LITERATURE REVIEW

Household energy consumption, conservation & efficiency

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Literature Review for ASC: Summary

This paper presents a brief summary of a literature review prepared as part of the Alice Solar City (ASC) monitoring and evaluation work and aimed at enabling a comparison between the ASC project and available academic information. The literature reviewed was primarily selected for its relevance to energy conservation within households. Although quite comprehensive, the review is by no means a complete examination of all available literature within the field, and there are few Australian studies available, compared to those from Europe and North America. The broad topics of the review (below) have been summarised within the context of the ASC project.

1. Socio-demographic Factors

Research into the area of energy consumption has demonstrated that socio-demographic variables can be highly related to household energy use. While there is some contention within the literature about the influence of socio-demographic variables on energy consumption, there is no significant debate over the fact that they do.

Variable	Influence on Energy Consumption	Implications for ASC

Income	Characterised by opposing trends:
	• Wealthier households have been shown to:
	  - Purchase/own more energy efficient services and appliances (often newer/new technology)
	  - Have higher levels of appliance ownership
	  - Afford high energy costs
	• Poorer households have been shown to:
	  - Own/purchase less energy efficient services and appliances (often older/old technology)
	  - Own fewer appliances
	  - Not afford high energy expenditures.
		• 80% of ASC registered households have gross incomes above $50,000 per year (45% earn $50-100K), compared to only 55% of Alice Springs (AS) households.
		• Climatic extremes may be a significant mediating factor for AS.
		• Energy intensities (consumption per square meter and/or per resident) may be relevant
		• Income influences may be mediated by personal/household values, attitudes and intentions.

Age	• Health driven energy use is related to age – for very young and elderly, space heating/cooling must be regulated for longer daily periods. • Non-health age group variation: one study showed younger women consume more energy than older women. To reduce energy consumption older women alter their behaviour while younger women prefer technological methods (refer to habitus in behavioural models).	• The age distribution of ASC participants reflects a clear tendency for the family structure (higher proportion of children aged 0-17 & adults aged 25-44). • It is possible that AS households with children or elderly people consume more energy per capita, given the frequent occurrence of very hot summer days and very cold winter nights • Different energy use & conservation behaviours may also be noted within different age groups.
House(hold) Characteristics	• Age - recently built houses tend to include more energy saving features & appliances, but they often have more appliances in general, increasing potential energy use.	• The clear majority of dwellings in AS (& ASC registrations) are either completely separate or semi detached. Only 10% of the dwellings within AS

	• Size -houses use approximately 70% more electricity than residential units - related largely to (floor) space and energy required for heating/cooling and lighting. • Occupant Numbers - However, per capita household energy consumption is largely an economy of scale: with increasing occupant numbers, the per capita amount and cost of energy usage declines, although totals generally increase.	are flats, units or apartments- detached dwellings may therefore have higher energy use, based on household space alone. • In AS rental costs are quite high- this may increase the number of people residing in shared accommodation. When combined with the number of families participating in the ASC project, economies of scale may reduce the per capita cost and amount of energy consumption.
Education	• Overall, reported studies on the relationship between education level and household energy use appear inconclusive. • Although the number of domestic appliances owned has been linked to the level of education held by a household's 'chief economic supporter', this trend is likely to be a result of the positive general correlation between income and education.	• There is a substantial difference between the percentages of AS & ASC residents with tertiary education (despite being similar for both TAFE & High School education). • Around 50% of the households registered with the ASC project have at least one member who has completed a University degree (compared to 14% of the total residents counted within the 2006 census)- combined effects of income & education may lead to increased household energy consumption.
Gender	• Little research has been conducted into the energy consumption differences between men & women in developed countries. • Trends suggest that more women then men live in poverty- energy consumption may be restricted in line with household budget. • Comparisons of single male & female households demonstrate a divergence in the types of appliances owned. • Encouraged behavioural changes to reduce household energy consumption may disproportionately affect a woman's workload.	• When implementing energy policy measures (e.g. CRT) women who have young children and who also work outside of the home may be subject to increased stress, especially if they are required to significantly alter their behaviour. "This is an important insight for policy makers who have an overall responsibility for the well-being of citizens and who cannot consider one policy instrument in isolation from another"

2. Strategies to Alter Household Energy Consumption

Programs aiming to reduce household energy consumption often employ various strategies to achieve change. Two common approaches involve either presenting information to alter an individual's knowledge, perceptions and/or habits (*psychological/informational strategies)* or addressing the context of energy consumption (e.g. by providing incentives), effectively making the conservation or efficient use of energy more appealing to the individual (*structural strategies).*

Strategy	Key Points	Implications for ASC
Psychological (Informational)	• Though attempts to change an individual's knowledge, perceptions or habits may be longer lasting than structural strategies, more often than not, information campaigns only result in slight behavioural modifications. • A higher level of environmental awareness does not guarantee that the knowledge will be put into practice; however this may be in part caused by misunderstandings related to energy and behaviour, the types of information available & the ways in which it is presented. • It is reported that higher household energy reductions are obtained through a combination of home energy audit, formal commitment and goal setting, compared to one aspect alone.	• A Belgian study determined that householders who received customised advice (e.g. energy audit) aimed at procuring energy savings rarely followed the advice given- only 11% of the suggested measures were implemented within the first year. • Highlights a possible benefit from examining the ways in which information is presented to ASC customers and of undertaking some sort of follow up, after the initial customer energy audits. • Targets, tailored feedback and formal commitment may be worthwhile considerations.
Structural (Incentives)	• Structural/physical strategies (e.g. incentives) encourage individuals to alter energy consumption in situations where the change required is costly or difficult. • Rewarding positive actions is more effective for change than enforcing sanctions. • However, given that the positive reinforcement of behaviour generally produces changes that may not persist in the longer term, individuals often revert to their original behaviour once the rewards are removed. • These strategies may also be influenced by external factors (e.g. home ownership, householder education, age and income).	• With all other things being equal, households favour 'non-investment measures'- easily achieved habitual measures (turning off a light) to improve household efficiency • Reducing the external barriers to pro-environmental actions (e.g. financial incentives) addresses the above preference. • Need to confront the reversal of behaviour once incentive to act is removed. May also be related to the rebound effect- possible area for investigation.

3. The Rebound Effect

Active household energy conservation and efficiency measures do not always result in energy usage reduction, even when encouraged by the previously mentioned strategies. In many instances, the rebound effect (also known as the 'takeback' effect) may negate the energy savings made, or even increase overall energy consumption.

There appears to be three primary types of rebound effect:

1. *The direct rebound effect*- occurs when the use of energy services increases as a by-product of greater efficiency e.g. purchasing energy efficient lighting but leaving the lights on for a longer period of time.
2. *The indirect rebound effect*- occurs from the reduction in the cost of energy services- households have extra money to spend on other, possibly more energy intensive, goods and

services e.g. going on a holiday and flying to the destination or installing additional split system air-conditioners.

3. *The general equilibrium effect-* encompasses production and consumption at an economy wide (macro) level and is essentially the sum of the previous outlined rebound effects.

It has been suggested that "…rebound effects matter and need to be taken seriously… their continued neglect may result as much from their uncomfortable implications as from a lack of methodological tools". For ASC, assessments concerning the effectiveness of incentives in reducing household energy use should take into consideration possible rebound effects.

4. Behavioural Models

It is likely that no single model will predict or account for the full range of ASC participant energy consumption behaviours. For ASC, the most relevant and fruitful models appear to be the theory of planned behaviour, the notion of habitus (embodied social knowledge), and rational utility (particularly discrete choice). Consideration of a hybrid model may prove useful.

Theory/Model	Key Points
Utility Maximisation & Rationality	• Proposes that households aim to maximise utility in line with household budget constraints. • The concept of 'utility' may be used as a measure of the preferences an individual holds for different outcomes- also viewed as a substitute for personal benefit or well being. • Individuals will therefore tend to favour an outcome with higher utility when making a decision. • Discrete choice allows estimations of an individual's discount rates. "Discount rates measure an individual's willingness to exchange present consumption for future consumption (e.g. spending more up front on an appliance that uses less energy). Different discount rates apply in different circumstances- refrigerators & hot water systems are generally given higher discount rates by consumers when compared to weatherisation measures (e.g. insulation). • However, the theory makes the assumption that consumers behave as logical actors- that their preferences remain organised, known and consistent. Instead habits, emotions and mental associations often influence the individual choices made.

Theory of Planned Behaviour	• Posits that behaviour is governed by a person's intention to perform it, and a person's behavioural intention is influenced by the following three factors:
	  1. Attitude- the individual's evaluation of performing the behaviour
	  2. Perceived control- the perceived ease or difficulty of engaging the behaviour
	  3. The subjective norm- the individual's perception of social pressure (related to behaviour)
	• Altering an individual's behaviour would involve addressing unfavourable attitudes, perceived associated difficulties and the individual's perception of the social norm.

Habitus, Field & Capital	• Suggests that household comfort and cleanliness expectations are learnt social norms powered by the vast realm of social knowledge which encompasses the daily aspects of life. • Addressing the habitus (embodied social knowledge), effectively involves altering the norms reinforced by everyday activity within society. • In general, energy resources may be viewed by the public as replaceable; constructed "as something that is used for the essentials of life, rather than something that can sensibly be said to be wasted". • This indicates a fundamental barrier to altering household energy consumption- the necessity to transform the crucial social assumption of energy as an essential, non-negotiable aspect of life.

Norm Activation Model	• Hypothesises that pro environmental behaviour is, in essence, a form of altruistic, egoistic or biospheric behaviour. • Behaviour is thought to be influenced by personal norms (feelings and a sense of moral obligation). • The theory requires that each individual is aware of the consequences of their behaviour and that these individuals feel personally responsible for the consequences.	
Perceived Customer Effectiveness	• Operates on the premise that those who believe their actions will produce a positive change within the environment are ultimately motivated to act; providing they see themselves as part of a collective action. • If this model is plausible, it may actually provide a disincentive to act- any behavioural changes viewed by the individual as insignificant may ultimately outweigh any 'distant' environmental benefit.	

5. Knowledge, Attitudes and Behaviour

Psychological and behavioural factors (e.g. attitudes, values, norms and habits) and contextual characteristics (e.g. physical infrastructure, appliance numbers) interact regularly and often influence an individual's or household's behaviour.

	Key Points	**Implications for ASC**
Environmental Knowledge	• Various studies suggest that there is a discrepancy between environmental knowledge and action.	• Analysis can be designed around factually based statements presented as an attitudinal measure (utilising a Likert-type scale). • May indicate areas for potential improvement within ASC project- will also enable participant behaviour & attitude to be placed in context.
Environmental Attitude	• "The way that an individual views, or behaves towards an object". • Various classifications have been created to organise similar attitudes and it seems that environmental values may be classified into two dimensions: a biocentric view which reflects the conservation and protection of nature (Protectionist) & an anthropocentric view which reflects the utilisation of natural resources for human benefit (Utilitarian).	• Analysis achieved by asking participants to rate a series of statements on a Likert-type scale which ranges from strongly agree to strongly disagree. • The scale formed for use within the ASC project will be based on the area of energy consumption and perhaps, to a lesser extent, climate change. • It is expected that analyses of participant attitude may provide an understanding of the way energy conservation/efficiency is viewed.
Environmental Behaviour	• Most studies measure self-reported environmental actions (again by using a Likert-type scale). Participants are generally directed to specify how often they undertake each of the activities listed. • Some studies have reported low correlations when comparing actual & reported behaviour.	• It may be possible to compare reported energy conservation/efficiency with actual household energy consumption. Assuming that all other variables remain equal, household energy usage may be considered a gross indicator of behaviour.

LITERATURE REVIEW

1. Introduction

Although many scientists worldwide accept that the global climate is being influenced by human activities it appears that public misunderstanding concerning the issue remains a barrier to effective action (Lowe et al. 2006; Lorenzoni & Hulme 2009).

In 1994, researchers at the Massachusetts Institute of Technology (MIT) concluded that public confusion about the influence of human activities on climate change results from the neglect of two basic facts: "That carbon dioxide will be primarily responsible for any global warming that does occur; and that the major source of this carbon dioxide is burning fossil fuels" (Read et al. 1994; Bulkeley 2000). Instead it has been demonstrated that the public often attributes aerosols, insecticides, nuclear power generation and ozone depletion with being potential causes of climate change (Bord et al. 2000; Lowe et al. 2006).

Lately, it is likely that increased global publicity surrounding the issue has enhanced public understanding. Though as Steg (2008 p. 4449) has noted "given the complex processes involved, some confusion is still likely. Moreover, people know little about the energy use related to their behaviour". Individuals, for example, may use a 'simple heuristic' to determine the energy use of appliances, potentially assuming that consumption is based solely on size (Steg 2008). Individuals may also overlook the energy used in activities such as water heating, reinforcing their misconstruction of appliance contribution toward household energy consumption (Steg 2008).

The lack of understanding regarding climate change may be equally enhanced by the difficulty individuals face when associating the local with the global (Whitmarsh 2009a). More often than not, the social and environmental costs and benefits of an individual's action are far removed from the individual themselves (Hummel et al. 1978). The immediate personal benefit gained from turning on an air-conditioner, for instance, may override the distant, widespread costs associated with that action (Hummel et al. 1978). Individuals can have difficulty understanding the ways in which their energy consumption choices influence environmental issues (Whitmarsh 2009b).

Within the OECD countries, residential greenhouse gas emissions (based on fossil fuel consumption) constitute approximately 15-20% of total emissions (Abrahamse 2007). Locally, it has been suggested that households within Alice Springs account for around 40% of the baseload

electricity supply alone. In submitting their argument for the creation of a 'Solar City' within Alice Springs, the Alice Springs Town Council maintained that this level of usage provided reasonable grounds for a large and varied intervention (ASTC 2006).

In response, the Alice Springs Solar City project has been designed to explore the ways in which energy efficiency, solar technologies and energy pricing can combine to invoke changes within residential and commercial energy consumption, potentially enabling a reduction in greenhouse gas emissions. Since the residential sector is a crucial element of energy programs, the literature presented within this review has been primarily selected for its relevance to energy conservation within households. To enable an effective comparison with the academic information, this paper begins with a basic overview of the Solar City, Alice Springs. Socio-demographic correlation with energy use, methods for altering household energy consumption, the rebound effect, environmental behaviour models and potential methods for measuring participant knowledge, attitude and behaviour have likewise been summarised. It is hoped that this will provide a strong and useful knowledge base, especially within the framework of the Alice Solar City project.

2. Alice Springs, Solar City

The rural city of Alice Springs is situated within Australia's Northern Territory; Latitude: 23° 41' 60S (23.7000), longitude 133° 52' 60E (133.8833). Though a certain portion of the population comprising Alice Springs is short-term, the 2006 Australian census documented 23,893 permanent citizens within the town's local government area (LGA) (ABS 2006a). This equates to just over 9,000 occupied private residences (ABS 2006a). Consequently, community engagement has been and remains a fundamental aspect of the Alice Solar City project. By mid 2010 over 1700 households had joined the Solar City residential participant group, a sizable portion of the town's total private residences. It is also likely that characteristics of Alice Springs, such as its size, contained location and somewhat small population have increased the flow-on influence of the program to hitherto non-participating residents.

Although the arid climatic conditions experienced by the residents of Alice Springs may be seen as relatively harsh, they provide an ideal environment for the implementation and use of solar hot water systems and photovoltaic rooftop power generators. Based on a yearly average, Alice Springs receives approximately 9 hours of sunlight per day. The district also has the highest solar

insolation (7.4 kWh/m2/day) in Australia. However, as shown in table 1, the mean maximum temperature is also generally high for most of the year. This may lead to elevated requirements for air-conditioning and thus potentially higher rates of appliance ownership and household energy usage.

Table 1: Mean maximum temperature ($_o$C), Alice Springs Jan 1991- March 2010 (BOM 2010)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	35.1	34.6	34	29.2	23.6	23.1	21.5	23.6	29.6	33.7	34.9	36.5	30
1992	36	37.1	35.4	29.5	21.6	20.2	20.9	22.3	27.7	29.2	33.1	34.8	29
1993	37.1	35	35	30	22.7	16.2	20.2	22.5	25.4	28.9	35.2	34	28.5
1994	39.2	35	32.7	28.1	24.9	20	20.3	21.5	28.5	32.6	32.9	36.9	29.4
1995	35.5	34.4	31.6	28.2	20.7	19.5	20.4	24.1	29.1	30.3	34.3	36.4	28.7
1996	37.5	36.7	33.8	28.3	23.1	23.6	21.6	23.2	30.3	32.1	35.3	36.6	30.2
1997	35.6	33.4	31.9	28.9	21.5	19.7	17.6	23.2	30.2	30.9	36.1	36.8	28.8
1998	38.9	37.9	34.7	27.7	24.7	19.5	19.2	24.2	28.7	32.3	33.6	35.6	29.8
1999	39	36.5	36	27.2	27.2	20	20.9	23.7	29.8	31.4	32	33.7	29.8
2000	36.6	32.6	32.5	25	19.7	18.9	22.9	23.3	30.4	27.9	33.6	33.3	28.1
2001	37.3	35.1	27.4	28.2	24	20	19.3	23.6	28.5	29	32.2	31.9	28
2002	36.1	32.7	33.8	33.5	26.9	21.5	22.4	23.9	30	33.3	35	36.5	30.5
2003	36.8	35.3	32.1	31.1	24.9	21.4	21.4	24.5	30.6	30.9	34.2	36.4	30
2004	39.1	35.7	33.2	30.3	21.6	21.1	20.7	23.2	26.2	33.6	35.1	36.5	29.7
2005	37.3	36.8	35.2	33.1	26	21	19.3	22.4	30.3	32.8	34.7	36.1	30.4
2006	40	37.7	34	28.8	21.9	18.1	19.1	24.5	28.3	33.6	37.1	35.1	29.9
2007	34	38	33.8	30.9	26.1	16.9	21.3	23.9	30.1	33.7	31.8	35.2	29.6
2008	39.8	35	33.4	29	24.5	20.1	21.4	19.8	29.6	33.3	32.1	34.6	29.4
2009	36.1	36.5	35.3	29	21.6	20.7	20.6	28.1	29.9	30.9	35.6	35.6	30
2010	35.2	34.2	30.1										

For the residential element of the Alice Solar City project, primary focus has been placed on achieving successful change within the following three key areas:

— Uptake of solar technologies e.g. solar hot water, rooftop PV panels

— Implementation of household energy efficiency measures

— Load reduction and time of use management through cost reflective pricing

As such, a range of incentives are available to households registered with the Solar City. These incentives have been designed to motivate household energy efficiency or conservation, and currently include:

— Financial incentives for the installation or upgrade of passive heating and cooling options (e.g. insulation, window tinting, painting household roof white etc.)

— Financial incentives for the installation or service of solar hot water and rooftop photovoltaic systems

— The elective implementation of a cost reflective tariff (aimed at obtaining a shift in base energy load)

— A 10:10/20:20 energy savings offer [1]

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[1] A detailed overview of the incentives offered by Alice Solar City may be obtained online: http://www.alicesolarcity.com.au/residents/incentives

From the literature, it appears that household energy consumption patterns are related to socio-demographic variables. Although the level of influence is variable, income, age, household type and gender all combine to shape both the amount of energy used by households and the ways in which the energy is used. An understanding of these variables and the manner in which they influence residential energy consumption may provide fundamental insight into the energy trends relevant to the Alice Solar City project.

3. Socio-Demographic correlation with energy usage

Previous research into the area of energy consumption has shown that socio-demographic variables (outlined below) can be highly related to household energy use (Gatersleben et al. 2002; Lenzen et al. 2006; Abrahamse 2007; Abrahamse & Steg 2009). Income, for example, influences purchase decisions while age increases the need for heating or cooling, thereby raising energy consumption (Abrahamse & Steg 2009). As knowledge of household energy usage patterns will contribute to programs aiming to alter residential energy consumption, an examination of these variables is relevant to the Alice Solar City project.

Additionally, socio-demographic variables may also provide deeper insight into the environmental attitudes, and knowledge of participants within the Alice Solar City project. As these factors contribute to an individual's behaviour (Steg 2008), an understanding of the demographic composition of households may add an important dimension to any attitude-knowledge-behaviour analyses undertaken. This in turn may enhance any efforts to encourage behavioural change in participants.

The following subsections contain comparisons between ASC demographic data from customers and ABS 2006 census data. The ASC demographic data categories were specified by DEWHA and generally do not match the ABS categories. Therefore, combinations and interpretations of data categories were undertaken to provide comparisons that were as meaningful as possible, but which under the circumstances are not ideal- they could be regarded as indicative rather than absolute. Explanations of the reworked data comparisons are provided as an appendix.

Income

Primarily, it appears that two somewhat opposing ideas relate the influence of income to household energy consumption. On the one hand, it has been suggested that a household's energy intensity (the ratio of consumption to a measure of the demand for services e.g. total floor space) tends to weaken towards higher household income and expenditure brackets, as was the case with a study conducted in Sydney (Lenzen et al. 2006). Wealthier households favour the purchase of services and luxuries that may be less energy intensive (Lenzen et al. 2006). Households with lower incomes and expenditure, in comparison, regularly live in housing with little or no insulation and often utilise older appliances with a lower energy efficiency rating (Clancy & Roehr 2003). Absolute energy consumption may be higher within these households as a result.

On the other hand, a higher level of income has been equated with increased appliance ownership and a higher level of energy consumption (O'Neill & Chen 2002; Abrahamse 2007; Roberts 2008; Abrahamse & Steg 2009; Sovacool & Brown in press). It has been suggested, for instance, that the likelihood of a household keeping a 'beer fridge' increases with household income, the higher the income band of a household, the higher the probability of that household keeping and maintaining a second fridge (Young 2007). It is quite simply assumed that households with a higher income can afford to consume more energy, while those with a lower household income can not, and are consequently forced to conserve. The period of low Norwegian residential energy usage which occurred before the 1970s, for example, is thought to have been caused by the significantly lower income levels compared with those seen in Denmark or Sweden at that time (Unander et al. 2004).

Figure 1: Combined household income (per annum), Alice Springs LGA & Solar City (ABS 2006a; ASC 2010)
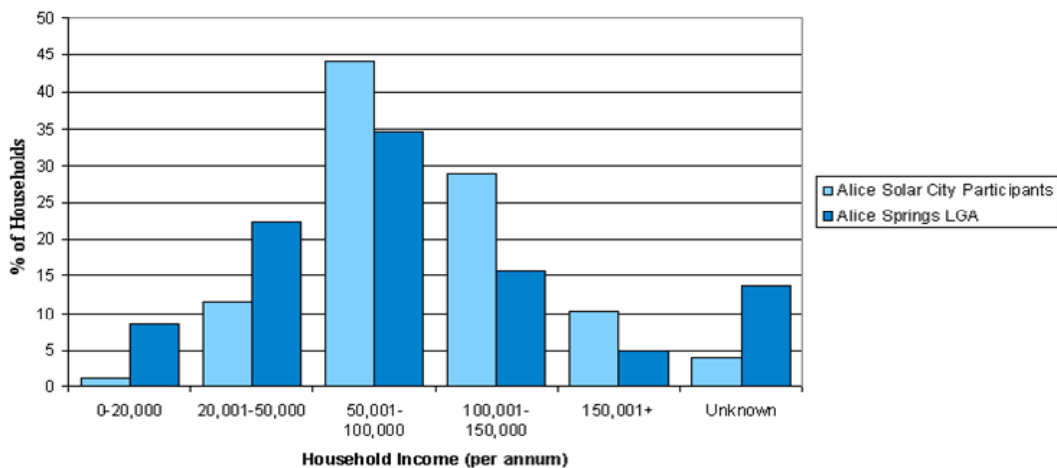
Figure 1 (above), presents a basic overview of income distribution within both the Alice Springs Local Government Area (LGA) (ABS 2006a) and Alice Solar City participant households (ASC 2010). Generally speaking, either of the scenarios outlined could be assumed plausible within Alice Springs, given the climate. Higher levels of income may indeed increase appliance ownership, particularly air-conditioning systems, throughout the town, and may likewise allow for their prolonged daily use. Equally, households with a lower income may reside in housing with little insulation and may make use of older, less effective appliances. Perhaps further detailed analysis will reveal a combination of these scenarios.

As noted in table 2 (below), a larger percentage of Alice Solar City households earn above $50,000 per year (83.27%) when compared to the LGA data (55.49%). However, this divergence may be in part due to the number of Alice Solar City participant households with combined income, e.g. families. It may also be possible for the percentage differences between the unknown annual incomes to account for a portion of this variation (see income in appendix 1).

Table 2: Combined household income, Alice Springs LGA & Solar City (ABS 2006a; ASC 2010)

Annual Household Income:	ASC %	LGA %
Below $50,000	12.80	30.81
Above $50,000	83.27	55.49
Total	96.07	86.30

Note: Excludes unknown annual income

As an interesting side note, the relatively similar demographic correlation between registered Alice Solar City participants and Alice Springs LGA census data (age, income and dwelling type) may provide an indication of adequate general public representation within the Solar City participant group. Though the census data has been re-categorised to enable comparison with the data collected by Alice Solar City (which is based on DEWHA specifications dissimilar to the brackets used for data collection within the Australian census) the apparent trend seems quite reasonable.

Age

In Australia, age may also exert a strong influence on energy consumption as older individuals tend to require greater vehicle use for mobility (Lenzen et al. 2006). Likewise, health driven energy usage tends to be correlated with age. To preserve the health of both children and elderly people, winter heating and summer cooling must be regulated for longer periods each day and for

higher than average indoor temperatures (O'Neill & Chen 2002; Clancy & Roehr 2003; Roberts 2008). Residential age distribution for both Alice Solar City registered households and the Alice Springs LGA is shown in figure 2.

Figure 2: Residential Age Structure, Alice Springs LGA & Solar City (ABS 2006a; ASC 2010)
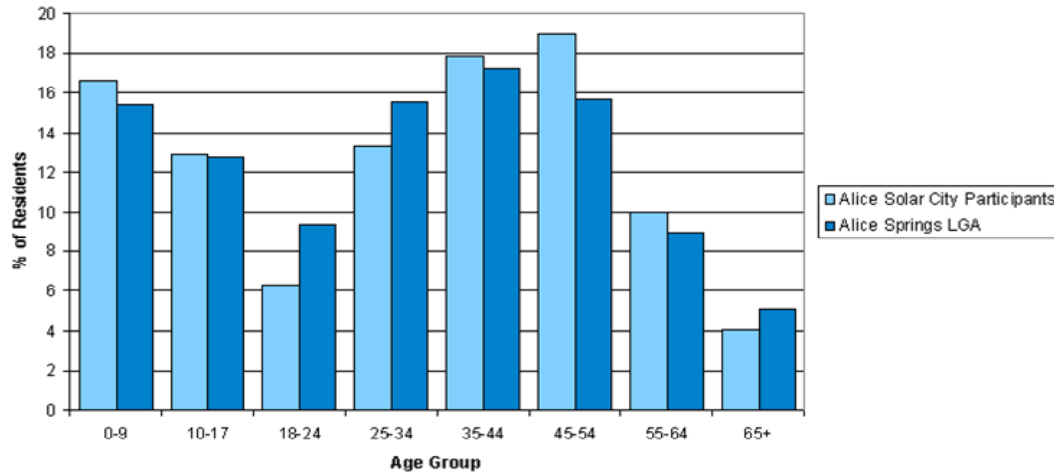
The distribution of participants within the age cohorts (figure 2) reflects a clear tendency for the family structure; characterised by a higher proportion of residents aged between 0-17 (children) and also 25-44 (parents). It is possible that Alice Springs households with children or elderly people consume more energy per capita, given the frequent occurrence of very hot summers and very cold winter nights.

In addition, it has been found that energy usage varies between age groups. In Germany, younger women have a greater propensity to consume more energy than elderly women. Energy conservation between the two age groups is also varied in method; elderly women alter their behaviour directly while younger women prefer technological methods to reduce energy consumption (Clancy & Roehr 2003). Within both the Solar City demographic data and Alice Springs LGA data, the majority of residents are under 55 years of age (figure 2). While this age-related trend in energy consumption may be present, it may also be somewhat difficult to measure, depending on the number of Alice Solar City participants in the older age groupings. Accurate investigation would essentially require the comparison of single person households, based on age and perhaps even gender.

Although recently built houses tend to include more energy saving features and appliances, they often have more appliances in general. In Ireland, O'Doherty et al. (2008) suggest that "an increase of £100,000 in the market value of a home is likely to increase the number of energy-saving features by 3.4%, but is also likely to increase the number of energy-using appliances such that its potential energy use goes up by 5%". They also found that a £100 increase in household income per week resulted in 1.1% more energy-saving features and a 0.76% higher potential energy use (O'Doherty et al. 2008).

Table 3: Dwelling Type, Alice Springs LGA & Solar City (ABS 2006a; ASC 2010)

	Alice Solar City (%)	Alice Springs LGA (%)
Apartment/unit/flat	8.24	10.36
House detached	83.14	69.59
House semi-detached	2.41	19.99
Unknown	6.21	0.05

Furthermore, houses (including detached, semi-detached and town houses) use an average of 74% more electricity than residential units (Holloway & Bunker 2006). These housing types tend to be larger in size, with more floor space, and may require more energy to heat, cool and light the space (Abrahamse 2007; Abrahamse & Steg 2009). The clear majority of dwellings within the Alice Springs LGA and Alice Solar City participant group are either completely separate or semi detached houses (table 3). Only 10% of the dwellings are flats, units or apartments (ABS 2006a) and it may be expected that the majority of the detached Alice Springs households have higher energy consumption than these residences, based on household space alone. Still, when examining per-capita household usage, as outlined below, this effect may be reversed.

Per capita household energy consumption is ultimately determined by economies of scale, as the number of individuals within a house increases, the per capita amount and cost of energy usage declines (O'Neill & Chen 2002). Energy usage is effectively shared between residents, so heating or cooling a living space for a family of five becomes more energy efficient (per person) than heating or cooling the same space for a single occupant. Within Alice Springs, the cost of rental properties is quite high. It is therefore commonplace for a certain portion of residents, mainly those without families or purchased housing, to reside in shared accommodation. Economies of scale for these households would reduce the per capita cost and amount of energy consumption, potentially contributing to overall efficient household energy use throughout the town.

Education

Overall, the relationship between education level and energy usage appears inconclusive within the literature. While Poortinga et al. (2004), for example, have argued that a higher level of education may be associated with lower household energy use (see also Leahy & Lyons 2009); Gatersleben et al. (2002) have suggested that education is not notably related to energy consumption.

Nonetheless, Leahy & Lyons (2009) have concluded that domestic appliance ownership may be linked to the level of education held by a household's chief economic supporter. Those with a lower level of education are less likely to own fridge/freezers, washing machines, vacuum cleaners, microwaves, tumble dryers and dishwashers (Leahy & Lyons 2009). This trend is likely caused by the positive correlation of income with education; those with a higher education are often employed in jobs with a higher salary and so have a greater purchasing capacity (Leahy & Lyons 2009).

Figure 3: Highest level of Education Obtained, Alice Springs LGA & Solar City (ABS 2006b; ASC 2010)
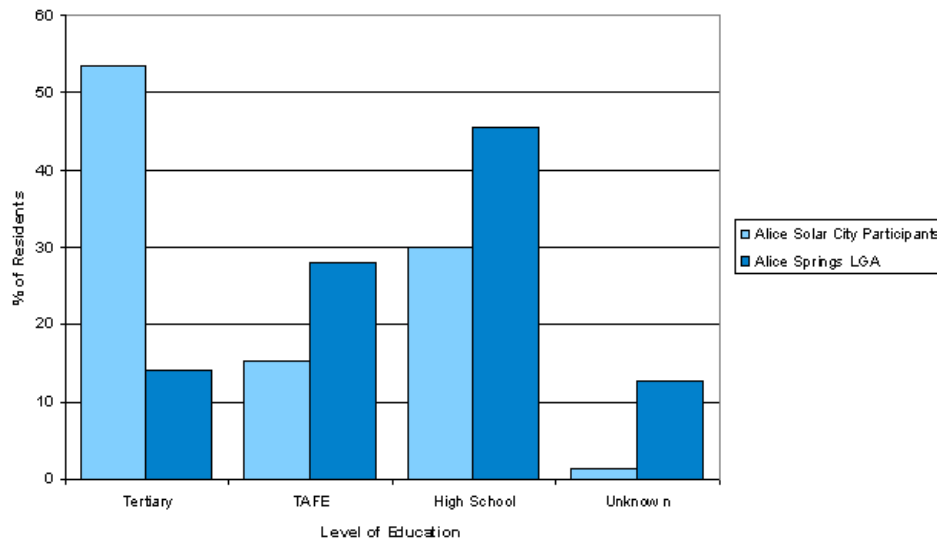
Shown in figure 3, the comparison of Solar City participants with the Alice Springs LGA reveals a substantial difference between the percentages of residents with tertiary education, despite being similar for both TAFE and High School education. Though two different counting methods have been used for the data collection: ABS data includes every member of a household over the age of 15 while ASC data records only the highest level of education obtained out of all the residents within a household, the figure displays a prominent tendency. 53% (n= 844) of the households registered with the Alice Solar City project have at least one member who has completed

university education, in contrast with only 14% of the total residents counted within the 2006 census (ABS 2006b).

Gender

Interestingly, little research has been conducted into the energy consumption differences between men and women in developed countries (Clancy & Roehr 2003). Demographic trends suggest that more women then men live in poverty, as single parents or alone when elderly, thus energy consumption may be restricted in line with household budget (Clancy & Roehr 2003). Comparisons of single male and female households also demonstrate a divergence in the types of appliances owned, women tend to own more appliances associated with the household, such as washing machines, while men own a greater number of appliances such as computers and mobile phones (Clancy & Roehr 2003).

Behavioural changes aimed at reducing household energy consumption may, in addition, disproportionately affect a woman's workload, depending on how the household tasks are divided among family members (Carlsson-Kanyama & Linden 2007). In a Swedish study, it was concluded "… that any (energy) savings related to laundry were the women's responsibility and that they would adapt substantially by increasing their time for household chores in order to reduce the energy bill. This is an important insight for policymakers who have an overall responsibility for the well-being of citizens and who cannot consider one policy instrument in isolation from another" (Carlsson-Kanyama & Linden 2007 p2171). When implementing energy policy measures (e.g. a cost reflective pricing tariff) women who have both younger children and who also work outside of the home may be subject to increased stress, especially if they are required to significantly alter their behaviour (Carlsson-Kanyama & Linden 2007).

Given that the Alice Solar City project collects both demographic and household data for participants, the impact of demographic trends may prove interesting to examine. Still, an accurate assessment is entirely dependent on the number of Alice Solar City participants comprising the above categories. Presently, Alice Solar City residential registrations number over 1700, however basic demographic analysis indicates that the participants may be skewed in certain demographic categories. Over 50% of participants reside in households where the highest level of education obtained is a University degree (figure 4), approximately 72% of households have at least one member working full-time and 44% of households earn between $50,000 and $100,000 per year.

Skewed proportions of participants or households with certain demographic characteristics have the potential to influence analyses and will need to be factored into the results obtained.

Though some contention concerning the ways in which socio-demographic variables influence household energy consumption (e.g. income) may exist within the literature; there appears to be no significant debate over the fact that they do (Lenzen et al. 2006; Abrahamse & Steg 2009). Importantly, when examining the behaviour of Alice Solar City participants, these variables have the potential to provide valuable insight into larger residential energy use patterns. This in turn provides a basis for the formation of targeted, and perhaps more effective, energy conservation/efficiency measures and programs aimed at reducing household energy consumption.

4. Altering Household Energy Consumption

Principally, two approaches are employed to produce a reduction in household energy consumption. Psychological (also known as informational) strategies are often based on the provision of information, and aim to alter an individual's knowledge, perceptions or habits. It is generally assumed that mental changes will eventually affect consumption behaviour (Steg 2008). Structural strategies, on the other hand, address the context of energy consumption (by providing incentives, for example) - effectively making the conservation or efficient use of energy more appealing to the individual (Steg 2008).

While the Alice Solar City project utilises both approaches, it appears that structural methods are predominately employed. It is easier to encourage household energy conservation/efficiency by providing incentives (thus making a reduction in energy use attractive to individuals). As mentioned earlier, when required to reduce energy use people tend to avoid behavioural measures and changes in consumption patterns, unless they are easily achieved (Poortinga et al. 2003). Yet, the fact remains that psychological strategies should not be overlooked. Attempts to change an individual's knowledge, perceptions or habits may be longer lasting than those immediate measures employed to make a reduction in energy usage attractive in the short term.

Psychological (informational) Strategies

Although there have been some successful informational strategies implemented (e.g. Daamen et al. 2001; Benders et al. 2006; Abrahamse et al. 2007; Schultz et al. 2007), more often than not,

information campaigns only result in slight behavioural modifications (Steg 2008). Previous research conducted in Belgium (2004-2005) concluded that households with a greater understanding of climate change do not act in a more sustainable way (Bartiaux 2008). It seems that a higher level of environmental awareness does not guarantee that the knowledge will actually be put into practice (Ehrlich et al. 1999). However, this may be in part caused by the misunderstandings related to energy and behaviour (page 1), the types of information available and the ways in which it is presented to the public.

As Gardner & Stern (2008) point out, many of the books and articles providing residential advice on energy saving measures present the information in lengthy, unranked lists of suggested actions. This may subsequently lead the public to assume that actions such as changing to low-energy light bulbs have the same effect as reducing air-conditioning run times or temperatures. By presenting advice on energy saving methods this way (i.e. unranked), action lists have the potential to become counterproductive toward energy conservation/efficiency (Gardner & Stern 2008). Individuals may overvalue and feel satisfied with their relatively minor actions, and may not be motivated to engage in further action (Gardner and Stern 2008).

Interestingly, the previously mentioned Belgian study also determined that householders who received customised advice aimed at procuring energy savings rarely followed the advice given; only 11% of the suggested measures were implemented within the first year (Bartiaux 2008). It therefore appears that informational strategies tend to be very effective when the change in behaviour requested is relatively easy, cheap, doesn't take much time, does not incur social disapproval and does not limit the lifestyle of the individual (Steg 2008).

Structural Strategies

Structural strategies, in contrast, encourage individuals to alter energy consumption behaviour in situations when the change required is costly or difficult (Steg 2008). A Swedish study conducted in 2008 (Nair et al. 2009) demonstrated that less than 20% of the respondents interviewed planned to improve the energy efficiency of their building structure over the following 3 years (Nair et al. 2010). The results of this and other studies (Eurobarometer 2007; Mahapatra & Gustavsson 2008) seemingly indicate that, with all other things being equal, households favour 'non-investment measures'- easily achieved habitual measures such as turning off a light or appliance to improve their household energy efficiency (Nair et al. 2010). However, reducing the external barriers to pro-environmental actions (e.g. lowering the cost of installing household insulation by providing

financial incentives) effectively changes the context of the behaviour to be performed and addresses household preference for non-investment measures (Steg 2008). The perception, attitude and motivation of householders may also be indirectly altered as a result, potentially eliciting further action (Steg 2008).

Within the Alice Solar City project structural strategies (providing incentives to increase the uptake of household energy efficiency measures, elevated buyback for PV produced electricity, 10:10/20:20 incentive etc.) aim to reward and therefore encourage the "good" energy behaviour of participants. Rewarding positive actions (as opposed to enforcing sanctions) tends to be more effective in encouraging constructive environmental behaviour, as rewards are often associated with positive change and attitude (Steg 2008). However, given that the positive reinforcement of behaviour generally produces changes that may not persist in the longer term, individuals often revert to their original behaviour once the rewards are removed (Steg 2008).

It should furthermore be noted that the uptake of structural household investment measures, including those offered as part of the Alice Solar City project, can be influenced by external factors. Nair et al. (2010) suggest that householders who perceive the cost of their energy usage as high are generally more willing to implement investment measures. Likewise, home ownership (as opposed to rental), previous experience with implementing energy efficiency measures, householder education, age and income may all limit or encourage the uptake of investment measures (Nair et al. 2010). As with the influence of demographic variables on energy usage, these factors may present interesting trends for examination within the structure of the Alice Solar City project.

Additionally, active household energy conservation and efficiency do not always result in energy usage reduction, even when encouraged by the previously mentioned strategies. In many instances, the rebound effect (also known as the 'takeback' effect) may prove to negate the energy savings made or increase overall energy consumption. Explained in the following section, the rebound effect presents an interesting dilemma when attempting to elicit energy savings. Is it possible to reduce energy use by increasing efficiency and encouraging conservation or are the associated effects likely to instead reduce the effectiveness of the initial actions? 'Simple economic theory', as outlined by Sorrell (2009), would suggest that the latter may be the case.

5. Energy Efficiency and the Rebound Effect

Throughout the literature it has been surmised that overall increases in household energy efficiency reduce the implicit price of energy for consumers (Berkhout et al. 2000; Greening et al. 2000; Herring 2006; Abrahamse 2007; Brannlund et al. 2007; Sorrell 2009). The flow on effects of more affordable energy encourage growth in household energy use and thus environmental concerns, especially if the energy sourced originates from fossil fuels (Herring 2006; Abrahamse 2007). For this reason, it has been argued that "energy efficiency is not as 'environmentally friendly' as many claim. Its promotion will not necessarily lead to a reduction in energy use and hence reduced CO2 emissions. It will, however, save consumers money, promote a more efficient and prosperous economy, and allow the financing of the move towards a fossil-free energy future. It is a means not an end." (Herring 2006 p10).

In slightly more detail, there appears to be three primary types of rebound effect. The first, known as the direct rebound effect, occurs when the use of energy services increases as a by-product of greater efficiency (Berkhout et al. 2000; Herring 2006; Oikonomou et al. 2009; Sorrell 2009). A commonly used example of this is air travel; an increase in aeroplane efficiency enables air travel companies to provide cheaper airfares and in so doing so, initiate a rise in the number of trips made (Herring 2006). In much the same way households who implement energy efficient technology may increase their energy usage, countering any initial savings (Berkhout et al. 2000; Abrahamse 2007; Oikonomou et al. 2009; Sorrell 2009). A household, for instance, may purchase and use energy efficient light globes but may leave them on for much longer (Abrahamse 2007). This has the potential to drive up their energy usage, reducing the effectiveness of their original energy saving actions by up to 30% (Dimitropoulos 2007).

The second type of effect, the indirect rebound effect, occurs from the reduction in the cost of energy services. Households, as a result, have extra money to spend on other, possibly more energy intensive, goods and services (Berkhout et al. 2000; Herring 2006; Abrahamse 2007; Oikonomou et al. 2009; Sorrell 2009). This type of rebound effect occurs when households use their monetary savings to purchase things like airfares or additional appliances. Somewhat intriguingly, this effect may also be encouraged when participants within the Alice Solar City project make a 10:10/20:20 claim. The incentive aims to promote a reduction in household energy consumption; if a participant reduces their consumption by 10% (or 20%) compared to the same quarter of the previous year, a 10% (or 20%) discount on the value of the current bill is awarded.

Presently, the largest discount provided has been $276.90; the household receiving the discount reduced their average daily energy consumption by almost 60%. In addition, this reduction in household energy consumption equated to a weekly monetary saving of approximately $60. It is entirely plausible to assume that the household redirected these financial savings, possibly toward alternative goods and services, diminishing the overall effect of the initial reduction in energy usage.

On a broader scale the final type of rebound effect, the general equilibrium effect, encompasses production and consumption at an economy wide (macro) level (Berkhout et al. 2000; Greening et al. 2000; Herring 2006; Oikonomou et al. 2009). Increases in energy efficiency ultimately generate increases in gross output (Berkhout et al. 2000; Greening et al. 2000). In this sense, the general equilibrium effect becomes the sum of the previously outlined direct and indirect rebound effects, expressed as a percentage of the total estimated energy savings (Sorrell 2009). An economy wide rebound effect of 50% would indicate that 50% of the estimated energy savings had been countered through the effects summarised above (Berkhout et al. 2000; Sorrell 2009). Economy wide rebound effects exceeding 100%, known as backfire, produce an overall rise in energy use, as predicted by Jevons (Sorrell 2009).

Though it is improbable that each and every energy efficiency gain will produce backfire, it has been suggested that the issue remains a knowledge gap within the field (Sorrell 2009). As Sorrell (2009 p.1468) writes, "… rebound effects matter and need to be taken seriously" and while they are "difficult to study, they are not necessarily any more difficult than well-researched issues… Their continued neglect may result as much from their uncomfortable implications as from a lack of methodological tools. Too much is at stake for this to continue". In the context of the Alice Solar City project, it is possible that rebound effects will reduce the overall outcome of any household energy savings achieved. When assessing the effectiveness of the incentives employed to accomplish reductions in household energy use it would be wise to incorporate any potential types of rebound effect. This may enable an accurate appraisal of the project itself, highlighting areas for future investigation.

In conjunction with the rebound effect, the level of household energy savings achieved may also be influenced by the environmental stance of an individual. Often there is a substantial difference between an individual's attitude and their actual behaviour. When forming strategies to invoke a decrease in household energy consumption (and when monitoring the effectiveness of these

strategies) it may be useful to examine possible environmental behaviour models. These models have foundations within the discipline of psychology and can provide insights into the individual processes driving energy consumption and conservation.

6. Environmental Behaviour Models

Previously, many attempts have been made to explain the attitude-behaviour gap noted in studies examining the contrast between public behaviour and attitudes towards environmental issues. Often, the theories and models presented are varied and somewhat contradictory. The theory of planned behaviour, for example, posits that an individual's attitude and their perception of any given behaviour is one of the components which dictate how that individual will act. The norm activation model, on the other hand, suggests that behaviour is controlled by personal norms- the feelings and sense of moral obligation perceived by an individual.

Within the Alice Solar City project, and irrespective of possible rebound effects, the reduction of residential and commercial energy consumption is a primary goal. In this respect, understanding the psychological processes driving attitudes towards energy conservation/efficiency and actual household energy consumption may be crucial. The theories and models presented below may well explain household behaviour and may also aid in the identification of significant behavioural forces, particularly relevant for effectively targeted household energy reduction measures (Wilson & Dowlatabadi 2007).

Utility Maximisation & Rationality
Theories based on the financial aspects of consumption and individual choice propose that households aim to maximise utility in line with household budget constraints (Wilson & Dowlatabadi 2007). Although the concept of 'utility' may be used as a measure of the preferences an individual holds for different outcomes, it is also commonly viewed as a substitute for "well-being, personal benefit or the 'betterness' of an outcome" (Wilson & Dowlatabadi 2007 p172). Thus individuals will always tend to favour an outcome with higher utility when making a decision.

If applied to the situation of household energy use, the theory of utility maximisation and rational choice may potentially explain the decision making process (Wilson & Dowlatabadi 2007). The

discrete choice model has been utilised to estimate individuals' discount rates on the basis of their partiality towards energy efficient appliances (Wilson & Dowlatabadi 2007). As explained by Wilson & Dowlatabadi (2007 p173) "discount rates measure an individual's willingness to exchange present consumption for future consumption, for example, by spending more up front on an appliance with lower operating (energy) costs". Interestingly, it has been found that individuals apply diverse discount rates to different goods in different circumstances (Wilson & Dowlatabadi 2007). Refrigerators and hot water systems are generally given higher discount rates when compared to alternative weatherisation measures, such as insulation (Wilson & Dowlatabadi 2007).

Maximisation and rationality theories, however, generally make the assumption that consumers behave as logical actors, specifically, that their preferences for an outcome remain organised, known and consistent (Wilson & Dowlatabadi 2007). Instead, previous studies concerning consumption behaviour indicate that the decision making process of individuals is in actuality not always a logical procedure (Wilson & Dowlatabadi 2007). Habits, emotions and mental associations often influence the individual choices made (Wilson & Dowlatabadi 2007). From an Alice Solar City perspective, these theories may offer explanations for participant uptake of residential energy efficiency measures and, when altered to account for the influence of habits, emotions and mental associations, provide direction for the targeted improvement of the incentives offered.

The Theory of Planned Behaviour

The theory of planned behaviour (Ajzen 1991) suggests that behaviour results from the process of considering the time, financial, social and energy costs and benefits associated with any given behaviour. Behaviour is governed by a person's intention to perform it, and a person's behavioural intention is influenced by the following three factors:

1. Attitude- the individual's favourable or unfavourable evaluation of performing the behaviour.
2. Perceived control- the perceived ease or difficulty of engaging behaviour.
3. The subjective norm- the individual's perception of social pressure to perform or not to perform the behaviour (Ajzen 1991; Abrahamse & Steg 2009; Davis et al. 2009).

Given this theory and its application in various studies (e.g. Tonglet et al. 2004a; Davis et al. 2009) it appears that perceived behavioural control and attitudes are the leading determinants of pro-

environmental behaviours and intentions (Abrahamse & Steg 2009). However, it has been argued that the inclusion of additional variables (e.g. moral norm, situational outcomes, concern for the environment and previous behaviour) may be necessary to accurately account for any variances in behavioural intentions (Tonglet et al. 2004b).

Based on the context of household energy efficiency, this theory suggests that an individual's energy saving behaviour is primarily determined by their attitude, the perceived difficulty of performing the behaviour and their concept of the social norm. An individual's willingness to perform easier measures, such as changing to energy efficient light globes, or drive to meet a perceived social norm by maintaining a cooled house in summer can be adequately described. Altering the behaviour of an individual, according to this theory, would involve addressing unfavourable attitudes, perceived difficulties associated with energy efficient actions and, perhaps most challengingly, the individuals perception of the social norm. As this is ingrained in everyday social interaction, a community wide approach would be required.

The Habitus, Field & Capital Model

Originally explained by Bourdieu, an individual's habitus (their 'embodied social knowledge[2]') exerts its influence within a field (social context) and as determined by the individual's available capital (knowledge and wealth) (Strengers 2008). Household comfort and cleanliness expectations, as a result, are learnt social norms powered by the vast realm of social knowledge which encompasses the daily aspects of life (Strengers 2008). In applying the model to energy consumption, Strengers (2008 p.12) concisely suggests that "while our habitus generates habits around certain practices, such as showering or switching on a heater at a certain time each day, it also provides the justification for those habits. It is the step before the habit- and therefore a logical place to target if our aim is to change energy and water practices". Nevertheless, it has been argued in opposition that the notion of habitus "assumes unity and permanence" of the individual, ignoring "discontinuities and plurality" in behaviour (Bartiaux 2008 p.1171).

Addressing the habitus of an individual, from the perspective of energy consumption, involves the alteration of their embodied social knowledge, effectively the norms reinforced by everyday activity within society. As Kurz et al. (2005) found, energy resources are generally viewed by the public as replaceable. In the series of interviews, participant discourse on the topic of energy

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[2] An individual's embodied social knowledge may be formed from the interaction of the individual with their environment. It is based on the actions and routines of the individual.

consumption revealed that energy was "constructed as something that is used for the essentials of life, rather than something that can sensibly be said to be wasted" (Kurz et al. 2005 p.616). If this model accurately represents public behaviour, the ideas presented by Kurz et al. (2005) indicate a fundamental barrier to altering household energy consumption, that is, the necessity to transform the crucial social assumption of energy as an essential and non-negotiable aspect of life.

The Norm Activation Model

In comparison, the norm activation model (Schwartz 1977; Schwartz & Howard 1981) hypothesizes that pro-environmental behaviour is, in essence, a form of altruistic (Abrahamse & Steg 2009), egoistic or biospheric behaviour (Berenguer 2010). In this sense, behaviour is thought to be influenced by personal norms (feelings and a sense of moral obligation). Actions in accordance with these norms may foster a feeling of pride and self-satisfaction, while those conducted against may induce a feeling of guilt. However, the theory requires that each individual is aware of the consequences of their behaviour and that these individuals feel personally responsible for the consequences (Abrahamse & Steg 2009). As outlined earlier (page 1), the environmental costs associated with energy consumption are often far-removed from the individual and it is therefore difficult for individuals to comprehend how their actions impact upon the social/environmental collective (Hummel et al. 1978; Whitmarsh 2009a).

Managing household energy consumption from the perspective of the norm activation model would imply a need for improvement in individual knowledge and understanding concerning residential energy conservation and efficiency. Even so, informational strategies tend to be most effective when the behavioural changes required to reduce household energy consumption are relatively simple and easy to achieve (Steg 2008). Instead, the changes needed may be perceived as costly by households (e.g. installation of insulation or solar hot water systems), or may exert an influence over individual behaviour (e.g. altering consumption patterns). As a result, Norgaard (2006 p.352) argues that it is not a lack of individual knowledge preventing public action toward climate change but it is instead a minimisation of the "psychological, political or moral implications that conventionally follow". With this social minimisation, the sense of guilt felt by individuals conducting anti-environmental behaviour is diminished, effectively enabling the unthinking continuation of the action. Residential energy efficiency and conservation measures may hence remain disregarded by households.

The Value-Belief-Norm Model

Developed on the basis of the norm activation model, the value-belief-norm model posits that individuals will alter their behaviour if they accept responsibility for the consequences of their actions (Faiers et al. 2007). Once an individual has recognised the beliefs of an environmental movement they then accept that their actions may influence their new found beliefs and make the required changes to their behaviour (Faiers et al. 2007). Although there is the possibility that individuals may benefit from the collective actions of others, this effect can be reduced when individuals cannot see the differences made by their efforts in comparison to those of others (e.g. in the amount of energy conserved).

As with the other models presented previously, the value-belief-norm model seemingly assumes a 'non-negotiable' public view of energy consumption. If an individual does accept responsibility for the consequences of their actions, energy use is still seen to a certain extent as an invariable necessity (Kurz et al. 2005). Thus behavioural changes caused by a responsible acceptance of the environmental consequences may only extend so far as to influence the energy usage which may be seen by households as negotiable- perhaps turning off a light upon leaving a room or changing to energy efficient light bulbs.

The Perceived Customer Effectiveness Model

Perceived customer effectiveness has also been linked to environmental behaviour and may therefore be applied to household energy conservation and efficiency. The theory operates on the premise that those who believe their actions will produce a positive change within the environment are ultimately motivated to act by this belief; providing they see themselves as part of a collective action (Faiers et al. 2007). An innate trust in the behaviour of others, that they will do their part in working towards an environmental goal, is assumed (Faiers et al. 2007). As with the norm activation model, the consequences of energy consumption are often 'external' to an individual's actions. If an individual does recognise the impacts of their energy consumption, it is unlikely that they will view their mitigation actions as significant, given the global implications of climate change. If it is assumed that this model is plausible, perceived minimal effectiveness may actually provide a disincentive to act- any changes in behaviour may be viewed by the individual as being insignificant and, when combined with the notion of habitus, may ultimately outweigh any 'vague' and 'distant' environmental benefit.

Cognitive Consistency Theories

Theories centred on the notion of cognitive consistency draw attention to an individual's need for consistency (Faiers et al. 2007). Any deviation from consistency creates dissonance, conflict or anxiety within the individual, and drives their push to return to stability (Faiers et al. 2007). In order to prevent the occurrence of dissonance, individuals will generally favour the knowledge which validates their original belief and actively seek this information out (Faiers et al. 2007). This theory may present an adequate explanation for the argued ineffectiveness of informational strategies on their own (page 10). If the information presented to an individual counters their original beliefs and understandings, in this instance those that are related to energy consumption and climate change, then the individual may be less likely to accept the information presented and ultimately not implement any suggested energy saving actions.

Given the basic overview of the models and theories presented, it appears that no single idea will predict or account for the full range of Alice Solar City participant energy consumption behaviours. However, there is potential for other theories (e.g. the theory of Social Learning or the Diffusion theory) to provide additional insights and this should be considered in future reviews. In relation to the Alice Solar City project, it is possible that a fruitful model may be the theory of planned behaviour. The influence of variation in household circumstances seems sufficiently incorporated within this theory and as such, it may reasonably represent the diversity of the Alice Solar City participants. Nonetheless, when utilising the theory, it may be wise to integrate both the discrete choice model and the notion of habitus, to account for individuals' discount rates and embodied social knowledge respectively.

On the whole, it has been argued that that "a theory-driven approach towards the behavioural components of environmental problems will provide a basis for understanding and managing these problems" (Steg & Vlek 2009 p315). Residential energy usage is one such environmental issue. While it is simple to assess the theoretical validity of the models presented, the actual circumstances under which any of the above theories are successful in creating programs that will reduce household energy consumption require further investigation (Steg & Vlek 2009). Hence, it becomes necessary to investigate the measurable elements that may influence the energy conservation/efficiency actions of households, just as it is necessary to link these models with socio-demographic trends.

7. Measuring Participant Attitudes, Behaviour & Knowledge

The examination of psychological factors (e.g. attitudes, values, norms and habits) and contextual characteristics (e.g. physical infrastructure, appliance numbers) is necessary when examining household energy consumption (Steg 2008). These variables interact regularly and often influence an individual's or household's behaviour (Steg 2008). In order to perceive and explain any changes in participant attitude, knowledge and action throughout the duration of the Alice Solar City project, data collection on these topics is essential. Most importantly, this data may then be correlated to present an accurate overview of the Solar City project.

Demographic Analysis

Primary demographic analysis of Alice Solar City participants will provide a crucial background on residential energy consumption within Alice Springs. The data collected about project participants covers basic demographics including residence location, income, household age composition and highest level of education attained. Information is also collected on housing type and build, and appliance type and quantity. Ultimately, it will be possible to relate this information to actual household energy consumption data, as supplied by Power & Water, the sole Northern Territory energy utility company and compare it with ABS demographic data.

Environmental Knowledge

The knowledge of participants will be an important characteristic to bear in mind when examining trends within the Alice Solar City project. Various studies have shown that there is often a significant discrepancy between environmental knowledge and action (Halder et al. 2010 in press). In order to place behaviour in perspective, public knowledge (and attitudes) must likewise be considered.

The analysis of public knowledge in regard to environmental issues such as energy conservation has, in a number of cases, been designed around factually based statements. Hayes (2001) for example, formulated a series of sentences concerning various topics associated with scientific knowledge. Based again on a Likert-type scale, the respondents were required to select whether the statements were 'definitely true', 'probably true', probably not true' or 'definitely untrue'. For all intents and purposes the survey appeared to be a measure of attitude, when in reality it was designed as a method of evaluating participant knowledge. Studies such as Johnson & Frank's (2006) examination of public understanding and the environmental impacts related to electricity

deregulation and Flamm's (2009) analysis of the impacts of environmental knowledge and attitudes on vehicle ownership have used the same approach to data collection (see also Halder et al. 2010).

Environmental Attitude

On a basic level, attitude may be described as "the way that an individual views, or behaves towards an object" (Faiers et al. 2007). It has been argued that an individual's attitudes, including environmental concern, political orientation and perceived customer effectiveness (outlined above), provide fundamental links to behaviour (Faiers et al. 2007).

In order to organise and group similar attitudes, various classifications have been created within the literature. There is, for example, the division of public attitudes into the homocentric (for the benefit of humanity), ecocentric (for the benefit of nature) and egocentric (for self benefit) (Berenguer 2010). Wiseman and Bogner (2003) conclude that environmental values may be classified into two dimensions; a biocentric view which reflects the conservation and protection of nature (Preservationist) and an anthropocentric view which reflects the utilisation of natural resources for human benefit (Utilitarian) (Milfont & Duckitt 2004). Similarly, Thompson and Barton (1994) have suggested a broad value division based on the anthropocentric (nature should be preserved because of its value for humanity- it has no intrinsic moral value) and ecocentric (nature should be preserved for its own sake- it has its own intrinsic value). Other authors argue that this is perhaps the most fundamental distinction, as it is the very basic determinant of personal attitude- which do we place a higher value on- humanity or nature (Berenguer 2010)?

In most studies, the measurement of attitude or concern toward environmental issues is achieved by asking participants to rate a series of statements on a Likert-type scale which ranges from strongly agree to strongly disagree (Corral-Verdugo 1997; Fujii 2006; Davis et al. 2008; Wray-Lake et al. 2010). The questionnaires employed often include statements similar to 'I think environmental problems are very important' and 'science will find other substitutes for fossil fuels when the current supplies are exhausted' (Fujii 2006). Although seemingly fairly straightforward, this method allows researchers to categorise participant responses in accordance with the groupings outlined above. A questionnaire related to household energy use may demonstrate that respondents are primarily utilitarian in their attitude toward energy consumption or that their concern about climate change is based on an egocentric view.

Ultimately, the attitudinal scale formed for use within the Alice Solar City project will be based on the area of energy consumption and perhaps, to a lesser extent, climate change. Though the scale may include a small number of generalised statements, it is anticipated that the focus placed on the attitudes associated with residential energy usage will provide insights specifically relevant to the project. It is expected that analyses of participant attitude may provide an understanding of the way that participants view and evaluate energy conservation/efficiency and climate change.

Environmental Behaviour

In order to quantify participant behaviour, most studies measure self-reported environmental actions by again utilising a Likert type scale. Study participants are generally directed to specify how often they undertake each of the activities listed (see Shultz et al. 2005; Fujii 2006; Davis et al. 2008; Dono et al. 2009). Commonly, the activities range from easy to difficult, and may include questions such as 'have you given money to an environmental group in the last 12 months' and 'how often do you recycle'.

Though this method appears sufficient for the researchers utilising self-reports, other studies have reported low correlations when comparing actual behaviour with reported behaviour (Steg & Vlek 2009). Pertaining to the Alice Solar City project, it will be interesting to see if this is the case, as it may be possible to compare reported energy conservation/efficiency behaviour with actual household energy consumption. Assuming that all other variables remain equal, household energy usage may be considered a gross indicator of behaviour. As advised by Steg & Vlek (2009), it is important "to measure actual behaviour whenever possible, and to pay attention to the validity and reliability of self-reported environmental measures". This will enhance the results obtained and, in the case of Alice Solar City, provide interesting insight into household energy consumption behaviour.

As with monitoring changes in participant attitude throughout the duration of the Alice Solar City project, the evaluation of participant behaviour will likewise focus on household energy conservation/efficiency measures. The monitoring, evaluation and reporting (MER) plan formulated for the Alice Solar City project proposes that the main collection of participant knowledge, behaviour and attitude data will occur through a survey distributed before and after the implementation of household energy efficiency measures. However, as the detailed MER plan was developed and instigated after the commencement of the Solar City project as a whole, this questionnaire has not yet been conducted. A control group has been created to enable a comparison

between households participating in the Solar City project and a sample of households who are not.

The formation of the questionnaire will consider the existing literature within the field of residential energy consumption and will focus on quantifying household electricity usage and household response to conservation/efficiency measures. Though this review is by no means a complete appraisal of all academic literature available, some of the concepts presented may improve the framing and relevance of the questions created. Follow up interviews and focus groups have likewise been planned and will aim to elaborate on and elicit further information from participants with reference to the outlined topics.

While it would be convenient to summarise this paper by simply suggesting that residential energy use may be adequately characterised by demographic analysis and therefore easily reduced by strategies aimed at addressing the areas outlined (pages 4-8), this would not present the actuality of energy saving within households. Given the literature reviewed, it appears that achieving a reduction in household energy use offers a multifaceted puzzle. Not only is household energy usage based on socio-demographic variables, but its reduction is dependent upon the strategies employed to encourage behavioural change, the economics of the rebound effect and the behavioural understandings potentially provided by psychological modelling.

It is interesting to note, though, that the main theme recurring in one sense or another within the theories and models mentioned (pages 14-18) arises from the importance placed on the social aspects of energy consumption. Social pressure within the theory of planned behaviour; social expectations within the habitus, field and capital model; the social collective within the norm activation model and the requirement for collective social action within both the value-belief-norm and perceived customer effectiveness models. Although residential energy consumption may initially appear confined to each individual household, the factors which influence individual behaviour are in reality ingrained within the social aspects of everyday life.

Concerning the Alice Solar City project, current participant levels stand at approximately 1700 households- roughly 19% of the occupied households within the Alice Springs LGA (ABS 2006a). While the project has been designed to explore the ways in which changes to household energy consumption may be produced, it also provides an excellent opportunity to increase knowledge

within the field of residential energy consumption, conservation and efficiency. Most importantly, this knowledge may be obtained within the framework of a localised, community based program. The variables which influence everyday life and therefore energy consumption within one household are also likely to act upon the residents of another. Any positive results arising from the Alice Solar City project may provide learnings which help address energy issues in the Australian community. An accurate and thorough evaluation of the Solar City project will only serve to encourage this knowledge and its diffusion.

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Appendix 1: Alice Springs LGA & Alice Solar City data comparisons (Income)

<table>
<tr><td colspan="2">Alice Springs LGA (ABS 2006a)
Gross household income (weekly)</td></tr>
<tr><td></td><td>Households</td></tr>
<tr><td>Negative/Nil income</td><td>50</td></tr>
<tr><td>$1-$149</td><td>91</td></tr>
<tr><td>$150-$249</td><td>229</td></tr>
<tr><td>$250-$349</td><td>306</td></tr>
<tr><td>$350-$499</td><td>118</td></tr>
<tr><td>$500-$649</td><td>555</td></tr>
<tr><td>$650-$799</td><td>544</td></tr>
<tr><td>$800-$999</td><td>556</td></tr>
<tr><td>$1,000-$1,199</td><td>903</td></tr>
<tr><td>$1,200-$1,399</td><td>439</td></tr>
<tr><td>$1,400-$1,699</td><td>760</td></tr>
<tr><td>$1,700-$1,999</td><td>652</td></tr>
<tr><td>$2,000-$2,499</td><td>705</td></tr>
<tr><td>$2,500 -$2,999</td><td>551</td></tr>
<tr><td>$3,000 or more</td><td>400</td></tr>
<tr><td>Partial income stated</td><td>838</td></tr>
<tr><td>All incomes not stated</td><td>251</td></tr>
<tr><td>Total</td><td>7,948</td></tr>
</table>

ASC combined household annual income categories:

$0- $20,000
$20,001- $50,000
$50,001- $100,000
$100,001- $150,000
$150,001+
Unknown

Alice Springs LGA & ASC Data Comparison:

Annual Household Income ($):	ASC DATA		ABS Data	
	Households	%	Households	%
0-20,000	18	1.14	676 (a)	8.51
20,001-50,000	184	11.66	1,773 (b)	22.31
50,001-100,000	695	44.04	2754 (c)	34.65
100,001-150,000	456	28.90	1,256 (d)	15.80
150,001+	163	10.33	400 (e)	5.03
Unknown	62	3.93	1,089 (f)	13.70
Total	**1,578**	**100**	**7,948**	**100**

a) ABS 2006. Negative/Nil income to $349 per week

b) ABS 2006. $350 to $999 per week

c) ABS 2006. $1,000 to $1,999 per week

d) ABS 2006. $2,000 to $2,999

e) ABS 2006. $3,000 or more

f) ABS 2006. 'Partial' & 'incomes not stated'

Note: ASC data based on combined annual household income; ABS data collected in the form of gross household income per week. Census data re-categorised to match ASC data- though not exact matches of categories, the data adequately reflects approximate household income.

Appendix 1 (cont.): Alice Springs LGA & Alice Solar City data comparisons
(Dwelling Structure)

Alice Springs LGA (ABS 2006a)	
Dwelling structure (occupied private dwellings)	
	Dwellings
Separate house	5,311
Semi-detached with:	
One storey	1,141
Two or more storeys	374
Total	*1,515*
Flat, unit or apartment:	
In a one or two storey block	752
In a three storey block	39
In a four or more storey block	0
Attached to a house	11
Total	*802*
Other dwelling:	
Caravan, cabin, houseboat	227
Improvised home, tent, sleepers out	75
House or flat attached to a shop, office, etc.	14
Total	*316*
Dwelling structure not stated	4
Total	**7,948**

ASC Dwelling Type Categories:
Apartment/Unit/Flat - multi-story
Apartment/Unit/Flat - single story
House complex
House detatched
House semi-detatched

Alice Springs LGA & ASC Data Comparison:
Dwelling structure (occupied private dwellings)

Dwelling Type	ASC DATA		ABS Data	
	Dwellings	*%*	*Dwellings*	*%*
Apartment/unit/flat	130 (a)	8.24	791 (c)	10.36
House detached	1,312	83.14	5311 (d)	69.59
House semi-detached	38 (b)	2.41	1526 (e)	19.99
Unknown	98	6.21	4 (f)	0.05
Total	1578	100	7,632	100.00

a) ASC Data: Single & multi storey apartments combined

b) ASC Data: Housing complex combined with 'house semi-detached' data

c) ABS 2006. Flat, unit or apartment (one, two, three & 4+ block)

d) ABS 2006. Separate house

e) ABS 2006. Semi-detached total (1,515) and attached to a house (11)

f) ABS 2006. Dwelling structure not stated

Note: Does not include other dwelling structures (ABS 2006 data)

Appendix 1 (cont.): Alice Springs LGA & Alice Solar City data comparisons
(Education)

Alice Springs LGA (ABS 2006b) Non-school qualification: Level of Education (age/sex)	Total Persons
Postgraduate Degree	511
Graduate Diploma and Graduate Certificate	379
Bachelor Degree	1,997
Advanced Diploma and Diploma	1,238
Certificate:	
Certificate nfd	271
Certificate III & IV(c)	2,899
Certificate I & II(d)	262
Total	*3,432*

ASC Level of Education Categories:
High School - Unspecified
TAFE
Tertiary
Other
Unknown
High School - Year 10
High School - Year 12

Alice Springs LGA (ABS 2006) Highest year of school completed (age/sex)	Total Persons
Highschool:	
Year 12 or equivalent	6,924
Year 11 or equivalent	2,755
Year 10 or equivalent	3,668
Year 9 or equivalent	1,175
Year 8 or below	1,216
Total	15,738
Highest year of school not stated	2,281

ASC data is based on highest level of education obtained by one member of household. ABS data is based on highest level of education obtained by each member of household aged over 15 years.

Alice Springs LGA & ASC Data Comparison:				
Highest level of school completed:	ASC DATA		ABS Data	
	Persons	*%*	*Persons*	*%*
Tertiary	844	53.49	2,508 (a)	13.92
TAFE	240	15.21	5,049 (b)	28.02
High School	474	30.04	8,181 (c)	45.40
Unknown	20 (d)	1.27	2,281 (e)	12.66
Total	**1,578**	**100**	**18,019**	**100**

a) ABS 2006. Postgraduate degree & bachelor degree
b) ABS 2006. Graduate diploma, graduate certificate, advanced diploma, diploma & certificate
c) ABS 2006. High school total (15,378)-(a+b)
d) ACS Data. Combined other & unknown
e) ABS 2006. Highest year of school not stated