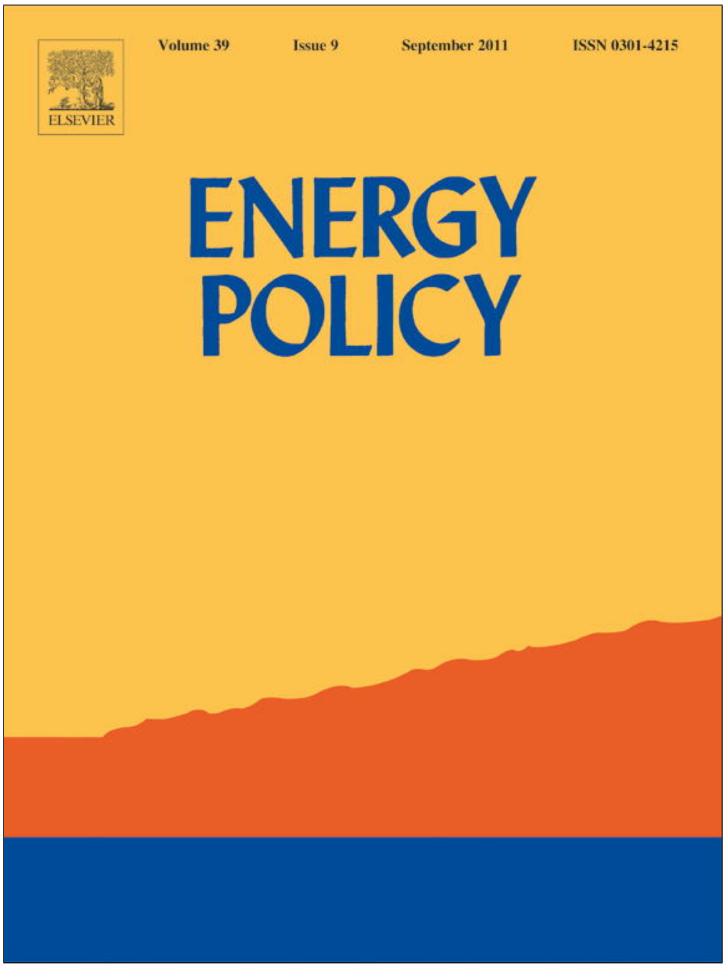
Volume 39
Issue 9
September 2011
ISSN 0301-4215
ELSEVIER
ENERGY POLICY

Energy Policy 39 (2011) 5105–5115

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Valuing energy policy attributes for environmental management: Choice experiment evidence from a research institution

Timothy M. Komarek [a,*], Frank Lupi [b,c], Michael D. Kaplowitz [d]

[a] Department of Agricultural Food and Resource Economics, Michigan State University, 20 Cook Hall East Lansing, MI 48824, USA
[b] Department of Agricultural Food and Resource Economics, Michigan State University, 301 B Agriculture Hall, East Lansing, MI 48824, USA
[c] Department of Fisheries and Wildlife, Michigan State University, 301 B Agriculture Hall, East Lansing, MI 48824, USA
[d] Department of Community, Agriculture, Recreation and Resource Studies, Michigan State University, 331 C Natural Resources, East Lansing, MI 48824, USA

ARTICLE INFO

Article history:
Received 2 January 2011
Accepted 31 May 2011
Available online 22 June 2011

Keywords:
Climate change policy
Fuel portfolio
Stated preferences

ABSTRACT

Many governments, firms, institutions and individuals have become increasingly cognizant of their impact on the environment, most notably with respect to global climate change. Coupled with the possibility of future regulations aimed at curbing greenhouse gas emissions, firms and institutions have begun to critically evaluate their own carbon footprint. This paper examines the preferences of stakeholders within a large academic institution for attributes of alternative greenhouse gas (GHG) reduction strategies. The attributes considered by constituents include: the fuel portfolio mix, effort for conserving energy use, carbon emissions reduction, timeframe for emissions reduction to be achieved and cost. We use a choice experiment technique that enables the examination of greenhouse gas reduction program attribute preferences across three constituent groups. The results show that each of the constituent groups have a positive WTP for carbon emissions reductions and prefer investments in reductions in the shorter- rather than longer-term. The results also suggest differences between the constituent groups in their WTP for types of fuels in the fuel portfolio. Finally, we use the results to examine the welfare implications of different combinations of the policy attributes that coincide with alternative GHG program strategies.

1. Introduction

Public awareness regarding global climate change has increased in recent years, and with it has come rising concern for greenhouse gas (GHG) emissions. Countries around the world are developing policies and regulations such as the Kyoto protocol and European Union Emissions Trading Scheme aimed at curbing greenhouse gas emissions. The threat of future regulation along with a desire for a 'green' image, among other reasons, has led firms and individuals to begin critically evaluating and managing their own "carbon footprint". A firm or individual's carbon footprint can be separated into the direct (primary) footprint and the indirect (secondary) footprint. The direct footprint is a measure of energy from fossil fuels used in the production of a good or service, while the indirect footprint measures fossil fuel energy used during the life-cycle of a product or service (Tukker and Jansen, 2006). The direct carbon footprint is often used in policy analyses because it is more straightforward and transparent. While strategies for managing or reducing one's carbon footprint differ across individuals, firms, and institutions, voluntary yet legally binding programs for individual firms and small government entities provide economic incentives for them to reduce their carbon footprint.

In this paper, we present results of a study into constituents' (members of an institution) preferences for attributes of alternative carbon management strategies at their institution. Using a choice experiment survey, members of a large university campus community were asked about alternative greenhouse gas reduction strategies for the institution. Study participants revealed their preferences for alternative strategy attributes. The strategies consist of different bundles of attributes of greenhouse gas reduction strategies that include: alternative mixes of fuels, varying levels of energy conservation effort, alternative carbon emissions targets, and cost. The results also allow for examination of welfare implications for different combinations of GHG reduction program attributes that make up potential investment plans. Our results show that the three groups of constituents share some preferences for attribute types, such as the desirability for lower carbon emitting fuels and shorter investment time frames. Conversely, we find significant heterogeneity between segments of our study population in terms of their willingness to pay (WTP) for increased levels of some attributes of the carbon reduction

* Corresponding author. Tel.: +1 6167804794; fax: +1 5174321800.
E-mail address: komarekt@msu.edu (T.M. Komarek).

0301-4215/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2011.05.054

strategies. Perhaps in line with expectations that faculty earn more than staff, faculty respondents appear willing to pay almost twice as much as staff for additional carbon emissions reduction.

2. Review of the literature

Researchers have used stated preference techniques to understand underlying preferences for carbon emissions. Typically this branch of valuation research has focused on consumer WTP for either climate change mitigation programs or attributes of renewable energy policy, both of which often incorporate the examination of some carbon equivalent for greenhouse gas emissions. Climate change mitigation research has examined WTP to avoid negative effects on ecosystems (Fleischer and Sternberg, 2006; Layton and Brown, 2000; Ready et al., 2006; Turpie, 2003), and animal populations (Pendleton and Mendelsohn, 1998; Tseng and Chen, 2008). Lee and Cameron (2008) considered the attributes of a carbon reduction policy by examining preferences for programs that keep climate conditions at their current levels. Those authors found that individuals are more supportive of programs that use an energy tax as well as programs that have cost shares distributed internationally.

Several studies that have examined renewable energy policy focus on the external effects such as on the environment (Alvarez-Farizo and Hanley, 2002), as well as non-environmental effects such as jobs (Bergman et al., 2006; Johnson and Desvousges, 1997), and energy security (Hartmann et al., 1991; Layton and Moeltner, 2005). Several other studies examined the payment scheme for green energy programs. For example, Kotchen and Moore (2007) used market data on green electricity programs to compare two different contribution mechanisms, and Wiser (2007) used contingent valuation methods to compare collective and voluntary payment schemes for renewable energy generation.

The type of energy production technology has been a carbon policy attribute often examined in previous research. A variety of studies considered a specific technology such as wind (Alvarez-Farizo and Hanley, 2002; Ek, 2005), or underground coal gasification (Shackley et al., 2006), and still yet others used renewable energy generation in general terms (Bergman et al., 2006; Bollino, 2009; Menges et al., 2005). Several studies have extended this literature by considering multiple technologies concurrently. Roe et al. (2001) used an experimental design that includes a mix of fuels, but they do not estimate the WTP for each energy source individually. Instead, they estimated the tradeoff for replacing fossil fuels with renewable fuels and nuclear power. On the other hand, Borchers et al. (2007) compared respondents' WTP for generic or undistinguished renewable energy with that of specific technologies such as wind, solar, farm methane, and biomass. They found a positive WTP for both generic 'green' energy as well as several individual types of renewable technologies. The only specific technology respondents preferred to generic 'green' energy was solar power.

The majority of carbon emissions research appears to examine individual or household preferences, while limited work has considered firms or institutions. The recent trend in corporate environmental management (see Besley and Ghatak, 2007) has seen businesses, non-profits, and the public sector pay increasingly more attention to their carbon footprint. Therefore, institutions and firms can benefit from feedback about their own members' preferences for environment-friendly activities, such as carbon footprint reduction strategies. Some studies have examined voluntary purchases of green power by firms and institutions. First, Wiser et al. (2001) surveyed 464 firms, and found that altruism and employee morale were important motivating factors for the firms' renewable energy purchase. However, Haar and Stanciu (2002) critiqued this finding by noting deficiencies in the survey techniques of Wiser et al., data analysis, and the difficulty of mapping individual preferences into an aggregate organizational preference function. Goett et al. (2000) used conjoint style experiments to analyze commercial and industrial customers WTP for service attributes, which included renewable energy sources. They found that consumers were willing to pay price premiums for renewable technologies, for example as much as 2 cents/kWh for a change to 100% hydroelectric power.

This paper builds upon and extends the previous literature. First, we examine the preferences for carbon management policies among various types of constituents of a large institution. Specifically, students, faculty, and staff of a large, tier 1 university that generates its own electricity and steam. These three population segments parallel both the constituencies of large private and non-profit firms as well as that of small municipalities. Furthermore, similarities can be seen in the types of mechanisms available to the university as those available to firms, institutions, and small municipalities for managing their carbon footprint. Second, we examine attributes of carbon management programs generally available to firms and institutional decision makers, which have rarely been considered simultaneously by previous research. Specifically, attributes of an institutions' energy program may include employee training, use of energy efficient technologies, and flexible investment time frames. Finally, we extend the work of Borchers et al. (2007) and Roe et al. (2001) by examining respondents' WTP for energy supplied by various production technologies. We evaluate constituents' preferences and WTP for six different energy generation technologies (i.e., fuel portfolios) together with other possible energy program characteristics for the institution.

3. Research site

The research site is a large, tier 1 university (Michigan State University) that sits on a 5200 acre campus, of which 2100 acres are developed. There are approximately 577 buildings spread throughout the campus that vary in age from new to over 100 years old. In 2009, the Michigan State University (MSU) population was comprised of approximately 47,000 students, 5000 faculty and 6300 staff. The university's governance structure parallels that of private and non-profit firms. It is overseen by a board of trustees, and administrators control the university's day-to-day operations. The university also has the ability to charge various fees to its constituents, which provides a plausible mechanism for designing a study that can quantify respondent's preferences monetarily. In fact, the university's environmental stewardship initiatives and carbon reduction targets resulted in the levying a $57 energy fee per semester on all students in 2008 and included energy fees as part of enrollment fees in 2009, the year in which we conducted our survey.

The co-generation power plant produces all of the electricity and steam for the campus. For fiscal year 2006–2007, peak levels of electricity demand were 58.4 MW, while steam demand for heating and cooling reached 537,000 lbs/h. In total, the university's emissions level for 2007 amounted to 601,579 tons of carbon equivalent emissions, and it is estimated that the power plant accounts for 96% of the university's carbon emissions (Boomer, 2008). The power plant gives the university direct control over its energy supply, and an ability to manage its carbon footprint through altering its sources of energy production. The co-generation power plant currently uses approximately 90% coal, 10% natural gas, and less than 1% biomass. The university uses steam created during electricity production to heat and cool most of the buildings on campus. In the winter, steam heats many campus buildings while in the summer, steam is used to run refrigeration units for air conditioning on campus. The heating, ventilation, and air conditioning (HVAC) system on campus requires that a baseline level of steam be produced year-round. However, the electricity demands in excess of the electricity generated to meet the steam baseline may be met with non-thermal technologies such as wind and solar. The high costs associated with changing the current steam-based heating and cooling infrastructure makes steam generation from the power plant necessary for the foreseeable future. Historically, the demand for electricity from the power plant has been greater than that generated to meet the steam needs for the HVAC system.

Michigan State University joined the Chicago Climate Exchange (CCX) in 2006 to, among other things, demonstrate its commitment to environmental sustainability and take credible actions to lower its carbon footprint. The CCX provides economic incentives for voluntary, yet legally binding reductions in greenhouse gas emissions (Chicago Climate Exchange (CCX), 2009). Each CCX member is required to reduce carbon emissions according to a reduction schedule based on emissions relative to an agreed upon baseline year (e.g., 2000). CCX members represent all sectors of the economy, including several major research universities. The university's CCX membership requires a carbon reduction target of 6% below 2000 levels by 2010. Beyond its CCX obligations, the university has pledged to further reduce carbon emissions to 15% or more below its 2000 baseline by 2015.

4. Conceptual framework

The choice experiment approach is a technique that is widespread within environmental economics with many benefits as well as potential drawbacks. Louviere et al. (2000) outlines a variety of advantages and applications for stated preference techniques. In relation to the current research, stated preference models are often advantageous when products, services or programs do not exist or are not traded within a market setting. That is, individuals are not able to reveal their preferences for a particular good or service through a market transaction. Furthermore, choice experiments allow individuals to make multidimensional tradeoffs between different characteristics or attributes. In our application, we can simultaneously investigate preferences for several different attributes of an overall carbon management strategy. While the hypothetical market created in a choice experiment enables a great deal of flexibility, nonetheless, it is also a point of contention. Mitchell and Carson (1989) describe the different types of bias that can occur using stated preference techniques, which include hypothetical bias from hypothetical choice scenarios. Therefore, choice scenarios should mimic reality so that respondents can make accurate and realistic decisions (Carson et al., 2001).

To examine respondents' preferences for attributes of carbon management policies, we employ a choice experiment method with an underlying theoretical framework derived from both Lancaster's consumer theory of demand and random utility theory (RUT). First, Lancastrian demand theory posits that utility is derived from the characteristics or attributes of a good rather than in the consumption of the good itself (Lancaster, 1966). That is, a good consists of a bundle of attributes and its value is derived by the sum of the value of the good's attributes (Louviere et al., 2000). This framework can be extended to analyze a wide array of goods and services, and in our case we use it to evaluate carbon management strategies by considering individuals' preferences in terms of strategy attributes.

Second, complementing the characteristic-based approach, we use RUT to evaluate individuals' choices among competing management alternatives. Underlying RUT is the behavioral assumption that economic agents seek to maximize their utility given their choice set. The random utility specification takes uncertainty into account by modeling the utility of a representative individual as the sum of observable and unobservable components:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

where U_{ij} is the latent, unobservable utility for the ith individual and jth alternative, V_{ij} is the observable portion of utility, and ε_{ij} is the unobservable random component of utility capturing the uncertainty. The statistical model is driven by the probability that choice j is made over alternative k, which we denote as $Y=1$ (Greene, 2003):

$$\Pr(Y=1) = \Pr(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \tag{2}$$

or equivalently:

$$\Pr(Y=1) = \Pr(V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij}) \quad \forall j \neq k \tag{3}$$

We assume the deterministic portion of utility has the form:

$$V_{ij} = \alpha X_j + \beta(I_i - p_j) \tag{4}$$

such that α is a vector of parameters for a vector of attributes X corresponding to choice alternative j. Similarly, I_i is the income of respondent i, which does not vary across alternatives and subsequently drops from Eq. (5). Note that p_j is the cost of alternative j, and β is the corresponding parameter. Therefore, we can rewrite the probability of choosing alternative j over k by combining Eqs. (3) and (4)as

$$\Pr(Y=1) = \Pr[\alpha(\Delta X) - \beta(\Delta p) > \varepsilon_{ik} - \varepsilon_{ij}] \quad \forall j \neq k \tag{5}$$

To obtain estimates for the parameters on the deterministic portion of utility we assume that the error term is normally distributed, and hence the differenced error term i.e., $\Delta\varepsilon = \varepsilon_{ik} - \varepsilon_{ij}$ is also normally distributed. For choice sets with two alternatives, this yields the probit form for the probability of choosing alternative j over alternative k:

$$\Pr(Y=1) = \Pr[\alpha(\Delta X) - \beta(\Delta p) > \Delta\varepsilon] = \Phi[\alpha(\Delta X) - \beta(\Delta p)] \tag{6}$$

where Φ is the cumulative distribution function for the standard normal distribution.

In the survey instrument, respondents were presented with three separate pairs of program alternatives that they were asked to choose between. Although there are differences of opinion on the ideal number of choice situations to present respondents in the various literatures that make use of choice experiments (e.g., Stopher and Hensher, 2000; Hensher, 2001; Arentze et al., 2003; Bradley and Daly 1994; Ortúzar et al., 2000), the number of choice scenarios is considered much less important than other choice experiment design dimensions and considerations (Caussade et al., 2005; Fenichel et al., 2009; Hoehn et al., 2010). While respondents may be able to handle many choice sets in well-designed studies, when sample size is not a limiting factor and when overall survey burden may be a concern, the use of smaller numbers of choice sets is appropriate. As Bech et al. (2011) recently reported, respondents to fewer choice (e.g., 5) sets have lower response variance compared to respondents exposed to many choice sets (e.g., 9 or 15) indicating that cognitive burden may increase with the number of choice sets presented to subjects. Since we expected large numbers of respondents and given that our study was one component of several being implemented using the Web-based survey, we decided to minimize the cognitive effort by only asking respondents three sets of choice questions.

Due to the multiple responses possible for each individual it is likely that individual specific effects carry across responses (i.e., unobserved characteristics unique to each individual can induce correlation among responses). Therefore, the random effects probit estimation technique is used (Wooldridge, 2002). From the random utility framework outlined above the model can be written as follows:

$$\Delta U_{ij} = \alpha(\Delta X_j) + \beta(\Delta p_j) + \mu_i + \varepsilon_{ij} \quad (7)$$

where μ_i represents an unobservable individual specific effect likely present in the panel data. The coefficients of the model (7) (α and β) can be used to estimate the *ceteris paribus* tradeoffs between attributes or attribute levels that respondents would be willing to make. In particular, the price coefficient can be used to estimate a WTP metric for each of the attributes or attribute levels, which is calculated as $-(\alpha/\beta)$, where α is an attribute coefficient and β is the coefficient on the price.

5. Study design

The data used in this analysis were obtained from a choice experiment survey implemented during the spring semester of 2009 that was designed to elicit university constituents' preferences for alternative carbon management strategies. The survey guided respondents through a series of information treatments that asked questions about their carbon management and energy conservation knowledge, explained the attributes, and then elicited carbon emission reduction strategy preferences. Special attention was paid to making the choice experiment credible and capable of being understood by the sample population, while enabling the answering of the policy questions at hand. Respondents were also reminded a number of times that their input would be used to shape the university's carbon management strategy.

5.1. Survey instrument development

The survey instrument was developed in multiple phases using an iterative process (Kaplowitz et al., 2004). A key part of this process was to identify and refine the set of attributes to be used in the choice experiment. The pertinent attributes were identified through interviews with administrators, physical plant staff, as well as with focus groups of students and staff. Informative interviews were held with university administrators and engineers to identify policy-relevant attributes that were or potentially could be available as part of the university's carbon management strategy. The interviews revealed that any relevant carbon management strategy for the university needed to explicitly include the power plant. Subsequently, technical experts were used to identify possible energy generation attributes and attribute levels. Focus groups with students and staff helped gauge their knowledge and understanding of energy use and carbon management strategies on campus and of alternative energy generation and conservation approaches. Following the focus groups, a survey instrument was developed and pretested in the field. This allowed for the collection of additional feedback, which along with further technical input, helped identify and refine the study's attributes and other aspects of the survey instrument.

5.2. Choice experiment attributes

In the end, five key attributes for the university's carbon management scheme were selected for the study: the mix of fuel types, the level of university energy conservation effort, carbon emissions reduction target, the year that the emissions reduction will be achieved, and the cost of an additional per semester fee per person. Table 1 describes the attributes and the attribute levels.

Table 1
Carbon management strategy attributes and attribute levels.

Attribute	Attribute level
Fuel portfolio mix	
Coal	0–100%
Natural gas	0–100%
Biomass	0–30%
Wind	0–10%
Solar	0–10%
Nuclear	0–50%
Energy conservation effort	Minimal, moderate, extensive
Carbon emissions reduction (%)	15, 17, 19, 21, 23
Year reduction achieved	2015, 2020, 2025
Additional semester fee per person	$25, $50, $100, $150

The survey instrument was designed to inform subjects about the carbon management program attributes and attribute levels before presenting subjects with program choice questions. That is, respondents were first asked to answer some simple questions at the end of specially designed information treatments on each program attribute, attribute characteristics, and possible attribute levels before they were presented with the choice questions. For example, survey respondents were informed that the university's current fuel mix varies according to relative input prices and consists of approximately 90% coal, 10% natural gas, and less than 1% biomass. They were also informed that the university's fuel portfolio is variable in the long term and that the portfolio may include coal, natural gas, biomass, wind, solar, and nuclear. The fuel portfolio mix and its innovative use in the choice experiment are described in detail in Section 5.3 on the experimental design for the choice experiment.

Survey respondents also learned that energy conservation efforts, at the university and in the survey, are comprised of two approaches—an energy education campaign and the level of conservation technology adoption. Increasing amounts of these two conservation approaches were used to describe three levels – minimal, moderate, and extensive – of energy conservation effort available to the university. The minimal conservation effort entails a general, campus-wide education campaign and upgrading of outdated appliances and fixtures. The moderate level adds targeted energy conservation training and certification for new students and additional conservation certification for all new buildings. Finally, the extensive conservation level involves the conservation training for all segments of the population and the use of technology so that all buildings on campus are certified as energy efficient. Thus, the choice experiment includes an attribute for the overall level of energy conservation effort for the campus.

In the information treatments prior to the choice experiment, the respondents learned about the university's carbon emissions and feasible time frame for reducing carbon emissions. The possible values of the carbon emissions reduction and year the reduction would be achieved are presented in Table 1. Respondents were also informed that the university was considering levying an energy fee every semester, which could range from $25 to $150, on all stakeholder groups (students, faculty, and staff) for a carbon footprint reduction strategy. A fee levied on all stakeholder groups allows us to consider tradeoffs respondents are making with money from their own budget constraints, and thus infer their willingness to pay for other carbon management strategy attributes.

Which of these strategies do you prefer?

Characteristics	Strategy A	Strategy B
Fuel Type	Coal 70% Biomass 20% Wind 10%	Coal 60% Biomass 30% Solar 10%
Energy Conservation Effort	Minimal -campus wide education campaign -upgrade outdated appliances/fixtures	Extensive -training all faculty/staff/students -efficiency cert. for all buildings
Carbon Emissions Reduction	17%	21%
Year Reduction Achieved	2020	2015
Additional Semester Fee Per Person	$50	$150

Compare the characteristics of Strategy A and Strategy B. Choose the strategy that you prefer for MSU.

☐ **Strategy A** or ☐ **Strategy B**

Fig. 1. Example of a choice set.

5.3. *Experimental design for the choice experiment*

In the choice experiment, each respondent was presented with three sets of two potential carbon management strategies. Due to the political environment in which the survey was conducted, respondents were not given the option to select a "neither strategy" response. Respondents were asked to select their preferred strategy between each pair (see Fig. 1 for an example of the choice pairs). An experimental design was used to vary attributes across respondents to allow for statistical analysis of the effect of each attribute level on the probability that an alternative strategy set is preferred.

Our experimental design accounts for actual university energy generation and conservation design constraints and the unique nature of having the fuel mix as an attribute of the choice experiment. Since the university is considering six different types of energy sources, stakeholder preferences were needed for the amount of each fuel type in the energy portfolio. University engineers and administrators identified particular thresholds (minima and maxima) for the amount that each energy source could be used. Within ranges set by engineering and infrastructure constraints (e.g., need for steam generation, inability of climate to support 100% solar or wind power), the different fuel types take on continuous levels with the percentage of each type adding up to a full energy portfolio (100%). The pertinent percentages of the overall fuel portfolio for each fuel type are presented in Table 1. By having the different fuel types vary within their feasible ranges we are able to estimate preferences and WTP for each individual fuel type. Including the more complex fuel bundle attribute in the choice experiment required a more sophisticated experimental design than the typical main-effects design for the discrete attribute levels.

The subsequent experimental design for the choice experiment incorporates both the use of an algorithm to generate the levels for the fuel type mix and a conventional main-effects design for the non-fuel attributes. First, an algorithm was created to draw levels for the different fuel types subject to both the infrastructure and adding-up constraints. Within the choice experiment the fuel types were continuous variables, except for nuclear. The nuclear option consists of building a small-scale nuclear plant on the outskirts of campus, which would provide for 50% of the university's energy consumption. In designing the algorithm for the levels for the fuel mix attributes, we minimized the amount of correlation among attributes that is induced by the adding-up constraint on fuel-mix. A table of the correlation coefficients for the fuel type variables can be found in Appendix A. For the non-fuel variables, an experimental design was used to ensure that the main effects were orthogonal. The complete choice sets were generated by combining the fuel portfolio from the algorithm approach and non-fuel attributes from main effect experimental design. Completed choice sets were then distributed randomly to each respondent.

5.4. *Survey implementation*

The choice experiment survey was implemented using a Web-based questionnaire. Web-based survey formats provide potential benefits as well as limitations vis-à-vis other survey formats (e.g., mail survey questionnaires or face to face surveys). For surveys with complex experimental designs and/or skip patterns as well as surveys that could benefit from use of graphical user interface, Web-based instruments offer advantages of computing strength that is hidden to the respondent. For example, respondent choices can be instantaneously used to update subsequent questions or question parameters. Likewise, complex choice experiment designs that might require the printing, distribution, and tracking of upwards of 50 alternative hardcopy survey booklets, can be implemented seamlessly online with Web-surveys. Furthermore, use of Web-based instruments allows for data to be automatically entered into databases avoiding the expense and possible errors associated with data entry of hardcopy survey responses. However, Web-based surveys do face a significant sampling drawback especially in general population studies. As Baker et al. (2010) have pointed out, Web-based surveys with Web panels are generally poor approaches to obtaining accurate estimates of general population opinions and survey data. However, in our

Table 2
Descriptive statistics of individual characteristics.

	Students	Faculty	Staff
% Male	44.43	58.53	37.28
# of respondents	1722	684	1673
Average age (in years)	23.92	49.08	46.02
Standard deviation	6.29	11.50	11.03
Average income	$16,442	$84,986	$45,508
Standard deviation	$23,609	$42,085	$28,272
Aware of current energy per semester fee imposed on students (%)	65.10	21.80	27.53
Aware of power plant for producing steam and electricity (%)	46.14	72.97	70.68

case, we implemented a Web-based survey with a special population that is required to use email, Web-based forms, and Web-based surveys as part of their institutional life. We found that use of the Web-based instrument worked extremely well with our three groups of institutional constituencies (students, staff, and faculty) and that response rates for these groups were in line with or exceeded previous studies.

For an accurate representation of the university population, the registrar provided the researchers with a random sample of student, faculty and staff email and mailing addresses drawn from official university records. The members of the sample populations were invited to participate in the Web-based survey during spring of 2009. The invitations informed recipients about the study and provided them with a link to the survey as well as a unique username and password. The study populations all have email and Internet access, as students, faculty, and staff at the university are expected to conduct business using the Internet. Members of the sample that failed to reply to the initial survey invitation were sent up to two more invitations. After adjusting for undeliverables, the overall response rate was about 25% (15% for students, 34% for faculty, and 49% for staff). A total of 4079 individuals responded yielding 12,086 usable choice experiment responses.

6. Data analysis and results

Table 2 reports descriptive statistics from our sample. The descriptive statistics coincide with the demographic characteristics of the three populations and general assumptions about the three populations. Faculty members on average are older than staff members. To examine the income of the constituent groups we used the midpoint of income ranges reported by each respondent. The income choices had a range of $15,000 for the levels from $0 up to the $60,000 threshold, then increased to $20,000 ranges from $60,000 up to the $100,000 threshold and end with a range of $100,000 to $150,000 and more than $150,000. The descriptive statistics show that faculty have a much higher mean income than staff, and that students are the lowest income group. Not surprisingly, students were more aware of the current energy fee than faculty and staff, while faculty and staff were more aware of the power plant's role on campus than students.

In order to examine the representativeness of the data, when possible we compared the demographic characteristics of our respondent groups with those reported by the university. As Table 2 shows, the average student age in our sample is 23.92 years old, which closely coincides with the student population average age of 23.35 years. Similarly, our student sample was comprised of 44.43% males, and the population was 45.9% male. Furthermore, we compared several demographic characteristics from our sample with data from other surveys of the same population and found similar results. Unfortunately, because of the limitations on disclosure of personal information of students and employees by the university we do not have demographic and other characteristics of individual non-respondents.

Table 3
Log likelihood for the random effects probit estimation for pooled and respondent group data.

	RE probit	LR statistic	*p*-value	Degrees of freedom
Pooled (faculty, students and staff)	−6883.7245			
Student	−2840.5676			
Faculty	−1188.4835			
Staff	−2782.593	144.16	0.0000	22
Faculty and staff	−4008.4714			
Faculty	−1188.4835			
Staff	−2782.593	74.79	0.0000	11
Faculty and students	−4047.4788			
Faculty	−1188.4835			
Student	−2840.5676	36.86	0.0001	11
Student and staff	−5658.5025			
Student	−2840.5676			
Staff	−2782.593	70.68	0.0000	11

The empirical model used in the analysis that follows is shown in Eq. (8) and is derived directly from the conceptual model in Section 4. The first five variables measure the fuel types that are a part of the overall fuel mix and are percentages that add up to 100%. Each coefficient for a fuel type variable should be interpreted relative to the fuel baseline, coal, which is left out of Eq. (8). The next two variables are dummy variables for moderate and extensive energy conservation effort and are interpreted relative to minimal effort, which is excluded from Eq. (8). The final three variables are carbon emissions reduction, year the reduction is achieved and fee. These last three variables are not interpreted relative to any other baseline variable:

$$\begin{aligned}\Delta U_{ij} = {} & \alpha_1 \Delta NaturalGas_j + \alpha_2 \Delta Biomass_j + \alpha_3 \Delta Wind_j + \alpha_4 \Delta Solar_j \\ & + \alpha_5 \Delta Nuclear_j + \alpha_6 \Delta ModerateEffort_j + \alpha_7 \Delta ExtensiveEffort_j \\ & + \alpha_8 \Delta EmissionReduction_j + \alpha_9 \Delta yearReductionAchieved_j \\ & + \alpha_{10} \Delta Fee_j + \mu_i + \varepsilon_{ij} \end{aligned} \quad (8)$$

Since the data were drawn from random samples of the campus constituency groups – students, faculty, and staff – we first test whether it may be appropriate to pool the data by comparing the pooled data to each individual segment. One reason that the constituent group's preferences might differ is that students, faculty, and staff face different incentives in responding to the choice experiment. For example, students would only pay a fee while attending the institution (4+ years) and could potentially graduate by the time a carbon reduction policy was enacted, whereas faculty and staff are more likely to face a fee for a longer time horizon and be impacted by a carbon reduction policy. Using a log likelihood ratio test (Wooldridge, 2002), we tested each possible combination of faculty, students, and staff, against the pooled data, and the results are reported in Table 3. The results show that for each possible combination of the population segments we can reject the null hypothesis that pooling the segments together is the same as treating them individually at the 99% confidence level. Thus, we report separate models for students, faculty, and staff.

6.1. Estimation results of within-group preferences

The results of the random effects probit estimation can be found in Table 4. They show that *ceteris paribus* all segments of the population prefer energy for the campus to be produced from lower carbon intensive technologies and that respondents prefer to have carbon reductions happen sooner rather than later. Not surprisingly, all constituencies prefer carbon reduction strategies to be low cost.

Fuel type: As previously discussed, the fuel portfolios for all of the choices were constrained to add up to 100%, which requires the fuel type attributes in the model be evaluated relative to a baseline fuel. Since the *status quo* fuel mix is coal intensive, we use 100% coal as the baseline fuel in our analysis. The results show that, *ceteris paribus*, all three segments of the university population most prefer the zero-carbon emitting options of wind and solar power.

Given the long term planning horizon that power plant managers consider, we were asked to include nuclear power as an option. Note that the survey was implemented before the 2011 nuclear reactor accidents in Japan. The estimation results show that nuclear power is a statistically insignificant attribute for faculty at any reasonable statistical level in comparison to an all coal portfolio. This means that faculty have the same preference for coal as they do for nuclear power. Conversely, the nuclear option was negative and statistically significant at the 5% confidence level for the staff segment, which means that staff prefer coal to nuclear power. Students had a low, yet positive preference for nuclear energy relative to the use of coal. These estimation results, along with the qualitative focus group data concerning nuclear power, suggest that there may be a generational shift in preferences concerning nuclear power. At the time of the survey, younger generations, represented by the student segment, seemed more likely to accept nuclear power as a potential greenhouse gas-neutral energy solution, while acknowledging obstacles like the transportation and storage of nuclear waste. The staff clearly prefer less nuclear and the faculty appear to be indifferent between nuclear and the baseline coal dominated portfolio. Apprehension in the older population segments toward nuclear may be due to remaining sentiment from the accident at the Three Mile Island Nuclear Plant in 1979 and memories of the Chernobyl disaster in 1986. This is supported by hedonic studies of nuclear power plants in the literature, such as Clark and Allison (1999), which find a decline in home values due to visual reminders and proximity to nuclear plants.

Energy conservation effort: Firms and others can also reduce greenhouse gas emissions by using energy conservation. On one hand, reduced energy demand can be achieved through education initiatives designed to change individuals' energy consumption habits and behaviors. On the other hand, energy demand can be reduced through the installation and use of energy efficient technologies that provide the same services with lower energy input. Each of the three conservation effort levels is used as an indicator variable with "minimal conservation" as a baseline level in the analysis. As a result, preferences for energy conservation effort should be interpreted relative to the baseline of minimal conservation. The estimation results indicate that faculty and staff do not prefer moderate or extensive conservation to minimal conservation as a greenhouse gas reduction strategy. However, students have a significant positive preference for moderate conservation effort as opposed to minimal conservation. Perhaps students believe, rightly or wrongly, that conservation may result in significant reductions in greenhouse gas emissions. At the same time, faculty and staff may believe that increased conservation may or may not work and they may be conflicted between possible disruptions to their work schedule as a result of the education initiative and the technology upgrades.

Reduction target and timeframe: The heart of any carbon management strategy revolves around two separate yet related attributes; the level of emissions reduction to be achieved, and

Table 4
Estimation results from the random effects probit model.

	Students	Faculty	Staff
Fuel type (% of total)			
Coal (baseline)	–	–	–
Natural gas	0.0124*** (0.001)	0.0128*** (0.001)	0.0111*** (0.001)
Biomass	0.0187*** (0.001)	0.0187*** (0.002)	0.0209*** (0.001)
Wind	0.0440*** (0.003)	0.0400*** (0.005)	0.0449*** (0.003)
Solar	0.0438*** (0.003)	0.0388*** (0.005)	0.0338*** (0.003)
Nuclear	0.0055*** (0.001)	0.0003 (0.001)	−0.0022** (0.001)
Energy conservation effort			
Minimal (baseline)	–	–	–
Moderate	0.0947*** (0.033)	0.0336 (0.051)	0.0340 (0.033)
Extensive	0.0546 (0.036)	−0.0049 (0.056)	−0.0516 (0.036)
Carbon emissions reduction (% of year 2000 emissions)	0.0773*** (0.004)	0.0557*** (0.007)	0.0492*** (0.004)
Year reduction achieved	−0.0382*** (0.004)	−0.0458*** (0.006)	−0.0329*** (0.004)
Fee ($ in 100's)	−0.0063*** (0.000)	−0.0045*** (0.000)	−0.0063*** (0.000)
σ_U	0.0739	0.155	0.00289
p	0.00543	0.0234	8.36e-06
Log likelihood	−2840.57	−1188.48	−2782.59
Number of choices	5140	2017	4929
Number of respondents	1722	684	1673

Standard errors in parentheses. *$p < 0.1$.

*** $p < 0.01$.
** $p < 0.05$.

the time frame in which the reduction will be achieved. Our results show that all of the university's population segments have a statistically significant positive preference for increased emissions reduction and for emissions reductions to happen sooner rather than later. These finding are further supported by another question in the survey which asked whether a target of 15% reductions by 2015 is too little, just right or too much. As Table 5 illustrates, less than 10% of students, faculty and staff think that the university's target of 15% by 2015 is too much abatement. At the same time, over one-third of the population reported that an abatement larger than the 15% target might be warranted.

Fee: Finally, the estimation results for the per person per semester energy fee show that within each group the respondents preferred carbon reduction strategies that cost them less. This result is statistically significant at the 1% lever and is consistent with our *a priori* assumptions about the constituent groups.

The estimation results from the model in Table 4 allow us to evaluate within-group preferences for each of the strategy attributes. However, since each constituency group is estimated separately the underlying variances may differ, confounding comparisons of parameter estimates between groups. However, if parameter ratios are used, any common unidentified variance will cancel out, facilitating comparison across models. Therefore, we calculate the amount that each respondent group is willing to pay for the attributes and make further comparisons between groups.

6.2. Willingness to pay [WTP]

The WTP, also called the implicit price, is defined as the rate at which a person is willing to make a tradeoff between an attribute and cost. It is the amount of money respondents would pay for a marginal increase in one of the carbon management strategy attributes (i.e., for a 1% increase in any of the fuel types; for a change in energy conservation effort in comparison to ‘‘minimal'' energy conservation effort; for a 1% change in the carbon emissions reduction; and for a 1 year reduction in the year for achieving the emission reduction). In the choice experiment, program costs are presented as an energy fee levied on all students, faculty and staff each semester. Using this fee as our payment vehicle allows us to calculate each group's WTP for the various attributes. Table 6 presents the mean WTP for the strategy attributes for each of the constituent groups. The standard errors are calculated using the delta method and appear in parentheses below each WTP value.

Fuel type: In examining the WTP for the fuel mix attributes, the values should be interpreted as the amount that respondents are WTP for a marginal (1%) increase in the fuel attribute compared to the baseline coal fuel type. The WTP values for the fuel mix shows that the faculty revealed a higher WTP for each fuel type as compared to students and staff. That respondents prefer less carbon intensive technologies such as wind and solar power. Faculty do not have a statistically significant WTP for carbon free nuclear power, while staff have a statistically significant negative WTP, implying they require compensation for nuclear power. Wind energy appears to be slightly more preferable than solar for each constituent group. For example, students are willing to pay $6.98 of a fee each semester for an additional percentage increase of wind power in the institution's overall fuel portfolio.

Energy conservation effort: The WTP values for the energy conservation effort should be interpreted relative to the baseline level of minimal effort, and yield results that are largely statistically insignificant. These WTP metrics suggest that with the exception of the student group's WTP for moderate energy conservation effort, respondents in all three constituency groups do not have a strong preference for the different levels of energy conservation effort. Due to this, we limit the discussion of preferences for energy conservation effort, and do not include it in the alternative investment policy scenarios in Section 6.3.

Reduction target and timeframe: The results reveal differences in WTP between the constituent groups in terms of their support for the amount of emissions reduction and the time frame reductions would be achieved. Students and faculty appear willing to pay $12 per semester for an increase in emissions reductions beyond the 15% university target as compared to $8 for staff members. All three groups prefer to see emissions reductions made in the near-term rather than in the distant future. The marginal WTP values show that students and staff have a WTP of −$6.09 and −$5.20 for extending the emissions target one year into the future. Put differently, they would be WTP $6.09 and $5.20 respectively for the emission reduction to be achieved one year earlier. While the faculty group is WTP $10.25 for reducing the emissions target by one year. Each constituency groups has a statistically significant WTP for advancing the emissions reduction, which shows common preference for emissions reductions in the near-term, but with some differences in WTP for how much and how fast reductions are achieved.

Table 5
A target of a 15% emissions reduction by 2015.

	Student	Faculty	Staff
Too little	36.54	36.65	34.52
Just right	60.65	58.46	59.36
Too much	2.8	4.89	6.12

Table 6
WTP per person for changes carbon management strategy attributes.

	Students	Faculty	Staff
Fuel type (% of total)			
Coal (baseline)	–	–	–
Natural gas	$1.98 (0.165)	$2.86 (0.422)	$1.76 (0.158)
Biomass	$2.99 (0.247)	$4.18 (0.610)	$3.30 (0.255)
Wind	$7.02 (0.528)	$8.95 (1.308)	$7.10 (0.534)
Solar	$6.98 (0.537)	$8.68 (1.315)	$5.35 (0.496)
Nuclear	$0.88 (0.149)	$0.07 (0.328)	−$0.35 (0.152)
Energy conservation effort			
Minimal (baseline)	–	–	–
Moderate	$15.09 (5.730)	$7.51 (12.597)	$5.37 (5.672)
Extensive	$8.69 (5.147)	−$1.10 (11.395)	−$8.15 (5.187)
Carbon emissions reduction (% of year 2000 emissions)	$12.31 (0.833)	$12.47 (1.874)	$7.77 (0.731)
Year reduction achieved	−$6.09 (0.615)	−$10.25 (1.526)	−$5.20 (0.603)

6.3. Alternative investment plans

One strength of choice based modeling is the ability to use the estimated coefficients from the econometric model and the subsequent WTP measures to assess the economic value of alternative policy scenarios. To examine some alternative policy scenarios we calculate the economic surplus of each bundled carbon reduction strategy in relation to a base scenario. We omit energy conservation effort from our scenario analysis, due to the statistical insignificance among some constituent groups and for simplicity. We calculate the economic surplus of each scenario in relation to the baseline (Bennett and Blamey, 2001):

$$\text{Economic Surplus} = -\left(\frac{1}{\beta_{Fee}}\right)(V_i - V_k)$$

V_i represents the indirect utility for the policy scenarios, where i denotes the baseline scenario and k indexes the an alternative policy scenario. We use as our base scenario an all coal fuel mix, with a 15% emissions reduction target to be reached by the year 2015. This base scenario is feasible through energy reduction and the purchase of carbon offsets, which are already used by the University, among other techniques. Since other techniques are available to the University for lowering its carbon footprint besides the attributes studied here, it is feasible to reach a 15% emissions reduction by 2015 with a 100% coal fuel portfolio. In Table 7 we consider four scenarios that are characterized by different levels of the fuel mix, reductions in carbon emissions and time frames relative to our baseline. The four policy scenarios considered were:

- *Nuclear power reactor* [A]: 25 MW of electricity, small self-contained device buried in the ground in outskirts of campus.
- *Wind* [B]: 5 MW of electricity, 2–3 large turbines each at a height of 80 m.
- *Wind and solar* [C]: 2.5 MW of electricity from 1 to 2 large wind turbines with hub height of 80 m, and 2.5 MW of solar panels installed on campus buildings.
- *Fuel switching* [D]: Using 30% less coal by building a small biomass facility to use energy crops in current boilers and use of more natural gas.

The welfare measures in Table 7 can be interpreted as how much the average member of each constituent group would be WTP per semester for each scenario instead of the baseline. For example, staff members welfare change would be $91.62 for hypothetical scenario B, which includes 10% of the fuel portfolio coming from wind power and a 21% reduction in the university carbon footprint to be achieved 11 years from the survey date. Our scenarios suggest that option B, only increasing the share of wind power generation on campus yields, the highest welfare gains for all of the constituent groups. Option C, switching fuels from coal to natural gas and biomass, is the second best scenario for the employee groups (faculty and staff), while students prefer the renewable energy in either B or C. It is also easily verified that the nuclear option is the least preferable option for campus constituents, yielding low welfare effects for faculty and negative effects for staff. The negative WTP effect by the staff group suggests that they would have to be paid $7.34 for the nuclear option over the baseline.

7. Discussion and conclusions

In response to the changing global climate, social and political pressure, and the threat of future regulation, firms and individuals have begun to critically evaluate their carbon footprint and contemplate changes. The heterogeneity of firms and institutions can present challenges in generalizing results across sectors and industries. Nonetheless, there are several aspects of carbon management policy that can apply to many firms, institutions, and municipalities. Our results examine several key attributes of carbon footprint reduction strategies and shed light on the preferences for them by students, faculty and staff at a large, research intensive university. In particular we examine the fuel mix that energy is generated from, a notion of energy conservation effort on the part of the firm or institution, the amount of carbon emissions being reduced and an investment time frame. Use of a choice experiment approach allows us to analyze constituents' WTP for either different levels or marginal changes of each attribute. We also use the WTP metrics to examine welfare implications for four alternative investment strategies.

Our results show that each of the constituent groups have a positive WTP for carbon emissions reductions and prefer investments in reductions in the shorter- rather than longer-term. We did find differences between the segments in the amount that they are willing to pay for increased reductions, with students and faculty willing to pay approximately 60% more than the staff. We also found that none of the constituent groups hold a strong preference for having extensive levels of energy conservation, even though technology upgrades and education campaigns would most likely have the most influence on their daily lives. Because our definition of the intensity of conservation effort included both the intensity of behavioral modifications and the intensity of technological changes, we suspect, but cannot be sure, that the constituents' lack of preference for some of the conservation effort levels reflects an aversion to high levels of behavioral change. In future efforts, it would be interesting to separate these two types of conservation effort.

A unique component of our analysis was our treatment of the university's fuel portfolio within the choice experiment. We created an algorithm for the fuel portfolio to draw percentages of each fuel (coal, natural gas, biomass, wind, solar, and nuclear) that simultaneously met engineering feasibility constraints and create full portfolios adding to 100%. The study results show that given the institutional and engineering constraints of the

Table 7
Willingness to pay (in $'s) for selected carbon management strategies.

Scenarios	Baseline	A Nuclear	B Wind	C Wind and solar	D Fuel switching
Attributes					
Fuel portfolio change	100% Coal	50% Nuclear	10% Wind	5% Wind, 5% solar	15% Biomass, 15% natural gas
Carbon footprint reduction	15%	23%	21%	23%	19%
Time frame	2015	2025	2020	2025	2020
Welfare change					
Students	–	$81.58	$113.61	$107.58	$93.34
Faculty	–	$0.76	$113.07	$85.41	$104.23
Staff	–	−$7.34	$91.62	$72.41	$80.98

Table A1
Correlation matrix for generated data.

	Coal	Natural gas	Biomass	Wind	Solar	Nuclear
Coal	1.000	−0.417	−0.220	−0.099	−0.105	−0.534
Natural gas		1.000	−0.374	−0.183	−0.164	−0.283
Biomass			1.000	0.003	−0.001	−0.002
Wind				1.000	−0.010	0.017
Solar					1.000	0.005
Nuclear						1.000

university, stakeholders across the board have the highest WTP for marginal increases in use of lower carbon fuels, especially carbon free wind and solar power. We also found relatively low WTP for nuclear power as a source of electricity in comparison to the other carbon free technologies among students and a negative WTP relative to coal for nuclear power for the staff.

Due to the unique nature of our constituent group and the policy focus of our attributes for firm decision making one should use caution in directly comparing our WTP results with the extant literature. In general, our findings support the previous literature. For example, our results for the different fuel types show a higher WTP for wind and solar power. This result matches Borchers et al. (2007) findings that households have the highest WTP for solar, generic green energy, and wind power, and Goett et al. (2000) that find industrial customers are willing to pay a premium for a mix of renewables within their energy portfolio. Similarly, Roe et al. (2001) find that several of their constituent groups are WTP more for emissions reductions that stem from renewables. Furthermore, our positive WTP for university constituents for carbon emissions reduction is also consistent with WTP for greenhouse gas reduction found in Longo et al. (2008).

The survey results have been well received by the MSU Office of Finance and Operations and the MSU Office of Campus Sustainability. As of 2011, the results of the study are being used by an energy steering committee tasked with designing goals and strategies for university's energy future. The survey results have helped this planning effort focus on things such as the inclusion of renewable energy. In particular, Michigan State University has recently installed solar panels on several buildings and increased use of biomass in the university's power plant.

Acknowledgements

We thank the Michigan State University Office of the Vice President for Finance and Operations for funding the research on which this paper is based. We also appreciate the support of MSU AgBio Research and the MSU Environmental Research Initiative. We thank Laurie Thorp, Felix Kwame Yeboah, and Aimee Wilson for helpful comments and assistance.

Appendix A

A table of the correlation coefficients for the fuel type variables can be found in Table A1.

References

Alvarez-Farizo, B., Hanley, N., 2002. Using conjoint analysis to quantify public preferences over the environmental impacts of wind farms. An example from Spain. Energy Policy 30, 107–116.
Arentze, T., Borgers, A., Timmermans, H., Del Mistro, R., 2003. Transport stated choice responses: effects of task complexity, presentation format and literacy. Transportation Research 39E, 229–244.
Bech, M., Kjaer, T., Lauridsen, J., 2011. Does the number of choice sets matter? Results from a Web survey applying a discrete choice experiment. Health Economics 20, 273–286.
Baker, R., Blumberg, S.J., Brick, J.M., Couper, M.P., Courtright, M., Dennis, J.M., Dillman, D., Frankel, M.R., Garland, P., Grovers, R.M., Kennedy, C., Krosnick, J., Lavrakas, P.J., 2010. Research synthesis: AAPOR report on online panels. Public Opinion Quarterly 74 (4), 711–781.
Bennett, J., Blamey, R. (Eds.), 2001. Edward Elgar, Cheltenham, UK.
Bergmann, A., Hanley, M., Wright, R., 2006. Valuing the attributes of renewable energy investments. Energy Policy 34, 1004–1014.
Besley, T., Ghatak, M., 2007. Retailing public goods: the economics of corporate social responsibility. Journal of Public Economics 91, 1645–1663.
Bollino, C.A., 2009. The willingness to pay for renewable energy sources: the case of Italy with socio-demographic determinants. Energy Journal 30, 81–96.
Boomer, L., Environmental Engineer, Michigan State University. Personal interview. 11 December 2008.
Borchers, A.M., Duke, J.M., Parsons, G.R., 2007. Does willingness to pay for green energy differ by source? Energy Policy 35, 3327–3334.
Bradley, M., Daly, A.J., 1994. Use of the logit scaling approach to test rank-order and fatigue effects in stated preference data. Transportation 21, 167–184.
Carson, R.T., Flores, N.E., Meade, N.F., 2001. Contingent valuation: controversies and evidence. Environmental and Resource Economics 19 (2), 173–210.
Caussade, S., de Dios Ortuzar, J., Rizzi, L.I., Hensher, D.A., 2005. Assessing the influence of design dimensions on stated choice experiment estimates. Transportation Research Part B: Methodological 39, 621–640.
Chicago Climate Exchange (CCX) 2009. Available from 〈http://www.chicagoclimatex.com/〉 (accessed 1 June 2009).
Clark, D.E., Allison, T., 1999. Spent nuclear fuel and residential property values: the influence of proximity, visual cues and public information. Papers in Regional Science 78, 403–421.
Ek, K., 2005. Public and private attitudes towards "green" electricity: the case of Swedish wind power. Energy Policy 33, 1677–1689.
Fenichel, E., Lupi, F., Hoehn, J., Kaplowitz, M., 2009. Split-sample tests of 'no opinion' responses in an attribute based choice model. Land Economics 85, 349–363.
Fleischer, A., Sternberg, M., 2006. The economic impact of global climate change on Mediterranean rangeland ecosystems: a space-for-time approach. Ecological Economics 59, 287–295.
Goett, A.A., Hudson, K., Train, K.E., 2000. Customers' choice among retail energy suppliers: the willingness-to-pay for service attributes. Energy Journal 21, 1–28.
Greene, W.H., 2003. Econometric Analysis, Pretince-Hall fifth ed.
Haar, L., Stanciu, L.N., 2002. Comment upon "Public goods and private interests: understanding non-residential demand for green power". Energy Policy 30, 1357–1361.
Hartman, R.S., Doane, M.J., Woo, C.K., 1991. Consumer rationality and the status-quo. Quarterly Journal of Economics 106, 141–162.
Hensher, D.A., 2001. Measurement of the valuation of travel time savings. Journal of Transport Economics and Policy 35, 71–98.
Hoehn, J., Lupi, F., Kaplowitz, M., 2010. Complexity in stated choice experiments: the effect of information formats on estimated variances and choice parameters. Journal of Agriculture and Resource Economics 35, 568–590.
Johnson, F.R., Desvousges, W.H., 1997. Estimating stated preferences with rated-pair data: environmental, health, and employment effects of energy programs. Journal of Environmental Economics and Management 34, 79–99.
Kaplowitz, M., Frank Lupi, Hoehn, J., 2004. Multiple-methods of developing and evaluating a stated preference survey for valuing wetland ecosystems. In: Presser, S. (Ed.), Questionnaire Development, Evaluation, and Testing Methods. Wiley, New Jersey, pp. 503–524.
Kotchen, M.J., Moore, M.R., 2007. Private provision of environmental public goods: household participation in green-electricity programs. Journal of Environmental Economics and Management 53, 1–16.
Lancaster, K.J., 1966. New approach to consumer theory. Journal of Political Economy 74, 132–157.
Layton, D.F., Brown, G., 2000. Heterogeneous preferences regarding global climate change. Review of Economics and Statistics 82, 616–624.
Layton, D.F., Moeltner, K., 2005. The cost of power outages to heterogeneous households. In: Scarpa, R., Alberni, A. (Eds.), Applications of Simulation Methods in Environmental and Resource Economics. Spring, Dordrecht, pp. 35–54.
Lee, J.J., Cameron, T.A., 2008. Popular support for climate change mitigation: evidence from a general population mail survey. Environmental & Resource Economics 41, 223–248.
Longo, A., Markandya, A., Petrucci, M., 2008. The internalization of externalities in the production of electricity: willingness to pay for the attributes of a policy for renewable energy. Ecological Economics 67, 140–152.
Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. Stated Choice Methods: Analysis and Application. Cambridge University Press, Cambridge.
Menges, R., Schroeder, C., Traub, S., 2005. Altruism, warm glow and willingness-to-donate for green electricity: an artefactual field experiment. Environmental and Resource Economics 31, 431–458.
Mitchell, R.C., Carson, R.T., 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Johns Hopkins University Press, Baltimore, MD.
Ortúzar, J., de, D., Roncagliolo, D.A., Velarde, U.C., 2000. Interactions and independence in stated preference modeling. In: Ortúzar, J.de D. (Ed.), Stated Preference Modeling Techniques. Perspectives 4. PTRC, London.

Pendleton, L.H., Mendelsohn, R., 1998. Estimating the economic impact of climate change on the freshwater sportsfisheries of the Northeastern US. Land Economics 74, 483–496.

Ready, R., Fisher, A., Guignet, D., Stedman, R., Wang, J.C., 2006. A pilot test of a new stated preference valuation method: continuous attribute-based stated choice. Ecological Economics 59, 247–255.

Roe, B., Teisl, M.F., Levy, A., Russell, M., 2001. US consumers' willingness to pay for green electricity. Energy Policy 29, 917–925.

Shackley, S., Mander, S., Reiche, A., 2006. Public perceptions of underground coal gasification in the United Kingdom. Energy Policy 34, 3423–3433.

Stopher, P.R., Hensher, D.A., 2000. Are more profiles better than fewer. searching for parsimony and relevance in stated choice experiments. Transportation Research Record 1719, 165–174.

Tseng, W.C., Chen, C.C., 2008. Valuing the potential economic impact of climate change on the Taiwan trout. Ecological Economics 65, 282–291.

Tukker, A., Jansen, B., 2006. Environmental impacts of products—a detailed review of studies. Journal of Industrial Ecology 10, 159–182.

Turpie, J.K., 2003. The existence value of biodiversity in South Africa: how interest, experience, knowledge, income and perceived level of threat influence local willingness to pay. Ecological Economics 46, 199–216.

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.

Wiser, R.H., Fowlie, M., Holt, E.A., 2001. Public goods and private interests: understanding non-residential demand for green power. Energy Policy 29, 1085–1097.

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, MA.