The Public's Preference for Green Power in Australia

Chunbo Ma[†] (Chunbo.ma@uwa.edu.au) and Michael Burton[†*] (Michael.burton@uwa.edu.au)

[†]School of Agricultural and Resource Economics, Centre for Environmental Economics and Policy, University of Western Australia

Abstract

Green electricity products are increasingly made available to consumers in many countries in an effort to address a number of environmental and social concerns. Most of the existing literature on this green electricity market focuses on consumer's characteristics and product attributes that could affect participation. However, the contribution of this environmental consumerism to the overall environmental good does not depend on participation alone. The real impact made relies on market penetration for green consumers (the proportion of green consumers) combined with the level of green consumption intensity – the commitment levels, or proportion of consumption that is green. We design an online interface that closely mimics the real market environment for electricity consumers in Western Australia and use an error component model to analyze consumers' choice of green electricity products as well as their commitment levels. Our main conclusions are that the choice of green products is much more strongly influenced by consumer characteristics than product attributes. When green products are selected, the vast majority select the minimum commitment possible, and this is insensitive to the premium being charged on green power, suggesting that we are largely observing a 'warm glow' for carbon mitigation.

Keywords: Green Electricity, Choice Modelling, Error Components Model, Warm Glow

JEL: D11, Q42, Q51

[*] Corresponding Author, Tel: (+61) 8 6488 2531

1. Introduction

The past few decades have witnessed a significant increase in the demand and supply of "environmentally friendly" or "green" products. Market research on consumers behavioural patterns involved in green product choice has shown a very high percentage of consumers willing to buy green products. Another body of research, however, indicates that consumers are only willing to purchase green products with preferred attributes within certain constraints. Research in this field has been primarily conducted by market research companies, the results of which are not in the public domain (Blamey et al., 2001). Academic research in the area only focuses on the factors and attributes that influence consumers' choice of green products. Very little research looks at the level of commitment (defined here as the proportion of an individual's use of a product that is 'green'). The environmental impact as a result of green consumption not only depends on consumers' choice of environmentally friendly products, but the level of commitment is also crucial. For instance, the contribution of residential rooftop solar panel adoption to a clean energy supply depends on the size (capacity) of each installation as well as the number of installations. However, Andreoni (1989; 1990) argued that consumers not only derive utility from the contribution to the environmental good (which is pure altruism and is linked to the level of commitment), but utility is also derived from the pro-environmental behavior itself – often termed as a "warm glow" i.e. is generate by participation irrespective of commitment level.. The amount that consumers are willing to pay has been found to be highly non-linear in the percent of energy that is generated from renewables (Farhar, 1999) and customers are more concerned about the concept of consuming green energy than its actual environmental impact (Goett et al., 2000). One implication is that if a "warm glow" effect is significant, the actual contribution to the environmental good may be limited even if there are a substantial number of green consumers. During the second quarter of 2013, Synergy (the principle supplier of energy to households in Perth) sold green electricity to 5,649 residential customers, which represents a 0.63% penetration at the customer level (Synergy, 2013). However the latest quarterly statistics on actual green electricity sale to these green customers translates to a mere 31% average commitment level (GP, 2013) (assuming a representative household with 18-unit consumption per day). As a result of the low commitment level, the genuine contribution to the environmental good is much less than the penetration level often considered at the customer level.

Consumers' decision making at the commitment level will have significant implications for the actual impact of policies that aim to promote pro-environmental behaviors. It is thus important to study both consumers' choice of green products (participation) and their commitment levels. In this paper, we study both elements of consumers' behavior in green electricity programs in Western Australia. We design a survey that closely mimics the real decision context facing the consumers in Western Australia and use an error component model to investigate both consumers' choices of products and commitment levels. The rest of the paper proceeds as follows. Section 2 provides the background of Australian green electricity programs and reviews relevant literature. Section 3 describes our experimental design. Section 4 introduces our statistical model. We present results in Section 5 and conclusions in the last section.

2. Background and Literature

The option to purchase green electricity products is increasingly available to consumers in many countries. For instance, Kotchen and Moore (2007) identified 29 green electricity suppliers currently competing in eight US states. Mewton and Cacho (2011) also studied 21 green electricity schemes provided by utility retailers in Australia. The willingness of consumers to pay for green electricity or actual participation in the green electricity market has been investigated in a large number of countries including the US (Farhar and Houston, 1996; Wiser, 2007; Bird et al., 2007; Kotchen and Moore, 2007), Australia (Mewton and Cacho, 2011, Ivanova, 2012), Sweden (Ek and Söderholm, 2008), Norway (Navrud and Bråten, 2007), Finland (Salmela and Varho, 2006), UK (Scarpa and Willis, 2010; Diaz-Rainey, 2012), Germany (Menges et al., 2005), Canada (Rowlands et al., 2003) and Japan (Nomura and Akai, 2004). These studies primarily address two questions: 1) what motivates consumers to participate in green electricity programs? 2) how do consumers' characteristics and a product's attributes (eg. energy sources and payment mechanisms) affect participation? Conventional electricity is mostly generated from fossil fuels, which is by far the largest emitter of a number of local as well as global air pollutants such as carbon and fine particulates. Demand for green electricity thus contributes to the mitigation of these pollutants. However, the contribution of this environmental consumerism to the overall environmental good does not depend on participation alone. If a "warm glow" effect is the dominant driver for participation, we would expect a low commitment level overall. As a result, the real impact of this green consumerism and policies promoting it may also be rather limited. It is thus important to investigate both participation and commitment levels.

Under all-or-none schemes, where consumers either choose a conventional electricity product or commit 100% to electricity generated from renewable sources, it is understandable that studies mostly focus on participation. However, this all-or-none approach is increasingly being moderated in real markets, with many green electricity products offering different commitment levels. In Australia, the green electricity market is largely driven by the Australian National Green Power Accreditation Program (NGPAP) which is a market-based program initiated by the NSW government in 1997. The objective of the program is to encourage investment in new renewable energy generation by increasing consumer demand and confidence in accredited "GreenPower" products by letting consumers opt-in to pay a premium and buy more expensive green electricity on a voluntary basis. Currently, a total of 44 "GreenPower" products are provided by 28 NGPAP accredited retailers nationally. In addition, there are other unaccredited green electricity products offered in the market. For instance, Synergy which is the electric utility company that serves the metropolitan Perth area offers residential customers two NGPAP accredited "GreenPower" products – "EasyGreen" (EG) and "NaturalPower" (NP), and one unaccredited product – "EarthFriendly" (EF). Consumers can make a choice between conventional electricity product and these accredited and unaccredited green electricity products. In addition, they can also choose the level of commitment through different payment schemes. For "EasyGreen", consumers can commit a fixed amount (ranging from \$10 - \$80 in \$10 steps) on top of their regular bill. For "NaturalPower" and "Earth Friendly", customers can choose a fixed proportion of their electricity to be generated from renewable sources (25% - 100%) or choose to offset the carbon emission of a fixed proportion of their conventional electricity consumption (25% - 100%). This green electricity market thus provides an excellent real market setting to study consumers' commitment levels as well as product choices.

3. Choice Experiment Design

The majority of the WA households are served by Western Power's South West Interconnected Systems (SWIS). Synergy is responsible for the retail delivery of electricity in this area. The SWIS covers the entire metropolitan Perth area where we recruit all our respondents. There are currently four electricity products offered by Synergy – the conventional fossil fuel generated electricity, two NGPAP accredited

"GreenPower" products – "EasyGreen" and "NaturalPower", and one unaccredited product – "EarthFriendly". Synergy provides an online interface for consumers to compare and make a choice among electricity products and commitment levels[1]. Information on the cost of selecting different products and commitment levels and associated environmental impacts is also provided through the interactive interface. This online interface thus represents the real market environment that households face in metropolitan Perth area. In the hypothetical experimental setting we slightly modify this interface to include extra information regarding the attributes of the electricity products, while trying to closely mimic the real market environment. Figure 1 and Figure 2 present images of Synergy's actual interface and our modified version where we embed our choice experiments[2].

Consumers (respondents in our case) can navigate across products (tabs) to see attribute differences. They can also change commitment levels by moving the slider bar to see the extra cost to their electricity bill and the impact on the level of carbon emissions (shown in panel 2). Once a consumer (respondent) is satisfied with a specific combination of a product and a commitment level, they can make an order (choice in our case). It is reasonable to think that consumers in the real market would need time to get familiar with the structure of the interface before they can make an order. To facilitate this process in our choice experiment, we provide a 5-minute video demonstration to explain how to compare alternative products, adjust commitment levels and make a choice. This video is placed before respondents start with the formal choice questions. Each respondent answers six choice sets. When making the commitment level respondents were restricted to the discrete levels available: $10-$80 for EasyGreen (in steps of $10), or 25, 50, 75, 100% for NaturalPower and EarthFriendly[3]. Thus respondents can be considered to have selected 1 out of 4 products, if the analysis is considered at the product level, or 1 of 17 product/commitment levels, if one considers the full choice process.

[1] http://www.synergy.net.au/at_home/gogreen.xhtml

[2] Although Synergy approved the use of a simile of their web site, they are not responsible for any of the implementation and conclusions drawn from this study.

[3] These are also the actual discrete commitment levels marketed by Synergy.

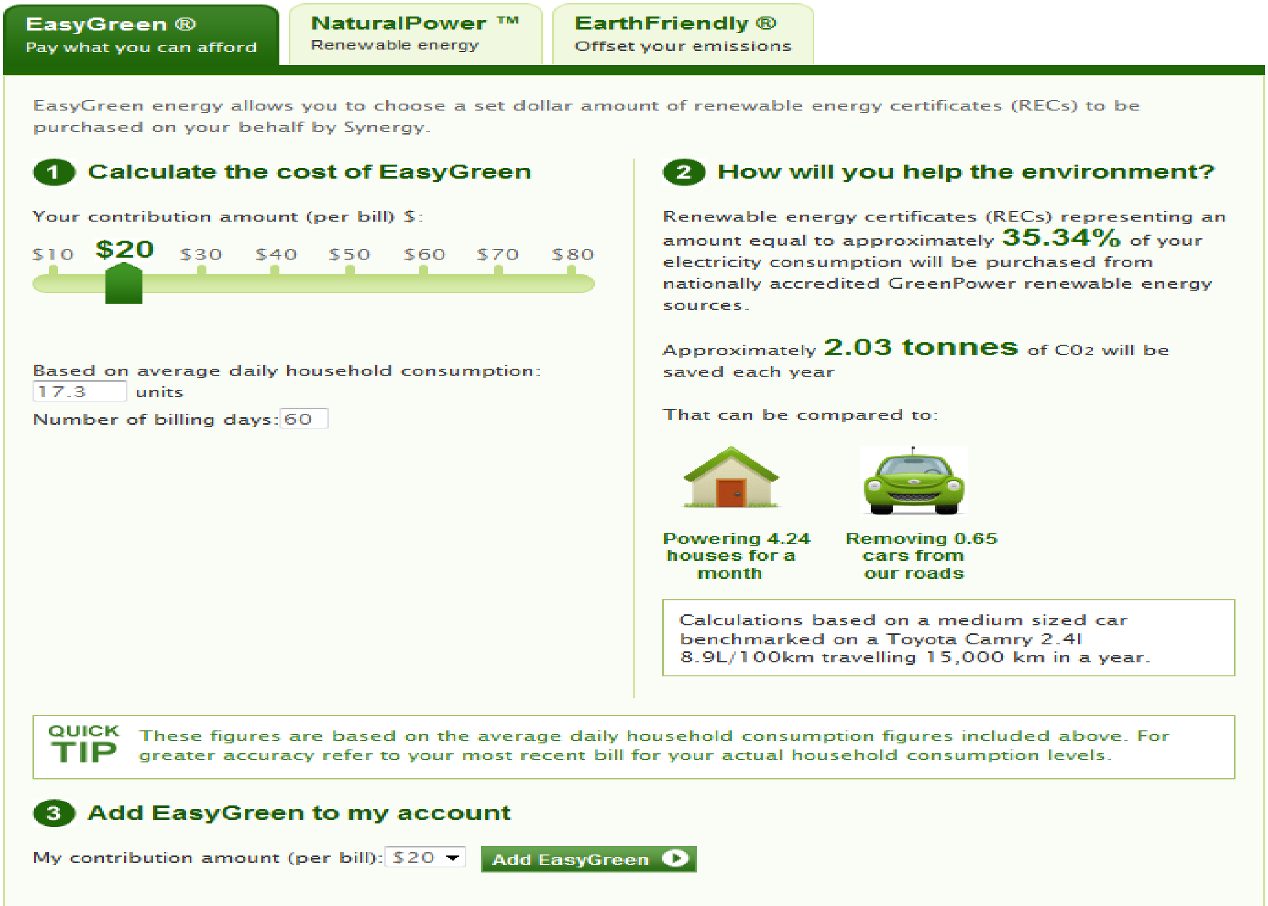


Figure 1: Synergy's Green Power Web Interface

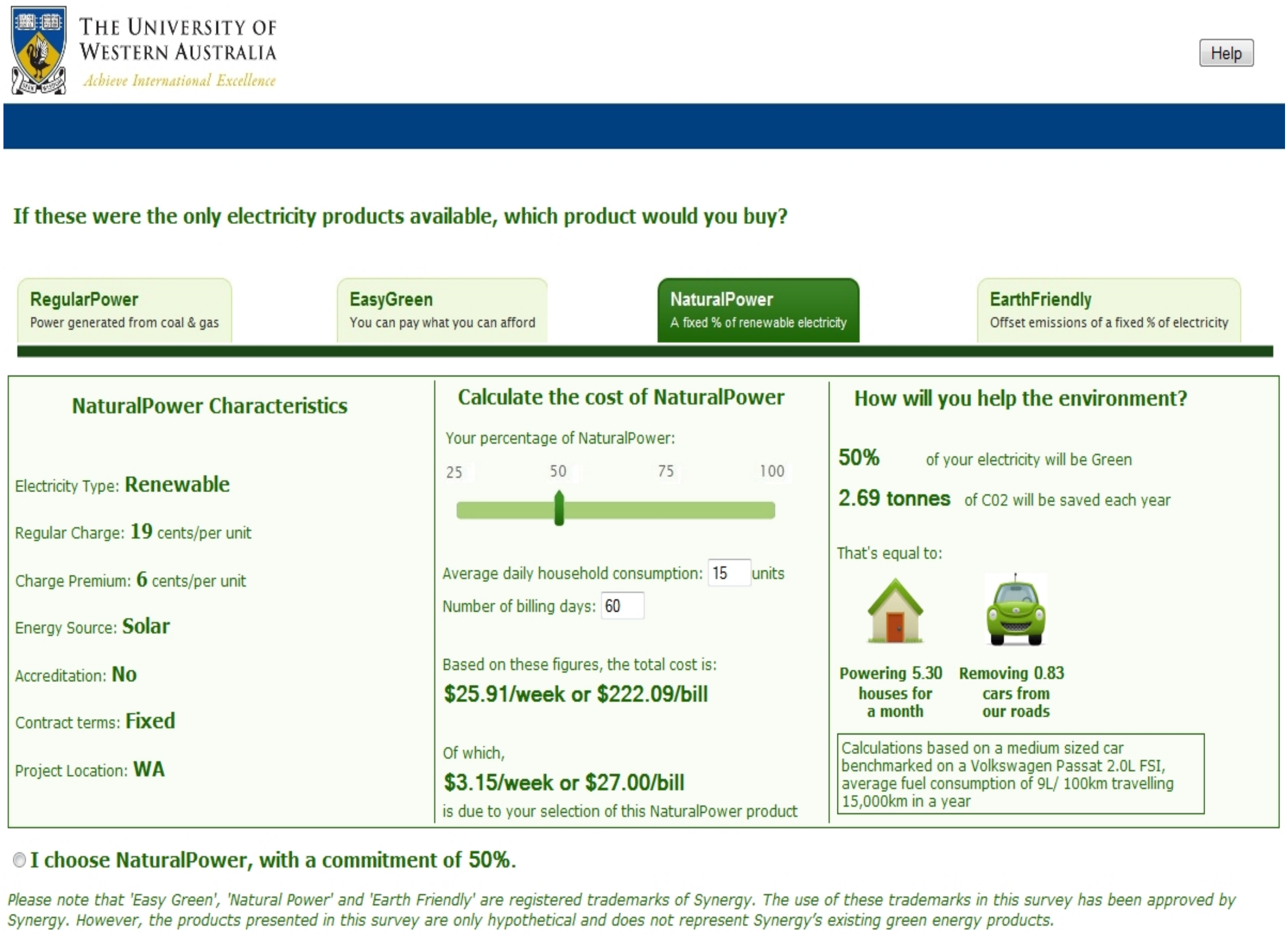


Figure 2: An Example of a Choice Set within the Modified Interface

Table 1 summarizes the attributes and associated values that are used to describe the products. These attributes and values are carefully chosen to capture the differences in existing green electricity products in the Australian market, but it should be noted that the type of source, accreditation, contract terms and location of renewable energy source are not attributes that are described as part of the actual Synergy products. The regular charge (which defines the cost of the conventional electricity, and provides the baseline costs for the green products, to which the elected contribution is added) is fixed within any choice set, but varies across choice sets. The implication is that this cannot be considered as a direct attribute to explain choices across products. However, we anticipate that the level of the regular charge (or more specifically, the expected total utility bill, which will also be influenced by average daily use) may influence the choice between conventional and green products. Thus, if regular charge is high, leading to a high baseline bill, respondents may be less willing to commit to further expenditure. The appropriateness of the attributes and associated value ranges were verified in a pilot study.

The design of the survey used an s-efficiency criteria (using Ngene), with 12 choice sets, blocked into 2 groups of 6. For the 6 choice sets each respondent saw, there was a different regular charge (which was common to all alternatives within the choice set, and hence not used in the design itself). These progressively increased in value (from 19 to 29) through the design for half of the sample, while they declined for the other half (29 through 19). The online survey was conducted in the June of 2012, with 831 completed responses.

Table 1: Product Attributes and Attribute Values

Attributes	Attribute Values
Regular Charge	19,21,23,25,27,29
Charge Premium	0,1,2,4,6
Energy Source	Coal & Gas, Hydro, Bio, Wind, Solar
Accreditation	Yes, No
Contract Terms	Fixed (2-Year), Flexible
Location	WA, Non-WA

4. Modeling Approach

Consumer choice analysis has made extensive use of random utility models where the utility from option j for respondent i is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

The utility U_{ij} consists of a systematic component V_{ij} and a random disturbance ε_{ji}. Utility maximization implies that the probability that consumer i will choose alternative j, P_{ij}, is determined by

$$Prob_{ij} = Prob\ (U_{ij} > U_{ik}) \qquad \forall\ k \neq j$$

The probability can be empirically estimated once the specification of the deterministic component V_{ij} and the characteristics of the stochastic component ε_{ji} are known. A large number of choice analyses have focused on multinomial or conditional logit models where the stochastic disturbance is assumed to be independently and identically distributed (IID) with a Gumbel distribution. The IID assumption has an important behavioral association with a property known as the Independence of Irrelevant Alternatives (IIA) which states that the ratio of the choice probabilities of any pair of alternatives is independent of the presence or absence of any other alternative in a choice set. An important behavioral implication of IIA is that any pair of alternatives (choices) are equally similar or dissimilar (Hensher et al., 2005). In our choice setting where households need to choose among different electricity products as well as different commitment levels, it is very likely that the IIA/IID assumption is violated if some commitment levels are perceived as closer substitutes. For instance, entry-level commitments (or top-level commitments) may be viewed as closer substitutes than intermediate commitment levels. The assumption is also violated if households perceive commitment levels for the same product are closer substitutes as compared to those for a different product. If there is unobserved correlation among alternatives, multinomial or conditional logit models will generate inconsistent parameter estimates. We relax the IIA assumption and estimate an error component multinomial (ECM) logit model. The random utility specification is accordingly modified as follows:

$$U_{ij} = \boldsymbol{\beta}'\boldsymbol{x}_{ij} + \theta_j E_{ij} + \varepsilon_{ij}, j = 1, \dots, 17$$

$\boldsymbol{x}$ refers to the vector of variables that enter into utility functions. The 17 alternatives correspond to conventional power ($j = 1$), 8 commitment levels for EasyGreen ($j = 2, \dots, 9$), 4 commitment levels for NaturalPower ($j = 10, \dots, 13$) and EarthFriendly ($j = 14, \dots, 17$). The random disturbances ε_{ij} are IID with the same Gumbel distribution. The error components E_{ij} are alternative specific random individual effects that account for choice situation invariant variation that is unobserved and not accounted for by the other model components. It is made explicit that the error component has a zero mean and a unit variance such that the parameter θ_j is the standard deviation. The ECM specification resembles a random effects model for panel data. The conditional probability for the choice of commitment level *j* under the IID assumption on ε_{ij} is:

$$Prob(y_i = j | E_{i1}, E_{i2}, \dots) = \exp(\boldsymbol{\beta}'\boldsymbol{x}_{ij} + \theta_j E_{ij}) \Big/ \sum_{q=1}^{17} \exp(\boldsymbol{\beta}'\boldsymbol{x}_{iq} + \theta_q E_{iq})$$

where y_i is the index of the choice made. Parameters can then be estimated using the method of maximum simulated likelihood. The individual random "error components" do not need to be alternative specific. These error components can be rearranged to capture correlation across alternatives such that utility functions of correlated alternatives may share a common error component. We have assumed that the model includes the following six error components:

1) E_{i1} for conventional electricity ($j = 1$);
2) E_{i2} for all commitment levels of EasyGreen ($j = 2, \dots, 9$);

3) E_{i3} for all commitment levels of NaturalPower ($j = 10, \ldots, 13$);

4) E_{i4} for all commitment levels of EarthFriendly ($j = 14, \ldots, 17$);

5) E_{i5} for all entry commitment levels ($j = 2, 10, 14$);

6) E_{i6} for all top commitment levels ($j = 9, 13, 17$).

We define utility at the lowest level, i.e. at the commitment level, but assume that there are some cross utility function parameter restrictions e.g. that the effect of a green product characteristic has the same effect on utility derived from all commitment levels of that product. We assume that utility of conventional depends on the total cost, and individual attributes. The utilities for the commitment levels of each of the green products depends on the attributes of the product, and the total cost and carbon emission savings at each of the commitment levels. As the premium level differs across products, there is not a collinear relationship between costs and emissions within the alternatives of a choice set (the lower the premium, the higher the emissions savings for any particular level of total cost). An alternative specific constant is introduced for each of the commitment levels of all three green products Green product attributes are effects coded and other variables are described in Table 2. An explicit statement of the utility equations is given in the Appendix.

Table 2 – Variables Definition

Variables	Definition
TotalCost	Total cost of an average bill on a 60-day billing cycle ($)
Female	1 for female head of household
HighSchool	1 if the respondent's highest education level attained is high school; the default is primary school
TertiaryUndergraduate	1 if the respondent's highest education level attained is tertiary undergraduate; the default is primary school
TertiaryPostgraduate	1 if the respondent's highest education level attained is tertiary postgraduate; the default is primary school
TradeTAFE	1 if the respondent's highest education level attained is Trade or TAFE; the default is primary school
ClimateBelief2	1 if the respondent answers - "No" - to the question "Do you believe that climate change is occurring"; the default is "Yes"
ClimateBelife3	1 if the respondent answers - "I'm not sure" - to the question "Do you believe that climate change is occurring"; the default is "Yes"
GreenParty	1 if the respondent chooses to vote for the Green Party in the next federal election
Trust1	Likert scale (1-5): "How trustworthy do you think utility companies are?",

	with 5 associated with the highest level of trust
Trust2	Likert scale (1-5): "How trustworthy do you think the government's accreditation and annual auditing of green electricity products is?", with 5 associated with the highest level of trust
Carbon	Tonnes of carbon saved each year
Accreditation*	1 for products accredited by the National GreenPower Accreditation Program
Contract*	1 if the electricity contract is fixed (2 years)
Location*	1 if renewable or offset projects are located in Western Australia
Hydro*	1 if energy source is hydro; the default is bio-energy
Solar*	1 if energy source is solar; the default is bio-energy
Wind*	1 if energy source is wind; the default is bio-energy

* Green products attributes are effects coded.

Although not reported below, we have also investigated whether there are any effects of the level of the regular charge (beyond the implications for total cost) on choices. Because the regular charge is constant across all alternatives we do this by introducing it as a factor that may affect only the utility of the conventional electricity choice. Our prior hypothesis was that a higher regular charge may crowd out the green products (even if, relatively, costs of all products will be increased). We did not find any evidence of this effect.

5. Results

Table 2 presents our results from an Error Components Multinomial Logit model. Most variables are significant with expected signs. Female customers with higher education levels are more likely to choose green electricity products. Customers who believe that climate change is occurring, those who would like to vote for the Green Party, and those who have higher level of trust in utility companies are all also more likely to buy green electricity products. Among different green electricity products, people favor products that have been accredited by the NGPAP. Flexible contract terms are preferred. People would like renewable energy projects or carbon offset projects to be located locally in WA. Among all renewable energy sources, only solar is significantly favored, which is possibly a reflection of the high penetration of solar panels in the Australian residential sector as well as high solar awareness due to frequent media exposure and public and private campaigns. The absolute values of the entry-level ASCs

(ASC_2, $ASC_{10,}$ ASC_{14}) are substantially less than those of intermediate ASCs, implying that consumers strongly favor the entry level even after controlling for cost and carbon saved. That is – consumers have chosen the minimum commitment levels not simply because they cost less. In fact, for all cases where a green electricity product is chosen, over 60 percent have selected the minimum commitment levels – that is, $10 for EasyGreen, 25% for Natural Power and 25% for EarthFriendly. The utility associated with carbon contribution is out of pure altruism while the utility associated with entry level ASCs can be interpreted as impure altruism or warm glow effect.

Table 3 – Results from Error Component Model (ECM)

Attributes	Coefficient	Std. Error	Lower 95%	Upper 95%
Common to all alternatives				
TotalCost	-.08160**	-21.06	-0.08919	-0.07401
Specific to conventional				
Female	-1.01398**	-5.03	-1.40937	-0.61858
HighSchool	-4.19068*	-2.17	-7.96876	-0.4126
TertiaryUndergraduate	-5.80375**	-2.99	-9.61108	-1.99642
TertiaryPostgraduate	-4.87351*	-2.52	-8.66929	-1.07773
TradeTAFE	-5.11783**	-2.65	-8.90436	-1.3313
ClimateBelief2	2.51672**	5.39	1.60124	3.4322
ClimateBelife3	2.06446**	7.98	1.55722	2.5717
GreenParty	-2.82638**	-7.12	-3.6046	-2.04816
Trust1	-.53156**	-4.14	-0.78292	-0.2802
Trust2	0.00124	0.01	-0.23193	0.2344
Specific to green products				
Carbon	.02458*	2.04	0.00102	0.04815
Accreditation	.21035**	8.48	0.16174	0.25897
Contract	-.17020**	-6.01	-0.22572	-0.11468
Location	.24726**	9.42	0.19582	0.2987
Hydro	0.01441	0.32	-0.07427	0.10308
Solar	.11264**	2.66	0.02978	0.19549
Wind	0.01947	0.45	-0.06614	0.10507
ASC's for EasyGreen				
ASC_2 ($10)	-7.43582**	-3.85	-11.2224	-3.64923
ASC_3 ($20)	-8.37479**	-4.31	-12.185	-4.56462
ASC_4 ($30)	-8.61598**	-4.43	-12.4316	-4.80037
ASC_5 ($40)	-8.32665**	-4.27	-12.1531	-4.50021
ASC_6 ($50)	-7.18364**	-3.67	-11.0183	-3.349
ASC_7 ($60)	-8.45255**	-4.21	-12.386	-4.51913
ASC_8 ($70)	-8.42474**	-4.07	-12.477	-4.37247
ASC_9 ($80)	-8.75859**	-4.31	-12.7407	-4.77649
ASC's NaturalPower				
ASC_{10} (%25)	-7.14055**	-3.69	-10.9379	-3.3432
ASC_{11} (%50)	-8.06658**	-4.15	-11.8779	-4.25531
ASC_{12} (%75)	-9.05339**	-4.65	-12.8676	-5.2392
ASC_{13} (%100)	-9.28424**	-4.75	-13.114	-5.45444
ASC's EarthFriendly				
ASC_{14} (%25)	-7.45116**	-3.86	-11.2361	-3.66623
ASC_{15} (%50)	-8.66594**	-4.46	-12.4716	-4.86026
ASC_{16} (%75)	-9.19173**	-4.73	-12.9981	-5.38539
ASC_{17} (%100)	-10.0030**	-5.12	-13.8294	-6.1766
Error Components				
Sigma1	3.98053**	22.09	3.6274	4.33365

Sigma2	1.42842**	17.09	1.2646	1.59225
Sigma3	.22847**	2.96	0.07734	0.3796
Sigma4	.85283**	12.12	0.71491	0.99075
Sigma5	2.45561**	22.91	2.24553	2.6657
Sigma6	2.92429**	15.86	2.56288	3.2857
Maximized log likelihood		-7038.32387		
AIC/N		2.839		
BIC/N		2.892		
Number of obs.		4986		

Note: **, * ==> Significance at 1%, 5% level.

Table 4 – Direct and Cross Marginal Effects of a Change in a Product Attribute and Individual Characteristics on the Probability of Choice at Product[$] Level

Attributes	**Unconditional Marginal Effects of Attributes of Green Electricity**[†]		
	Change in* EasyGreen** ***on **C EG NP EF**	***Change in* Natural Power** ***on*** **C EG NP EF**	***Change in* Earth Friendly** ***on*** **C EG NP EF**
Accreditation	-0.0093, **0.0382**, -0.0168, -0.0121	-0.0133, -0.0169, **0.0504**, -0.0202	-0.0101, -0.0119, -0.0203, **0.0422**
Contract	0.0076, **-0.0308**, 0.0134, 0.0098	0.0108, 0.0136, **-0.0412**, 0.0168	0.0081, 0.0097, 0.0166, **-0.0344**
Location	-0.0110, **0.0449**, -0.0199, -0.0140	-0.0131, -0.0171, **0.0506**, -0.0205	-0.0118, -0.0142, -0.0240, **0.0500**
Solar	-0.0052, **0.0208**, -0.009, -0.0065	-0.0073, -0.0091, **0.0274**, -0.0110	-0.0057, -0.0066, -0.0112, **0.0236**
Premium	0.0031, **-0.0073**, 0.0030, 0.0012	0.0048, 0.0084, **-0.0200**, 0.0069	0.0071, 0.0065, 0.0063, **-0.0199**
Unconditional Marginal Effects of Personal Characteristics [†]			
Variable	***on*** **C EG NP EF**	**Variable**	***on*** **C EG NP EF**
Female	**-0.0798**, 0.0228, 0.0323, 0.0247	ClimateBelief2	**0.2028**, -0.0580, -0.0821, -0.0627
HighSchool	**-0.3035**, 0.0872, 0.1222, 0.0940	ClimateBelief3	**0.1665**, -0.0476, -0.0674, -0.0515
TertiaryUndergraduate	**-0.4304**, 0.1235, 0.1737, 0.1333	GreenParty	**-0.2057**, 0.0586, 0.0835, 0.0637
TertiaryPostgraduate	**-0.3581**, 0.1028, 0.1443, 0.1109	Trust1 (1-3) [††]	**-0.0841**, 0.0240, 0.0341, 0.0260
TradeTAFE	**-0.3774**, 0.1084, 0.1522, 0.1169	Trust1 (1-5) [†††]	**-0.1641**, 0.0469, 0.0665, 0.0507

[$] C, EG, NP, EF indicate Conventional, Easy Green, Natural Power and Earth Friendly respectively

[†] Unconditional direct marginal effects at the product level are marked in bold and unbolded numbers are cross marginal effects

[††] Marginal effects for a change from the lowest level of trust to the medium level of trust

[†††] Marginal effects for a change from the lowest level of trust to the highest level of trust

Table 5 – Unconditional Marginal Effects of a Simultaneous Change in Green Product Attribute Values across all Products on Probability of Selecting Green Products

Attribute Values	**Unconditional Marginal Effects**			
	Green Total†	**EasyGreen**	**NaturalPower**	**EarthFriendly**
Accredited	0.0328	0.0093	0.0135	0.0101
Flexible Contract	0.0266	0.0077	0.0109	0.0080
Local Projects	0.0395	0.0113	0.0162	0.0120
Solar (vs. Bio)	0.0180	0.0051	0.0072	0.0057
††Total	0.1169	0.0334	0.0478	0.0358

† "Green Total" provides marginal effects on the Green nest of a generic value change

†† "Total" gives marginal effects of simultaneous changes for all four green attributes from the baseline value i.e. of shifting from least preferred to most preferred level

Table 6 – Conditional Marginal Effects of Premium on Commitment Levels

EasyGreen		**NaturalPower**	
Commitment Levels	**Marginal Effects**	**Commitment Levels**	**Marginal Effects**
		25%	0.0290
$10	0.0139	50%	-0.0141
$20	-0.0012	75%	-0.0079
$30	-0.0021	100%	-0.0070
$40	-0.0026	**EarthFriendly**	
$50	-0.0059	**Commitment Levels**	**Marginal Effects**
$60	-0.0011	25%	0.0268
$70	-0.0007	50%	-0.0117
$80	-0.0003	75%	-0.0101
		100%	-0.0050

Using this fitted ECM, we have simulated unconditional and conditional direct and cross marginal effects of changing attributes' values. Table 4 provides unconditional direct and cross marginal effects of attributes of interest. Unconditional direct marginal effects represent the change in the unconditional choice probability for an alternative given a 1-unit change in an attribute of interest for the same alternative, *ceteris paribus*, while for effects coded bivariate attributes, this means a change of value from negative one to positive one. Unconditional cross marginal effects represent the impact that a 1-unit change in an attribute of interest to one alternative has upon the unconditional choice probabilities of competing alternatives, *ceteris paribus*. Direct and cross marginal effects for the each product and each attribute should sum to unity with possible rounding errors. As suggested by Louviere et al. (2000) we use the probability weighted sample enumeration (PWSE) rather than sample average or "naïve pooling" to simulate these marginal effects. As shown in the table, individual characteristics have large impacts on unconditional probabilities of product choice. The impacts of product attributes on choice probabilities are relatively smaller. This is also confirmed in Table 5 where we provide marginal effects for generic changes to all three green products in the value of a single green attribute as well as changes to all green attributes. This is to simulate the situation where a supplier changes the attributes of all the green products in their portfolio simultaneously. Even with all green attributes changing from the most unfavorable values to the most favorable values generically, the probability of selecting one of the three green products as compared to the conventional production increases by only 11.69%. The decomposition of this change across the three green products is 3.34%, 4.78% and 3.58% for EasyGreen, NaturalPower and EarthFriendly respectively. On the other hand, individual characteristics such as gender, education, climate beliefs, environmental ideology and trust in utility companies have much larger marginal effects ranging from 7.98% to 43.04%.

Table 6 reports the conditional (on the product being selected) marginal effect of a change in the premium on the level of commitment selected. Similarly, conditional marginal effects for each product should also sum to unity with only rounding errors. Increasing the premium makes the minimum commitment level more attractive (positive conditional marginal effect) compared to higher commitment levels (negative conditional marginal effect). However, this effect is very small if one considers that the maximum difference in premium in our experimental design is 6 cents: the probability of selecting the minimum commitment increases by only 1.39%, 2.90% and 2.68% for the green products for this change in premium, reflecting the lack of price sensitivity of commitment. This suggests that the (conditional) price elasticity of demand for green electricity within each product category is very low.

It is of interest to compare our results with the market data for green electricity penetration. The NGPAP releases quarterly report on each utility company's aggregated customer numbers and sales for accredited GreenPower products. As Synergy only has two accredited products – EasyGreen and NaturalPower, the reported statistics covers these two products only. We have discussed the low commitment level in Western Australia. However, compared with other states, green power penetration at the commitment level in Western Australia is relatively high. Figure 3 shows the total number of green electricity customers and total green electricity sales in each state by quarter from 2004 to 2013. If we assume consumption for a representative household is 18-units per day, we can infer the average commitment level in each state, which is shown in Figure 4. Over time, commitment for subscribed green power customers in all states have converged to a low level ranging from 10% to 30% of total consumption. Considering that NGPAP has a compulsory requirement for a minimum 10% commitment for all accredited GP products and some GP products may have a higher entry commitment level (e.g. 25% for NaturalPower), the observed market commitment levels (Figure 4) represent a strong preference for minimum levels of commitment. Our research shows that this preference is insensitive to premium changes.

Figure 2: Residential Green Power Sales (GWHs) and Customer Numbers ('000)

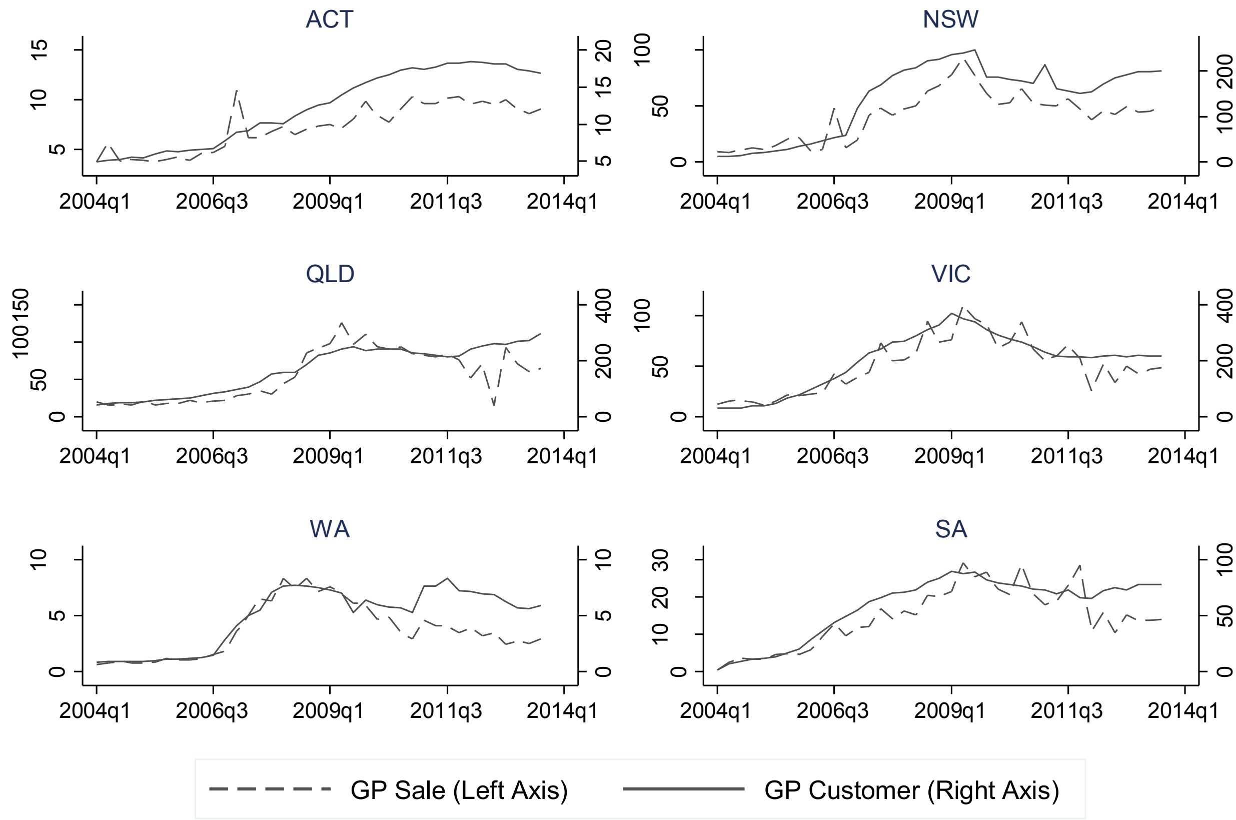
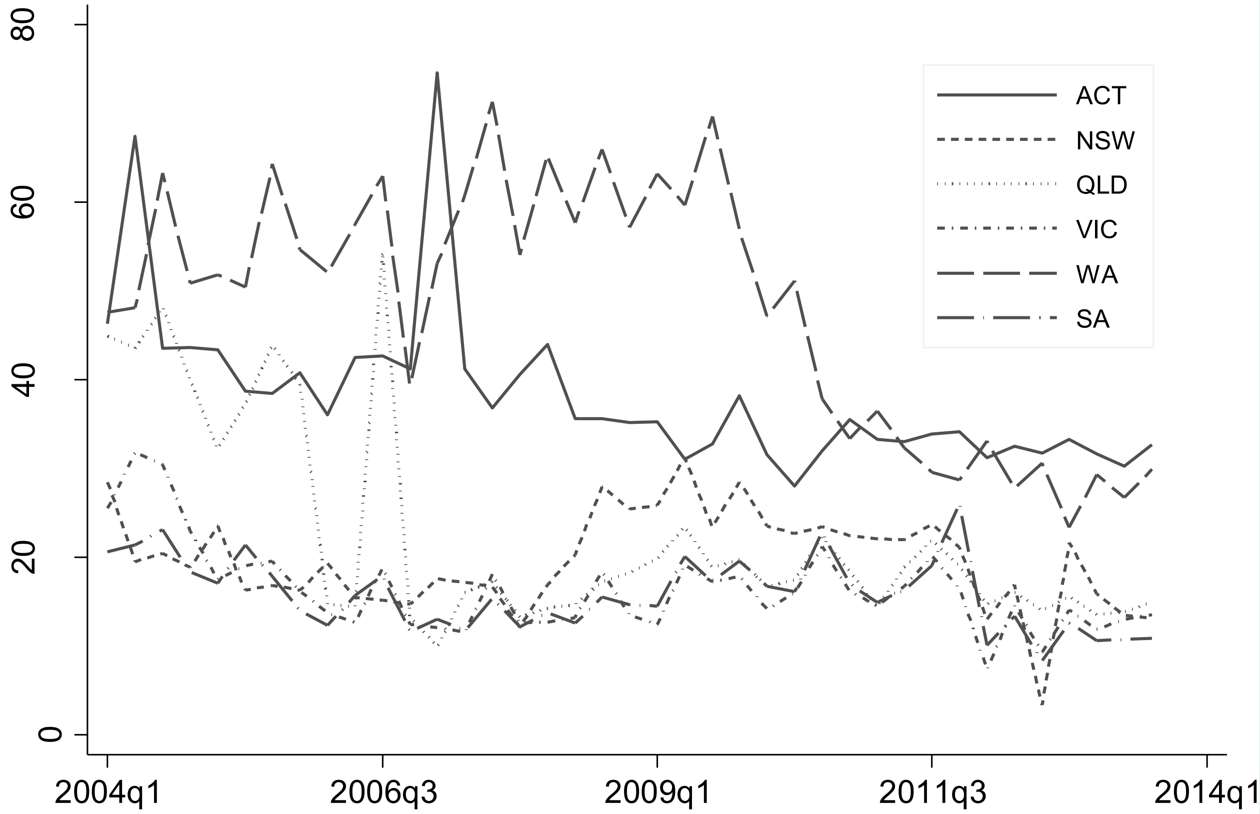


Figure 4: Inferred Average Residential Green Power Commitment Levels (%)



6. Conclusion

This paper has made a number of contributions to understanding consumer preferences for green electricity products. The design has allowed us to evaluate not just the choice of product, but also the level of commitment (i.e. the quantity of green power) that consumers purchase. We do that within an Error Components Model that exploits the fact that commitment level in the real market is discrete, and hence there are limited numbers of levels that are open to consumers.

We find that the decision to opt into the green market is strongly influenced by characteristics of the individual, with greater participation driven by higher education, and being female. One's belief in whether climate change is occurring is also important, which is consistent with a prior expectations: those who do not see carbon emissions as an issue are not willing to mitigate them. In addition, voting for the Greens party (which may indicate an additional level of environmental commitment, and belief in the need for change), increases choice of green power. Increased trust in the utility companies also increases uptake. This is potentially an area where more progress can be made, as, on a 5 point 'trust' scale, over 85% of respondents rate both utility companies and government at 3 or below. The nature of the green products themselves seems to have relatively little impact on demand, although there are preferences for 'local' generation and solar power as the source of the renewable. Comparing Easy Green and Natural Power (where the only substantive difference in the products offered by Synergy is in the method of making the commitment: fixed contribution or % of bill), then Natural Power is the preferred product. At the level of commitment, respondents had a strong preference for the minimum commitment level available, and this is insensitive to the level of premium and associated cost. Respondents appear to be willing to pay $2.50 per tonne of carbon emissions reduced. This is relatively low, and much lower than the current price ($23/t) operating at the national level. This is also consistent with our interpretation of the commitment being made as largely 'warm glow', given the high proportion who are selecting the minimum contribution.

This raises an interesting issue which we can not address here: what would the consequences for choices be if the minimum levels were increased (e.g. from $10 to $40, or from 25% to 50%)? Would adoption of the green products remain at the current levels? If consumers are relatively less sensitive to premium and cost but more likely to choose the default minimum level, then a product design with a higher minimum level would contribute to greater environmental good.

Appendix

$$U_{i,1} = \alpha_1\text{TotalCost} + \varphi_2\text{Female} + \varphi_3\text{HighSchool} + \varphi_4\text{TertiaryUndergraduate}$$
$$+ \varphi_5\text{TertiaryPostgraduate} + \varphi_6\text{TradeTAFE} + \varphi_7\text{ClimateBelief2}$$
$$+ \varphi_8\text{ClimateBelife3} + \varphi_9\text{GreenParty} + \varphi_{10}\text{Trust1} + \varphi_{11}\text{Trust2} + \theta_1\text{E}_{\text{i1}} + \varepsilon_{\text{i,1}}$$

$$U_{i,j=2} = \text{ASC}_\text{j} + \alpha_1\text{TotalCost} + \alpha_2\text{Carbon} + \alpha_3\text{Accreditation} + \alpha_4\text{Contract} + \alpha_5\text{Location}$$
$$+ \alpha_6\text{Hydro} + \alpha_7\text{Solar} + \alpha_8\text{Wind} + \theta_2\text{E}_{\text{i2}} + \theta_5\text{E}_{i5} + \varepsilon_{\text{i,2}}$$

$$U_{i,j=3,\ldots,8} = \text{ASC}_\text{j} + \alpha_1\text{TotalCost} + \alpha_2\text{Carbon} + \alpha_3\text{Accreditation} + \alpha_4\text{Contract} + \alpha_5\text{Location}$$
$$+ \alpha_6\text{Hydro} + \alpha_7\text{Solar} + \alpha_8\text{Wind} + \theta_2\text{E}_{\text{i2}} + \varepsilon_{\text{i,j}}$$

$$U_{i,j=9} = \text{ASC}_\text{j} + \alpha_1\text{TotalCost} + \alpha_2\text{Carbon} + \alpha_3\text{Accreditation} + \alpha_4\text{Contract} + \alpha_5\text{Location}$$
$$+ \alpha_6\text{Hydro} + \alpha_7\text{Solar} + \alpha_8\text{Wind} + \theta_2\text{E}_{\text{i2}} + \theta_6\text{E}_{i6} + \varepsilon_{\text{i,9}}$$

$$U_{i,j=10} = \text{ASC}_\text{j} + \alpha_1\text{TotalCost} + \alpha_2\text{Carbon} + \alpha_3\text{Accreditation} + \alpha_4\text{Contract} + \alpha_5\text{Location}$$
$$+ \alpha_6\text{Hydro} + \alpha_7\text{Solar} + \alpha_8\text{Wind} + \theta_3\text{E}_{\text{i3}} + \theta_5\text{E}_{i5} + \varepsilon_{\text{i,10}}$$

$$U_{i,j=11,12} = \text{ASC}_\text{j} + \alpha_1\text{TotalCost} + \alpha_2\text{Carbon} + \alpha_3\text{Accreditation} + \alpha_4\text{Contract} + \alpha_5\text{Location}$$
$$+ \alpha_6\text{Hydro} + \alpha_7\text{Solar} + \alpha_8\text{Wind} + \theta_3\text{E}_{\text{i3}} + \varepsilon_{\text{i,j}}$$

$$\boldsymbol{U_{i,j=13}} = \mathrm{ASC_j} + \alpha_1\mathrm{TotalCost} + \alpha_2\mathrm{Carbon} + \alpha_3\mathrm{Accreditation} + \alpha_4\mathrm{Contract} + \alpha_5\mathrm{Location} + \alpha_6\mathrm{Hydro} + \alpha_7\mathrm{Solar} + \alpha_8\mathrm{Wind} + \theta_3\mathrm{E_{i3}} + \theta_6\mathrm{E}_{i6} + \varepsilon_{\mathrm{i,13}}$$

$$\boldsymbol{U_{i,j=14}} = \mathrm{ASC_j} + \alpha_1\mathrm{TotalCost} + \alpha_2\mathrm{Carbon} + \alpha_3\mathrm{Accreditation} + \alpha_4\mathrm{Contract} + \alpha_5\mathrm{Location} + \alpha_6\mathrm{Hydro} + \alpha_7\mathrm{Solar} + \alpha_8\mathrm{Wind} + \theta_4\mathrm{E_{i4}} + \theta_5\mathrm{E}_{i5} + \varepsilon_{\mathrm{i,14}}$$

$$\boldsymbol{U_{i,j=15,16}} = \mathrm{ASC_j} + \alpha_1\mathrm{TotalCost} + \alpha_2\mathrm{Carbon} + \alpha_3\mathrm{Accreditation} + \alpha_4\mathrm{Contract} + \alpha_5\mathrm{Location} + \alpha_6\mathrm{Hydro} + \alpha_7\mathrm{Solar} + \alpha_8\mathrm{Wind} + \theta_4\mathrm{E_{i4}} + \varepsilon_{\mathrm{i,j}}$$

$$\boldsymbol{U_{i,j=17}} = \mathrm{ASC_j} + \alpha_1\mathrm{TotalCost} + \alpha_2\mathrm{Carbon} + \alpha_3\mathrm{Accreditation} + \alpha_4\mathrm{Contract} + \alpha_5\mathrm{Location} + \alpha_6\mathrm{Hydro} + \alpha_7\mathrm{Solar} + \alpha_8\mathrm{Wind} + \theta_4\mathrm{E_{i4}} + \theta_6\mathrm{E}_{i6} + \varepsilon_{\mathrm{i,17}}$$

Reference

Andreoni, J. (1989), Giving with Impure Altruism: Applications to Charity and Ricardian Equivalence, Journal of Political Economy 97: 1447-1458.

Andreoni, J. (1990), Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving, Economic Journal 100: 464-477.

Blamey, R., J. Bennett, J.J. Louviere and M. Morrison (2001), Green Product Choice, in: J. Bennett and R. Blamey, eds., The Choice Modelling Approach to Environmental Valuation, Edward Elgar, Cheltenham, UK.

Börsch-Supan, A. (1990), On the compatibility of nested logit models with utility maximization, Journal of Econometrics 43: 373:388.

Diaz-Rainey, I. and Tzavara, D (2012), Financing the Decarbonized Energy System Through Green Electricity Tariffs: A Diffusion Model of an Induced Consumer Environmental Market, Technological Forecasting and Social Change 79(9): 1693-1704.

Ek, K., P. Söderholm (2008), Norms and economic motivation in the Swedish green electricity market, Ecological Economics 68: 169-182.

Farhar, B. (1999), Willingness to Pay for Electricity from Renewable Resources: A Review of Utility Market Research, NREL/TP.550.26148. Golden, CO: National Renewable Energy Laboratory.

Farhar, B.C. and A. H. Houston (1996), Willingness to Pay for Electricity from Renewable Energy, NERL Report No. TP-460-21216, National Renewable Energy Laboratory, Golden, Colorado, USA.

Goett, A.A., K. Hudson and K.E. Train (2000), Customers Choice among Retail Energy Suppliers: The Green Power (2013), National GreenPower Accreditation Program Status Report Quarter 2. http://www.greenpower.gov.au/~/media/Business%20Centre/Quarterly%20Reports/2013Q2Report.pdf.

Hensher, D.A, J.M Rose and W.H. Greene (2005), Applied Choice Analysis A Primer, Cambridge University Press.

Ivanova, G. (2012), Are Consumers Willing to Pay Extra for the Electricity from Renewable Energy Sources? An example of Queensland, Australia, International Journal of Renewable Energy Research 2 (4): 758-766.

Kotchen, M.J. and M.R. Moore (2007), Private provision of environmental public goods: Household participation in green-electricity programs, Journal of Environmental and Economics and Management

53: 1-16.

Louviere, J.J., D.A. Hensher and J. Swait (2000), Stated Choice Methods: Analysis and Applications in Marketing, Transportation and Environmental Evaluation, Cambridge: Cambridge University Press.

Menges, R., C. Schroeder and S. Traub (2005), Altruism, Warm Glow and the Williness-to-Donate for Green Electricity: An Artefactual Field Experiment, Environmental and Resource Economics 31: 431-458.

Mewton, R.T and O.J. Cacho (2011), Green Power voluntary purchases: Price elasticity and policy analysis, Energy Policy 39: 377-385.

Navrud, S. and K.G. Bråten (2007), Consumers' Preferences for Green and Brown Electricity: a Choice Modelling Approach, Revue d'économie politique 5 (117): 795-811.

Nomura, N. and M. Akai (2004), Willingness to pay for green electricity in Japan as estimated through contingent valuation method, Applied Energy 78: 453-463.

Rowlands, I., D. Scott and P. Parker (2003), Consumers and green electricity: Profiling potential purchasers, Business and Strategy and the Environment 12: 36-48.

Salmela, S. and V. Varho (2006), Consumers in the green electricity market in Finland, Energy Policy 34: 3669-3683.

Scarpa, R. and K. Willis (2010), Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies, Energy Economics 32: 129-136.

Synergy (2013), Electricity Retail Indicators 2012-2013 Year in Review, http://www.synergy.net.au/docs/Electricity_Retail_Indicators_2012_13_Year_in_review.pdf.

Wiser, R.H. (2007), Using contingent valuation to explore willingness to pay for renewable energy: A comparison of collective and voluntary payment vehicles, Ecological Economics 62: 419-432.