in dwellings (mainly separate houses) with 3 or more bedrooms, 18% live in dwellings with 2 bedrooms and 4% live in 1 bedroom dwellings (mainly flats, units or apartments) [12].

Figure 1 shows the distribution of dwelling structure by number of bedrooms according to the ABS census data. The census data does not differentiate the number of storeys for separate houses. 'Building Stock %' in the table is tabulated as the percentage of the dwelling structure type within its own type for better understanding of the distribution of the building stock. The tabulation excludes 'other dwellings' and 'dwellings structure not stated' as formulated in the

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ABS census data. The dwelling types shaded in 'blue' are considered the main types as they constituted more than 10% of their respective building stock. The dwelling types shaded in 'green' are considered sub-types as they represent 5-10% of their respective building stock.

Dwelling Structure (Dwelling Type)	No. of storeys	1 bedroom		2 bedrooms		3 bedrooms		4 bedrooms		4 bedrooms +	
		No.	% of Dwelling Type	No.	% of Dwelling Type	No.	% of Dwelling Type	No.	% of Dwelling Type	No.	% of Dwelling Type
Separate house	1+	65005	1.1%	568512	9.7%	2839940	48.4%	1850583	31.6%	393131	6.7%
Semi-detached, row or terrace house, townhouse	1	38818	5.1%	200991	26.2%	171532	22.4%	21927	2.9%	3674	0.5%
	2+	13181	1.7%	81990	10.7%	162549	21.2%	32411	4.2%	5836	0.8%
Flat, unit or apartment	1 to 3	148575	14.1%	446823	42.3%	118434	11.2%	8172	0.8%	2561	0.2%
	4+	64704	6.1%	149513	14.2%	46671	4.4%	2036	0.2%	571	0.1%

Figure 1 Dwelling structure by number of bedrooms distribution

ABSA Certificate Manager Data and TCO Data Analysis

The ABSA databases comprise the Certificate Manager Data, with more than 268,000 datasets (i.e. projects) from 2005 to 2011, and The Certificate Office (TCO) Data, with more than 8,000 datasets from 2010 to 2012. As this research is only concerned with data from 2010 to 2012, both ABSA datasets were 'mapped' to exclude duplicate data. The final number of datasets analysed was 56,170.

The ABSA database contains approximately 225 building information parameters. Of these, 51 parameters were found to be relevant to this project, including climate zone, external wall construction, window area, star rating, roof covering and insulation.

The number of new dwellings constructed from 2010 to 2012 is approximately to 471,054 [13]. The sample size required for a confidence level of 99% with confidence interval of 1 (information is highly reliable) for the population of 471,054 dwellings is 16,073. The 56,170 datasets analysed in this project represents approximately 12% of the total new dwelling stock and also represents a good statistical sample number.

Figure 2 shows the most common roof eave width for detached dwelling in climatic zone 1 is 900mm and 600mm in climatic zones 2 and 3. Roof eave width of 450mm is the common length for the rest of the climatic zones as indicated.

Figure 3 shows conditioned floor areas for different types of dwellings. The range of conditioned floor are for apartment unit is 50-100m^2, for single storey dwelling is 100-150m^2, and for double storey dwelling is 100-250m^2.

Survey of Typical Residential Building Plans

Residential building plans from ten major house developers were examined to determine common building designs on the market for detached, semi-detached and apartment dwellings. The findings of this survey, together with the analysis of ABS building stock

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statistics, provided the grouping method for the main building categories (e.g. separate/detached) into one-storey or two-storey building (with 3 or 4 bedrooms, etc).

The aerial photographs survey confirm that dwellings in hotter climates, like Darwin, typically have lighter roof colours, while in colder climates, like Melbourne, darker colours are typically used. Most dwellings are of rectangular shape but some are square shape. Some of the buildings seem to have been 'mirrored' compared to the adjacent surrounding buildings perhaps for better solar orientation optimisation.

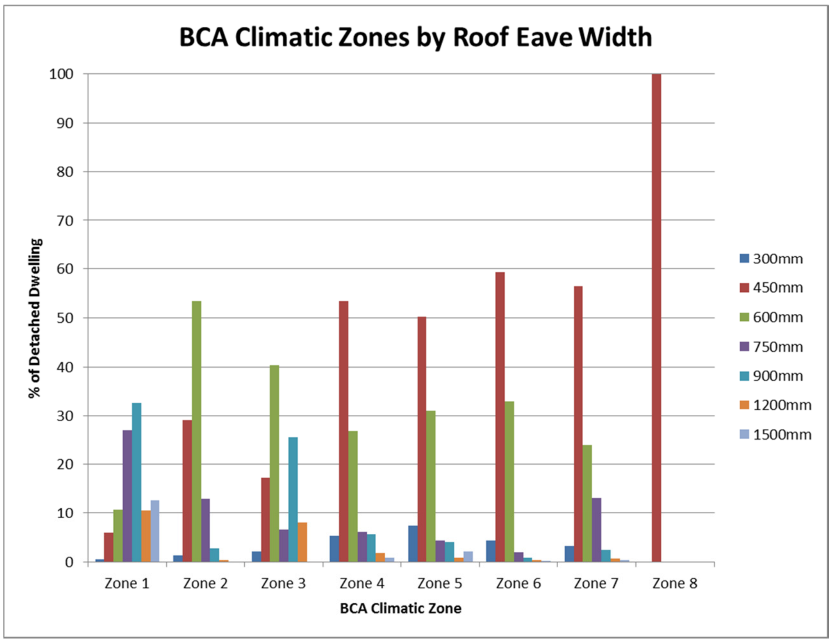

Figure 2 Roof eaves width distribution in BCA climatic zones

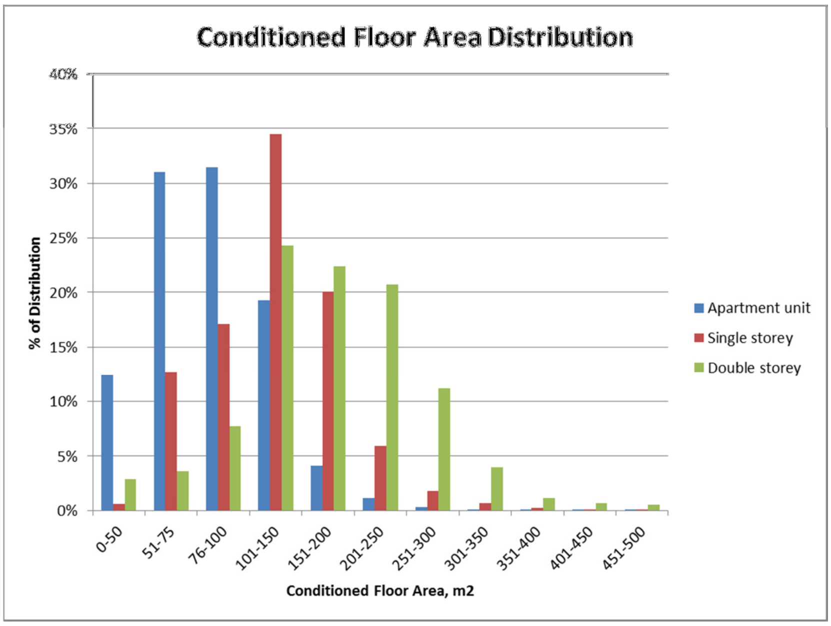

Figure 3 % of detached dwelling distribution with various roof eaves in BCA climatic zones

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Simulation Analysis of Typical Residential Building Plans

Typical building plans for separate houses, attached houses and apartments are created from an analysis of ABS data, ABSA data and developer building designs. A sensitivity analysis of the typical building plans is undertaken using the NatHERS oftware to determine the effect of selected design factors on building energy performance.

New Residential Building Typology

This research shows that the most common new residential dwelling for separate (detached) houses is a 3-bedroom dwelling, for attached houses is a 1-storey 2-bedroom dwelling and for apartments is a walk-up 2-bedroom unit. The dwelling types shaded in 'blue' are considered the main types as they constituted more than 10% of their respective building stock. The dwelling types shaded in 'green' are considered sub-types as they represent 5-10% of their respective building stock. Therefore the main dwelling types for walk-up apartment are 1-bedroom, 2-bedrrom and 3-bedroom dwellings, and consequently the sub-type for high-rise apartment is a 1-bedroom dwelling.

Figure 4 shows the proposed new residential building typology formulated through the analysis of the ABS data, ABSA data and survey of typical building plans from property developers. The 'representative' dwelling plans are combined with construction descriptions and essential dimensions to allow modelling in NATHERS software.

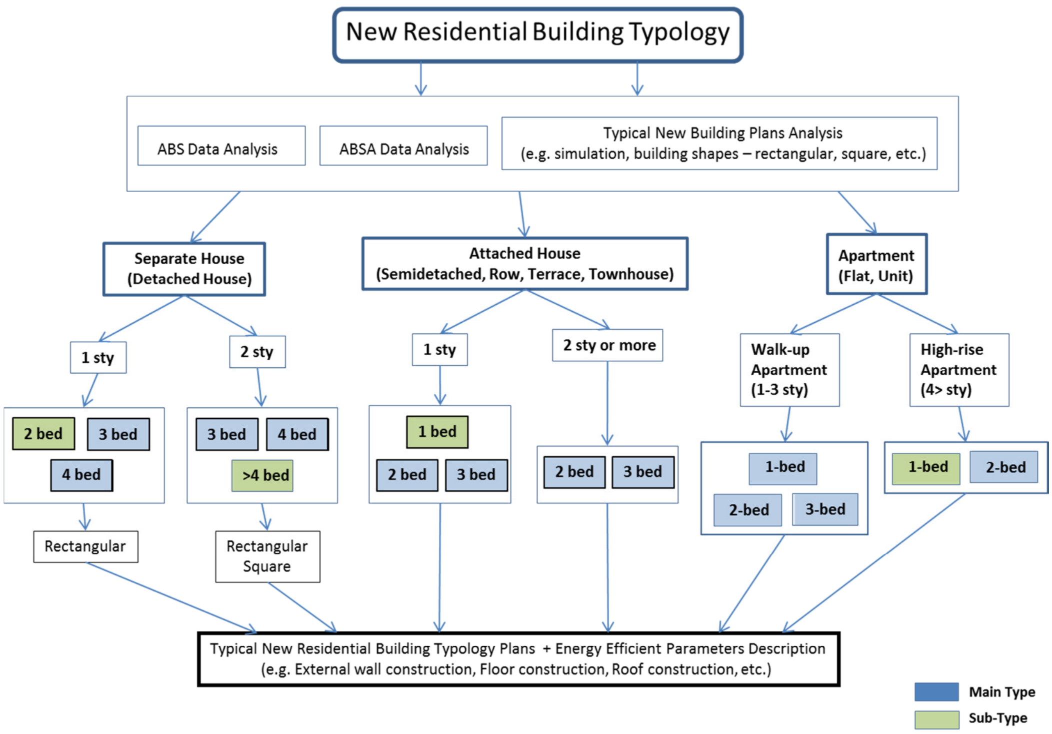

Figure 4 New residential building typology

Conclusion

A comprehensive new residential building typology is presented with clear categories of 'typical' dwelling structures grouped under various building types, number of storeys, number of bedrooms and the form of the building plans. This new building typology together with the 'typical' building plans (with building construction descriptions) provide valuable resource for analysing the energy performance of the residential building stock and for future policy application to improve the overall energy performance of the Australia residential building stock.

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