IPART
New South Wales

Independent Pricing and Regulatory Tribunal

Determinants of residential energy and water consumption in Sydney and surrounds

Regression analysis of the 2008 and 2010 IPART household survey data

Electricity, Gas and Water — Research Report
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ISBN 978-1-921929-61-8 RP-34

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1 Introduction and executive summary

The Independent Pricing and Regulatory Tribunal of NSW (IPART) surveyed households in the Sydney region in 2010 and in the Hunter, Gosford and Wyong areas in 2008. We collected electricity, gas and water consumption data as well as data about the household, the dwelling and what energy and water are used for. The 2008 and 2010 household survey reports provide further information about the surveys, and are available on our website.[1]

The household survey reports describe the survey results and provide some simple analysis using descriptive statistics. To extend the analysis, we used regression techniques to identify the marginal contributions to consumption of different household characteristics and uses for energy and water. In so doing, we sought to explain the observed variations in energy and water consumption between households. This report presents the results of that analysis.

Some households spend a significant proportion their disposable income on energy because they use a fairly large amount. In a recent report, IPART identified as particularly vulnerable low-income households with higher than average consumption.[2] Our results can help to identify some ways to reduce the energy consumption of these households while maintaining their quality of life.

We report the regression results for both survey areas, but our discussion focuses mainly on the Sydney survey area. We focus on Sydney firstly because the consumption data are more complete for this area, and secondly because it provides a more diverse range of dwelling types and climate zones than does the Hunter, Gosford and Wyong survey area.

1 IPART, *Residential Energy and Water Use in the Hunter, Gosford and Wyong - Results from the 2008 household survey*, December 2008 and IPART, *Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey*, December 2010. The reports are available on our website at http://www.ipart.nsw.gov.au/Home/Industries/Research/Reviews_All/Household_Survey.

2 IPART, *Changes in regulated electricity retail prices from 1 July 2011 – Final Report*, June 2011.

1.1 We specified 2 types of model - 'characteristics' models and 'uses' models

We were interested in the relationship between household characteristics and consumption, as well as in the marginal impact on consumption of specific uses. Therefore, we specified 2 types of regression model:

- A 'characteristics' model, where the explanatory variables are only socio-economic, climate and dwelling-type characteristics. The main characteristics we used are the number of adults and children, income, the type and size of the dwelling and the climate zone.
- An 'energy uses' or 'water uses' model, which aims to identify the impact on consumption of what a household uses energy or water for. The model includes explanatory variables such as how often a household uses an air conditioner or a clothes dryer, and whether or not it has a swimming pool.

The advantage of the first type of model is that the regression results can potentially be generalised to other households on an area basis, for example by postcode or census district, using ABS Census and other data that are publicly available.[3] This could have useful planning and policy implications.

The second type of model (focussing on uses) provides an insight into why some apparently similar households use such different amounts of energy and water.[4] This analysis could be useful for identifying the most effective measures for energy and water efficiency programs and for helping households to better understand their own consumption.

We used simple linear regressions for most of our analysis. However, we also used semi-log regressions to check that our results are sensible.

For water, we confined most of our analysis to detached houses. We did this because we wanted to include only individually metered households and we were most confident about the data for detached houses.

3 For this reason we limited the dwelling-type characteristics to those for which data are easily available for the general population, for example from ABS Census data. Therefore, we did not include characteristics that might for other purposes be categorised as dwelling characteristics, such has having a swimming pool or dual flush toilets.

4 By 'apparently similar households' we mean households with similar household and dwelling characteristics.

1.2 Overview of results for the 'characteristics' models

1.2.1 The relationship between household characteristics and consumption

We found that the number of people in the household is an important explanatory variable for both energy and water consumption, in terms of both the magnitude of the impact (ie, the regression coefficient) and the strength of the relationship (ie, the t-value). Adults add more to consumption (and bills) than children. Income is also an important explanatory variable, with higher incomes associated with more consumption. However, income has significantly more explanatory power for energy consumption (particularly for electricity) than for water consumption. For water, the number of people in the household is the key driver of consumption (Figure 1.1 and Table 1.1).

Living in a detached house is associated with higher energy consumption, as is the size of the dwelling (indicated by the number of bedrooms or the number of indoor showers). For households in detached houses, having more showers and living on a larger plot are associated with higher water consumption (Figure 1.1 and Table 1.1.)

Using a slightly different model, we investigated the impact of dwelling type on water consumption. We found that households in detached dwellings use more water than otherwise similar households in semi-detached dwelling or flats, but only because they use water outdoors.

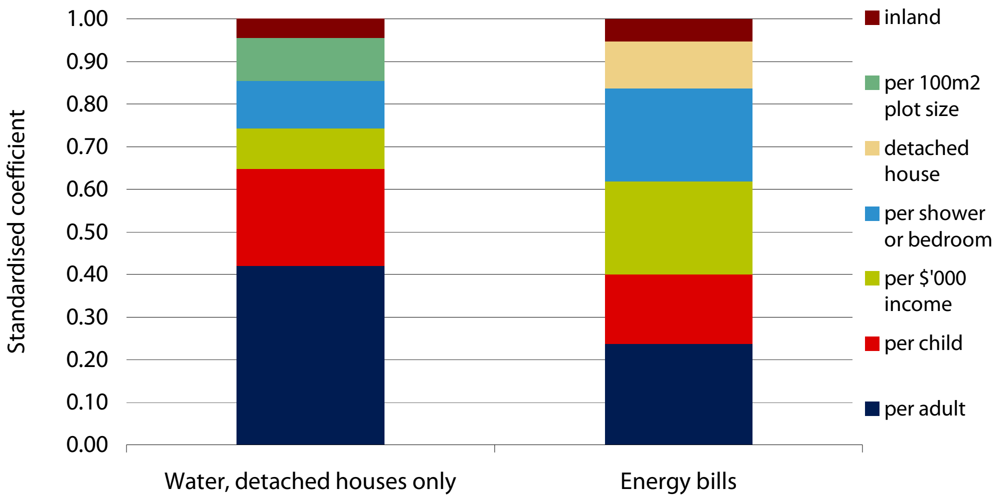
Households with mains gas use significantly less electricity than otherwise similar households without mains gas. However, this seems to have little impact on energy bills (usage component only) once the presence or absence of a Controlled Load electricity supply is taken into account. Having a Controlled Load electricity supply (and therefore paying a lower tariff for some electricity) means lower energy bills, on average about $110 per annum lower (Table 1.1).

Households in coastal areas on average use less energy and water than otherwise similar households in inland areas. But the relationship is relatively weak (comparatively low t-values), and the coefficients provide only a rough indication of the impact of climate on consumption (Table 1.1).[5]

The 'characteristics' models explain about 40% of the variation between households in electricity consumption and energy bills. For water, the model explains about 35% of the variation in consumption between households living in detached houses.

5 In particular, one might expect to find larger differences between the coastal areas of NSW and the central and western inland areas.

Figure 1.1 The relative impact of household characteristics on water consumption and energy bills, using standardised coefficients[a]



a A standardised coefficient measures the expected change in the dependent variable when the explanatory variable is increased by 1 standard deviation. The purpose of these coefficients is to identify which explanatory variables have a bigger impact on the dependent variable when the former are measured in different units. However, using standardised coefficients for this purpose is somewhat controversial. Therefore, we have not used them elsewhere in this report. (*http://en.wikipedia.org/wiki/Standardized_coefficient*), accessed 15 November 2011).

Note: Linear regression analysis of Sydney (2010) data. An adult means a person older than 15 years, and a child means a person 15 years or younger. The model for water uses the number of indoor showers, while the model for energy bills uses the number of bedrooms to indicate dwelling size.

Table 1.1 The relationship between household characteristics, consumption and bills

	Electricity		Energy bills		Water[a]	
	kWh pa	**(t-value)**	**$ pa**	**(t-value)**	**kL pa**	**(t-value)**
% of variation explained (R^2)	41		39		35	
Sample size	2,166		2,164		1,652	
Household						
Per adult[b]	896	(11.5)	236	(12.3)	43	(19.6)
Per child[b]	749	(8.7)	207	(9.7)	29	(11.5)
Per $10,000 income pa	165	(10.5)	41	(10.7)	1.9	(3.9)
Did not provide income data	1,566	(6.4)	390	(6.5)	21	(2.8)
Dwelling						
Live in a detached house	1,470	(7.5)	278	(5.5)	Detached	only
Per bedroom or indoor shower[c]	892	(10.6)	214	(10.3)	16	(5.2)
Use mains gas	-2,210	(-15.4)	ns	(0.7)	-	
Have Controlled Load			-112	(-2.6)		
Plot size (per $100m^2$)	-		-		4.1	(3.3)
Climate zone					-	
Live in a coastal area	-368	(-2.5)	-110	(-3.0)	-10	(-2.3)

a Detached houses only.

b An adult means a person older than 15 years, and a child means a person 15 years or younger.

c The explanatory variable for electricity consumption and energy bills is the number of bedrooms, and for water consumption is the number of indoor showers.

Note: Linear regression analysis of Sydney (2010) data. Coefficients are shown if they are significant at a 90% level of confidence. A t-value of 2 or more means the coefficient is significant at the 95% level of confidence.

1.2.2 Explaining the relationships between household characteristics and what energy or water are used for

Household characteristics do not directly 'cause' consumption. Rather, each characteristic is associated with some of the uses for energy or water that directly cause consumption. We used regression analysis to identify some of the relationships between household characteristics and these uses.[6]

6 For binary variables we used a logit regression model.

We found a number of (statistically) significant relationships. For example, we found that:

- Households with higher incomes are more likely to have a swimming pool and/or a spa, and to frequently use a dishwasher, clothes dryer and an air conditioner than otherwise similar households with lower incomes.
- Households with more adults are likely to use a dishwasher, a clothes dryer and a washing machine more frequently, and are more likely to have a 2nd fridge.
- Households that live in a detached house and have more bedrooms are more likely to have a swimming pool, a spa, a 2nd fridge and an air conditioner, and to use a dishwasher more frequently (but not a clothes dryer).

1.3 Overview of results for the 'energy uses' models

1.3.1 Results for electricity

The most important findings of the 'energy uses' model for electricity are that:

- Having a swimming pool and using electricity for hot water have the biggest impact on consumption, and are statistically the strongest (on average more than 2,500 kWh per annum, worth about $570 or more).
- Having a 2nd fridge or a spa and frequently using an air conditioner, a clothes dryer or a dishwasher can also add significantly to consumption.
- Using an electric boosted solar hot water system reduces consumption by about half as much as having a gas hot water system does (roughly 1,400 kWh per annum, worth about $320).
- Using electricity for space heating (other than air conditioning) also adds to consumption, but by how much varies widely between households.
- Having a higher income, more occupants, more bedrooms, living in a detached house and living in an inland area are all associated with additional electricity consumption.

The model explains almost 60% of the variation in consumption between Sydney (2010) households, and 55% of the variation between Hunter, Gosford and Wyong (2008) households.

1.3.2 Results for gas

Our analysis suggests that about half of residential gas in Sydney is used for hot water, about a third for space heating and the rest for cooking. How much gas a particular household uses depends very much on what it uses gas for, in combination with its household characteristics.

Combining household characteristics and uses, the most important findings of the 'energy uses' model are that:

- If a household uses gas for hot water, there is a very strong relationship between gas consumption and the number of adults. Children use approximately half as much hot water as adults. (A typical adult uses about 3,700 MJ per annum, worth $80, and a typical child uses about 1,800 MJ per annum, worth $40).
- Gas heating increases gas consumption by varying amounts, depending on what type of heating system a household has (eg, ducted or stand-alone) and how often it uses it. On average, a Sydney household that has a gas-only heating system uses between 6,500 MJ and 7,900 MJ per annum for heating, depending on the climate zone (worth about $140 to $170 per annum).
- Cooking uses the least amount of gas, and the amount varies widely between households.
- Income has an independent effect on consumption, suggesting that higher income household have larger appliances and /or use them more often.
- Living in a detached house and having more indoor showers are both associated with higher levels of consumption.[7]

The 'energy uses' model explains about 35% of the observed variation between Sydney (2010) households and about 47% of the variation between Hunter, Gosford and Wyong (2008) households.

1.3.3 Results for energy bills

About half of Sydney households use gas instead of electricity to provide the energy they need for hot water, space heating and/or cooking. Gas typically provides about 30% of a household's energy requirements. Therefore, to meaningfully compare energy consumption across all households, we combined electricity and gas consumption. To do this, we analysed energy bills (usage charges only).

Our findings are broadly similar to those for electricity discussed above, and are not repeated here. But using energy bills as the dependent variables also allowed us to look at tariff related issues. In this regard, our most important findings are that:

- Households with a Controlled Load electricity supply use more electricity but face lower bills than otherwise similar households without a Controlled Load supply.
- Gas hot water systems are cheaper to run than standard electric ones, but are probably more expensive than Controlled Load systems.
- Using gas for space heating costs about the same as using electricity.

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7 The number of indoor showers has far more explanatory power than the number of bedrooms, which suggest that it captures more than simply the size of the dwelling.

1.4 Applying the 'energy uses' models to households with the same incomes and the same numbers of occupants

We conducted further analysis to better understand why households with similar levels of income or the same number of occupants consume very different amounts of energy. To do this, we sought to explain variations *within* income groups and for households with the same number of occupants. We focussed on electricity consumption and energy bills (rather than water) because of a growing concern about the ability of some less well-off households to pay their energy bills.[8]

1.4.1 What we found

We found that most of the variables that explain variations across all households also explain variations between households with similar levels of income, and between households with the same number of occupants. But we also found some interesting differences between the groups with regard to the relative importance of the explanatory variables and the magnitude of their effect.

Comparing income groups, our most interesting findings are that:

- The model is a better fit for high-income households. This suggests that factors not included in our model - such as the capacity and efficiency of appliances and the use of appliances such as kettles, stoves and vacuum cleaners - account for more of the variation between low-income households than is the case for high-income households.
- The number of occupants (particularly adults) explains more of the variation between low-income households than is the case for higher income households.
- For low-income households, the type of dwelling is more important than the number of bedrooms. In contrast, for high-income households only the number of bedrooms (ie, the size of the dwelling) explains variations in consumption.
- The consumption volumes associated with swimming pools and appliances are larger for high-income households than for low-income ones, with the exception of clothes dryers. Part of the reason for this might be that high-income households on average have larger or more powerful appliances than low-income ones, and/or use them more often. However, some of the differences are likely to be due to associated uses that are more likely amongst high-income households (ie, due to the effect of omitted variables).

We found similar things when we compared households with different numbers of occupants.

8 IPART, *Changes in regulated electricity retail prices from 1 July 2011 – Final Report*, June 2011, pp 81-88.

1.5 Policy implications: how to reduce energy consumption while maintaining the quality of life

As previously indicated, some households spend a significant proportion their disposable income on energy because they use a fairly large amount. Our results can help to identify some ways to reduce the consumption (and bills) of these households while maintaining their quality of life.

Possible ways to do this include replacing inefficient electric hot water systems; getting rid of 2nd fridges; modifying the use of appliances such as clothes dryers and air conditioners; and ensuring that those low-income households that do not already have them, gain access to low-flow showerheads and tap aerators (to reduce hot water consumption).[9] The NSW Home Power Saving program is an important initiative in this regard.[10]

Our findings also suggest that living in a detached house is associated with higher energy bills even when there are only 1 or 2 people in the household. This is potentially an important issue because a fairly high proportion of low-income 1 and 2 person households live in detached houses, many of which have 3 or more bedrooms.[11] These households are more likely to have things like large hot water systems, large heating/cooling systems, 2nd fridges and swimming pools than households in other dwelling types.

1.6 Overview of results for the 'water uses' model

Using a combination of uses and proxy variables, our main findings were that:

- The number of adults and the number of children are both strongly related to consumption. Probably, the coefficients mainly capture the amount of water that is used for personal hygiene, for example bathing, showering, toilet flushing and hand washing (About 40 kL per adult and 20 kL per child per annum).
- The number of times a washing machine is used is closely related to the number of people in the household and washing machines use a fair amount of water; far more so than dishwashers (Used once weekly, washing machines are associated with about 8kL of water per annum compared less than 3 kL per annum for dishwashers, Sydney 2010 data).
- Having a swimming pool and watering the garden, especially with a sprinkler, can add significantly to consumption – but less so in coastal areas than in inland areas. (A pool uses more than 30 kL per annum in coastal Sydney, and a sprinkler uses almost 40kL per annum. Living in an inland area on average adds about 12 kL per annum to outdoor use.)

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9 About 37% of low-income households in Sydney (2010) had a 2nd fridge, 53% had a clothes dryer and 55% had an air conditioner (Appendix A, Table A.1).

10 *http://www.savepower.nsw.gov.au/households/home-power-savings-program/about-the-program.aspx*

11 In Sydney (2010), more than 35% of low-income 1 person households and more than 70% of low-income 2 person households lived in a detached house.

- Only in the Hunter area did washing cars outdoors have a (statistically significant) impact on consumption (about 17 kL per annum). One possible reason for the difference between Sydney and the Hunter area may be that, in Sydney, households were permitted to wash their cars with hoses only if the hoses were fitted with trigger nozzles. Another reason may simply be that households in the Hunter area wash their cars more often.
- Having a rainwater tank, using grey water and/or using bore water are all associated with using less mains water. But by how much and how strong the relationship is differs between the areas. The impact of rainwater tanks was strongest in Gosford/Wyong, possibly because of water restriction regulations that encouraged households to use rainwater indoors.
- In Sydney, Water Wise households used an average of 28 kL per annum less compared to otherwise similar households. This represents more than 10% of the average consumption per household in a detached house in Sydney (210 kL per annum in 2010/11).[12]

The 'water uses' model explains about 43% of the observed variation between Sydney (2010) households, 45% of the variation in the Hunter Water area (2008) area and 34% in Gosford/Wyong (2008).

Box 1.1 Technical note – how we dealt with excluded variables

The surveys did not collect data about all the factors that directly cause consumption. To partially take into account the excluded variables, we used household characteristics to act as 'proxies' for the actual causes of consumption. But each of these proxy variables captures a range of influences, which means that their contributions to consumption (ie, the regression coefficients) need to be interpreted with care.

The missing variables also mean that the amount of consumption that the model associates with a particular use may capture other uses (which are not included in the model). Where possible, we used independent technical information to test the size of our coefficients. We found that most of the coefficients seem to reflect the modelled uses fairly accurately. Exceptions to this are dishwashers and, to a lesser extent, 2nd fridges and washing machines

12 Our surveys did not ask households about water saving behaviour. However, for Sydney (2010) we found a strong relationship between having solar hot water and using less water. To interpret this finding, we believe it is fair to assume that a household with solar hot water is more likely than an 'average' household to be concerned about the environment and therefore to conservatively use both energy and water. Therefore, we used having solar hot water as a proxy for being Water Wise. The alternative explanation – that households with solar hot water use less because they run out of hot water – is not plausible because more than 90% of solar hot water systems in the sample were electric or gas boosted.

1.7 The Consumption Comparator

We used the results of the 'energy uses' and 'water uses' models to develop a Consumption Comparator. By entering some information about their household and its electricity, gas and water consumption into the Consumption Comparator, users can see how their annual consumption compares with other similar households. Where their consumption is high, the Consumption Comparator can help explain why.

The Consumption Comparator is available from our website and should provide a useful tool to help households better understand their energy and water consumption.

1.8 The structure of the report

The rest of this report is structured as follows:

- Chapter 2 explains how we analysed the data.
- Chapters 3, 4 and 5 respectively present our results for electricity consumption, gas consumption and energy bills.
- Chapter 6 presents our analysis of electricity consumption and energy bills for households with the same incomes and the same number of occupants.
- Chapter 7 presents our results for water consumption.

The appendices provide more detailed information:

- Appendix A provides more information about the surveyed households. It also contains the detailed regression results for the relationship between selected socio-economic and dwelling-type characteristics.
- Appendix B explains in more detail how we analysed the data.
- Appendices C to G respectively provide the detailed regression results that informed the discussion in Chapters 3 to 7.
- Appendix H provides details about the independent technical information we used to evaluate our regression results.

2 How we analysed the household survey data

We surveyed households in Sydney between January and March 2010, and in the Hunter, Gosford and Wyong areas between March and July 2008.[13] We asked a range of demographic and socio-economic questions, as well as questions about appliance ownership and use. We then obtained electricity, gas and water consumption data from the utilities for the most recently available 5 quarters. The 2008 and 2010 household survey reports provide further information about the surveys.[14]

Each survey provides a unique data set that combines household characteristics and consumption data at the household level. We have records for more than 2,000 households in each survey area. Using regression techniques, we analysed these data to identify the main determinants of household consumption for electricity, gas and water.

The remainder of this chapter explains how we analysed the data and why we specified a 'characteristics' model and 'uses' model for each service. The final section defines some of the terms we use in this report.

2.1 We used regression models to analyse the household survey data

We used regression analysis to identify some of the key characteristics and uses for energy and water that determine residential consumption. Box 2.1 provides a brief overview of our regression analysis, and Appendix B explains what we did in more detail.

We report the results separately for the 2 areas, but our analysis focuses mainly on the Sydney (2010) area. This is because the consumption data are more complete for the Sydney (2010) area than for the Hunter, Gosford and Wyong (2008) areas, and because the Sydney area provides a more diverse range of dwelling types and climate zones.

13 The surveys covered the operating areas of the following water suppliers: Sydney Water, Hunter Water, Wyong Shire Council and Gosford City Council.

14 IPART, *Residential Energy and Water Use in the Hunter, Gosford and Wyong - Results from the 2008 household survey,* December 2008 and IPART, *Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey,* December 2010.

Box 2.1 Overview of our regression analysis

Regression analysis is a statistical technique that isolates the impact of each explanatory variable on consumption (the dependent variable). For example, we isolated the effect on electricity consumption of living in a detached house for households that have the same number of occupants and bedrooms, levels of income, access to mains gas and location.

Our first task was to select the form of the regression model. We chose to use a linear model because it is simple, transparent and can easily be used to predict consumption.

However, the consumption data have a positively skewed 'tail'. This can mean that a linear regression model is not the most appropriate type. For this reason, we also considered a *semi-log* model. That is, we converted the consumption data to logarithmic form (which has a bell shape) then used this as the dependent variable. We then compared the results of the linear and the semi-log regression models to check that the linear models gave sensible results. We show the comparisons for electricity, energy and water in Appendices C, E and G respectively.

Our next task was to identify data issues that could affect our results. These include:

- 'Multicollinearity', where the explanatory variables are highly correlated. Most economic data are inter-related, so the practical issue is to what *extent* this is the case rather than whether it occurs. As expected, many of our explanatory variables were correlated (eg, income and household size). But the problem was well within the bounds of (statistical) tolerance, so it did not invalidate our results. However, the presence of some multicollinearity means that the results need to be interpreted with care.
- 'Heteroscedasticity', where there is more variation in what is left 'unexplained' for some household groups than for others (eg, for high-income households than for low-income households). We found some evidence of heteroscedasticity and tested the likely impact of this on our results. Our checks showed that heteroscedasticity is not of major concern.
- 'Outliers', which refer to consumption volumes that are far larger or smaller than the rest. The problem with outliers is that they can skew the results of the analysis. Consequently, for the purposes of our analysis we excluded:
  - 16 Sydney households and 6 Hunter, Gosford and Wyong households that used more than 25,000 kWh of electricity per annum
  - 4 Sydney households that used more than 80,0000 MJ of gas per annum
  - 18 Sydney household households with energy usage bills of more than $6,000 per annum
  - 11 Sydney households, 7 Hunter households and 5 Gosford/Wyong households that used more than 300 kL of water per person per annum or more than 750 kL per household per annum.
- Omitted variables, where our models do not include all the factors that affect consumption. We took steps to take this into account, but it may nevertheless have affected our results.
- Measurement error, where some of our explanatory variables are measured imprecisely. For example, several of our explanatory variables are measured in bands (eg, income and how often a dishwasher is used). This may have affected our results.

Appendix B explains what we did in more detail.

2.2 We specified 2 types of model - 'characteristics' models and 'uses' models

To identify the determinants of consumption we specified 2 types of regression model. The first type includes only socio-economic, climate and dwelling-type characteristics as explanatory variables. The second type focuses on what energy or water is used for, but also uses socio-economic, climate and dwelling-type characteristics as 'proxies' for excluded variables.

The advantage of the first type of model (characteristics) is that the regression results can potentially be generalised to other households on an area basis, for example by postcode or census district, using ABS Census and other data that are publicly available.[15] This could have useful planning and policy implications. For example, the regression results could be used to help predict residential electricity and water consumption in a new development depending on what socio-economic groups are targeted, what types of housing are provided and what the climate is like.

The second type of model (focused on energy or water uses) provides an insight into why some apparently similar households[16] use such different amounts of energy and water. This analysis could be used for purposes such as identifying the most effective measures for energy and water efficiency programs and for helping households to better understand their own consumption.

For simplicity, we grouped together the socio-economic, climate and dwelling-type variables and called them 'household' characteristics. We called the other variables 'uses'. Appendix B provides more information about how we organised the explanatory variables.

2.3 How we present the results

In the chapters that follow we report the regression coefficients only for variables that are significant at the 90% level of confidence. To indicate how reliable a coefficient is, we report the t-values. We also report how much of the variation between households each model explains (R^2). We report the full results in the Appendices. Box 2.2 briefly describes the statistical information that regression analysis provides.

15 For this reason, we limited the dwelling-type characteristics to those for which data are easily available, for example from ABS Census data. Therefore, we did not include characteristics that might for other purposes be categorised as dwelling characteristics, such has having a swimming pool or dual flush toilets.

16 By 'apparently similar households' we mean households with similar characteristics (eg, low-income, 2 person households who live in detached houses in coastal areas and do not use gas).

To help interpret the electricity and gas coefficients we converted the volumes to dollar values. This provides an 'indicative cost'.[17] But it is important to note that the indicative cost does not accurately reflect bills, because it does not take into account the complexities of the different tariff structures. Chapter 5 looks at energy bills, and in so doing considers some of the implications for households of the electricity and gas tariff structures.

The tariff structure for water is very simple: each area has a usage charge of roughly $2/kL for all water consumed.[18] Therefore, to simplify the presentation we do not report the indicative cost of water.

Box 2.2 The statistical information that regression analysis provides

Regression analysis provides 3 important types of information.

- Firstly, it measures how much consumption is associated with each characteristic or 'use' variable (the regression coefficients).
- Secondly, it measures how reliable each regression coefficient is (t-values, significance levels and confidence intervals).
- Thirdly, it measures how much of the variation between households the model explains (R^2).

2.4 Some of the terms used in this report

For the purposes of this report we use the following definitions for adults, children and income.

- Adults means people older than 15 years.
- Children means people 15 years old or younger.
- Income means total household income before tax, including all sources of income, expressed in 2009/10 prices.

These definitions are the same as for the household surveys.

17 For electricity, we used EnergyAustralia's 2011/12 regulated residential block 1 tariff (22.66c/kWh, including GST). For gas, we used AGL's 2011/12 regulated residential tariff, average of block 1 and block 2 usage charges (2.195 c/MJ, including GST).

18 The 2011/12 charges are $2.10 per kL for Sydney Water, $1.90 per kL for Hunter Water and $1.98 per kL for Gosford and Wyong.

The surveys asked respondents to provide their income data in 9 income bands. For some of our analysis we consolidated these bands into 4 income categories, namely low-income, lower-middle income, higher-middle income and high-income. The table below shows how we grouped the income bands into these categories. Note that we inflated income data from the 2008 household survey to 2010 prices using the Average Wage Index.[19]

Table 2.1 Definition of income categories used in this report

Income category	Sydney (2010)	Hunter, Gosford and Wyong (2008)[a]
Low-income	Less than $33,800 per annum	Less than $33,800 per annum
Lower-middle income	$33,800 to $62,400 per annum	$33,800 to $56,300 per annum
Higher-middle income	$62,400 to $130,000 per annum	$56,300 to $112,700 per annum
High-income	More than $130,000 per annum	More than $112,700 per annum

a We indexed the original survey categories to 2010 prices by the increase in Average Wage Index of 8.3% (Full- time adult earnings NSW, average for the year to Feb 2010 divided by average for the year to Feb 2008). ABS, 6302.0 *Average Weekly Earnings, Australia*, Table 11A.

19 See Table 2.1, note a.

3 The determinants of electricity consumption

As indicated in Chapter 2, the household surveys provide a range of information about the household, the dwelling and various behaviours (uses) that may influence electricity consumption. To identify the determinants of consumption we developed 2 regression models, namely a 'characteristics' model and an 'energy uses' model. We also used regression analysis to help explain why certain household characteristics, such as having a higher income, are associated with higher consumption.

Our 'characteristics' model found that dwelling type and size, the number of adults and children, income, access to mains gas and climate zone are all important explanatory variables. But these household characteristics do not directly 'cause' consumption. We found that each characteristic is associated with some of the uses that directly cause consumption.

Our 'energy uses' model identified a number of uses that have a significant impact on consumption, such as having a swimming pool and using a clothes dryer. But we did not have data about all the factors that affect consumption, and consequently used a number of proxy variables. Therefore, the coefficients need to be interpreted with care.

Despite its limitations, the 'energy uses' model provides some very useful insights into the determinants of electricity use and serves as a fairly good estimator of a household's electricity consumption.

Our analysis is discussed in more detail below.

3.1 The context: average and median electricity consumption in NSW

It is easier to understand the significance of the regression results if one knows how much electricity NSW households use on average, and what this means in dollar terms. Table 3.1 provides a rough estimate of average and median consumption volumes for NSW households and indicative bills using EnergyAustralia's standard regulated tariff.

Table 3.1 Average and median consumption for NSW households and indicative bills

	Volume	Indicative cost[a]
	kWh pa	$ pa
Average consumption	7,000	1,760
Median consumption	6,000	1,530

a Bills calculated using EnergyAustralia's standard Residential tariff for 2011/12, including the fixed charge and GST.

3.2 The relationship between household characteristics and electricity consumption - the 'characteristics' model

Our first task was to understand the relationship between household characteristics and consumption. We found a statistically significant relationship between electricity consumption and

- the type and size of dwelling
- the number of people in the household (adults and children)
- household income (before tax)
- using mains gas, and
- living in a coastal area rather than an inland area.

These variables explain about 40% of the variation in electricity consumption between households (Table 3.2).

The type and size of dwelling

Our analysis suggests that, in Sydney, living in a detached house adds around 1,500 to a household's annual consumption (around $330). We did not have data on the size of dwellings (ie, floor space), so we used the number of bedrooms as a proxy for size. We found that each bedroom adds an additional 600 kWh to 900 kWh per annum, or about $140 to $200 (Table 3.2).

Our results also suggest that living in a detached house in the Hunter, Gosford and Wyong area has a smaller impact on consumption than in Sydney (Table 3.2). However, this finding may be largely a consequence of the small proportion of flats compared to semi-detached dwellings in the Hunter, Gosford and Wyong survey sample.[20]

20 Flats comprised about 20% of non-detached dwellings in the Hunter/Gosford/Wyong sample compared to almost 50% in Sydney. This difference in housing composition would affect the difference between detached and non-detached dwellings because flats generally require less indoor temperature control than semi-detached dwellings.

The number of people in the household

As expected, the more people who live in a household, the higher the household's electricity consumption. We found that in Sydney, an adult adds about 20% more consumption than a child, ie, about 900 kWh ($200) per annum compared to about 750 kWh ($170) per annum.

Household income

A higher income household is likely to use more electricity than an otherwise similar household with a lower income. We found that each additional $10,000 of annual income (before tax) is associated with additional consumption of roughly 170 kWh ($40) per annum (Table 3.2.)

Mains gas

Gas can be used for hot water, space heating and/or cooking. Therefore, it is not surprising that using mains gas significantly reduces electricity consumption. Our results indicate that using gas reduces electricity consumption by an average 2,200 kWh per annum. This means a saving of about $500 per annum on a standard tariff (Table 3.2).[21]

Climate

Households that live in coastal areas[22] use less electricity than otherwise similar households that live in inland areas. The main reason for this is probably the additional heating and cooling requirements of an inland climate.

It is important to note that our household survey data provide only a rough indication of the influence of climatic conditions on energy consumption. One might expect to find larger differences between the coastal areas and the central and western areas of NSW than between the coastal and inland areas of Sydney.

21 The saving would be smaller if some or all of the gas replaced electricity on a Controlled Load tariff (used mainly for hot water). Chapter 5 discusses Controlled Load hot water and the different tariff structures.

22 Appendix A shows the survey areas we classified as respectively coastal and inland.

Table 3.2 Relationship between household characteristics and electricity consumption

Data set	Sydney (2010)			Hunter, Gosford and Wyong (2008)		
	kWh pa	(t-value)	$ pa[a]	kWh pa	(t-value)	$ pa[a]
% of variation explained (R^2)	41			39		
Sample size	2,166			2,107		
Live in a detached house	1,470	(7.5)	333	659	(3.0)	149
Per bedroom	892	(10.6)	202	618	(6.8)	140
Per adult	896	(11.5)	203	1,355	(15.6)	307
Per child	749	(8.7)	170	896	(11.8)	203
Per $10,000 income pa	165	(10.5)	37	177	(9.8)	40
Did not provide income data	1,566	(6.4)	355	*1,094*	(4.4)	248
Use mains gas	-2,210	(-15.4)	-501	-2,247	(-14.9)	-509
Live in a coastal area	-368	(-2.5)	-84	-405	(-1.8)	-92

a Calculated using EnergyAustralia's regulated 2011/12 block 1 tariff including GST (ie, 22.66c/kWh x kWh).

Note: Linear regressions, excluding household with consumption of more than 25,000 kWh per annum (16 and 6 households from the 2010 and 2008 surveys respectively). Coefficients are shown if they are significant at the 90% level of confidence. Appendix C shows the detailed regression results.

3.2.2 The (statistical) strength of the relationships

The t-value is a statistical measure of the strength of the relationship between consumption and each household characteristic. The larger the t-value, the more confident we can be that the value of the coefficient is, on average, reliable (ie, the narrower the confidence interval). A t-value of at least 2 (in absolute terms) means we are confident that the explanatory variable is related to the dependent variable at the 95% level of confidence.

Looking at the t-values in Table 3.2, our data show that using mains gas, income and the number of people are all strongly related to consumption. As expected, dwelling type and the number of bedrooms are more strongly related to consumption in Sydney (2010) than in the Hunter, Gosford and Wyong (2008) areas (see discussion above). Living in a coastal area rather than an inland area on average means lower consumption, but this relationship is weaker than the others and we are less confident about how much this affects consumption.

3.3 How household characteristics are associated with different uses for electricity

Having established the relationship between household characteristics and consumption, the next question is why these relationships exist. For example, is the additional consumption associated with living in a detached house only due to the additional space heating and cooling it requires, or are there other factors involved? And why does a higher income mean higher consumption for an otherwise similar household? Using the Sydney (2010) data, we identified some of these relationships by running regressions in which a 'use' variable (eg, having a swimming pool) became the dependent variable.[23]

We found that households living in detached houses are more likely to have a swimming pool and a 2nd fridge than households in semi-detached dwellings or flats. These households also make more use of air conditioners and dishwashers. However, households in detached houses on average make less use of clothes dryers, possibly because of the greater likelihood of an outdoor area to hang clothing out to dry (Table 3.3).[24] They also make less use of electric heaters.

Larger dwellings (ie, more bedrooms) are associated with a number of electricity using activities such as having a swimming pool and frequently using a dishwasher. This helps to explain our finding that each extra bedroom adds a significant amount to total consumption even when the type of dwelling, income and the number of adults and children are held constant (Table 3.3).

Unlike the presence of more children, the presence of more adults in a household is associated with an increased likelihood of having a 2nd fridge and a spa. This finding helps to explain why an adult adds more to a household's electricity consumption than a child does (Table 3.3).

Higher income households are more likely to have a swimming pool or a spa than lower income households, and are more inclined to use clothes dryers and dishwashers. These findings go some way towards explaining why higher income is associated with higher electricity consumption, even when other household characteristics are the same (Table 3.3).

23 For binary variables, for example having a swimming pool where 1 = 'yes' and 0 = 'no', we used a logit regression model. Appendix C shows the detailed regression results.

24 Interestingly, we found that households in detached houses are more likely to *have* a clothes dryer than households in other dwelling types, even though they *use* them less often.

The impact of air conditioning on peak demand[25] and consumption has for many years been an issue of interest to electricity businesses and policy makers. In this context it is interesting to note that differences in income explain very little of the variation in how often an air conditioner is used, with household characteristics together accounting for only 5% of the variation in hours of usage. We also found that high-income households were no more likely to *have* an air conditioner than low-income households, *ceteris paribus.* Dwelling characteristics and climate zone are better predictors than income of having an air conditioner, but even these account for only a small proportion of the variation (less than 15% - Table 3.3). However, our analysis is Chapter 6 suggests that high-income households on average may have more powerful air conditioners than low-income households. In addition, we found some evidence that high-income households use their air conditioners more frequently than low-income households (Appendix C, section C.4.4).

25 'Peak demand', also know as 'peak load', refers to the amount of power required to supply all customers at the busiest times.

Table 3.3 Relationships between household characteristics and what electricity is used for

	Detached house	# of bed-rooms	# of adults	# of children	Income	Coastal	% variation explained (R^2)
Swimming pool	strongly +ve	strongly +ve	ns	+ve	strongly +ve	ns	**10-16**[a]
Wald score	*39.5*	*27.1*	*0.1*	*3.3*	*33.7*	*0.0*	
2nd fridge	strongly +ve	strongly +ve	strongl y +ve	ns	ns	ns	**13-18**[a]
Wald score	*78.7*	*24.1*	*12.2*	*0.7*	*2.5*	*0.3*	
Spa	+ve	strongly +ve	+ve	ns	+ve	ns	**3-7**[a]
Wald score	*3.3*	*12.5*	*4.2*	*0.0*	*3.7*	*0.5*	
Clothes dryer use per week	-ve	ns	+ve	+ve	+ve	ns	**5**
t-value	*-2.3*	*-0.1*	*3.8*	*4.6*	*5.8*	*1.4*	
Dishwater use per week	+ve	+ve	+ve	+ve	strongly +ve	+ve	**22**
t-value	*2.1*	*6.9*	*3.0*	*5.5*	*14.4*	*5.0*	
Air conditioner use - hours pa	+ve	ns	ns	ns	+ve	-ve	**5**
t-value	*2.4*	*1.2*	*-0.5*	*1.3*	*2.6*	*-8.0*	
Have air conditioner	+ve	strongly +ve	ns	ns	ns	strongly -ve	**11-15**[a]
Wald score[b]	*9.9*	*25.0*	*1.5*	*0.4*	*1.6*	*128.9*	
Use electric heaters	strongly -ve	ns	-ve	ns	ns	ns	**4-5**[a]
Wald score[b]	22.2	2.4	3.1	2.0	1.0	0.7	

[a] The lower value is the Cox & Snell R Square and the higher value is the Nagelkerke R Square (Psuedo R-square' statistics produced by SPSS logit analysis).

[b] The Wald score is always a positive number.

[c] All the coefficients for using electric heaters are negative except the coefficient for living in a coastal area.

Note: For binary variables we used a logit regression model. The Wald score and the t-value both measure the strength of the statistical relationship between the explanatory variable and the dependent variable. A Wald score of 4 or more and an absolute t-value of 2 or more or more mean the relationship is significant at the 95% level of confidence. We have labelled as 'strongly positive' a Wald score of 20 or more and at t-value of 10 or more (5 times the 95% confidence level). 'ns' means not significant at the 90% level of confidence. Appendix C shows the detailed regression results.

3.4 The relationship between electricity consumption and what it is used for - the 'energy uses' model

Our surveys collected a range of useful data about appliances and their use, and we used these to specify an 'energy uses' model. However, the surveys did not collect data about *all* electrical appliances and their use, nor did they ask about the capacity or efficiency of appliances.

These information gaps meant that we needed to include household characteristics in our 'energy uses' model to act as proxies for at least some of the missing causes of consumption. Each of these household characteristics is likely to capture a range of causes of consumption. Therefore, their contributions to consumption (ie, their regression coefficients) need to be interpreted with care. Box 3.1 discusses the types of information that the household characteristics are likely to capture.

It is unlikely that these proxy variables capture all of the use-related factors that are not included in the model. Consequently, the regression coefficients for the 'energy uses' model may also capture some of these excluded factors. This means that the regression coefficient may not reflect the true marginal impact on consumption of that particular use. Where possible, we used independent technical information to test the size of our coefficients. Appendix B discusses the issue of excluded variables in more detail.

Table 3.4 shows the explanatory variables that we included in our 'energy uses' model, and Table 3.5 compares their regression coefficients with the technical data. We discuss these below.

Box 3.1 'Energy uses' captured by household characteristics

We used household characteristics as proxy variables in the 'energy uses' model to capture some of the missing factors that influence consumption. Each household characteristic probably captures a number of factors, for example:

- Income, the number of bedrooms and the number of occupants (particularly adults) are likely to be indicators of what electricity-using appliances a household has other than those included in the survey, such as computers, television sets and entertainment centres. They are also likely to indicate the amount of lighting that is used.
- Income is also likely to be an indicator of the nature of some of the appliances/amenities that were included in the survey. For example, the size of a swimming pool and the likelihood that it is heated may be related to income. Similarly, higher income households may have more powerful air conditioners and/or use them to maintain a more constant temperature than lower income households. Conversely, higher income households may have more efficient (newer) appliances than lower income households which may offset some of the additional consumption associated with a higher income.
- The number of people in a household is an indicator of how much hot water (and therefore energy) is used, how often appliances such as washing machines are used and how much energy is used for activities such as cooking, boiling kettles and ironing.
- Dwelling type and the number of bedrooms are likely to be associated with the capacity of space heating and cooling systems as well as the hot water system.
- Dwelling type is also associated with how much energy is used for space heating and cooling. In particular, detached houses tend to have larger rooms and more external walls than flats or semi-detached dwellings. These features affect heat absorption and loss, and therefore the energy required for heating and cooling.
- Climate zone (along with dwelling type) serves as an indicator of how frequently and intensively heating and cooling appliances are used.

Hot water systems

Our analysis shows that the type of hot water system a household uses has a very large impact on consumption. It also shows that using gas for hot water reduces electricity consumption significantly more than using an electric boosted solar hot water system.[26] The coefficients compare well with the independent technical information, which suggests that they are good indicators of the amount of electricity used by hot water systems.

Swimming pools and spas

As expected, swimming pools and spas use large amounts of electricity. Again, these coefficients compare well with the independent technical information.

26 In the 2010 survey sample more than 80% of solar hot water systems were electric boosted. In the 2008 survey sample more than 90% were electric boosted.

Second fridges

Second fridges also use fairly large amounts of electricity. However, comparing the regression coefficients with the technical information shows that the amount of electricity associated with a 2nd fridge is fairly large compared to the amount of electricity that a modern energy-rated fridge uses (for Sydney, 1,171 kWh per annum compared to less than 500 kWh per annum for a modern energy-rated 400 L capacity fridge - see Appendix H). However, old fridges use up to 3 times as much electricity as modern ones and available information indicates that 2nd fridges are, on the whole, fairly old.[27] The coefficients for 2nd fridges probably reflect the age profile of these fridges, as well as capturing other factors that are associated with having a 2nd fridge.

Clothes dryers and dishwashers

The consumption and dollar amounts shown for clothes dryers and dishwashers are the total annual amounts associated with using each appliance once a week. To predict the amount of electricity that a particular household would use, these amounts need to be multiplied by the average number of times a week the household uses the appliance. For example, using a clothes dryer 3 times per week is associated with 870 kWh of electricity consumption per annum (3 x 290 kWh, or about $210). Similarly, using a dishwasher 6 times per week is associated with roughly 1,850 kWh per annum (6 x 309 kWh, or about $420).[28]

Comparing the regression coefficients with the technical information suggests that the coefficients for clothes dryer are fairly good estimates of the amount of energy that this appliance actually uses.

27 A survey conducted by the ABS in 2008 found that 54% of 2nd fridges in NSW were 10 years old or older, compared to 29% of main fridges. At the same time, less than 20% of 2nd fridges were 5 year old or less, compared to more than 40% of main fridges. (ABS, *Environmental Issues: Energy Use and Conservation, Mar 2008*, Data cube for Chapter 5, Table 5.7 and Table 5.8, available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4602.0.55.001Mar%20 2008?OpenDocument.)

28 Calculated using the results for Sydney (2010).

However, the coefficients for dishwashers are much larger than the amount that a modern dishwasher actually uses (309 kWh and 220 kWh per annum respectively for the 2 surveys compared to 81 kWh or less per annum for a modern dishwasher[29] (Table 3.4 and Table 3.5). Part of the explanation for the high coefficients may lie in our assumption, discussed in Appendix B, that households in the top usage band use a dishwasher on average 6.5 times per week whereas some households use their dishwasher far more often that this.[30] Also, households might on average use dishwashers on more energy-intensive cycles than those used to provide the technical information. But these coefficients clearly also reflect other factors that are associated with using a dishwasher.

Air conditioners

The amounts shown for air conditioning in the tables are for an average level of usage of 280 hours per annum. This is equivalent to about 5.5 hours per day on 2 days per week for 6 months of the year. Every hour adds about 2.5 kWh to electricity consumption. So, for example, using an air conditioner for 5 days per week, 6 hours per day for 6 months of the year could add around 2,000 kWh per annum to a household's consumption (around $450).[31]

The coefficients for air conditioners compare well with the independent technical information. The technical information shows a wide range of consumption, which depends mainly on the size of the unit. Our coefficients are reasonable if we assume that households have a range of different sized air conditioners, some of which are ducted systems and some of which are individual room units (Table 3.5 and Appendix H).

29 We were unable to find information about the amount of electricity that older dishwashers use.

30 If we assume that households in the '6 times per week or more' band used their dishwasher 7 times per week on average, the value of the regression coefficients for Sydney (2010) falls from 309 kWh to 291 kWh. If we assume they used it 10 times per week, the coefficient falls to 201 kWh. But this is still far higher than the actual amount of electricity that a modern energy rated dishwasher actually uses (81 kWh per annum for once weekly use).

31 Calculated using the results for Sydney (2010).

Proxy variables (household characteristics)

We found that some household characteristics are associated with significantly lower amounts of electricity consumption in the 'energy uses' model compared to the 'characteristics' model, while others are only marginally affected. In particular:

- The consumption associated with dwelling type, the number of bedrooms, the number of children and income is significantly lower (30% or more). For example, the impact of living in a detached dwelling is 1,470 kWh per annum in the 'characteristics' model compared to only 697 kWh per annum in the 'energy uses' model. And instead of each $10,000 of income adding 165kWh per annum, in the 'energy uses' model it adds only 77 kWh per annum (Table 3.2 and Table 3.4).
- The consumption associated with the number of adults or living in a coastal area is fairly consistent in both models - they differ by less than 10% (Table 3.2 and Table 3.4).

The consumption associated with the first group of characteristics is significantly lower in the 'energy uses' model because of the relationship between these characteristics and the uses for electricity, as discussed in Section 3.3 above. For example, living in detached house is associated with having a swimming pool and a 2nd fridge as well as using a dishwasher and an air conditioner. When these uses for electricity are not included as explanatory variables, some of the consumption that is associated with them is ascribed to the dwelling type.

The relatively consistent amount of consumption that is associated with the number of adults or living in a coastal area suggests that these variables are picking up influences that are not included as variables in the 'energy uses' model.

Table 3.4 Relationship between electricity consumption and what it is used for

Data set	Sydney (2010)			Hunter, Gosford and Wyong (2008)		
	kWh pa	(t-value)	$ pa[a]	kWh pa	(t-value)	$ pa[a]
% of variation explained (R^2)	59			55		
Sample size	2,157			2,107		
Have a swimming pool	2,520	(15.7)	570	2,269	(12.6)	510
Have a 2nd fridge	1,171	(9.3)	270	756	(6.2)	170
Have a spa	959	(4.0)	220	1,680	(6.2)	380
Per 280 hours of air conditioner use	691	(12.7)	160	701	(11.4)	160
Clothes dryer – used once per week	290	(6.4)	70	327	(7.7)	70
Dishwasher - used once per week	309	(11.5)	70	220	(8.0)	50
Use electricity for space heating other than air conditioner	322	(2.4)	70	ns	(-0.2)	ns
Live in a detached house	679	(4.0)	150	478	(2.5)	110
Per bedroom	555	(7.8)	130	336	(4.2)	80
Per adult (16 years or older)	812	(12.5)	180	1,038	(13.6)	240
Per child	522	(7.2)	120	610	(8.8)	140
Per $10,000 income per annum	77	(5.6)	20	87	(5.4)	20
Did not provide income data	886	(4.3)	200	770	(3.5)	170
Main source for hot water is gas	-2,762	(-22.0)	-630	-2,846	(-19.5)	-640
Main source for hot water is solar	-1,397	(-6.0)	-320	-1,685	(-5.7)	-380
Live in a coastal area	-342	(-2.8)	-80	ns[b]	(1.0)	ns

a Calculated using EnergyAustralia's regulated 2011/12 block 1 tariff including GST (ie, 22.66c/kWh x kWh).

b Note that only a small proportion of households live in inland areas in the 2008 survey region. This may have affected the result.

Note: Linear regressions, excluding household with consumption of more than 25,000 kWh per annum (16 and 6 households from the 2010 and 2008 surveys respectively). Coefficients are shown if they are significant at the 90% level of confidence. Appendix C shows the detailed regression results.

Table 3.5 Comparison of regression coefficients with independent technical information

	Sydney (2010) kWh pa	Technical estimates kWh pa	Coefficient within plausible range?	Comments	Sources
Have a swimming pool	2,520	2,223 – 4,015	Yes	Depends on size of pump and number of hours run	1 and 2
Have a 2nd fridge	1,171	146 – 1,830	No, probably a bit too high	Wide range depending on age, capacity and features such as freezer, frostless etc. Modern fridges generally use less than 1,000 kWh pa.	1,2, 3 and 4
Have a spa	959	945	Yes	Consumption for use 12 hours once per week	1
Per 280 hours of air conditioner use	691	186 – 1,820	Yes	Depends on capacity. Ducted systems use far more than single room systems. Bottom of range is for a small bedroom unit.	1, 2 and 3
Clothes dryer – used once per week	290	77 - 404	Yes	Depends on capacity, energy rating and how long it is used for. Range is for modern 2.5 kg – 9kg energy rated dryers, per cycle. 5kg dryers use about 230kWh per cycle.	1, 2, 3 and 4
Dishwasher - used once per week	309	32 - 81	No, far higher than technical information indicate	Range is for modern energy-rated 12 place setting dishwashers, 1 to 4 star rated, used on the normal cycle.	1, 2 and 4
Electric hot water system	2,762	2,710 – 3,103	Yes	Range is for storage systems. Consumption depends on how much hot water is used and the water temperature.	1 and 2
Main source for hot water is solar	-1,397	-1,953	Yes, roughly	This is the difference between a standard and an electric boosted hot water system, calculated from Origin data (source 1).	1, also see 5

Note: Appendix H provides further details. We did not compare the regression coefficient for using electricity for space heating with technical information because of the wide range of heaters and usage patterns.

Sources:

1. Origin, New South Wales estimated household energy consumption, for summer period 2011 and winter period 2011/12. Available at http://www.originenergy.com.au/3531/State-fact-sheets.
2. OkSolar website at http://www.oksolar.com/technical/consumption.html, accessed 7 October 2011.
3 Michael Bluejay website at http://michaelbluejay.com/electricity, accessed 7 October 2011. (See Specific appliances section.)
4. Australian Energy rating website, at http://reg.energyrating.gov.au/, accessed 7 October 2011. (Comparing products section.)

5. NSW Office of Environment and Heritage website, at http://www.environment.nsw.gov.au/energy/hwschoose.htm, accessed 7 October 2011.

3.4.2 The (statistical) strength of the relationships

As previously discussed, the t-values indicate how strongly the variable is associated with consumption and how confident we about the amount of electricity that is associated with that variable. We found that using gas for hot water, having a swimming pool, using an air conditioner and using a dishwasher are all strongly related to consumption and we are fairly confident about how much they add to consumption (t-values are greater than 10). We are least confident about the magnitude of the effect of living in a coastal area and using electricity for heating from a source other than an air conditioner (t-values are less than 3) (Table 3.4).

3.5 How well our 'energy uses' model predicts electricity consumption

We tested how well our model predicts consumption in 2 ways. Firstly, we tested the model's predictions against the average consumption of the surveyed samples. Secondly, we compared the model's predicted consumption to the actual consumption of volunteer households that were not included in the surveys.

We found that the model could accurately predict the average consumption of the 2008 and the 2010 samples. We also found that the model could fairly accurately predict average consumption for the different income groups – to within 4% of their actual average consumption (Table 3.6).[32]

[32] To predict average consumption we used the average sample values for all the input parameters, for example 2.17 adults per household and 0.15 of a swimming pool (which means that 15% of households have pools). For the 2010 survey we used the weighted sample values because these are the best estimates for all households in the survey region (see Appendix A). We predicted the 2010 sample averages using the 2010 coefficients and the 2008 sample average using the 2008 coefficients. Appendix A shows the sample values for each input parameter.

Table 3.6 Model predictions compared to actual average consumption of surveyed households (kWh pa)

	All households	low-income	low-middle	high-middle	high-income	refused
Sydney (2010) data						
Predicted average	7,130	5,286	6,558	7,808	9,279	7,669
Actual average	7,225	5,312	6,466	8,014	9,560	7,779
Percentage difference	1	1	-1	3	3	1
Hunter, Gosford and Wyong (2008) data						
Predicted average	7,579	6,000	7,751	8,884	10,466	7,930
Actual average	7,596	5,887	7,900	9,243	10,681	7,820
Percentage difference	0	-2	2	4	2	-1

Note: For each survey area we used the associated model coefficients and sample averages.

We predicted the consumption of a number of volunteer Sydney households that had not participated in the surveys, using the Sydney (2010) coefficients. We then compared each prediction to the household's actual consumption and found that, for most of the volunteers, the model predictions proved to be fairly accurate. This means that these households consumed amounts that were close to the average for other Sydney households with similar characteristics and uses (Table 3.7).

For some households, actual consumption varied substantially from predicted consumption. This is not surprising, given that the coefficients are the average within a range, and sometimes the ranges are fairly wide (see Appendix 3). Also, the model includes only some of the uses that affect consumption and does not take into account the capacity and efficiency of appliances.

Some of the reasons that we identified for the observed variations include:

- The number of people in a household can vary over a 12 month period, which will significantly affect consumption.
- An energy conscious household is likely to consume less electricity than an 'average' household with the same characteristics and appliances. For example, energy conscious households are more likely to switch off lights and appliances that are not in use, have appliances that are more energy efficient, turn the thermostat down on the hot water tank and use less energy-intensive dishwasher and washing machine cycles.
- The model may not work very well when a household uses electricity for heating (other than reverse cycle air-conditioning). The regression coefficient is for an 'average' user, but the type of heater and usage patterns vary widely.[33]

33 The t-value for this variable was comparatively small (2.4) and the 95% confidence interval was wide (59 to 586 kWh). Appendix C shows the confidence intervals for all the variables.

- A controlled load hot water system has a larger capacity than a standard electric hot water system, and uses more electricity (see Box 5.1 and Chapter 5).
- When consumption is very small or very large, the model does not perform very well. The main reason for this is that we use a linear model to approximate a non-linear relationship (see Appendix B).

Table 3.7 Model predictions compared to actual consumption of volunteer Sydney households (kWh pa)

	Volunteer 1	Volunteer 2	Volunteer 3	Volunteer 4	Volunteer 5	Volunteer 6
Predicted consumption	13,182	6,605	8,296	6,498	5,312	8,697
Actual consumption	13,192	5,853	7,237	6,615	3,137	9,401
Percentage difference	0	-11	-13	2	-41	8
Key characteristics						
Dwelling type	house	house	semi	house	flat	house
Occupants	4 adults	3.5 adults (average)[a]	2 adults 3 children	2 adults 1 child	1.75 adults (average)[a]	2 adults
Hot water system	gas	gas	solar	solar	electric	electric
Have swimming pool?	yes	no	no	no	no	no
Use air conditioner often?	yes	no	no	no	no	yes
Comments						
Energy conscious household?	no	yes	yes	yes	yes	no
Controlled load hot water?	no	no	no	CL electric boosted	no	yes
Other reasons for variation				Electric heater on all night in child's bedroom	Very small hot water tank, low water pressure. Frequently spend time away.	

[a] When household members regularly spend time away from home, we allowed fractions.

Note: We asked a number of Sydney households about their characteristics and what they use electricity for. They also provided 4 quarterly electricity bills. We used the Sydney (2010) coefficients.

4 The determinants of gas consumption

Our household surveys asked respondents whether or not they used gas, and whether it was mains gas or cylinder gas.[34] If they used gas, they were asked whether they used it for cooking, hot water and/or space heating. We then obtained information about how much mains gas each household had used in the previous 12 months.

We found that half of households in Sydney and about a third of households in the Hunter, Gosford and Wyong areas use mains gas. Cylinder gas is less common, and we were unable to obtain information about how much cylinder gas households used.[35] Consequently, our analysis focuses on mains gas (referred to simply as gas in this report).

The amount of gas that a household uses depends both on what it uses gas for and the household's characteristics (eg, the number of adults and children and the type of dwelling). For this reason, we analysed residential gas consumption by looking firstly at household characteristics, and then by considering what gas is used for. The third and final step was to combine these factors to specify an 'energy uses' model for gas.

We found that household characteristics alone do not have much explanatory power; nor does what gas is used for when considered alone. But combining these factors in an 'energy uses' model provides some useful insights into the determinants of gas consumption. However, as for electricity the 'energy uses' model includes some but not all of the factors that directly cause gas consumption. Therefore, the coefficients need to be interpreted with care.

The 'energy uses' model serves as a fairly good predictor of gas consumption for some households but not for others. It is particularly unreliable for households that use gas only for cooking and for households that have ducted gas heating.

34 Mains gas refers to gas supplied by gas distribution pipes connected to the dwelling. Cylinder gas refers to liquid petroleum gas (LPG) supplied in large cylinders that then connect to the dwelling or appliance. Only some areas have a gas pipeline (ie, mains) network.

35 Cylinder gas is fairly uncommon in the Sydney metropolitan area where less than 5% of households use it. It is more commonly used in the Hunter, Gosford and Wyong area (9%). (IPART, *Residential energy and water use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey*, December 2010, p76.)

These findings are discussed in more detail below, after a brief discussion about who use gas.

4.1 The characteristics of households that use gas

Whether or not a household uses gas depends mainly on where the gas mains (ie, pipelines) run. Unfortunately, we did not have sufficiently detailed information about the gas mains network to include access to gas in our analysis.

To gain some idea of the socio-economic and geographic profile of households that use gas, we investigated the relationship between household characteristics and using gas. We found that:

- Sydney (2010) households are more likely to use mains gas if they live in a coastal area, whereas Hunter, Gosford and Wyong (2008) households are less likely to use gas if they live in a coastal area.[36] This probably reflects the gas pipeline network.
- In both areas, having a higher income increases the probability of using gas.[37] The main reason for this is probably that gas pipelines are more concentrated in higher income areas than in lower income areas. But it may also indicate that a high-income household is more likely to connect to a gas main than a low-income household in the same area.
- In Sydney, living in a flat decreases the probability of using gas.[38]

However, in both areas these household characteristics explain only a small proportion of the likelihood of using gas (less than 10%).

36 About 55% of Sydney (2010) households in coastal areas used mains gas, compared to 44% in inland areas. In the Hunter/Gosford/Wyong area (2008), 27% of households in coastal areas used mains gas compared to 41% in inland areas.

37 In Sydney (2010), 38% of low-income household used mains gas compared to 61% of high-income households. In the Hunter/Gosford/Wyong area (2008), 24% of low-income households used mains gas compared to 41% of high-income households.

38 About 42% of households in flats used mains gas compared to 52% in both detached and semi-detached dwellings.

Table 4.1 Relationship between household characteristics and using gas

	Live in a flat	Number of adults	Number of children	Income	Coastal	% variation explained
Sydney (2010)						
Use gas	-ve	+ve	+ve	strongly +ve	strongly +ve	6 – 8[a]
Wald score[b]	*10.5*	*3.5*	*4.8*	*28.3*	*57.6*	
Hunter, Gosford and Wyong (2008)						
Use gas	ns	+ve	ns	strongly +ve	strongly -ve	3 - 4[a]
Wald score[b]	*0.0*	*7.0*	*1.9*	*24.3*	*20.5*	

[a] The lower value is the Cox & Snell R Square and the higher value is the Nagelkerke R Square ('Psuedo R-square' statistics produced by SPSS logit analysis).

[b] The Wald score is always a positive number.

Note: Logit regression analysis. The Wald score measures the strength of the statistical relationship between the explanatory variable and the dependent variable. A score of 4 or more means the relationship is significant at the 95% level of confidence. 'ns' means not significant at the 90% level of confidence. Appendix D shows the detailed regression results.

4.2 The relationship between household characteristics and gas consumption - the 'characteristics' model

Our next task was to understand the relationship between household characteristics and gas consumption. Looking at Sydney (2010) households that used gas, we found statistically significant relationships between gas consumption and

- the type of the dwelling, with detached houses using more gas
- the number of occupants, with more occupants meaning higher consumption
- income, with higher income associated with higher consumption
- the climate zone, with households in coastal areas using less gas (Table 4.2).

These relationships are similar to the relationships between household characteristics and electricity consumption shown in Table 3.2.

However, unlike for electricity we found that having more bedrooms – which serves as a proxy for the size of the dwelling - was not associated with higher gas consumption in a statistically significant manner. But we found that the number of indoor showers was a statistically significant predictor of consumption (Table 4.2). Possible reasons for the relationship between the number of showers and gas consumption are discussed in Box 4.1 (Section 4.4).

In the Hunter, Gosford and Wyong area only the number of adults and the number of children had significant explanatory power. Dwelling-type characteristics did not explain variations in consumption, but this result may be a consequence of the smaller sample size and the very small number of households that lived in flats or semi-detached dwellings[39] (Table 4.2).

Household characteristics alone explain only about 20% of the variation in gas consumption between households (Table 4.2). This is not surprising because the amount of gas that a household uses also very much depends on what it uses gas for.

Table 4.2 Relationship between household characteristics and gas consumption

Data set	Sydney (2010)		Sydney (2010)		Hunter, Gosford and Wyong (2008)	
	# bedrooms		# showers		# showers	
	MJ pa (t-values)	$ pa[a]	MJ pa (t-values)	$ pa[a]	MJ pa (t-values)	$ pa[a]
% of variation explained (R^2)	19		20		20	
Sample size	1,097		1,097		561	
Live in a detached house	2,833 (2.8)	62	2,945 (3.2)	65	ns (-0.2)	ns
Per bedroom	ns (0.6)[b]	ns	-	-	-	-
Per indoor shower	-	-	1,530 (2.9)	34	ns (0.5)	ns
Per adult (16 years or older)	3,542 (9.1)	78	3,371 (9.0)	74	3,753 (7.3)	82
Per child	2,032 (4.8)	45	2,006 (4.8)	44	3,007 (6.1)	66
Per $10,000 income pa	334 (4.4)	7	309 (4.1)	7	ns (1.6)	ns
Did not provide income data	*ns (0.9)*	*ns*	*ns (0.7)*	*ns*	*ns (1.3)*	*ns*
Live in a coastal area	-1,229 (-1.7)	-27	-1,298 (-1.8)	-28	ns (0.0)	ns

a Calculated using AGL's 2011/12 regulated residential tariff, average of block 1 and block 2 usage charges respectively 2.74c/MJ and 1.649c/MJ, average 2.195 c/MJ (including GST).

b The number of bedrooms is significant at an 88% level of confidence, with a coefficient of 976 MJ per bedroom.

Note: Linear regressions, excluding households with consumption exceeding 80,000 MJ per annum (4 households from the 2010 survey). Coefficients are shown if they are significant at a 90% level of confidence. Appendix D shows the detailed regression results.

4.3 The amount of gas used for and cooking, heating and hot water

Looking at the relationship between gas consumption and what it is used for (ie, cooking, heating or hot water), we found that on average hot water uses more gas than space heating or cooking. Cooking uses the least amount of gas, and the amount varies the most between households in percentage terms (indicated by the comparatively low t-value - Table 4.3.)

39 We had gas consumption data for 562 households and of these, only 6 lived in a flat and 43 lived in a semi-detached dwelling.

Sydney (2010) households on average used more gas for space heating if this was their only form of heating than if they used both gas and electricity. Households in the Hunter, Gosford and Wyong area (2008) on average used about the same amount of gas for heating whether or not they also used electricity. Again, this finding might be due to limitations of the 2008 data (Table 4.3).

Table 4.3 The amount of gas used for and cooking, heating and hot water

Data set	Sydney (2010)		Hunter, Gosford and Wyong (2008)	
	MJ pa (t values)	$ pa[a]	MJ pa (t values)	$ pa[a]
% of variation explained (R^2)	18		30	
Sample size	1,097		561	
Cooking	2,686 (2.9)	59	ns (1.6)	ns
Hot water	10,254 (12.2)	225	12,994 (13.2)	285
Heating, gas only	7,536 (9.0)	165	7,038 (6.0)	154
Heating, gas and electricity	5,350 (5.9)	117	7,042 (7.3)	155

[a] Calculated using AGL's 2011/12 regulated residential tariff, average of block 1 and block 2 usage charges respectively 2.74c/MJ and 1.649c/MJ, average 2.195 c/MJ (including GST).

Note: Linear regressions, excluding households with consumption exceeding 80,000 MJ per annum (4 households from the 2010 survey). Coefficients are shown if they are significant at a 90% level of confidence. Appendix D shows the detailed regression results.

4.4 The relationship between gas consumption and what it is used for - the 'energy uses' model

Clearly, a household's gas consumption depends on what it uses gas for as well as characteristics like the number of occupants, the type and size of the dwelling and the climate zone.

We combined these 2 sets of variables in a single 'energy uses' model to identify the main determinants of gas consumption. In the sections that follow we discuss the explanatory variables first, and then we present the results. We mainly focus on Sydney (2010), but we also show the results for Hunter, Gosford and Wyong (2008).

4.4.1 The explanatory variables we used in our 'energy uses' model

The importance of a household's characteristics depends, to a large extent, on what the household uses gas for. For example, the amount of gas a household uses for

- hot water will depend more on the number of people than the type or size of the dwelling or the climate
- space heating will depend more on the type and size of the dwelling and the climate than on the number of people
- cooking will depend on the number of people rather than on the type and size of the dwelling or the climate.

A household's gas consumption will also depend on whether it uses only gas for a particular purpose, or both gas and electricity. For example, many households use both gas and electricity for space heating and cooking.

Like for electricity, the capacity and efficiency of a household's gas appliances, and how often it uses them, will affect consumption. Unfortunately our surveys did not collect this type of information, so our analysis could not explicitly take these factors into account.

Using the data that was available from the household surveys, we included the following explanatory variables in our model:

- If a household uses gas for hot water, the number of adults and the number of children.[40]
- Whether or not the household uses gas for cooking.
- If a household uses only gas for heating (not electricity[41]), whether it lives in a coastal or an inland area.
- If a household uses both gas and electricity for heating, whether it lives in a coastal or an inland area.
- Whether or not the dwelling is a detached house. This variable mainly captures the additional heating requirements of a detached house, but it may also capture some information about the capacity of the hot water system.
- The number of indoor showers. This indicates the number of bathrooms and, as such, serves as a proxy for the size of the house. But it also seems to capture information about the amount of hot water that each person is likely to use. Box 4.1 explains the possible reasons for this.
- Income, which serves as a proxy for the capacity of appliances and, for heaters, possibly the extent to which they are used.

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40 We do not know whether a household used only gas or both gas and electricity for hot water, because the survey only asked about the *main* source of energy for hot water.

41 A few households in our survey samples used both gas and another form of heating, such as oil, wood or coal.

Box 4.1 What information does 'the number of indoor showers' capture?

We used the number of indoor showers rather than the number of bedrooms as an explanatory variable in the 'energy uses' model for gas because it captures 2 important influences:

- Like bedrooms, the number of indoor showers serves as a proxy for the size of the house. Dwellings with more showers (which indicate the number of bathrooms) are likely to be larger than dwellings with fewer showers.
- The number of showers may capture information about the amount of hot water that each person is able to use. The reasoning behind this is that the more showers (or bathrooms) there are for a given number of occupants (particularly adults), the longer a person can spend in the shower. Also, the number of showers may indicate the capacity of the hot water system and therefore that amount that is available for use.

The ability of this variable to also capture information about hot water is suggested by the fact the regression coefficient is significant at the 99% level of confidence (t-value = 4.4). In contrast, the coefficient for the number of bedrooms (instead of showers) is significant only at the 90% level of confidence (t-value = 1.8). In addition, the number of indoor showers better explains variations in water usage than does the number of bedrooms (see Chapter 7).

4.4.2 What we found to be the main determinants of gas consumption

Our findings for Sydney (2010) show that the amount of gas a household uses for hot water depends strongly on the number of people (particularly adults). It also seems to depend on the number of indoor showers because, as explained in Box 4.1, this probably affects how much hot water people are *able* to use (Table 4.4).

Children on average use about half as much gas for hot water as adults do (about 1,800 MJ per annum compared to more than 3,700 MJ per annum). But there is more variability in the amount that children use (indicated by the t-value, which is much lower for children than for adults – Table 4.4).

As expected, Sydney households use more gas for space heating if they use only gas for this purpose. Also, households in inland areas use more gas for heating than otherwise similar households in coastal areas. And like for electricity, living in a detached house on average means higher gas consumption. This probably reflects the additional heating requirements of this type of dwelling (Table 4.4).

The 'energy uses' model confirms that cooking uses less gas than either hot water or space heating. The model also shows that income has an independent effect on consumption, suggesting that higher income households have larger appliances and/or use them more often (Table 4.4).

Looking at the strength of the relationships between consumption and the explanatory variables (ie, the t-values), our analysis suggests that households use widely varying amounts of gas for cooking. Similarly, households in coastal areas that use both gas and electricity for heating use widely varying amounts. This means that we cannot predict with much accuracy how much these activities add to a particular household's gas consumption. We are more confident about how much consumption the other activities/characteristics add, and in particular the amount that each adult uses for hot water (Table 4.4).

The model for the Hunter, Gosford and Wyong area (2008) is simpler than that for Sydney (2010) because of the smaller sample size. In particular, when looking at space heating we estimated only the impact on consumption of the climate zone. Our findings for this area are broadly consistent with those for Sydney, given the previously discussed limitations of the survey data with respect to sample size and dwelling types (Table 4.4).

Table 4.4 Relationship between gas consumption and the explanatory variables

Data set	Sydney (2010)		Hunter, Gosford and Wyong (2008)	
	MJ pa (t values)	$ pa[a]	MJ pa (t values)	$ pa[a]
% of variation explained (R^2)	35		47	
Sample size	1,097		561	
Per adult using gas hot water[b]	3,712 (15.0)	81	4,741 (15.4)	104
Per child using gas hot water[b]	1,808 (4.3)	40	2,918 (6.5)	64
Use gas for cooking as main source (only or with electricity)	2,335 (2.8)	51	ns (1.4)	ns
Inland and use gas for heating no electricity	7,871 (7.6)	173	-	-
Inland and use gas and electricity for heating	7,071 (6.8)	155	-	-
Coastal and use gas for heating no electricity	6,448 (7.2)	142	-	-
Coastal and use gas and electricity for heating	2,058 (2.0)	45	-	-
Inland and use gas for heating[c]	-		7,521 (5.9)	165
Coastal and use gas for heating[c]	-		6,423 (7.8)	141
Detached house	2,760 (3.4)	61	ns (-0.9)	ns
Per indoor shower	2,055 (4.4)	45	ns (0.2)	ns
Per $10, 000 income	265 (4.0)	6	166 (1.8)	4

[a] Calculated using AGL's 2011/12 regulated residential tariff, average of block 1 and block 2 usage charges respectively 2.74c/MJ and 1.649c/MJ, average 2.195 c/MJ (including GST).

[b] We do not know whether a household uses only gas or both gas and electricity for hot water, because the survey only asked what the *main* source of energy is for hot water.

[c] The 2008 survey sample was too small to estimate the impact of both climate zone and the type of heating.

Note: Linear regressions, excluding households with consumption exceeding 80,000 MJ per annum (4 households from the 2010 survey). Coefficients are shown if they are significant at a 90% level of confidence. Appendix D shows the detailed regression results.

4.5 How well our 'energy uses' model predicts gas consumption

Like for electricity, we tested how well our 'energy uses' model predicts consumption in 2 ways. Firstly, we tested the model's predictions against the average consumption of the surveyed samples. Secondly, we compared the model's predicted consumption with the actual consumption of a number of volunteer Sydney households that were not included in the survey.

We found that the model could accurately predict the average consumption of the 2008 and the 2010 samples.[42] It could also predict the average consumption of the different income groups, although it was somewhat less accurate for some groups (Table 4.5).

Table 4.5 Model predictions compared to actual sample average consumption (MJ pa)

	All households	low-income	low-middle	high-middle	high-income	refused
Sydney (2010)						
Predicted average	18,343	13,536	16,760	18,912	23,534	16,384
Actual average	18,404	14,843	16,904	19,336	22,655	17,097
Percentage difference	0	-9	-1	-2	4	-4
Hunter, Gosford and Wyong (2008)						
Predicted average	18,130	14,294	18,021	20,429	23,739	19,723
Actual average	18,278	14,023	18,189	21,368	22,697	19,640
Percentage difference	-1	2	-1	-4	5	0

Note: For each survey area we used the associated model coefficients and sample averages. We tested the model using only the coefficients that were significant, shown in Table 4.4.

We then compared the consumption for a number of volunteer households with the model's predicted consumption (Table 4.6). Like for electricity, we found that the model was fairly accurate for some households but not for others. Again, this is not surprising given that the model includes only some of the factors that affect consumption; that the coefficients are the average within a range while sometimes the ranges are fairly wide; and that we used household characteristics as proxies for some of the factors that affect consumption (eg, the capacity of gas heaters).

As expected, the model was not very accurate when the volunteer household used gas only for cooking. The model was also not always accurate when the household used gas for heating, and was particularly inaccurate for households with ducted heating. Table 4.6 identifies some reasons for observed variations between actual and predicted consumption.

42 To predict average consumption we used the average sample values for all the input parameters, for example 1.77 adults per household that used hot water and 0.81 of a household that used gas for cooking (which means that 81% of gas using households used it for cooking). For the 2010 survey we used the weighted sample values because these are the best estimates for all households in the survey region (shown in Appendix A). We predicted the 2010 sample averages using the 2010 coefficients and the 2008 sample average using the 2008 coefficients.

Table 4.6 Model predictions compared to actual consumption by volunteer households (MJ pa)

	Volunteer 1	Volunteer 2	Volunteer 3	Volunteer 4	Volunteer 5	Volunteer 6
Predicted consumption	23,786	31,137	11,408	2,335[a]	15,081	27,377
Actual consumption	23,438	33,778	11,454	1,921	46,757	38,782
Percentage difference	-1	8	0	-18	210	42
Key characteristics						
Use gas for cooking?	yes	yes	yes	yes	yes	yes
Use gas for hot water?	yes	yes	no	no	no	yes
Use gas for heating	no	yes	yes	no	yes	yes
Comments						
Reasons for variation	na	na	na	Cooking only, wide variations expected	Ducted heating of whole house on automatic timer, used very frequently	Ducted heating of whole house, used frequently

a For households that use gas for cooking only, we used as a prediction only the amount associated with using gas for cooking (ie, we excluded the constant term).

Note: We asked a number of Sydney households about their characteristics and what they use gas for. They also provided 4 quarterly gas bills. We used the Sydney (2010) coefficients.

5 The determinants of energy usage bills

About half of Sydney households use gas instead of electricity to provide the energy they need for hot water, space heating and/or cooking. Gas typically provides about 30% of a household's energy requirements. Therefore, to meaningfully compare energy consumption across all households, one needs to combine electricity and gas consumption.

For technical reasons it is difficult to reliably convert gas consumption to electricity in 'kWh equivalents'. For this reason, we analysed energy bills instead of energy consumption. We excluded the fixed charges and energy rebates from the analysis because these do not vary with consumption. We used 2011/12 regulated tariffs and the Sydney (2010) survey data.

Because we analysed bills rather than consumption, our results reflect both energy consumption and tariff structures (usage charges only). Consequently, energy bills are only roughly indicative of energy consumption (because they also reflect the different tariffs).

We analysed energy bills using a 'characteristics' model as well as an 'energy uses' model. Our findings are broadly similar to those for electricity discussed in Chapter 3. Using energy bills also allowed us to look at tariff related issues. In this regard, our findings suggest that having a Controlled Load electricity supply means lower bills despite higher consumption; that gas hot water systems are cheaper to run than standard electric ones; and that, when used for space heating and cooking, there is little cost difference between gas and electricity.

Our analysis is discussed in more detail below.

5.1 Why we used energy bills to estimate consumption

Ideally, we would have liked to compare the amounts of energy associated with different characteristics and uses by converting gas consumption to 'kWh equivalents'. But converting gas consumption is complicated by the fact that some gas appliances lose energy. For example, a flued gas heater loses energy because heat is lost in the chimney. This means that more gas is needed to achieve the same level of 'service' that an equivalent amount of electricity would provide.

Instead, we converted both electricity and gas consumption to dollar values. To do this, we calculated the usage component of each household's bill (ie, excluding the fixed charges and rebates) using the applicable regulated tariffs for 2011/12.[43] We used only the Sydney (2010) survey data, because we did not have sufficiently detailed consumption data for the Hunter, Gosford and Wyong (2008) survey. Table 5.1 shows the regulated tariffs that we used.

Where possible, in this chapter we compare our results for energy bills with the indicative cost of electricity shown in Chapter 3. However, for bills the dollar value attached to each kWh of electricity used depends on the network area and the type of tariff that applies (Table 5.1). This differs from the way we calculated the indicative cost of electricity in Chapter 3. In that chapter, we used only *one* usage charge, ie, EnergyAustralia's Block 1 rate of 22.66 c/kWh. The main reasons why, for the same amount of electricity, a bill may differ from the indicative cost of electricity are:

- The household is in a different network area; therefore Integral Energy's tariffs apply.
- Inclining block tariffs mean that any consumption in excess of 1,750 kWh per quarter is charged at a higher rate. This means that bills go up faster than consumption when a household consumes more than this amount per quarter.
- Controlled Load tariffs are far lower than standard tariffs. Box 5.1 explains what a Controlled Load electricity supply is and what it is used for. Our analysis takes into account Controlled Load tariffs by including as a variable whether or not a household has this type of electricity supply.[44] Section 5.4 further investigates the impact on consumption and bills of having a Controlled Load supply.

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43 We calculated quarterly bills then adjusted the annual bill to reflect 365 days of consumption. For customers in Integral Energy's network supply area (the network provider is now called Endeavour Energy), we assumed that all customers with Controlled Load consumption were on the Off-peak 1 tariff because we did not have information about which off-peak tariff they were on.

44 Appendix E shows the impact on the regression coefficients of not including 'having a Controlled Load supply' as an explanatory variable (section E.6, Table E.14 and Table E.15).

Box 5.1 What is a Controlled Load electricity supply and what is it used for?

A Controlled Load electricity supply is remotely controlled by the network provider, and is usually switched on only at night. It has a separate meter, and is far cheaper than normal electricity (see Table 5.1). Most Controlled Load electricity is used for hot water, including both electric storage systems and electricity boosted solar hot water systems. But it can also be used for other purposes such as swimming pool pumps and certain types of heating.[a]

Controlled Load (or off-peak) hot water systems generally use more electricity than standard electric ones. The reason for this is that Controlled Load systems need to be larger than standard electric ones because the water is heated only at night, rather than continuously.[b]

a For example, see *Pricing definitions for electricity customers New South Wales,* Red Energy at http://www.google.com.au/search?q=pricing+definitions+NSW+Red+energy&rls=com.microsoft:en-au:IE-SearchBox&ie=UTF-8&oe=UTF-8&sourceid=ie7&rlz=1I7GGLR_enAU311, accessed 4 October 2011.

b Controlled Load hot water systems must have a storage capacity of at least 160 L. Standard electric hot water systems have a smaller storage capacity or may be continuous flow systems. (NSW Office of Environment and Heritage website, *Choosing a hot water system*, at http://www.environment.nsw.gov.au/energy/hwschoose.htm, accessed 4 October 2011.)

Table 5.1 Regulated electricity and gas tariffs (effective 1 July 2011, including GST)

	Unit	EnergyAustralia (now TRUenergy)	Integral Energy (now Origin)	AGL
Inclining block tariff				
Block 1 rate, up to 1,750 kWh per quarter	c/kWh,	22.66	24.04	na
Block 2 rate	c/kWh	32.01	26.61	na
Supply charge (not used)	$ pa	193	240	na
Time of Use tariff (TOU)				
Peak	c/kWh	44.66	b	na
Shoulder	c/kWh	18.04	b	na
Off-peak	c/kWh	10.56	b	na
Supply charge (not used)	$ pa	237	b	na
Controlled load tariffs				
Off-peak 1	c/kWh	9.02	8.01	na
Supply charge	$ pa	0	18	na
Off-peak 2	c/kWh	11.88	**b**	na
Supply charge (not used)	$ pa	0	**b**	na
Gas tariffs				
Block 1 rate, up to 3,750 MJ per quarter	c/MJ	na	na	2.74
Block 2 rate , up to 8,250 MJ per quarter	c/MJ	na	na	1.65
Block 3 rate, up to 25,500 MJ per quarter	c/MJ	na	na	1.63
Block 4 rate, up to 250,500 MJ per quarter (not used)**a**	c/MJ	na	na	1.61
Supply charge (not used)	$ pa	na	na	174

a Fewer than 30 of the households included in our analysis used more than 25,000 MJ in any 1 quarter, and we calculated the bills using only the first 3 consumption block rates. AGL actually has 6 block rates, but it is very unlikely that an individual household will consume enough gas to be charged beyond the 4th consumption block.

b We did not use Integral Energy's TOU tariff because no households in our sample were on this tariff. We did not use their Off-peak 2 tariff because we did not know which households were on this tariff, so we assumed that all off-peak consumption was charged at the Off-peak 1 rate.

Note: Supply charges are shown for information only. We did not use these to calculate the usage bills.

Sources: EnergyAustralia, Origin Integral Energy and AGL websites accessed October 2011, respectively at http://www.energyaustralia.com.au/nsw/residential/products_and_services/price_and_product_information_statements,http://www.integral.com.au/wps/wcm/connect/28e00d0047664dc59782d78c06da372e/OR0089_IE+2011+Price+Guide.pdf?MOD=AJPERES and http://www.agl.com.au/Downloads/NSW-Gas-Regulated-Prices-1Jul11.pdf.

5.2 The relationship between household characteristics and energy bills - the 'characteristics' model

We found that the relationship between household characteristics and energy bills is very similar to the relationship between household characteristics and electricity consumption (and therefore the indicative costs). Higher annual energy bills are associated with

- living in a detached house (about $280 more)
- a larger dwelling (about $200 per bedroom)
- more occupants (about $240 per adult and $200 per child)
- higher income (about $40 per $10,000 of annual income before tax)[45]
- living in an inland area (about $110 more) (Table 5.2).

Turning to the impact of tariffs on energy bills, we found that having a Controlled Load electricity supply reduces the average energy bill by more than $100 per annum. As discussed in more detail below, this occurs even though households with a Controlled Load supply use more electricity than similar households without this form of supply (section 5.4).

Comparing the relative cost of gas and electricity, our results show that using gas has no (statistically significant) impact on energy bills, once the presence or absence of a Controlled Load supply is taken into account (Table 5.2). This suggests that households with gas spend about as much on energy as (otherwise similar) households that have neither gas nor a Controlled Load supply. Section 5.5 further explores the relationship between energy bills, using gas and having a Controlled Load supply.

As previously discussed, the energy bills cannot be directly compared with the indicative cost of electricity consumption shown in Chapter 3. Despite their differences, the approaches give fairly similar results in terms of both the magnitude of the effects and the strength of the relationships (Table 5.2).[46]

45 Households that did not provide income data on average consumed about $370 worth of 'income related' energy.

46 Note that the 'mains gas' variable measures different things in the 2 regression models. In the model for energy bills, it measures the impact of using gas rather than electricity as a form of energy. In the model for electricity consumption, it measures how much les electricity a household uses if it also uses gas.

Table 5.2 Relationship between household characteristics, energy bills and the indicative cost of electricity

Data set	Energy bills (excluding fixed charges)		Indicative cost of electricity[a]	
	$ pa	(t-value)	$ pa	(t-value)
% of variation explained (R^2)	39		41	
Sample size	2,164		2,166	
Live in a detached house	278	(5.5)	333	(7.5)
Per bedroom	214	(10.3)	202	(10.6)
Per adult (16 years or older)	236	(12.3)	203	(11.5)
Per child	207	(9.7)	170	(8.7)
Per $10,000 income pa	41	(10.7)	37	(10.5)
Did not provide income data	390	(6.5)	355	(6.4)
Have Controlled Load supply	-112	(-2.6)	na	na
Use mains gas	ns	(0.7)	-501	(-15.4)
Live in a coastal area	-110	(-3.0)	-84	(-2.5)

a Calculated using EnergyAustralia's 2011/12 block 1 tariff of 22.66c/kWh multiplied by the consumption volumes.

Note: Linear regressions, excluding households with usage bills exceeding $6,600 per annum. Coefficients are shown if they are significant at a 90% level of confidence. Appendix E shows the detailed regression results.

5.3 The relationship between energy bills and what energy is used for - the 'energy uses' model

Our 'energy uses' model for energy bills is very similar to that for electricity consumption (Chapter 3). The main difference is that the energy bills model includes a variable for Controlled Load, to take into account the lower tariffs that are associated with this form of supply. The 2 models also differ slightly in how they treat gas (Table 5.3).

Like for household characteristics, we found that the relationship between what energy is used for and energy bills is very similar to the relationship between what electricity is used for and electricity consumption (and therefore the indicative cost of electricity). However, looking at the dollar values there are 2 important differences that arise due to way tariffs are structured:

- The impact on energy bills of solar hot water is about half as much as the indicative cost of electricity saved ($164 compared to $320 per annum). The main reason for this is that solar hot water frequently replaces a Controlled Load hot water system, and the tariff for Controlled Load electricity is far lower than the rate we used to calculate the indicative cost of electricity. Section 5.5 further discusses the impact on bills of different hot water systems.

- The impact on energy bills of having a swimming pool is fairly large compared to the indicative cost of electricity ($620 compared to $570 per annum). The reason for this is that a household with a pool is likely to pay the (higher) block 2 rate for a significant proportion of its electricity.

Looking at Controlled Load, the 'energy uses' model confirms that households that have a Controlled Load supply pay less than similar households that do not (about $150 per annum).

Looking at gas, the 'energy uses' model again suggests that, after taking into account whether or not a household has a Controlled Load electricity supply, there is no (statistically significant) difference in the bill of a household with gas compared to an otherwise similar one without gas. Section 5.5 further discusses the impact on bills of using gas.

The relationships between the other variables and electricity consumption (and therefore indicative bills) are discussed in some detail in Chapter 3. Most of that discussion applies equally to an analysis of energy bills, and we do not repeat the discussion here. Instead, we briefly summarise the key findings:

- Air conditioners and clothes dryers add significantly to energy bills if they are used frequently. For example, using a clothes dryer 3 times per week on average would add about $230 per annum, and using an air conditioner for 5 hours per day 7 times per week in summer and in winter would add about $530 per annum.
- Having a 2nd fridge and frequently using a dishwasher are also associated with significantly higher energy bills. However, some of the additional cost is probably due to other factors that are associated with using these items, particularly dishwashers.
- Living in a coastal area reduces bills by an average of $70 to $80, presumably because of the more temperate climate.
- Having an (electric boosted) solar hot water system on average saves about $170 per annum.[47] But the actual magnitude of the saving will depend on a number of factors, one of which is what type of hot water system it replaces, ie, a Controlled Load system, a standard electric system or a gas hot water system.
- The household characteristics that are included in the model serve as proxies for information that we do not have, such as the presence of other appliances and how often they used; the capacity and efficiency of appliances and amenities; and how much hot water is used. As discussed in Chapter 3, these variables each reflect a number of different influences. Therefore, the dollar values associated with each of the characteristics needs to be interpreted with care.

47 As discussed in Chapter 3, more than 80% of the solar hot water systems in our survey sample were electric boosted systems.

Table 5.3 Relationship between what energy is used for, energy bills and the indicative cost of electricity

	Energy bills (excluding fixed charges)		Indicative cost of electricity[a]	
	$ pa	**(t-value)**	**$ pa**	**(t-value)**
% of variation explained (R^2)	56		59	
Sample size	2,156		2,157	
Have a swimming pool	620	(15.3)	570	(15.7)
Have a 2nd fridge	290	(9.2)	270	(9.3)
Have a spa	244	(4.0)	220	(4.0)
Per 280 hours of air conditioner use	163	(11.9)	160	(12.7)
Clothes dryer - used once per week	77	(6.7)	70	(6.4)
Dishwasher - used once per week	77	(11.3)	70	(11.5)
Live in a detached house	130	(3.0)	150	(4.0)
Per bedroom	131	(7.3)	130	(7.8)
Per adult (16 years or older)	205	(12.4)	180	(12.5)
Per child	152	(8.3)	120	(7.2)
Per $10,000 income pa (before tax)	18	(5.1)	20	(5.6)
Did not provide income data	213	(4.1)	200	(4.3)
Main source for hot water is solar	-174	(-3.0)	-320	(-6.0)
Use mains gas	ns	(-0.5)	na[b]	na[b]
Have Controlled Load supply	-154	(-4.3)	na[b]	na[b]
Live in a coastal area	-69	(-2.2)	-80	(-2.8)

a Indicative cost calculated using EnergyAustralia's 2011/12 block 1 tariff of 22.66c/kWh multiplied by the consumption volume.

b The electricity consumption model separately identified the source of energy for hot water and space heating (other than air conditioning) rather than simply having mains gas, and did not include a Controlled Load variable.

Note: Linear regressions, excluding households with usage bills exceeding $6,600 per annum and with electricity consumption exceeding 25,000 kWh per annum. Coefficients are shown if they are significant at a 90% level of confidence. Appendix E shows the detailed regression results.

5.4 The impact on energy bills and electricity consumption of having a Controlled Load electricity supply

The analysis in section 5.2 and section 5.3 showed that having a Controlled Load electricity supply means lower bills, *ceteris paribus*. But a Controlled Load supply is likely to mean a larger hot water system (Box 5.1). Therefore, one would expect that a household with a Controlled Load supply uses more electricity than an otherwise similar household without a Controlled Load supply. We investigated the relationship between bills and consumption by looking at the bills and consumption of households without gas. We used our 'energy uses' regression model for this analysis.

As expected, we found that having a Controlled Load supply on average increases electricity consumption by about 510 kWh per annum but reduces bills by about $270 per annum compared to otherwise similar households without a Controlled Load supply (Table 5.4).[48]

Table 5.4 Impact of Controlled Load on the electricity consumption and bills (households without gas only)

	Consumption		Usage bill (2011/12 prices)	
	kWh pa	t-value	$ pa	t-value
R2	62		55	
Sample size	1,056		1,056	
Have a swimming pool	2,234	(9.8)	521	(9.4)
Have a 2nd fridge	981	(5.5)	236	(5.5)
Have a spa	990	(2.5)	245	(2.6)
Per 280 hours of air conditioner use	641	(8.0)	159	(8.2)
Clothes dryer – used once per week	389	(5.3)	88	(4.9)
Dishwasher - used once per week	322	(8.1)	81	(8.4)
Live in a detached house	646	(2.5)	171	(2.8)
Per bedroom	511	(5.1)	124	(5.1)
Per person older than 15 years	947	(9.9)	189	(8.1)
Per person 15 years or younger	632	(5.9)	132	(5.1)
Per $10,000 income per annum	110	(5.4)	26	(5.1)
Did not provide income data	1,434	(5.1)	339	(5.0)
Have CL electricity supply	507	(2.4)	-272	(-5.3)
Mains source for hot water is solar	-1,282	(-4.6)	-181	(-2.7)
Live in a coastal area	-442	(-2.4)	-92	(-2.1)

Note: Linear regressions, excluding households with usage bills exceeding $6,600 per annum. Coefficients are shown if they are significant at a 90% level of confidence. Appendix E shows the detailed regression results.

5.5 The impact on energy bills of using gas for hot water and space heating

The analysis in section 5.2 and section 5.3 found that using gas does not have a (statistically) significant impact on energy bills once the presence or absence of a Controlled Load electricity supply is taken into account. However, we would also like to know whether the impact on energy bills depends on what gas is used for.

48 Note that the regression coefficients for this sub-set of the sample differ somewhat from those shown in Table 5.3 for the full survey sample. This happens because the sub-set differs from the total sample in some important ways. In particular, households that do not use gas are more likely to live in a flat, have a lower income and live inland compared to all households (see Chapter 4).

To estimate the impact on energy bills of using gas for different purposes we divided the survey sample into 2 groups: households with a Controlled Load supply and households without this form of supply. We then applied the 'energy uses' model separately to these 2 sets of households, with one change: we specified whether gas was used for space heating and/or hot water rather than simply whether or not a household used gas.[49]

Comparing these 2 sets of households is complicated by the fact that they display different characteristics. In particular, households with a Controlled Load supply are far more likely to live in a detached house and to have more bedrooms, and are far less likely to use mains gas. They are also somewhat more likely to live in an inland area, to have fewer children and to have a lower income.[50] Because of these differences, the impact on bills of each characteristic (ie, the regression coefficient) varies somewhat between the 2 groups.

Despite the differences between the 2 groups, the results clearly indicate that, on average, a gas hot water system is cheaper to run than a standard electric system. But a gas hot water system is probably more expensive to run than a Controlled Load system, even after allowing for the additional electricity required by the Controlled Load system. Looking at space heating, for both sets of households there appears to be no (statistically significant) difference in cost between using gas and using electricity (other than a reverse cycle air-conditioner) (Table 5.5).

The results also confirm that a solar hot water system means a smaller saving on energy bills if the alternative is a Controlled Load system rather than a standard electric or gas system. However, this is a consequence of the tariff structure rather than electricity consumption. A solar hot water system is likely to have a *bigger* impact on electricity consumption if it replaces a Controlled Load system because, as discussed in Box 5.1 and shown in section 5.4, Controlled Load systems use more electricity than standard electric ones.[51]

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49 We did not include gas for cooking as a variable because more than 80% of households used gas for this purpose and very few used gas only for cooking. This means that the sample of households that did not use gas for cooking was too small to provide meaningful results.

50 We used binary logistic regression to establish these relationships. Appendix E, Section E.4 shows the detailed regression results.

51 We found that solar hot water reduces annual electricity consumption by about 1,500 kWh for households with a Controlled Load supply and by about 1,100 kWh for households without this form of supply.

Table 5.5 Impact on bills of using gas for households with and without Controlled Load

Data set	Households without Controlled Load		Households with Controlled Load	
	$ pa	(t-value)	$ pa	(t-value)
% of variation explained (R^2)	57		57	
Sample size	1,172		983	
Have a swimming pool	689	(11.3)	551	(10.4)
Have a 2nd fridge	277	(6.2)	295	(6.7)
Have a spa	281	(3.3)	226	(2.6)
Per 280 hours of air conditioner use	176	(9.2)	148	(7.6)
Clothes dryer - used once per week	54	(3.7)	115	(6.3)
Dishwasher - used once per week	68	(7.1)	90	(9.4)
Live in a detached house	158	(2.8)	191	(2.5)
Per bedroom	142	(5.8)	123	(4.7)
Per adult (16 years or older)	257	(11.1)	152	(6.6)
Per child	173	(7.0)	120	(4.5)
Per $10,000 income pa (before tax)	12	(2.5)	28	(5.3)
Did not provide income data	ns	(0.8)	371	(5.2)
Mains source for hot water is solar	-425	(-4.0)	-110[a]	(-1.6)
Main source for hot water is gas	-200	(-3.8)	279[b]	(2.8)
Use gas for heating	ns	(-0.5)	ns	(-0.3)
Live in a coastal area	ns	(-0.2)	-115	(-2.6)

a This coefficient is significant only at an 89% level of confidence.

b Few households with a Controlled Load electricity supply use gas as their main source of energy for hot water. Consequently, this coefficient should be treated with caution due to the small number of observations (49 observations).

Note: Linear regressions, excluding households with usage bills exceeding $6,600 per annum. Coefficients are shown if they are significant at least an 89% level of confidence. Appendix E shows the detailed regression results.

6 The determinants of energy consumption by income and number of occupants

The previous chapters used regression analysis to explain variations in energy consumption across *all* households in each survey area. The purpose of this chapter is to explain variations *within* income groups and for households with the same number of occupants. We conducted this analysis to better understand why households with similar levels of income or number of occupants consume very different amounts of energy.[52]

We focused on electricity consumption and energy bills (rather than water) because of a growing concern about the ability of some less well-off households to pay their energy bills.[53] Concern about affordability has become increasingly urgent due to recent large increases in electricity prices in NSW[54] and expected future increases. In a recent report, IPART identified as particularly vulnerable low-income households with higher than average consumption.[55]

For this analysis we excluded households with incomes below $13,000 per annum.[56] We did this because most of these households are likely to have only temporarily low-incomes and consequently to have consumption patterns more like those of higher income households.[57] Including these households in the analysis would have skewed our findings for low-income households.

To analyse electricity consumption we used the 'energy uses' model specified in Chapter 3 and to analyse energy bills we used the 'energy uses' model specified in Chapter 5. We used the Sydney (2010) survey data.

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52 For example, see IPART, *Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey*, December 2010, pp 118-119 and IPART, *Residential Energy and Water Use in Hunter, Gosford and Wyong - Results from the 2008 household survey*, December 2008, pp 65-67.

53 Our household surveys have consistently shown that households experience far more difficulty paying their energy bills than their water bills. For example, see IPART, *Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey*, December 2010, pp 132-135.

54 Electricity prices rose by almost 60% in real terms in the 5 years to 1 July 2011. (IPART, *Changes in regulated electricity retail prices from 1 July 2011, Electricity – Final Report and Determination*, June 2011, p113).

55 IPART, *Changes in regulated electricity retail prices from 1 July 2011, Electricity – Final Report*, June 2011, pp 81-88.

56 This was the lowest income band in our survey questionnaires.

57 This category includes households with income from businesses that, for whatever reason, were not profitable in the preceding year. These households tend to be 'asset rich', and their consumption patterns are more like that of their higher-income counterparts.

We found that most of the 'energy uses' characteristics that explain variations across all households also explain variations between households with similar levels of income and between households with the same number of occupants. But we also found some interesting differences between the groups, both with regard to the relative importance of the explanatory variables and the magnitude of their effect.

We used our results to identify some possible ways to reduce the consumption of low-income households while maintaining their quality of life.

Our analysis is discussed in more detail below.

6.1 The relationship between energy consumption and what it is used for by income group - the 'energy uses' model

Most of the variables that explain variations across all households also explain variations between households with similar levels of income. For example, things that help to explain the variations include how often a household uses a dishwasher, a clothes dryer and/or an air conditioner; whether or not a household has a swimming pool and/or a 2nd fridge, and how many people live at home (Table 6.1 and Table 6.2).

Like for all households, whether electricity or gas is used for hot water has a large impact on electricity consumption across all income groups. But the impact on bills of using gas (for hot water and other purposes) has no (statistically significant) impact on bills once the presence or absence of a Controlled Load electricity supply is taken into account (Table 6.2).

We also found some interesting differences between the income groups, which we discuss below mainly with reference to electricity consumption (Table 6.1). The results for energy bills generally confirm our findings for electricity consumption (Table 6.2).

The model is a better fit for high-income households

The model explains more of the variation between high-income households than between low-income households (for consumption, 59% compared to 48% - Table 6.1). This suggests that factors not included in our model - such as in the capacity and efficiency of appliances and the use of appliances such as kettles, stoves and vacuum cleaners - account for more of the variation between low-income households than is the case for high-income households.

The number of occupants is more important for low-income households

The number of occupants (particularly adults) explains more of the variation in consumption and bills between low-income households than is the case for higher income households. A possible reason for this is that low-income households tend to have fewer electrical goods than higher income households, so that person-related consumption - such as how much hot water is used and how often a washing machine is used – accounts for more of the variation.

Dwelling type and size are not equally important across income groups

For low-income households, the type of dwelling accounts for far more of the variation between households than does the size of the dwelling. In contrast, for high-income households only the number of bedrooms (ie, the size of the dwelling) explains variations in consumption. One reason for this could be that the flats and semi-detached dwellings occupied by high-income households tend to be more spacious compared to those occupied by low-income households.[58]

For low-income households, an additional bedroom adds only a small amount of consumption (191 kWh compared to 748 kWh per annum for high-income households – Table 6.1). Also, the statistical relationship for low-income households is relatively weak (t-value is 1.7 compared to more than 3 for the other income groups). As discussed in section 6.3 below, the majority of low-income households have only 1 or 2 occupants and many of these are likely to be retirees living in the family home. Possibly, many of these households only use some of their rooms.

Income explains variations only amongst high-income households

Differences in income (within an income group) explain some of the variation only within the high-income group. This makes intuitive sense, since high-income households have more discretionary income and one would expect to find a wider range of other appliances, capacities and usage patterns within this group. However, the value of the coefficient needs to be treated with care because, as discussed in Appendix B, our income data are limited.

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58 For households that do not live in detached houses, the proportion of flats and semi-detached dwellings was similar for all income groups. Therefore, our finding is not a consequence of flats making up a larger share of other dwelling types for lower income households.

The consumption associated with appliances differs across income groups

The consumption volumes associated with swimming pools and appliances are larger for higher income households than for lower income ones, with the exception of clothes dryers. Reasons for this might include:

- For 2nd fridges, higher income households may on average have larger fridges than lower income households and/or use them more.[59]
- For dishwashers, a larger proportion of high-income households than low-income households in the '6 or more time a week' category may use their appliances more than 6.5 times per week.[60]
- For air conditioners, higher income households may on average have more powerful/larger systems than lower income households, including more ducted systems.
- For swimming pools, the highest income group may on average have more powerful pumps, run their pumps for longer and/or may be more likely to heat their pools.[61]

However, some of the observed differences between income groups are likely to be due to associated factors that are more likely to apply to higher income households (and that are not included in the model). This is likely to be the case particularly for dishwashers and 2nd fridges. As discussed in Chapter 3, the independent technical information indicates that the regression coefficients for fridges and, more particularly, for dishwashers are higher than the amounts they actually use (Table 3.5 and Appendix H).

Higher income households use more electricity for hot water

The hot water systems of higher income households use more electricity than those of lower income households with otherwise similar characteristics. This might indicate that higher income households have larger systems, and/or that these households tend to use more hot water per person (perhaps because they have more bathrooms per person[62]). However, like for appliances, some of the difference may be due to other, associated factors.

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59 Our 2010 survey found that less than 80% of low-income households ran their 2nd fridges all year round, compared to almost 90% of high-income households. (The differences in usage patterns are statistically significant.)

60 As discussed in Appendix B, our surveys only asked whether households use their dishwasher 6 or more times per week. For our analysis we recorded this as 6.5 times per week, but some households use their dishwashers far more often than this.

61 For low-income households, the consumption associated with having a swimming pool should be treated with care due to the small number of observations (40 observations).

62 The possible relationship between the number of indoor showers and how much hot water a households uses is discussed in Chapter 4 in relation to gas and in Chapter 7 in relation to water.

Having a Controlled Load electricity supply means lower bills for most groups

The Controlled Load supply is a significant explanatory variable (lower bills) for all income groups except the highest income group. The reasons for the latter finding are unclear, but might be partly because hot water is a smaller portion of the bills of high-income households than those of other income groups. It might also be simply a consequence of the small sample size.

The results need to be interpreted with caution

The results for both consumption and bills need to be treated with caution. One reason for this is that some households may be included in the wrong income category, because they provided inaccurate information about their income. Another reason is that the samples for each group are comparatively small (Table 6.1). The small sample sizes could explain, for example, why climate zone and using electricity for space heating (other than air conditioning) are not statistically significant explanatory variables for any income group.

Appendix A provides a profile of each income group with respect to their characteristics and what they use energy for.

Table 6.1 Relationship between electricity consumption and what it is used for by income group

	Low-income	Low-mid income	High-mid income	High-income
	up to $33,800 pa	$33,800-$62,400 pa	$62,400-$130,000 pa	above $130,000 pa
	kWh pa	kWh pa	kWh pa	kWh pa
	(t value)	(t value)	(t value)	(t value)
% of variation explained (R2)	48	52	57	59
Sample size	415	434	645	323
Have a swimming pool	2,343 (6.0)[a]	2,122 (6.3)	2,311 (7.8)	3,058 (7.3)
Have a 2nd fridge	756 (3.4)	912 (3.6)	1,466 (6)	1,345 (3.2)
Per 280 hours of air conditioner use	546 (5.6)	549 (4.6)	789 (7.2)	957 (6.1)
Clothes dryer – used once per week	300 (3.5)	408 (4.1)	181 (2.0)	298 (2.7)
Dishwasher - used once per week	174 (2.7)	258 (4.5)	322 (6.9)	356 (4.6)
Use electricity for space heating other than air conditioner	ns (0.9)	ns (0.9)	471 (1.8)	ns (0.9)
Live in a detached house	658 (2.4)	922 (2.7)	ns (0.9)	ns (0.7)
Per bedroom	191 (1.7)	536 (3.6)	870 (6.2)	748 (3.3)
Per person older than 15 years	1,227 (8.2)	744 (5.2)	640 (5.3)	552 (2.9)
Per person 15 years or younger	622 (3.9)	384 (2.5)	408 (3.3)	ns (1.5)
Per $10,000 income	ns (-0.3)	ns (0.1)	ns (0.9)	145 (1.9)
Mains source for hot water is gas	-2,085 (-9.1)	-2,266 (-8.7)	-2,850 (-12.0)	-3681 (-9.5)
Live in a coastal area	ns (-0.7)	ns (-1.2)	ns (-1)	ns (0.3)

[a] Regression coefficient should be treated with care due to the small number of observations.

Note: Linear regressions, excluding households with incomes before tax of less than $13,000 per annum or consumption exceeding 25,000 kWh per annum. The results for having a spa and solar hot water are not shown due to the small number of observations in each group. Coefficients are shown if they are significant at the 90% level of confidence. Appendix F shows the detailed regression results.

Table 6.2 Relationship between energy bills and what energy is used for by income group

	Low-income up to $33,800 pa $ pa (t-value)	Low-mid income $33,800-$62,400 pa $ pa (t-value	High-mid income $62,400-$130,000 pa $ pa (t-value)	High-income above $130,000 pa $ pa (t-value)
% of variation explained (R^2)	45	43	50	54
Sample size	415	434	645	321
Have a swimming pool	687 (7.0)[a]	478 (5.4)	517 (7.0)	736 (6.9)
Have a 2nd fridge	170 (3.0)	266 (4.0)	348 (5.7)	340 (3.2)
Per 280 hours of air conditioner use	116 (4.7)	131 (4.2)	196 (7.2)	212 (5.4)
Clothes dryer - used once per week	82 (3.7)	91 (3.5)	48 (2.2)	82 (2.9)
Dishwasher - used once per week	46 (2.8)	55 (3.7)	76 (6.6)	94 (4.9)
Live in a detached house	176 (2.4)	170 (1.9)	ns (0.5)	ns (0.4)
Per bedroom	ns (0.7)	120 (3.1)	219 (6.2)	196 (3.4)
Per person older than 15 years	295 (7.9)	192 (5.2)	159 (5.3)	133 (2.8)
Per person 15 years or younger	127 (3.2)	146 (3.6)	127 (4.2)	101 (1.9)
Per $10,000 income per annum (before tax)	ns (0.1)	ns (-0.3)	ns (1.4)	45 (2.3)
Use mains gas	ns (-0.3)	ns (0.3)	ns (-0.1)	ns (0.0)
Have Controlled Load supply	-208 (-3.3)	-233 (-3.1)	-195 (-2.8)	ns (0.5)
Live in a coastal area	ns (-1.1)	ns (-0.9)	ns (-0.9)	ns (0.5)

[a] Regression coefficient should be treated with care due to the small number of observations.

Note: Linear regressions, excluding households with incomes before tax of less than $13,000 per annum or energy usage bills exceeding $6,000 per annum. The results for having a spa and solar hot water are not shown due to the small number of observations in each group. Coefficients are shown if they are significant at the 90% level of confidence. Appendix F shows the detailed regression results.

6.2 The relationship between energy consumption and what it is used for by household size - the 'energy uses' model

We also analysed variations in consumption between households with the same number of occupants.[63] Like for income groups, uses such as having a swimming pool or a 2nd fridge, and frequently using an air conditioner or a dishwasher are all important reasons why consumption and bills vary between households with the same number of occupants. However, we again found some interesting differences between the groups which we discuss below with reference to Table 6.3 and Table 6.4.

63 We do not show the results for households with more than 4 occupants due to the small number of observations.

The model explains less of the variation between 1 person households than between larger households (for consumption, 39% compared to 49% or more – Table 6.3). Like for income groups, this suggests that factors such as the capacity and efficiency of appliances and the use of common appliances such as kettles, stoves and vacuum cleaners account for more of the variation between small households than between larger ones.

Dwelling type is one of the main factors that explain variations in consumption for 1-person households.[64] Within this group, the number of bedrooms has little explanatory power (possibly because some of the rooms are unused). The opposite is true for 3 or 4 person households, where the number of bedrooms (ie, the dwelling size) has significant explanatory power but the dwelling type has little explanatory power. For 2 person households, both dwelling type and the number of bedrooms have significant explanatory power.

Income explains variations in consumption between 2 and 3 person households but not between 1 and 4 person households. This might be simply a consequence of the sample sizes and the distribution of income within each group.[65]

As expected, the more people there are in a household, the more energy is used for hot water.

Compared to income groups, there is little difference between these groups in the amounts of electricity associated with air conditioners and dishwashers. This suggests, firstly, that smaller households do not necessarily have smaller appliances, and secondly that associated factors do not vary systematically with the number of occupants (but do with income).

Like for income groups, the amount of consumption associated with having a 2nd fridge and a swimming pool is smaller for 1 or 2 person households than for larger households. This may indicate that smaller households have smaller 2nd fridges and pool pumps, and/or that they use them less often.[66] It may also suggest that, unlike for air conditioners and dishwashers, associated factors *do* vary systematically with the number of occupants.

Again, the results for both consumption and bills need to be treated with caution due to the smaller sample sizes and the data limitations discussed in Appendix B.

64 In Sydney (2010), 32% of 1 person households lived in detached houses.

65 There was less variation in income within the 1 and 4 person groups than between the 2 and 3 person groups. Specifically, 1 person households were concentrated in the 2 lowest income categories, and 4 person households were concentrated in the top 2 income categories. The incomes of 2 and 3 person households were more evenly spread over at least 3 income categories.

66 Our 2010 survey found that about 16% of 1 person households ran their 2nd fridges for no more than 10 weeks per annum, compared to less than 8% of 3 and 4 person households. (The differences in usage patterns are small but statistically significant.)

Table 6.3 Relationship between electricity consumption and what it is used for by number of occupants

	1 person kWh pa (t value)	2 people kWh pa (t value)	3 people kWh pa (t value)	4 people kWh pa (t value)
% of variation explained (R2)	39	49	54	52
Sample size	382	761	353	383
Have a swimming pool	a	2,142 (8.1)	3,120 (8.0)	3,045 (8.2)
Have a 2nd fridge	676 (3.1)	1,024 (5.2)	1,754 (5.5)	1,580 (4.7)
Per 280 hours of air conditioner use	656 (6.9)	721 (8.0)	764 (5)	763 (5.8)
Clothes dryer – used once per week	289 (2.8)	381 (4.9)	ns (1.6)	ns (1.6)
Dishwasher - used once per week	368 (4.7)	307 (7.1)	229 (3.4)	338 (5.3)
Use electricity for space heating other than air conditioner	319 (1.7)	ns (1.6)	ns (1.2)	ns (0.2)
Live in a detached house	936 (4.0)	720 (2.6)	ns (0.1)	ns (0.1)
Per bedroom	ns (1.4)	622 (5.3)	701 (3.6)	561 (2.9)
Per $10,000 income per annum	ns (1.5)	112 (5.0)	97 (2.8)	ns (0.7)
Did not provide income data	ns (1.3)	1,151 (3.6)	1,132 (2.1)	ns (0.5)
Per child	na	a	-783 (-2.6)	ns (-1.6)
Mains source for hot water is gas	-1,236 (-6.0)	-2,399 (-11.6)	-3,377 (-10.4)	-3,641 (-11.4)
Mains source for hot water is solar	a	-1056 (-3.3)	a	a
Live in a coastal area	ns (-1.5)	-693 (-3.5)	ns (0.4)	ns (-0.4)

[a] Regression coefficient not shown due to the small number of observations.

Note: Linear regressions, excluding households with incomes before tax of less than $13,000 per annum or consumption exceeding 25,000 kWh per annum. The results for having a spa and solar hot water are not shown due to the small number of observations in most groups. Coefficients are shown if they are significant at the 90% level of confidence. Appendix F shows the detailed regression results.

Table 6.4 Relationship between energy bills and what energy is used for by number of occupants

	1 person	2 people	3 people	4 people
	$ pa	$ pa	$ pa	$ pa
	(t-value)	(t-value	(t-value)	(t-value)
% of variation explained (R2)	36	41	42	45
Sample size	382	760	352	384
Have a swimming pool	a	477 (7.4)	735 (7.4)	817 (8.4)
Have a 2nd fridge	158 (2.9)	253 (5.3)	456 (5.6)	394 (4.4)
Per 280 hours of air conditioner use	154 (6.6)	159 (7.4)	186 (4.9)	189 (5.4)
Clothes dryer - used once per week	96 (3.6)	96 (5.1)	54 (1.8)	52 (1.9)
Dishwasher - used once per week	84 (4.3)	74 (7.1)	49 (2.9)	91 (5.4)
Live in a detached house	211 (3.4)	204 (3.0)	ns (-0.5)	ns (-0.2)
Per bedroom	44 (1.7)	123 (4.3)	177 (3.6)	152 (2.9)
Per $'000 income per annum	ns (1.4)	24 (4.5)	27 (3.1)	ns (0.9)
Did not provide income data	ns (1.0)	233 (3.0)	301 (2.3)	ns (0.9)
Per person 15 years or younger	na	a	-184 (-2.4)	-93 (-2.0)
Use mains gas	ns (0.9)	ns (-0.9)	ns (-1.0)	ns (-0.6)
Have Controlled Load supply	-152 (-2.7)	-118 (-2.1)	-197 (-2)	-248 (-2.4)
Live in a coastal area	ns (-1.4)	-122 (-2.5)	ns (0.3)	ns (0.0)

a Regression coefficient not shown due to the small number of observations.

Note: Linear regressions, excluding households with incomes before tax of less than $13,000 per annum or energy usage bills exceeding $6,000 per annum. The results for having a spa and solar hot water are not shown due to the small number of observations in most groups. Coefficients are shown if they are significant at the 90% level of confidence. Appendix F shows the detailed regression results.

6.3 Policy implications: how to reduce energy consumption while maintaining the quality of life

The results of our analysis can help to identify how best to reduce household consumption. In particular, our results can help to identify how best to assist low-income households while maintaining their quality of life:

- Hot water uses a large amount of electricity. There are already a number of policies in place to replace electric hot water with gas or solar power. However, for low-income owners and renters, retrofit programs or other policy measures to replace old and inefficient electric hot water systems could have a significant impact on power bills.[67]

67 As part of IPART's 2011 electricity review, community groups and other stakeholders made a number of suggestions about how the NSW government might improve customer assistance measures. One of these suggestions was to introduce 'inter-governmental energy efficiency retro-fit programs' (IPART, *Changes in regulated electricity retail prices from 1 July 2011 – Final Report*, June 2011, pp 116-117).

- Low-flow showerheads, shower timers and tap aerators can also have a big impact on hot water consumption. Programs to install these fixtures have been in place for a number of years, and low-flow showerheads in particular are widely used. However, some low-income households may still not have them. Therefore, well targeted and properly managed programs to install these fixtures, and to fix leaks, may be worth pursuing. The NSW Home Power Saving program is an important initiative in this regard.[68]
- Our survey data show that many low-income households have 2nd fridges, including those with only 1 or 2 occupants.[69] Since fridges can use large amounts of electricity, particularly if they are old, getting rid of a 2nd fridge could be an effective way to reduce consumption without much affecting a household's quality of life.
- Frequent and prolonged use of an air conditioner, a clothes dryer and even a dishwasher can add significantly to power bills and is an important reason why some households use substantially more electricity than others. Providing quantified information about this to households could be helpful, along with effectively communicated information about strategies to modify usage. This could benefit many households because a high proportion of them have such items.[70]

Our findings also suggest that living in a detached house is associated with higher energy bills even when there are only 1 or 2 people in the household. This is potentially an important issue because a fairly large proportion of low-income 1 and 2 person households live in detached houses, which often have 3 or more bedrooms. Box 6.1 provides information about low-income households in Sydney (2010).

Living in a detached house may lead to higher energy bills compared to living in a semi-detached dwelling or a flat for the following reasons:

- Detached houses generally use more energy to heat or cool. This happens because they have more external walls and are likely to be more spacious than other dwelling types.
- Detached houses are usually designed for more than 2 occupants, and are therefore likely to have relatively large hot water systems. This could have significant implications for energy consumption.
- People are more likely to keep unnecessary items such as 2nd fridges if they have more space to put them (Box 6.1).
- A few low-income, 1 and 2 person households that live in detached houses have swimming pools. This adds significantly to their electricity bills (Box 6.1).

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68 See http://www.savepower.nsw.gov.au/households/home-power-savings-program/about-the-program.aspx.

69 In Sydney (2010) more than a quarter of 1 person households and almost half of 2 person households with incomes between $13,000 and $33,800 per annum had a 2nd fridge. More than 35% of all low-income households had one.

70 For example, 27% of low-income Sydney (2010) households had a dishwasher, 37% had a 2nd fridge, 53% had a clothes dryer and 55% had an air conditioner (Appendix A, Table A.1)

Box 6.1 Profile of low-income households in Sydney (2010) [a]

In Sydney (2010), about 80% of low-income households had only 1 or 2 occupants. Their ages and incomes suggest that the majority of these households were pensioners:

- More than 70% of 1 person households were aged 65 years or older and only 11% were younger than 55 years (survey respondent's age).
- More than 60% of 2 person households were headed by people aged 65 years or older and only 16% were younger than 55 years (survey respondent's age).

Many of these households lived in detached houses – more than 35% of 1 person households and more than 70% of 2 person households. Many of these houses had 3 or more bedrooms.

The households that lived in detached houses were more likely to

- have a 2nd fridge, for example 45% of 1 person households compared to 13% in a flat, and 59% of 2 person households compared to 8% in a flat
- have a dishwasher, for example 26% of 1 person households compared to 10% in a flat, and 39% of 2 person households compared to 23% in a flat
- have air conditioning, for example 59% of 1 person households compared to 27% in a flat, and 75% of 2 person households compared to 39% in a flat
- have a swimming pool – almost 10% of both 1 and 2 person households.

Low-income 1 and 2 person households living in detached houses had higher energy bills in 2010/11[b] than households in flats:

- For 1 person households, the median annual usage charge was almost $1,000 in a detached house, just over $900 in a semi-detached dwelling and less than $670 in flat. About 18% of those in detached houses had bills exceeding $1,500 per annum, compared to less than 3% of those in other dwelling types.
- For 2 person households, the median annual bill was almost $1,400 in a detached house but around $1,200 in a flat or a semi-detached dwelling. About 37% of those in detached houses had bills exceeding $1,500 per annum, compared to about 15% of those in other dwelling types.

a Low-income households are those that reported an annual income of between $13,000 and $33,800 in 2010 (before tax). The survey data are weighted to correct for sample biases in dwelling type, household structure and income.

b Bills after rebates. Calculated using survey consumption volumes and 2010/11 electricity and gas tariffs.

Source: IPART analysis of data from the Sydney (2010) household survey,

7 The determinants of water consumption

The household surveys provide a range of information about what water is used for, and we used this information to analyse the determinants of water consumption (mains water only).[71]

We separately analysed the determinants of water consumption for the Sydney Water area (ie, Sydney, 2010), the Hunter Water area (2008) and the combined Gosford/Wyong areas (2008). We did this because the areas faced very different water supply conditions at the time of the surveys.

We confined most of our analysis to households in detached houses. We did this because we wanted to include only individually metered households and we were most confident about this consumption data for detached houses.[72,73] We used a separate model and the Sydney (2010) data to identify the impact on consumption of dwelling type. We found that indoor water use is not much affected by the type of dwelling that a household lives in.

For households in detached houses, we specified a 'characteristics' model and a 'water uses' model. Our 'characteristics' model found that the number of adults and the number of children are by far the most important explanatory variables. In contrast to energy, income is far less strongly related to water consumption than is the number of people in the household.

Our 'water uses' model for Sydney and the Hunter area includes explanatory variables for indoor use, outdoor use, alternative sources of water to mains water and being conservation-minded (or Water Wise). For Gosford/Wyong, the model excludes most of the variables for outdoor use due to water restrictions.

71 Mains water refers to water delivered through a network of pipelines by a water service provider. Some households also use water from rainwater tanks, bore water and/or grey water, but we excluded these sources of water from our analysis because we had no information about how much each household uses.

72 We had information about which flats and semi-detached dwelling were individually metered, but we were not confident that this information was always correct. We were least confident about the 2008 survey data.

73 For households in dwelling complexes with shared meters (eg, blocks of flats), we had information only about the average amount that each household used. This may be a good indication of the amount of water that a household is charged for, but is a poor indication of the amount that the household actually uses.

Using a combination of water uses and household characteristics, our 'water uses' model identified a number of factors that have a significant impact on consumption. For example, having a large number of occupants, frequently using a washing machine, having a swimming pool and using a sprinkler are all strongly associated with higher consumption. Despite its inevitable limitations, the model serves as a fairly good predictor of a household's water consumption.

Our analysis is discussed in more detail below, after a brief discussion about supply conditions in the survey areas.

7.1 The context: water supply conditions and average consumption in the survey areas

7.1.1 Water supply conditions and water restrictions

Our survey areas faced very different water supply conditions at the time of the surveys:

- The Gosford/Wyong areas had experienced water shortages for a number of years and a high level of water restrictions were in place. Gosford City Council and Wyong Shire Council are the water supply authorities for these areas.
- The Hunter Water area had not experienced water shortages and no water restrictions were in place.
- Sydney Water imposed water restrictions in October 2003 and fairly strict water restrictions were in place from June 2005 until the introduction of 'Water Wise Rules' in June 2009. Although the survey was conducted after the introduction of 'Water Wise Rules', the consumption data includes 4 to 6 months during which fairly strict water restrictions still applied.

Box 7.1 and Box 7.2 respectively describe water restrictions in the Gosford/Wyong areas and in Sydney up to the time of the surveys.

Box 7.1 Water restrictions in Gosford and Wyong

Water restrictions have been applied to households in Gosford and Wyong since February 2002. Level 3 or 4 restrictions have been in place since June 2006. Level 3 restrictions applied at the time of the 2008 survey.

Under level 3 restrictions, households may not use mains water to water gardens except with watering cans or buckets; may not wash external surfaces such as driveways or courtyards; may wash cars, boats etc with buckets or hoses with trigger nozzles; and may not top up or fill private swimming pools.

For households with internally connected rainwater tanks, restrictions were relaxed on watering gardens and filling or topping up private swimming pools.

Source: IPART, *Residential Energy and Water Use in the Hunter, Gosford and Wyong. Results from the 2008 household survey*, December 2008, p46. Original source is Gosford/Wyong Councils' Water Authority website at http://gwcwater.nsw.gov.au/WaterNews/restrictions/restrictions_index.htm, accessed August 2008.

Box 7.2 Water restrictions in Sydney

Sydney Water imposed level 3 water restrictions on 1 June 2005. In June 2008, it relaxed some of the restrictions. In June 2009, it lifted the restrictions, and introduced Water Wise Rules. Water Wise Rules were in place during the 2010 survey.

Restrictions	Rules	Apply from
Level 1	1. No hosing of hard surfaces.	1 October 2003
	2. No sprinklers or watering systems.	Dams below 60%
Level 2	Level 1 plus	1 June 2004
	1. Hand-held (garden) hosing (only) before 9am and after 5pm on Wednesdays, Fridays and Sundays.	Dams below 50%
	2. No filling of new or renovated pools over 10,000L except with a permit.	
Level 3	Level 2 plus	1 June 2005
	3. No hoses or taps to be left running unattended, except when filling pools or containers.	Dams below 40%
	4. Fire hoses used only for fire fighting purposes - not for cleaning.	
Level 3 changes	At home permitted to wash cars, boats, caravans, windows and walls with a hose as long as a trigger nozzle is fitted.	21 June 2008
Water Wise Rules	5. All hoses must have a trigger nozzle.	21 June 2009
	6. Garden watering is allowed before 10am and after 4pm.	Dams above 60% for 12 months
	7. No hosing of hard surfaces such as paths and driveways. Washing vehicles is allowed.	
	8. Fire hoses must only be used for fire fighting activities only.	

Source: IPART, Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra. Results from the 2010 household survey, December 2010, p31. Original source is The history of Water Wise Rules, Sydney Water website, http://www.sydneywater.com.au/Water4Life/WaterWise/WhenWereWaterRestrictionsIntroduced.cfm, accessed September 2010.

7.1.2 Average (mains) water consumption

To better understand the significance of the regression results, Table 7.1 provides an estimate of the average consumption per household in the areas supplied by Sydney Water, Hunter Water and the Gosford and Wyong Councils respectively. On average, households in detached houses use about 210 kL per annum in Sydney, 190 kL per annum in the Hunter area and about 160kL per annum in the Gosford/Wyong area.

Table 7.1 Average household mains water consumption and water usage charge by water utility

Data set	Sydney Water 2010/11 kL pa	Hunter Water 2010/11 kL pa	Gosford and Wyong 2010/11 kL pa
Average consumption, 2010/11 (kL pa, rounded)			
Detached houses	210	190	160
All households	190	170	160

Sources: Consumption from data provided to IPART by the utilities. Usage charges from utility websites.

7.2 The relationship between household characteristics and water consumption - the 'characteristics' model

When looking at the relationship between water consumption and the characteristics of households living in detached houses, we took into account both indoor and outdoor use. For outdoor use we included property size and the climate zones as explanatory variables.

The model explains between 35% and 40% of the variation in water consumption between households in the Sydney Water and Hunter Water areas, and slightly less in the Gosford/Wyong area (30% - Table 7.2). We discuss the rest of our findings below.

The number of people in the household

As expected, the more people who live in a household, the higher the household's water consumption. In all 3 areas, each adult adds between 40 kL and 50 kL per annum and each child adds between 25 kL and 30 kL per annum.

The number of indoor showers

Like for gas, we found that the number of indoor shower better explains variations in water consumption than does the number of bedrooms. As discussed in Chapter 4, the number of indoor showers indicates the number of bathrooms, and as such is a proxy for the size of the dwelling (like the number of bedrooms). But it also seems to capture other relevant information, such as the amount of water that each person is able to use in the bathroom (Box 4.1). Each additional shower adds between 15 kL and 20 kL to annual household consumption (Table 7.2).

Household income

A higher income household is likely to use more water than an otherwise similar household with a lower income. We found that each additional $10,000 of annual income (before tax) is associated with additional consumption of roughly 2 kL per annum (Table 7.2).

Plot size

We included the size of the plot to take into account the amount of water that is likely to be used outdoors, mainly for garden watering and swimming pools. We found that each 100 m^2 of plot size was associated with additional usage of about 4 kL per annum in all the areas.

However, we found the same relationship between plot size and water consumption in all 3 areas despite the different water restrictions that were in place at the time of the surveys (Box 7.1). Clearly, plot size captures more information than simply the amount of water used in the garden and for swimming pools. We discuss this further in Section 7.3 and Section 7.4 below.

Live in coastal area

Households that live in coastal areas use between 10 kL and 15 kL less water per annum than otherwise similar households that live in inland areas. One reason for this might be that households in inland areas use more water outdoors, because they have less rain and hotter summers compared to coastal areas.

Table 7.2 Relationship between water consumption and household characteristics - households in detached houses only

Water supplier	Sydney Water (2010)		Hunter Water (2008)		Gosford and Wyong (2008)	
	kL pa	(t-value)	kL pa	(t-value)	kL pa	(t-value)
% of variation explained (R^2)	35		39		30	
Sample size	1,652		1,397		675	
Per person older than 15 years	43	(19.6)	51	(18.9)	47	(12.7)
Per person 15 years or younger	29	(11.5)	30	(12.6)	26	(7.3)
Per indoor shower (proxy for per bathroom)	16	(5.2)	21	(5.8)	ns	(0.9)
Per $10,000 income pa	1.9	(3.9)	2.3	(4)	ns	(0.5)
Did not provide income data	21	(2.8)	ns	(1.3)	ns	(1.0)
Per 100m2 plot size	4.1	(3.3)	3.7	(2.6)	3.6	(1.7)
Do not know size of plot	ns	(1.4)	na	na	na	na
Live in a coastal area	-10	(-2.3)	-15	(-2.5)	all	coastal

Note: Detached houses only. Linear regressions, excluding household with consumption of more than 300 kL per capita or 750 kL per household per annum (11, 7 and 5 households in the 3 areas respectively). Coefficients are shown if they are significant at the 90% level of confidence. 'na' means not applicable because there were no observations in the sample. Appendix G shows the detailed regression results.

7.2.2 The (statistical) strength of the relationships

As discussed in Chapter 3, the t-values indicate how strongly the variable is associated with consumption and how confident we about the amount of water that is associated with that variable. Looking at the t-values in Table 7.2, our data show that the number of adults and the number of children are very strongly related to consumption and we are fairly confident about how much water each person adds. These relationships are far stronger than for any of the other explanatory variables.

Unlike for electricity, the relationship between income and water consumption is far weaker than is the relationship between consumption and the number of occupants.[74] This makes intuitive sense, firstly because water has a more limited range of uses than is the case for electricity, and secondly because most indoor uses are strongly person-related (eg, showering, flushing toilets and washing clothes).

74 For electricity, the t-values for income and the number of adults are both around 10 for the Sydney (2010) data set (Table 3.2).

7.3 How household characteristics are associated with different uses for water

Household characteristics do not themselves 'cause' consumption. Rather, they are associated with activities that cause consumption. For example, an additional person means more showering (or bathing), more toilet flushing and additional clothes washing.

To help understand the relationship between our model's explanatory variables and water consumption, we looked at the relationship between household characteristics and some uses for water. We used the Sydney (2010) data for this analysis.[75]

Not surprisingly, we found a very strong relationship between the number of adults and children and how often a washing machine is used. Similarly, we found a fairly strong relationship between the number of people in the household and how often a dishwasher is used (Table 7.3). These activities are responsible for some of the water consumption that the 'characteristics' model associates with each adult and each child.

The number of children is associated on the one hand with having a swimming pool (higher consumption), but on the other hand with not watering the garden and not washing the car outdoors (lower consumption - Table 7.3). These relationships provide some indication about why the amounts differ between adults and children.

Income and the number of indoor showers are both (positively) associated with a number of water uses such as having a swimming pool, using a dishwasher and using a sprinkler to water the garden. A higher income also means more washing loads and less likelihood of using grey water to replace mains water (Table 7.3). These factors account for some of the consumption that is associated with indoor showers and income.

The relationship between plot size and water consumption seems to be due to the greater likelihood of a swimming pool on a large plot rather than due to watering a larger garden. Indeed, households on large plots seem to water their gardens *less* with a garden hose and about the same with a sprinkler. On the other hand, households on large plots are more likely to have a rainwater tank and therefore to use less mains water. This means that the 'plot size' variable captures a number of (partially offsetting) factors (Table 7.3).

Households in coastal areas are less likely to water their gardens with sprinklers, a finding that partly explains why living in a coastal area means lower water consumption. However, we do not know *how much* water households use on their gardens or to top up pools, and these might also be key differences between coastal and inland areas. Overall, our analysis does not shed much light on why households in coastal use less water than otherwise similar households in inland areas.

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75 For binary variables, for example having a swimming pool, we used a logit regression model. Appendix G shows the detailed regression results.

Appendix G shows the detailed regression results.

Table 7.3 Relationships between household characteristics and what water is used for - detached houses only

	Number of adults	Number of children	Number of indoor showers	Income	Plot size	Coastal	% variation explained (R^2)
Swimming pool	ns	+ve	Strongly +ve	Strongly +ve	Strongly +ve	ns	10-16[a]
Wald score	0.8	5.6	57.2	34.8	17.1	0.2	
Dishwater uses per week	+ve	+ve	+ve	Strongly +ve	+ve	+ve	22
t-value	3.0	5.9	7.9	11.8	1.6	3.4	
Washing machine use per week	Strongly +ve	Strongly +ve	-ve	+ve	ns	+ve	26
t-value	15.8	14.4	-2.4	3.3	0.1	2.6	
Use a sprinkler	ns	ns	+ve	+ve	ns	-ve	2-5[a]
Wald score[b]	0.0	0.1	8.7	8.9	0.7	3.3	
Water garden with a hose	ns	-ve	ns	ns	-ve	ns	1-2[a]
Wald score[b]	0.1	7.5	1.5	0.5	8.9	0.1	
Have a rainwater tank	ns	ns	+ve	ns	Strongly +ve	ns	2
Wald score	0.2	0.0	3.5	1.7	17.3	0.2	
Use grey water	ns	ns	ns	-ve	ns	ns	1-2[a]
Wald score [b]	0.6	-2.4	0.0	8.0	2.8	-0.2	
Wash car outdoors	ns	-ve	+ve	ns	ns	+ve	1-2[a]
Wald score[b]	1.7	4.0	3.4	1.3	0.2	9.3	

[a] The lower value is the Cox & Snell R Square and the higher value is the Nagelkerke R Square (Psuedo R-square' statistics produced by SPSS logit analysis).

[b] The Wald score is always a positive number.

Note: For binary variables we used a logit regression model. The Wald score and the t-value both measure the strength of the statistical relationship between the explanatory variable and the dependent variable. A Wald score of 4 or more and an absolute t-value of 2 or more or more mean the relationship is significant at the 95% level of confidence. We have labelled as 'strongly positive' a Wald score of 20 or more and at t-value of 10 or more (5 times the 95% confidence level). 'ns' means not significant at a 90% level of confidence. Appendix G shows the detailed regression results.

7.4 The relationship between water consumption and what it is used for - the 'water uses' model

Using information from the household surveys, we identified a number of variables for both indoor and outdoor use (many of which are proxy variables). We also identified whether a household used an alternative source of water to mains water, ie, bore water, grey water or water from a rainwater tank. Finally, we included a (proxy) variable to identify whether a household was conservation-minded, or 'Water Wise'.

Where possible, we compared our regression coefficients with independent technical information. For washing machines and dishwashers, we did this to judge the extent to which the coefficients capture influences other than the actual marginal contribution of using the appliance. For the other variables, we did this to check that our regression coefficients are sensible.

Table 7.4 shows the variables that we included in the 'water uses' model and Table 7.5 compares selected coefficients with consumption data from independent sources. Our findings are discussed below.

7.4.1 Indoor water use

Our surveys asked about only 2 important indoor water-using uses, namely using a washing machine and using a dishwasher. Consequently, we used proxy variables to capture other uses. Specifically, we used as proxy variables the number of adults, the number of children and the number of toilets. We also measured the impact on consumption of dual flush toilets.

The number of adults and children

A significant proportion of water is used for personal hygiene, such as bathing or showering, cleaning teeth, washing hands and flushing toilets. One would therefore expect to find a strong relationship between the number of people and indoor water use. We found that this is indeed the case, with a strong relationship between consumption and the number of both adults and children. Each adult adds roughly 40 kL per annum, and each child in Sydney (2010) and the Hunter area (2008) adds about half of that amount (Table 7.4).

The amount of water associated with each child is lower in the Gosford/Wyong areas (13 kL per annum compared to around 20 kL per annum in the other areas). The reasons for this are unclear.

Our coefficients compare well with consumption data from Hunter Water's 'Water Usage Calculator' that is available on their website (Table 7.4 and Table 7.5).[76]

[76] Available at http://www.hunterwater.com.au/Save-Water/Water-Usage-Calculator.aspx.

Washing machines and dishwashers

Like for electricity, the consumption amounts shown in Table 7.4 for washing machines and dishwashers are the total annual amounts associated with using each appliance once per week. To predict the amount of water that a particular household would use, these amounts need to be multiplied by the average number of times a week the household uses the appliance. For example, using a washing machine 6 times per week is associated with 48 kL per annum (ie, 6 times the coefficient shown in Table 7.4, using the coefficient for Sydney).

Comparing the regression coefficients for washing machines with the technical information suggests that the coefficients are a bit high, and reflect more than just the amount of water that a washing machine uses. Box 7.3 explains why we believe this is the case.

The coefficients for dishwashers are much larger than the amount that a *modern* dishwasher actually uses (2-3 kL compared to 1.2 kL or less per annum for once weekly use). They are large even compared to the estimated 2kL used by a 1980's model dishwasher (Table 7.4 and Table 7.5). As we found for electricity, the coefficients clearly capture other factors that are associated with using a dishwasher.[77]

The total number of toilets and dual flush toilets

The total number of toilets (single and dual flush) is closely related to the number of indoor showers and, like showers, indicates the number of bathrooms as well as the size of the dwelling.[78] For the 'water uses' model we used the number of toilets instead of the number of indoor showers so that we could also test the impact on consumption of some (or all) of the toilets being dual flush.

Like the number of showers, the number of toilets probably captures a number of different influences related to both dwelling size (eg, how much water is used for house cleaning) and the amount of water that each person is able to use in the bathroom. In this model it may also capture some income-related usage, because income is not included as an explanatory variable and there is a fairly strong association between income and the number of toilets.[79] Finally, it may capture information about leaks: more taps and toilets mean more chance for drips and leaks.

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77 Increasing the number of times that households in the '6 times per week or more' band used a dishwasher from 6.5 to 7 times per week had only a small impact on the regression coefficients. Doing so reduced the coefficient for Sydney (2010) from 3.1 kL to 2.9 kL per annum and for Hunter (2008) from 2.3 kL to 2.2 kL per annum.

78 For the Sydney (2010) data, the correlation coefficient between the number of toilets and the number of indoor showers is 0.74.

79 We excluded income because it was not (statistically) significant and had no additional explanatory value. As indicated, there is positive relationship between income and the number of toilets, for example for Sydney (2010) the correlation coefficient is 0.26 and regression analysis (using the number of toilets as the dependent variable) shows a strong relationship (t-values of 8.5, shown in Appendix G Table G.28).

For Sydney (2010) and the Hunter area (2008), we found that each toilet is associated with roughly 15 kL per annum of consumption. But we found no (statistically significant) relationship for Gosford/Wyong (2008), possibly again because of drought-related behaviour.

Looking at dual flush toilets, we found that for Sydney (2010) each toilet reduces household consumption by about 5kL per annum compared to a single flush toilet. The coefficients for the other areas are smaller and (statistically) not significant. The reasons for the latter finding are unclear.

Box 7.3 How much water do washing machines use?

Top loading and front loading washing machines

Automatic washing machines can be either front loading or top loading. Most top loading washing machines use far more water than front loading ones. According to the Australian Water Efficiency Labelling and Standards Scheme (WELS) website[a], modern star rated top loaders use between 3 kL and10 kL per annum for once weekly use compared to between 2 kL and 6 kL per annum for front loading ones. Accordingly, Hunter Water's Water Usage Calculator[b] uses a volume of 7 kL per annum for a (modern) top loading machine and 3 kL per annum for a front loading one for once weekly use.

More than 75% of NSW households have top loading washing machines.[b,c]

What do our regression coefficients capture?

Based on the Hunter Water's Water Usage Calculator[b] estimates, washing machines on average are likely to account for a bit more than 6 kL per annum if used once weekly (assuming an 80/20 split between 7kL per annum top loading and 3 kL per annum front loading machines). But the regression coefficient for Sydney (2010) is higher than this – 8 kL per annum. Therefore, the coefficient probably captures more than just washing machine usage.

The coefficients for Hunter and Gosford/Wyong are slightly higher than for Sydney (respectively 10 kL and 9 kL). This may indicate older machines, and/or a higher proportion of top loading ones (which are cheaper than front loading ones). But the difference is probably also a consequence of other factors that our model does not take into account.

Sources:

a http://www.environment.gov.au/wels_public/searchPublic.do.

b http://www.hunterwater.com.au/Save-Water/Water-Usage-Calculator.aspx.

c ABS, *Domestic Water and Energy Use, New South Wales.,* catalogue number 4621.1, 2007, Table 6.

d ABS, *Environmental Issues: Energy Use and Conservation,* Mar 2008, Data cube for Chapter 5, available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4602.0.55.001Mar%202008?OpenDocument Table 5.12.

7.4.2 Outdoor water use

Our results for outdoor use reflect the particular circumstances of each area with respect to both water restrictions and climate. Therefore, we consider each area separately.

For Sydney (2010), having a swimming pool and using a sprinkler to water the garden have the biggest impact on consumption. In addition, the size of the plot matters if the household waters the garden. For example, our results indicate that in 2009/10, on average a household on a 500 m^2 plot used 16 kL per annum in the garden, whereas a household on a 800 m^2 plot used 26 kL per annum (without using a sprinkler). The climate zone also matters, with households in inland areas on average using about 12 kL per annum more water outdoors than otherwise similar households in coastal areas.

Like in Sydney (2010), having a pool and using a sprinkler have the biggest impact on water consumption in the Hunter area (2008). But volumes associated with having a pool and watering the garden are smaller in the Hunter area (2008), which possibly reflects its predominantly coastal nature.

Washing cars outdoors did not account for differences in consumption between Sydney households. In contrast, in the Hunter area this activity was associated with additional consumption of about 17 kL per annum. One possible reason for the difference between the 2 areas may be that, in Sydney, households were permitted to wash their cars with hoses only if the hoses were fitted with trigger nozzles. (Box 7.1).

Outdoor use in the Gosford/Wyong areas was not permitted due to water restrictions, and the survey did not ask these households about watering gardens or washing cars. The smaller volumes associated with having a swimming pool may be related to the water restrictions that had been in force since June 2006: households were permitted to top up their pools only if they had internally connected rainwater tanks (Box 7.1).

Comparing our regression coefficients with the technical information indicates that our results for outdoor use are reasonable (Table 7.5).

7.4.3 Alternative sources of water to mains water

Mains water can be supplemented by water from boreholes, by using grey water or by water from rainwater tanks. By how much an alternative source of water reduces mains water consumption will depend what the alterative sources are used for. In general, if the house is plumbed to use rainwater or grey water indoors, the savings will be greater than if the household uses the alternative source(s) of water only for outdoor use.

We found that having a rainwater tank reduced consumption in all 3 areas by between 12 kL and 20 kL per annum. The saving was greatest in the Gosford/Wyong area, possibly because water restrictions encouraged more households to use the rainwater indoors (see Box 7.2).

Using bore water explains variations between household only in the Hunter area (2008). For Sydney, the (statistically) insignificant result is probably due to the small number of households in our sample that used bore water.[80] For the Gosford/Wyong area, the main reason is probably that bore water is mainly used outdoors, and households without bore water made very little use of mains water outdoors (due to water restrictions). In other words, in the Gosford/Wyong area bore water was largely an additional source of water rather than a substitute for mains water.

Using grey water reduced the consumption of Sydney households by an average of 13 kL per annum. Like bore water, grey water is mainly used outdoors. Therefore, the (statistically) insignificant result for the Gosford/Wyong area may again be due to the likelihood that grey water provided and additional source of water to mains water for outdoor use, rather than an alternative source. The reason for the (statistically) insignificant finding in the Hunter area is unclear.

7.4.4 Water Wise households

Some households are particularly concerned about the need to use water sparingly. Such households are more likely to have their houses plumbed to use less water, for example by having low flow shower heads and tap aerators. They are also more likely to fix leaks quickly, to have gardens that use less water and to generally use water carefully. We call these households 'Water Wise'.

Our surveys did not ask households about water saving behaviour. However, for Sydney (2010) we found that there was a strong relationship between having solar hot water and using less water. To interpret this finding, we believe it is fair to assume that a household with solar hot water is more likely than an 'average' household to be concerned about the environment and therefore to conservatively use both energy and water.[81] Consequently, we used having solar hot water as a proxy for being Water Wise.

80 Only 25 households in the sample that we used for our analysis used bore water (less than 2% of the total sample).

81 An alternative explanation could be that households with solar hot water simply use less hot water because the supply runs out. However, this explanation is unlikely because most solar hot water systems are electric (or gas) boosted. Boosting means that solar hot water systems are no more likely to run out of hot water other hot water systems.

We found that, in Sydney, households with solar hot water on average used about 28 kL less water than otherwise similar households with gas or electric hot water systems. This represents a saving or more than 10% of the average amount that Sydney households in detached dwellings use (210 kL per annum in 2010/11 – Table 7.1). We used the regression coefficient in our model of household water consumption to indicate being Water Wise.[82] This seems reasonable, in the light of Hunter Water's 'Water Usage Calculator' estimate that an adult can save about 23 kL per annum by having shorter showers and using water saving bathroom devices (Table 7. 5).

7.4.5 The (statistical) strength of the relationships

In all areas, the number of adults in a household is more strongly related to consumption than any of the other variables, and we are fairly confident about the amount that each adult adds. The number of children and how often a washing machine is used are also strongly related to consumption. Looking at outdoor use, having a swimming pool and using a sprinkler are fairly strongly related to consumption, particularly for Sydney (2010). We are not very confident about *how much* the climate matters, and by *how much* alternative sources of water on average reduce mains water consumption.

82 In the model we adjust the saving to a per person amount.

Table 7.4 Relationship between water consumption and what water is used for - detached houses only

Data set	Sydney (2010)		Hunter (2008)		Gosford and Wyong (2008)	
	kL pa	(t-value)	kL pa	(t-value)	kL pa	(t-value)
% of variation explained (R^2)	43		45		34	
Sample size	1,649		1,391		672	
Indoor use						
Per person older than 15 years	37	(17.5)	40	(15.0)	38	(9.7)
Per person 15 years or younger	20	(8.0)	19	(7.8)	13	(3.3)
Washing machine - used once per week	8	(7.8)	10	(10.0)	9	(5.5)
Dishwasher - used once per week	3.0	(3.4)	2.4	(2.4)	2.9	(1.9)
Per toilet (single and dual flush, indicates number of bathrooms)	17	(4.4)	14	(3.4)	ns	(-0.1)
Per dual flush toilet	-5	(-1.8)	ns	(-0.5)	ns	(-0.2)
Outdoor use						
Have a swimming pool	33	(6.4)	21	(3.4)	19	(2.1)
Use sprinkler	39	(5.2)	20	(3.1)	na	-
Per 100m2 plot size if water garden	3.2	(4.0)	1.5	(2.2)	na	-
Do not know plot size and water garden	ns	(1.4)	na	-	na	-
Wash car outdoors	ns	(0.1)	17	(3.9)	na	-
Inland and water garden or have pool	12	(2.9)	ns	(0.5)	na	-
Alternative sources of water (mainly used outdoors)						
Have rainwater tank	-12	(-2.6)	-13	(-2)	-20	(-2.9)
Use bore water	ns	(-0.1)	-27	(-3.6)	ns	(-0.7)
Use grey water	-13	(-2.7)	ns	(-1.1)	ns	(-0.6)
Water wise and region						
Proxy used: have solar hot water[a]	-28	(-3.9)	ns	(-1.4)	ns	(-0.6)

[a] Significant at an 89% level of confidence.

Note: Detached houses only. Linear regressions, excluding household with consumption of more than 300 kL per capita or 750 kL per household per annum (11, 7 and 5 households in the 3 areas respectively). Coefficients are shown if they are significant at the 90% level of confidence. 'na' means not applicable because there were no observations in the sample. Gosford/Wyong households were not asked about watering gardens or washing cars. Appendix G shows the detailed regression results.

Table 7.5 Comparison of regression coefficients with independent data

	Survey co-efficients kL pa	Technical estimates per person kL pa	Coefficient within plausible range?	Comments	Sources
Per adult	37 - 40	20-79	Yes	Range is for 4 minute and 10 minute daily showers assuming no leaks. Lower estimate also assumes water saving fixtures. Usage for 5 minute showers with no water saving fixtures is 43kL.	1
Washing machine – used once per week	8 - 10	2-10	A bit high, captures some related factors	Range is for 4 star front loading to 1 star top loading machines. Top loading most common.	1,2
Dishwasher - used once per week	2-3	0.3-2.1	No, captures related factors	Range is for 1980's model to modern 4 star model. Modern 1 star model uses about 1.2 kL.	1, 2 and 3
Have a swimming pool	19 - 33	13-52	yes	Calculated using weekly top-up in summer and occasional top-up in winter. Low end assumes 10 minutes per top-up; high end assumes 40 minutes per top-up.	1
Water the garden (per household)	<10 - 39	Wide range, similar to pools	yes	Depends on how garden is watered and, if with hose or sprinkler, for how long. Similar to analysis for pool.	1
Wash car outdoors	17	8-31	yes	Range is for occasional or weekly wash in Hunter Water area. (Trigger nozzle not required?)	1
Have a rainwater tank	12-20 (saving)	Wide range	yes	Wide range depending on rainfall, tank capacity, roof area and uses for rainwater. Can exceed 100 kL per annum.	4
Water Wise	-28	-23	yes	Per person for 1 minute shorter shower per day, water saving shower head and tap aerators.	1

Note: Appendix H provides further details.
Sources:
1. Hunter Water's Water Usage Calculator, accessed 14 October 2011, available at http://www.hunterwater.com.au/Save-Water/Water-Usage-Calculator.aspx,
2. Australian Government Water Efficiency Labelling and Standards scheme (WELS) website, accessed 15 October 2011, at http://www.environment.gov.au/wels_public/productSearch.do,
3. Sydney Water website, accessed 15 October 2011, at http://www.sydneywater.com.au/Water4Life/InYourHome/InTheKitchen/Dishwashers.cfm,
4. Sydney Water *Rainwater tank calculator,* accessed 15 October 2011, available at http://www.sydneywater.com.au/Water4Life/InYourGarden/RainwaterTanks/ResidentialCalculator.cfm.

7.5 How well our 'water uses' model predicts water consumption

Like for electricity and gas, we tested how well our model predicts consumption in 2 ways. Firstly, we tested the model's predictions against the average consumption of the surveyed samples. Secondly, we compared the model's predicted consumption to the actual consumption of volunteer households that were not included in the surveys.

We found that the model could accurately predict the average consumption of the Sydney, Hunter Water area and Gosford/Wyong samples. We also found that the model could fairly accurately predict average consumption for the different income groups (Table 7.6).

Table 7.6 Model predictions compared to actual average consumption of surveyed households (kL pa)

	All house-holds	low-income	low-middle	high-middle	high-income	refused
Sydney (2010)						
Predicted average	196	144	182	216	248	194
Actual average	198	151	178	218	248	203
Percentage difference	1	5	-2	1	0	4
Hunter Water area (2008)						
Predicted average	189	151	193	222	252	200
Actual average	185	145	190	217	257	197
Percentage difference	-2	-4	-1	-2	2	-1
Gosford/Wyong (2008)						
Predicted average	164	131	171	196	201	163
Actual average	164	122	171	199	196	179
Percentage difference	0	-7	0	2	-3	9

Note: For each area we used the associated model coefficients and sample averages. We tested the model using only the coefficients that were significant, shown in Table 7.4.

We predicted the consumption of a number of volunteer Sydney households that had not participated in the surveys, using the Sydney (2010) coefficients. We then compared each prediction to the household's actual consumption and found that, for most of the households, the model predictions proved to be fairly accurate. But for other households, actual consumption varied substantially from predicted consumption (Table 7.7). Some of the reasons that we identified for the observed variations include:

- Leaks and dripping taps can have a significant impact on consumption.
- The number of people in a household can vary over a 12 month period, which will significantly affect consumption.
- Some household members regularly shower elsewhere, such as at a gym or public swimming pool.
- Some households have water-saving fixtures and/or appliances without being otherwise Water Wise.

Table 7.7 Model predictions compared to actual consumption of volunteer Sydney households (kL pa)

	Volunteer 1	Volunteer 2	Volunteer 3	Volunteer 4	Volunteer 5	Volunteer 6
Predicted consumption	281	189	151	143	125	138
Actual consumption	306	159	147	153	217	128
Percentage difference	9	-16	-3	7	74	-7
Key characteristics						
Dwelling type	house	house	house	house	house	semi
Occupants	4 adults	3.5 adults (average)[a]	2 adults 1 child	2 adults 1 child	2 adults	3 adults
Front or top loading washing machine?	front	front	top	front	top	top
Have swimming pool?	yes	no	no	no	no	no
Water garden?	no	no	yes	yes	no	no
Have rainwater tank?	no	no	no	yes	no	no
Use grey water?	no	no	no	no	no	no
Water Wise?	no	yes	yes	yes	no	yes
Comments						
	Long showers may offset front loading washing machine	Household members do not always shower at home.	Water garden only a little	Keen gardener	Long suspected leak	Very water conscious household

[a] When household members regularly spend time away from home, we allowed fractions.

Note: We asked a number of Sydney households about their characteristics and what they use water for. They also provided 4 quarterly water bills. We used the Sydney (2010) coefficients.

7.6 The impact of dwelling type on water consumption

Using the Sydney (2010) data, we investigated the impact on consumption of dwelling type. We also investigated to what extent any differences in consumption between dwelling types are due to outdoor use rather than indoor use.

We conducted our analysis by specifying 2 'characteristics' models, the first of which excluded variables for garden watering and the second of which included these variables (Table 7.8). For this analysis we included all households that were recorded as being individually metered.

We found that dwelling type has virtually no impact on consumption once garden watering is taken into account. This suggests that indoor water consumption is very little affected by dwelling type. Households in detached houses are likely to use more water mainly because they use it outdoors (Table 7.8).

Table 7.8 Relationship between household characteristics and water consumption for individually metered households, Sydney (2010)

	Excluding outdoor use variables		Including outdoor use variables	
	kL pa	(t-value)	kL pa	(t-value)
% of variation explained (R^2)	36		37	
Sample size	1,836		1,836	
Detached house	22	(3.2)	ns	(-0.2)
Per person older than 15 years	43	(20.7)	43	(21.0)
Per person 15 years or younger	29	(12.3)	30	(12.7)
Per indoor shower	17	(5.7)	15	(5.0)
Per $10,000 income pa	2.0	(4.5)	2.0	(4.4)
Did not provide income data	21	(3.0)	23	(3.3)
Per 100m2 plot size and water garden	not	included	3.8	(4.7)
Do not know size of plot and water garden	not	included	ns	(1.4)
Live in a coastal area	-14	(-3.3)	-11	(-2.7)

Note: Individually metered households only. Linear regressions, excluding household with consumption of more than 300 kL per capita or 750 kL per household per annum. Coefficients are shown if they are significant at the 90% level of confidence. Appendix G shows the detailed regression results.

Appendices

A Information about the surveyed households

Section A.1 below provides a profile of the surveyed households with reference to the variables included in the regression models. Section A.2 shows how we classified the Sydney (2010) and Hunter, Gosford and Wyong (2008) regions into coastal and inland areas.

A.1 Household characteristics of surveyed households

The importance to a household's consumption of a characteristic or use depends on whether or not the household displays that characteristic or uses energy or water for that purpose. For example, the amount of electricity that is used by a 2nd fridge matters only if the household has a 2nd fridge. The tables below show what proportion of households display each of the identified characteristics or use. Further information is available in Appendix E of our household survey reports, available on the IPART website.[83]

We excluded households with incomes below $13,000 from the low-income group. We did this because most of these households are likely to have received income from businesses that, for whatever reason, were not profitable in the year prior to the survey. These households tend to be 'asset rich', and their consumption patterns are more like those of their higher income counterparts. Households whose only source of income was a government pension and other payments would have received income exceeding $13,000 per annum in 2009/10.

83 IPART, *Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey,* December 2010, Appendix E, available at http://www.ipart.nsw.gov.au/investigation_content.asp?industry=6&sector=17&inquiry=202&doctype=4&doccategory=1&docgroup=1 and IPART, *Residential Energy and Water Use in the Hunter, Gosford and Wyong - Results from the 2008 household survey,* December 2008, Appendix E, available at http://www.ipart.nsw.gov.au/investigation_content.asp?industry=6&sector=17&inquiry=146&doctype=4&doccategory=1&docgroup=1.

The Sydney (2010) survey data are weighted to correct for sample biases in dwelling type, income and household structure. The main sample bias was dwelling type, as shown in Appendix 2 and discussed in more detail in the 2010 household survey report.[84] The Hunter, Gosford and Wyong (2008) survey data are corrected only for an over-representation of households in the Hunter and Gosford areas and an under-representation of those in the Wyong area. The 2008 household survey report discusses the weights in more detail.[85]

84 IPART, *Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra - Results from the 2010 household survey*, December 2010, Appendix A, pp 195-196.

85 IPART, *Residential Energy and Water Use in the Hunter, Gosford and Wyong - Results from the 2008 household survey*, December 2008, Appendix A, pp 108-110.

Table A.1 Household and energy-related characteristics of Sydney households (2010)

		Low-income[a]	Low-mid income	High-mid income	High-income	No income data	All h/holds
Sample size		457	470	574	350	248	2,192
Live in a flat	%	30	29	22	22	20	25
Live in a detached house	%	55	58	67	66	67	62
bedrooms	no.	2.8	3.1	3.3	3.6	3.4	3.2
showers	no.	1.3	1.5	1.7	1.9	1.7	1.6
adults (> 15 years)	no.	1.6	2.1	2.4	2.7	2.3	2.2
children (<=15 years)	no.	0.2	0.4	0.6	0.6	0.3	0.4
Average income	$'000	22	48	93	167	na	75
Use mains gas	%	39	44	57	61	49	49
Have Controlled Load	%	41	41	38	33	44	40
Live in a coastal area	%	44	50	44	59	49	48
Use gas for cooking[b]	%	32	39	52	55	41	43
Use gas for space heating[b]	%	23	24	34	35	27	28
Use electricity for space heating (not aircon)	%	37	33	31	27	24	31
Gas hot water (main source)	%	28	34	42	53	35	38
Solar hot water (main source)	%	5	6	6	6	7	6
Have a swimming pool	%	7	13	17	28	17	15
Have a 2nd fridge	%	37	47	49	54	52	47
Have a spa	%	2	6	6	9	6	6
Have a clothes dryer	%	53	64	72	81	65	66
Have a dishwasher	%	27	47	63	80	57	52
Have an air conditioner	%	55	60	59	64	61	59
Clothes dryer - times per week used[c]	no.	0.7	0.8	1.0	1.4	0.8	0.9
Dishwasher - times per week used[c]	no.	0.7	1.4	2.4	3.5	1.9	1.9
Air conditioner – hours used per annum[c]	no.	155	157	181	192	170	167

[a] Excluding households with incomes below $13,000 per annum.

[b] Including mains and cylinder gas.

[c] Average for all households, including those that do not have or do not use the appliance.

Note: Survey data are weighted to correct for sample biases in dwelling type, income and household structure.

Table A.2 Household and energy-related characteristics of Hunter, Gosford and Wyong households (2008)

		Low-income[a]	Low-mid income	High-mid income	High-income	No income data	All h/holds
Sample size		987	434	579	243	250	2,608
Live in a flat	%	13	9	4	4	7	9
Live in a detached house	%	83	87	93	96	89	87
bedrooms	no.	2.9	3.2	3.5	3.7	3.3	3.2
showers	no.	1.4	1.5	1.6	1.9	1.7	1.5
adults (> 15 years)	no.	1.7	2.2	2.4	2.7	2.2	2.1
children (<=15 years)	no.	0.2	0.6	0.8	0.8	0.4	0.5
Average income	$'000	21 2	44	83	155	na	54
Use mains gas	%	3	24	36	41	29	29
Have Controlled Load	%	65	69	60	58	64	64
Live in a coastal area	%	90	91	91	93	88	91
Use gas for cooking[b]	%	21	26	35	41	31	28
Use gas for space heating[b]	%	23	26	34	36	28	28
Use electricity for space heating (not aircon)	%	45	36	30	29	33	38
Gas hot water (main source)	%	18	18	27	33	23	22
Solar hot water (main source)	%	3	3	4	5	5	4
Have a swimming pool	%	6	12	20	30	17	13
Have a 2nd fridge	%	44	53	61	66	55	52
Have a spa	%	3	7	7	7	4	5
Have a clothes dryer	%	62	72	82	88	67	71
Have a dishwasher	%	31	47	59	79	53	46
Have an air conditioner	%	69	71	75	75	68	71
Clothes dryer - times per week used[c]	no.	0.7	1.1	1.3	1.7	0.9	1.0
Dishwasher - times per week used[c]	no.	0.8	1.5	2.3	3.5	1.8	1.6
Air conditioner – hours used per annum[c]	no.	150	174	192	222	149	169

[a] Excluding households with incomes below $13,000 per annum.

[b] Including mains and cylinder gas.

[c] Average for all households, including those that do not have or do not use the appliance.

Note: Survey data are weighted to correct for the under-representation of households in Wyong and the over-representation of households in Gosford and the Hunter area.

Table A.3 Water-related characteristics of Sydney (2010) households – detached houses

		Low-income[a]	Low-mid income	High-mid income	High-income	No income data	All h/holds
Sample size		308	323	521	260	215	1,678
adults (> 15 years)	no.	1.8	2.3	2.7	3.1	2.5	2.5
children (<=15 years)	no.	0.3	0.4	0.7	0.7	0.3	0.5
bedrooms	no.	3.4	3.7	3.9	4.2	3.7	3.8
showers	no.	1.4	1.6	1.8	2.1	1.8	1.7
toilets (all)	no.	1.7	2.0	2.2	2.5	2.2	2.1
dual flush toilets	no.	1.3	1.6	1.9	2.2	1.8	1.7
Average income	$’000	22	48	94	169	na	80
Size of plot	m^2	723	739	729	746	742	734
Live in a coastal area	%	32	36	35	48	42	38
Washing machine - times per week used[b]	no.	3.0	4.1	4.6	4.9	4.2	4.1
Dishwasher - times per week used[b]	no.	0.9	1.9	2.7	4.1	2.2	2.3
Have a swimming pool	%	11	18	23	41	22	22
Use sprinkler	%	4	7	10	12	5	8
Water garden with hose	%	66	73	73	70	69	70
Wash car	%	30	37	32	32	36	33
Have rainwater tank	%	23	29	28	25	28	27
Use grey water	%	28	24	25	17	27	24
Use bore water	%	2	1	2	2	1	1

a Excluding households with incomes below $13,000 per annum.
b Average for all households, including those that do not have or do not use the appliance.
Note: Survey data are weighted to correct for sample biases in dwelling type, income and household structure.

Table A.4 Water-related characteristics of Hunter (2008) households – detached houses

		Low-income[a]	Low-mid income	High-mid income	High-income	No income data	All h/holds
Sample size		526	233	332	148	129	1,437
adults (> 15 years)	no.	1.8	2.2	2.4	2.8	2.3	2.1
children (<=15 years)	no.	0.3	0.5	0.9	0.7	0.4	0.5
bedrooms	no.	3.0	3.2	3.4	3.8	3.4	3.2
showers	no.	1.3	1.5	1.5	1.9	1.6	1.5
toilets (all)	no.	1.5	1.7	1.8	2.3	1.9	1.7
dual flush toilets	no.	1.1	1.4	1.4	1.9	1.6	1.3
Average income	$'000	21	44	82	153	na	55
Size of plot	m^2	711	710	715	728	742	715
Live in a coastal area	%	81	83	84	89	76	83
Washing machine - times per week used[b]	no.	3.2	4.0	4.7	5.3	4.2	3.9
Dishwasher - times per week used[b]	no.	0.8	1.4	2.2	3.6	2.0	1.6
Have a swimming pool	%	5	14	21	32	19	14
Use sprinkler	%	11	14	15	22	13	13
Water garden with hose	%	68	61	59	63	58	62
Wash car	%	49	66	65	59	64	57
Have rainwater tank	%	9	15	12	10	14	11
Use grey water	%	23	23	18	18	23	21
Use bore water	%	9	9	5	7	12	8

a Excluding households with incomes below $13,000 per annum.
b Average for all households, including those that do not have or do not use the appliance.
Note: Survey data are not weighted.

Table A.5 Water-related characteristics of Gosford/Wyong (2008) households – detached houses

		Low-income[a]	Low-mid income	High-mid income	High-income	No income data	All h/holds
Sample size		293	144	204	86	94	838
adults (> 15 years)	no.	1.8	2.2	2.6	2.7	2.2	2.2
children (<=15 years)	no.	0.3	0.7	0.8	0.9	0.5	0.6
bedrooms	no.	3.1	3.4	3.6	3.8	3.4	3.4
showers	no.	1.5	1.6	1.8	1.9	1.8	1.7
toilets (all)	no.	1.8	2.0	2.1	2.2	2.2	2.0
dual flush toilets	no.	1.3	1.6	1.7	2.0	1.8	1.6
Average income	$'000	22	45	84	155	na	58
Size of plot	m^2	676	679	718	717	734	699
Live in a coastal area	%	100	100	100	100	100	100
Washing machine - times used per week used[b]	no.	3.3	4.4	5.2	5.0	4.2	4.2
Dishwasher - times used per week used[b]	no.	0.7	1.9	2.7	3.4	1.9	1.8
Have a swimming pool	%	10	14	22	28	20	16
Use sprinkler	%	na	na	na	na	na	na
Water garden with hose	%	na	na	na	na	na	na
Wash car	%	na	na	na	na	na	na
Have rainwater tank	%	35	41	41	49	47	41
Use grey water	%	36	34	34	22	44	35
Use bore water	%	14	9	6	8	7	10

a Excluding households with incomes below $13,000 per annum.

b Average for all households, including those that do not have or do not use the appliance.

Note: Survey data are weighted to correct for under-representation of Wyong households in the sample. Due to water restrictions, households were not asked about outdoor water use.

A.2 How we classified areas as 'coastal' and 'inland'

Our models include a variable to indicate the climate zone. The table below shows how we classified the Sydney (2010) and Hunter, Gosford and Wyong (2008) survey regions into coastal and inland areas. It also shows how many households we surveyed in each area.

Table A.6 Classification of survey regions into coastal and inland

Coastal Areas	# house-holds	Inland Areas	# house-holds
Sydney (2010)			
North Sydney to Manly	95	Liverpool	108
Concord to Lane Cove	62	Villawood to Cabramatta	68
Balmain to Strathfield	137	Lakemba to Hurstville	133
Botany to Arncliffe	73	Ryde to Hornsby	207
Eastern Suburbs	105	Baulkham Hills to Rouse Hill	124
City	49	Blacktown to Penrith	159
Collaroy to Palm Beach	76	North Rocks to Parramatta	81
The Shire	103	Campbelltown to Mittagong	114
Wollongong	156	Bankstown to Georges Hall	117
Lake Illawarra	117	Blue Mountains	108
Total	973	Total	1,219
Hunter, Gosford and Wyong (2008)			
Gosford	342	Cessnock	124
Lake Macquarie	587	Maitland	130
Newcastle	501	Muswellbrook (A)	1
Port Stephens	312		
Singleton	9		
Wyong	602		
Total	2,353	Total	255

B Information about our regression analysis

In specifying a regression model and addressing modelling difficulties, a number of choices need to be made. Here, we briefly outline some of the complications we faced, the modelling choices we made, and the diagnostic tests we performed.

We investigated the raw consumption data and excluded 'outliers' when we used the raw data as the explanatory variable (ie, for our 'linear') models. We also transformed the data to log form and specified 'semi-log' models. But for most of our analysis we used simple linear models. We did this because they are simpler to interpret and better suited to predicting a household's consumption than are semi-log models.

We dealt with sample biases mainly by specifying flexible models, and in particular by including dwelling type as an explanatory variable. Dwelling type is particularly important because the main bias in both survey samples was an over-representation of detached houses and an under-representation of flats.

We found evidence of 'omitted variable bias', which means that our results need to be interpreted with some care. We also found some evidence of 'multicollinearity', 'heteroscedasticity' and 'measurement error', but concluded that these are not of great concern.

We discuss these issues in more detail below.

B.1 Snapshot of the raw consumption data and dealing with outliers

A common assumption when employing the classical linear regression model is that the residuals are normally distributed.[86] In order to probe this assumption and to test informally for the presence of outliers, we started by plotting the raw consumption data (Figure B.1).

[86] Note that normality is not required for many of the desirable properties of the linear regression model. In addition to linearity, the principal assumptions of the linear regression model are that there is no exact linear relationship among any of the explanatory variables; that the explanatory variables are independent of the error term; and that the variance of the error term is constant across observations. For more details see, for example, Greene, William H, *Econometric Analysis*, 6th Ed., 2008.

Plots of the raw data reveal that the consumption data for electricity, gas, and water are positively skewed. This suggests 2 possible issues. First, it may reflect the existence of outlying observations. Households with unusually high or low consumption may reflect atypical circumstances which our simple regression framework may not be able to explain. Second, it may suggest that the relationship between consumption and household characteristics is not a linear one. High consumption households in particular may be difficult to explain with a linear model.

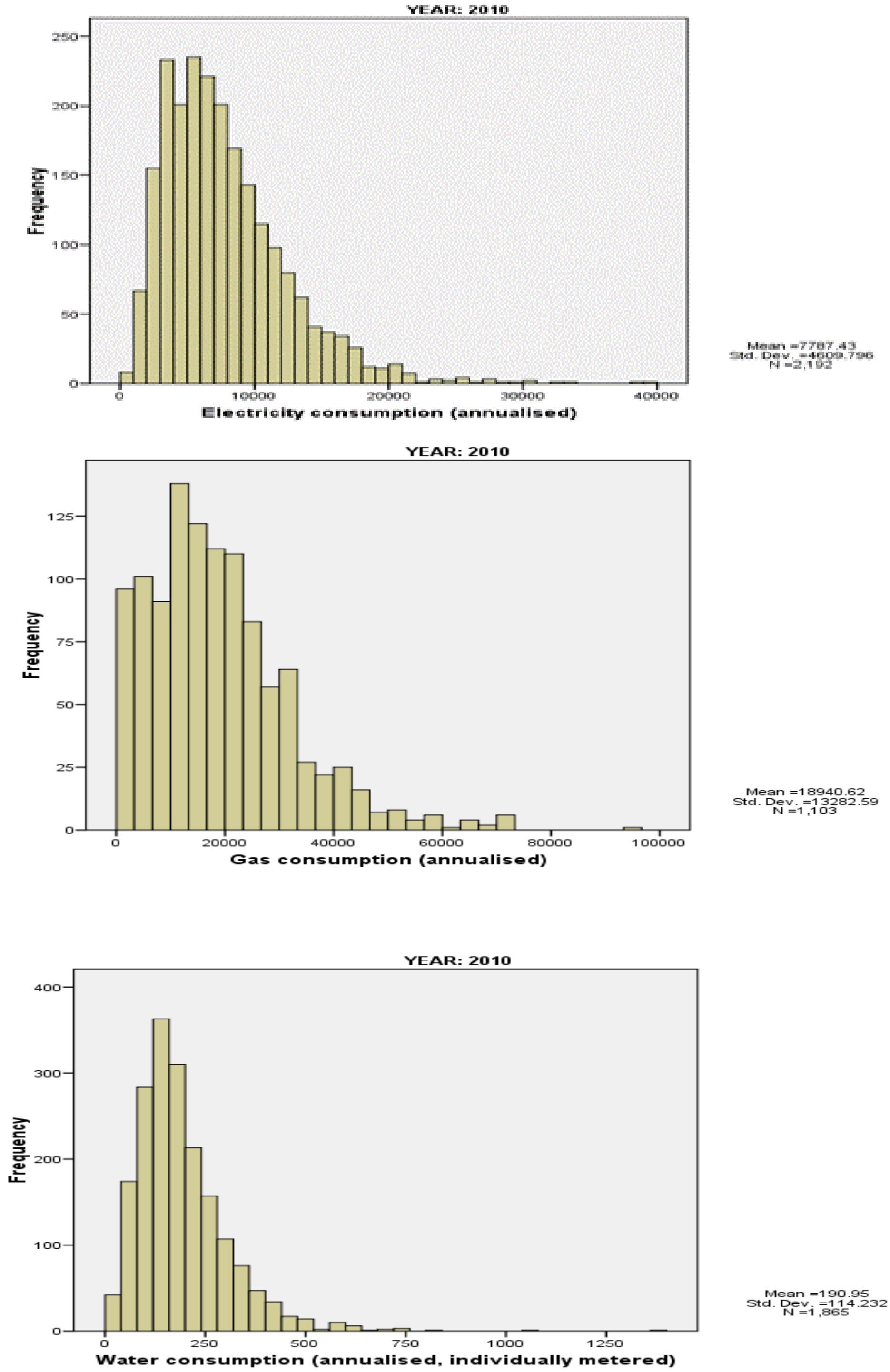
We responded to this observation in 2 ways. Firstly, we excluded households with very high consumption when we used the raw consumption data as the dependent variable (ie, for our 'linear' models). This strategy means that the few households with very high consumption no longer skew the regression results. Specifically, we excluded households that:

- used more than 25,000 kWh of electricity per annum (16 Sydney households and 6 Hunter, Gosford and Wyong households)
- used more than 80,0000 MJ of gas per annum (4 Sydney households)
- had energy usage bills of more than $6,000 per annum in 2011/12 prices (18 Sydney household)
- used more than 750 kL per annum or more than 300kL of water per person per annum[87] (11 Sydney households, 7 Hunter households and 5 Gosford/Wyong households).

Secondly, we examined simple transformations of the data. In particular, we took natural logs of the consumption data. The transformed data much more closely resembled a normal distribution than the raw data, particularly for electricity and water (Figure B.2). Therefore, we converted the consumption data to logarithmic form and used these data as the dependent variables. That is, we ran *semi-log* regression models. However, a semi-log regression model is not as well suited to the kind of predictive exercise that we were interested in as part of this project. Accordingly, most of the results we report are from the linear model. The next section discusses in more detail the semi-log model and the reasons behind our choice.

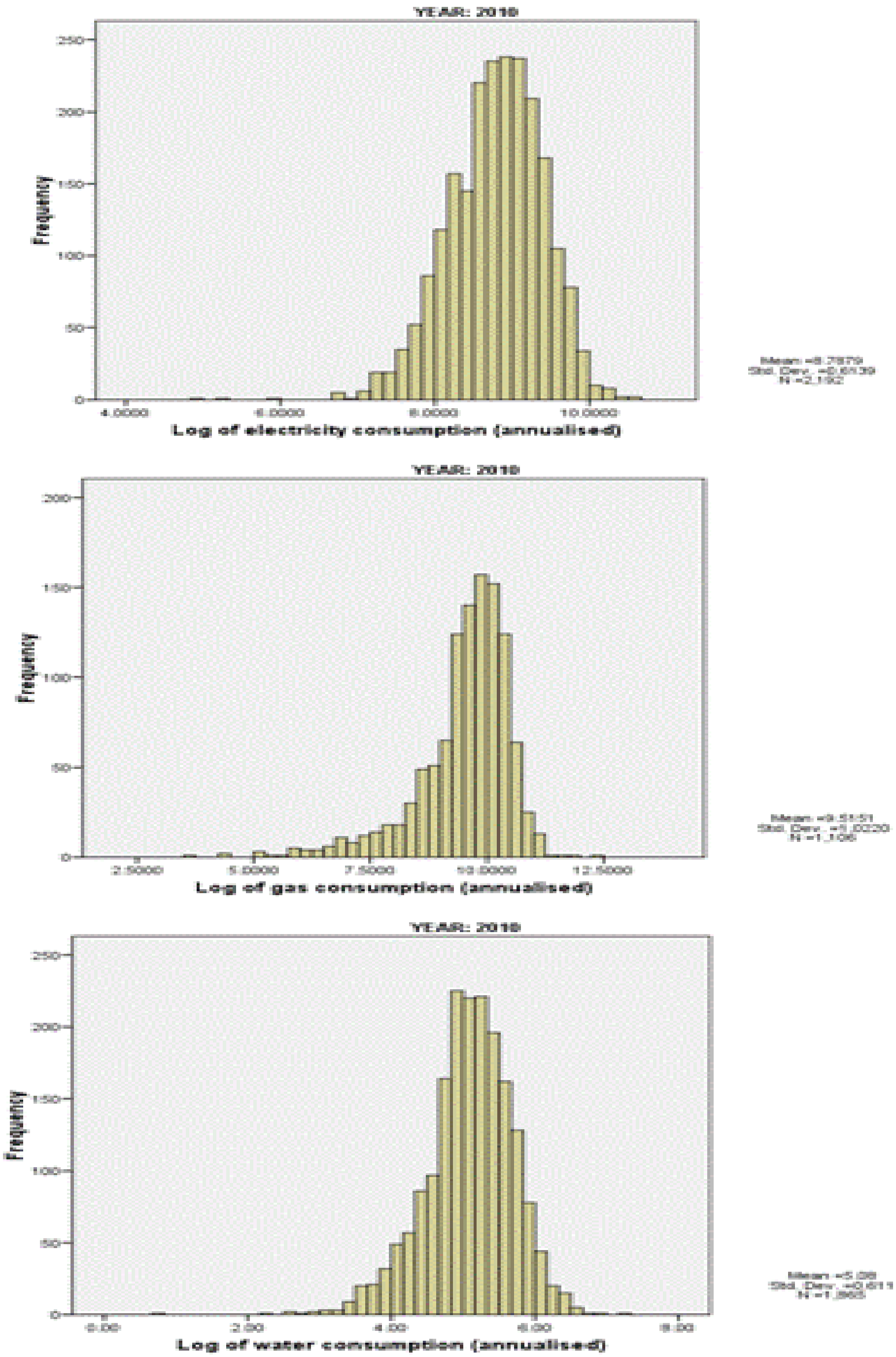
87 We excluded households with consumption exceeding 300 kL per person per annum to minimise the possibility of including bulk metered households that were mistakenly recorded as being individually metered.

Figure B.1 Distribution of electricity, gas and water consumption for Sydney (2010)



Note: Three households with gas consumption of more than 100,000 MJ per annum are excluded. The gas histogram excludes households that do not use gas.

Figure B.2 Logarithmic distribution of consumption for Sydney (2010)



Note: The gas histogram excludes households that do not use gas.

B.2 Choosing the functional form of our regressions

A fundamental decision in any regression analysis is the functional form of the model.

B.2.1 Simple and semi-log linear models

A linear model is a natural choice because it is simple, transparent, and amenable to forecasting exercises. In reality, empirical relationships are rarely strictly linear, but a linear model can provide a reasonable approximation. The model is very easy to understand and estimate, and forecasts can be obtained simply and with minimal data requirements.

As the name suggests, a linear regression model expresses the dependent variable (eg, electricity consumption) as a linear function of a set of explanatory variables (such as household characteristics).

eg, Consumption = (Household characteristics) b + error term

ie, $C = Xb + u$,

where C represents consumption, X contains a set of explanatory variables, b is a vector of coefficients expressing the strength of the relationship, and u contains unobserved determinants of consumption (the error term).

By definition, a linear model restricts the impact of the explanatory variables on the dependent variable to be constant across the range of values the explanatory variables could take. For example, a linear relationship between electricity consumption and income implies that the effect of an additional dollar of income on consumption is the same whether the household is a heavy user of electricity or a light user (and whether the household has a low income or a high income).

Specifying the model in logs provides an alternative that retains most of the appealing features of the linear model, but permits some variation in the impact of characteristics over their range of values.

eg, log (Consumption) = (Household characteristics) b + error term

ie, $\ln C = Xb + e$,

where the notation ln indicates that natural logarithms have been taken of consumption.

The above specification is known as a 'semi-log' specification, because the dependent variable is specified in log form, while the explanatory variables are not. Once we transform the dependent variable in logs, we can treat the model as a linear regression. Hence, we retain the benefits of simplicity and transparency of the linear model.

This specification also imposes restrictions on the relationship between the dependent variable and the explanatory variables. For example, if we were to specify a semi-log relationship between electricity consumption and income, the percentage change in consumption arising from a given change in income is restricted to be the same for high and low consumption households (and high-income and low-income households). In some applications, these restrictions might be reasonable. In particular, the semi-log model provides a very simple method to allow the absolute level of consumption of high consumption households to respond more sensitively to changes in the explanatory variables.

B.2.2 Choosing the form best suited to forecasting exercises

Once we move away from the simple linear model to the semi-log model, forecasting exercises (ie, predictions) become more complex and require substantially more detailed data. To illustrate this, suppose that we are interested in the relationship between consumption (C) and the explanatory variables X_1 and X_2. Further, suppose X_1 is an indicator variable for households living in a detached house (it takes the value 1 if the dwelling type is a detached house, and 0 otherwise), and X_2 is household income. We could use a linear model of the form

Consumption = b_1 (live in a detached house) + b_2 (income) + error term

ie, $C = b_1X_1 + b_2X_2 + u$

We can estimate the model to obtain the parameters b_1 and b_2. Suppose we are interested in the average consumption for households living in detached houses. To pursue this, let us introduce some additional notation. Let

E[X] = the *expected value* or average of the variable X.

E[C|X=x] = the expected value of consumption for those observations for which the variable X takes the value x.

We are interested in the average consumption for those households who live in detached houses:

ie, Expected value of [Consumption for households in detached houses]

or $E[C \mid X_1 = 1]$

In the linear regression model, the only information we need for this calculation is the average income across those households living in detached houses. That is, from the assumptions of the linear regression model,

Expected value of [Consumption for households in detached houses]

= $b_1 + b_2$ [Expected value of income for households in detached houses]

ie, $E[C \mid X_1 = 1] = b_1 + b_2 E[X_2 \mid X_1 = 1]$.

Once we obtain the regression coefficients b_1 and b_2, we just need to calculate the average income across those households in detached houses and evaluate the above expression to obtain an estimate of average consumption for households living in detached houses.

Now, suppose instead that we adopt the semi-log model

Log of Consumption = b_1(live in a detached house) + b_2(income)+ error term

ie, $\ln C = b_1X_1 + b_2X_2 + u$

We can again estimate the model to obtain the parameters b_1 and b_2. However, our forecasting exercise is now more complicated and more data intensive. To see this, first notice that to reverse our log transformation, we must use an exponential transformation. That is, under the above semi-log model,

$C = \exp(b_1X_1 + b_2X_2 + u)$,

where exp is the exponential function.

We are then interested in the average consumption for households living in detached houses:

$E[C \mid X_1 = 1] = E[\exp(b_1X_1+b_2X_2+u) \mid X_1=1]$.

We can use the properties of the exponential function together with the assumptions of the regression model to show that

$E[C \mid X_1 = 1] = \exp(b_1) * E[\exp(b_2X_2) \mid X_1=1] * E[\exp(u)]$.

There are 2 challenging aspects to this expression. First, notice that the middle term is more involved than a simple calculation of average income for households living in detached houses. If dwelling type and income are correlated (as we would expect them to be), we now need additional information about the distribution of income, conditional on dwelling type for this calculation. Second, we also need to incorporate information about the empirical distribution of the error term to evaluate the last piece of this expression.

As we can see from the simple example above, even a simple specification like the semi-log model can quickly become too demanding of the data to perform forecasting exercises.

B.2.3 We used mainly simple linear models

In the body of the report we presented results for a linear model because this model provides a reasonable approximation of what we want to measure while being simple to interpret. Further, we wanted to provide representative calculations for different subsets of the population (including individual households) for which the kind of forecasting exercise describe above is required.

In the appendices for electricity, energy bills and water (respectively appendices C, E and G) we also presented some results for the semi-log model. We did this for 2 reasons. Firstly, the semi-log model acts as a simple check on the robustness of the linear model. In this regard, the results for the linear and semi-log models are quite similar.

Secondly, some readers may be interested in the semi-log results for their own sake. While the semi-log model is more difficult to use for forecasting, our analysis suggests that it performs at least as well as the linear model in explaining the nature of the relationship between consumption and household characteristics.

One particular issue that a semi-log model is better suited to deal with is heteroskedasticity. Heteroskedasticity occurs when the variance of the error term is not constant across observations, as assumed by the classical regression model. This is more of a problem for linear models because the relationship between consumption and the characteristics is actually a non-linear one. The issue of heteroskedasticity is discussed in Section B.3.4 below.

B.3 Regression modelling challenges we considered

Empirical settings rarely conform precisely to the assumptions of the classical linear regression model. Here, we detail some issues we considered and how we dealt with them in the report.

B.3.1 Sample biases

The report shows clearly that households differ markedly in how much energy and water they use, and for what purposes. Further, consumption differs systematically across households with different characteristics. Therefore, in order to generalise the regression results to the population from which the sample was drawn, it is important to deal with sample biases.

Biases in our survey samples and how we dealt with them

As is frequently the case in surveys of this type, our household survey samples were not truly representative. The main sample bias in both survey areas was an under-representation of households in flats and an over-representation of households in detached houses (Table B.1).

Table B.1 Surveyed households by dwelling type compared to the actual 2006 distribution of households by dwelling type (%)

	Survey data	2006 Census	Difference
Sydney 2010			
Detached house	77	64	12
Semi-detached dwelling	12	11	1
Flat/unit	11	24	-13
Hunter, Gosford and Wyong 2008			
Detached house	88	84	4
Semi-detached dwelling	10	9	1
Flat/unit	3	8	-5

Sources: 2010 and 2008 household survey data, ABS 2006 Census Quickstats and IPART calculations.

The problem with sample biases is that they can bias the regression coefficients. This can happen if households are missing from the sample for reasons that are related to their energy or water consumption (eg, if households living in flats are missing and if flats use less energy for space heating and cooling compared to detached houses). The (technical) reason for this has to do with the unobserved determinant of consumption, which we explain as follows.

We cannot hope to explain all of the energy or water consumption decisions of households, given the limitations of our data and the simplicity of our model. Therefore, there will necessarily be unobserved determinants of energy or water consumption (this is simply the error term in the regression model).

A maintained assumption of the regression model is that these unobserved determinants of consumption are uncorrelated with the model's explanatory variables. But if the reason that a household is missing from our sample is related to these unobserved determinants of consumption (eg, if households in flats require less space heating or cooling), then this could introduce correlation between our explanatory variables and the error term. In turn, this would lead to biased estimates of model parameters.

We minimised the unobserved determinants of consumption (ie, the error terms) by specifying relatively flexible models (ie, by including a fairly large number of explanatory variables). Clearly, one particular concern was to address the over-representation of detached houses in our samples. According, we specified models that account for the different decisions made by households in different types of housing in a relatively flexible manner. Most importantly, we included dwelling type as a variable in the regression models.

By accounting for dwelling type we go some way to controlling the extent of sample selection bias and the impact of this on the coefficients. Dwelling type is an important explanatory variable accounting for a non-trivial proportion of the variation in consumption. By controlling for dwelling type (among other household characteristics), we limit the unobserved determinants of consumption.[88]

As we discuss in the section below, we also allowed some of our explanatory variables to interact, increasing the flexibility of our models.

The randomness of Hunter, Gosford and Wyong (2008) survey data was further compromised by the fact that consumption data were available for only a proportion of the surveyed households.[89] In contrast, for Sydney (2010) we obtained a complete data set for almost 2,200 households. Partly for this reason, most our analysis relies on the 2010 household survey data rather than on the 2008 data.

Interaction terms to increase flexibility

To allow heterogeneity in household consumption patterns to enter more flexibly into a linear regression model, we also incorporated interaction terms between explanatory variables.

For example, households that live in detached houses also tend to have more occupants than households in semi-detached dwellings or flats. We took this relationship into account by including an additional variable that combines dwelling type and number of occupants. To see how this works, consider the following illustrative relationship,

Consumption = b_1(if live in a detached house) + b_2(number of occupants) + b3(number of occupants if live in a detached house) + error term

88 Of course, it is still possible that some bias remains due to selection into the sample. A more comprehensive solution would involve modelling the determinants of inclusion in the sample and incorporating this information in the regression specification in the manner of Heckman, J, 'Sample Selection Bias as a Specification Error', *Econometrica*, 47, 1979, pp 153-161. This approach was beyond the scope of the current study.

89 Electricity consumption data were obtained for 81% of households and gas consumption data for 74% of households with mains gas. Water consumption data were obtained for 92% of households in Hunter Water's area, 85% in Gosford and only 64% in Wyong (IPART, *Residential Energy and Water Use in the Hunter, Gosford and Wyong - Results from the 2008 survey*, December 2008, p 108).

ie, $C = X_1b_1 + X_2b_2 + X_1*X_2b_3 + u$

where C is electricity consumption, X_1 is an indicator variable taking the value of 1 if the household lives in a detached house (and 0 otherwise), and X_2 is the number of occupants in the household. The third term on the right hand side is the interaction between housing type and household size. This is simply the product of the variables X_1 and X_2. We can use this simple model to calculate predicted average consumption for different types of households.

Suppose we estimated the model, and obtained the parameters b_1, b_2, and b_3. We could then calculate the average consumption for households living in detached houses as follows:

$$E[C|X_1 = 1] = b_1 + b_2.E[X_2|X_1 = 1] + b_3.E[X_1*X_2|X_1 = 1]$$

$$= b_1 + (b_2+b_3).E[X_2|X_1 = 1]$$

ie, $b_1 + (b_2+b_3)$ x (the expected number of occupants of households in detached houses)

Notice that to make this conditional forecast, we need to explicitly consider the relationship between our explanatory variables. That is, we need to have information on average household size for the subset of households living in detached housing. This increases the data requirement of our forecasting exercise, but provides a model with a richer specification of heterogeneity between households.

We included interaction terms of this kind in our regression specifications. We retained these interaction terms if they had any explanatory power.[90] If they did not add significant additional explanatory power, we did not include them in our reported specifications.

B.3.2 Multicollinearity

The term 'multicollinearity' refers to the existence of explanatory variables in the model that are highly correlated. This can lead to the following symptoms:

- Coefficient estimates may be statistically insignificant even though the model may explain a considerable amount of the variation in the data.
- Small changes in the data or in the model specification may lead to dramatic changes in parameter estimates.
- Estimates of coefficients may be inaccurate, possibly even taking the wrong sign.

90 Statistical significance at the 10% level was sufficient for us to retain the interaction terms.

In most empirical settings, there is some correlation between explanatory variables. Consequently, some care needs to be taken when interpreting results (the discussion on interaction terms in section B.3.1 above provides an example of correlation). Multicollinearity arises when such correlation is sufficiently high to lead to the above symptoms.

We performed a number of formal and informal tests to probe the existence of multicollinearity. In particular, the Variance Inflation Factor (VIF) measures the contribution of the correlation between explanatory variables to the variance in a parameter estimate. We examined the VIF for all the coefficients in each of our models. We also examined the sensitivity of our parameter estimates to changes in the model specification and the data. We did not find evidence that multicollinearity is a substantial problem. (Nevertheless, in interpreting our results, it is always worthwhile considering the correlation between explanatory variables.)

B.3.3 Omitted variable bias

There are a multitude of factors that could potentially influence the energy or water consumption of a household. A parsimonious model cannot hope to include all such influences, nor are the data available from the surveys. Inevitably, some determinants of energy or water consumption will be missing. If some important explanatory variables are missing and these missing variables are correlated with explanatory variables in the model, then the model may suffer from omitted variable bias.

The classic regression model assumes that the error term is uncorrelated with the explanatory variables of the model. If important influences on energy consumption are not incorporated in the model, they will necessarily be subsumed in the error term. Therefore, if these factors are correlated with explanatory variables of interest, their omission will induce a correlation between the error term and the model's explanatory variables. In the classical regression model, this will lead to biased estimates of coefficients.

We employed a Ramsey Reset test to investigate whether important factors were omitted. The idea of the test is to examine whether the residuals can be explained by additional information not included in the original specification. The test uses powers of the fitted values of the dependent variable as proxies for omitted information.

Using this test, we found some evidence for omitted variables. Given the likely number of factors that explain energy or water consumption, this is not surprising. This will be an issue for our regression results if important omitted variables are correlated with the explanatory variables we use. Therefore, we need to exercise some care in interpreting our results, particularly where we suspect that important omitted information may be related to our set of explanatory variables.

As discussed in the report, where possible we used independent technical information as a test of the size of our coefficients. Where there are disparities, omitted variable bias is one possible explanation. We found evidence of this for some variables (eg, dishwashers and, to lesser extent, 2^{nd} fridges and washing machines).

To help deal with the problem of omitted variables we used 'proxy' variables from the survey where we could sensibly do this. For example, we use the number of bedrooms or indoor showers as a proxy for the size of the dwelling unit. Similarly, we included income and the number of adults and children in our 'energy uses' model to serve as proxies for factors such as the amount of hot water used, the capacity of appliances and the presence other appliances/amenities.

B.3.4 Heteroskedasticity

An assumption of the classical regression model is that errors from the model have a constant variance. The model is said to be heteroskedastic if the variance of the residuals are not constant across observations. We tested for heteroskedasticity using the Breusch-Pagan test. This test suggests some evidence for heteroskedasticity. This has 2 potential consequences.

First, estimates of the variance of parameters may be biased, thus affecting our statistical inferences. To examine this issue, we also calculated White heteroskedasticity consistent (commonly known as 'robust') standard errors. This calculation did not have a major impact on our estimates of the standard errors, suggesting that the implications for statistical inference are slight.

Second, in the presence of heteroskedasticity, parameter estimates may be inefficient. That is, we may not be getting the most information possible out of our data. One way to address this issue is to model the heterogeneity in the variance of observations directly, and account for this in estimation. This is the method of generalised least squares (GLS). Intuitively, we want to give less weight in estimation to observations exhibiting greater variance. Given the size of our data set, efficiency of estimation is not a great concern, and we have chosen not to estimate the model with GLS.

B.3.5 Missing information

Some of the households in our sample responded incompletely to the survey. The most common omission related to household income, with about 10% of households not providing this information. Plausibly, income is an important factor in a household's energy or water consumption choices. One possible response is to drop respondents who do not provide this information. However, we found that those households that omitted income information were systematically different from the average household. For example, these households have more adults and more bedrooms but fewer children than the average household. Therefore, omitting these households would lead to an inaccurate portrayal of average energy or water consumption behaviour.

To deal with this issue, we retained these households in our sample. We recorded their income as 0. We then created an indicator or 'dummy' variable recording the omission of income information. This variable was given a value of 1 for households with missing income information, and 0 for other households. The coefficient on this dummy variable then provides some information about how these households are different from other households.[91] For example, we used the coefficients for the 'characteristics' model (shown in Table 3.2 in the report) to estimate that, on average, a household that chose not to provide income information consumed about 330 kWh per annum more electricity than an otherwise similar household that reported an average income.

B.3.6 Measurement error

There are many factors that determine the energy and water consumption decisions of households. The choice of explanatory variables to use in our empirical models is constrained by data availability. Some of our explanatory variables are measured imprecisely or coarsely. For example, several of our explanatory variables are measured in bands. For Sydney (2010) income is reported in 9 bands, with the highest income band including all households earning more than $156,000 per annum. Similarly, our survey constrains the highest reported dishwasher use to be 6 or more times per week. In both of these cases the explanatory variables for some households will be mismeasured. Box B.1 discusses the variables that the surveys collected in bands and how we converted them to numerical values.

The problem of the mismeasurement of explanatory variables is called measurement error. The presence of measurement error leads to attenuation bias. That is, coefficient estimates tend to be biased towards zero. The extent of the attenuation bias depends on the extent of the measurement error (ie, the extent of the variation in the true explanatory variable that is mismeasured).

A potential remedy to the problem of measurement errors is to use instrumental variables estimation. This involves identifying factors that are correlated with the variable of interest (eg, income), but uncorrelated with the measurement error. In the absence of convincing instruments that satisfy these criteria, we have not accounted for measurement error. We do not believe measurement error is severe, but to the extent that it is present, it will likely result in an underestimation of the strength of the relationships we identify.

91 A more comprehensive solution to this issue would involve directly modelling the reasons for the omission of income information and incorporating this information in the regression model, in the manner of Heckman, J. (1979), "Sample Selection Bias as a Specification Error", *Econometrica*, 47, pp. 153-161.

Box B.1 How we converted survey responses to numerical values

Income

We asked about household income in 9 bands, and converted the survey responses to dollar values as follows:

- For the middle bands, we chose the mid-point of the range. For example, we assumed that a household had an income of $37,700 if the respondent said that their income was between $33,800 and $41,600 pa.
- For the lowest income band (less than $13,000 pa), we assumed a value of $10,000 pa.
- For the highest income band (more than $156,000 pa), we assumed a value of $190,000 pa.

Dishwashers, clothes dryers and washing machines

We also asked about appliance usage in bands, and converted the survey responses to values as follows:

- For the middle bands, we chose the mid-point of the range. For example, we assumed that a household used a dishwasher on average 3.5 times per week if they said that they used it 3-4 times per week.
- For using an appliance less than once per week we assigned a value of 0.5 times per week.
- For using a washing machine 6 or more times a week we assigned a value of 8 times per week. To select this value we used information from the ABS survey conducted in October 2006, *Domestic Water and Energy Use, New South Wales.*
- For using a dishwasher or a clothes dryer 6 or more times per week we assigned a value of 6.5 times per week. (Unfortunately the ABS survey did not provide information about the frequency of using these appliances).

Air conditioners

We asked a number of questions about using air conditioners, and used the responses to estimate for how many hours per annum each household used an air conditioner (if they had one).

We asked, separately for summer and winter:

- How often they used an air conditioner (from never to more than 4 days per week).
- For how many hours per day they typically used it on week days and on weekends/public holidays (from less than 2 hours to more than 20 hours).

To calculate the number of hours of usage per annum, we used the mid-point of each range and also assumed that:

- Summer and winter each lasted for 3 months of the year.
- Using an air conditioner less than once a month meant twice per season.
- Using an air conditioner more than 4 days per week meant on average 5 days per week.
- Using and air conditioner for more than 20 hours per day meant on average 21 hours per day.

B.3.7 Inconsistent survey responses and data entry errors

Survey respondents may not always provide accurate information. For example, respondents may not know what their combined annual household income is, or may be unwilling to report the full amount. Similarly, respondents may not know whether or not their electric hot water system is an off-peak (ie, Controlled Load) system (see Table 2.1). Also, some respondents may have misunderstood some questions. For example, some respondents seem to have been confused by the questions about the number of people who live at home, and their ages (see Box B.2).

In addition, there may have been data entry errors which have remained undetected.

We corrected inconsistencies in the data where we could make obvious corrections, and we deleted information that was clearly not sensible. We also used alternative data where we could, for example instead of the survey responses about having an off-peak hot water systems we used the presence of Controlled Load consumption (which we obtained from the electricity supplier) as a variable. But the data sets undoubtedly still contain some inaccurate information, which will have introduced some additional unexplained variation into the analysis.

Box B.2 Some examples of inconsistent survey responses

Inconsistencies in the reported number of people living at home

We asked respondents how many people lived at home, then we asked how many of them were over the age of 15 years and how many were 15 years or younger. Some respondents provided inconsistent answers, which may indicate that they misunderstood the questions. For example:

- A single person over the age over 64 years reported 1 person living at home. But she said that 4 people were older than 15 years. Perhaps she understood the second question to be about the number of people in her family.
- A couple with no children living at home and over 64 years of age reported 11 people aged 15 years or younger. Perhaps the respondent reported the number of her grandchildren.

Confusion about off-peak electric hot water systems

We asked households that had an electric hot water system whether this was an off-peak system, in other words whether their water was heated at night and they paid an off-peak (ie, Controlled Load) tariff for hot water. We were able to cross-check their responses with the Controlled Load consumption data that we obtained from the electricity agencies, because it is unlikely that a household with Controlled Load consumption has a standard electric hot water system as the main source for hot water.

When we compared the 2 sets of information for Sydney (2010), we found that:

- 21% of respondents who said they had a standard electric hot water system had consumption on a Controlled Load tariff.
- 7% of respondents who said they had an off-peak hot water system did not have any consumption on a Controlled Load tariff.
- 6% of respondents did not know whether they had standard electric or off-peak hot water systems, and of these 35% had consumption on a Controlled Load tariff.

Of course, some of the inconsistencies may have been due to data entry errors.

B.3.8 Causality

It is tempting to interpret regression results in a causal manner; that is, to infer that changes in the explanatory variables cause changes in the dependent variable. In general, we must exercise caution with respect to causality. Our regressions show an association between the dependent variable and the explanatory variables, but they do not, by themselves, imply a particular causal relationship.

At an abstract level, if 2 variables, let us call them A and B, are correlated, we can imagine several broad reasons for this. First, changes in A may induce changes in B. Second, changes in B may induce changes in A. Third, changes in A and B might both be caused by changes in some other related factor.

In some of the settings that we consider, we can plausibly distinguish between some of these different possible explanations. For example, in some of our regression analysis, we investigated the relationship between energy consumption and household characteristics such as household income and the size and composition of a household. In this setting, it is unlikely that energy consumption decisions have a causal impact on household structure and income.

Even in this setting it is difficult to distinguish quantitatively between the other 2 possibilities. For example, consider the relationship between energy consumption and dwelling type. Households in larger dwellings (detached houses and dwellings with a greater number of rooms) tend to consume more energy. It is likely that dwelling type has a causal impact on consumption. That is, households in larger dwellings consume more energy because they have more space to heat and cool, for example. However, it is also possible that the type of household that consumes more energy also tends to live in a larger dwelling. That is, there are some unmodeled characteristics of the household that influence both energy consumption and housing choices. This may explain some of the correlation between energy consumption and dwelling type. Notice that these different interpretations potentially have different policy implications. One interpretation suggests that increased dwelling sizes lead to increased energy use, while the other interpretation suggests that there is no such causal relationship, but that household preferences determine both energy use and dwelling type.

In Chapter 2 and in the section below we distinguish between household characteristics and 'use' variables. Inferring the causal relationship between energy or water consumption and 'use' variables is even more challenging. We used the independent technical information mentioned above to help guide our interpretation.

B.4 How we organised the explanatory variables

The household surveys provide a range of information about the factors that affect consumption, and we needed to decide how to meaningfully organise the information. We did this by analysing the underlying 'causes' of consumption, as well considering the usefulness of our analysis for policy purposes.

The amount of energy and water that a household uses depends on what amenities and appliances it has, the capacity and efficiency of these appliances and how frequently it uses them. In turn, what appliances and amenities a household has and how it uses them to a large extent depend on factors such as a household's income, the number of occupants, climate zone and type of dwelling.

To help our analysis we categorised our survey data into 3 groups:

1. Socio-economic and climate zone: the income and demographic characteristics of the household, including the number of occupants, the age structure and gross annual household income. We included the climate zone (ie, the location) in this category because we regard it to be a primary determinant of consumption.[92]
2. Dwelling-type: the characteristics of the dwelling, for example flat or detached house, the number of bedrooms, the number of bathrooms and access to mains gas. Note that for our purposes we limited the dwelling-type characteristics to those for which data are easily available for the general population, for example from ABS Census data.
3. Uses: what the household uses energy or water for, and its choices and behaviours. For example these include how often its occupants use an air conditioner and/or a dishwasher (if at all), what they use mains gas for (if at all) and if they water a garden. For the purposes of our analysis we include some characteristics that, for other purposes, might be categorised as dwelling characteristics, such as having a swimming pool.[93]

Unfortunately, our household surveys did not collect information about the capacity and efficiency of appliances and amenities, or about how well buildings are insulated. Therefore, we were unable to include these factors in our analysis.

In principle, the 'uses' characteristics (category 3) result in consumption, whereas socio-economic/climate zone (category 1) and dwelling-type (category 2) characteristics mainly 'cause' choices and behaviour rather than consumption. For example, the number of people in a household (category 1) will to a large extent determine how much hot water is used and how often a washing machine is used. Similarly, a household living in a detached house (category 2) in an inland area (category 1) is likely to choose a more powerful space heating system, and to use it more often, than an otherwise similar household living in a flat in coastal area.

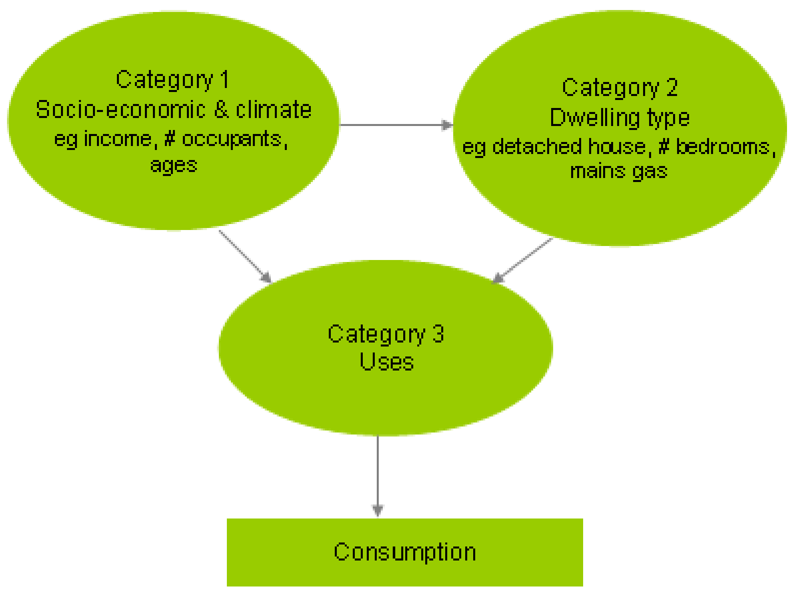
Furthermore, socio-economic characteristics (category 1) will to an extent determine dwelling-type characteristics (category 2). In other words, a household's income and demographic characteristics will partly determine the size and type of the dwelling it lives in.

92 A household's income and demographic characteristics may have some impact on where it chooses to live, particularly in the Sydney area. However, there are many other factors that determine where households choose to live, for example family and friendship ties, familiarity with an area and the location of jobs.

93 The distinction between dwelling type and 'uses' characteristics is not always clear. For example, how does one categorise items such as swimming pools, dual flush toilets and low-flow shower heads? The answers will to a large extent depend on the purpose of the analysis and whether a sort-term or a longer term view is taken.

Figure B.3 shows the relationships between the categories and consumption. Box B.3 discusses the relationship between socio-economic (category 1) and dwelling-type (category 2) characteristics for Sydney (2010). Chapters 3, 4 and 7 in the report discuss the relationship between 'use' characteristics (category 3) and socio-economic/climate and dwelling-type characteristics for electricity, gas and water respectively.

Figure B.3 Directions of causation between explanatory variables and consumption



Box B.3 How socio-economic characteristics 'determine' dwelling characteristics

We investigated the relationship between socio-economic (category 1) variables and dwelling-type (category 2) variables for Sydney (2010). We did this by running regressions in which one of the dwelling-type (category 2) variables became the 'dependant' variable and the socio-economic (category 1) variables became the 'explanatory' variables.

We specified the following models:

1. Live in a detached house = f(number of adults, number of children, income, location)
2. Number of bedrooms = f(number of adults, number of children, income, location)

We included a location variable (coastal or inland) because the housing stock differs between inland and coastal areas, and we wanted to isolate the impact of occupants and income on the 'dependent' variable.

We did not specify a model for access to mains gas because this depends mainly on where the gas pipelines are, rather than on socio-economic or dwelling characteristics. Chapter 4 discusses who uses gas.

We found that:

- The probability of living in a detached house is very strongly related to the number of adults in the household and positively (but less strongly) related to the number of children (Wald scores are respectively 138.8 and 8.0). There was a negative relationship between income and living in a detached house (Wald score = 5.1). There are probably 2 reasons for the latter finding. Firstly, many retired couples and single dwellers living on pensions still live in the (detached) family home. Secondly, many high-income households prefer to live nearer the main coastal commercial centres where there is a higher concentration of flats and semi-detached dwellings. As expected, there was a strong negative relationship between living in a detached house and living in a coastal area.
- The number of bedrooms depends very strongly on the number of adults in the household (t-value = 20.1), but also on the number of children (t-value=5.2) and the level of income (t-value = 5.5). There is a strong negative relationship between the number of bedrooms and living in a coastal area (t-value = -6.7), which is to be expected given the higher concentration of flats and semi-detached dwellings in these areas. (R^2 = 25%.)

We also note that there is a fairly strong positive relationship between household income and the number of people, particularly adults (both of which are category 1 variables). (T-values are 14.5 for adults and 8.1 for children, R^2 = 12%)

C Detailed regression results for electricity

Chapter 3 discusses the determinants of electricity consumption. The tables below provide the detailed regression results that informed the discussion.

As discussed in Appendix B, for our linear regressions we excluded households that used more than 25,000 kWh per annum. We included all households when looking at the relationships between the explanatory variables.

The results are organised as follows:

- Section C1 shows the linear regression results for the 'characteristics' model for Sydney (2010) and Hunter, Gosford and Wyong (2008). (See section 3.2.)
- Section C2 shows the linear regression results for the 'energy uses' model for Sydney (2010) and Hunter, Gosford and Wyong (2008). (See section 3.4.)
- Section C3 shows the semi-log regression results for the 'characteristics' model and 'energy uses' model for Sydney (2010). The section also compares the semi-log results with the linear regression results.
- Section C4 shows the regression results for the relationship between household characteristics and selected uses for electricity, for Sydney (2010). (See section 3.3.)

C.1 Linear regression results for the 'characteristics' model

The tables below show the detailed regression results that informed the discussion in Section 3.2 about the relationship between household characteristics and electricity consumption.

Table C.1 Linear regression results for 'characteristics' model, Sydney (2010) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,116	265		4.20	0.00	595	1,636		
Detached house	1,470	197	0.15	7.47	0.00	1,084	1,856	0.70	1.43
Per bedroom	892	84	0.23	10.64	0.00	728	1,057	0.60	1.66
Per adult	896	78	0.22	11.48	0.00	743	1,050	0.72	1.39
Per child	749	86	0.15	8.66	0.00	579	918	0.94	1.06
Income, per $'000	16.5	1.6	0.22	10.48	0.00	13.4	19.6	0.64	1.57
No income data	1,566	246	0.12	6.38	0.00	1,084	2,048	0.75	1.33
Use mains gas	-2,210	144	-0.26	-15.40	0.00	-2,491	-1,928	0.94	1.06
Coastal area	-368	148	-0.04	-2.49	0.01	-658	-79	0.90	1.11

Note: Households with consumption of more than 25,000 kWh per annum are excluded (16 households).

Table C.2 Linear regression results for 'characteristics' model, Hunter, Gosford and Wyong (2008) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,818	351		5.19	0.00	1,130	2,505		
Detached house	659	220	0.05	3.00	0.00	228	1,090	0.86	1.16
Per bedroom	618	91	0.14	6.82	0.00	440	795	0.69	1.44
Per adult	1,355	87	0.31	15.63	0.00	1,185	1,525	0.72	1.38
Per child	896	76	0.21	11.79	0.00	747	1,045	0.90	1.11
Income, per $'000	17.7	1.8	0.20	9.83	0.00	14.1	21.2	0.67	1.49
No income data	1,094	251	0.08	4.36	0.00	602	1,585	0.84	1.19
Use mains gas	-2,247	151	-0.26	-14.91	0.00	-2,543	-1,951	0.97	1.03
Coastal area	-405	231	-0.03	-1.75	0.08	-858	48	0.98	1.02

Note: Households with consumption of more than 25,000 kWh per annum are excluded (6 households).

C.2 Linear regression results for 'energy uses' model

The tables below show the detailed regression results that informed the discussion in Section 3.4 about the relationship between electricity consumption and what it is used for.

Table C.3 Linear regression results for 'energy uses' model, Sydney (2010) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,275	238		5.35	0.00	807	1,742		
Detached house	679	168	0.07	4.04	0.00	349	1,008	0.65	1.53
Per bedroom	555	71	0.14	7.80	0.00	415	694	0.57	1.75
Per adult	812	65	0.20	12.47	0.00	684	940	0.70	1.42
Per child	522	72	0.10	7.22	0.00	380	664	0.92	1.08
Income, per $'000	7.7	1.4	0.1	5.6	0.0	5.0	10.3	0.6	1.7
No income data	886	205	0.07	4.32	0.00	483	1,288	0.74	1.36
Have pool	2,520	161	0.23	15.67	0.00	2,204	2,835	0.88	1.13
Have 2nd fridge	1,171	125	0.14	9.34	0.00	925	1,417	0.85	1.18
Have spa	959	241	0.06	3.98	0.00	486	1,431	0.97	1.04
Clothes dryer, per use per week	290	45	0.09	6.41	0.00	201	378	0.92	1.08
Dishwasher, per use per week	309	27	0.18	11.46	0.00	256	362	0.74	1.36
Aircon, per hour	2.5	0.2	0.18	12.67	0.00	2.1	2.9	0.91	1.10
Gas hot water	-2,762	126	-0.32	-21.97	0.00	-3,009	-2,516	0.89	1.13
Solar hot water	-1,397	231	-0.09	-6.04	0.00	-1,850	-943	0.92	1.08
Other electric heating	322	134	0.03	2.40	0.02	59	586	0.92	1.09
Coastal area	-342	124	-0.04	-2.76	0.01	-584	-99	0.88	1.14

Note: Households with consumption of more than 25,000 kWh per annum are excluded (16 households).

Table C.4 Linear regression results for 'energy uses' model, Hunter, Gosford and Wyong (2008) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,748	320		5.47	0.00	1,121	2,375		
Detached house	478	191	0.04	2.50	0.01	104	853	0.85	1.18
Per bedroom	336	80	0.08	4.18	0.00	178	494	0.65	1.53
Per adult	1,038	76	0.24	13.58	0.00	888	1,188	0.69	1.44
Per child	610	69	0.14	8.84	0.00	475	745	0.81	1.23
Income, per $'000	8.7	1.6	0.1	5.4	0.0	5.5	11.8	0.6	1.6
No income data	770	218	0.06	3.53	0.00	342	1,199	0.82	1.22
Have pool	2,269	180	0.20	12.57	0.00	1,915	2,622	0.87	1.15
Have 2nd fridge	756	123	0.10	6.15	0.00	515	997	0.86	1.16
Have spa	1,680	272	0.09	6.18	0.00	1,147	2,214	0.98	1.02
Clothes dryer, per use per week	327	42	0.12	7.74	0.00	244	410	0.85	1.18
Dishwasher, per use per week	220	28	0.13	7.98	0.00	166	274	0.75	1.33
Aircon, per hour	2.5	0.2	0.17	11.40	0.00	2.1	2.9	0.93	1.08
Gas hot water	-2,846	146	-0.29	-19.47	0.00	-3,133	-2,560	0.94	1.06
Solar hot water	-1,685	295	-0.08	-5.71	0.00	-2,264	-1,106	0.97	1.03
Other electric heating	-24	122	0.00	-0.20	0.84	-264	215	0.92	1.09
Coastal area	213	203	0.02	1.05	0.30	-186	611	0.94	1.06

Note: Households with consumption of more than 25,000 kWh per annum are excluded (16 households).

C.3 Semi-log regression results for characteristics and 'energy uses' models for Sydney (2010)

As noted in Box 2.1 and discussed in Appendix B, we used a semi-log regression model to check the results of our linear regression model. To do this, for each explanatory variable we compared the 2 models' estimated contribution to consumption as well as the t-values. We found a fairly high degree of consistency between the 2 types of model, despite the problems associated with translating the semi-log regression coefficients into kWh contributions (discussed in Appendix B). Appendix B explains why we included an additional variable in the semi-log model (house x number of people).

The first 2 tables below show the semi-log regression results for the 'characteristics' model and the 'energy uses' model respectively. The next 2 tables compare the results of the semi-log model with those of the linear model, for the 'characteristics' model and the 'energy uses' model respectively.

Table C.5 Semi-log regression results for 'characteristics' model, Sydney (2010) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	7.747	0.051	0.00	151.37	0.00	7.646	7.847	0.00	0.00
Detached house	0.385	0.052	0.27	7.42	0.00	0.283	0.487	0.20	4.88
House x # people[a]	-0.053	0.020	-0.15	-2.59	0.01	-0.093	-0.013	0.08	12.88
Per bedroom	0.119	0.012	0.21	9.95	0.00	0.095	0.142	0.60	1.68
Per adult	0.182	0.021	0.32	8.73	0.00	0.141	0.223	0.20	5.02
Per child	0.142	0.021	0.19	6.77	0.00	0.101	0.183	0.32	3.08
Income, per $'000	0.002	0.000	0.20	10.03	0.00	0.002	0.003	0.64	1.57
No income data	0.221	0.035	0.12	6.30	0.00	0.152	0.290	0.75	1.34
Use mains gas	-0.345	0.021	-0.28	-16.80	0.00	-0.385	-0.304	0.94	1.06
Coastal area	-0.042	0.021	-0.03	-2.01	0.04	-0.084	-0.001	0.90	1.11

[a] This variable is included to correct for the over-representation of detached houses in the sample. (See Appendix B.)

Table C.6 Semi-log regression results for 'energy uses' model, Sydney (2010) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	7.735	0.045	0.00	171.55	0.00	7.647	7.824	0.00	0.00
Detached house	0.297	0.044	0.21	6.70	0.00	0.210	0.384	0.20	4.99
House x # people[a]	-0.065	0.017	-0.19	-3.76	0.00	-0.099	-0.031	0.08	12.95
Per bedroom	0.073	0.010	0.13	7.02	0.00	0.052	0.093	0.57	1.77
Per adult	0.181	0.018	0.32	10.23	0.00	0.147	0.216	0.20	5.07
Per child	0.126	0.018	0.17	7.10	0.00	0.091	0.160	0.32	3.10
Income, per $'000	0.001	0.000	0.09	5.01	0.00	0.001	0.001	0.57	1.75
No income data	0.125	0.030	0.07	4.17	0.00	0.066	0.184	0.73	1.37
Have pool	0.289	0.023	0.18	12.33	0.00	0.243	0.335	0.88	1.14
Have 2nd fridge	0.185	0.018	0.15	10.10	0.00	0.149	0.221	0.85	1.18
Have spa	0.138	0.035	0.06	3.97	0.00	0.070	0.206	0.96	1.04
Clothes dryer, per use per week	0.046	0.007	0.10	7.02	0.00	0.033	0.059	0.92	1.09
Dishwasher, per use per week	0.042	0.004	0.17	10.56	0.00	0.034	0.049	0.73	1.37
Aircon, per hour	0.000	0.000	0.18	12.27	0.00	0.000	0.000	0.91	1.10
Gas hot water	-0.422	0.018	-0.33	-22.95	0.00	-0.458	-0.386	0.89	1.13
Solar hot water	-0.177	0.034	-0.07	-5.25	0.00	-0.244	-0.111	0.92	1.08
Other electric heating	0.051	0.020	0.04	2.58	0.01	0.012	0.089	0.92	1.09
Coastal area	-0.044	0.018	-0.04	-2.44	0.01	-0.079	-0.009	0.88	1.14

[a] This variable is included to correct for the over-representation of detached houses in the sample. (See Appendix B.).

Table C.7 Comparison of semi-log and linear 'characteristics' model outputs, Sydney (2010) – kWh pa

Data set	**Sydney (2010)**			**Sydney (2010)**		
Type of regression model	**Semi-log**			**Linear[a]**		
	kWh pa	**(t-value)**	**$ pa[b]**	**kWh pa**	**(t-value)**	**$ pa[b]**
% of variation explained (R^2)	43			41		
Sample size	2,182			2,166		
Regression results in volumes (kWh pa)						
Live in a detached house	1,479	(7.4)	335	1,470	(7.5)	333
Per bedroom	730	(10.0)	165	892	(10.6)	202
Per adult (16 years or older)	1,001	(8.7)	227	896	(11.5)	203
Per child	753	(6.8)	171	749	(8.7)	170
Per $10,00 income pa	130	(10.0)	30	165	(10.5)	37
Did not provide income data	1,397	(6.3)	317	1,566	(6.4)	355
Use mains gas	-2,000	(-16.8)	-453	-2,210	(-15.4)	-501
Live in a coastal area	-245	(-2.0)	-56	-368	(-2.5)	-84

a Households with consumption of more than 25,000 kWh per annum are excluded (16 households).
b Calculated using EnergyAustralia's regulated 2011/12 block 1 tariff including GST (ie, 22.66c/kWh x kWh).

Table C.8 Comparison of semi-log and linear 'energy uses' model outputs, Sydney (2010) – kWh pa

Data set	Sydney (2010)			Sydney (2010)		
Type of regression model	Semi-log			Linear[a]		
	kWh pa	t-value	$ pa[b]	kWh pa	t-value	$ pa[b]
% of variation explained (R^2)	60			59		
Sample size	2,173			2,157		
Have a swimming pool	1,803	(12.3)	410	2,520	(15.7)	570
Have a 2nd fridge	1,051	(10.1)	240	1,171	(9.3)	270
Have a spa	828	(4.0)	190	959	(4.0)	220
Per 280 hours of air conditioner use	549	(12.3)	120	691	(12.7)	160
Clothes dryer – used once per week	264	(7.0)	60	290	(6.4)	70
Dishwasher - used once per week	239	(10.6)	50	309	(11.5)	70
Use electricity for space heating other than air conditioner	288	(2.6)	70	322	(2.4)	70
Live in a detached house	767	(6.7)	170	679	(4.0)	150
Per bedroom	424	(7.0)	100	555	(7.8)	130
Per adult (16 years or older)	927	(10.2)	210	812	(12.5)	180
Per child	580	(7.1)	130	522	(7.2)	120
Per $10,000 income per annum	56	(5.0)	10	77	(5.6)	20
Did not provide income data	740	(4.2)	170	886	(4.3)	200
Mains source for hot water is gas	-2,268	(-22.9)	-510	-2,762	(-22.0)	-630
Mains source for hot water is solar	-924	(-5.3)	-210	-1,397	(-6.0)	-320
Live in a coastal area	-248	(-2.4)	-60	-342	(-2.8)	-80

a Household with consumption of more than 25,000 kWh per annum are excluded (16 households).
b Calculated using EnergyAustralia's 2011/12 block 1 tariff of 22.66c/kWh multiplied by the consumption volumes.

C.4 Relationships between households characteristics and what electricity is used for

In Chapter 3 we identified some of the underlying reasons for the observed relationships between household characteristic and electricity consumption (section 3.3). The tables below show the detailed regression results that informed the discussion.

C.4.1 Relationship between having a swimming pool and household characteristics

Having a swimming pool is the dependent variable and the household characteristics are the explanatory variables. The results show that having a swimming pool is associated with living in a detached house, having more bedrooms, having a higher income and, to a lesser extent, having more children. But household characteristics explain no more than 16% of the variation between households.

Table C.9 Relationship between having a swimming pool and household characteristics – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	1.352	.215	39.506	1	0.000	3.866
# bedrooms	.372	.071	27.065	1	0.000	1.450
# adults	-.024	.065	.141	1	0.708	.976
# children	.125	.068	3.340	1	0.068	1.133
Income ($'000 pa)	.008	.001	33.703	1	0.000	1.008
No income data	.765	.226	11.478	1	0.001	2.148
Coastal	.003	.133	.000	1	0.985	1.003
Constant	-4.733	.278	289.810	1	0.000	.009

Note: Binary logistic regression.

Table C.10 Relationship between having a swimming pool and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1,822	0.099	0.162

C.4.2 Relationship between having a 2nd fridge and household characteristics

Having a 2nd fridge is the dependent variable and the household characteristics are the explanatory variables. The results show that having a 2nd fridge is strongly associated with living in a detached house, having more bedrooms and having more adults. There is also a weak association between having a 2nd fridge and a higher income. But household characteristics explain no more than 18% of the variation between households.

Table C.11 Relationship between having a 2nd fridge and household characteristics – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	1.173	.132	78.746	1	0.000	3.233
# bedrooms	.279	.057	24.098	1	0.000	1.322
# adults	.187	.054	12.203	1	0.000	1.206
# children	-.047	.056	.705	1	0.401	.954
Income ($'000 pa)	.002	.001	2.474	1	0.116	1.002
No income data	.194	.162	1.441	1	0.230	1.214
Coastal	-.052	.096	.290	1	0.590	.949
Constant	-2.197	.188	136.395	1	0.000	.111

Note: Binary logistic regression.

Table C.12 Relationship between having a 2nd fridge and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2,698	0.133	0.178

C.4.3 Relationship between having a spa and household characteristics

Having a spa is the dependent variable and the household characteristics are the explanatory variables. The results show that having a spa is strongly associated with living in a detached house and with having more bedrooms, more adults and a higher income. But household characteristics explain less than 10% of the variation between households.

Table C.13 Relationship between having a spa and household characteristics – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	.583	.322	3.274	1	0.070	1.791
# bedrooms	.340	.096	12.489	1	0.000	1.405
# adults	.167	.081	4.230	1	0.040	1.182
# children	-.016	.101	.026	1	0.873	.984
Income ($'000 pa)	.003	.002	3.682	1	0.055	1.004
No income data	.319	.315	1.026	1	0.311	1.376
Coastal	.133	.183	.530	1	0.467	1.142
Constant	-5.187	.404	165.015	1	0.000	.006

Note: Binary logistic regression.

Table C.14 Relationship between having a spa and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	991	0.027	0.071

C.4.4 Relationship between air conditioners and household characteristics

In next 2 tables, *having* an air conditioner is the dependent variable and the household characteristics are the explanatory variables (Tables C17 and C18). In the subsequent 2 tables, *using* and air conditioner is the dependent variable (Tables C19 and C20).

The results show that a *having* an air conditioner is associated with living in an inland area, living in a detached house and having more bedrooms. There would appear to be no relationship between having an air conditioner and income.

Similarly, *using* an air conditioner is associated with living in an inland area, living in a detached house and having more bedrooms. But, unlike having an air conditioner, using one is positively associated with having a higher income. In other words, the results suggest that higher income households are likely to *use* an air conditioner more frequently than lower income households, even though they are no more likely to have one.

But household characteristics explain no more than 16% of the variation in ownership between households and less than 5% of the variation in usage.

Table C.15 Relationship between having an air conditioner and household characteristics – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	.403	.128	9.856	1	0.002	1.497
# bedrooms	.296	.059	25.000	1	0.000	1.345
# adults	-.065	.054	1.464	1	0.226	.937
# children	.039	.060	.418	1	0.518	1.040
Income ($'000 pa)	.000	.001	.030	1	0.863	1.000
No income data	.216	.169	1.641	1	0.200	1.241
Coastal	-1.105	.097	128.859	1	0.000	.331
Constant	-.093	.177	.278	1	0.598	.911

Note: Binary logistic regression.

Table C.16 Relationship between having an air conditioner and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2,588	0.113	0.155

Table C.17 Relationship between using an air conditioner and household characteristics – regression results (hours)

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	142.6	24.4		5.84	0.00	94.7	190.5		
Detached house	43.7	18.3	0.06	2.38	0.02	7.8	79.7	0.70	1.43
Per bedroom	9.3	7.8	0.03	1.20	0.23	-6.0	24.6	0.60	1.68
Per adult	-3.5	7.2	-0.01	-0.49	0.62	-17.7	10.6	0.71	1.40
Per child	10.6	8.0	0.03	1.33	0.18	-5.0	26.3	0.95	1.06
Income, per $'000	0.4	0.1	0.07	2.64	0.01	0.1	0.7	0.64	1.55
No income data	42.2	22.9	0.04	1.84	0.07	-2.7	87.1	0.75	1.34
Coastal area	-108.8	13.6	-0.17	-8.01	0.00	-135.4	-82.1	0.93	1.08

Note: Linear regression. Including all households, whether or not they have an air conditioner.

Table C.18 Relationship between using an air conditioner and household characteristics – model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.219	0.048	0.045	304

C.4.5 Relationship between dishwashers and household characteristics

In next 2 tables, *having* a dishwasher is the dependent variable and the household characteristics are the explanatory variables (Tables C21 and C22). In the subsequent 2 tables, *using* a dishwasher is the dependent variable (Tables C23 and C24).

The results show that having a dishwasher is associated with having a higher income and more bedrooms. Dishwashers are also more common in coastal areas.

In contrast to air conditioners, we found a strong relationship between income and both having and using a dishwasher (Table C.21 and Table C23). The relationship between dishwashers and income is far stronger than the relationship between dishwashers and the number of people in the household. Our results suggest that having and using dishwasher tends to be a high-income phenomenon.

Household characteristics explain about 20% of the variation between households in both having and using a dishwasher.

Table C.19 Relationship between having a dishwasher and household characteristics – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	.039	.135	.086	1	0.770	1.040
# bedrooms	.612	.064	91.620	1	0.000	1.843
# adults	-.099	.055	3.192	1	0.074	.906
# children	-.038	.060	.402	1	0.526	.962
Income ($'000 pa)	.015	.001	144.438	1	0.000	1.015
No income data	1.147	.163	49.349	1	0.000	3.149
Coastal	.477	.101	22.290	1	0.000	1.611
Constant	-2.852	.202	200.059	1	0.000	.058

Note: Binary logistic regression.

Table C.20 Relationship between having a dishwasher and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2,545	0.180	0.242

Table C.21 Relationship between using a dishwasher and household characteristics – regression results (days per week)

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	-1.32	0.18		-7.46	0.00	-1.67	-0.98		
Detached house	0.27	0.13	0.05	2.06	0.04	0.01	0.53	0.70	1.42
Per bedroom	0.39	0.06	0.17	6.86	0.00	0.28	0.50	0.60	1.68
Per adult	0.16	0.05	0.07	2.99	0.00	0.05	0.26	0.71	1.40
Per child	0.32	0.06	0.11	5.47	0.00	0.20	0.43	0.95	1.06
Income, per $'000	0.02	0.00	0.34	14.39	0.00	0.01	0.02	0.64	1.55
No income data	1.04	0.17	0.14	6.25	0.00	0.71	1.36	0.75	1.34
Coastal area	0.49	0.10	0.10	5.00	0.00	0.30	0.69	0.93	1.08

Note: Linear regression. Including all households, whether or not they have a dishwasher.

Table C.22 Relationship between using a dishwasher and household characteristics – model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.474	0.225	0.222	2.203

C.4.6 Relationship between clothes dryers and household characteristics

In next 2 tables, *having* a clothes dryer is the dependent variable and the household characteristics are the explanatory variables (Tables C25 and C26). In the subsequent tables, *using* a clothes dryer is the dependent variable (Tables C27 and C28).

Our findings suggest that while households living in detached houses are *more* likely to *have* a clothes dryer, they are *less* likely to frequently *use* one. The explanation for this might be that these households are also more likely to have an outdoor hanging area, and therefore to use their clothes dryer only irregularly.

Like for dishwashers, we found a strong relationship between income and both having and using a clothes dryer. Again, our results suggest that having and using a clothes dryer tends to be a high-income phenomenon. But household characteristics explain only about 5% of the variation between households in both having and using a clothes dryer. Like for air conditioners, there are clearly many other factors involved in these decisions.

Table C.23 Relationship between having a clothes dryer and household characteristics – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	.322	.129	6.229	1	0.013	1.381
# bedrooms	.067	.057	1.371	1	0.242	1.069
# adults	.045	.055	.681	1	0.409	1.046
# children	.033	.061	.296	1	0.586	1.034
Income ($'000 pa)	.008	.001	46.678	1	0.000	1.008
No income data	.390	.162	5.815	1	0.016	1.476
Coastal	-.118	.099	1.423	1	0.233	.889
Constant	-.283	.177	2.554	1	0.110	.754

Note: Binary logistic regression.

Table C.24 Relationship between having a dishwasher and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2,602	0.046	0.065

Table C.25 Relationship between using a clothes dryer and household characteristics – regression results (days per week)

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	0.40	0.11		3.79	0.00	0.19	0.61		
Detached house	-0.18	0.08	-0.06	-2.31	0.02	-0.34	-0.03	0.70	1.42
Per bedroom	0.00	0.03	0.00	-0.14	0.89	-0.07	0.06	0.60	1.67
Per adult	0.12	0.03	0.09	3.80	0.00	0.06	0.18	0.71	1.40
Per child	0.16	0.03	0.10	4.57	0.00	0.09	0.23	0.95	1.06
Income, per $'000	0.00	0.00	0.15	5.80	0.00	0.00	0.00	0.65	1.55
No income data	0.21	0.10	0.05	2.11	0.03	0.01	0.40	0.75	1.33
Coastal area	0.08	0.06	0.03	1.43	0.15	-0.03	0.20	0.93	1.08

Note: Linear regression. Including all households, whether or not they have a clothes dryer.

Table C.26 Relationship between using a clothes dryer and household characteristics – model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.228	0.052	0.049	1.311

D Detailed regressions results for gas

Chapter 4 discusses the determinants of gas consumption. The tables below provide the detailed regression results that informed the discussion.

As discussed in Appendix B, for our linear regressions we excluded households that used more than 80,000 MJ per annum. We did not do semi-log regression modelling for gas.

The results are organised as follows:

- Section D1 shows the relationships between household characteristics and using mains gas. (See section 4.1.)
- Section D2 shows the linear regression results for the 'characteristics' model. (See section 4.2.)
- Section D3 shows the linear regression results for the relationship between gas consumption and what gas is used for. (See section 4.3.)
- Section D4 shows the linear regression results for the 'energy uses' model. (See section 4.4.)

Each section shows the results for both Sydney (2010) and Hunter, Gosford and Wyong (2008).

D.1 Relationship between using mains gas and household characteristics

As discussed in section 4.1, whether or not a household uses mains gas depends to a large extent on whether or not it has access to a gas pipeline (ie, a gas main). However, we also used regression analysis to gain some understanding of the geographic and socio-economic profile of households that use gas. The tables below show the detailed regression results that informed the discussion about who uses mains gas.

Table D.1 Relationship between using mains gas and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Live in a flat	-.475	.147	10.482	1	.001	.622
# adults	.086	.046	3.497	1	.061	1.090
# children	.120	.054	4.848	1	.028	1.127
Income ($'000 pa)	.005	.001	28.283	1	.000	1.005
No income data	.332	.153	4.665	1	.031	1.393
Coastal	.697	.092	57.643	1	.000	2.007
Constant	-.854	.126	45.925	1	.000	.426

Note: Binary logistic regression.

Table D.2 Relationship between using mains gas and household characteristics, Sydney (2010) – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2,896	.057	.077

Table D.3 Relationship between using mains gas and household characteristics, Hunter, Gosford and Wyong (2008) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Live in a flat	-.035	.161	.049	1	.826	.965
# adults	.136	.052	6.982	1	.008	1.146
# children	.064	.046	1.926	1	.165	1.066
Income ($'000 pa)	.005	.001	24.285	1	.000	1.005
No income data	.297	.162	3.387	1	.066	1.346
Coastal	-.625	.138	20.490	1	.000	.535
Constant	-.969	.167	33.682	1	.000	.380

Note: Binary logistic regression.

Table D.4 Relationship between using mains gas and household characteristics, Hunter, Gosford and Wyong (2008) – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	3,052	.028	.041

D.2 Linear regression results for the 'characteristics' model

The tables below show the detailed regression results that informed the discussion in Section 4.2 about the relationship between household characteristics and gas consumption. As explained in Section 4.2, we ran regressions for Sydney (2010) using either the number of bedrooms or the number of indoor showers. We excluded households that used more than 80,000 MJ per annum (discussed in Appendix B).

Table D.5 Regression results for 'characteristics' model using number of bedrooms, Sydney (2010) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	4,381	1,417		3.09	0.00	1,601	7,162		
Detached house	2,833	1,004	0.09	2.82	0.00	863	4,804	0.74	1.35
Per bedroom	276	432	0.02	0.64	0.52	-571	1,123	0.61	1.64
Per adult	3,542	387	0.29	9.15	0.00	2,782	4,301	0.74	1.35
Per child	2,032	424	0.13	4.79	0.00	1,199	2,865	0.93	1.08
Income, per $'000	33.4	7.6	0.15	4.37	0.00	18.4	48.4	0.64	1.56
No income data	1,217	1,300	0.03	0.94	0.35	-1,334	3,769	0.73	1.37
Coastal area	-1,229	739	-0.05	-1.66	0.10	-2,680	221	0.93	1.08

Note: Households with consumption of more than 80,000 MJ per annum are excluded (4 households).

Table D.6 Regression results for 'characteristics' model using number of indoor showers, Sydney (2010) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,979	1,237		1.60	0.11	-448	4,405		
Detached house	2,945	906	0.09	3.25	0.00	1,167	4,724	0.90	1.11
Per shower	1,530	526	0.08	2.91	0.00	497	2,563	0.87	1.15
Per adult	3,371	373	0.27	9.04	0.00	2,639	4,102	0.79	1.26
Per child	2,006	420	0.13	4.78	0.00	1,183	2,830	0.94	1.06
Income, per $'000	30.9	7.6	0.14	4.06	0.00	15.9	45.8	0.64	1.55
No income data	847	1,297	0.02	0.65	0.51	-1,698	3,393	0.73	1.38
Coastal area	-1,298	736	-0.05	-1.76	0.08	-2,741	145	0.93	1.07

Note: Households with consumption of more than 80,000 MJ per annum are excluded (4 households).

Table D.7 Regression results for 'characteristics' model using number of indoor showers, Hunter, Gosford and Wyong (2008) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	6,544	1,820		3.60	0.00	2,969	10,118		
Detached house	-239	1,574	-0.01	-0.15	0.88	-3,330	2,853	0.95	1.06
Per shower	377	755	0.02	0.50	0.62	-1,106	1,861	0.86	1.16
Per adult	3,753	511	0.31	7.34	0.00	2,748	4,757	0.78	1.28
Per child	3,007	491	0.24	6.13	0.00	2,043	3,971	0.91	1.10
Income, per $'000	19	12	0.08	1.61	0.11	-4	42	0.64	1.57
No income data	2,251	1,733	0.06	1.30	0.19	-1,153	5,655	0.77	1.30
Coastal area	40	1,259	0.00	0.03	0.97	-2,432	2,513	0.97	1.03

Note: No household had consumption of more than 80,000 MJ per annum.

D.3 Linear regression results for what gas is used for

In Section 4.3 we identified the relationship between gas consumption and what gas is used for (ie, cooking, space heating and hot water). We did this before we specified a 'energy uses' model in section 4.4. The tables below show the detailed regression results that informed the discussion in section 4.3. Again, we excluded households that used more than 80,000 MJ per annum.

Table D.8 Regression results for what gas is used for, Sydney (2010) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	5,300	1,067		4.97	0.00	3,206	7,394		
Cooking	2,686	937	0.08	2.87	0.00	848	4,524	0.96	1.04
Hot water	10,254	839	0.34	12.22	0.00	8,607	11,900	0.96	1.05
Heating, gas only	7,536	837	0.27	9.00	0.00	5,894	9,177	0.84	1.19
Heating, gas and electricity	5,350	899	0.18	5.95	0.00	3,585	7,114	0.84	1.19

Note: Households with consumption of more than 80,000 MJ per annum are excluded (4 households).

Table D.9 Regression results for what gas is used for, Hunter, Gosford and Wyong (2008) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	2,568	1,229		2.09	0.04	154	4,983		
Cooking	1,693	1,044	0.06	1.62	0.11	-358	3,743	0.89	1.12
Hot water	12,994	988	0.49	13.15	0.00	11,054	14,935	0.89	1.13
Heating, gas only	7,038	1,171	0.25	6.01	0.00	4,739	9,337	0.74	1.35
Heating, gas and electricity	7,042	971	0.30	7.25	0.00	5,135	8,948	0.73	1.37

Note: No households used more than 80,000 MJ per annum.

D.4 Linear regression results for the 'energy uses' model

The tables below show the detailed regression results that informed the discussion in Section 4.4 about the relationship between how gas is used and gas consumption. As discussed in section 4.4, the model for Hunter, Gosford and Wyong (2008) has fewer explanatory variables due to the smaller sample size. Again, we excluded households that used more than 80,000 MJ per annum.

Table D.10 Regression results for 'energy uses' model, Sydney (2010) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	-1,486	1,278		-1.16	0.25	-3,994	1,023		
Detached house	2,760	809	0.09	3.41	0.00	1,173	4,347	0.93	1.08
Per indoor shower	2,055	466	0.11	4.41	0.00	1,141	2,970	0.91	1.10
Per $1,000 income	26.5	6.7	0.12	3.95	0.00	13.3	39.7	0.68	1.48
No income data	640	1,164	0.02	0.55	0.58	-1,643	2,924	0.74	1.36
Per adult using gas hot water	3,712	247	0.39	15.04	0.00	3,228	4,197	0.88	1.14
Per child using gas hot water	1,808	418	0.11	4.32	0.00	988	2,629	0.93	1.08
Use gas for cooking as main source (only or with electricity)	2,335	838	0.07	2.79	0.01	692	3,979	0.97	1.04
Inland and use gas for heating no electricity	7,871	1,040	0.20	7.57	0.00	5,830	9,911	0.84	1.18
Coastal and use gas for heating no electricity	6,448	896	0.19	7.19	0.00	4,689	8,206	0.83	1.20
Inland and use gas and electricity for heating	7,071	1,047	0.18	6.76	0.00	5,018	9,125	0.87	1.16
Coastal and use gas and electricity for heating	2,058	1,036	0.05	1.99	0.05	26	4,091	0.87	1.15

Note: Households with consumption of more than 80,000 MJ per annum are excluded (4 households).

Table D.11 Regression results for 'energy uses' model, Hunter, Gosford and Wyong (2008) – MJ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	3,469	1,573		2.20	0.03	378	6,559		
Detached house	-1,224	1,294	-0.03	-0.95	0.34	-3,765	1,316	0.93	1.07
Per indoor shower	109	610	0.01	0.18	0.86	-1,088	1,307	0.88	1.14
Per $1,000 income	16.6	9.2	0.07	1.82	0.07	-1.4	34.7	0.71	1.41
No income data	1,764	1,411	0.04	1.25	0.21	-1,009	4,536	0.77	1.30
Per adult using gas hot water	4,741	308	0.53	15.39	0.00	4,136	5,347	0.80	1.25
Per child using gas hot water	2,918	447	0.22	6.53	0.00	2,041	3,795	0.87	1.14
Use gas for cooking as main source (only or with electricity)	1,265	906	0.05	1.40	0.16	-514	3,045	0.90	1.11
Inland and use gas for heating	7,521	1,285	0.20	5.85	0.00	4,996	10,046	0.77	1.29
Coastal and use gas for heating	6,423	828	0.27	7.75	0.00	4,796	8,050	0.78	1.28

Note: No household had consumption of more than 80,000 MJ per annum.

E Detailed regressions results for energy

Chapter 5 analyses the determinants of energy consumption by looking at the usage component of energy bills (ie, excluding all fixed charges and rebates). We analysed bills rather than consumption because, for technical reasons, it is difficult to convert gas to 'kWh equivalents'. We also explored the impact on energy bills of having a Controlled Load electricity supply and of using mains gas.

As discussed in Appendix B, for our linear regressions we excluded households with usage bills of more than $6,000 per annum.

The tables below provide the detailed regression results that informed the discussion about energy bills. The results are organised as follows:

- Section E1 shows the linear regression results for the 'characteristics' model. (See section 5.2.)
- Section E2 shows the linear regression results for the 'energy uses' model. (See section 5.3.)
- Section E.3 shows the regression results for the impact on electricity consumption and energy bills of having a Controlled Load supply. (See section 5.4.)
- Section E.4 shows the regression results for the impact on energy bills of using mains gas for hot water and heating. (See section 5.5.)
- Section E.5 shows the semi-log regression results for the 'characteristics' model and the 'energy uses' model.

E.1 Linear regression results for the 'characteristics' model

The tables below show the detailed regression results that informed the discussion in Section 5.2 about the relationship between household characteristics and energy bills.

Table E.1 Linear regression results for 'characteristics' model, Sydney (2010) – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	79	67		1.18	0.24	-52	210		
Detached house	278	50	0.12	5.53	0.00	179	377	0.64	1.56
Per bedroom	214	21	0.22	10.33	0.00	173	254	0.60	1.68
Per adult	236	19	0.24	12.32	0.00	199	274	0.72	1.39
Per child	207	21	0.17	9.72	0.00	165	249	0.94	1.06
Income, per $'000	4.1	0.4	0.22	10.66	0.00	3.4	4.9	0.64	1.57
No income data	390	60	0.13	6.47	0.00	272	508	0.75	1.33
Use mains gas	30	41	0.01	0.73	0.47	-50	110	0.70	1.43
Have Controlled Load	-112	42	-0.05	-2.64	0.01	-195	-29	0.66	1.52
Coastal area	-110	36	-0.05	-3.04	0.00	-181	-39	0.90	1.11

Note: Households with usage bills of more than $6,000 per annum are excluded (18 households). Usage bills calculated using regulated 2011/12 tariffs.

E.2 Linear regression results for the 'energy uses' model

The tables below show the detailed regression results that informed the discussion in Section 5.3 about the relationship between what energy is used for and energy bills.

Table E.2 Linear regression results for 'energy uses' model, Sydney (2010) – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	174	59		2.96	0.00	59	290		
Detached house	130	44	0.05	2.98	0.00	45	216	0.61	1.63
Per bedroom	131	18	0.14	7.27	0.00	96	166	0.57	1.76
Per adult	205	16	0.21	12.43	0.00	172	237	0.71	1.42
Per child	152	18	0.12	8.33	0.00	116	188	0.92	1.09
Income, per $'000	1.75	0.35	0.10	5.06	0.00	1.07	2.43	0.58	1.73
No income data	213	52	0.07	4.11	0.00	111	315	0.74	1.36
Have pool	620	41	0.23	15.26	0.00	540	700	0.89	1.13
Have 2nd fridge	290	32	0.14	9.16	0.00	228	352	0.85	1.18
Have spa	244	61	0.06	4.00	0.00	124	364	0.97	1.04
Clothes dryer, per use per week	77	11	0.10	6.75	0.00	55	99	0.92	1.09
Dishwasher, per use per week	77	7	0.19	11.27	0.00	63	90	0.74	1.35
Aircon, per hour	0.58	0.05	0.18	11.95	0.00	0.49	0.68	0.93	1.08
Use mains gas	-17	35	-0.01	-0.49	0.62	-86	52	0.69	1.46
Solar hot water	-174	57	-0.04	-3.04	0.00	-287	-62	0.96	1.04
Have Controlled Load	-154	36	-0.08	-4.25	0.00	-224	-83	0.65	1.53
Coastal area	-69	32	-0.03	-2.19	0.03	-131	-7	0.86	1.16

Note: Households with usage bills of more than $6,000 per annum are excluded (18 households). Usage bills calculated using regulated 2011/12 tariffs.

E.3 Regression results for the impact on electricity consumption and energy bills of having a Controlled Load supply

In section 5.4 we investigated the impact of having a Controlled Load electricity supply on both energy bills and electricity consumption. To do this, we used the 'energy uses' model but applied it only to households without mains gas. The tables below show the detailed regression results for electricity consumption and energy bills respectively.

Table E.3 Linear regression results for 'energy uses' model for households without mains gas, Sydney (2010) – electricity consumption - kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	851	317		2.68	0.01	228	1,474		
Detached house	646	255	0.07	2.53	0.01	146	1,146	0.53	1.89
Per bedroom	511	100	0.13	5.09	0.00	314	707	0.56	1.79
Per adult	947	96	0.23	9.89	0.00	759	1,135	0.68	1.47
Per child	632	107	0.12	5.93	0.00	423	841	0.94	1.07
Income, per $'000	11.02	2.05	0.13	5.39	0.00	7.01	15.04	0.59	1.68
No income data	1,434	282	0.11	5.09	0.00	881	1,987	0.75	1.33
Have pool	2,234	228	0.20	9.78	0.00	1,786	2,682	0.86	1.16
Have 2nd fridge	981	178	0.12	5.50	0.00	631	1,330	0.82	1.22
Have spa	990	392	0.05	2.53	0.01	221	1,759	0.96	1.04
Clothes dryer, per use per week	389	74	0.10	5.27	0.00	244	533	0.93	1.07
Dishwasher, per use per week	322	40	0.18	8.13	0.00	244	400	0.76	1.31
Aircon, per hour	2.29	0.29	0.16	8.01	0.00	1.73	2.85	0.90	1.11
Have Controlled Load	507	210	0.05	2.42	0.02	95	918	0.70	1.42
Solar hot water	-1,282	276	-0.09	-4.64	0.00	-1,824	-740	0.95	1.05
Coastal area	-442	181	-0.05	-2.44	0.01	-797	-87	0.86	1.16

Note: Households with electricity consumption exceeding 25,000 kWh per annum are excluded.

Table E.4 Regression results for 'energy uses' model for households without mains gas, Sydney (2010) – usage bills - $ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	271	77		3.52	0.00	120	423		
Detached house	171	62	0.08	2.75	0.01	49	292	0.53	1.89
Per bedroom	124	24	0.14	5.07	0.00	76	171	0.56	1.79
Per adult	189	23	0.20	8.13	0.00	143	235	0.68	1.47
Per child	132	26	0.11	5.11	0.00	82	183	0.94	1.07
Income, per $'000	2.56	0.50	0.14	5.15	0.00	1.58	3.53	0.59	1.68
No income data	339	68	0.12	4.95	0.00	205	473	0.75	1.33
Have pool	521	55	0.21	9.40	0.00	413	630	0.86	1.16
Have 2nd fridge	236	43	0.12	5.46	0.00	151	321	0.82	1.22
Have spa	245	95	0.05	2.57	0.01	58	432	0.96	1.04
Clothes dryer, per use per week	88	18	0.10	4.89	0.00	52	123	0.93	1.07
Dishwasher, per use per week	81	10	0.20	8.38	0.00	62	99	0.76	1.31
Aircon, per hour	0.57	0.07	0.18	8.18	0.00	0.43	0.70	0.90	1.11
Have Controlled Load	-272	51	-0.13	-5.35	0.00	-372	-172	0.70	1.42
Solar hot water	-181	67	-0.06	-2.69	0.01	-312	-49	0.95	1.05
Coastal area	-92	44	-0.05	-2.09	0.04	-178	-6	0.86	1.16

Note: Households with usage bills of more than $6,000 per annum are excluded. Usage bills calculated using regulated 2011/12 tariffs (excluding fixed charges).

E.4 Regression results for the impact on energy bills of using mains gas

To analyse the impact on energy bills of using mains gas for different purposes, we divided the survey sample into 2 groups: households with a Controlled Load electricity supply and households without. We did this so that we could compare the impact on bills of different hot water systems.

Comparing the regression results for these 2 groups of households is complicated by the fact that they display different characteristics. These differences means that all of the regression coefficients differ somewhat. To better understand how the 2 groups differ with respect to their household characteristics, we used a binary logistic regression model. We show the results of this analysis in the section that follows (section E.4.1), then we show the results for the 'energy uses' model (section E.4.2).

E.4.1 Relationship between household characteristics and having a Controlled Load electricity supply

This section shows how the 'without Controlled Load' and 'with Controlled Load' groups differ with respect to their household characteristics. As Table E.5 shows, households are more likely to have a Controlled Load supply if they:

- live in a detached house rather than a flat or a semi-detached dwelling
- have more bedrooms
- have fewer children and/or a lower income
- live in an inland area.

Households with a Controlled loads supply are also less likely to use mains gas, particularly for hot water (Table E7).

Table E.5 Relationship between having a Controlled Load supply and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
Detached house	1.441	.141	103.764	1	0.000	4.225
# bedrooms	.187	.055	11.646	1	0.001	1.206
# adults	-.042	.050	.707	1	0.401	.959
# children	-.165	.056	8.836	1	0.003	.848
Income ($'000 pa)	-.004	.001	16.355	1	0.000	.996
No income data	-.177	.160	1.219	1	0.270	.838
Coastal	-.324	.094	11.728	1	0.001	.724
Constant	-1.365	.182	56.222	1	0.000	.255

Note: Binary logistic regression. Households with usage bills of more than $6,000 per annum are excluded.

Table E.6 Relationship between having a Controlled Load supply and household characteristics, Sydney 2010 – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2741.100[a]	.116	.155

a Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Table E.7 Proportion of households with and without Controlled Load that use gas, Sydney (2010) - %

	No Controlled Load	Have Controlled Load
Use mains gas	73	25
Use gas for hot water (main source)	66	5
Use gas for cooking	64	22
Use gas for space heating	40	23

E.4.2 Regression results for the 'without Controlled Load' and 'with Controlled Load' groups – 'energy uses' model

The next 2 tables show the regression results for the 'energy uses' model for the 'without Controlled Load' and 'with Controlled Load' groups respectively.

Table E.8 Regression results for 'energy uses' model for households without Controlled Load, Sydney (2010) – usage bills, $ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	193	74		2.60	0.01	47	339		
Detached house	158	57	0.07	2.79	0.01	47	269	0.55	1.82
Per bedroom	142	25	0.15	5.77	0.00	94	191	0.52	1.93
Per adult	257	23	0.26	11.13	0.00	211	302	0.69	1.46
Per child	173	25	0.14	6.98	0.00	125	222	0.90	1.11
Income, per $'000	1.16	0.46	0.06	2.52	0.01	0.26	2.06	0.59	1.70
No income data	63	74	0.02	0.84	0.40	-83	208	0.74	1.36
Have pool	689	61	0.23	11.29	0.00	569	808	0.89	1.12
Have 2nd fridge	277	45	0.13	6.22	0.00	190	365	0.81	1.23
Have spa	281	84	0.07	3.35	0.00	116	446	0.96	1.04
Clothes dryer, per use per week	54	15	0.07	3.65	0.00	25	82	0.92	1.09
Dishwasher, per use per week	68	10	0.16	7.09	0.00	49	86	0.71	1.42
Aircon, per hour	0.63	0.07	0.19	9.18	0.00	0.49	0.76	0.91	1.10
Solar hot water	-425	107	-0.08	-3.96	0.00	-636	-214	0.83	1.21
Gas hot water	-200	53	-0.09	-3.81	0.00	-304	-97	0.65	1.53
Gas space heating	-26	47	-0.01	-0.54	0.59	-118	67	0.76	1.32
Coastal area	-10	43	0.00	-0.22	0.82	-95	75	0.86	1.16

Note: Households with usage bills of more than $6,000 per annum are excluded. Usage bills calculated using regulated 2011/12 tariffs (excluding fixed charges).

Table E.9 Regression results for 'energy uses' model for households with Controlled Load, Sydney (2010) – usage bills, $ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	4	101		0.04	0.97	-193	202		
Detached house	191	77	0.06	2.49	0.01	40	342	0.84	1.19
Per bedroom	123	26	0.12	4.71	0.00	71	174	0.70	1.44
Per adult	152	23	0.16	6.57	0.00	107	197	0.72	1.40
Per child	120	27	0.10	4.45	0.00	67	172	0.91	1.10
Income, per $'000	2.82	0.53	0.15	5.34	0.00	1.78	3.85	0.54	1.84
No income data	371	71	0.13	5.21	0.00	232	511	0.72	1.39
Have pool	551	53	0.23	10.37	0.00	446	655	0.89	1.12
Have 2nd fridge	295	44	0.15	6.69	0.00	208	382	0.91	1.10
Have spa	226	87	0.06	2.59	0.01	55	397	0.96	1.04
Clothes dryer, per use per week	115	18	0.14	6.33	0.00	79	150	0.90	1.11
Dishwasher, per use per week	90	10	0.23	9.38	0.00	71	109	0.75	1.33
Aircon, per hour	0.53	0.07	0.17	7.64	0.00	0.39	0.67	0.90	1.11
Solar hot water	-110	68	-0.03	-1.62	0.11	-243	23	0.97	1.03
Gas hot water	279	101	0.06	2.77	0.01	81	476	0.90	1.12
Gas space heating	-14	52	-0.01	-0.27	0.79	-117	88	0.87	1.15
Coastal area	-115	45	-0.06	-2.56	0.01	-204	-27	0.89	1.12

Note: Households with usage bills of more than $6,000 per annum are excluded. Usage bills calculated using regulated 2011/12 tariffs (excluding fixed charges).

E.5 Semi-log regression results for characteristics and 'energy uses' models for Sydney (2010)

As noted in Box 2.1 and discussed in Appendix B, we used a semi-log regression model to check the results of our linear regression model. To do this, for each explanatory variable we compared 2 models' estimated contribution to energy bills as well as the t-values. We found a fairly high degree of consistency between the 2 types of model, despite the problems associated with translating the semi-log regression coefficients into dollar contributions (discussed in Appendix B). Appendix B explains why we included an additional variable in the semi-log model (house x number of people).

The first 2 tables below show the semi-log regression results for the 'characteristics' model and the 'energy uses' model respectively. The next 2 tables compare the results of the semi-log model with those of the linear model, for the 'characteristics' model and the 'energy uses' model respectively.

Table E.10 Semi-log regression results for 'characteristics' model, Sydney (2010) – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	6.225	0.048		130.44	0.00	6.131	6.318		
Detached house	0.382	0.049	0.283	7.76	0.00	0.285	0.478	0.20	5.10
House x # people[a]	-0.076	0.019	-0.234	-4.04	0.00	-0.114	-0.039	0.08	12.94
Per bedroom	0.104	0.011	0.197	9.40	0.00	0.083	0.126	0.59	1.70
Per adult	0.213	0.019	0.397	10.97	0.00	0.175	0.251	0.20	5.03
Per child	0.172	0.019	0.252	8.89	0.00	0.134	0.210	0.32	3.09
Income, per $'000	0.002	0.000	0.232	11.45	0.00	0.002	0.003	0.64	1.57
No income data	0.223	0.033	0.128	6.84	0.00	0.159	0.287	0.75	1.34
Have Controlled Load	-0.058	0.023	-0.051	-2.53	0.01	-0.103	-0.013	0.65	1.53
Use mains gas	0.019	0.022	0.017	0.88	0.38	-0.024	0.063	0.70	1.44
Coastal area	-0.058	0.020	-0.051	-2.98	0.00	-0.097	-0.020	0.90	1.11

a This variable is included to correct for the over-representation of detached houses in the sample.

Table E.11 Semi-log regression results for 'energy uses' model, Sydney (2010) - $ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	6.253	0.041	0.000	151.38	0.00	6.172	6.334	0.00	0.00
Detached house	0.330	0.042	0.244	7.78	0.00	0.247	0.413	0.19	5.21
House x # people[a]	-0.091	0.016	-0.279	-5.63	0.00	-0.123	-0.059	0.08	13.02
Per bedroom	0.059	0.010	0.111	6.05	0.00	0.040	0.078	0.56	1.78
Per adult	0.208	0.017	0.390	12.58	0.00	0.176	0.241	0.20	5.08
Per child	0.156	0.017	0.228	9.41	0.00	0.123	0.188	0.32	3.10
Income, per $'000	0.001	0.000	0.101	5.57	0.00	0.001	0.001	0.57	1.75
No income data	0.122	0.028	0.070	4.36	0.00	0.067	0.177	0.73	1.37
Have pool	0.293	0.022	0.197	13.42	0.00	0.250	0.336	0.88	1.14
Have 2nd fridge	0.176	0.017	0.154	10.27	0.00	0.142	0.210	0.85	1.18
Have spa	0.148	0.033	0.064	4.57	0.00	0.085	0.212	0.96	1.04
Clothes dryer, per use per week	0.044	0.006	0.104	7.26	0.00	0.032	0.056	0.92	1.09
Dishwasher, per use per week	0.040	0.004	0.177	11.03	0.00	0.033	0.048	0.73	1.37
Aircon, per hour	0.000	0.000	0.174	12.21	0.00	0.000	0.000	0.93	1.08
Use mains gas	-0.010	0.019	-0.008	-0.50	0.62	-0.047	0.028	0.68	1.47
Solar hot water	-0.084	0.031	-0.038	-2.71	0.01	-0.145	-0.023	0.96	1.04
Controlled Load	-0.080	0.020	-0.070	-4.08	0.00	-0.118	-0.041	0.65	1.54
Coastal area	-0.037	0.017	-0.032	-2.19	0.03	-0.071	-0.004	0.86	1.16

a This variable is included to correct for the over-representation of detached houses in the sample.

Table E.12 Comparison of semi-log and linear 'characteristics' model outputs, Sydney (2010) – $ pa

Data set	Sydney (2010)		Sydney (2010)	
Type of regression model	**Semi-log**		**Linear[a]**	
	$ pa	**(t-value)**	**$ pa**	**(t-value)**
% of variation explained (R^2)	43		39	
Sample size	2,182		2,164	
Live in a detached house	280	(7.8)	278	(5.5)
Per bedroom	157	(9.4)	214	(10.3)
Per adult	284	(11.0)	236	(12.3)
Per child	228	(8.9)	207	(9.7)
Per $10,000 income pa	34	(11.4)	41	(10.7)
Did not provide income data	347	(6.8)	390	(6.5)
Have Controlled Load supply	-82	(-2.5)	-112	(-2.6)
Use mains gas	ns	(-0.5)	ns	(0.7)
Live in a coastal area	-83	(-3.0)	-110	(-3.0)

a Households with usage bills of more than $6,000 per annum are excluded (18 households).

Note: Usage bills calculated using regulated 2011/12 tariffs (excluding fixed charges).

Table E.13 Comparison of semi-log and linear 'energy uses' model outputs, Sydney (2010) – $pa

Data set	**Sydney (2010)**		**Sydney (2010)**	
Type of regression model	**Semi-log**		**Linear**[a]	
	$ pa	**(t-value)**	**$ pa**	**(t-value)**
% of variation explained (R^2)	59		56	
Sample size	2,173		2,156	
Have a swimming pool	451	(13.4)	620	(15.3)
Have a 2nd fridge	245	(10.3)	290	(9.2)
Have a spa	219	(4.6)	244	(4.0)
Per 280 hours of air conditioner use	124	(12.2)	163	(11.9)
Clothes dryer - used once per week	63	(7.3)	77	(6.7)
Dishwasher - used once per week	57	(11.0)	77	(11.3)
Live in a detached house	142	(7.8)	130	(3.0)
Per bedroom	84	(6.0)	131	(7.3)
Per adult (16 years or older)	256	(12.6)	205	(12.4)
Per child	178	(9.4)	152	(8.3)
Per $10,000 income pa (before tax)	14	(5.6)	18	(5.1)
Did not provide income data	177	(4.4)	213	(4.1)
Mains source for hot water is solar	-112	(-2.7)	-174	(-3.0)
Use mains gas	ns	(-0.5)	ns	(-0.5)
Have Controlled Load supply	-109	(-4.1)	-154	(-4.3)
Live in a coastal area	-51	(-2.2)	-69	(-2.2)

a Households with usage bills of more than $6,000 per annum are excluded (17 households).

Note: Usage bills calculated using regulated 2011/12 tariffs (excluding fixed charges).

E.6 Impact on regression results of not including Controlled Load as an explanatory variable

We tested the impact on both the 'characteristics' model and the 'energy uses' model of not including having a Controlled Load electricity supply as an explanatory variable. For both models, the main impacts were as follows:

- Using mains gas means higher bills compared to all households without mains gas when we ignore the presence of absence of a Controlled Load supply.
- The impact on bills of living in a detached house is lower when we ignore the presence of absence of a Controlled Load supply (by about $40 to $50). This occurs because detached houses are far more likely to have a Controlled Load supply than other dwelling types (Section E.4.1 above). In turn, this means that the model ascribes most of the lower costs to 'living in a detached house' rather than the real reason, ie, having a Controlled Load supply.

Table E.14 Relationship between household characteristics and energy bills with and without CL ($ pa)

Data set	Energy bills with Controlled Load		Energy bills without Controlled Load	
	$ pa	t-value	$ pa	t-value
% of variation explained (R^2)	39		39	
Sample size	2,164		2,164	
Live in a detached house	278	(5.5)	241	(5.0)
Per bedroom	214	(10.3)	208	(10.1)
Per adult (16 years or older)	236	(12.3)	237	(12.3)
Per child	207	(9.7)	210	(9.8)
Per $10,000 income pa	41	(10.7)	42	(10.7)
Did not provide income data	390	(6.5)	390	(6.5)
Have Controlled Load supply	-112	(-2.6)	na	na
Use mains gas	ns	(0.7)	84	(2.4)
Live in a coastal area	-110	(-3)	-111	(-3.1)

Note: Coefficients are shown if they are significant at a 90% level of confidence. Excluding household with usage bills of more than $6,000 per annum (2011/12 $).

Table E.15 Relationship between what energy is used for and energy bills, with and without Controlled Load ($ pa)

Data set	Energy bills with Controlled Load identified		Energy bills without Controlled Load identified	
	$ pa	(t-value)	$ pa	(t-value)
% of variation explained (R^2)	56		56	
Sample size	2,156		2,156	
Have a swimming pool	620	(15.3)	616	(15.1)
Have a 2nd fridge	290	(9.2)	285	(9)
Have a spa	244	(4.0)	247	(4)
Per 280 hours of air conditioner use	163	(11.9)	164	(12)
Clothes dryer - used once per week	77	(6.7)	77	(6.7)
Dishwasher - used once per week	77	(11.3)	76	(11.1)
Live in a detached house	130	(3.0)	82	(1.9)
Per bedroom	131	(7.3)	125	(6.9)
Per adult (16 years or older)	205	(12.4)	205	(12.4)
Per child	152	(8.3)	156	(8.5)
Per $10,000 income pa (before tax)	18	(5.1)	18	(5.2)
Did not provide income data	213	(4.1)	214	(4.1)
Mains source for hot water is solar	-174	(-3.0)	-181	(-3.2)
Have Controlled Load supply	-154	(-4.3)	na	na
Use mains gas	ns	(-0.5)	58	(1.9)
Live in a coastal area	-69	(-2.2)	-70	(-2.2)

Note: Coefficients are shown if they are significant at a 90% level of confidence. Excluding household with usage bills of more than $6,000 per annum (2011/12 $).

F Detailed regressions results by household income and number of occupants

In chapter 6 we used regression analysis to explain variations in electricity consumption and energy bills within income groups, as well as between households with the same number of occupants. We used the Sydney (2010) data and the 'energy uses' model for our analysis. Chapter 2 explains how we defined income groups.

As discussed in Appendix B, for electricity consumption we excluded households that used more than 25,000 kWh per annum. For energy bills we excluded households with usage bills of more than $6,000 per annum (2011/12 prices). We also excluded households with incomes below $13,000 per annum (income band 1), for reasons discussed in Chapter 6.

The tables below provide the detailed regression results that informed the discussion. The results are organised as follows:

- Section F1 shows the linear regression results for electricity consumption by income group. (See section 6.1.)
- Section F2 shows the linear regression results for energy bills by income group. (See section 6.1.)
- Section F3 shows the linear regression results for electricity consumption by number of occupants. (See section 6.2.)
- Section F4 shows the linear regression results for energy bills by number of occupants. (See section 6.2.)

F.1 Regression results for electricity consumption by income group (Sydney, 2010) – 'energy uses' model

The tables below show the detailed regression results that informed the discussion in Section 6.1 about the relationship between household characteristics and electricity consumption by income group. The tables respectively show the results for low-income, low middle-income, high middle-income and high-income households.

Table F.1 Regression results for low-income households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,961	572		3.43	0.00	837	3,085		
Detached house	658	273	0.10	2.41	0.02	121	1,194	0.69	1.46
Per bedroom	191	114	0.07	1.67	0.10	-33	415	0.68	1.48
Per adult	1,227	149	0.33	8.25	0.00	934	1,519	0.80	1.25
Per child	622	158	0.14	3.93	0.00	311	933	0.94	1.07
Income, per $'000	-7.17	21.36	-0.01	-0.34	0.74	-49.16	34.82	0.90	1.11
Have pool	2,343	388	0.22	6.04	0.00	1,581	3,106	0.94	1.06
Have 2nd fridge	756	221	0.13	3.42	0.00	321	1,191	0.83	1.21
Have spa	2,237	673	0.12	3.32	0.00	913	3,561	0.95	1.06
Clothes dryer, per use per week	300	87	0.12	3.46	0.00	129	471	0.96	1.04
Dishwasher, per use per week	174	64	0.10	2.70	0.01	48	301	0.88	1.14
Aircon, per hour	1.95	0.35	0.21	5.57	0.00	1.26	2.64	0.87	1.16
Gas hot water	-2,085	230	-0.34	-9.06	0.00	-2,537	-1,633	0.89	1.13
Solar hot water	-886	424	-0.08	-2.09	0.04	-1,719	-52	0.89	1.12
Other electric heating	210	225	0.04	0.93	0.35	-232	651	0.90	1.11
Coastal area	-166	225	-0.03	-0.74	0.46	-609	277	0.84	1.20

Note: Households with consumption of more than 25,000 kWh per annum and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.2 Regression results for low middle-income households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,719	983		1.75	0.08	-214	3,652		
Detached house	922	340	0.12	2.71	0.01	254	1,590	0.61	1.65
Per bedroom	536	150	0.15	3.57	0.00	241	831	0.61	1.63
Per adult	744	142	0.19	5.25	0.00	465	1,022	0.83	1.20
Per child	384	155	0.09	2.47	0.01	79	689	0.93	1.08
Income, per $'000	1.72	17.79	0.00	0.10	0.92	-33.24	36.69	0.95	1.06
Have pool	2,122	335	0.22	6.34	0.00	1,465	2,780	0.91	1.10
Have 2nd fridge	912	254	0.13	3.59	0.00	412	1,412	0.84	1.19
Have spa	903	475	0.07	1.90	0.06	-31	1,838	0.95	1.05
Clothes dryer, per use per week	408	100	0.14	4.08	0.00	211	604	0.91	1.10
Dishwasher, per use per week	258	57	0.16	4.51	0.00	146	371	0.85	1.17
Aircon, per hour	1.96	0.43	0.16	4.61	0.00	1.12	2.79	0.88	1.13
Gas hot water	-2,266	260	-0.31	-8.70	0.00	-2,778	-1,754	0.90	1.11
Solar hot water	-1,172	440	-0.09	-2.66	0.01	-2,036	-307	0.91	1.10
Other electric heating	243	270	0.03	0.90	0.37	-288	773	0.90	1.11
Coastal area	-311	254	-0.05	-1.23	0.22	-809	187	0.84	1.19

Note: Households with consumption of more than 25,000 kWh per annum are excluded. Results are for Sydney (2010).

Table F.3 Regression results for high middle-income households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,018	750		1.36	0.18	-456	2,491		
Detached house	317	350	0.03	0.90	0.37	-371	1,005	0.63	1.59
Per bedroom	870	141	0.22	6.17	0.00	593	1,147	0.55	1.81
Per adult	640	121	0.16	5.27	0.00	401	878	0.73	1.37
Per child	408	122	0.09	3.33	0.00	167	648	0.94	1.07
Income, per $'000	6.03	6.82	0.02	0.88	0.38	-7.37	19.43	0.94	1.06
Have pool	2,311	296	0.21	7.81	0.00	1,730	2,892	0.90	1.11
Have 2nd fridge	1,466	245	0.17	5.99	0.00	986	1,947	0.84	1.19
Have spa	904	432	0.06	2.09	0.04	56	1,752	0.97	1.03
Clothes dryer, per use per week	181	90	0.05	2.02	0.04	5	357	0.93	1.07
Dishwasher, per use per week	322	46	0.20	6.93	0.00	231	413	0.85	1.18
Aircon, per hour	2.82	0.39	0.20	7.15	0.00	2.04	3.59	0.86	1.17
Gas hot water	-2,850	237	-0.33	-12.01	0.00	-3,316	-2,384	0.91	1.10
Solar hot water	-1,220	466	-0.07	-2.62	0.01	-2,135	-306	0.92	1.08
Other electric heating	471	267	0.05	1.76	0.08	-54	995	0.89	1.13
Coastal area	-250	245	-0.03	-1.02	0.31	-731	231	0.86	1.17

Note: Households with consumption of more than 25,000 kWh per annum are excluded. Results are for Sydney (2010).

Table F.4 Regression results for high-income households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	5	1,415		0.00	1.00	-2,780	2,790		
Detached house	390	546	0.03	0.71	0.48	-685	1,465	0.59	1.70
Per bedroom	748	226	0.17	3.31	0.00	303	1,193	0.50	2.01
Per adult	552	187	0.13	2.95	0.00	183	920	0.66	1.52
Per child	317	212	0.06	1.50	0.14	-100	733	0.85	1.18
Income, per $'000	14.55	7.66	0.07	1.90	0.06	-0.51	29.61	0.94	1.06
Have pool	3,058	419	0.29	7.30	0.00	2,233	3,882	0.81	1.24
Have 2nd fridge	1,345	418	0.13	3.22	0.00	522	2,168	0.73	1.37
Have spa	751	623	0.05	1.21	0.23	-475	1,976	0.93	1.08
Clothes dryer, per use per week	298	111	0.10	2.68	0.01	79	517	0.90	1.11
Dishwasher, per use per week	356	77	0.19	4.65	0.00	205	506	0.76	1.31
Aircon, per hour	3.42	0.56	0.23	6.08	0.00	2.31	4.53	0.91	1.10
Gas hot water	-3,681	386	-0.38	-9.54	0.00	-4,440	-2,922	0.82	1.22
Solar hot water	-2,111	763	-0.11	-2.77	0.01	-3,613	-609	0.82	1.22
Other electric heating	388	428	0.03	0.91	0.37	-454	1,230	0.91	1.10
Coastal area	107	381	0.01	0.28	0.78	-643	856	0.84	1.18

Note: Households with consumption of more than 25,000 kWh per annum are excluded. Results are for Sydney (2010).

F.2 Regression results for energy bills by income group – 'energy uses' model – Sydney (2010)

The tables below show the detailed regression results that informed the discussion in Section 6.1 about the relationship between household characteristics and energy bills by income group.

The tables respectively show the results for low-income, low middle-income, high middle-income and high-income households.

Table F.5 Regression results for low-income households, energy bills – $ pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	447	143		3.12	0.00	165	729		
Detached house	176	72	0.11	2.44	0.01	34	318	0.63	1.58
Per bedroom	20	29	0.03	0.70	0.48	-37	78	0.67	1.50
Per adult	295	37	0.32	7.94	0.00	222	368	0.82	1.21
Per child	127	40	0.12	3.18	0.00	49	206	0.93	1.07
Income, per $'000	0.54	5.40	0.00	0.10	0.92	-10.08	11.15	0.90	1.11
Have pool	687	98	0.26	6.98	0.00	493	880	0.94	1.06
Have 2nd fridge	170	56	0.12	3.04	0.00	60	280	0.84	1.20
Have spa	603	170	0.13	3.54	0.00	268	937	0.95	1.05
Clothes dryer, per use per week	82	22	0.14	3.71	0.00	38	125	0.96	1.04
Dishwasher, per use per week	46	16	0.11	2.83	0.00	14	78	0.90	1.12
Aircon, per hour	0.41	0.09	0.18	4.71	0.00	0.24	0.58	0.89	1.13
Use mains gas	-16	62	-0.01	-0.25	0.80	-137	106	0.70	1.43
Solar hot water	-148	107	-0.05	-1.39	0.17	-357	62	0.91	1.10
Controlled Load	-208	63	-0.15	-3.31	0.00	-331	-84	0.66	1.52
Coastal area	-60	57	-0.04	-1.05	0.29	-172	52	0.84	1.19

Note: Households with usage bills of more than $6,000 per annum and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.6 Regression results for low middle-income households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	439	251		1.75	0.08	-55	933		
Detached house	170	91	0.09	1.87	0.06	-9	349	0.58	1.73
Per bedroom	120	39	0.14	3.06	0.00	43	197	0.61	1.64
Per adult	192	37	0.21	5.19	0.00	119	265	0.83	1.20
Per child	146	41	0.14	3.60	0.00	66	226	0.93	1.08
Income, per $'000	-1.47	4.65	-0.01	-0.32	0.75	-10.61	7.66	0.95	1.05
Have pool	478	88	0.21	5.45	0.00	305	650	0.90	1.11
Have 2nd fridge	266	66	0.16	4.00	0.00	135	397	0.84	1.19
Have spa	261	124	0.08	2.10	0.04	17	505	0.95	1.05
Clothes dryer, per use per week	91	26	0.13	3.48	0.00	40	142	0.91	1.10
Dishwasher, per use per week	55	15	0.14	3.69	0.00	26	84	0.86	1.17
Aircon, per hour	0.47	0.11	0.16	4.23	0.00	0.25	0.68	0.89	1.12
Use mains gas	23	72	0.01	0.32	0.75	-118	164	0.72	1.39
Solar hot water	-162	114	-0.05	-1.43	0.15	-385	61	0.93	1.07
Controlled Load	-233	75	-0.14	-3.10	0.00	-381	-85	0.65	1.55
Coastal area	-58	67	-0.03	-0.87	0.39	-189	73	0.83	1.20

Note: Household with usage bills of more than $6,000 per annum are excluded. Results are for Sydney (2010).

Table F.7 Regression results for high middle-income households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	10	184		0.06	0.95	-352	373		
Detached house	43	90	0.02	0.48	0.63	-133	220	0.59	1.69
Per bedroom	219	35	0.23	6.24	0.00	150	288	0.55	1.81
Per adult	159	30	0.17	5.27	0.00	100	218	0.73	1.36
Per child	127	31	0.12	4.16	0.00	67	187	0.93	1.07
Income, per $'000	2.40	1.71	0.04	1.40	0.16	-0.95	5.74	0.94	1.07
Have pool	517	74	0.21	6.99	0.00	372	662	0.90	1.11
Have 2nd fridge	348	61	0.17	5.72	0.00	229	468	0.84	1.19
Have spa	245	108	0.06	2.27	0.02	33	457	0.96	1.04
Clothes dryer, per use per week	48	22	0.06	2.17	0.03	4	91	0.93	1.07
Dishwasher, per use per week	76	11	0.20	6.63	0.00	54	99	0.86	1.16
Aircon, per hour	0.70	0.10	0.22	7.21	0.00	0.51	0.89	0.87	1.15
Use mains gas	-6	67	0.00	-0.08	0.93	-137	126	0.71	1.41
Solar hot water	-103	114	-0.03	-0.91	0.37	-327	121	0.96	1.05
Controlled Load	-195	70	-0.10	-2.79	0.01	-332	-57	0.64	1.56
Coastal area	-57	61	-0.03	-0.93	0.35	-178	63	0.84	1.18

Note: Household with usage bills of more than $6,000 per annum are excluded. Results are for Sydney (2010).

Table F.8 Regression results for high-income households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	-602	359		-1.68	0.09	-1,309	104		
Detached house	55	139	0.02	0.40	0.69	-219	330	0.58	1.74
Per bedroom	196	57	0.18	3.41	0.00	83	309	0.49	2.03
Per adult	133	48	0.13	2.78	0.01	39	227	0.66	1.52
Per child	101	53	0.08	1.90	0.06	-4	206	0.84	1.20
Income, per $'000	4.54	1.93	0.09	2.35	0.02	0.74	8.34	0.95	1.06
Have pool	736	106	0.29	6.93	0.00	527	944	0.81	1.23
Have 2nd fridge	340	105	0.14	3.24	0.00	134	547	0.74	1.36
Have spa	194	157	0.05	1.24	0.22	-115	503	0.93	1.07
Clothes dryer, per use per week	82	28	0.12	2.94	0.00	27	137	0.91	1.10
Dishwasher, per use per week	94	19	0.21	4.87	0.00	56	133	0.76	1.32
Aircon, per hour	0.76	0.14	0.21	5.38	0.00	0.48	1.03	0.93	1.08
Use mains gas	-1	117	0.00	-0.01	0.99	-232	230	0.60	1.67
Solar hot water	-157	185	-0.03	-0.85	0.40	-521	207	0.89	1.12
Controlled Load	55	115	0.02	0.48	0.63	-172	282	0.62	1.60
Coastal area	48	97	0.02	0.50	0.62	-143	239	0.83	1.20

Note: Household with usage bills of more than $6,000 per annum are excluded. Results are for Sydney (2010).

F.3 Regression results for electricity consumption by number of occupants– 'energy uses' model – Sydney (2010)

The tables below show the detailed regression results that informed the discussion in Section 6.2 about the relationship between household characteristics and electricity consumption by number of occupants.

The tables respectively show the results for 1 person, 2 person, 3 person and 4 person households. We do not show the results for larger households due to the small sample sizes.

Table F.9 Regression results for 1 person households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	2,685	347		7.74	0.00	2,002	3,367		
Detached house	936	235	0.21	3.99	0.00	475	1,397	0.60	1.67
Per bedroom	151	106	0.07	1.43	0.15	-57	359	0.64	1.57
Income, per $'000	4.55	3.07	0.07	1.49	0.14	-1.48	10.58	0.73	1.37
No income data	402	305	0.06	1.32	0.19	-197	1,002	0.77	1.31
Have pool	1,876	383	0.21	4.89	0.00	1,122	2,630	0.92	1.09
Have 2nd fridge	676	220	0.14	3.08	0.00	244	1,108	0.83	1.21
Have spa	-429	615	-0.03	-0.70	0.49	-1,637	780	0.95	1.05
Clothes dryer, per use per week	289	105	0.11	2.75	0.01	82	496	0.96	1.05
Dishwasher, per use per week	368	78	0.20	4.73	0.00	215	521	0.87	1.15
Aircon, per hour	2.34	0.34	0.30	6.89	0.00	1.67	3.01	0.86	1.16
Gas hot water	-1,236	207	-0.25	-5.97	0.00	-1,643	-828	0.92	1.09
Solar hot water	69	654	0.00	0.11	0.92	-1,216	1,354	0.94	1.06
Other electric heating	319	192	0.07	1.66	0.10	-58	696	0.92	1.09
Coastal area	-313	203	-0.07	-1.54	0.13	-712	87	0.80	1.25

Note: Households with consumption of more than 25,000 kWh and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.10 Regression results for 2 person households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	2,431	448		5.42	0.00	1,550	3,311		
Detached house	720	274	0.08	2.63	0.01	182	1,258	0.68	1.48
Per bedroom	622	118	0.16	5.29	0.00	391	853	0.73	1.37
Income, per $'000	11.16	2.22	0.16	5.02	0.00	6.80	15.52	0.68	1.47
No income data	1,151	316	0.11	3.64	0.00	531	1,771	0.76	1.32
Have pool	2,142	263	0.22	8.14	0.00	1,625	2,659	0.89	1.13
Have 2nd fridge	1,024	197	0.14	5.19	0.00	637	1,411	0.90	1.11
Have spa	1,531	405	0.10	3.78	0.00	736	2,326	0.97	1.03
Clothes dryer, per use per week	381	77	0.13	4.92	0.00	229	533	0.89	1.12
Dishwasher, per use per week	307	43	0.20	7.14	0.00	222	391	0.85	1.17
Aircon, per hour	2.58	0.32	0.22	8.05	0.00	1.95	3.20	0.89	1.13
Gas hot water	-2,399	207	-0.32	-11.57	0.00	-2,806	-1,992	0.85	1.17
Solar hot water	-1,056	319	-0.09	-3.31	0.00	-1,683	-429	0.91	1.10
Other electric heating	368	225	0.04	1.63	0.10	-74	809	0.92	1.08
Coastal area	-693	200	-0.10	-3.46	0.00	-1,086	-300	0.85	1.18
Per child	521	676	0.02	0.77	0.44	-807	1,849	0.96	1.04

Note: Households with consumption of more than 25,000 kWh and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.11 Regression results for 3 person households, electricity – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	3,808	736		5.17	0.00	2,360	5,256		
Detached house	27	453	0.00	0.06	0.95	-863	917	0.68	1.47
Per bedroom	701	193	0.16	3.64	0.00	322	1,080	0.68	1.48
Income, per $'000	9.73	3.43	0.14	2.84	0.01	2.99	16.48	0.57	1.75
No income data	1,132	529	0.10	2.14	0.03	93	2,172	0.64	1.56
Have pool	3,120	391	0.31	7.98	0.00	2,351	3,889	0.87	1.15
Have 2nd fridge	1,754	322	0.21	5.45	0.00	1,121	2,388	0.87	1.14
Have spa	658	577	0.04	1.14	0.26	-477	1,793	0.94	1.06
Clothes dryer, per use per week	188	116	0.06	1.62	0.11	-40	417	0.95	1.05
Dishwasher, per use per week	229	67	0.14	3.40	0.00	97	362	0.81	1.24
Aircon, per hour	2.73	0.55	0.19	4.98	0.00	1.65	3.81	0.92	1.09
Gas hot water	-3,377	326	-0.40	-10.36	0.00	-4,018	-2,736	0.87	1.15
Solar hot water	-2,567	636	-0.15	-4.04	0.00	-3,818	-1,316	0.90	1.11
Other electric heating	417	345	0.05	1.21	0.23	-262	1,096	0.87	1.15
Coastal area	126	322	0.02	0.39	0.70	-508	759	0.90	1.11
Per child	-783	297	-0.10	-2.64	0.01	-1,366	-200	0.89	1.13

Note: Households with consumption of more than 25,000 kWh and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.12 Regression results for 4 person households, Sydney (2010) – kWh pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	5,591	855		6.54	0.00	3,910	7,273		
Detached house	76	523	0.01	0.15	0.89	-953	1,105	0.75	1.34
Per bedroom	561	195	0.12	2.87	0.00	176	945	0.72	1.40
Income, per $'000	2.69	3.65	0.04	0.74	0.46	-4.49	9.87	0.50	1.99
No income data	311	644	0.02	0.48	0.63	-956	1,578	0.57	1.77
Have pool	3,045	370	0.31	8.23	0.00	2,318	3,773	0.89	1.13
Have 2nd fridge	1,580	337	0.18	4.69	0.00	917	2,243	0.84	1.20
Have spa	1,418	553	0.09	2.57	0.01	331	2,505	0.96	1.04
Clothes dryer, per use per week	159	99	0.06	1.60	0.11	-37	355	0.92	1.09
Dishwasher, per use per week	338	64	0.22	5.31	0.00	213	463	0.72	1.39
Aircon, per hour	2.73	0.47	0.22	5.75	0.00	1.79	3.66	0.89	1.13
Gas hot water	-3,641	319	-0.43	-11.41	0.00	-4,269	-3,014	0.88	1.13
Solar hot water	-2,303	589	-0.15	-3.91	0.00	-3,460	-1,145	0.87	1.15
Other electric heating	83	392	0.01	0.21	0.83	-687	853	0.93	1.08
Coastal area	-139	320	-0.02	-0.43	0.67	-768	491	0.89	1.12
Per child	-270	174	-0.06	-1.56	0.12	-611	71	0.86	1.16

Note: Household with consumption of more than 25,000 kWh and with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

F.4 Regression results for energy bills by number of occupants (Sydney, 2010) – 'energy uses' model

The tables below show the detailed regression results that informed the discussion in Section 6.2 about the relationship between household characteristics and energy bills by number of occupants.

The tables respectively show the results for 1 person, 2 person, 3 person and 4 person households. We do not show the results for larger households due to the limited sample size.

Table F.13 Regression results for 1 person households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	598	85		7.04	0.00	431	764		
Detached house	211	63	0.19	3.35	0.00	87	335	0.52	1.92
Per bedroom	44	27	0.09	1.67	0.10	-8	96	0.64	1.57
Income, per $'000	1.11	0.77	0.07	1.45	0.15	-0.40	2.63	0.73	1.38
No income data	73	76	0.04	0.96	0.34	-77	224	0.77	1.31
Have pool	509	96	0.23	5.30	0.00	320	697	0.92	1.09
Have 2nd fridge	158	55	0.13	2.88	0.00	50	266	0.83	1.20
Have spa	21	153	0.01	0.14	0.89	-281	323	0.95	1.05
Clothes dryer, per use per week	96	26	0.15	3.64	0.00	44	148	0.96	1.04
Dishwasher, per use per week	84	20	0.19	4.28	0.00	46	123	0.86	1.17
Aircon, per hour	0.55	0.08	0.28	6.57	0.00	0.38	0.71	0.89	1.12
Use mains gas	45	52	0.04	0.87	0.38	-57	147	0.79	1.27
Solar hot water	58	163	0.02	0.36	0.72	-263	380	0.95	1.06
Controlled Load	-152	56	-0.13	-2.74	0.01	-261	-43	0.72	1.38
Coastal area	-73	51	-0.07	-1.43	0.15	-173	28	0.80	1.26

Note: Households with usage bills of more than $6,000 per annum and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.14 Regression results for 2 person households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	534	108		4.95	0.00	322	746		
Detached house	204	69	0.10	2.98	0.00	70	339	0.64	1.55
Per bedroom	123	29	0.14	4.28	0.00	67	180	0.72	1.39
Income, per $'000	2.44	0.55	0.15	4.48	0.00	1.37	3.51	0.68	1.47
No income data	233	77	0.10	3.03	0.00	82	385	0.75	1.33
Have pool	477	64	0.22	7.44	0.00	351	602	0.90	1.11
Have 2nd fridge	253	48	0.16	5.27	0.00	159	347	0.90	1.11
Have spa	463	99	0.13	4.68	0.00	269	657	0.96	1.04
Clothes dryer, per use per week	96	19	0.15	5.14	0.00	59	132	0.89	1.13
Dishwasher, per use per week	74	10	0.21	7.10	0.00	54	95	0.86	1.17
Aircon, per hour	0.57	0.08	0.22	7.39	0.00	0.42	0.72	0.90	1.12
Use mains gas	-50	54	-0.03	-0.93	0.35	-156	56	0.70	1.44
Solar hot water	-143	76	-0.05	-1.89	0.06	-293	6	0.95	1.05
Controlled Load	-118	56	-0.07	-2.10	0.04	-228	-7	0.63	1.58
Coastal area	-122	49	-0.08	-2.47	0.01	-219	-25	0.83	1.21
Per child	173	165	0.03	1.05	0.30	-151	497	0.95	1.05

Note: Households with usage bills of more than $6,000 per annum and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.15 Regression results for 3 person households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	773	183		4.24	0.00	414	1,132		
Detached house	-60	118	-0.03	-0.51	0.61	-293	172	0.63	1.58
Per bedroom	177	49	0.18	3.64	0.00	81	272	0.68	1.47
Income, per $'000	2.69	0.86	0.17	3.12	0.00	0.99	4.38	0.57	1.74
No income data	301	133	0.11	2.26	0.02	39	563	0.64	1.55
Have pool	735	99	0.32	7.40	0.00	540	931	0.86	1.16
Have 2nd fridge	456	81	0.24	5.62	0.00	296	615	0.88	1.14
Have spa	120	145	0.03	0.82	0.41	-166	406	0.94	1.06
Clothes dryer, per use per week	54	29	0.08	1.84	0.07	-4	112	0.95	1.06
Dishwasher, per use per week	49	17	0.13	2.91	0.00	16	83	0.82	1.22
Aircon, per hour	0.66	0.14	0.20	4.87	0.00	0.40	0.93	0.95	1.05
Use mains gas	-96	94	-0.05	-1.02	0.31	-282	90	0.63	1.58
Solar hot water	-450	160	-0.12	-2.82	0.01	-764	-136	0.91	1.10
Controlled Load	-197	97	-0.11	-2.03	0.04	-388	-7	0.60	1.67
Coastal area	28	82	0.01	0.34	0.73	-133	188	0.90	1.11
Per child	-184	75	-0.11	-2.44	0.02	-331	-36	0.88	1.14

Note: Households with usage bills of more than $6,000 per annum and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

Table F.16 Regression results for 4 person households, energy bills – $pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1,093	230		4.74	0.00	640	1,545		
Detached house	-26	139	-0.01	-0.19	0.85	-299	247	0.74	1.35
Per bedroom	152	52	0.13	2.92	0.00	49	254	0.70	1.43
Income, per $'000	0.83	0.97	0.05	0.86	0.39	-1.07	2.73	0.50	2.01
No income data	157	170	0.05	0.92	0.36	-178	492	0.55	1.81
Have pool	817	98	0.34	8.36	0.00	625	1,009	0.88	1.14
Have 2nd fridge	394	89	0.18	4.45	0.00	220	569	0.84	1.19
Have spa	312	148	0.08	2.10	0.04	20	604	0.96	1.04
Clothes dryer, per use per week	52	27	0.08	1.94	0.05	-1	104	0.92	1.09
Dishwasher, per use per week	91	17	0.24	5.43	0.00	58	124	0.72	1.39
Aircon, per hour	0.68	0.12	0.22	5.43	0.00	0.43	0.92	0.90	1.11
Use mains gas	-65	108	-0.03	-0.60	0.55	-278	148	0.56	1.79
Solar hot water	-179	150	-0.05	-1.19	0.23	-473	115	0.94	1.06
Controlled Load	-248	105	-0.12	-2.37	0.02	-454	-43	0.58	1.73
Coastal area	1	86	0.00	0.01	0.99	-168	170	0.87	1.16
Per child	-93	46	-0.08	-2.03	0.04	-184	-3	0.85	1.17

Note: Households with usage bills of more than $6,000 per annum and households with incomes below $13,000 per annum are excluded. Results are for Sydney (2010).

G Detailed regressions results for water

Chapter 7 discusses the determinants of water consumption. The tables below provide the detailed regression results that informed the discussion.

As discussed in Chapter 7 and Appendix B, for more most of our analysis we included only individually metered households living in detached houses. Also, we excluded households that used more 300 kL per person or more than 750 kL per annum. We did this because these households were outliers and we were concerned that they may have experienced a serious leak or may have been incorrectly identified as having an individual meter.[94] However, we included all households when looking at the relationships between the explanatory variables.

We separately analysed the determinants of consumption for the Sydney Water area (ie, Sydney, 2010), the Hunter Water area (2008) and the combined Gosford/Wyong areas (2008). We did this because the areas faced very different water supply conditions at the time of the surveys.

The results are organised as follows:

- Section G1 shows the linear regression results for the 'characteristics' model for Sydney (2010), the Hunter area (2008) and Gosford/Wyong (2008). (See section 7.2.)
- Section G2 shows the linear regression results for the 'energy uses' model for Sydney (2010), the Hunter area (2008) and Gosford/Wyong (2008). (See section 7.4.)
- Section G3 shows the semi-log regression results for the 'characteristics' model and the 'water uses' model for Sydney (2010). The section also compares the semi-log results with the linear regression results.
- Section G4 shows the regression results for the relationship between household characteristics and selected uses for water, for Sydney (2010). (See section 7.3.)
- Section G5 shows the regression results for our analysis of the impact of dwelling type on consumption. (See section 7.6.)

94 We also excluded a few households that reported living in a detached house but were not individually metered.

G.1 Linear regression results for the 'characteristics' model

The tables below show the detailed regression results that informed the discussion in Section 7.2 about the relationship between household characteristics and water consumption.

Table G.1 Linear regression results for 'characteristics' model, detached houses, Sydney (2010) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	8.00	11.31		0.71	0.48	-14.19	30.19		
Per adult	42.62	2.18	0.43	19.59	0.00	38.35	46.88	0.82	1.22
Per child	28.74	2.50	0.23	11.48	0.00	23.83	33.65	0.96	1.05
Income, per $'000	0.19	0.05	0.10	3.86	0.00	0.09	0.28	0.61	1.63
No income data	21.40	7.56	0.07	2.83	0.00	6.58	36.22	0.73	1.37
Coastal area	-10.20	4.51	-0.05	-2.26	0.02	-19.05	-1.35	0.95	1.05
Plot size, per m^2	0.041	0.012	0.10	3.33	0.00	0.02	0.07	0.40	2.48
Plot size unknown	17.16	11.96	0.04	1.43	0.15	-6.31	40.63	0.41	2.44
Per shower	16.13	3.08	0.11	5.24	0.00	10.09	22.18	0.85	1.18

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (11 households).

Table G.2 Linear regression results for 'characteristics' model, detached houses, Hunter (2008) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	3.27	12.91		0.25	0.80	-22.05	28.60		
Per adult	50.97	2.69	0.44	18.92	0.00	45.69	56.26	0.83	1.21
Per child	29.97	2.37	0.27	12.64	0.00	25.32	34.63	0.95	1.05
Income, per $'000	0.23	0.06	0.10	3.99	0.00	0.12	0.35	0.69	1.46
No income data	10.61	8.48	0.03	1.25	0.21	-6.02	27.24	0.83	1.21
Coastal area	-15.07	5.96	-0.05	-2.53	0.01	-26.75	-3.38	0.97	1.03
Plot size, per m^2	0.037	0.014	0.06	2.60	0.01	0.01	0.07	0.97	1.03
Per shower	20.72	3.55	0.13	5.83	0.00	13.75	27.68	0.90	1.11

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (7 households).

Table G.3 Linear regression results for 'characteristics' model, detached houses, Gosford/Wyong (2008) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	5.53	16.91		0.33	0.74	-27.68	38.73		
Per adult	47.50	3.75	0.45	12.67	0.00	40.14	54.86	0.83	1.20
Per child	25.82	3.52	0.24	7.34	0.00	18.91	32.73	0.94	1.06
Income, per $'000	0.04	0.09	0.02	0.46	0.65	-0.13	0.21	0.66	1.50
No income data	11.30	11.69	0.04	0.97	0.33	-11.65	34.24	0.79	1.27
Plot size, per m^2	0.036	0.021	0.06	1.69	0.09	-0.01	0.08	0.97	1.03
Per shower	4.42	5.06	0.03	0.87	0.38	-5.51	14.35	0.91	1.09

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (5 households).

G.2 Linear regression results for 'water uses' model

The tables below show the detailed regression results that informed the discussion in Section 7.5 about the relationship between water consumption and what water is used for.

Table G.4 Linear regression results for 'water uses' model, detached houses, Sydney (2010) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1.42	8.55		0.17	0.87	-15.35	18.18		
Per adult	36.94	2.11	0.37	17.48	0.00	32.80	41.09	0.77	1.31
Per child	20.06	2.52	0.16	7.97	0.00	15.12	24.99	0.84	1.19
Have pool	32.75	5.13	0.13	6.38	0.00	22.69	42.82	0.89	1.13
Dishwasher, per use per week	3.04	0.88	0.07	3.45	0.00	1.31	4.77	0.79	1.27
Washing machine, per use per week	7.87	1.00	0.17	7.83	0.00	5.90	9.83	0.71	1.42
Solar hot water	-28.03	7.15	-0.07	-3.92	0.00	-42.06	-14.00	0.98	1.02
Inland and use water for garden or pool	12.44	4.22	0.06	2.94	0.00	4.15	20.72	0.90	1.11
Per toilet	16.76	3.82	0.13	4.39	0.00	9.27	24.25	0.42	2.36
Per dual flush toilet	-5.23	2.96	-0.05	-1.77	0.08	-11.04	0.57	0.44	2.29
Per m^2 plot size if water garden	0.032	0.01	0.10	3.99	0.00	0.02	0.05	0.60	1.66
Plot size unknown and water garden	12.69	9.13	0.03	1.39	0.16	-5.22	30.60	0.66	1.53
Use sprinkler	39.27	7.57	0.10	5.18	0.00	24.41	54.13	0.95	1.05
Wash car	0.42	4.34	0.00	0.10	0.92	-8.10	8.94	0.95	1.05
Use bore water	-1.40	16.54	0.00	-0.08	0.93	-33.84	31.04	0.99	1.02
Use grey water	-12.80	4.72	-0.05	-2.71	0.01	-22.06	-3.55	0.98	1.02
Have rainwater tank	-12.13	4.67	-0.05	-2.60	0.01	-21.29	-2.97	0.92	1.09

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (11 households).

Table G.5 Linear regression results for 'water uses' model, detached houses, Hunter (2008) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	4.63	7.76		0.60	0.55	-10.59	19.85		
Per adult	39.91	2.66	0.34	15.03	0.00	34.70	45.12	0.76	1.32
Per child	19.41	2.50	0.18	7.78	0.00	14.52	24.31	0.77	1.30
Have pool	21.47	6.39	0.07	3.36	0.00	8.95	34.00	0.87	1.15
Dishwasher, per use per week	2.35	0.98	0.05	2.41	0.02	0.44	4.27	0.79	1.27
Washing machine, per use per week	10.12	1.02	0.24	9.96	0.00	8.13	12.11	0.66	1.52
Solar hot water	-14.21	10.09	-0.03	-1.41	0.16	-34.01	5.59	0.97	1.04
Inland and use water for garden or pool	3.37	6.45	0.01	0.52	0.60	-9.28	16.03	0.90	1.11
Per toilet	13.90	4.07	0.10	3.42	0.00	5.92	21.88	0.47	2.15
Per dual flush toilet	-1.63	3.25	-0.01	-0.50	0.62	-8.01	4.75	0.48	2.07
Per m^2 plot size if water garden	0.02	0.01	0.05	2.15	0.03	0.00	0.03	0.86	1.16
Use sprinkler	19.85	6.44	0.06	3.08	0.00	7.21	32.48	0.90	1.11
Wash car	16.61	4.29	0.08	3.87	0.00	8.19	25.03	0.94	1.06
Use bore water	-27.11	7.52	-0.07	-3.60	0.00	-41.87	-12.35	0.97	1.03
Use grey water	-5.60	5.08	-0.02	-1.10	0.27	-15.57	4.37	0.98	1.02
Have rainwater tank	-13.28	6.64	-0.04	-2.00	0.05	-26.30	-0.25	0.96	1.04

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (7 households).

Table G.6 Linear regression results for 'water uses' model, detached houses, Gosford/Wyong (2008) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	**Std error**	**Beta**			**Lower Bound**	**Upper Bound**	**Tolerance**	**VIF**
Constant	36.58	11.29		3.24	0.00	14.41	58.75		
Per adult	37.88	3.90	0.36	9.72	0.00	30.22	45.53	0.73	1.37
Per child	12.72	3.91	0.12	3.25	0.00	5.04	20.40	0.72	1.39
Have pool	19.12	9.03	0.07	2.12	0.03	1.39	36.85	0.90	1.11
Dishwasher, per use per week	2.93	1.52	0.07	1.93	0.05	-0.06	5.93	0.74	1.36
Washing machine, per use per week	9.06	1.66	0.22	5.46	0.00	5.81	12.32	0.61	1.63
Solar hot water	-10.86	17.17	-0.02	-0.63	0.53	-44.58	22.85	0.97	1.03
Per toilet	-0.28	5.61	0.00	-0.05	0.96	-11.30	10.74	0.44	2.28
Per dual flush toilet	-0.92	4.68	-0.01	-0.20	0.84	-10.12	8.27	0.45	2.21
Use bore water	-7.40	10.96	-0.02	-0.68	0.50	-28.92	14.11	0.95	1.05
Use grey water	-4.19	7.01	-0.02	-0.60	0.55	-17.95	9.57	0.98	1.02
Have rainwater tank	-20.30	6.99	-0.10	-2.90	0.00	-34.03	-6.58	0.91	1.10

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (7 households).

G.3 Semi-log regression results for 'characteristics' model and 'water uses' model for Sydney (2010)

As noted in Box 2.1 and discussed in Appendix B, we used a semi-log regression model to check the results of our linear regression model. To do this, for each explanatory variable we compared 2 models' estimated contribution to consumption as well as the t-values. We found a fairly high degree of consistency between the 2 types of model, despite the problems associated with translating the semi-log regression coefficients into kL contributions (discussed in Appendix B).

The first 2 tables below show the semi-log regression results for the 'characteristics' model and the 'energy uses' model respectively. The next 2 tables compare the results of the semi-log model with those of the linear model, for the 'characteristics' model and the 'water uses' model respectively.

Table G.7 Semi-log regression results for 'characteristics' model, detached houses, Sydney (2010) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	4.129	0.062		66.73	0.00	4.007	4.250		
Per adult	0.232	0.012	0.425	19.53	0.00	0.209	0.256	0.82	1.22
Per child	0.165	0.014	0.243	12.05	0.00	0.138	0.192	0.96	1.05
Income, per $'000	0.001	0.000	0.121	4.83	0.00	0.001	0.002	0.61	1.63
No income data	0.145	0.041	0.081	3.50	0.00	0.064	0.226	0.73	1.37
Coastal area	-0.054	0.025	-0.044	-2.20	0.03	-0.103	-0.006	0.95	1.05
Plot size, per m^2	0.0001	0.0001	0.064	2.05	0.04	0.000	0.000	0.40	2.48
Plot size unknown	0.055	0.065	0.026	0.84	0.40	-0.073	0.183	0.41	2.44
Per shower	0.090	0.017	0.114	5.34	0.00	0.057	0.123	0.85	1.18

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (11 households).

Table G.8 Semi-log regression results for 'water uses' model, detached houses, Sydney (2010) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	4.033	0.047		86.29	0.00	3.942	4.125		
Per adult	0.202	0.012	0.370	17.51	0.00	0.180	0.225	0.77	1.31
Per child	0.118	0.014	0.173	8.55	0.00	0.091	0.145	0.84	1.19
Have pool	0.172	0.028	0.120	6.14	0.00	0.117	0.227	0.89	1.13
Dishwasher, per use per week	0.022	0.005	0.095	4.57	0.00	0.013	0.031	0.79	1.27
Washing machine, per use per week	0.044	0.005	0.178	8.10	0.00	0.034	0.055	0.71	1.42
Solar hot water	-0.125	0.039	-0.060	-3.19	0.00	-0.201	-0.048	0.98	1.02
Inland and use water for garden or pool	0.092	0.023	0.077	3.96	0.00	0.046	0.137	0.90	1.11
Per toilet	0.092	0.021	0.126	4.43	0.00	0.052	0.133	0.42	2.36
Per dual flush toilet	-0.033	0.016	-0.057	-2.03	0.04	-0.065	-0.001	0.44	2.29
Per m^2 plot size if water garden	0.0002	0.0000	0.090	3.75	0.00	0.000	0.000	0.60	1.66
Plot size unknown and water garden	0.084	0.050	0.039	1.69	0.09	-0.013	0.182	0.66	1.53
Use sprinkler	0.167	0.041	0.076	4.03	0.00	0.086	0.248	0.95	1.05
Wash car	0.015	0.024	0.012	0.65	0.52	-0.031	0.062	0.95	1.05
Use bore water	0.052	0.090	0.011	0.57	0.57	-0.125	0.229	0.99	1.02
Use grey water	-0.062	0.026	-0.045	-2.42	0.02	-0.113	-0.012	0.98	1.02
Have rainwater tank	-0.077	0.026	-0.058	-3.01	0.00	-0.127	-0.027	0.92	1.09

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (11 households).

Table G.9 Comparison of semi-log and linear 'characteristics' model outputs, detached houses, Sydney (2010) – kL pa

Data set	Sydney (2010)		Sydney (2010)	
Type of regression model	**Semi-log**		**Linear**	
	kL/$	**(t-value)**	**kL/$**	**(t-value)**
% of variation explained (R^2)	37		35	
Sample size	1,652		1,652	
Regression results in volumes (kL pa)				
Per person older than 15 years	44	(15.8)	43	(19.6)
Per person 15 years or younger	30	(8.4)	29	(11.5)
Per indoor shower	16	(5.3)	16	(5.2)
Per $10,00 income pa	2.2	(1.8)	1.9	(3.9)
Did not provide income data	26	(2.0)	21	(2.8)
Per 100m² plot size	2.4	(2.1)	4.1	(3.3)
Do not know size of plot	ns	(0.8)	ns	(1.4)
Live in a coastal area	-9	(-2.2)	-10	(-2.3)

Note: Households with consumption exceeding 300 kL per person or 750 kL per household per annum are excluded (11 households).

Table G.10 Comparison of semi-log and linear 'water uses' model outputs, detached houses, Sydney (2010) – kL pa

Data set	Sydney (2010)		Sydney (2010)	
Type of regression model	**Semi-log**		**Linear**	
	kL pa	**(t-value)**	**kL pa**	**(t-value)**
% of variation explained (R^2)	44		43	
Sample size	1,649		1,649	
Indoor use				
Per person older than 15 years	38	(17.5)	37	(17.5)
Per person 15 years or younger	21	(8.6)	20	(8.0)
Washing machine - used once per week	8	(8.1)	8	(7.8)
Dishwasher - used once per week	3.8	(4.6)	3.0	(3.4)
Per toilet (similar to per shower)	16	(4.4)	17	(4.4)
Per dual flush toilet	-5	(-2.0)	-5	(-1.8)
Outdoor use		`		
Have a swimming pool	30	(6.1)	33	(6.4)
Use sprinkler	30	(4.0)	39	(5.2)
Per 100m2 plot size if water garden	2.8	(3.8)	3.2	(4)
Do not know plot size and water garden	15	(1.7)	ns	(1.4)
Wash car outdoors[a]	ns	(0.6)	ns	(0.1)
Inland and water garden or have pool	15	(4.0)	12	(2.9)
Alternative sources of water (mainly used outdoors)				
Have rainwater tank	-13	(-3.0)	-12	(-2.6)
Use bore water[a]	ns	(0.6)	ns	(-0.1)
Use grey water	-10	(-2.4)	-13	(-2.7)
Water wise				
Proxy used: have solar hot water	-20	(-3.2)	-28	(-3.9)

[a] Not statistically significant.

G.4 Relationships between households characteristics and what water is used for

In Chapter 7 we identified some of the underlying reasons for the observed relationships between household characteristic and water consumption (section 7.3). The tables below show the detailed regression results that informed the discussion.

G.4.1 Relationship between having a swimming pool and household characteristics

Having swimming pool is the dependent variable and the household characteristics are the explanatory variables. The results show that having a swimming pool is associated with living in a detached house, having more indoor showers, having a higher income, living on a larger plot and, to a lesser extent, having more children. These household characteristics explain no more than 16% of the variation between households.

Table G.11 Relationship between having a swimming pool and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
# adults	-.057	.062	.847	1	0.36	.945
# children	.160	.068	5.565	1	0.02	1.173
Income ($'000 pa)	.008	.001	34.833	1	0.00	1.008
No income data	.656	.226	8.414	1	0.00	1.927
Coastal	-.060	.133	.201	1	0.65	.942
Plot size	.002	.000	17.132	1	0.00	1.002
Plot size unknown	.815	.388	4.422	1	0.04	2.260
# showers	.669	.088	57.231	1	0.00	1.952
Constant	-4.221	.357	139.729	1	0.00	.015

Note: Binary logistic regression.

Table G.12 Relationship between having a swimming pool and household characteristics, Sydney (2010) – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1584	.103	.157

G.4.2 Relationship using a dishwashers and household characteristics

In next table *using* a dishwasher is the dependent variable and the household characteristics are the explanatory variables. The results confirm our finding in Appendix C that frequently using a dishwasher tends to be a high-income phenomenon (ie, it is strongly associated with income and the number of indoor showers). How often a dishwasher is used also depends on the number of people in the household (particularly children). The household characteristics explain 22% of the variation between households.

Appendix C shows the relationship between *having* a dishwasher and household characteristics (Table C.21 and Table C.22).

Table G.13 Relationship between using a dishwasher and household characteristics, Sydney (2010) – regression results (days per week)

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	-1.02	0.29		-3.53	0.00	-1.59	-0.45		
# adults	0.17	0.06	0.07	3.04	0.00	0.06	0.28	0.82	1.23
# children	0.38	0.06	0.13	5.88	0.00	0.25	0.51	0.96	1.04
Income ($'000 pa)	0.01	0.00	0.32	11.77	0.00	0.01	0.02	0.62	1.62
No income data	1.04	0.20	0.13	5.31	0.00	0.65	1.42	0.72	1.38
Coastal	0.40	0.12	0.08	3.39	0.00	0.17	0.63	0.95	1.06
Plot size	0.00	0.00	0.05	1.59	0.11	0.00	0.00	0.40	2.47
Plot size unknown	0.11	0.31	0.01	0.35	0.73	-0.50	0.72	0.41	2.43
# showers	0.62	0.08	0.18	7.87	0.00	0.47	0.77	0.85	1.18

Note: Linear regression. Including all households, whether or not they have a dishwasher.

Table G.14 Relationship between using a dishwasher and household characteristics – model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.476	0.227	0.223	2.259

G.4.3 Relationship using a washing machine and household characteristics

In next table using a washing machine is the dependent variable and the household characteristics are the explanatory variables. The results show that how often a washing machine is used depends mainly on the number of adults and children in the household. The household characteristics together explain 26% of the variation between households.

Table G.15 Relationship between using a washing machine and household characteristics – regression results (days per week)

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1.79	0.20		8.76	0.00	1.39	2.19		
# adults	0.62	0.04	0.37	15.79	0.00	0.55	0.70	0.82	1.23
# children	0.65	0.05	0.31	14.40	0.00	0.56	0.74	0.96	1.04
Income ($'000 pa)	0.003	0.001	0.09	3.32	0.00	0.00	0.01	0.62	1.62
No income data	0.42	0.14	0.08	3.04	0.00	0.15	0.69	0.72	1.38
Coastal	0.22	0.08	0.06	2.63	0.01	0.06	0.38	0.95	1.06
Plot size	0.00	0.00	0.00	0.08	0.94	0.00	0.00	0.41	2.47
Plot size unknown	-0.07	0.22	-0.01	-0.31	0.76	-0.50	0.36	0.41	2.43
# showers	-0.14	0.06	-0.06	-2.44	0.02	-0.24	-0.03	0.85	1.18

Note: Linear regression. Including all households, whether or not they have a washing machine.

Table G.16 Relationship between using a washing machine and household characteristics – model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.515	0.266	0.262	1.590

G.4.4 Relationship between using a sprinkler and household characteristics

Using a sprinkler is the dependent variable and the household characteristics are the explanatory variables. The results show that, like using a dishwasher, using a sprinkler tends to be a high-income phenomenon (ie, it is strongly associated with income and the number of indoor showers). Using a sprinkler is also associated with living in an inland area, but this association is not very strong. These household characteristics explain no more than 5% of the variation between households.

Table G.17 Relationship between using a sprinkler and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
# adults	-0.002	0.087	0.000	1.000	0.984	0.998
# children	0.034	0.098	0.122	1.000	0.727	1.035
Income ($'000 pa)	0.006	0.002	8.880	1.000	0.003	1.006
No income data	0.129	0.366	0.123	1.000	0.726	1.137
Coastal	-0.367	0.202	3.308	1.000	0.069	0.693
Plot size	0.000	0.001	0.660	1.000	0.416	1.000
Plot size unknown	-0.282	0.613	0.211	1.000	0.646	0.755
# showers	0.361	0.123	8.707	1.000	0.003	1.435
Constant	-3.747	0.481	60.744	1.000	0.000	0.024

Note: Binary logistic regression.

Table G.18 Relationship between using a sprinkler and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	890	0.023	0.053

G.4.5 Relationship between watering the garden with a hose and household characteristics

Watering the garden with a hose (with a trigger nozzle) is the dependent variable and the household characteristics are the explanatory variables. The only significant finding is that households are less likely to water the garden with a hose if they have children and/or live on a large plot. The household characteristics explain very little of the variation between households (less than 2%).

Table G.19 Relationship between watering the garden with a hose and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
# adults	0.021	0.055	0.148	1.000	0.701	1.021
# children	-0.166	0.061	7.461	1.000	0.006	0.847
Income ($'000 pa)	0.001	0.001	0.503	1.000	0.478	1.001
No income data	-0.044	0.190	0.055	1.000	0.815	0.957
Coastal	0.031	0.115	0.074	1.000	0.785	1.032
Plot size	-0.001	0.000	8.918	1.000	0.003	0.999
Plot size unknown	-0.668	0.308	4.717	1.000	0.030	0.513
# showers	0.094	0.077	1.462	1.000	0.227	1.098
Constant	1.394	0.288	23.426	1.000	0.000	4.033

Note: Binary logistic regression.

Table G.20 Relationship between watering the garden with a hose and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1997	0.011	0.015

G.4.6 Relationship between having a rainwater tank and household characteristics

Having a rainwater tank is the dependent variable and the household characteristics are the explanatory variables. Households on large plots and/or with more indoor showers are more likely to have a rainwater tank. The household characteristics explain very little of the variation between households (less than 3%).

Table G.21 Relationship between having a rainwater tank and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
# adults	0.024	0.055	0.187	1.000	0.666	1.024
# children	-0.012	0.064	0.038	1.000	0.846	0.988
Income ($'000 pa)	-0.002	0.001	1.671	1.000	0.196	0.998
No income data	-0.023	0.193	0.014	1.000	0.906	0.977
Coastal	0.057	0.116	0.237	1.000	0.626	1.058
Plot size	0.001	0.000	17.314	1.000	0.000	1.001
Plot size unknown	0.628	0.324	3.741	1.000	0.053	1.873
# showers	0.144	0.077	3.480	1.000	0.062	1.155
Constant	-2.145	0.295	52.700	1.000	0.000	0.117

Note: Binary logistic regression.

Table G.22 Relationship between having a rainwater tank and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1945	0.017	0.024

G.4.7 Relationship between using grey water and household characteristics

Using grey water is the dependent variable and the household characteristics are the explanatory variables. The only significant result is that higher income households are less likely use grey water than lower income households. The household characteristics explain very little of the variation between households (less than 2%).

Table G.23 Relationship between using grey water and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
# adults	0.045	0.058	0.605	1.000	0.437	1.046
# children	-0.110	0.071	2.400	1.000	0.121	0.896
Income ($'000 pa)	-0.004	0.001	8.003	1.000	0.005	0.996
No income data	-0.189	0.198	0.916	1.000	0.339	0.828
Coastal	-0.055	0.121	0.201	1.000	0.654	0.947
Plot size	0.001	0.000	2.803	1.000	0.094	1.001
Plot size unknown	0.373	0.322	1.343	1.000	0.247	1.452
# showers	-0.017	0.082	0.042	1.000	0.839	0.983
Constant	-1.269	0.302	17.616	1.000	0.000	0.281

Note: Binary logistic regression.

Table G.24 Relationship between using grey water and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1843	0.010	0.016

G.4.8 Relationship between washing cars outdoors and household characteristics

Washing cars outdoors is the dependent variable and the household characteristics are the explanatory variables. Households in coastal areas are more likely to wash their cars, but households with children are less likely to do so. Again, the household characteristics explain very little of the variation between households (less than 2%).

Table G.25 Relationship between washing cars outdoors and household characteristics, Sydney (2010) – regression results

	Coefficients		Statistics			Expo-nential
	B	SE	Wald	df	Sig	Exp(B)
# adults	0.068	0.052	1.716	1.000	0.190	1.071
# children	-0.126	0.063	4.013	1.000	0.045	0.881
Income ($'000 pa)	-0.001	0.001	1.274	1.000	0.259	0.999
No income data	-0.034	0.182	0.035	1.000	0.852	0.967
Coastal	0.331	0.109	9.257	1.000	0.002	1.393
Plot size	0.000	0.000	0.212	1.000	0.645	1.000
Plot size unknown	-0.189	0.292	0.418	1.000	0.518	0.828
# showers	0.136	0.074	3.395	1.000	0.065	1.145
Constant	-0.947	0.273	12.070	1.000	0.001	0.388

Note: Binary logistic regression.

Table G.26 Relationship between washing cars outdoors and household characteristics – model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2116	0.013	0.018

G.4.9 Relationship between the number of toilets and household characteristics

In next table the number of toilets (single and dual flush) is the dependent variable and other household characteristics are the explanatory variables. The results show that number of toilets is most strongly associated with income and the number of adults in the household. The household characteristics together explain 15% of the variation between households.

Table G.27 Relationship between number of indoor toilets and household characteristics – regression results (number of toilets)

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	1.021	.095		10.724	0.00	.834	1.207		
# adults	.143	.018	.190	7.806	0.00	.107	.179	.857	1.167
# children	.038	.022	.041	1.773	0.08	-.004	.080	.959	1.042
Income ($'000 pa)	.004	.000	.240	8.519	0.00	.003	.004	.639	1.566
No income data	.432	.065	.174	6.657	0.00	.305	.559	.737	1.356
Coastal	.130	.039	.077	3.341	0.00	.054	.207	.953	1.049
Plot size	.001	.000	.175	4.972	0.00	.000	.001	.411	2.433
Plot size unknown	.068	.104	.023	.653	0.51	-.136	.271	.412	2.425

Note: Linear regression. Including all households, whether or not they have a washing machine.

Table G.28 Relationship between number of indoor toilets and household characteristics – model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.397	0.157	0.154	0.756

G.5 Linear regression results for the impact of dwelling type on water consumption

The tables below show the detailed regression results that informed the discussion in Section 7.6 about the impact of dwelling type on water consumption.

Table G.29 Linear regression results for the impact of dwelling type on consumption, excluding outdoor variables Sydney (2010) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	14.85	8.41		1.77	0.08	-1.65	31.34		
Detached house	21.89	6.76	0.06	3.24	0.00	8.63	35.16	0.96	1.04
Per shower	16.58	2.90	0.11	5.72	0.00	10.89	22.26	0.87	1.15
Per adult	42.68	2.06	0.43	20.75	0.00	38.64	46.71	0.81	1.24
Per child	28.81	2.35	0.23	12.29	0.00	24.21	33.41	0.96	1.04
Income, per $'000	0.20	0.04	0.11	4.49	0.00	0.11	0.29	0.62	1.61
No income data	21.00	7.00	0.07	3.00	0.00	7.27	34.74	0.73	1.37
Coastal area	-13.52	4.13	-0.06	-3.27	0.00	-21.63	-5.41	0.96	1.04

Note: Households with consumption exceeding 300 kL per person or 750 kWh per household per annum are excluded.

Table G.30 Linear regression results for the impact of dwelling type on consumption, including outdoor variables Sydney (2010) – kL pa

	Un-standardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
Constant	15.79	8.37		1.89	0.06	-0.63	32.21		
Detached house	-1.69	8.53	-0.01	-0.20	0.84	-18.41	15.04	0.60	1.68
Per shower	14.62	2.91	0.10	5.02	0.00	8.91	20.33	0.85	1.18
Per adult	42.85	2.05	0.43	20.96	0.00	38.84	46.86	0.81	1.24
Per child	29.71	2.34	0.24	12.69	0.00	25.12	34.30	0.95	1.05
Income, per $'000	0.20	0.05	0.10	4.40	0.00	0.11	0.28	0.62	1.62
No income data	22.73	6.98	0.07	3.26	0.00	9.04	36.43	0.73	1.38
Coastal area	-11.14	4.14	-0.05	-2.69	0.01	-19.26	-3.03	0.95	1.06
Per m^2 plot size and water garden	0.04	0.01	0.13	4.74	0.00	0.02	0.05	0.48	2.08
Unknown plot size and water garden	12.75	9.43	0.03	1.35	0.18	-5.75	31.24	0.66	1.52

Note: Households with consumption exceeding 300 kL per person or 750 kWh per household per annum are excluded.

H Technical information for electricity and water

We used independent technical information to evaluate a number of the regression coefficients for the 'energy uses' model for electricity in Chapter 3 and the 'water uses' model in Chapter 7. This section provides the detailed technical information that informed those discussions.

- Table H1 provides the detailed information for fridges. (See section 3.4, Table 3.5.)
- Table H2 provides the detailed information for other electricity. (See section 3.4, Table 3.5.)
- Table H3 provides the detailed information for water. (See section 7.4, Table 7.5.)

Table H.1 Technical information about electricity consumption compared to regression coefficients for 2nd fridges.

Sydney (2010)	H,G &W (2008)	Origin		OkSolar		Michael Bluejay			Australian Energy rating website	
kWh pa co-efficient	kWh pa co-efficient	kWh pa	comments	kWh pa	comments	kWh pa,18 cu ft (510L)[a]	kWh pa 22 cu ft (623 L)[a]	comments	kWh pa	comments
1,171	756	316	200 L capacity	1,250	Manual Defrost	1,800	2,200	<1976	146	50 L, 3 Star (no freezer)
		474	400 L capacity	1,830	Automatic Defrost	1,400	1,700	1976-86	234	76 L, 1.5 Star (no freezer)
		717	700 L capacity	999	16 cu ft (453 L) fridge-freezer	950	1,150	1987-89	448	472 L, 3 Star fridge-freezer
			All modern, compressor running about 30% of the time	1,577	16 cu ft (453 L) fridge-freezer (frostless)	900	1,100	1990-92	555	690 L, 3 Star fridge-freezer
						700	850	1993-00	1,014	750 L, 1 Star fridge-freezer
						500	600	2001-2010		
						450	550	2001-2004 Energy Star		
						425	525	2004-2008 Energy Star		
						400	500	2008-2010 Energy Star		

a Ice makers can double usage. Consumption assumes ice makers are turned off.

Source: As for Table C6.

Table H.2 Technical information about electricity consumption of other appliances compared to regression coefficients

	Sydney (2010)	H,G &W (2008)	Origin		OkSolar		Michael Bluejay		Energy Rating website	
	kWh pa	kWh pa	kWh pa	comments	kWh pa	comments	kWh pa	comments	kWh pa	comments
Have a swimming pool	2,520	2,269	2,223	1.1kW pump used 3 hrs per day in winter and 8 hrs per day in summer	4,015	2kW pump used 3 hrs per day in winter and 8 hrs per day in summer	na	na	na	na
Have a spa	959	1,680	945	1.5 kW heater used for 12 hours once per week	na	na	na	na	na	na
Per 280 hours of air conditioner use	691	701	186	bedroom size - 2.5kW	532	1 ton ducted system	980	2.5 ton ducted system	na	na
			391	lounge size - 5 kW	1,820	3.5 ton ducted system				
			969	small ducted - 12 kW						
Clothes dryer – used once per week	290	327	239	5kg unit used once per week	290	used 2 hours once per week	230	used 1 hour once per week	77	4 Star 2.5kg load
							340	used 1.5 hours once per week	231	1.5 Star 5kg load
									404	2 star 9kg load
Dishwasher - used once per week	309	220	55	12 place settings, normal load	62	used 1 hour per week	na	na	32	Modern, 4 Star rated
									81	Modern, 1 Star rated
Use electricity for space heating other than	322	ns		7hrs per day, 85 days in winter and 1 day per week in summer	na	na	na	na	na	na
			1,205	personal, 1000 W						
			1,804	small room, 1500 W						

	Sydney (2010)	H,G &W (2008)	Origin		OkSolar		Michael Bluejay		Energy Rating website	
	kWh pa	kWh pa	kWh pa	comments	kWh pa	comments	kWh pa	comments	kWh pa	comments
air conditioner			2,889	lounge room, 2400 W						
Main source for hot water is gas	-2,762	-2,846	2,555	electric hot water system, summer	2,710	electric water heater, power on 3 hrs per day	na	na	na	na
			3,650	electric hot water system, winter						
			3,103	Average for the year						
Main source for hot water is solar[a]	-1,397	-1,685	-1,533	calculated summer saving		na	na	na	na	na
			-2,373	calculated winter saving						
			-1,953	average for the year						

a NSW Office of Environment and Heritage website states that 'In NSW, approximately 65-80% of your (electric boosted solar) hot water will be free of charge' (*http://www.environment.nsw.gov.au/energy/hwschoose.htm*, accessed 7 October 2011).

Sources: Origin, *New South Wales estimated household energy consumption*, summer period 2011 and winter period 2011/12, available at *http://www.originenergy.com.au/3531/State-fact-sheets* accessed 7 October 2011. OkSolar website at http://*www.oksolar.com/technical/consumption.html*, accessed 7 October 2011. Michael Bluejay website *at http://michaelbluejay.com/electricity*, accessed 7 October 2011 (specific appliances section). Australian Energy rating website at *http://reg.energyrating.gov.au/*, accessed 7 October 2011 (comparing products section).

Table H.3 Technical information about water consumption compared to regression coefficients

	Sydney (2010)	Hunter (2008)	Gosford & Wyong (2008)	Hunter Water		Sydney Water		Water Efficiency Labelling and Standards Scheme (WELS)	
	kL pa	**kL pa**	**kL pa**	**kL pa`**	**comments**	**kL pa**	**comments**	**kL pa**	**comments**
Per adult	37	40	38	20	4 minute shower, water saving showerhead, tap aerators, dual flush toilets				
				43	5 minute shower, dual flush toilets				
				79	10 minute shower, single flush toilets				
				95	5 minute shower, dual flush toilets, leaking taps and toilet				
Washing machine – used once per week	7.9	10.1	9.1	3.0	modern front loading, no hand washing			2.2	Front loading 6 kg, 4 Star
				7.0	modern top loading, no hand washing			3.1	Front loading 7 kg, 4.5 Star
				4.0	Hand washing once per week			3.2	Top loading 6 kg, 4 Star
								6.4	Front loading 9 kg, 3 Star
								6.8	Top loading 7 kg, 2 Star
								9.8	Top loading, 7kg, 1 Star
Dishwasher - used once per week	3.0	2.4	2.9	2.0	Dishwasher only, no sink washing	0.94	AAA rated modern machine, 18 L per cycle	0.35	6 place settings, 4 Star, eco setting
				3.0	Dishwasher plus 1 sink wash per week	2.08	Old machine, 40 L per cycle	0.60	12 place settings, 4 Star, normal wash

							0.82	12 place settings, 2.5 Star, normal wash
							1.20	14 place settings, 1 Star
Rainwater tank	-12	-13	-20		4	100 m2 roof, 2000L tank, 10 minutes pw garden watering. Coastal.		
					10	100 m2 roof, 2000L tank, 20 minutes pw garden watering. Inland (Penrith).		
					24	200 m2 roof, 4000L tank, 30 minutes pw garden watering. Coastal.		
					97	300 m2 roof, 4000L tank, 30minutes pw garden watering, used for laundry, toilets, hot water for 5 people. Inland (Penrith).		

	Sydney (2010)	Hunter (2008)	Gosford & Wyong (2008)	Hunter Water - Water Usage Calculator	
	kL pa	kL pa	kL pa	kL pa	comments
Pool and garden watering					Use hose weekly in summer and occasionally in winter for:
1 - Have a swimming pool	33	21	19	13	10 minutes, summer and winter
2 - Water garden with sprinkler	39	20	na	23	20 minutes summer, 10 minutes winter
3 - Water garden with hose, average plot (700m^2)	23	11	na	36	30 minutes summer, 20 minutes winter
- small plot (300m^2)	10	5		52	40 minutes summer and winter
Wash car outdoors	ns	17	na	8	occasionally
				31	weekly
'Water wise'	-28	ns	ns	-23	Per person, 1 minute shorter shower, water saving shower head and tap aerators in bathroom

Sources:
Hunter Water's Usage Calculator, available at *http://www.hunterwater.com.au/Save-Water/Water-Usage-Calculator.aspx*, accessed 14 October 2011.
Australian Government Water Efficiency Labelling and Standards scheme (WELS) website, at *http://www.environment.gov.au/wels_public/productSearch.do*, accessed 15 October 2011.
Sydney Water website at *http://www.sydneywater.com.au/Water4Life/InYourHome/InTheKitchen/Dishwashers.cfm*, accessed 15 October 2011.
Sydney Water *Rainwater tank calculator* available at http://www.sydneywater.com.au/Water4Life/InYourGarden/RainwaterTanks/ResidentialCalculator.cfm, accessed 15 October 2011.

Glossary

Adult	Person older than 15 years.
Amenities	Facilities including toilets, showers, baths, spas and swimming pools.
Appliances	Items such as dishwashers, washing machines, clothes dryers, microwave ovens, refrigerators and air conditioners. Note that the surveys did not ask about small appliances.
Binary variable	A variable that takes on the value of 0 or 1, where 0 means 'no' and 1 means 'yes'. Examples include having a swimming pool and using mains gas.
Child	Person 15 years or younger.
Coefficient, or Regression coefficient	For linear regression, it is a value that represents the rate of change of one variable (y) as a function of changes in the other (x); it is the slope of the regression line. For example, if y = 2x+b, the regression coefficient is 2.
Confidence interval	In regression analysis, the range of values that is likely to contain the 'true' population parameter (ie, for the whole population rather than just the sample that is being tested). The upper and lower bounds depend on the level of confidence that is used. (The confidence intervals shown in the Appendices are for a 95% level of confidence.)
Controlled Load electricity supply	Electricity supply that is switched on and off by the network provider. Electricity is provided during certain hours only, usually at night. Most common use is for hot water, commonly known as off-peak hot water.
Cylinder Gas	Liquid petroleum gas (LPG) supplied in large gas cylinders that are connect to appliances in dwellings.
Detached house	Separate house not structurally attached to another dwelling.
Flats	Low, medium or high rise block of flats or units, granny flats.

Grey water	Wastewater generated from domestic activities such as laundry, dishwashing, and bathing, which can be recycled on-site.
Higher-middle income	Income between $62, 400 and $130,000 per annum for Sydney (2010), and between $56,300 and $112,700 per annum for Hunter, Gosford and Wyong (2008). Expressed in dollars for the year to February 2010.
High-income	Income greater than $130,000 per annum for Sydney (2010), and greater than $112,700 per annum for Hunter, Gosford and Wyong (2008). Expressed in dollars for the year to February 2010.
Income	Total household income before tax, including all sources of income.
Kilolitres (kL)	Unit of water measurement equal to 1,000 litres.
Kilowatt hours (kWh)	Unit of electricity measurement equal to 1,000 watts.
Lower-middle income	Income between $33,800 and $62, 400 per annum for Sydney (2010), and between $33,800 and $56,600 per annum for Hunter, Gosford and Wyong (2008). Expressed in dollars for the year to February 2010.
Low-income	Income less than $33,800 per annum in 2010. Expressed in dollars for the year to February 2010.
Mains gas	Gas delivered through a network of pipelines ('gas mains') by the gas service provider.
Mains water	Water delivered through a network of pipelines ('water mains') by the water service provider.
Megajoules (MJ)	Unit of gas measurement equal to 1,000,000 J (joules)
Multi-unit dwelling	Flats Semi-detached and dwellings such as townhouse, semi-detached or terrace house, villa unit or duplex.
Off-peak hot water system	Hot water systems which heat water outside the most popular and expensive times (usually 10pm to 7am). Also know as a controlled load system (as the electricity network operator controls when water is heated).
Peak demand	The amount of power required to supply customers at the busiest times. Also know as peak load.

Regression	A statistical technique that is used to establish the relationship between a dependent variable (eg, water consumption) and one or more independent or explanatory variables (eg, the number of people in a household and how often they water the garden).
Semi-detached dwelling	Townhouse, semi-detached or terrace house, villa unit or duplex
T-value	In regression analysis, a statistical measure of the strength of the relationship between a dependent and an explanatory variable. For large samples, a t-value of 2 or more (in absolute terms) means that we are 95% confident that the explanatory variable is related to the dependent variable, ie, that the value of the regression coefficient is not zero. Not used for binary variables.
Wald score	In regression analysis, a statistical measure of the strength of the relationship between a dependent variable and a binary explanatory variable, such has using mains gas (when 1 = yes and 0 = no). A Wald score of 4 or more means that we are 95% confident that the explanatory variable is related to the dependent variable.