PLANNING, HOUSING AND ENERGY USE

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Abstract

In recent times the way we use energy in our homes has come under increased scrutiny. As our cities head towards a more environmentally sustainable form and the vexed issue of maintaining infrastructure with population growth continues there is an ever increasing need to reduce our energy use. The introduction of the NSW Government's Building Sustainability Index (BASIX) for new housing and a recent report by the Productivity Commission also add other dimensions to the energy debate in Sydney. This paper examines the energy use in different forms of housing with particular emphasis on Sydney. The paper begins by reviewing the sources of energy and its uses in the urban environment and summarises the results of recent studies into energy use and the built form. The next part identifies the kind of further investigations needed to improve the sustainability of urban development, before discussing some of the planning and policy implications.

1. Introduction

The concept of sustainability is a multi-dimensional one, with many meanings, yet one that has imersed itself in our every day lives. One of the critical issues associated with sustainability, including urban sustainability, is how do reduce our use of energy and therefore greenhouse gases. The Australian Building Codes Board (ABCB) estimates that energy used in buildings accounts for almost 27% of all energy related greenhouse gas emissions (EcoLibrium 2005a). In moving towards more sustainable urban forms the ability to model how different kinds of urban development might perform in terms of energy (and water) use would be a significant tool in enhancing sustainability. This is an ambitious task as there are a number of considerations including transport, infrastructure, the operational (day-to-day) energy consumption of households, as well as the energy embodied in the housing itself. Further, in spatial terms, most research to date has concentrated on broader spatial levels (e.g. Moriarty 2002) or by sector (e.g. Appelbaum Consulting Group 2001; Australian Greenhouse Office, 1999, Lenzen, 1999). There has also been some research conducted at the household level (e.g. IPART 2004a, Lenzen 2004), although at this level research is still limited.

In between these macro and micro scales there is little we know about energy use and greenhouse gas emissions by different localities, densities and housing type (Bunker and Holloway, 2003). This is mainly due to the lack of data available (or collected) for such analyses. As Yencken and Wilkinson (2000) contend:

> '…the first critical requirement is refinement of and agreement about techniques for the comprehensive assessment of the sustainability of settlements, the development of databases for each part of the assessment, agreement on indicators, and a commitment to the production of time series data (data from trend analysis) to tell us whether we are moving forwards or backwards' (p. 143).

Nevertheless, at the estate or small-area level we know little about the characteristics of energy use in different localities. Local government had been quite innovative in its approach to energy use and greenhouse gas emissions (Mills and Stock 1999, Bulkeley 2000) although spatial based analyses are less common. Further, at the State level there have been initiatives such as BASIX in NSW (discussed later), as well as the introduction of energy rating systems in other authorities. These have the potential to reduce energy use in new housing developments. However, these initiatives exclude the housing stock already developed (the majority of current stock), and do not account for the behaviour of residents in dwellings developed under these initiatives.

The objective of the paper is to enhance policy debates surrounding energy use in different forms of housing through a review of recent research into the issue. In particular, the paper aims to add to debates surrounding current metropolitan planning strategies that promote particular sustainable urban development forms. Of course, this then leads to more broader policy debates about urban sustainability (which include water, transport, infrastructure and individual behaviours). This paper migrates across the planning, housing and energy literature although it is aimed at the planning discipline, and particularly concentrates on Sydney. The paper starts with an

overview of energy sources and uses in the urban environment and summarises the results of recent studies into energy use and the built form. Current planning strategies and initiatives aimed at reducing energy use in Sydney are then investigated. The paper goes on to identify the kind of further investigations needed to improve the sustainability of urban development. Finally, the paper discusses some of the policy implications of recent research.

2. Energy sources and uses

The main sources of energy used by urban residents are in the form of gas, electricity, and fuel for vehicles. There are other forms of energy such as heating oil, wood and bottled gas, although these are not used extensively in our towns and cities. There has been extensive research and discussion on how the form and structure of cities might affect energy use. Most of this has focussed on how densities of development affect choice of travel mode by private car or public transport (Newman and Kenworthy 1999). This research has shown that such densities and arrangements of land uses can influence travel habits and behaviour, however, there are many other factors which also determine how personal trips are made (Mees 2000).

On the built form side, there has been a good deal of experiment and expertise in designing dwellings to minimise energy use, and in the layout of small groups of dwellings as in the AMCORD and Building Code of Australia (BCA) approach. It is important to measure both the operational and embodied energy in different kinds of urban development in making assessments about the contribution of built form to more sustainable use of energy. Operational energy is that used from day to day in the city to make it function in terms of living, production and distribution. Embodied energy is the store of sunk energy in the buildings, infrastructure and capital equipment of the city – its roads, pipes, wires, transmission lines and vehicles (Pullen, 2000). Over a hundred year period the embodied energy in a dwelling can amount to around 40% of the household's operational energy demands over the same period (Australian Greenhouse Office, 1999).

3. Recent research into the localised nature of energy use in Australia

For over twenty years in Australia there has been research into the energy consumption of households (Centre for Urban Research and Action 1984, Bartels *et al* 1985, Bartels 1988, Poulsen and Forrest 1988). More recently though, Moriarty (2002) published an article in which he analysed energy use in the inner and outer rings of five state capital cities, other urban areas, and rural areas. He found that inner city residents used less energy and water than their outer suburban counterparts when adjusted for income. However, when 'indirect' inputs were considered such as travel to outlying country areas, the differences were small. But at such a coarse spatial scale he was only able to make tangential reference to embodied energy. Moriarty concluded that a change towards more travel on electric public transport and non-motorised forms of travel had important potential in reducing energy use.

Another two studies conducted in Adelaide examined energy use in different areas. Perkins (2002 and 2003) compared the delivered energy use by households in a city fringe area and an inner city area. Delivered energy includes both operational energy and the embodied energy used in dwellings and motor vehicles over their life cycles.

The embodied energy calculation was also extended to take account of on-site structures and paving and the road/footpath infrastructure serving the dwellings. These life cycle energy calculations were also converted into the resultant greenhouse gas emissions. Perkins's calculations were based on a sample survey of 212 households and dwellings located in an inner and outer suburb which were then used to measure the resulting life cycle operational and embodied energy/emissions contained in the whole of the transport and housing systems.

The difference in total life cycle delivered energy consumption between the two areas was significant. While energy consumption of all other kinds was slightly higher in the outer suburb, it was mainly due to the extra energy used in motorised travel that accounted for the fringe sample consuming nearly twice as much energy per household as the inner location. Statistical analysis showed that of the 'urban form' variables used, site area, location, number of shared walls, dwelling type, and dwelling energy efficiency rating were the most significant in explaining variation in delivered energy use - in that order. Urban form was more important in explaining variations in household's use of operational energy than embodied energy, although the latter was still significant. Interestingly, Perkins's research showed no consistent influence of household size, age of residents or socio-economic characteristics on energy use, although other studies have found these to be of significance (see IPART 2004a).

In a similar vein, a pilot study by Troy *et al* (2002 and 2003) in Adelaide interrogated three data sets for six small areas, each comprising a Census Collector's District (or two in the case of one area). These data sets comprise aggregated measures of household energy consumption collected from the electricity and gas supply authorities; socio-economic and demographic data about households from the 1996 Census; and details about the characteristics of each building and its site from property records held by Planning SA. The six case study areas were deliberately chosen as representative of Adelaide's development and character. Three are almost entirely residential and the others of mixed use character. They were developed at different times in the history of Adelaide and were located in different parts of the city. Adelaide City, Hindmarsh and Norwood are central and inner city areas, hawthorn is a middle suburban area while Brahma Lodge and Woodcroft are outer suburban areas.

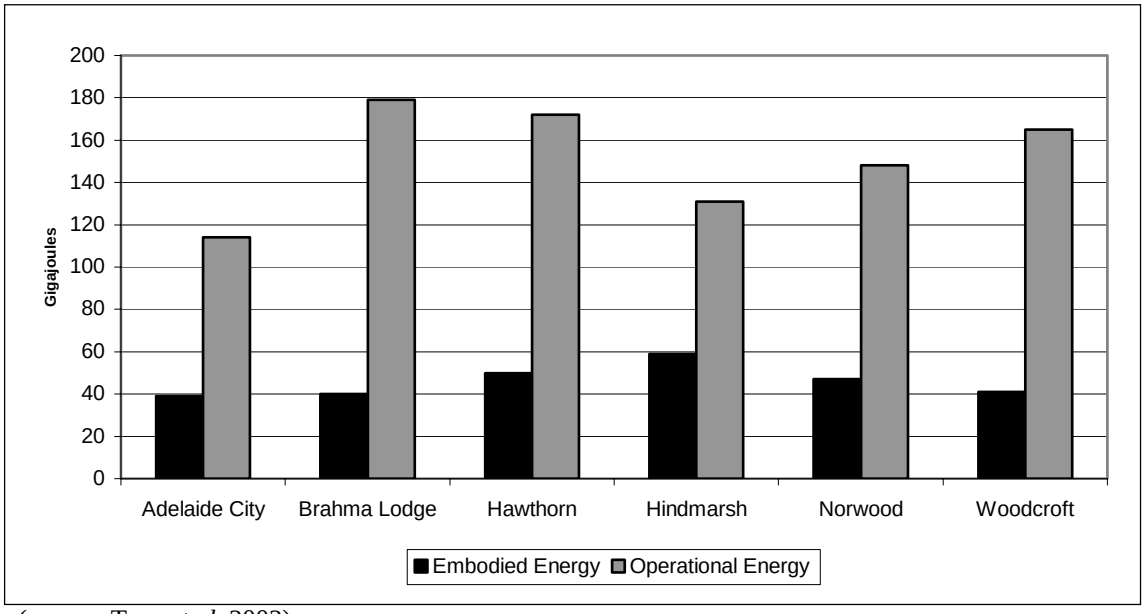
As a pilot study, the Troy *et al* project deliberately set an ambitious framework. While its basic purpose was to see if the three data sets could be interrogated and associated in various ways to build up measurements of energy (and water) use in different localities, it also used these as a basis for estimates of the *operational* and *embodied* energy used in these areas and the *primary* energy needed to produce the different forms of energy – vehicle fuel, electricity, and gas. Consequent greenhouse gas emissions were then calculated.

Figure 1 is a summary of the annual consumption of embodied and operational energy by households in the six case study areas in Adelaide analysed by Troy *et al*. Operational energy measurements are those for gas, electricity and vehicle fuel in gigajoules. The figures for embodied energy include not only that used in the dwellings but in the supporting local infrastructure and vehicles. The data support Perkins's findings that differences in the use of operational energy reflect the greater

use of cars in the outlying suburbs as compared with the inner suburbs and central city. Figure 2 shows, however, that on a *per capita* basis the differences in operational energy use are less significant because of the larger size of households in the outlying suburbs. The results reflected the mingled influence of built form and household characteristics on the use of energy, with socio-economic factors influencing consumption patterns.

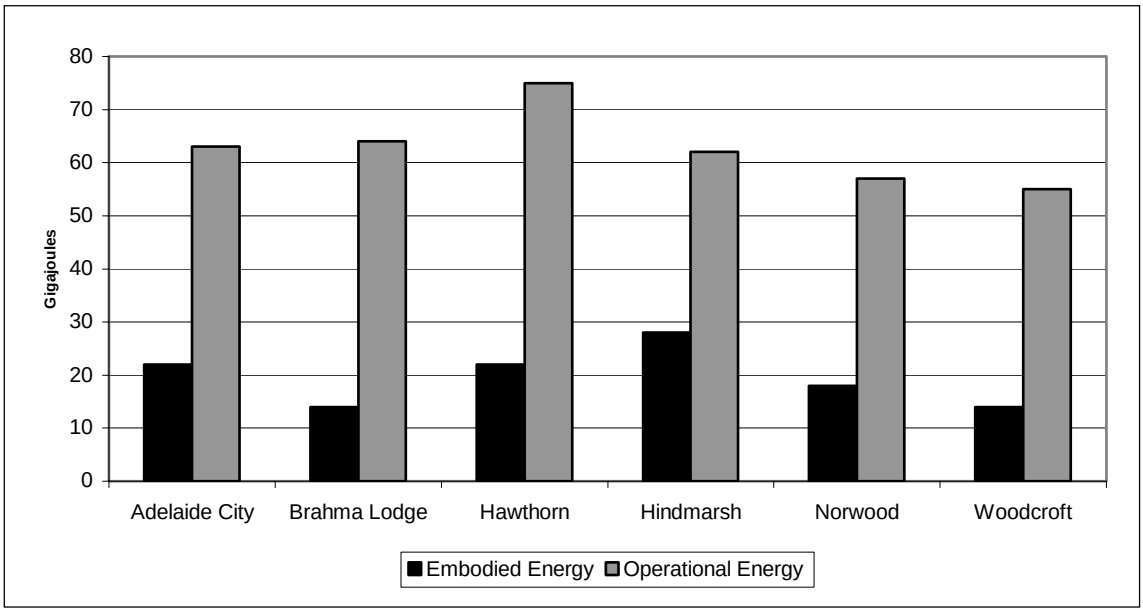
In 2003, the NSW Independent Pricing and Regulatory Tribunal (IPART) surveyed 2604 households across the greater Sydney area to collect information about households' energy requirements (IPART 2004a). Some 2004 households were selected on a random basis with a further 600 respondents specifically selected from lower income areas. The IPART study found that in 2002-03 average electricity consumption in the greater Sydney area was 7539 kilowatt hours (kWh) and average household gas consumption was 21,000 megajoules (MJ). Higher consuming energy households tended to be larger households (particularly couples with children) and live in houses. Households with one or two persons used half as much energy as households with five or more persons. Single person households had the highest per capita consumption, followed by couple only households, single parent families and two parent families.

FIGURE 1: Annual Embodied and Operational Energy per Household in Six Case Study Areas in Adelaide



(source: Troy *et al*, 2002)

FIGURE 2: Annual Embodied and Operational Energy Per Capita in Six Case Study Areas in Adelaide



(source: Troy *et al*, 2002)

Further, IPART found that households who rent their home are also more likely to use less energy. Households that lived in houses (defined as detached houses, semi detached dwellings and townhouses) used 74% more electricity than those in multi-unit dwellings. IPART contends that this is mainly due to the larger household sizes in houses. Thus, on a per capita basis IPART found that houses use 18% more electricity than multi-unit dwellings (3086 kWh for houses compared to 2608 kWh for units).

IPART also contended that higher income households use more electricity than lower income households. However, IPART suggest that this is due more to the larger number of household appliances in their dwelling. Furthermore, IPART also state that owners use more energy than tenants. However, there is no exact indication in the report as to whether the tenants are private or public renters. This is interesting considering that an earlier report from IPART found that water consumption was high in publicly rented dwellings (IPART 2004b).

More recently in 2005 the Southern Sydney Regional Organisation of Councils (SSROC) surveyed 4572 households in the southern and eastern areas of Sydney (Canterbury, Hurstville, Kogarah, Rockdale, Waverley and Woollahra local government areas). Respondents were asked a series of questions about household appliances, appliance use, car and transport use and recycling, as well as some socio-demographic questions. The survey was adapted from the CSIRO's National Kilowatt Count Survey (2002) which was developed from the Australian Greenhouse Gas Calculator created for the Victorian EPA. This enabled the project to use the software created by the Victorian EPA to calculate greenhouse gas emissions and energy costs.

Some of the findings from the survey include:

- Average annual household greenhouse gas emissions were 16.1 tonnes compared to a national average of 15 tonnes.
- Transport contributed to 45% of all emissions.
- 64% of respondents believed they had a water saving showerhead. This is very high compared with other studies that suggest 30-40% of households have a water saving showerhead.
- As household size increases greenhouse gas emissions increase. The incremental increase is not significant once a household has four or more people in it.
- Owners produced 14.6 tonnes of greenhouse gases compared with 13.9 tonnes for renters.
- Houses produce 15.9 tonnes of greenhouse gases compared to 12.0 tonnes for multi-unit developments.
- Households in Hurstville (approximately 15 tonnes) produced more greenhouse gas emissions than those from Kogarah or Rockdale (around 14 tonnes).

Interestingly, the survey concluded that detached houses should be targeted by initiatives and strategies that encourage lower energy use by these households. However, the final report did not take account of the occupancy rates of the different housing types even though it found, overall, that households with one or two residents emit 2-3 times more greenhouse gases on a per person basis than households with four or more persons.

4. Planning for more sustainable development

In most state capital cities in Australia the major form of urban development being pursued through current metropolitan policies is one of increasing residential densities (DIPNR 2004a, DOI 2002, Planning SA 2005, DLGPSR 2005) In Sydney, for example, it is estimated that up to 70% of future development will be within the existing urban area through higher density developments (DIPNR 2004b). This increasing of densities is generically referred to in Australia as urban consolidation. In the urban context, such developments are also referred to as 'urban villages', 'transit oriented developments', or developments concentrated in 'activity centres' (as in Melbourne) or 'growth centres' (as in Sydney). The basic premise is to increase residential densities in existing town centres and/or corridors, linking residential development with commercial and retail developments (mixed use areas) and good transport links. Whether such a strategy is sustainable is a matter of debate.

The debate about the advantages and disadvantages of higher density residential development are beyond the scope of this paper. However, under current planning strategies there is limited information about the perceived benefits of pursing initiatives aimed at increasing residential densities. One of the reasons for this is the lack of information available about the environmental impacts such developments will have on an area. In terms of energy use, for example, there are no tools available to examine the impact certain developments will have on an area. Initiatives such as energy rating systems and BASIX (see below) attempt to do this for new individual buildings built on the fringe, but this only answers part of the question.

Research conducted at the city wide or sectoral level provides useful background information. Household surveys like those conducted by IPART and SSROC are important in modelling the impacts of development and better understanding the behavioural impacts of policies, however, are expensive to undertake. Further, energy rating standards for buildings only deal with the individual physical nature of the building. In between the most useful analysis in examining the impacts of new development is that available at the estate or neighbourhood level, be they greenfields of infill development. The work of Troy *et al* in Adelaide is important in this respect, as it collected individual level data which could be presented at the estate level and importantly used data already collected and available form the Census and property records. Secondly, the exercise conducted by Troy *et al* was also important as it tried to address all aspects of development including the operational, embodied and infrastructural requirements of different built forms. Thirdly, it took account of both physical circumstances and household socio-demographic characteristics.

5. The NSW Building Sustainability Index (BASIX)

The Building Sustainability Index (BASIX) is a system introduced in NSW to reduce energy and water consumption in new residential development. As of July 2004 all development applications submitted for new residential development (house and dual occupancies) in *Sydney* must obtain a BASIX Certificate. To get a BASIX certificate the builder/designer enters the house design data (floor area, water and energy saving devices, insulation, etc) into the BASIX assessment tool (access is available over the Internet) which calculates whether the design meets certain targets. If the dwelling to be built reaches these targets a BASIX Certificate is issued.

To obtain a BASIX certificate, new residential developments must reach two targets – reduce water consumption by 40% and reduce greenhouse gas emissions (energy) by 25%. The decreases in energy and water consumption required to comply with BASIX are based on the *NSW* average.

In practice, to reach the BASIX targets a 'typical detached house' of 3 bedrooms and two bathrooms with a gross floor area of 250 square metres on a 550 square metre block would need to contain the additional actions presented in Table 1. The costs of achieving the BASIX targets are also include in the Table.

To comply with BASIX at July 2004 it would cost an extra $8,988 for a 'typical' detached house. NSW DIPNR (2004c) estimated that this additional outlay will save the 'average' family in the order of $300-$600 per year.

As of July 2005 BASIX applies to all new single dwellings and dual occupancies in NSW. In October 2005 BASIX will apply to new multi-unit dwellings. From July 2006 BASIX will apply to all additions and alterations to dwellings and the energy target will be increased from 25% to 40%. In the short term, BASIX will only apply to residential dwellings, although the system could be applied to commercial and retail developments.

In mid 2005, the Centre for International Economics (CIE) assessed the additional cost of complying with BASIX for multi-unit development. A summary of the

additional costs to three different multi-unit developments are presented in Table 2. These developments are actual developments.

Table 1: The additional actions and costs required by a 'typical' detached dwelling to meet BASIX targets

Target as at July 2004	Actions	Additional Costs for 'Typical' Detached House
Water – BASIX rating of 40	AAA-rated shower heads (9 litres per minute)	$59
	Dual flush toilets	No cost – Industry Standard
	Flow arrestors on all kitchen taps (9 litres per minute) and bathroom taps (4.5 litres per minute)	$136
	Rainwater tank for toilet flushing and garden irrigation (5000 litres including connection)	$4,915
	Total	**$5,100**
Energy – BASIX rating of 25	Gas hot water system – high efficiency (5 star)	$757
	Ceiling fans	$1,805
	Well ventilated refrigerator space	$40
	Outdoor clothes line	$416
	External shading (600mm eaves)	$860
	Wall insulation	$1,100
	Total	**$3,878**
TOTAL		**$8,988**

(source: NSW DIPNR, 2004c)

Table 2: The additional costs for multi-unit developments to meet BASIX requirements

Development	Number of Units	Cost per Unit ($) (excludes GST)	Total Cost ($) (excludes GST)	Estimated Variance (%)
Townhouse	5	7,570	37,900	4.2
Mid-Rise	49	6,770	331,900	3.1
High-Rise	190	9,080	1,724,800	3.6
Weighted average		**8,590**		

(source: CIE, 2005)

6. Other Energy Efficiency Measures for Buildings

While it is not the objective of this paper to review energy efficient measures in buildings there are some important points to consider, particularly in light of recent contentions made by the Productivity Commission (2005) (see Ecolibrium 2005b). At a national level energy measures were included in the Building Code of Australia (BCA) 2003 Housing Provisions and came into effect in most states at the beginning of 2003. It is expected that energy measures for multi-unit dwellings will come into force in 2006. State and Territory governments in Australia administer the BCA in

Australia and are responsible for adopting the BCA in their building legislation. Most states include alterations to the BCA as part of this process.

In Victoria the *Greenhouse Neighbourhood* and *Urban Villages* projects have demonstrated the potential reductions in heating and cooling energy requirements in higher rise dwellings in Melbourne. Pears (2005) states that a number of factors can lead to increased energy consumption in higher density dwellings. This includes, but is not limited to, the use of lifts, inefficiencies in equipment (including centralised systems) and appliances, and the thermal performance of the building envelope. Thus, Pears, backed up by work by NSW Department of Planning, Infrastructure and Natural Resources (DIPNR), contends that there is evidence to suggest that when energy per person is used instead of energy per dwelling high rise apartments can generate above average energy consumption per capita.

Nevertheless, what the future holds for energy rating standards in buildings is still a matter of debate (see Ecolibrium 2005b). In 2005 a draft report by the Productivity Commission suggested that compulsory minimum energy performance standards in buildings were a waste of time. The draft report acknowledged that minimum energy performance standards for household appliances had been successful in achieving energy savings but that such procedures for buildings still had a long way to go. The Productivity Commission's preference was for programs that provided better information for consumers and producers rather than regulatory measures. Interestingly though, the report suggested that low electricity prices in Australia (relative to other countries) sent to the wrong signal to consumers about conserving energy.

7. Discussion of Policy Options

Given the range of factors influencing energy consumption by households (Holloway and Bunker, 2003), policy responses exist in the field of regulation, transport and town planning, and pricing. Regulation to ensure more energy efficient forms of housing is widespread in terms of building and planning controls, although this is now a matter of debate. These are essentially aimed at individual dwellings or groups of dwellings. Pricing tariffs have not generally been used to limit the use of energy, although they undoubtedly affect consumption by low income households. Widespread and increasing use of the car is as much a function of the unavailability or poor performance of public transport, as on low suburban densities.

Planning is about creative anticipation, and there are clear signs that our use of energy in the home and for travel, including the consequent emission of greenhouse gases will need to be subject to more control and direction. This will involve a range and combination of different measures.

How to design an equitable and effective pricing regime is difficult. It would also have to take into account the differences in energy use brought about by varying climatic conditions. At the present, the BASIX system does not allow for this but may in the future depending on the availability of sufficient information and data. However, one principle flowing from the work conducted in Adelaide is to have a stepwise tariff with price per unit increasing above a basic threshold, which should comfortably cover the essential needs of all households. In NSW, such a pricing

system is being touted for both residential water and electricity consumption (SMH 2003, SMH 2005a).

Recent research in California and in NSW also suggests that by using new technologies such as Smart Meters can reduce household energy consumption. These meters allow usage to be measured at different times during the day, with higher prices for electricity paid during peak periods. Where smart meters have been introduced households have modified their behaviour accordingly. For example, households are choosing to do their domestic chores during off-peak periods when prices are lower (SMH 2005b).

There also needs to be a comprehensive assessment of proposed types of urban development in terms of their likely energy use and consequent greenhouse gas emissions as a necessary planning tool to improve sustainability. To a certain extent the BASIX system does this at the moment, but only on an individual dwelling basis. The recent research in Adelaide has confirmed the potential for the use of existing data sources coded to census collectors' districts to calculate life cycle energy/emissions expenditure. This enables areas within and between cities to be compared over time, something BASIX or energy efficient regulations do not have built into them. Finally, energy expenditure on travel generated by proposed developments could be modelled as in current trip generation and distribution exercises of this kind.

Questions also need to be raised about the effectiveness of rebate schemes. In relation to energy it has been estimated that it would cost an extra $3,878 for the 'average' house to comply with BASIX at the 25% level. However, in complying with both energy and water this blows out to nearly $9,000. Interestingly though, there are a very limited number of schemes for installing energy efficient products (the Photovoltaic Rebate Program is an exception) in dwellings and the water tank rebate in NSW is minimal. Questions must be asked therefore, whether households in *existing* dwellings will fork out the money for products that enhance energy and water efficiency without significant incentives. This also applies to rental properties, where without some form of incentives landlords may be unwilling to retrospectively upgrade their investment properties to more energy and water efficient forms.

Further, it is also important that current demand management strategies continue. In other words, it is important to continue to educate the public about energy and water efficiency. For example, SSROC (2005) found that 64% of households thought they had a water efficient showerhead, yet the report suggests that the real proportion is 30%-40%.

8. Conclusion

This paper has attempted to bring together recent research in Australia on energy use in different forms of housing to contribute to debates surrounding current metropolitan development strategies being pursued in our capital cities. This paper concludes that there is a limited amount of information available to model the impacts of residential development in Australia. City wide level analyses are important for wider reporting obligations but have a limited role in assessing the sustainability of residential developments. Household surveys have their role to play in assessing

policy options and modelling impacts, but are expensive to undertake. In between, the use of currently held data sets and the flexibility of exercises such as that undertaken by Troy *et al* in Adelaide provide an important tool in assessing the environmental impacts of development. Further, energy efficient standards and initiatives such as BASIX in NSW only go part of the way to improving the sustainability of development. Importantly, energy efficient standards and BASIX are limited in their ability to understand how household behaviour is influencing energy (and water) usage in a household.

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