The Importance of Environmental Attitudes in Accounting for Energy Consumption

***P.Newton*[1], *D.Meyer*[2]**

[1] Swinburne Institute of Social Research; [2]Statistics, Data Science & Epidemiology,

Swinburne University of Technology, Australia

pnewton@swin.edu.au, dmeyer@swin.edu.au

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Abstract

The take-up of solar photovoltaics (PV) in cities all over the developed world signals a new era of eco-efficiency in energy production, also expected to reduce the impact of energy pricing on supply and demand. Politicians must therefore look for alternative tools to pricing for restraining the demand for energy and generation of greenhouse gas emissions. This paper examines the demand for residential energy consumption focusing on environmental attitudes. The environmental predispositions of households are measured using a set of attitude and intention questions related to key factors in the theory of planned behaviour. This produces a typology consisting of 3 clusters of survey respondents – *committed greens, material greens and enviro-sceptics.* An analysis of covariance reveals significant differences for the energy consumption of these clusters after taking into account income, household size and dwelling size. These results confirm that energy policy addressing voluntary behavioural change remains an important priority at a time when technological change is allowing steady growth in the supply of renewable energy and sustainable urban design is gradually ensuring greater energy efficiency – but not at a rate likely to halt the increase in global demand for energy, and the associated growth in carbon emissions foreshadowed by the International Energy Agency and the IPCC.

1 Introduction

In the 1970's and 1980's energy pricing was seen as an important policy tool used for three important purposes: economic efficiency in the allocation of resources for energy production, funding of infrastucture and income redistribution [1]. The changes taking place in the energy industry since these times have included changes in ownership, with the privatisation of many aspects of energy supply in most developed countries. In addition there have been technical changes driven largely by the need to reduce dependence on fossil fuels in favour of renewable energy resources, in order to reduce carbon emissions and mitigate global warming. In particular, the increased deregulation of the energy sector in the 21st century has seen the rise of a distributed generation technology in the form of solar photovoltaics. Along with major structural changes in the Australian economy, resulting in a continued decline in the manufacturing sector characteristic of most post-industrial societies, this has resulted in reductions in end user demand for centralised electricity supply, ending the forecasts of continued future growth in electricity demand in Australia. Electricity consumption fell 3.2% over the three years to 2011 [2] with a further decline of 6.7% between 2011 and 2014 according to the Australian Energy Regulator [3].

In an environment evidencing declining demand, price increases are difficult to justify. In the past economists believed that consideration of pricing and incomes were all that was needed in order to 'manage' energy demand [4]. However, in the present climate of declining demand, pricing is no longer an effective tool for controlling electricity demand in the short-term.

Urban design and voluntary behaviour change are two important areas that are available for reducing energy demand, albeit more complex than pricing. More sustainable urban design is critical in that built environments account for an estimated 80% of all global emissions [5]. However, it has been advanced that voluntary behaviour change has more *potential for rapid change* at a relatively low public cost, ***if*** the 'attitudes-action' gap between environmentally-friendly attitudes and actual resource consumption behaviours can be better understood and overcome [6].

The authors' previous research in this area revealed that there were three environmental lifestyle clusters: "committed" greens, "material" greens and "enviro-sceptics". However, no significant differences were found between these clusters in relation to their *per capita consumption of energy*, suggesting that there are factors that override environmental attitudes, contributing to an Attitudes-Action Gap in regard to the energy consumption of individuals. In this paper, instead of considering per capita consumption of energy, we consider *household energy consumption*, in order to better understand the effects of household income, household size and size of dwelling, as reflected in the number of bedrooms.

After controlling for these factors the three previously defined clusters are compared in terms of household energy consumption, assuming that the environmental attitudes of survey respondents adequately reflect the attitudes of their households. This assumption has been supported in several studies [7, 8], with good agreement found between mothers and fathers and their adolescent daughters, but less agreement for adolescent sons.

We investigate the impact of environmental attitudes on household energy consumption at a single point in time. The relationships between environmental attitudes, household income, household size and size of dwelling are considered initially. These last three variables were often included with energy prices in econometric models to explain energy demand [9]. The effect of environmental attitudes on household energy consumption is then assessed, using the attitudinal cluster variable derived previously [10] and controlling for household income, household size and dwelling size.

2 Methodology

A postal survey undertaken in June 2009 in seven different types of residential neighbourhood across Melbourne (Australia) resulted in data for adult individuals representing 1,250 households at a response rate of 16%. The questionnaire was designed to collect information on the structural and attitudinal attributes of individuals, their household and dwelling characteristics, as well as household consumption data for electricity, gas and water, based on the most recent utility bills.

2.1 Dependent Variables

The most recent electricity and gas bills were combined to measure energy consumption in this analysis because both electricity and gas are used for operating the spectrum of built-in and plug-in domestic appliances in a dwelling. In contrast to previous analyses conducted using these data [10, 11, 12], energy consumption was modelled on a household rather than a per capita basis. The household granularity is more appropriate in this study because of the fixed cost component in energy bills and because of the household granularity of the variables used to predict energy consumption. However, this does mean that it has been assumed that the attitude of the respondent reflects/represents the attitudes of the household.

2.2 Independent Variables

2.2.1 Attitudinal Clusters

As described previously [10], 13 key variables were used in the final allocation of 1122 survey responses to three attitudinal clusters. The responses to these questions were obtained from an adult member of each household. The demographic of these respondents showed a reasonable mix (46% university graduates, 49% under the age of 45, 40% male, 24% living alone, 34% couples without children living at home, 35% families with children).

Table 1. Definition of Attitudinal Clusters

	Percentage agree			
Attitudinal Cluster	**1**	**2**	**3**	**All**
Sample Size (N)	376	452	294	1122
Prepared to pay more tax?	50	1	13	20
Prepared to pay higher charges for utilities?	56	4	11	23
The environmental crisis is exaggerated	2	20	44	20
Choose to buy green-labelled products	86	84	32	71
Environment has highest priority even if it hurts the economy	80	43	32	52
The expense is not worth the benefits	24	56	80	52
Give up using plastic bags	89	83	35	73
I have more important things to do	14	22	55	28
Donate an hour or two each month to do voluntary work for the environment	61	30	16	37
There is no regulation requiring me to	15	20	54	27
The balance of nature is very delicate and easily upset	86	80	61	77
Reducing my household's energy/water consumption is not worth the trouble	2	4	13	6
It's not my responsibility	8	18	45	22

Based on the responses to this battery of 13 questions, Table 1 suggests that the first cluster consists of "*Committed Greens*"; the second cluster consists of environmentally sympathetic respondents whose actions are governed by materialistic concerns related to time and money ("*Materialistic Greens*"), while the third cluster consists of respondents who have little or no environmental motivation ("*Enviro-sceptics*"). The *Committed Greens* were not only pro-environment in terms of their beliefs and behavioural preferences, they were also prepared to contribute financially to the support of the environment. In contrast, the *Material Greens*, although moderately supportive of the environment and sensitive to environmental risks, were not prepared to pay higher taxes or utility bills in order to help the environment. Only 43% of the *Material Greens* were prepared to sacrifice the economy for the environment and 56% felt that this expense was not worth the effort. However, 84% chose to buy environmentally-friendly products, and 83% were prepared to give up using plastic bags, suggesting that they would support the environment provided that the cost was not too high. The *"Enviro-Sceptics"* were less convinced that the environment needed looking after, with 80%

claiming that the expense was not worth the effort. Interestingly 45% thought that looking after the environment was not their responsibility and 54% suggested that they would only support the environment if this was regulated.

2.2.2 Household and Dwelling Factors

The other key independent variables in this analysis were annual household income, household size and the size of the dwelling as measured by the number of bedrooms. In a previous study [11] it was found that the household context, including household size and household income accounted for 35% of the variation in per capita energy consumption, while the dwelling context, including the number of bedrooms, accounted for 11% of the variation in per capita energy consumption. This previous study found that individual characteristics were less important than contextual factors representing the household, the dwelling and the location when considering per capita consumption.

In this study annual household income is measured on a 6-point ordinal scale. The above three clusters differ in terms of household income, with *Committed Greens* better represented in the categories $120,000-$179,999 and least represented in the <$36,000 category compared to the other two clusters (see Table 2). By controlling for any income differences in energy consumption before comparing the attitudinal clusters it is ensured that the effects of income elasticity are contained.

Table 2. Cluster Differences for Predictor Variables

Predictor	**Cluster Percentages**					
	1	**2**	**3**	**All**	χ^2	**df**
Household Income					18.8 *	10
<$36,000	12.8	18.5	19.5	16.9		
$36,000-$59,999	15.0	20.1	16.7	17.5		
$60,000-$79,999	19.3	16.2	12.9	16.4		
$80,000-$119,999	24.3	23.6	26.1	24.5		
$120,000-$179,999	18.3	12.8	13.6	14.8		
$180,000 plus	10.4	8.7	11.1	9.9		

Also, as shown in Table 3, the clusters differ in terms of household size with *Materialistic Greens* tending to have larger households, indicating families with children living at home.

Table 3. Cluster Differences for Household Size

Predictor	**Cluster Percentages**					
	1	**2**	**3**	**All**	χ^2	**df**
Household Size					16.7 ***	2
1	27.2	21.5	23.5	24.0		
2	43.7	33.4	46.4	40.2		
3	10.5	18.2	12.8	14.2		
4	14.0	17.9	11.4	14.9		
At least 5	4.6	8.9	5.8	6.7		

Finally, as shown in Table 4, the *Committed Greens* were more likely than the *Material Greens* to live in dwellings with one or two bedrooms while the *Material Greens* were more likely to live in dwellings with three or four bedrooms than the *Committed Greens*. However, the *Enviro-sceptics* did not differ significantly from either of these clusters in terms of dwelling size as measured by number of bedrooms.

Table 4. Cluster Differences for Number of Bedrooms

Predictor	**Cluster Percentages**					
	1	**2**	**3**	**All**	χ^2	**df**
Number of bedrooms					26.4 ***	6
1	16.9	10.0	14.4	13.4		
2	38.1	27.9	32.0	32.3		
3	27.6	37.6	30.2	32.3		
≥4	17.4	24.6	23.4	21.9		

2.3 Loglinear Analysis

In order to better understand how the three control variables, household income, household size and dwelling size related to the attitudinal clusters a log-linear analysis was performed in order to detect the significant interaction effects. In this analysis household size was treated as a categorical variable as shown in Table 3. The two-way interactions could be explained in tables but a Multiple Correspondence Analysis and plot were needed to explain the significant 3-way interaction [13]. Multiple correspondence analysis (sometimes called optimal scaling) is an extension of simple correspondence analysis which can be used for visualising 2-way interactions for

categorical variables. These methods are often explained as generalizations of principal component analysis when the variables to be analysed are categorical rather than quantitative.
In correspondence analysis the associations between categorical variables are illustrated in a plot that suggests the proximity of the categories for each variable. Such plots are particularly useful when the large number of categories makes a cross-tabulation difficult to interpret, as is the case in this instance. Correspondence analysis transforms categorical data to a quantitative form involving two (or more) dimensions. The origin for a correspondence analysis plot corresponds to the point where these dimensions cross. Some caution is advisable when interpreting correspondence analysis plots. In any correspondence analysis plot, the plot for one variable is never strictly comparable with the plot for another variable. This means that the proximity of categories for different variables does not necessarily reflect the strength of their associations.

The strength of association for the categories of different variables must therefore be assessed by creating axes from crucial "points" (the clusters in this case) through the origin, and then dropping perpendicular lines to these new axes from the category "points" for the other variables. The intersection points between these perpendicular lines and the new axes reflect the true position of these other variable categories relative to the clusters. Intersection points furthest from the origin on the same side of the origin as a cluster have the strongest positive relationship with that cluster. Intersection points furthest from the origin on the opposite side of the origin as a cluster have the strongest negative relationship with that cluster.

2.4 Analysis of Covariance

After applying a log transformation for the energy consumption variable, as commonly done in previous studies [4,9,10,11] due to the extreme positive skewness in this variable, a reliable Analysis of Covariance can be performed. The Analysis of Covariance was conducted, testing for the significance of the attitudinal clusters while controlling for household size, annual household income and number of bedrooms. In this analysis household size was treated as a quantitative variable rather than a qualitative variable allowing for the effects of very large households to be observed. Missing data for utility bills and income meant that only 796 households could be included in the analysis. The residuals exhibited independence, approximate normality and homoscedasticity, confirming that the log transformation for energy consumption was appropriate and that the coefficient for household size did not differ significantly across clusters, income categories or number of bedrooms, making an analysis of covariance a suitable method of analysis.

3 Results

3.1 Log-Linear Analysis

The log-linear analysis was conducted using the four predictor variables for energy consumption. Household income and household size represented the household context, while number of bedrooms represented the dwelling context and the clusters represented the attitudinal context. There were significant two-way interactions between the number of bedrooms and each of the other variables as indicated by the following Chi-Square (crosstab) tests of association; for household size (Chi-Square = 49.8, df=12, p<.001), for annual household income (Chi-Square = 37.9, df=15, p<.001) and for the attitudinal clusters (Chi-Square = 15.7, df=6, p=.015). The relationship between the number of bedrooms and the clusters is illustrated in Table 4, showing significantly more bedrooms for *Material Green* households than for *Committed Green* households. As expected Table 5 shows more bedrooms in the case of larger households.

Table 5: Relationship between Household Size and Number of Bedrooms.

	Percentage of Respondents					
Predictor	**Household Size**					
Number bedrooms	**1**	**2**	**3**	**4**	**5**	**All**
1	33.2	12.8	1.1	0.0	0.0	13.5
2	42.8	42.8	28.4	7.7	1.1	32.9
3	19.7	32.6	51.1	43.2	20.7	32.7
≥4	4.3	11.8	19.3	49.1	78.2	20.9

Table 6 shows an more interesting relationship, between annual household income and the number of bedrooms. For people with incomes above $119000 per annum two-bedroom dwelling are more common than for other income brackets while one-bedroom dwellings and dwellings with four or more bedrooms are relatively uncommon. Although dwellings with four or more bedrooms are relatively uncommon for households with incomes of less than $36,000 per annum, three-bedroom dwellings account for 37% of these households. Four-bedroomed dwellings are most common for those with moderate incomes of between $36,000 per annum and $119000 per annum.

Table 6: Relationship between Annual Household Income ($1000) and Number of Bedrooms.

	Percentage of respondents
Predictor	**Annual Household Income ($1000)**

No. Bedrooms	<36	36-60	60-80	80-119	119-180	>180	All
1	16.3	18.6	15.5	13.2	8.0	5.3	13.6
2	30.5	24.5	29.5	32.9	40.3	44.2	32.6
3	37.3	31.4	31.6	28.2	33.0	36.3	32.5
≥4	15.9	25.5	23.3	25.7	18.8	14.2	21.3

The Loglinear analysis showed only one significant three-way interaction (Chi-Square = 64.5, df=40, p=.008), which is illustrated in the multiple Correspondence Plot in Figure 1. This interaction suggests that the relationship between income and household size differs between the clusters.

Variable categories associated with more positive co-ordinates on Dimension 2 are more strongly associated with the *Material Greens* cluster. In particular the *Material Greens* are more likely to have moderate household incomes ($60,000 per annum - $80,000 per annum) with households comprising 3-5 members (i.e. typical suburban family households). Variable categories associated with more negative co-ordinates on Dimension 2 are more strongly associated with the *Enviro-Sceptics* cluster. The Enviro-sceptics tend to be 2-person households with either very low or very high household incomes. The *Committed Greens* also tended to be 2-person households but they tended to have incomes in excess of $119,000 per annum.

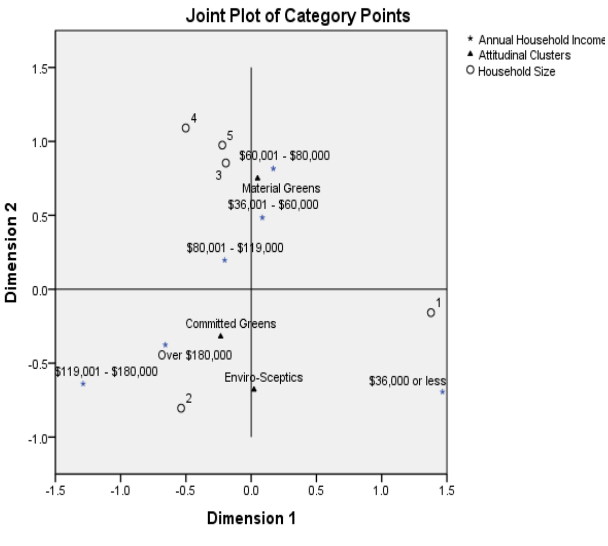

Figure 1: Multiple Correspondence Analysis Plot

These differences between the clusters mean that we must simultaneously control for annual household income, household size and the number of bedrooms when testing the relationship between household energy consumption and the attitudinal clusters.

3.2 Analysis of Covariance

The Analysis of Covariance showed significant household energy consumption effects for the attitudinal clusters (F(2,784) = 3.10, p=.046, partial η^2=.008), income (F(5,784) = 6.63, p<.001, partial η^2=.041), number of bedrooms (F(3,784) = 14.07, p=<.001, partial η^2=.052) and household size (F(1,784) 43.01, p<.001, partial η^2=.052). However, no significant interaction effects were observed for income and the attitudinal clusters (F(10,783)=.222, p=.994), suggesting the same income elasticity for all three clusters. Figure 2 shows the relationship between energy consumption and annual household income when household size is controlled at a mean level of 2.59 persons (the average household size for the sample). For all three clusters there is an increase in energy demand at higher income levels which is particularly noticeable for incomes in excess of $119,000 per annum.

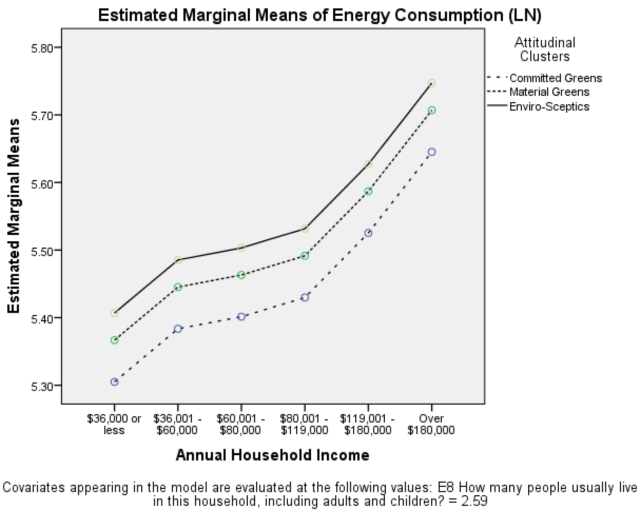

Figure 2. The Relationship Between Income and Log Transformed Energy Consumption when Household Size is 2.59 after controlling for Number of Bedrooms.

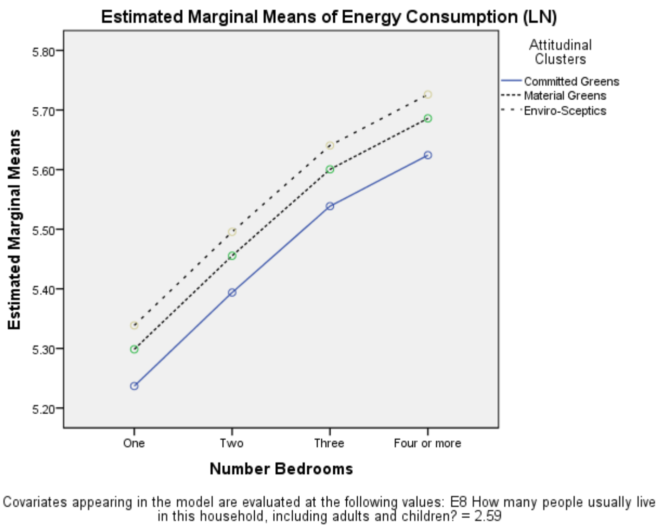

Figure 3 The Relationship Between Number of Bedrooms and Log Transformed Energy Consumption when Household Size is 2.59 after controlling for Income

There was also no significant interaction effect for household energy consumption between the attitudinal clusters and dwelling size as measured by the number of bedrooms (F(6,778) = .92, p=.479). Therefore, as shown in Figure 3, for all three clusters there is a similar increase in energy demand as the number of bedrooms increase. In Figure 3 the household size is again controlled at a mean level of 2.59 persons.

Pairwise comparisons for the three clusters were considered, testing for lower energy consumption in the case of the *Committed Greens* cluster. The results show that the mean household consumption of energy is indeed significantly lower for the *Committed Greens* than that for the *Material Greens* (t(784) = 1.58, p=.050), and also significantly lower than that for the *Enviro-Sceptics* (t(784)=2.43, p=.008), when household income, number of bedrooms and household size are controlled. However, there is no significant difference in the mean household energy consumption for the *Material Green*s and *Enviro-Sceptics* clusters.

The coefficient for household size (B=.089) suggests only a 9% increase in electricity consumption for each additional household member when number of bedrooms, attitudinal cluster and household income are controlled. Table 7 allows a comparison of the magnitude of the effects for income, number of bedrooms and the attitudinal clusters when controlling for household size.

Table 7: Percentage Increase in Energy Consumption relative to a "*Committed Green*s" household with an income of less than $36,000 per annum living in a one-bedroom dwelling

	Expected Increase Energy Consumed (%)
Income ($1000)	
<36	-
36-60	8.1
60-80	10.1
80-119	13.2
119-180	24.6
>180	40.5
No. Bedrooms	
1	-
2	17.0
3	35.1
At least 4	47.3
Cluster	
Committed Greens	-
Material Greens	6.4
Enviro-Sceptics	10.7

Table 7 shows that energy consumption is 49.5% higher for households with household incomes of above $180,000 per annum than for households with household incomes of less than $36,000per annum. Similarly compared to dwellings with a single bedroom there is a 17.0% increase in energy consumption for dwellings with two bedrooms, a further 18.1% increase for dwellings with a third bedroom and a further 12.2% increase for dwellings with four or more bedrooms. In comparison the effect of the attitudinal clusters is relatively small with an increase in energy consumption of only 6.4% for households with *Material Green* rather than *Committed Green* attitudes, and an increase of only 10.7% for households with *Enviro-Sceptic* attitudes rather than *Committed Green* attitudes.

4. Conclusions

A previous study [10] found no significant relationship between per capita consumption of energy and environmental attitudes. In this study instead of working with per capita energy consumption we have controlled for household income, number of bedrooms and household size when analysing the effect of membership of a particular (attitudinal) lifestyle cluster on household energy consumption. The results of this study suggest that households characterised by *Committed Green* attitudes have lower energy consumption than either the *Material Greens* or *Enviro-Sceptic* clusters. The magnitude of this attitudinal effect is small but still significant.

The apparent contradiction in these results (i.e. between the *per capita* analysis and this *household-level* analysis) can be explained by the interaction between the attitudinal, household and dwelling contexts. *Committed Green* households tend to have higher incomes and they tend to have smaller households living in smaller dwellings. *Material Green* households tend to have more moderate incomes and larger households, living in larger dwellings. *Enviro-Sceptic* households tend to be smaller, living in smaller dwellings with either very high or very low incomes. The effect of these *contexts* needed to be taken into consideration before the effects of attitudes could be revealed. The above analyses provide important information on how best to work with these three clusters in order to explore avenues for reducing residential energy consumption further.

Large *Material Green* households bear the full brunt of energy prices and it is therefore not surprising that environmental attitudes are tempered by cost implications for this cluster. Small *Committed Green* households living in smaller centrally located dwellings are where the gap between positive environmental attitudes and positive environmental actions are most apparent. Despite obvious concern for the environment the energy consumption of *Committed Greens* increases just as dramatically as that of the other clusters at higher income levels. The consumption of energy by the *Enviro-sceptic* cluster is on average only 10.7% higher than the *Committed Greens* cluster, but the high income of many *Committed Green* households clearly boosts energy consumption in other ways.

Although small, the significance of the impact of attitudes on consumptions suggests that energy policies that incorporate behavioural economics have a role to play in attempts directed at reducing the demand for energy by households. However, the increase in energy consumption with increasing income, especially in the case of household incomes over $120,000 suggests that income elasticity is alive and well in the case of energy consumption, indicating that a new *targeted* message is needed for those on higher incomes. This message should particularly address the *Committed Green* households, with a different message required for the high income earners in the *Enviro-Sceptic* cluster. Such a targeted approach for the reduction of energy consumption has been promoted by the Australian Greenhouse Office in their Cool Communities – Cool Solutions to Global Warming initiative, started in 2001 [14]. This office provides on-going publication of home energy action plans, including information on delivery, changing attitudes and financial incentives for reducing energy consumption. In particular, the Cool Communities suggest how policy messages need to be tailored to bridge the gap between environmental attitudes and actions, by informing households "with positive views but high home energy use of the discrepancy between their views and energy use" and pointing out that "positive attitudes call for positive action".

In the case of *Material Greens*, other Australian Greenhouse Office actions are more applicable. Actions such as "offer something for free" or "suggest very specific energy saving actions" are likely to be better received. Also of interest are the relatively low elasticity for energy consumption in the case of household size and the relatively high elasticity for energy consumption in the case of the number of bedrooms. Whereas each additional household member increases energy consumption by 9% on average, moving from a one-bedroom to a two or three-bedroom dwelling increases energy consumption by 17% and 35% respectively. Whether one cooks or washes for one or many has less effect on energy consumption than the effect of household size on dwelling size. This clearly highlights the fact that the built environment is an important factor for reducing energy consumption, but it also signals the need for special energy conservation messages for larger households, perhaps directed at children given the documented influence of children on adult behaviours [8].

Finally, special messages are needed to target the *Enviro-sceptics*. This cluster of households needs to be convinced that the environmental crisis is not exaggerated. If this is not possible it may be necessary to explore the option of regulatory messages.

5.Acknowledgments

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