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Information effects on consumer willingness to pay for electricity and water service attributes

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Summary
Consumers constantly make decisions about the goods and services they purchase, and in most cases they do this with incomplete information. Many products that are available in stores, in catalogues, or over the internet are not accompanied by a full list of attributes or technical specifications. Such a lack of information is most apparent in non-market goods, such as with regard to utility service attributes. This paper examines information effects on consumers' willingness to pay (WTP) for a number of electricity and water attributes, using two contingent valuation surveys administered in the United Kingdom. The attributes considered include WTP for a carbon cleaner electricity fuel mixture, and increasing security of supply. The results indicate that the quantity and complexity of information can potentially lead to individuals ignoring the information presented. The relevance of the attribute to the respondent is found to be a significant motivator in the processing of the information presented. The survey data also reveal a number of socio-economic, attitudinal and behavioural factors that affect WTP for the attributes considered.

Keywords: Contingent Valuation Method, Blackouts, Information Effect, Willingness to Pay, Zero Inflated Ordered Probit Model.

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1 Introduction

The role of information in consumers' decision-making processes is a rich area of research, especially with regards to market goods. An array of studies has analysed how the quantity and quality of information can affect consumers' purchase decisions (Kivets and Simonson, 2000; Haubl and Trifts, 2000). Less attention has been paid to information effects in consumers' valuation of non-market goods. The limited research in this area has focused on environmental amenities such as the conservation of lakes or endangered species, while exploration of information effects for other types of non-market goods, such as information about utility attributes, has been neglected.

Understanding how information can affect consumers is particularly pertinent to the electricity sector in the United Kingdom, which is undergoing fundamental changes that will have implications for both service levels and prices. Consumers are key stakeholders in the shifts in the electricity generation fuel mixture, as well as to changes in the security of supply. In this context, it is essential to assess consumer support for potential alterations in the electricity generation fuel mixture, as well as for measures to increase security of supply. One aspect that is particularly important to examine is whether providing the public with information can affect the level of support for these policies.

This paper applies the contingent valuation method (CVM) to investigate information effects in consumers' valuations of electricity and water attributes through two household surveys. This research explores two key issues: first, the paper explores whether the relevance of the service attribute can affect respondents' processing of the information presented in the survey. The relevance of the service attribute, and its effect on information processing, is explored with application to electricity and water service disruptions. The respondent's past experience of a service disruption is used as a measure of the relevance of the attribute to the respondent. The hypothesis of the paper is that the personal relevance of the utility service disruption to the respondent affects their motivation to process the information provided in the survey. Water service disruptions are likely to be less relevant to respondents than electricity disruptions, since water service disruptions occur less frequently than blackouts. The expectation is that information provided in the survey will lead to a higher willingness to pay (WTP) for the avoidance of blackouts than for water disruptions.

Second, the paper investigates whether the quantity and complexity of information places a cognitive burden on the respondents, by analysing UK households' willingness to pay a premium to achieve a lower carbon fuel mixture for electricity generation. The socio-economic, behavioural and attitudinal characteristics that affect WTP are also examined.

The paper focuses on security of supply and electricity generation fuel mixture because these two areas will be at the forefront of public policy into the future. In the coming years there are likely to be significant shifts in the electricity generation fuel mixture, as natural gas reserves from the North Sea decline, and a number of existing coal-fired power plants are closed. The issue of energy security will become more central, as dependence on foreign energy sources increases. In addition, the electricity industry will face the challenge of significantly increasing the share of renewable energy in electricity generation in order to meet the EU's and the UK government's, target of generating 15 per cent of energy from renewables by 2020.

One alternative to renewables is to introduce Carbon Capture and Storage (CCS) technology for coal and natural gas power plants.[1] CCS has the potential to reduce CO_2 emissions from coal and gas power stations by up to 90 per cent. At the moment CCS is not used in the United Kingdom, but is seen as an important technology, since it is currently the only option that would allow the use of fossil fuels in electricity generation without increasing emissions. The potential success of the uptake of CCS depends, in part, on consumer support for its development.

Another fuel option that is "carbon-clean" is nuclear energy, which is currently the largest non-fossil energy source in the electricity generation mixture. Although this fuel option is carbon-neutral, and has a number of advantages, including increasing energy security, investment in nuclear energy has declined over the years. Public support for nuclear energy has suffered, following the nuclear accidents at the Three Mile Island Nuclear Plant in 1979, Chernobyl in 1986, and more recently the Fukushima nuclear crisis. There are also concerns about disposing of the spent nuclear fuel. The proportion of nuclear power in the UK fuel mixture is likely to decline in the coming years, as a number of plants are coming to the end of their lifetime, with no replacements planned in the near future. Nuclear energy is still seen by policy-makers as an important fuel option, especially in light of government policy to lower CO_2 emissions and to increase energy security. However, public support for this controversial technology is an important component of any future nuclear policy.

In this context, it is important to analyse whether providing the public with information on the costs and benefits of fuel options for electricity generation and about investments to improve energy security impacts upon their support for these measures. The following section presents a theoretical framework for how information can impact respondent valuations, while Section 3 summarises the findings of previous studies on the factors affecting WTP. Section 4 provides an overview of the surveys used in the analysis, followed by the econometric model presented in Section 5. Section 6 presents the results, while conclusions are drawn in Section 7.

[1] CCS is a process through which emitted CO_2 can be captured and stored in underground sites, including depleted oil and gas fields.

2 Theoretical framework

Survey respondents invariably relied on prior information and beliefs when they were stating their valuation of the service attribute during the survey. However, the respondents' prior information could be incorrect, which could lead to overestimation or underestimation of the service quality. This section presents a general theoretical framework concerning how information included in the survey can affect respondents' WTP valuations. The final part of this section outlines some of the factors that could influence how the information presented in the CVM scenario is processed by the respondents.

2.1 Information effects on willingness to pay

For goods that exist in the market, a person's WTP is directly revealed through their purchase decision. However, several categories of goods and services are not traded in the market, such as public goods and utility service attributes. Stated preference approaches, such as contingent valuation surveys, are the main mechanisms through which valuations for these non-market goods can be revealed. In contrast to observed purchase decisions, stated preference approaches reveal only behavioural intentions rather than actual behaviour.

Stated preference techniques are used extensively in the valuation of utility attributes because there is no market mechanism through which a consumer can reveal their preference for an improvement in utility services. Instead, utility companies, as well as policy-makers, rely on stated preference surveys to elicit a valuation from the respondent for a proposed change in service levels.

Since stated preference methods are hypothetical scenarios, they face a number of issues. One of the main concerns is that the proposed change in service quality, as described in the survey, can be interpreted differently by the respondents. Respondents form their stated WTP valuations based on their perceptions of the change proposed. The respondent's stated WTP may be distorted if their perception of the proposed service quality and the one intended by the survey differ.

Adapting the terminology of Blomquist and Whitehead (1998), a respondent *i*'s willingness to pay can be defined as the difference between their expenditure with an increase in the quality of the service provided, and the expenditure for the status quo quality of service

$$WTP_i = e(\theta_1, u) - e(\theta_0, u) \tag{1}$$

where $e(.)$ is the expenditure function, with θ_0 being the current quality of service, while θ_1 is the quality of service with the suggested change by the CVM scenario, and u is expected utility.

The survey is trying to elicit the *true* WTP of the respondent, which is the respondent's WTP valuation for the objective service quality θ_1 as defined by the researcher. However, the respondent's *stated* WTP valuation depends on his or her perceived service quality. The respondent's perceived quality can differ from the objective quality the researcher has in mind. This will lead to divergences between the respondent's stated WTP and their true WTP, since the respondent will state their WTP for a service quality different from θ_1.

In order to guide the respondent's perceived quality closer to the objective quality, additional information is usually included in surveys. A respondent i's perceived quality, q_i, will then depend on the objective quality θ, and on any additional information provided in the survey, I. If a linear relationship is assumed then it can be expressed as

$$q_i[\theta, I] = \beta_i\theta + \delta_i I \tag{2}$$

where the parameter β_i represents the respondent's prior information, while δ_i accounts for how the respondent interprets the information that is contained in the CVM scenario.[2]

Equation (2) can be considered as a type of measurement error model. It models whether the respondent perceives the service quality erroneously, in which case $q_i \neq \theta$. The analyst can adjust the respondent's priors by supplying some information, I, to the respondent. The content of the information provided in the survey determines the sign of δ_i. If the information is not credible to the respondent then it will be disregarded, $\delta_i = 0$.

Substituting *(*2) into *(*1), the respondent's stated WTP becomes

$$WTP_i = e(q_{i1}[\theta, I], u) - e(q_{i0}[\theta, I], u) \tag{3}$$

and since $u = v(q_{i0}, m)$, where m is income and $v(.)$ is the indirect utility function,

$$WTP_i = e(q_{i1}[\theta, I], v(q_{i0}[\theta, I], m)) - m \tag{4}$$

The effect of changes in information about the service quality on willingness to pay can be found through differentiating (4) with respect to I

$$\frac{\partial WTP_i}{\partial I} = \frac{\partial WTP_i}{\partial q_{i0}[\theta, I]} \frac{\partial q_{i0}[\theta, I]}{\partial I}$$

and substituting from *(2)*

$$\frac{\partial WTP_i}{\partial I} = \frac{\partial WTP_i}{\partial q_{i0}[\theta, I]} \delta_i.$$

Based on this model, there are a number of ways in which the respondent will respond to the information that is provided, depending on their priors. There are three types of respondents: perfectly informed; imperfectly informed, who underestimate service quality; and imperfectly informed, who overestimate the quality of service. Each case is presented in Table 1. The first row in the table presents the perfectly informed respondent, in which case $\beta_i = 1$ and the respondent's perceived quality will be the same as the objective quality stated in the survey ($q_i = \theta$)

[2] $\beta_i > 0$ to ensure that the objective and perceived quality are positively related.

without any additional information. Additional information provided to such a respondent can have two potential effects. In the first case the information included in the survey can be ignored by the respondent, thus $\delta_i = 0$ and $q_i = \theta$. A second case is if the information causes information overload and the respondent becomes confused, causing his or her perceived quality to diverge from the objective quality, $q_i \neq \theta$ (Bergstrom et al., 1990).

Table 1: Potential information effects

	I=0 No additional information provided	I > 0 Additional information provided
Perfectly informed ($\beta_i = 1$)	$q_i = \theta$	Case 1: $\delta_i = 0$ then $q_i = \theta$ *or* Case 2: $\delta_i > 0$ then $q_i = \neq \theta$
Imperfectly Informed - underestimate quality($\beta_i < 1$)	$q_i < \theta$	$\delta_i > 0$
Imperfectly Informed - overestimate quality($\beta_i > 1$)	$q_i > \theta$	$\delta_i < 0$

For the imperfectly informed respondent, without additional information the perceived quality will be different than the objective quality. The second row of Table 1 shows the imperfectly informed respondent, who underestimates the level of service quality, and his or her perceived quality is lower than the objective quality, $\beta_i < 1$, $q_i < \theta$. In this case any additional information provided by the survey will increase perceived quality, $\delta_i > 0$, and increase stated WTP towards the true WTP. The final row in Table 1 presents the respondent who overestimates service quality levels, in which case their perceived quality is greater than objective quality, $\beta_i > 1$, $q_i > \theta$. Information presented to such a respondent will allow him or her to adjust perceived service quality to a lower level, $\delta_i < 0$ and decrease stated WTP towards his or her true WTP.

The information effect in both cases is desirable, since the information provided in the contingent market scenario allows the WTP for the perceived quality to move closer in line with WTP for the objective quality.

2.2 Factors that affect information processing

A number of factors can influence how the respondent processes the information provided in the survey, thus affecting δ_i. One such factor is the level of motivation of the respondent. In order for the respondent to process the information provided, the respondent must be motivated to carefully scrutinise the arguments contained in the information, to evaluate them, and to then formulate a valuation based on these evaluations. If the respondent has high motivation they are highly receptive to information, and expend energy to evaluate the substance of the information that is provided (Ajzen et al., 1996). If, on the other hand, the respondent has low motivation, they are less sensitive to the substance of the information, and they may base their judgements on factors that are unrelated to the message contained in the information, or they may disregard the information completely ($\delta_i = 0$).

The content and quantity of information can also impact upon respondent valuations. If the volume of information presented in the survey is too large, or is too cognitively demanding, it can lead to biased valuations, because the respondent can become confused and may therefore interpret the information in unintended ways, thereby distorting their stated valuations (Bergstrom et al., 1990). Information overload can also trigger respondents to disregard the information completely ($\delta_i = 0$), in which case there will be no differences in WTP between a group provided with the information and the control group. The effect of information overload is considered in this paper.

3 The evidence of information effects on WTP

Several studies within the CVM literature have empirically investigated "information effects." The literature has focused on examining information effects on valuations of environmental amenities. One of the first attempts was by Bergstrom and Dillman (1985), who looked at the role of information in stated WTP for prime-land preservation in the United States. They instituted a split sample survey, in which half of the sample received information on the potential scenic and environmental benefits of the preservation, while the other half of the sample was not given any information. The study finds evidence of information effects on WTP responses, with the mean WTP for the informed group being significantly higher than that of the uninformed group.

A number of subsequent studies also suggest that the extent and quality of information provided about environmental amenities in CVM surveys affects respondents' stated WTP. In a CVM study of WTP for wetlands it was found that the more information that was provided to the respondents about the ecological and social benefits of preservation, the higher were the WTP estimates (Bergstrom et al., 1990). As would be expected, CVM surveys that emphasised the benefits of the environmental good led to a higher valuation (Samples et al., 1986; Bergstrom et al., 1989) while those that included information about potential substitutes to the good in question observed lower WTP (Blomquist and Whitehead, 1991).

The role of the relevance of the good, and the quality of the information presented in the CVM scenario, as well as its impact on information effects, was explored by Ajzen et al. (1996), using a laboratory experiment. The authors found that the nature of the information provided affects WTP valuations. The study argues that the more personal relevance the good in question has to the respondent, the greater is the effect of information.

Hanley and Munro (1995) undertook a study that looked at whether the quantity of information affects valuation. The authors used four different information sets with varying levels of information. The WTP valuations between the sample that was provided with the most basic information, and the sample that was given the most information, showed an increase of 79 per cent in WTP in the latter case. However, there was no significant increase in WTP between the second and third samples. The authors interpret this as a case of "weak information overload": while the information effect is positive, it declines with added information.

The empirical results from the relatively few studies of information effects are mixed. But overall, the environmental amenities literature indicates that a higher level of information that is supplied in the survey leads to an increased WTP. The influence of the additional information on the WTP value appears to depend on the level of information possessed by the individuals (Boyle, 1989), and the results of one study indicate that the level of personal relevance of the issue to the respondent is an important consideration (Ajzen et al., 1996).

3.1 The effects of socio-economic and behavioural characteristics on WTP

Empirical analyses indicate that stated WTP valuations vary by socio-economic, demographic, attitudinal and behavioural factors.

3.1.1 WTP for renewables

In terms of WTP for specific fuel options for electricity generation, research has, in recent years, focused on renewables. There has been considerable research in the United States, Canada and Japan on the characteristics of consumers who are willing to pay a premium for energy generated from renewables. Table 2, which is slightly adjusted from Diaz-Rainey and Ashton's (2007) paper, summarises the findings of some of these studies. Except for the UK studies, most of the work has been constructed around a CVM framework. Zarnikau (2003) and Wiser (2003), in their CVM study, find that education and income impact upon the stated WTP. Age is also a significant factor in the US studies, with the older population less willing to pay a premium for renewables. The US studies surprisingly find that home ownership is negatively associated with willingness to pay; compared to home-owners, renters are more willing to pay a premium for renewables.

Table 2: Consumer characteristics from selected WTP studies

Variable	Zarnikau (2003)	Wiser (2003)	Rowlands et al. (2003)	Batley et al. (2001)	Diaz-Rainey and Ashton (2007)
Country	US	US	Canada	UK	UK
Age	-**	-*	-***		-**
Gender	+	+	+		+
Education	+**	+**	+***	+***	+
Income	+***	+	+***		+***
Homeowner	-*	-			
Race	+***				
Social Group				+***	
All Should Pay		+***			
Direct Benefits		-***			
Participation Expectations		+***	-		
Environmentalism		+		+**	+***
Liberalism		+	+***		
Ecological Concern			+***		
Knowledge					+**
Energy Efficiency				+***	+***

Source: Diaz-Rainey & Ashton (2007)

***,**,* significance to the 1%, 5% and 10% levels, respectively

"–" indicates negative effect, "+" indicates positive effect

The US and Canadian studies also consider a number of attitudinal factors. Wiser (2003) finds higher WTP to be associated with the belief that everyone should make a contribution towards renewables. Wiser's results also indicate that people who are environmentally active are more willing to pay a premium for green energy. Rowlands et al. (2003) find a similar pattern in Canada; those expressing concern for the environment had a higher WTP.

The research on this subject has been limited in the UK. There are, to date, only two published studies that analyse the characteristics of UK consumers' willingness to pay for renewable energy. One study, by Batley et al. (2001), which utilised a survey conducted in the city of Leicester, found a statistically significant positive correlation between the respondents' willingness to pay, and the factors: their income, their willingness to invest in energy-efficient appliances, the energy efficiency of individuals, and the individuals' social grouping. Diaz-Rainey and Ashton (2007) find a positive correlation between willingness to pay, and the factors: income, awareness of energy issues, concern for the environment, and several other attitudinal variables.

3.1.2 WTP for avoidance of service disruptions

Only two published studies have addressed the analysis of factors that affect WTP for the avoidance of power shortages. Carlsson and Martinsson (2007) use a choice experiment analysis to look at WTP of Swedish households for avoidance of power outages. The study finds that respondents living in big cities and in detached or terraced houses have lower WTP to reduce power cuts. Older respondents in their sample had a higher WTP than younger respondents, and gender was an insignificant factor.

Abdullah and Mariel (2010) use a choice experiment to analyse WTP for improvement in electricity services in Kenya. In terms of demographic factors, the study finds that older respondents were less likely to pay for increased reliability in electricity services. There was also a significant negative effect on WTP of being unemployed, while household size had a positive effect on WTP. The authors argue that since larger households are more reliant on electricity they are more likely to pay for service reliability. Frequency and duration of power outages had a highly significant negative impact on WTP.

Willingness to pay for water attributes has been analysed mainly in developing countries, particularly in Latin America and Asia. Casey et al. (2006) use a CVM survey in the Amazon Basin in Brazil to assess WTP for improved access and reliability of water supply. In terms of demographic characteristics, the results from the paper indicate that age has a negative effect on WTP, while the factors being employed and being a homeowner have a positive effect on WTP. Income, surprisingly, was found to be insignificant on WTP. The authors argue that potential income effect was captured by the utility bill, and employment variables were accounted for in the regression analysis.

Another CVM study, in Peru, found that income has a significant positive effect on WTP (Fujita et al., 2005). Similar to the Brazil study, age had a negative impact on WTP. Current levels of service was also identified as an important factor; the greater restrictions to water supply the respondent faced, the more they were willing to pay for improved services. Hensher et al.'s choice experiment to assess WTP for avoidance of water disruptions in Australia found the opposite effect (Hensher et al., 2005). In this study, the more interruptions the respondent faced, the less was their WTP. The authors argue that an increase in the number of disruptions faced by households increases the likelihood of taking measures to reduce the impact of disruptions, such as storing water.

4 Survey methods and data description

This paper uses two CVM surveys administered in England, Wales and Scotland, in 2006 and 2008. The Electricity Policy Research Group (EPRG) 2006 survey was conducted by YouGov, a consultancy company that specialises in the application of internet-based opinion surveys. For the survey, YouGov contacted 2,254 UK residents over the age of 18, of whom 1,019 responded, representing a 45 per cent response rate. The 2008 EPRG survey was conducted by Accent, with a sample size of 2,000 respondents.

The EPRG surveys were conducted online, in contrast with more traditional methods, such as by mail, over the phone, or face-to-face interviews. There are a number of advantages to internet surveys (or e-surveys), which led to the selection of this method. Internet-based surveys have faster response times, as well as higher response rates (Lazar and Preece, 1999; Opperman, 1995) compared to the traditional approaches. Furthermore, respondents are under no time pressure when completing surveys online, which can improve the validity of responses to complex questions. They also avoid the "interviewer effect", as people responding to the survey are filling in their questionnaires on a computer screen, rather than talking to a person.

While internet-based surveys are now widely used, there are some concerns over their representability, as the whole population does not have access to the internet. However, this is not a significant issue in the UK, where 63.9 per cent of households have access to the internet at home (ITU, 2007). Moreover, the traditional formats of survey execution can lead to higher biases than those observed in e-surveys. For instance, telephone and interview surveys tend to be biased towards those who spend most of their time at home, such as the retired or the unemployed. In contrast, internet surveys can be accessed in any location with an internet connection. For the 2008 EPRG survey, quotas were also imposed for key socio-demographic variables (age, gender, region and social class) to ensure that the sample was representative of the British population.

In order to examine whether information provided in CVM surveys affects the valuation of respondents, a split sample approach was adopted in both the 2006 and 2008 surveys. Half of the survey sample was presented with information on the attribute in question before being asked their valuations, while the other half was asked for their valuation without the information card.

In the 2006 survey each respondent was presented with Table 3, which states the 2006 fuel mixture in the UK electricity generation. The respondents then filled out the table allocating a percentage to each category in order to create their ideal electricity generation fuel mixture. Prior to this question half of the sample was presented with a one-and-a-half-page script, designed to portray a balanced view of the main advantages and limitations of each fuel type, focusing on their role in the UK's energy security and climate change initiatives. The script provided a description of each of the energy sources in the UK's electricity generation fuel mix.[3] The second half of the sample was presented only with the table, without the information document.

[3] Please refer to Appendix A to see the information script.

Table 3: EPRG 2006 survey question on respondent's ideal electricity generation fuel mixture

	Current % share	Respondent's ideal share
Natural gas	40	
Coal	34	
Nuclear	20	
Onshore wind	0.5	
Offshore wind	0	
Natural fas with CCS	0	
Coal with CCS	0	

Out of 1,020 respondents, 58 respondents did not fill out the table for their ideal electricity generation mixture. These respondents were excluded from the analysis.[4] The total number of observations available for analysis was 955 responses.

Figure 1 presents the distribution of the sample's ideal share by fuel type. Just over 90 percent of the sample's ideal wind share was significantly higher than the actual 0.5 per cent. Thirty per cent of the sample wanted the share of wind in the electricity mixture to rise to above 40 per cent. In the case of nuclear, as expected, there were divergent opinions about the ideal share of this fuel option. Half of the sample allocated a lower share than the status quo, with 30 per cent stating they did not want nuclear to be used in electricity generation. A significant share of the respondents wanted the share of coal and natural gas to decrease below the current levels.

The EPRG 2008 survey was designed to elicit WTP for avoidance of electricity and water service disruptions. Similarly, with the 2006 survey prior to answering the willingness to pay questions, half of the sample was provided with a short paragraph of information about the potential reasons for and uses of the premium on these attributes.[5]

4.1 WTP question format and bidding structure

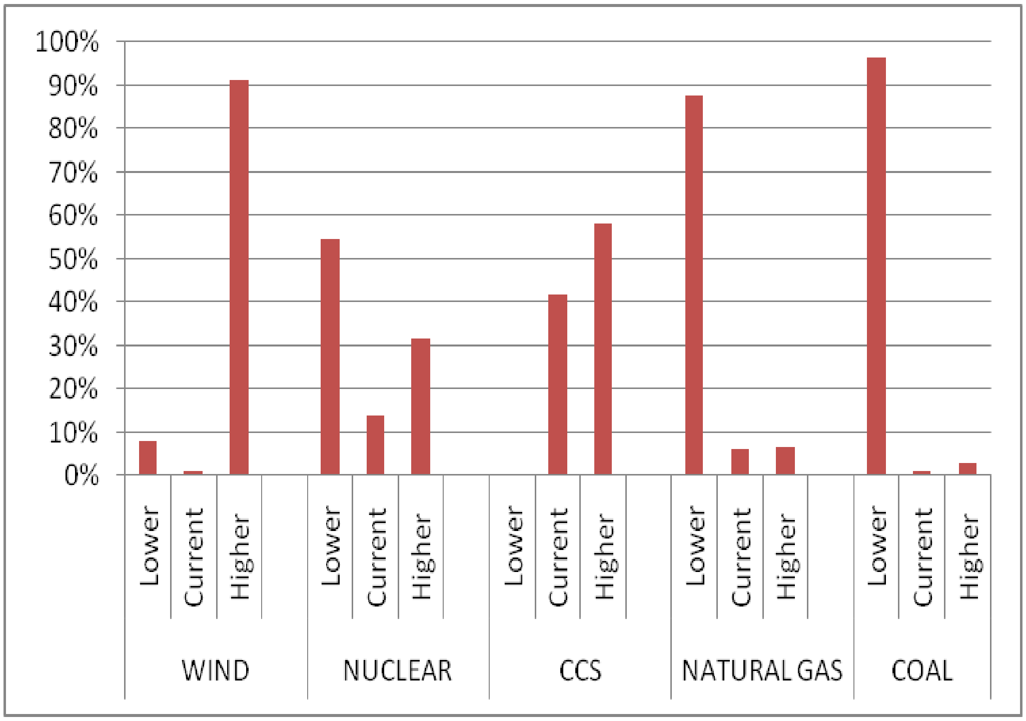
CV elicitation questions are of two basic forms: open-ended and closed-ended. The open-ended version asks the respondent to state the maximum amount he or she is willing to pay for the service in question. In a closed-ended format, the respondent is asked whether they are willing to pay a specified amount presented in the question. A closed-ended format was adopted in both the 2006 and 2008 surveys, since the open-ended question format is demanding on the respondents and has been documented to yield unrealistic responses.

In the closed-ended format, the respondent is presented with specific WTP values to choose from for their valuation of the service in question. There are several formats to present these bids, including payment card, discrete choice, or discrete choice with follow-up approaches. Due to the documented biases associated with the payment card, this method was discarded.

[4] Two additional respondents filled the table with all zeros and five respondents had a mixture summing significantly higher or less than 100 per cent these respondent were also dropped from the analysis.

[5] Please refer to Appendix B.1 and B.2 for a copy of the questions and information cards

Figure 1: Ideal fuel share for electricity generation



The dichotomous choice method provides the respondent with a single monetary value to either accept or reject. This format was rejected, since it only provides one threshold against which to measure individuals' WTP valuations. The dichotomous choice with follow-up method was seen as the most appropriate closed-ended approach for both surveys, since this method provides a double bound on the WTP estimations.

The dichotomous choice with follow-up format does not directly reveal the respondent's WTP; instead it provides a range within which the true WTP lies. The bidding structure of the 2006 survey yields seven ranges of WTP valuations, as presented in Table 4.

In the 2006 survey the respondents were first asked whether they were willing to pay an extra premium for their ideal fuel mixture. If the answer was "yes" the respondents were then asked whether they would pay £100 extra on their current utility bill. If the response was "yes" the bidding stopped at this level. If the answer was "no" the follow-up questions featured a lower amount. The bidding categories were £100, £40, £25, £10, £5 and £1.[6]

The bidding structure in the 2006 and 2008 surveys was slightly different. The primary distinction is that in the 2006 survey the bids were presented in absolute monetary values, while in the 2008 survey the bids were presented as a percentage of the respondent's utility bill. At the beginning of the 2008 survey the respondents were asked to state the amount of their electricity and water

[6] The bid levels were chosen after a pilot study.

Table 4: EPRG 2006 survey - WTP categories

WTP categories	WTP valuations
1	$wtp = £0$
2	$£1 \leq wtp < £5$
3	$£5 \leq wtp < £10$
4	$£10 \leq wtp < £25$
5	$£25 \leq wtp < £40$
6	$£40 \leq wtp < £100$
7	$£100 \leq wtp$

bills. This information was then incorporated into the WTP questions later in the survey, to remind the respondents of their current utility payments and to encourage them to take this into consideration before responding to WTP questions. This approach helps to anchor the stated values of respondents in the WTP questions to their actual revealed behaviour of how much they currently spend on utilities.

The bidding categories in the EPRG 2008 survey were 3%, 5%, 7%, 10%, 15%, 20% and 25% of the respondent's current electricity bill.[7] The median of the seven bids, 10%, was given as the initial bid to all respondents. The bidding structure of the 2008 survey leads to nine WTP categories (Table 5).

Table 5: EPRG 2008 survey - WTP categories

WTP categories	WTP valuations
1	$wtp = 0\%$
2	$0\% < wtp < 3\%$
3	$3\% \leq wtp < 5\%$
4	$5\% \leq wtp < 7\%$
5	$7\% \leq wtp < 10\%$
6	$10\% \leq wtp < 15\%$
7	$15\% \leq wtp < 20\%$
8	$20\% \leq wtp < 25\%$
9	$25\% \leq wtp$

A high frequency of zero WTP responses was observed in both EPRG surveys. In the 2006 survey 44 per cent of respondents stated that their WTP was zero. A high proportion of zero responses was again observed in the 2008 survey. Approximately 72 per cent of the sample reported zero WTP for avoidance of blackouts, while 77 per cent reported zero WTP for avoidance of water disruptions.

[7] These bids are the same as those used by the Ofgem and Ofwat surveys in assessing WTP for service disruptions.

4.2 Controls for potential CVM biases

CVM is exposed to several biases, including starting point bias, order bias and hypothetical bias. Considerable care has been taken to ameliorate these problems in the EPRG surveys. Starting point bias refers to the fact that the respondents may interpret the initial bid as the "correct" bid and anchor their valuation around this figure. The problem is greater, the less familiar the respondent is with the service in question and the payment vehicle. In order to limit starting point bias, both surveys utilise a payment vehicle that is familiar to the respondents, in the form of utility bills. The main method in ameliorating starting point bias is to randomise the initial bid. This is the approach that should be taken if the aim of the study is to estimate the mean WTP. However, the objective of this study is to analyse information effects. In order to eliminate potential discrepancies a randomised bid structure should be introduced; for this study the same starting bid was given to all respondents. Consequently, the results from the EPRG surveys are susceptible to starting point bias, but this is not a concern, since the focus is not to estimate the precise mean WTP.

CVM surveys that try to elicit willingness to pay valuations on multiple goods or attributes are also susceptible to ordering bias. In the 2008 survey, valuations were asked about several attributes; thus it is possible that respondents' valuations will be sensitive to the order in which these attributes are presented. In order to control for potential ordering bias, the sequence of the WTP questions in the EPRG 2008 survey - for avoidance of blackouts and water service disruptions - were varied randomly among the respondents.

5 Modeling Willingness to Pay

5.1 Ordered response models

The main aim of CVM studies is to estimate respondents' willingness to pay (y_i^*), and to evaluate the covariates that impact willingness to pay. In most CVM studies the latent variable y_i^* is not observed. Instead, the researcher observes whether the respondent accepts or rejects the bid presented, and the only conclusion that can be drawn from this observation is the range in which y_i^* can lie. Ordered response models are widely used to analyse such discrete data which has a natural ordering.

An ordered response model is based on an unobserved latent variable y_i^* that is modelled as a linear function of personal characteristics $\mathbf{z}_i$ and an error term ε_i, which is assumed to be independent and identically distributed, as in (5), where α is a vector of parameters reflecting the relationship between y_i^* and the variables in $\mathbf{z}_i$.

$$y_i^* = \alpha' \mathbf{z}_i + \varepsilon_i. \tag{5}$$

Although y_i^* is not observed, what is observed is an individual's choice, y_i, which has a discrete ordered value $(y_i = 1, 2, ..., M)$,

$$y_i = j \text{ if } \mu_{j-1} < y_i^* < \mu_j \tag{6}$$

where the μ_j are thresholds defining potential ordered outcomes for y_i. The probability of observing a particular ordinal outcome j is

$$\Pr\{y_i = j \mid \mathbf{z}_i\} = F(\mu_j - \alpha' \mathbf{z}_i) - F(\mu_{j-1} - \alpha' \mathbf{z}_i) \tag{7}$$

where $F(.)$ is a cumulative density function. These probabilities enter directly into the log-likelihood function, and the sample log-likelihood function can be written as

$$l(y|\theta) = {}_{i=1}^{N} {}_{j=1}^{M} h_{ij} \ln[\Pr(y_i = j|\mathbf{z}_i)] \tag{8}$$

where $\theta = (\alpha, \mu)$ and the indicator h_{ij} is

$$h_{ij} = \left\{ \begin{array}{c} 1 \text{ if } y_i = j \\ 0 \text{ otherwise} \end{array} \right\}.$$

In the case of CVM data, the bids presented in the CVM scenario form the thresholds, μ_j, where $\mu_0 = -\infty$, $\mu_1 = 0$, and $\mu_M = +\infty$, which in turn form the M categories within which the unobserved WTP may fall. Since the bids have a natural numerical ordering, y_i is an ordered variable; thus the above ordered response model can be used in the analysis. If it is assumed that ε_i are independent and identically distributed (i.i.d.) standard normal, then y_i^* can now be estimated using an ordered probit model, or if ε_i are i.i.d. logistic, then an ordered logit model can be utilised.

5.2 The excess zero problem

One of the potential difficulties in modeling WTP responses obtained from CVM surveys is that the distribution of WTP responses tends to be multi-modal, and in most cases with a spike at zero. The conventional models that are applied to estimate WTP, such as ordered logit or probit, ignore this potential multi-modality in the data set. In cases where the data has a high proportion of zeros, these conventional parametric models can fail to represent the empirical distribution of the data, which can lead to bias and inconsistent estimates.

There are two modelling options to account for excess zeros based on a mixture distribution. The first is the spike model, which uses a degenerate distribution at zero combined with a zero-truncated normal, or logit, distribution for the non-zero observations. The distribution function of the WTP values under a spike model is given by (9), where $F(y;\alpha)$ is an absolutely continuous cumulative distribution function. However, the function $G_{SPIKE}(y;\lambda,\alpha)$ is not a continuous function (An and Ayala, 1996). It has a point mass at $y^* = 0$, represented by the parameter λ, which is the share of the sample who stated that their WTP is zero and lies in the interval $[0,1]$.

An alternative model is the zero-inflated ordered probit (ZIOP), developed by Harris and Zhao (2007). ZIOP is similar to the spike model, except that the zero in the normal distribution is not truncated. In this set-up, the zero observations emerge from two different parts that have either two different sets of explanatory variables or the same covariates but potentially with different effects.

ZIOP is, in essence, a double-hurdle model that is a combination of a probit model and an ordered probit model. The distribution under ZIOP is given by (10), where α is the vector of parameters from the ordered probit part and β is the vector of parameters from the probit part.

$$G_{SPIKE}(y;\lambda,\alpha) = \left\{ \begin{array}{c} 0 \ \text{ if } y^* < 0 \\ \lambda \text{ if } y^* = 0 \\ F(y;\alpha) \ \text{ if } y^* > 0 \end{array} \right\} \tag{9}$$

$$G_{ZIOP}(y;\lambda,\alpha) = \left\{ \begin{array}{c} 0 \ \text{ if } y^* < 0 \\ \lambda \text{ if } y^* = 0 \\ F(y;\alpha,\beta) \ \text{ if } y^* \geq 0 \end{array} \right\} \tag{10}$$

ZIOP models WTP with two variables, r_i and y_i. The variable r_i is a binary variable which takes on the value 0 or 1. It models the first hurdle: whether the respondent is willing to pay anything for the service in question. If the respondent has answered “no”, then $r_i = 0$; while if the response is “yes”, then $r_i = 1$. This binary variable r_i is related to a latent variable r_i^*

$$r_i^* = \beta' \mathbf{x}_i + \omega_i$$

where $\mathbf{x}_i$ is a vector of covariates, β is a vector of unknown parameters, and ω_i is a standard-normal distributed error term.

The probability that the respondent has a positive WTP, ($r_i = 1$) is given by

$$\Pr(r_i = 1|\mathbf{x}_i) = \Pr(r_i^* > 0|\mathbf{x}_i) = \Phi(\beta' \mathbf{x}_i)$$

where $\Phi(.)$ is the cumulative distribution function of the univariate standard normal distribution.

The second hurdle in the ZIOP model is the decision about how much the respondent is willing to pay for the attribute. This hurdle is modelled as an ordered probit model as was described in the beginning of the section. The second latent variable y_i^*, is then

$$y_i^* = \alpha' \mathbf{z}_i + \varepsilon_i$$

where $\mathbf{z}_i$ is the vector of covariates with an unknown vector α, and ε_i is an error term following a standard normal distribution. It is important to note that the second hurdle also allows for zero WTP.

In this model we can observe zero WTP if $r_i = 0$, whereby the respondent expresses that they are uninterested in the attribute and value it at zero. We can also observe zero WTP if jointly $r_i = 1$ and $y_i = 0$, in which case the individual reports zero WTP because they are inhibited by the price, or due to their budgetary restrictions. This group of respondents could switch to positive WTP if their income was higher or the price offered was lower.

To observe positive WTP, it is required that the respondent has expressed that they are willing to pay ($r_i = 1$) and that $y_i^* > 0$. If it is assumed that both ε and ω identically and independently follow a standard normal distribution, then the full probabilities are

$$\Pr(y) = \left\{ \begin{array}{c} \Pr(y = 0|\mathbf{z},\ \mathbf{x}) = [1 - \Phi(\beta' \mathbf{x})] + \Phi(\beta' \mathbf{x})\Phi(-\alpha' \mathbf{z}) \\ \Pr(y = j|\mathbf{z},\ \mathbf{x}) = \Phi(\beta' \mathbf{x})[\Phi(\mu_j - \alpha' \mathbf{z}) - \Phi(\mu_{j-1} - \alpha' \mathbf{z})] \end{array} \right\}.$$

Thus, the probability for a zero observation has been “inflated”, since it is a combination of the probability of observing a zero observation from the ordered probit process, plus the probability of the individual being a “non-participant” from the binary probit part. The log-likelihood function then is given by

$$l(y|\theta) = \sum_{i=1}^{N} \sum_{j=1}^{M} h_{ij} \ln[\Pr(y_i = j|\mathbf{x}_i, \mathbf{z}_i)]$$

where $\theta = (\beta, \alpha, \mu)$, and the indicator h_{ij} is

$$h_{ij} = \left\{ \begin{array}{c} 1 \text{ if individual } i \text{ chooses outcome } j \\ 0 \text{ otherwise} \end{array} \right\}.$$

Spike and ZIOP present two approaches to modelling WTP data from CVM studies with a high level of zero WTP responses. Thus far, only the spike model, has been utilised in the CVM literature. ZIOP, which is a more recent model, provides a new alternative with an important benefit. Using ZIOP, the factors that affect zero WTP can be considered separately from the factors that affect positive WTP, which is not possible under the spike model. This is a particularly important feature in WTP studies, because the variables that influence respondents to state a zero WTP are likely to be different from the variables for those stating a positive amount of WTP.

6 Results

6.1 Testing for motivation effects - WTP for avoidance of service disruptions

Data from the EPRG 2008 survey is used to test whether the relevance of the service disruption has an effect on information processing by the respondent. The explanatory variables used in the analysis are presented in Table 6.

Table 6: EPRG 2008 survey - descriptive statistics

Explanatory Variables	Description	Mean	SD	Min	Max
Information dummy	Dummy identifying sample that received the information text; 0=no information, 1=information	0.50	0.50	0	1
Gender	1=Male, 2=Female	1.50	0.50	1	2
Age	1 to 6 scale of age of respondent; 0=under 25 years old, 5=over 65 years old	3.58	1.43	1	5
Household size	1 to 5 scale of number of people in the household; 1=single person household, 5= 5 or more people in the household	2.56	1.21	1	5
Income	1 to 6 scale of household monthly income; 1=Up to £900, 5=Over £4000, 6=Refused to answer question	3.14	1.55	1	6
Environmentalism	0 to 6 scale of level of environmentalism of respondent measured by the number of environmental actions taken by the respondent	3.05	1.54	0	6
Energy dependence concern	0 to 3 scale of level of concern expressed by respondent on UK's increasing dependence on imported energy sources; 0=not at all concerned, 3= very concerned	1.35	0.67	0	3
Awareness	0 to 3 scale to account for the number of questions the respondent answered correctly on energy-related questions asked to test respondent's awareness; 0= none answered correctly, 3=all correct	1.73	0.85	0	3
Number of blackouts	0 to 4 scale of number of blackouts experienced by the respondent in the last year; 0=none, 4=more than 20 blackouts	0.77	0.99	0	4
Duration of blackouts	0 to 4 scale of the average duration of blackouts experienced by the respondent in the last year; 0=none, 4=over 4 hours	1.03	1.29	0	4
Number of water service disruptions	0 to 3 scale of number of water disruptions experienced by the respondent in the last year; 0=none, 4=more than 6 disruptions	0.33	0.66	0	3
Duration of water disruption	0 to 3 scale of the average duration of disruptions experienced by the respondent in the last year; 0=none, 3=over 4 hours	0.53	1.02	0	3
Water meter	Variable on whether the respondent has a water meter; -1=Don't Know, 0=Do not have, 1=Have meter	0.29	0.55	-1	1

A dummy variable is used to distinguish between the sub-sample that received information and the sample without information. This dummy treatment allows testing of whether the information provided in the survey had a significant positive or negative impact on WTP. As discussed in Section 3, respondents can interpret the information provided in the CVM scenario, represented by δ_i, differently. However, it is not possible to assess δ_i from the survey data; instead δ is analysed in the model, thus imposing homogeneity in the respondents' interpretation of the information. Several demographic, behavioural and attitudinal variables are included in the analysis to allow for heterogeneity in the sample, as well as to analyse the impact of these factors on valuations.

The relevance of the electricity and water disruptions can be measured by the number of disruptions experienced by the respondent prior to the survey. The higher the number of disruptions, the higher is the likelihood that the issue of service disruption will be more relevant to the respondent, which will have an impact on their motivation to process the information presented in the CVM scenario.

Over half of the survey sample reported experiencing a blackout in the year prior to the survey, in contrast to less than 25 per cent of the sample that experienced a water disruption. Electricity shortages can then be considered to be more relevant to the respondents than water disruptions. As a consequence, the ex-ante expectation is for information effects to be observed for electricity disruptions but not for water disruptions.

This hypothesis is supported by the results. Both the benchmark ordered probit model and the zero-inflated ordered probit are used in the analysis; the non-nested Vuong's (1989) test favours the zero-inflated ordered probit model thus the focus of the discussion will be on the zero-inflated ordered probit results.[8] Table 7 presents the regression results for avoidance of blackouts, while Table 8 shows the results for avoidance of water disruptions.[9]

First, focusing on the information dummy one can see that the dummy is positive, and significant in the ordered probit model, indicating that the information included in the survey positively influenced the WTP of respondents ($\delta > 0$). Under ZIOP the effects of information can be assessed in more detail. The information dummy is only significant in the first hurdle indicating that the information included had a positive influence on WTP to become positive, but is insignificant when considering how much to pay for the attribute. In contrast, the information presented did not have any significant effect ($\delta = 0$) on WTP for avoidance of water disruptions (Table 8). The findings indicate that the relevance of the service attribute has an impact on the motivation of the respondent to process the information prior to their valuation.[10]

Tables 7 and 8 also present the results for a number of demographic and behavioural variables. Among the demographic characteristics that were considered in the regression analysis, gender is found to be insignificant in the ordered probit regressions for both water and blackouts. However, once the excess zeros were modelled using ZIOP, this variable does have an effect on the amount of WTP for avoidance of blackouts; females are less willing to contribute compared to male respondents. Older respondents also have a lower WTP for avoidance of blackouts, which is consistent with the findings of Abdullah and Mariel (2010).

[8] All estimations were implemented in Stata. The Stata command for ZIOP is written by the author.

[9] ZIOP, when run with all nine WTP categories for avoidance of blackouts, failed to converge, perhaps due to the low number of respondents in the last two categories (25 and 36 respondents respectively) or due to the similarities between the respondents of the last three categories. In order to not lose these observations, the last three categories for WTP for blackouts were merged into one category, resulting in six WTP categories for this attribute.

[10] Potential interaction effects between the information dummy and the demographic variables was tested using a separate regression. The results do not indicate any interaction effects.

Table 7: Results - EPRG surveys - WTP for avoidance of blackouts

	ZIOP				Ordered Probit	
	First Hurdle		Second Hurdle			
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Information dummy	0.10*	(0.04)	-0.05	(0.09)	0.18*	(0.07)
Gender	-0.01	(0.05)	-0.64***	(0.08)	-0.05	(0.08)
Age	-0.01	(0.02)	-0.08*	(0.03)	-0.06*	(0.03)
Household size	-0.01	(0.02)	-0.10*	(0.04)	0.04	(0.03)
Income (comparison group "less than £900")						
£901 to £1500	0.03	(0.07)	-0.25	(0.15)	0.36**	(0.13)
£1501 to £2600	0.09	(0.07)	-0.21	(0.15)	0.28*	(0.13)
£2601 to £4000	0.15	(0.08)	-0.08	(0.16)	0.46**	(0.14)
Over £4000	0.24*	(0.10)	-0.19	(0.17)	0.39*	(0.16)
Refused	-0.01	(0.08)	-0.42*	(0.20)	0.19	(0.16)
Environmentalism	0.04**	(0.01)	0.00	(0.03)	0.06**	(0.02)
Energy dependence concern	0.01	(0.02)	-0.19***	(0.04)	0.03	(0.04)
Awareness	0.02	(0.05)	-0.22*	(0.09)	-0.08	(0.08)
Number of blackouts	0.06*	(0.03)	0.09	(0.05)	0.12**	(0.04)
Duration blackouts	-0.02	(0.02)	-0.05	(0.04)	-0.02	(0.04)
Level of certainty in response			0.01***	(0.00)	0.04***	(0.00)
μ_1			-4.12***	(0.33)	1.85***	(0.22)
μ_2			-3.22***	(0.32)	1.94***	(0.25)
μ_3			-2.54***	(0.31)	2.21***	(0.25)
μ_4			-2.37***	(0.31)	2.65***	(0.26)
μ_5			-1.34***	(0.31)	2.79***	(0.26)
μ_6					3.75***	(0.26)
Log-likelihood:	-3162				-1200	
Number of observations:	1997				1997	
Vuong test:	28.16					
Significance: * p<0.05, ** p<0.01, *** p<0.001						

Table 8: Results - EPRG surveys - WTP for avoidance of water disruptions

	ZIOP				Ordered Probit	
	First Hurdle		Second Hurdle			
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Information dummy	-0.01	(0.04)	0.08	(1.00)	-0.09	(0.08)
Gender	-0.01	(0.04)	-0.17	(0.10)	-0.08	(0.08)
Age	0.00	(0.02)	-0.04	(0.04)	-0.04	(0.03)
Household size	0.00	(0.02)	-0.05	(0.05)	0.02	(0.03)
Income (comparison group "less than £900")						
£901 to £1500	0.00	(0.07)	0.28	(0.18)	-0.08	(0.13)
£1501 to £2600	0.49	(0.07)	0.36	(0.18)	-0.09	(0.13)
£2601 to £4000	0.11	(0.08)	0.69***	(0.19)	0.10	(0.14)
Over £4000	0.12	(0.10)	0.44**	(0.21)	-0.12	(0.16)
Refused	-0.03	(0.08)	0.10	(0.24)	-0.04	(0.16)
Environmentalism	0.04***	(0.01)	0.04	(0.03)	0.04	(0.02)
Number of disruptions	0.12**	(0.06)	0.42***	(0.09)	0.43***	(0.07)
Duration of disruption	-0.05	(0.04)	-0.18**	(0.06)	-0.19***	(0.05)
Water meter	0.01	(0.04)	0.30***	(0.09)	0.18**	(0.07)
Level of certainty in response			0.01***	(0.01)	0.04***	(0.00)
µ1			1.35***	(0.32)	1.59***	(0.22)
µ2			-0.53***	(0.31)	1.66***	(0.22)
µ3			0.16***	(0.31)	1.86***	(0.22)
µ4			0.33***	(0.31)	2.25***	(0.23)
µ5			1.43***	(0.31)	2.37***	(0.23)
µ6			2.17***	(0.32)	3.38***	(0.23)
µ7			2.59***	(0.33)	4.12***	(0.24)
µ8					4.55***	(0.25)
Log-likelihood:	-3151				-1078	
Number of observations:	1997				1997	
Vuong test:	25.06					
Significance: * p<0.05, ** p<0.01, *** p<0.001						

As expected, level of income has an effect on WTP, although there are some divergences between the results of ZIOP and OP models. Under the OP model all higher income groups had a higher WTP compared to the lowest income category. However, under ZIOP only the highest income category is significant and positive in the first hurdle. More interestingly, for the second hurdle income coefficients are negative although not significant. The effect of income on WTP for avoidance of water disruptions is also different under the two models. Income is insignificant under ordered probit, but the second hurdle of the ZIOP regression analysis reveals that the level of income has a positive impact on the amount of WTP.

With regards to behavioural and attitudinal factors that affect WTP for avoidance of blackouts, the results indicate that the level of environmentalism of the respondent has a positive impact on WTP. In the ZIOP model it has a positive impact only in respect of the decision on whether to pay anything, but is found to be insignificant on the amount of the valuation. Respondents' level of concern about the UK's increasing energy dependence on foreign fuel sources is not significant in OP, but has a strong negative effect on the respondents' WTP under ZIOP. This is a surprising result, as one would expect those who are more concerned about increasing energy dependence to be more willing to support policies that would reduce the occurrence of blackouts. The same result was found in the EPRG 2006 survey on WTP for increasing the share of domestic fuel options, which will be discussed in the next section.

The number of disruptions, as expected, has a positive impact on WTP. The higher the number of disruptions experienced in a one year period, the more is the WTP for avoidance of disruptions. Surprisingly, the duration of water disruptions had a negative impact on the amount of WTP in ZIOP. This may be because respondents' trust in their utility company could be lower if they experienced long disruptions in the past and thus are less willing to pay for the service. The level of certainty of the respondent on his or her valuations has a positive effect on WTP for both attributes.

6.2 Testing "information overload" - WTP for ideal electricity generation fuel mixture

Data from the EPRG 2006 survey on respondents' WTP for their ideal electricity mixture are used to examine whether information quantity and complexity can lead to information overload. The explanatory variables considered in the analysis are presented in Table 9.

A dummy variable is again included in the regressions to test information effects. The CVM literature indicates that more information is associated with higher WTP when the respondents are not already well informed. If the respondents are already well informed about the attribute in question they will disregard the information provided ($\delta = 0$), in which case the information dummy will be insignificant.

It is unlikely that the respondents in the EPRG 2006 survey had much prior information about the electricity generation fuel mixture in the UK or the specific benefits and costs associated with each fuel option, as this is not an issue that affects the respondents' daily life. Referring

Table 9: EPRG 2006 survey - descriptive statistics

Explanatory variables	Variable description	Mean	SD	Min	Max
Information dummy	Dummy of whether respondent received the information text; 0=no information, 1=information	0.50	0.50	0	1
Gender	1=Male, 2=Female	1.52	0.50	1	2
Age	1 to 6 scale of age of respondent; 0=under 25 years old, 5=over 65 years old	1.96	1.39	0	5
Price sensitivity	Index to measure price sensitivity of respondent based on whether respondents listed fuel prices as one of the most important issues facing the UK and whether they switched suppliers for a lower price	0.27	0.30	0	1
Political party	1 to 6 scale of political party respondent supports; 1=Labour, 2=Conservative, 3=Liberal Democrat, 4=other, 5=no party, 6=not sure	2.89	1.62	1	6
Environmentalism	0 to 1 scale index on level of environmentalism of respondent based on whether the individual ranked the environment as one of the two most important issues facing the UK and if the respondent switched electricity suppliers for environmental reasons	0.10	0.21	0	1
Climate change concern	0-1 dummy on whether respondent ranked climate change as one of the top two environmental problem facing the UK	0.57	0.50	0	1
Energy efficiency action	0 to 13 scale of number of energy saving actions taken by the respondent	4.39	3.19	0	13
Energy dependence concern	0 to 5 scale of level of concern expressed by respondent on UK's increasing dependence on imported energy sources; -1=Don't Know, 0=not at all concerned, 5= very concerned	3.06	1.10	-1	4
Awareness	0 to 3 scale to account for the number of questions the respondent answered correctly on energy-related questions asked to test respondent's awareness; 0= none answered correctly, 3=all correct	1.12	1.04	0	3

back to (2), it is not expected that $\beta_i = 1$; the respondents are not perfectly informed and will not disregard the information provided for this reason. If the respondent does not ignore the information provided in the EPRG 2006 survey, the ex-ante expectation is for the information dummy to be positive and significant.

The issue of climate change and energy security was a topic covered by the media during 2006, thus the respondents are expected to have some prior information about the fuel options for electricity generation ($0 < \beta_i < 1$). In order to take into account respondents' prior awareness, a number of questions were included in the survey to test the respondents' knowledge. An indicator of the respondent's awareness, of energy issues is constructed from these questions and is included in the regression analysis.[11] A number of variables are also included in the regression analysis to assess how the socio-economic, behavioural and attitudinal characteristics of respondents affect their willingness to pay.

The first column in Table 10 displays the results from the ordered probit analysis for the entire

[11] The awareness index takes into account whether the respondent was able to correctly identify that coal and natural gas constitute the largest sources of electricity in the UK and if they could correctly select the fuels that contribute significantly to global warming. Please refer to Table 9 for the description of the index.

sample. The information dummy is insignificant, indicating that the information provided to the sample had no effect on their valuations. The absence of information effects could be due to a number of factors. It is possible that the information provided did not change the perceptions of the respondents about the fuel mixture. A more likely explanation is that the information text led to information overload ($\delta = 0$).

The length of information provided in the EPRG 2006 survey was one-and-a-half pages, which may have been too much for the respondents to absorb.[12] Since the survey was administered online, the respondents could have skipped this information card completely. In a face-to-face or a phone-administered survey, there are controls to ensure the card is read out, however, for online surveys there is no way of determining how much time the respondent spent reading the information card.

Moreover, it is likely that the content, as well as the quantity, of information placed a cognitive burden on the respondents. The respondents had to assess a total of 28 facts, which were a mixture of benefits, shortcomings and some neutral facts on each fuel option. The respondents then had to utilise this information to allocate a share to each fuel option, and then assign a valuation for the entire mixture. This process is burdensome to respondents in terms of both time and effort to analyse the information fully. It is likely that the respondents often chose to disregard or even skip the information provided in the formation of their fuel choices as well as their valuations.[13]

Individuals may have different prior information sets and expectations, which may lead them to process the information provided differently (δ_i). One of the ways to allow for this heterogeneity is through the awareness index, which is a type of indicator of each respondent's prior information. In addition, a number of socio-economic and behavioural parameters, such as income, age, gender and level of environmentalism of the respondent, are included in the analysis. A second method to account for potential divergences in the sample is to divide the survey sample into subgroups. The heterogeneity in the sample could be based on the fuel options chosen for their ideal electricity generation fuel mixture (Table 3); these effects may vary across the subgroups but may cancel out in the aggregate group.

To examine whether there are differences based on preference for specific energy resource options for the electricity mixture, three subgroups were created from the EPRG 2006 data set. The first sub-group (S1) was formed from the respondents who indicated they wanted the share of wind to increase to comprise more than 10 per cent of the electricity fuel mixture. The second subgroup (S2) was created from the respondents whose ideal mixture included above 10 per cent from CCS. The threshold of 10 per cent was taken to form these two subgroups because it represents a significant increase from the shares for these two options in 2006 (0.5% for wind; 0% for CCS). A third subgroup (S3) was formed from those assigning a share above the current level of 20 per cent for nuclear. The results from the ordered probit model indicate that there are no information effects in any of the subsamples (Table 10); the information dummy is insignificant in all regressions.

[12] Please refer to Appendix A for a copy of the information script.

[13] In a separate analysis the interaction between the information dummy and the demographic variables was tested; the findings indicate no interaction effects.

Table 10: Results - EPRG surveys - ordered probit

	Whole sample		S1 - Wind		S2 - CCS		S3 - Nuclear	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Information dummy	-0.07	(0.07)	-0.06	(0.08)	0.05	(0.12)	-0.09	(0.14)
Gender	-0.13	(0.08)	0.00	(0.09)	-0.18	(0.13)	-0.15	(0.16)
Age	-0.10***	(0.03)	-0.10**	(0.03)	-0.11*	(0.05)	-0.06	(0.05)
Price sensitivity	-0.45***	(0.13)	-0.52***	(0.15)	-0.41*	(0.20)	-0.29	(0.23)
Political party (comparison group "Labour")								
Conservative	0.00	(0.11)	-0.03	(0.12)	-0.26	(0.17)	0.21	(0.19)
Liberal-Democrat	0.02	(0.12)	0.04	(0.13)	-0.19	(0.19)	0.33	(0.26)
Climate change concern	0.33***	(0.08)	0.33***	(0.09)	0.53***	(0.12)	0.23	(0.15)
Environmentalism	0.90***	(0.18)	0.79***	(0.19)	0.87**	(0.27)	1.13**	(0.37)
Energy dependence concern	-0.07	(0.04)	-0.09*	(0.04)	-0.10	(0.06)	-0.15	(0.08)
Energy efficiency action	0.06***	(0.01)	0.06***	(0.01)	0.04*	(0.02)	0.09***	(0.02)
Awareness	0.12**	(0.04)	0.14**	(0.04)	0.08	(0.06)	0.09	(0.06)
µ1	0.25	(0.26)	0.12	(0.28)	-0.67	(0.41)	-0.33	(0.58)
µ2	0.25	(0.26)	0.12	(0.28)	-0.66	(0.41)	-0.09	(0.52)
µ3	0.26	(0.26)	0.13	(0.28)	-0.45	(0.41)	0.27	(0.52)
µ4	0.51*	(0.26)	0.37	(0.28)	-0.07	(0.41)	1.78***	(0.54)
µ5	0.88***	(0.26)	0.75**	(0.28)	1.23**	(0.41)		
µ6	2.14***	(0.27)	2.00***	(0.29)				
Log-likelihood:	-1200		-973		-496		-343	
Number of observations:	942		731		385		300	

Table 11: Results - EPRG surveys - zero-inflated ordered probit

	Whole sample				S1 - Wind			
	ZIOP				ZIOP			
	First Hurdle		Second Hurdle		First Hurdle		Second Hurdle	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Information dummy	-0.01	(0.07)	-0.19*	(0.09)	0.00	(0.09)	-0.18	(0.10)
Gender	-0.03	(0.08)	-0.61***	(0.09)	0.03	(0.09)	-0.50***	(0.10)
Age	-0.06*	(0.03)	-0.08*	(0.04)	-0.07	(0.04)	-0.09*	(0.04)
Price sensitivity	-0.26*	(0.12)	-0.26	(0.16)	-0.29*	(0.14)	-0.32	(0.18)
Political party (comparison group "Labour")								
Conservative	-0.02	(0.10)	-0.16	(0.13)	-0.03	(0.12)	-0.15	(0.15)
Liberal-Democrat	0.08	(0.12)	-0.30*	(0.14)	0.10	(0.14)	-0.31*	(0.15)
Climate change concern	0.18*	(0.08)	-0.09	(0.10)	0.19*	(0.09)	-0.06	(0.11)
Environmentalism	0.77***	(0.22)	0.45*	(0.20)	0.64**	(0.24)	0.50*	(0.22)
Energy dependence concern	-0.01	(0.04)	-0.22***	(0.05)	-0.02	(0.05)	-0.22***	(0.05)
Energy efficiency action	0.03**	(0.01)	0.03	(0.02)	0.04*	(0.01)	0.02	(0.02)
Awareness	0.09*	(0.04)	-0.05	(0.05)	0.12**	(0.05)	-0.08	(0.05)
μ1			0.29	(0.25)			0.19	(0.28)
μ2			-5.05***	(0.35)			-5.09***	(0.38)
μ3			-4.59***	(0.24)			-4.59***	(0.27)
μ4			-3.12***	(0.17)			-3.23***	(0.20)
μ5			-2.38***	(0.17)			-2.49***	(0.20)
μ6			-0.78***	(0.17)			-0.89***	(0.20)
Log-likelihood:	-1464				-1132			
Number of observations:	942				731			
Vuong Test:	29.69				15.53			

	S2 - CCS				S3 - Nuclear			
	ZIOP				ZIOP			
	First Hurdle		Second Hurdle		First Hurdle		Second Hurdle	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Information dummy	0.13	(0.12)	-0.28*	(0.14)	0.02	(0.13)	-0.33	(0.19)
Gender	-0.11	(0.14)	-0.45***	(0.13)	-0.07	(0.15)	-0.51**	(0.19)
Age	-0.09	(0.05)	-0.04	(0.06)	-0.04	(0.05)	-0.02	(0.06)
Price sensitivity	-0.22	(0.20)	-0.38	(0.26)	-0.24	(0.22)	-0.01	(0.31)
Political party (comparison group "Labour")								
Conservative	-0.20	(0.17)	-0.08	(0.21)	0.09	(0.17)	0.04	(0.26)
Liberal-Democrat	-0.01	(0.21)	-0.31	(0.22)	0.22	(0.26)	-0.06	(0.32)
Climate change concern	0.31*	(0.13)	0.09	(0.16)	0.11	(0.14)	-0.07	(0.20)
Environmentalism	0.80*	(0.35)	0.62*	(0.31)	1.45**	(0.53)	-0.03	(0.43)
Energy dependence concern	0.01	(0.06)	-0.33***	(0.07)	-0.05	(0.08)	-0.26**	(0.10)
Energy efficiency action	0.04	(0.02)	-0.03	(0.03)	0.03	(0.02)	0.10**	(0.03)
Awareness	0.08	(0.07)	-0.02	(0.07)	0.06	(0.06)	-0.07	(0.08)
μ1			0.70	(0.43)			0.50	(0.50)
μ2			-5.06***	(0.46)			-3.39***	(0.34)
μ3			-3.51***	(0.31)			-2.62***	(0.33)
μ4			-2.73***	(0.30)			-0.65***	(0.35)
μ5			-1.04***	(0.30)				
μ6								
Log-likelihood:	-573				-440			
Number of observations:	385				300			
Vuong Test:	1.58				9.10			

In order to account for the excess zeros in the sample, the ZIOP model was used for the whole sample, as well as for the subsamples (Table 11). The results of the Vuong test indicate that the ZIOP regression fits the data better than the OP model for the whole sample, as well as the wind and nuclear subgroups. Under ZIOP, in the information dummy is again insignificant in the WTP to increase the share of wind (S1 subsample) as well as nuclear (S3 subsample). However, slight negative information effects are observed in WTP for a higher share from CCS technology and in the overall sample's WTP for their ideal mixture under the ZIOP model. The results from the ZIOP model on WTP for CCS indicate that the information provided does not influence the decision about whether to pay anything, but it does have a slight negative effect on the amount of WTP. The same pattern is observed in the analysis of WTP for the respondents' ideal fuel mixture.

Since information effects are absent in the other subgroups, it is likely that the information effect observed in the regression of the whole sample is coming from the CCS subgroup. It is not clear why the information provided would lead to lower WTP in the second hurdle, especially in the CCS subsample. The information card indicated that CCS could increase the price of coal and gas power by 20 to 40 per cent. Respondents that are price-sensitive would not choose this fuel type, in which case the informed sample should have a lower share of CCS in their electricity mixture. However, this is not the case. Information effects on the selection of fuel types was analysed in a separate series of regressions. Under both OP and ZIOP regressions the information dummy is insignificant for all fuel options. Thus, the information provided had no effect on the selection of fuel types for electricity generation.

Respondents allocating a positive share to CCS would be expected to state a higher WTP in the informed sample if they wished to support this technology, since they are more aware of the high costs associated with CCS. Information overload could explain the negative coefficient on the information dummy. Cognitively demanding information sets can confuse respondents, which may lead respondents to distort their stated valuations. The respondents who selected a higher share of CCS may have been overwhelmed by the amount of information, and become confused about the valuation for the electricity generation fuel mixture they created.

The results from the EPRG 2006 survey lead to a weak observation of information overload. From the data set it can be concluded that the information presented had no effect on the selection of fuel types or on WTP in the wind and nuclear subsamples. The information supplied also had the opposite effect than expected in the CCS subsample, who allocated a lower valuation to a mixture with CCS despite having the information about the costs associated with this technology. A stronger conclusion on information overload would have been possible if the survey had provided to part of the sample a medium level of information. However, an intermediate information set was not provided in the EPRG 2006 survey, which leads to a weaker conclusion about information overload.

The results from the ordered probit and ZIOP models also highlight a number of demographic, behavioural and attitudinal variables that influence WTP. Overall, the results from the demographic variables are consistent with those observed in previous studies.

A number of papers have found a positive correlation between willingness to pay and the level of income. The less income a person has, they are more likely to be sensitive to prices; thus it can be expected that they will be less willing to accept a higher electricity price. The EPRG 2006 survey did not contain a question on the respondent's income. Instead, a number of indirect questions were utilised to assess the respondents' sensitivity to electricity prices. An index was constructed from the responses as to whether respondents listed fuel prices as one of the most important issues facing the UK, and whether they had switched suppliers because of a lower price. As can be seen in Table 10, the price sensitivity index, as expected, is negative for the whole sample, as well as for all three subgroups; except it is insignificant for nuclear. Age also has a negative effect on WTP; older respondents are less willing to pay for these options (although the effect is insignificant for the nuclear subgroup). Gender is insignificant, except under ZIOP, in which females have a lower WTP for a mixture that increases the share of nuclear above current levels (Table 11).

Several variables were included in the analysis to assess how the behaviour and attitudes of respondents affect their willingness to pay. In terms of attitudinal variables, as can be seen in Table 10, the respondent's level of concern for climate change, as expected, had a positive effect on WTP. The number of energy efficiency actions taken by the respondent was also included in an index of energy efficiency action, which has a positive and significant effect on WTP for the whole sample and all subgroups. The respondent's prior knowledge on energy issues was tested through a number of questions in the survey. The awareness index takes into account the number of questions the respondent correctly answered. This variable is positive for all three subgroups, but is significant only for the wind subsample and the whole sample.

The environmental values of respondents are likely to influence their willingness to pay the premiums for carbon-clean options in the electricity generation mixture, such as wind, CCS and nuclear. If consumers regard some environmental problems as important, and believe that promoting a carbon-cleaner electricity will mitigate them, they will value these resources. An index of the respondent's degree of environmentalism was created in order to analyse this effect. As expected, the index is positively associated with willingness to pay for all three fuel options. Looking at the results from ZIOP in Table 11, the level of environmentalism has a positive influence, especially in deciding whether to contribute anything.

Another index was created to assess whether a person's concern about energy security would impact their willingness to pay. It is probable that if a person is more concerned about energy security then they should support renewable energy sources, since these are domestic resources and can be considered a "secure" source of supply. One would expect more concerned individuals to allocate a higher share to these sources in their "ideal" mixture, and also be more willing to pay. The Energy Dependence Concern index is positively related to selecting a higher share from wind sources. However, in both the OP and ZIOP regressions, it surprisingly has a negative influence on WTP for wind. Thus, while respondents who were more concerned about energy dependence did want a higher share from wind to increase energy security, they were less willing to pay for it. Another surprising result is that, the energy dependence concern index had a negative effect in the ZIOP model on the amount to contribute for nuclear, even though nuclear energy would increase energy security.

7 Conclusions

Utilising data from two EPRG surveys, this paper finds evidence that information affects WTP only if the service attribute in question has personal relevance to the respondent. The results from the EPRG 2006 survey also indicate that the quantity of information presented to the respondents has an effect. If the information is cognitively demanding then it may lead to information overload, and thus result in the information being ignored.

Out of the attributes considered, information effects were observed only in the case of valuation of blackouts, where the attribute in question had potential relevance to the respondents. In contrast, no information effects were found in WTP for avoidance of water service disruptions. The most likely explanation for the absence of information effects for this attribute is the low relevance of water disruptions to the respondents. Only a small fraction of the respondents had experienced a water disruption, and most ranked water services as the area least in need of attention, out of the eight general categories provided in the survey.

These findings suggest that information presented to the public should not be too cognitively challenging, and is likely to matter to the receiver only if the public has had some prior experience with the issue.

Appendices

A EPRG 2006 Survey Information Card

[HALF SAMPLE] Please read the following background information and then answer some questions about choosing amongst these alternatives:

Natural Gas:

- Gas accounts for over 90% of additions to electricity generation over the last decade.
- In the last few years, gas prices have risen substantially.
- The UK is in the process of moving from being self-sufficient in oil and gas to being a net importer over the next few years.
- To make up for the domestic shortfall, gas will either need to be imported via pipeline from Russia or as liquefied natural gas from the Middle East.
- Gas produces roughly half the amount of carbon dioxide as coal and even with the recent rise in prices, it is still the most economic option.
- Left to the market, we are likely to have more gas-fired stations built over the next few years.

Coal:

- In addition to domestic production, coal is imported from relatively stable countries such as South Africa, Australia, and Canada.
- With the rise in oil and gas prices over the last few years, coal power has become more attractive.
- Almost half of the current UK coal generation will be retired over the next few years because they would exceed European restriction on sulfur emissions.
- Those coal plants that remain have been fitted with ”scrubbers” that reduce sulfur pollution.
- Coal produces roughly twice as much CO_2 as natural gas.

Nuclear:

- Nuclear power does not produce carbon dioxide and does not contribute to global warming.
- Most nuclear power stations in the UK will be retired over the next 20 years.
- Many environmental groups remain opposed to nuclear power because of concerns over the disposal of radioactive waste, the threat of a serious accident or a potential terrorist attack.
- There are sharp disagreements over the cost of nuclear power - some companies claim they would be able to build nuclear plants at competitive prices, whereas others believe substantial subsidies would be needed.

Wind:

- Wind energy is clean - it produces no carbon dioxide or other air pollutants.
- Wind power is still relatively expensive and attracts government subsidies, but compared to other renewable energy options, such as solar or tidal power, wind power is much cheaper and is commercially viable in many situations.
- It would take several thousand wind turbines to replace a single nuclear power station or coal-fired power station.
- Some wind farms proposed for the countryside have been delayed or abandoned as a result of local opposition.
- Offshore wind would not face any local opposition or concerns over visual blight, although it is considerably more expensive than onshore wind and may pose occupational risks.
- The current generation of wind turbines is quite tall (100 meters high) and largely silent.
- Since wind is intermittent and does not blow consistently, if there is a large amount of wind installed (20-30% of total generation), there will be the need to ensure that there is ”backup” power amounting to a significant fraction of the installed wind generation (perhaps 30%)

CCS:

- Carbon dioxide capture and storage (CCS) can be applied to coal or gas-fired power plants.
- CCS would allow for continued use of fossil fuels such as coal and natural gas with a greatly reduced impact on the climate.
- The CO_2 capture process reduces the efficiency of the power plant, and is expected to capture roughly 90% of the CO_2 emitted.
- Although 90% of the CO_2 is captured, other air pollutants such as sulfur and nitrogen oxides would continue to be emitted.
- After being captured, the CO_2 would need to be piped or shipped to a reservoir and stored underground for decades, which would require monitoring.
- Adding capture technology would raise the price of coal or gas power by perhaps 20-40%, and so would be economic with subsidies the size of those currently given for wind power.

B EPRG Survey 2008 Information Cards

B.1 Avoidance of Blackouts

INFORMATION TO BE PROVIDED TO HALF THE SAMPLE

In the coming years, the UK is likely to face an electricity supply crunch. Many of the nuclear reactors that provide one-fifth of the electricity now will be closed. Many power stations running on coal are also due to close since they do not meet clean-air requirements. While renewable energy will help, it will not be able to fill the electric power shortage completely. Consequently, we have to use more natural gas to generate electricity. However, natural gas now has to be imported as UK's own natural gas resources are running out.

One outcome of the electricity generation shortfall and growing dependence on foreign energy is the likelihood of blackouts or power cuts unless we make strategic investments now to assure sustainable energy supply. These investments could take the form of clean and energy efficient technology for existing and future electricity plants and greater investment in renewable technology. However, these measures are costly investments.

B.2 Avoidance of Water Service Disruptions

INFORMATION TO BE PROVIDED TO HALF THE SAMPLE

Our need for water is rising due to population growth, demographic changes and increasing number of appliances that use water. Moreover, both the availability and the quality of water are declining due to the frequency of extreme weather and aging infrastructure. In the face of these changes, companies are facing difficulties to maintain supplies of water and already there are deficiencies reported in some regions. Measures to combat supply shortages involve costly investments.

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