WILLINGNESS TO PAY FOR ELECTRICITY SOURCED FROM NATURAL GAS EXTRACTED USING HYDRAULIC FRACTURING: LOCATION AND PREFERENCE HETEROGENEITY

by

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ABSTRACT

This study uses a choice experiment to measure the welfare impacts of electricity generated by natural gas from hydraulic fracturing. Our model estimates how proximity and location to drill sites and the Marcellus Shale impact willingness to pay. Our results from an Internet survey of New York State residents indicate that residents exhibit, on average, a negative willingness to pay for that electricity source. In addition, all subsamples of residents incur disutility on average, but those who live in counties within the Marcellus Shale have the greatest disutility. New York State residents' mean WTP ranged from a decrease in their monthly electric bill of $22 to $48 depending on proximity and whether they resided in a county within the Marcellus Shale Play. For comparison, the average electric bill was $124, so the negative impacts of hydraulic fracturing are perceived to be substantial by New York State residents.

Chapter 1

INTRODUCTION

Lauded as a domestic source of "cleaner" electricity but excoriated as environmentally dangerous, current policy debates about hydraulic fracturing reflect strong emotions. For the economist, however, little information exists about the benefits of hydraulic fracturing. Hydraulic fracturing has been used commercially as a means of extracting natural gas from shale formations since 1949 (Bateman 2010). However, new technological developments—specifically hydraulic fracturing coupled with horizontal drilling—have renewed commercial interest, and it is rapidly developing throughout various domestic and global shale plays. The Marcellus Shale in the Northeast U.S. has attracted the most attention for its size and potential gas reserve (Arthur et al. 2008), but also for the population density.

Hydraulic fracturing has been linked to a number of negative environmental externalities, including large water requirements during drilling, groundwater contamination from hydraulic fracturing chemicals, and a number of other concerns (NYS DEC 2011). Yet, natural gas has numerous positive environmental externalities and potential impacts on local economies as it is also the least harmful of the fossil fuels because: (1) it burns cleaner and emits a smaller fraction of carbon and particulates than coal and oil; (2) it provides a domestic source of energy (U.S. EPA

2007); and (3) may have large, positive impacts on local economies and employment (NYS DEC 2011). Externalities from hydraulic fracturing, positive and negative, are market failures in which the private cost to energy companies are not equal to the cost that society bears. This inequality cannot be corrected without market interventions, such as subsidies or taxes. Hydraulic fracturing is a case in which positive and negative externalities are both present; and therefore, achieving efficiency is extremely difficult, as it depends on the size of each externality. See appendix A for an extended background of the problem and summary of the positive and negative externalities associated with hydraulic fracturing.

Without a large, systematic research undertaking, it is difficult to conceptualize how the external benefits and costs of increased hydraulic fracturing would substitute for those arising from the exploration and use of other energy sources. Exploratory efforts are needed, simply, to enumerate the welfare impacts of increased hydraulic fracturing. Direct benefits most likely accrue to owners and employees of energy exploration and distribution companies, as well as those who sell mineral rights. These use values are more easily quantified than the indirect impacts incurred by those who receive “energy independence” and air quality benefits and also those who value the ecosystem services that are impaired by hydraulic fracturing. In sum, hydraulic fracturing may have positive and negative net social benefits on households—even those households that are not directly affected by hydraulic fracturing itself. This study is exploratory in that hypothesized net impacts are not known, a priori, and, thus, a flexible examination is used to allow empirical testing for potential positive and negative economic effects. To narrow the problem, this study focuses on the payment vehicle of household electricity, which can be supplied by natural gas from hydraulic fracturing, and restricts the sample to populations in and out of hydraulic fracturing counties in New York State.

Economists use choice experiments to estimate the welfare effects of environmental quality changes with large nonuse components. In recent years, a large number of green energy studies have used these methods, often with household electricity as the payment vehicle. U.S. studies generally find that households are willing to pay a premium for electricity from green energy sources such as wind, solar, and biomass (e.g. Roe et al. 2001; Borchers et al. 2007; Scarpa and Willis 2010; Oliver et al. 2011; Susaeta, et al. 2011). International studies find similar results in regards to consumers exhibiting positive WTP for green energy sources for electricity (Scarpa and Willis 2010; Oliver, et al. 2011; Gerpott and Ilaha 2010; Yoo and Kwak 2009). Menegaki (2008) provides a literature review of green energy valuation studies. Choice experiments have also been used to measure energy sources that are more traditional but have green and alternative energy characteristics (Solomon and Johnson 2009; Giraldo, et al. 2010; Sanders, et al. 2010; Jensen, et al. 2010; Aguilar and Zhen 2010; Johnson, et al. 2011). In addition to estimating benefits, choice experiments also estimate other attributes of green energy sources such as respondents' distance from the energy site. Studies show that welfare from green energy varies with location (Krueger, et al. 2011; Ladenburg and Dubgaard 2009; Meyerhoff, et al. 2010; Bergmann, et al. 2008; Navrud and Braten 2007). Similar results were found for active users (boaters near offshore wind) versus less active users (Ladenburg and Dubgaard 2009).

We were not able to locate any existing choice experiments about hydraulic fracturing. Studies do exist on natural gas, in general, as a fuel source, finding both positive and negative preferences. Choice experiments have found that consumers are willing to pay a premium for domestic natural gas supplies for its energy security and reliability (Damigos, et al. 2009). However, a choice experiment (Groothius et al. 2008) and hedonic literature exists for welfare associated with the story of wind power (Heintzelman and Tuttle 2012; Koundari et al., 2009) and a few studies were located on natural gas. Literature estimates that property values decrease as proximity to sour gas wells, wells containing an increased level of Hydrogen Sulfide (Boxall, et al. 2005), and gas refineries increases (Flower and Ragas 1994).

Although there is little evidence about the nonuse economic benefits of hydraulic fracturing, several recent non-economic examinations of hydraulic fracturing exist. Studies show that hydraulic fracturing in local communities will have both positive and negative implications for jobs, revenue, cost of living, and the natural environment (Alter, et al. 2010; Williamson and Kolb 2011; Christopherson and Righter 2011). A 2009 survey of landowners within 1,000 feet of active wells suggests that economic impacts are about 23,000 new jobs and $3.2 billion dollars for that year for the state, less than what past studies had expected (Kelsey, et al. 2009).

Economists use choice experiments to estimate the impacts on household utility of the various attributes that compose an environmental quality change. This study is framed as estimating the welfare impacts of household electricity consumption generated from conventional fuel mixes versus an intervention where the mix shifts to natural gas from hydraulic fracturing. The hypothesis to be tested is whether mean willingness to pay (WTP) for electricity from hydraulic fracturing differs from conventional sources and, if so, whether it has a net positive or negative impact on welfare. A second hypothesis is whether there is statistical heterogeneity in mean WTP for electricity from hydraulic fracturing. The third and fourth hypotheses involve the effect of household proximity to hydraulic fracturing wells on WTP. Proximity is conceptualized as: (1) a measure of distance to drill sites; and (2) whether the household is located in a county within the shale region versus the remainder of New York State. Proximity effects are examined because households near hydraulic fracturing are more likely to enjoy the direct use impacts and endure the disamenities. As with all of our hypotheses on WTP for electricity from hydraulic fracturing, we as researchers held no a priori beliefs about whether average net welfare impacts were positive or negative.

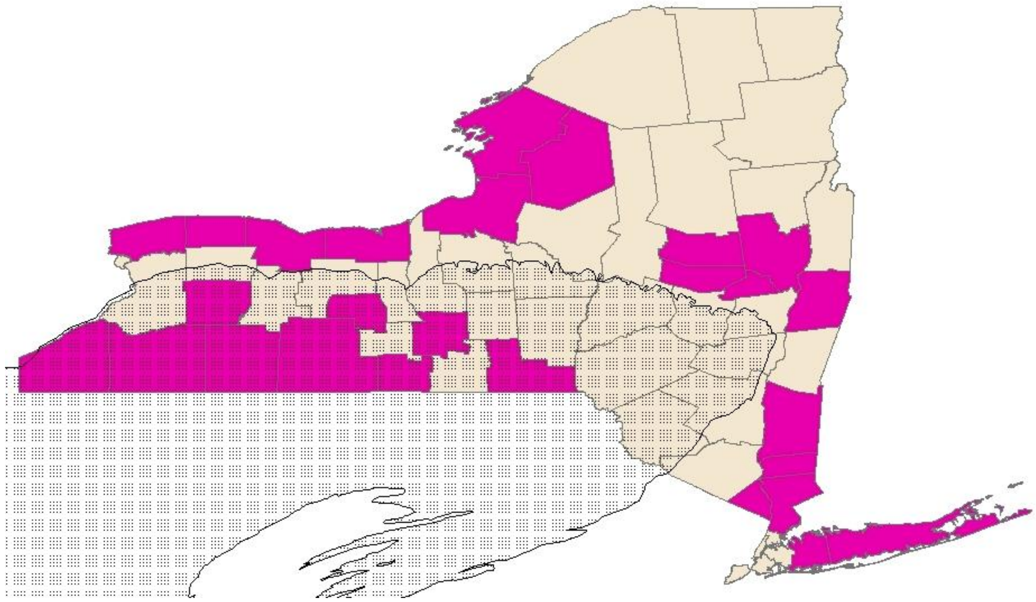
To the authors' knowledge this is the first economic valuation study for electricity generated by natural gas extracted via hydraulic fracturing. This next section of this article describes the economic model, framing of the valuation scenario, choice experiment, experimental design, sample, and estimation procedure. The third section presents the results of the estimation and welfare calculations. The final section discusses the results in terms of policy and offers conclusions.

Chapter 2

METHODS: CHOICE EXPERIMENT PROCEDURES

2.1 Choice Experiment Instrument and Choice Model

A survey instrument, “Willingness to Pay for Hydraulic Fracturing in New York State,” was designed specifically for this study to elicit residents’ WTP for changes to electricity costs associated with natural gas from hydraulic fracturing in the Marcellus Shale. As seen in figure 1, the Marcellus Shale extends from western New York State (NYS) through Pennsylvania, Ohio and West Virginia, and is approximately 95,000 square miles (Arthur et al. 2008, 2009). It is estimated to have 168 – 516 trillion cubic feet of natural gas trapped, the approximate energy equivalent of 28-88 billion barrels of oil (NYS DEC 2010). Enumeration occurred in May 2011, coinciding with a NYS temporary moratorium on new wells (Perkins 2011). Although some wells had been dug and were active, no new horizontal hydraulic fracturing wells could be drilled.



[1] Counties selected for the survey are highlighted. Source: NYS GIS Clearinghouse 2007
[2] Only the Marcellus Shale boundary is shown. Source: U.S. Energy Information Administration 2011b

Figure 1: Map of New York State Counties Surveyed[1] and the Marcellus Shale[2]

A major challenge of this research was to connect local and regional hydraulic fracturing to household welfare in a way that applies to a large majority of households. As in several other green and conventional energy studies (Roe et al. 2001; Borchers, et al. 2007; Yoo and Kwak 2009; Zografakis, et al. 2010; Susaeta, et al. 2011; Damigos, et al. 2009), the WTP scenario selected was to alter household electricity bills. The scenario is designed to mimic decisions about real life tradeoffs. Econometric analysis of respondent choices reveals the sample's underlying utility for the environmental amenity/disamenity and trade-offs among its various attributes. Arrow et al. (1993) proved that contingent valuation techniques are a systematic and appropriate approach to measuring non-use values, a method that was held up in court systems. Standard choice experiment procedures are used to guide this stated preference valuation exercise, including reminding respondents that money spent on environmental quality changes could not be used for other expenditures, that their answers should be on behalf of their household, and that the payments would occur/accrue as changes to their utility bills. The choice experiment is based on the well-known random utility model, which assumes that utility can be modeled in separate observable and random components (Adamowicz et al. 1998; Boxall et al. 1996; Hanley et al. 1998). Although the random component is unobservable to the investigator, the model assumes that there is no systematic tendency in the random component that biases the estimated results. Stated preference methods, such as the choice experiment used here, are critical tools for valuing environmental changes with large welfare impacts attributable to nonuse values (Hanley et al. 1998). Choice modeling allows for estimating the marginal contribution to utility from changes in attributes such as electricity cost and proximity to hydraulic fracturing wells. See appendix B for the economic theory of the RUM.

In our experiment, respondents choose among three options: two hypothetical options for electricity and a status quo option. The options include varying distance of drill sites from their household, the source of their household electricity, and a change to their monthly electric bill. The status quo option was presented in every choice set and represents electricity consumption as it is now for the household. Figure 2 presents an example of one of the survey choice sets.

You said that you pay $100. Your current electricity source is largely fossil fuel. Now consider only the following options, as proposed for your county. How would your household vote?

	Option A	Option B	Option C
Source	Natural gas from Hydraulic Fracturing	Natural gas from Hydraulic Fracturing	Largely Fossil Fuel
Your new monthly electric bill	$ 75 *(25% less)*	$ 125 *(25% more)*	$ 100 *(No change)*
Distance of drill site from your household	50 miles	250 miles	No Drilling

- I would choose Option A and pay 25% less on my household electric bill
- I would choose Option B and pay 25% more on my household electric bill
- I would choose Option C

How certain are you that the option you chose would be the one you would make if you had to make a real decision that involved your real energy source and real money?

- 1 I am completely unsure which option I would choose
- 2
- 3
- 4 I think I would choose my choice, but I am not completely sure
- 5
- 6
- 7 I am fairly sure that I would choose my choice
- 8
- 9
- 10 I am 100% certain that I would choose my choice

Figure 2: Sample Survey Question

2.2 Experimental Design

Environmental quality changes are expressed as different levels of electricity/hydraulic fracturing attributes. The change to the electric bill was presented as a percent change to the respondents' self-reported current average monthly electric bill: -25%, -10%, -5%, +5%, +10%, +25%, or +50%. The respondents first reported their bill, and, then, viewed these levels as both the percent change and their new electric bill in dollars after the change. The status quo alternative was the only time respondents viewed the level of "no change" in their electric bill. The negative and positive percentage changes provide the flexible format for testing the hypothesis that electricity from hydraulic fracturing provides either a net amenity or disamenity. In addition, by adjusting the current bill up or down by a percentage less than 100, the experimental design enables researchers to maintain a WTP format—a best practice in choice experiments—rather than introducing possibilities for willingness to accept compensation. See appendix F for a sample of the survey those who reside outside of the Marcellus Shale counties.

Utility also is hypothesized to depend on the source of a respondent's electricity and the distance of a drill site from the respondent's home. The experimental design is shown in figure 3. The source of electricity was presented as either "Natural Gas from Hydraulic Fracturing" in the non-status quo options or "Largely Fossil Fuels" in the status quo only. For the non-status-quo options, the drill site distance from a respondent's household was presented as a "near" or a "far" option. The specific distances (in miles) were dependent on whether the respondent resided in a county within the Marcellus Shale region or a county outside of the shale play. If the respondent resided within a hydraulic fracturing county, the distances were selected to be either 1 mile or 20 miles, thus capturing those who would be most likely to incur the negative local impacts of hydraulic fracturing such as small earthquakes and water contamination. The "near" distance also potentially captured the possibility of selling mineral rights. If respondents resided outside of hydraulic fracturing counties, then the options were presented as either 50 miles or 250 miles. At these distances, the positive and negative direct effects were assumed to be invariant. However, the "near" level of 50 miles but outside of a hydraulic fracturing county, allowed the possibility to commute for employment and positive impacts on the local economy. The "far" level of 250 miles was modeled to capture no direct impacts on the household, and, thus, it would capture pure nonuse impacts and test hypotheses about the perceive nonuse utility/disutility of hydraulic fracturing. No drilling was always the status quo option.

Attributes	Levels
Cost	-25% -10% -5% +5% +10% +25% +50% No Change*
Source	Natural gas from Hydraulic fracturing "Tradition Fossil Fuel" *
Distance	Near: (1mile – in / 50 miles – out) Far: (20 miles – in / 250 miles – out) No Drilling *

* = status quo option only

Figure 3: Experimental Design

Experimental design was used to select the choice sets presented to respondents (Hensher et al. 2005). Each respondent would select among hydraulic fracturing choices A or B and also the status quo of "neither." This study uses one of the simplest designs—the full factorial design—resulting in 49 possible choice sets of which each respondent saw four. The 49 choice sets were derived from two levels of distance, one source, and seven levels in the household electric bill; $(2x1x7)^2 = 196$ combinations (see figure 3 for all attributes and levels). After eliminating mirrored pairs (upper diagonal), duplicates (the diagonal itself), and cost-dominated pairs (within the lower diagonal), 49 A/B/Neither choice sets remained. Among the 49 choice sets, the researchers attempted to preempt potential ordering impacts by making each hydraulic fracturing option (A and B) the most expensive option exactly half the time—and an empirical test subsequently found that option A was no more likely to be chosen. When the cost was equal for A and B, then the "near" and "far" attribute was randomized so that each was first one-half of the time. The survey software then selected, at random, four choice sets for each respondent to see. The choices were designed balanced ex-ante, but responses and respondent certainty could not be controlled; thus the design was not expected to be perfectly balanced ex post. Although the regression will control for unbalanced response patterns, we nevertheless examined ex post balance. When accounting for response and certainty, 67% of choice sets used in the final data were selected from within 10% of expected rates. Another 24% were selected from at 11-18% greater or lower rates than expected ex ante. Three sets were selected from at 20% bias, and one set was 81% greater rate than anticipated.

2.3 Sampling

A surveying company with whom the researchers' University has an agreement, Qualtrics, provided web-based survey software and a sample. Qualtrics uses pre-secured samples via email addresses, and these samples are progressively contacted until a desired sample is drawn (Strauss, et al. 2011). Although representativeness is not assured ex ante—as with a competing service—access to the sample is much less expensive to purchase and representativeness can be assessed ex post by comparing the sample to known population demographics. Qualtrics reports that 991 surveys were started and 754 were completed. Among the 754 completed surveys, some were screened as not an adult decision maker, resulting in a final sample of 515 households from 27 different counties in New York State. The response rates (completed divided by started) were 68% and 41% for the in-hydraulic fracturing and out of hydraulic fracturing counties, respectively.

The researchers made several important design decisions in formulating the scenario of electricity from hydraulic fracturing natural gas. There was no affordable way to identify a sample in the regions that used natural gas for heating (the figure is 52% in New York) (U.S. Census Bureau 2011) nor could researchers determine what mix of fuels delivered electricity to any given household or even county. So, the researchers decided to focus on electricity because almost all households would be electrified and mixes of fuels including natural gas generate electricity. In 2010, natural gas constituted the largest share at 35.7% of the electric fuel mix in New York (US Energy Information Administration 2012); see table 1 for the residential electricity mix in New York State. This evidence collectively suggests that respondents would find believable and salient the intervention of using hydraulic fracturing natural gas to supply their electricity. To ensure this salience, a final decision was made to focus on only counties where natural gas was common. Specifically, 27 counties were selected based on a map of New York State created by the Northeast Gas Association (2012), which indicated that at least 50% of the towns in the county were serviced by natural gas. To differentiate counties in and out of the hydraulic fracturing region, the researchers excluded counties that encompass the border of the Marcellus Shale play. All five counties of New York City were excluded from this study because policy idiosyncrasies, population density, and urban living patterns suggested differences too great to warrant later pooling of the data with the up-state counties. Two different surveys were distributed, one to those who live in counties within the Marcellus Shale region (9 counties) and one to those who live in the remainder of the state (18 counties). Figure 1 highlights the counties that were chosen for the survey and their location to the Marcellus Shale Play.

Table 1: New York State 2010 Total Electricity Mix

Source[1]	Percent
Coal	9.9%
Petroleum	1.5%
Natural Gas	35.7%
Nuclear	30.6%
Hydroelectric	18.6%
Other Renewables	3.5%
Other	0.6

[1] U.S. Energy Information Administration, 2012

The household was the unit of analysis because respondents answered on behalf of their household and the informant was screened to be an adult decision maker of their electricity bill. Among the unweighted sample, 53% were female, 51 was the mean age, 53 was the median age, and 38% had an associate's or bachelor's degree. Researchers decided not to ask for the respondent's income because: (1) it was not central to the empirical choice experiment estimation; (2) it is correlated with education, which was surveyed; and (3) it would potentially lead to incomplete/abandoned surveys. There were minimal differences (less than 3%) between the unweighted and weighted[1] demographic statistics of the survey. Table 2 compares the sample versus Census statistics for the state. The sample largely, but not perfectly, reflects the population, suggesting potential but not necessarily substantive nonresponse bias. The Census indicates that all of New York State is 51.6% female, 26.5% have an associate's or bachelor's degree, and the median age is 46 (U.S. Census Bureau 2010). It is not unusual in choice experiment surveys to find that older, more educated people tend to respond.

[1] Both population weights were considered

Table 2: Sample and Census Statistics

	Sample*	State[1]
Female	53.0%	51.6%
Age (Median) **	53	46***
Associate or Bachelor's Degree	38.2%	26.5%
Graduate Degree	28.2%	13.8%
Mean Electric Bill	$120.44	$114.39[2]

[1]U.S. Census Bureau 2010
[2] U.S. Energy and Information Administration 2011b
*Unweighted
**Of adults,18 years and older, and electric-bill decision makers
***Calculation by authors from Census data.

2.4 Estimation

The most recent choice experiment research estimates the random utility model using mixed logit (ML) because it provides a number of advantages over the multinomial or conditional logit estimation. ML: (1) alleviates the need for the independence of irrelevant alternatives assumption; (2) allows for estimation where individual respondents deliver multiple observations (in this case, four); and (3) allows for testing for and measuring heterogeneity (Hensher and Greene 2003, p.135-136, p.159, p.136). From the estimated ML coefficients, researchers may calculate estimated WTP using simulation techniques, including the underlying distribution of parameter estimates (Poe et al. 2005). Unlike the technique of calculating WTP as a part-worth--or implicit marginal rate of substitution between the utility of an increased attribute level and money—this research compares the monetized utility of a world with the policy that improves an attribute level and the monetized utility of a world without that change (the status quo). This approach is more appropriate for comparing welfare associated with two states of the world (with and without electricity from hydraulic fracturing), in contrast to studies examining small welfare changes associated with marginal adjustments in an environmental attribute where part-worth calculations would be more appropriate. The with/without calculations are made through the simulation of the convolution of parameter space, finding the mean of the simulations and taking the mean (Poe et al. 2005).

Several other augmentations were made in light of recent evidence about best practices in choice experiments. Only a brief treatment is offered in this paper because these augmentations are of greater interest to economists concerned with choice experiment design. First, some researchers worry that respondents may overestimate their WTP in stated preference surveys, a phenomenon known as hypothetical bias. Following each of the four choices that respondents made there was a follow up question regarding respondent certainty (Ready et al. 2001; Blumenschein et al. 2008; Li and Mattsson 1995; Morrison and Brown 2009; Whitehead and Cherry 2007). For this survey, the authors followed recent work by Ready, et al. (2010), asking on scale of 1 - 10 how certain they are that they would make this decision in real life if they had to use real money, with 1 being not certain at all and 10 being completely certain. See appendix D for further discussion of hypothetical bias.

Second, recent literature suggests that respondents may not consider all attributes when making decisions in choice experiment, known as Attribute Non-Attendance (AN-A) (Hensher 2006; See Mariel, et al. 2011 for a summary of studies on AN-A). Systematic consideration of AN-A has been shown in some cases to lead to a better fit model. For this study, after making four choices, each respondent was asked to select the attribute of least importance to them. The results show little variation among respondents' attributes of least importance: 33.95%, 34.73%, and 31.31% indicated source, change to monthly household electric bill, and distance to be the attribute, respectively. From this we conclude there is not one single attribute that was systematically ignored so we make no further assumptions on it.

Chapter 3

RESULTS

This section assesses model fit. Opinion data about hydraulic fracturing helps inform researchers of the predispositions of respondents, apart from the choice experiment, and the salience of the choices. Then, model fit and quality is assessed statistically. The results of the choice experiment are presented—first in terms of the ML estimation and, then, with respect to welfare. Appendix C elaborates on the mixed logit model and model specifications for this research.

3.1 Opinion Results

The choice experiment scenario is meaningful only when the respondents have an understanding of the environmental amenity and its quality attributes. In this survey, 84% of respondents who lived in hydraulic fracturing counties indicated that they had heard of hydraulic fracturing prior to the survey. This contrasts with only 44% of outside of the Marcellus shale county respondents. Each respondent was then presented with basic information regarding hydraulic fracturing in New York so as to provide a minimum level of information for the choice experiment.

There is evidence that the respondents understood the attributes. For instance, on a scale of 1 (“extremely important”) to 6 (“not at all important”), 63% of respondents ranked “may lead to contamination of local groundwater” as extremely important. Respondents felt strongly about both the pros and cons of hydraulic fracturing, almost always ranking each option as “somewhat important” or greater. The results of the qualitative questions are presented in table 3. The Likert scale provides evidence that the impacts of hydraulic fracturing (both positive and negative) resonated with respondents because they ranked the qualities as important to them. The opinion results also show that the negatives presented to the respondents were almost always ranked as more important than the positives. That said, the Likert scale is not a controlled preference and only the mixed logit can tell use the relative importance of those attributes.

Table 3: Opinion Results

Likert Scale Questions[1]			
	Inside Shale County	Outside Shale County	Test of Differences of Means
	Mean Response (Std. Dev.)	Mean Response (Std. Dev.)	T- Value
It is a domestic source of energy	2.29 (1.20)	2.10 (1.13)	1.849 *
Natural gas is better for the environment than other fossil fuels	2.28(1.09)	2.11 (1.04)	1.810 *
It may bring jobs to the county	2.44 (1.20)	2.05 (1.15)	3.764***
It may lead to contamination of local ground water	1.57 (0.94)	1.61 (0.97)	-0.478
The process uses a lot of water	2.31(1.13)	2.34 (1.22)	-.290
It may increase truck traffic	2.71 (1.26)	2.92 (1.34)	-1.833*
	Yes, No, I don't know	Yes, No, I don't know	
Taking all this into consideration, do you support hydraulic fracturing?	31%, 40%, 29%	35%, 33%, 32%	

[1]1= Extremely Important, 2 = Very Important, 3= Somewhat Important, 4=Somewhat Unimportant, 5 = Very Unimportant, 6 = Not at all Important
***= 2.852, ** = 1.965, * =1.648 Critical T- Values at the 1%, 5% and 10% levels at which you reject the null hypothesis

3.2 Model Fit

This study will focus on ML3[2], which discarded any response that was made under less than "fairly certain" conditions, i.e., less than 7. For ML3, 30% of the observations were discarded in the estimation, the equivalent decrease of about 150 respondents. The model explains choice using designed attributes (cost, distance, source, whether the respondent lived in a hydraulic fracturing county), a status quo alternative (known as the alternative specific constant or ASC), and observed heterogeneity measures interacted with the ASC (age, education, and gender), described in table 4. It was a pooled model, with a dummy variable, *Incounty*, for the county region of the respondent, in or out of the shale region. The interaction effects of *Incounty* with each of the demographics were examined, but they lacked evidence of statistical significance and, thus, are not included in the final estimation.

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[2] Three models were estimated to examine respondent-choice certainty and examine potential hypothetical biases associated with stated preference surveys. ML1 was estimated without regard for respondent certainty. ML2 followed Ready et al. (2010) and automatically calibrated any response indicating a certainty level of less than 7 as opting for the status quo.

Table 4: Model Variable Descriptions and Summary Statistics

Variable Name	Description	Mean Value*	Min	Max
Cost	Change to monthly electric bill	4.84	-125	250
Incounty	Indicator for residence within the Marcellus Shale region	0.50	0	1
Distance_Near	Indicator for proximity to a well site (effects coded)	0.00	-1	1
Neither (ASC)	Indicator for the status quo	0.33	0	1
	Demographic Variables			
Age	Continuous variable for age	51.09	19	82
AgeSquared	Continuous variable for age*age	2802	361	6724
Edu_College	Indicator for education attainment	0.38	0	1
Edu_Grad	Indicator for education attainment	0.28	0	1
Female	Indicator for gender	0.53	0	1

The model was estimated in LIMDEP and had indicators of good fit. The null hypothesis on the joint significance of the model in explaining choice was rejected in a chi-square test ($p<0.0001$), and the pseudo r-square was 0.412. The model was weighted to account for the over sampling of those who live in hydraulic fracturing counties and the under sampling of those who live outside of the shale region[3]. This model was chosen as the best for further evaluation in this study; most coefficients were statistically significant despite the discarded data and respondent certainty suggests higher-quality choice data. Table 5 presents the model parameter estimates. See appendix E for the estimates of all three ML models.

[3]For ML1 and ML2 data corresponding to those who live in and out of the shale counties were assigned a weight of 0.23 and 1.76, respectively. For ML3 data corresponding to those who live in and out of the shale counties were assigned a weight of 0.21 and 1.84, respectively. The weights are calculated such that they average to one and do not create new data. For ML1 and ML2: $260w_i + 255w_o = 515$; Residents inside the shale counties (only considering the population of the in shale counties surveyed) constitute just 11.23% of the population (of the total counties surveyed) but 50.49% of the sample. Hence, $50.49\, w_i = 11.23$. Solving these two equations gives you the weights. For ML3: $186w_i + 173w_o = 359$; $51.81\, w_i = 11.23$. Solving these two equations gives you the weights.

Table 5: Parameter Estimates

	ML3	
Variable	Parameter Estimates	Std. Error
Random Parameters		
Neither	-7.733***	2.983
Distance_Near	-0.200**	0.090
Non – Random Parameters		
Cost	-0.067***	0.012
Parameters on Heterogeneity in Status Quo Utility		
NXIncounty	1.298*	0.752
NXFemale	1.316***	0.459
NXAge	0.285**	0.131
NXAgeSquared	-0.002	0.001
NXCollege	0.425	0.557
NXGrad	1.601***	0.580
Standard Deviation of Random Parameters		
Neither	3.516***	0.350
Distance_Near	0.645***	0.147
N = 1425		
Psuedo R- Squared = 0.412		
Chi – Squared (11 d.f.) = 1282.617		

***, **, * = Significance at the 1%, 5%, and 10% levels

3.3 Mixed Logit Estimation

ML3 coefficient estimates are used to interpret the relative importance of each attribute in impacting the average respondent's utility for the environmental intervention of using hydraulic fracturing gas for electricity. As expected, there was statistical evidence to reject the null hypothesis that the coefficient on cost was zero, and this impact was negative. Cost was presented to the respondent as both a percent change to their monthly electric bill and the new electric bill total for each month after that change, in dollars. Of the respondents included in ML3 50% chose the status quo when making their choices, 8% chose the cost increasing option, and 42% chose the cost decreasing option. The average monthly electric bill (weighted for ML3) for in shale counties and out of shale counties was $107.76 and $126.97, respectively. The *Cost* variable in the regression was the change to the monthly electric bill, in dollars. The results mean that more expensive electricity produces lower utility, on average.

The evidence on *Distance_Near* suggests that the closer a respondent is to a hydraulic fracturing drill site, the lower the average respondent's utility. The *Distance_Near* variable was "effects coded" with the more-distant option (either 20 miles if you lived in a hydraulic fracturing county or 250 miles if you live outside of the shale region) as the reference level (Bech and Gyrd-Hansen 2005). Bech and Gyrd-Hansen (2005) recommend effects coding instead of standard dummy variables in choice experiments to avoid frequent misrepresentations of the impact of the reference level of a dummy variable. See appendix E for the model estimates when the distance variable is modeled as a dummy variable, *Near_HydFracturing*. In turn, effects coding enables the proper estimation of welfare below. The parameter estimate of *Distance_Near*, which is effects coded, is equal to the difference of that parameter from the grand mean of all observations, which in this case is zero. In addition to the disutility found with proximity, the model also estimated the standard deviation on *Distance_Near*. This result shows that there is statistical heterogeneity in this *Distance_Near* result, suggesting that some have greater utility impacts than the mean shows while others have less utility. The results also show that 65% of respondents with the average demographics will have decreased utility from having a well near their households, and 35% of the respondents of the same average demographics will gain utility from having a well closer.

Evidence suggests the status quo indicator/ASC, *Neither*, has a negative effect on utility; however, it is difficult to interpret the ASC impact by itself and all else equal, and so many choice experiment papers do not discuss it. See Adamowicz, et al. (1998) for discussion of the ASC. Though *Neither* is estimated as negative it has been interacted with the socio-economic demographics. And when one accounts for the *Neither* parameter capturing the effects of all the other variables it is interacted with, the summation is positive, indicating preference for the status quo. The estimation also included a measure of heterogeneity in the ASC, which was the estimated standard deviation of *Neither*. The results show that there is statistical evidence for heterogeneity in utility associated with the status quo, all else equal. Of respondents of the average demographics, 69% will find the status quo utility increasing and 31% will find the status quo utility decreasing when controlling for cost.

The utility (or disutility) derived from hydraulic fracturing is also a function of the observed heterogeneity in the sample, as expressed as demographics interacted with the ASC. Evidence is available about the heterogeneity in received utility for the status quo between residents of hydraulic fracturing counties and residents of counties outside the shale region, using the indicator variable *Incounty*. The interaction of this variable with the ASC, *NxIncounty*, allows one to conclude that all else equal those respondents from hydraulic fracturing counties have higher utility for the status quo—which does not involve using hydraulic fracturing gas for electricity.

Among the demographic interactions with the ASC, several conclusions can be drawn. Respondents with potential use values were retained in the sample[4]. When household informants are female, a greater utility was found for the status quo. The age measures indicate that older respondents gain higher utility from the status quo,

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[4] The results should capture some direct use value of respondents. The survey asks respondents if they have ever, or expect to, gain employment or enter into a contract with a gas company. To examine this effect, we estimated the model with an indicator variable for a respondent who has, knows someone who has, or plans to benefit from hydraulic fracturing now or in the future. This estimate was significant, decreased the absolute value of all other parameters by less than a tenth and did not change any levels of significance. Respondents with potential use values are included in the final sample because they are a part of society and their non-use values should not be excluded. Further, it was decided that it would be difficult to interpret these results for use in policy if all respondents with use values were excluded.

but we cannot make conclusions on the impact of age on utility as age increases. The education variables (less than college, *College*, and *Grad*) indicate that respondents with a graduate degree had a stronger preference for the status quo than those with less schooling. Both of the lower two education categories were statistically indistinguishable in terms of their utility, with no net utility or disutility from hydraulic fracturing or status quo.

3.4 Welfare Analysis

The results of the parameter estimates can be used to calculate the mean WTP for electricity from natural gas extracted via hydraulic fracturing. The results in table 6 consistently show that hydraulic fracturing for electricity would make the average electricity consumer in New York State worse off. The smallest (absolute value) point estimate is -$21.84 for out-of-county residents who are farthest from the site (250 miles). This means that on average, their electricity bill would have to be lowered by $21.84 per month to make them indifferent (equalized monetized utility) between the status quo and a world where hydraulic fracturing was used to supply natural gas for electricity. The largest point estimate was -$47.63 for the average in-county residents who were near drill sites (1 mile). The intermediate distance groups had point estimates between these two extremes. Thus, in terms of point estimates on welfare, hydraulic fracturing electricity lowers all average household welfare but lowers it more the closer the household is to the site.

Table 6: WTP Estimates

	WTP per HH within shale counties				WTP per HH outside shale counties			
	Model 3 (ML3)							
Distance	Mean	Std. Dev.	10%	90%	Mean	Std. Dev.	10%	90%
Near	($47.63)	4.16	($53.32)	($42.08)	($27.76)	3.93	($32.96)	($22.78)
Far	($41.71)	4.21	($47.28)	($36.16)	($21.84)	3.89	($26.94)	($17.10)

Although these average results show a consistent pattern, there is heterogeneity between the groups. One way to test for this is using the 10th and 90th confidence intervals of the mean WTP within a group (following Poe et al 2005). When this form of heterogeneity is considered, all groups (for combinations of proximity and location) still have substantively negative welfare for hydraulic fracturing electricity. The 90th percentiles of the confidence intervals are all below $0, with the smallest (absolute value) being -$17.10 for the average out-of-county residents far from drill sites.

One can also look for statistically significant differences among the groups by determining if the 10th and 90th confidence intervals of any one group's welfare overlap another's. For the group within shale counties, there is a (small) overlap between the intervals on near and far, which suggests that welfare does not differ econometrically within this group. The same result is found for residents outside of shale counties. However, when one looks at the near results alone, there is an econometric difference between the welfare in and out of shale counties. The same result is found for the far results. This means, on average, more monetized disutility accrues from being near drill sites when the average respondents are in a hydraulic fracturing county relative to when they are outside a hydraulic fracturing county. The same result is found for being far from drill sites.

Chapter 4

DISCUSSION AND CONCLUSION

A choice experiment survey of over 500 households in 27 New York counties allowed estimation of household willing to pay (welfare) for electricity generated by natural gas extracted via hydraulic fracturing in the state. The analysis also allowed separate estimation of the effect on welfare of: (1) distance from households to drill sites; (2) whether households were in the Marcellus Shale region; and (3) demographic characteristics. The choice experiment has a high-degree of power in explaining nonuse values associated with hydraulic fracturing and also explains some use values. The welfare analysis indicated that on average households in New York incur a welfare loss from hydraulic fracturing as the source of their electricity. The welfare loss is substantive, approximating one-fifth to one-half of their monthly electric bill. In addition, the results were robust to various controls on proximity of the surveyed households to the potential hydraulic fracturing drill sites.

The results of the benefits calculation indicate that hydraulic fracturing for an electricity source is negative and will make electricity consumers worse off on average. For those who live closest to a well and within a shale county, the average electricity consumer would need to be compensated by about half of their electricity bill in order to be indifferent. Those who live furthest away from a well and out of shale counties would need to be compensated by 17% of their electric bill. The WTP estimates are not statistically different within regions however, the estimates of each proximity across regions indicated that those who live closer to a well site require additional compensation. That being said, parameter estimates indicate heterogeneity exists across populations depending on if they reside within a hydraulic fracturing county; those within the Shale region have a stronger preference for the status quo. Heterogeneity similarly exists across all demographic sub samples, females and the well-educated have a stronger preference for the status quo than their counterparts.

As with any choice experiment, several qualifications are in order. First, choice experiments may be viewed as inaccurate because they use hypothetical data. This study addressed potential hypothetical bias by implementing recently developed certainty protocols and discarding data where respondents did not indicate a high level of certainty. Second, although the point-estimate welfare estimates vary slightly with model specification, they are consistently different than zero and negative. Setting aside challenges to the choice experiment approach and econometric debates, it would be difficult to interpret the data as suggesting that on average New York residents favor (see utility in) hydraulic fracturing. Third, the results address nonuse values most fully, but use values (direct impacts) on households are captured only in part. It could be that omitted direct values are substantively positive. Future research should consider this in conducting a benefit-cost analysis. Fourth, the magnitude of the negative results was somewhat surprising to the researchers, who designed the instrument to allow for either positive or negative values. Replication and extensions are needed from other researchers to examine this exploratory work.

A comprehensive answer about the economic efficiency of hydraulic fracturing in New York would require a fully specified benefit-cost analysis. This work offers relatively comprehensive evidence on nonuse values. However, the evidence on use values could potentially omit large use benefits that accrue to the people who find employment, people who sell their mineral rights, and people who have invested in the company. There are two reasons for this potential omissions (1) the limited sample was unlikely to capture many if any the small number of large beneficiaries nor was the choice experiment designed to elicit the benefits the magnitudes that these beneficiaries were likely to receive; (2) the large scale benefits calculation would be extremely sensitive to the number and location of drill sites. These sites will largely be determined in the future after the temporary moratorium is lifted and the number and distribution of drill sites becomes known. Because the number and distribution are unknown, and the survey was not designed to capture large scale beneficiaries, any attempt to conduct the comprehensive BCA using the CE survey data in this paper would be systematically biased against hydraulic fracturing.

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Appendix A

EXTENDED BACKGROUND AND PURPOSE

Domestically, the U.S. produces the majority of the natural gas it consumes. Texas produces about a third of domestic natural gas (31%), followed by deep water offshore wells in the Gulf of Mexico (11%). Other natural gas producing states include Wyoming (11%), Oklahoma (8%), and Louisiana (7%) (U.S. Energy Information Administration 2010). Natural gas is being harvested from shale formations across the country: the Barnett Shale formation in Texas (the standard for shale gas production, in which all else are modeled after), the Haynesville Shale in Arkansas, and the Marcellus Shale of the Appalachian Mountains (Arthur et al. 2008; Brown and Krupnick 2010). These shale gases are some of the cleanest forms of natural gas and are greatly abundant throughout the country, but until recently had been the most difficult to extract (Arthur et al. 2008).

Hydraulic fracturing was first used in New York in the early 19th century when natural gas was able to be extracted from just a few feet below the surface (Frantz and Jochen 2005), but the technology – a more primitive form than what it is today – did not become common to the region until the 1980s (Arthur et al. 2008). This technique is not unique to just the Appalachia region or shale plays, and some may consider it the method of choice for most petroleum wells – utilized in more than 90% of gas wells and 70% of oil wells (Economides et al. 2007). The new hydraulic fracturing technique of interest is a process in which wells are drilled vertically down into the earth and then horizontally out beneath the surface. The well is then stimulated by pumping fluids down the well at extremely high pressures inducing seismic activity. This creates tiny fractures beneath the earth. The fluid that is sent down the well is a mixture of mostly water and proppant, a combination of sand and chemicals that is unique to each gas company (Frantz and Jochen 2005). The natural gas is then captured from the fractures and extracted. This technology increases the permeability of the shale yielding high rates of natural gas production and lowering costs (Brown and Krupnick 2010).

The energy industry is exploring and drilling wells across the entire Marcellus Shale formation, New York, Pennsylvania, Ohio, and West Virginia, with the majority of well development, at the present time, occurring in Pennsylvania (Arthur et al. 2008, 2009). New York State is progressing at a much slower pace, and as of recently all new well development has been halted. NYS Gov. David Patterson in late 2010 signed a bill that has put a temporary moratorium on the exploration of new natural gas wells that would use hydraulic fracturing drilling techniques (Perkins 2011). The temporary moratorium in New York State required additional environmental investigation before further development of the technology could proceed in the State’s shale resources. In June 2011 the bill was extended by the New York Assembly for an additional year and future decisions regarding hydraulic fracturing will depend on the results of the final environmental impact statement, additional studies, and public commentary (Wiessner 2011). This is in contrast to Pennsylvania which is considered a “High Volume Hydraulic Fracturing” state, companies use high volumes of water for hydraulic fracturing coupled with horizontal drilling, and it is reported that there are more than 4,000 gas wells in the Marcellus Shale wells in Pennsylvania (Griswold 2011). No new permits were to be issued until the completion of the state’s most recent final environmental impact statement in mid-2011 (Perkins 2011). As of March 2012 further decisions regarding the moratorium are dependent on further comment and draft reviews of the state’s environmental impact statements in which it received over 13,000 public comments (NYS DEC 2012)

There are a number of negative externalities which hydraulic fracturing imposes on environment. The fracturing process of a single well requires between 2.4 to 7.8 million gallons of water for each extraction process (NYS DEC 2011). In addition, there is a risk of potentially contaminating ground and drinking water due to leaked chemicals from during the fracturing process (NYS DEC 2011). The drilling process in question may also cause increased levels of methane to leak into local ground water sources (Pennsylvania DEP 2009). This would make water unsafe to drink, and high levels of methane trapped in unventilated spaces and water wells could lead to an explosion (Pennsylvania DEP 2009). In addition to water requirements and contamination concerns, the high-pressure injection of water into the wells will cause earthquakes underground (NYS DEC 2011). This seismic activity may range from undetectable to small earthquakes that can be felt at the surface (NYS DEC 2011). Despite worrisome reports from a number of state governments, and ongoing investigation into the chemicals used and other potential hazards of hydraulic fracturing by the U.S. Environmental Protection Agency, the hydraulic fracturing process was deemed exempt from the Safe Drinking Water Act, the Clean Water Act, and the Clean Air Act (Bateman 2010).

Though possibly imposing social costs on the environment, there are potential positive economic and environmental externalities from increased natural gas production and consumption, and more specifically doing so via hydraulic fracturing. Not only is natural gas considered a clean energy it is also a domestic source of energy. On a more local scale, hydraulic fracturing could potentially create positive community development and economic growth. Hydraulic fracturing development and expansion creates jobs and increases state revenue through development to the region and taxes and fees from energy companies (NYS DEC 2011; Kelsey, et al. 2009). Residents have the potential to directly benefit from hydraulic fracturing in the state. Financial gain is possible for citizens of the area by leasing their mineral rights to gas development companies. Landowners whose property lies above a shale gas deposit may be approached by an energy company to lease, receive royalties for, or receive other forms of payments for the mineral rights to drill beneath their property (Pennsylvania DEP 2010). Kelsey et al. (2009) surveyed landowners, local business owners, and government officials in Pennsylvania and used spatial data to determine the overall economic impact in the state. The study examined all aspects of economic development in regards to hydraulic fracturing employment, contracts for leasing land, and how that money is spent in the state. Results suggest that though less than what was previously estimated, the Marcellus Shale industry as a whole, will have a significant impact on employment and the economy but those impacts will spread over multiple years.

It is difficult to determine society's overall opinion of this controversial technology and its impacts. Many times the efficient outcome is not the privately optimal outcome. Traditional energy sources, fossil fuels that are primarily coal, create negative externalities and therefore their marginal private cost is less than their cost to society. Cleaner energies (like renewables and natural gas) tend to have a higher market price but lower external costs. Natural gas extracted from the Marcellus Shale using hydraulic fracturing exhibits both positive and negative social and environmental externalities and therefore one must elicit households' willingness to pay for shale gas to determine if an individual's willingness to pay is positive or negative. Considering externalities allows one to account for the unpaid costs and benefits that this technology may have on the environment and society.

Appendix B

ECONOMIC THEORY

This study will use a choice experiment to measure respondents' utility for household electricity generated by natural gas extracted via hydraulic fracturing. Using the Random Utility Model (RUM) it is assumed that an individual's utility for natural gas from hydraulic fracturing is the result observable components, attributes and parameters of natural gas from hydraulic fracturing, and an unobservable component, a stochastic component not captured from the survey The economic model used to measure utility of household electricity generated by hydraulic fracturing of natural gas, based upon the RUM is as follows:

$$U_{ij} = V_{ij} + \mathcal{E}_{ij}$$

Where *U* is the utility and is a measure of an observable component V of each alternative i (containing both options A and B, and the status quo option) by individual j and an unobservable component Ɛ. Assuming individuals are utility maximizing, the probability of choosing j is

$$\text{Prob } j = \text{Prob } (U_{ij} > U_{im}, \forall j, j \neq m)$$

Following Hensher and Greene (2003), the IID assumption of the mixed logit (ML) allows for correlation across observations but not within the error term. To account for this the error term is divided into two parts (1) accounts for correlation and (2) assumes IID for all observations:

$$U_{ij} = V_{ij} + [\ \eta_{ij} + \mathcal{E}_{ij}]$$

$\mathcal{E}_{ij}$ is considered IID for all alternatives and is not dependent on the data or parameters (Hensher and Greene 2003, p. 135).

Again, following the notation of Hensher and Greene (2003) the logit probability estimated at parameter B is

$$L_{ij}(V|\ B, \eta_{ij}) = \frac{\exp(V_{ij}(B)+\eta_{ij})}{\sum_{n=1}^{N}(V_{ij}(B)+\eta_{ij})}$$

The observed utility is conditional on the parameter (B) and η_{ij}. However, to account for the non-linear relationship, the probability model is estimated for all values of η_{ij} and weighted by its density, "$f(\eta_{ij}|\Omega)$ where Ω is the fixed parameters of the distribution" (Hensher and Greene 2003, p. 135).

$$Pij\ (V, \Omega) = \int L_{ij}(V|\ B, \eta_{ij})\ \ f(\eta_{ij}j|\Omega)d\eta_{ij}$$

Appendix C

THE MIXED LOGIT MODEL

The Mixed Logit (ML) model is the most appropriate estimation method for this study as it overcomes many of the limitations of the more tradition multinomial logit model. The main difference between the two is that mixed logit models relax the independence of irrelevant alternatives assumption, a problematic assumption for economists. ML recognizes that each individual leads to multiple observations (i.e. socioeconomic descriptors) and therefore observations are correlated. The error term in ML models assumes individual and identically distributed (iid) and accounts for correlation between parameters (Hensher et al. 2005).

The flexibility in assumptions of the ML allows for the measurement of preference heterogeneity as defined by the random parameters (Hensher et al. 2005). Heterogeneity demonstrates the differences between individuals and the choices they make. It can either be captured in the attributes presented in the choice experiment or in the stochastic error component, as the latter is unobservable (see Greene and Hensher 2006 for further explanation). Random parameters, through attributes of the environmental intervention in question, accommodate for correlation across alternatives, aiding in revealing heterogeneity within the sample population (see Hensher and Greene 2003).

Each attribute were assumed to have a normal distribution as there are customers who have preference for it and some who do not (Goett, et al., 2000). The distribution of the random parameters is important in the estimation of the model and cause of great concern but as stated in Hensher et al. (2005) “Distributions are essentially arbitrary approximations of real behavior” (p. 612).

Nonrandom parameters are the portion of the model that reveal the individual characteristics of the respondent, socio-economic demographics and the monetary change they would see from the random attributes. *Cost* was entered linearly as the change (in dollars to the monthly electric bill. The range of changes spanned both negative and positives and therefore a log linear model was inappropriate. Interacting the socio-demographic variables: age, gender, and education with ASC is evidence that with statistical significance, preference heterogeneity around the mean is present (Hensher and Greene 2003).

Appendix D

HYPOTHETICAL BIAS

In agreement with literature regarding the presence of hypothetical bias in choice experiments (see Ready et al. 2010 for a summary of past literature), our results show that WTP estimates are overstated when certainty is not accounted for. Three models were estimated to examine respondent-choice certainty and prevent some hypothetical biases associated with stated preference surveys. ML1 was estimated without regard for respondent certainty. ML2 followed Ready et al. (2010) and automatically calibrated any response indicating a certainty level of less than 7 as opting for the status quo. The results of all three estimations are in appendix E. The benefits that were calculated from ML3 were compared to ML1, in which certainty was disregarded completely. Estimating the full data set and ignoring respondent uncertainty shows that respondents are worse off when hydraulic fracturing is the source of their electricity, but less worse off than when only considering those who are at least somewhat certain of their decision. The WTP estimates for ML1 are significantly different within and across county regions. On average WTP estimates for ML1 were greater; people were between $7-$1 less worse off than when just considering those with the greatest certainty in their choice.

The difference in certainty across respondents can be seen among certain sample population groups and may help to explain the heterogeneity that exists. Females were more uncertain than men in making their decisions. This is especially noticeable in regards certainty in choosing the non-status quo option. In making any choice, the average women's certainty was a 6.93 relative to the average men's 7.418. For ML3 this shows that many of the women's choices were not included in the estimation. When making a decision in which one opted for hydraulic fracturing, women were even less sure of their responses, averaging a certainty level of 6.127 compared to men who averaged a certainty of 6.995. This disparity in confidence between males and females is evident in the parameter estimates which indicate women have a stronger preference for the status quo than men.

Education levels within the sample also reveal differences in certainty in their decisions. Against what one would expect, those with a graduate degree were less certain of choosing the hydraulic fracturing (non-status quo) option than their counterparts with an Associate's or Bachelor's degree (6.22 versus 6.887, respectively). However, those with graduate degrees were more certain overall of their responses relative to those with an Associate's or Bachelor's degree (7.316 vs. 7.250). Those with less than a college education were the least certain of their decisions, indicating an average certainty level of 6.94 for their choices. Again, the parameter estimates capture the inconsistency in certainty levels among the education level of respondents. The estimates reveal that a higher education will lead to preference for the status quo than their less educated counterparts.

Appendix E

MODEL CHOICE: EFFECTS VS DUMMY CODING TABLES

Particular attention was paid to properly defining the *Distance_Near* variable. Special consideration was made to how it should be coded, effects versus dummy. Both are legitimate methods for coding the *Distance_Near* variable however due to how the estimates are interpreted we have chosen to code *Distance_Near* using effects coding. We ran all 3 models using both effects coding, *Distance_Near,* and dummy coding, *Near_HydFracturing* for the "distance" variable. Hydraulic fracturing near was the reference category for both.

The following set of tables presents different comparisons of the parameter estimates of ML1, ML2 and ML3 with the distance parameter coded as both a dummy variable and with effects coding. Comparisons of the respective WTP estimates are presented as well.

Table E1 reports the parameter estimates of ML1 which includes all data with no regard for certainty. The parameter estimates indicate that there is little difference in the signs and magnitudes for each variable in each model. The slight variation that does exists, most evident in the "Distance" variable, is the result of the recoding; where effects coded *Distance_Near* has a mean equal to zero and the dummy coded variable, *Near_HydFracturing*, has a mean somewhere between 0 and 1. The difference in the "Distance" estimates will them impact the ASC, and its respective interactions.

Table E2 reports the results of ML2, and compares the difference between parameter estimates when "distance" is effects and dummy coded. This model follows Ready et al. (2010) and automatically changes the responses of any person who indicated a certainty of less than 7 to the status quo response. This type of model attempts to recode low quality as if it were high quality. A key result of both these models is that cost is nearly identical in both, indicating that people paid attention to price when making their decisions.

Table E3 reports the parameter estimates of ML3 when "distance" is effects and dummy coded. This is the model chosen for this research. Decisions were made under at least fairly certain conditions; and therefore consider only high quality data, allowing for a more accurate representation of market decisions, and consider possible symbolic responses. Differences between "distance" coded with effects coding versus dummy coding mirror the differences seen in ML1 and ML2.

Table E4 reports the parameter estimates for all three models, with "distance" effects coded, *Distance_Near*. One can see that as we took certainty into consideration, moving from ML1 to ML3, the number of variables that are statistically significant increased. The absolute value of the ASC increased, as did cost and all other variables.

Table E5 compares the parameter estimates for all 3 models with “distance” coded as a dummy variable, *Near_HydFracturing*. While the results differ from Table E4, the relative magnitude of the parameter estimates, signs, and levels of significance are similar to their effects coded counterparts.

For this paper, LIMDEP was used to estimate the model and WTP. However, we concurrently ran the same model in STATA. It is expected that there be some slight differences between the two programs. Table E6 is a comparison of the parameter estimates of ML3 using LIMDEP and STATA as reported in the paper.

Tables E7 and E8 report the WTP simulation estimates for both ML1 and ML3 when distance is effects coded and dummy coded, respectively. The estimates all change for each group (by location and proximity) in the same direction with the same magnitude.

Table E1: Parameter Estimates of ML1 with "Distance" Effects and Dummy Coded

	Effects Code		Dummy Code	
Variable	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error
	Random Parameters			
Neither	-4.080**	1.587		
Neither'			-4.168**	1.924
Distance_Near	-0.237***	0.062		
Near_HydFracturing			-0.624***	0.143
	Non – Random Parameters			
Cost	-0.056***	0.007	-0.056***	0.007
	Parameters on Heterogeneity in Status Quo Utility			
NXIncounty	0.692	0.476		
N'XIncounty			0.650	0.504
NXFemale	0.726**	0.315		
N'XFemale			0.717**	0.324
NXAge	0.153**	0.068		
N'XAge			0.146*	0.078
NXAgeSquared	-0.001	0.001		
N'XAgeSquared			-0.001	0.001
NXCollege	0.424	0.361		
N'College			0.368	0.356
NXGrad	0.694	0.428		
N'XGrad			0.403	0.498
	Standard Deviation of Random Parameters			
Neither	2.869***	0.242		
Neither'			2.803***	0.245
Distance_Near	0.630***	0.131		
Near_HydFracturing			1.236***	0.267
	N = 2039 Psuedo R- Squared = 0.352 Chi – Squared (11.d.f) = 1556.48		N = 2039 Psuedo R- Squared = 0.352 Chi – Squared (11 d.f.) =1555.74	

***, **, * = Significance at the 1%, 5%, and 10% levels

Table E2: Parameter Estimates of ML2 with "Distance" Effects and Dummy Coded

	Effects Code		Dummy Code	
Variable	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error
	Random Parameters			
Neither	-3.209	2.676		
Neither'			-3.997	2.589
Distance_Near	-0.179**	0.080		
Near_HydFracturing			-0.546***	0.163
	Non – Random Parameters			
Cost	-0.059***	0.009	-0.058***	0.009
	Parameters on Heterogeneity in Status Quo Utility			
NXIncounty	0.893	0.615		
N'Incounty			0.692	0.597
NXFemale	1.688***	0.396		
N'XFemale			1.729***	0.436
NXAge	0.192*	0.113		
N'Age			0.197*	0.113
NXAgeSquared	-0.002	0.001		
N'XAgeSquared			-0.002	0.001
NXCollege	0.005	0.430		
N'XCollege			0.284	0.512
NXGrad	1.346**	0.528		
N'XGrad			1.478***	0.563
	Standard Deviation of Random Parameters			
Neither	3.466***	0.323		
Neither'			3.380***	0.294
Distance_Near	0.713***	0.176		
Near_HydFracturing			1.197***	0.358
	N = 2039		N = 2039	
	Psuedo R- Squared = 0.499		Psuedo R- Squared = 0.497	
	Chi – Squared (11 d.f.) = 2206.51		Chi – Squared (11 d.f.) = 2195.66	

***, **, * = Significance at the 1%, 5%, and 10% levels

Table E3: Parameter Estimates of ML3 with “Distance” Effects and Dummy Coded

	Effects Code		Dummy Code	
Variable	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error
	Random Parameters			
Neither	-7.733***	2.984		
Neither’			-7.242***	2.776
Distance_Near	-0.200**	0.090		
Near_HydFracuturing			-0.600***	0.175
Non – Random Parameters				
Cost	-0.067***	0.012	-0.068***	0.012
	Parameters on Heterogeneity in Status Quo Utility			
NXIncounty	1.298*	0.752		
N’Incounty			1.098	0.781
NXFemale	1.316***	0.459		
N’XFemale			1.300***	0.445
NXAge	0.284**	0.131		
N’XAge			0.281**	0.117
NXAgeSquared	-0.002	0.001		
N’XAgeSquared			-0.002**	0.001
NXCollege	0.425	0.557		
N’XCollege			0.131	0.495
NXGrad	1.601***	0.580		
N’XGrad			1.367**	0.594
	Standard Deviation of Random Parameters			
Neither	3.516***	0.350		
Neither’			3.472***	0.349
Distance_Near	0.645***	0.147		
Near_HydFracturing			1.380***	0.280
	N = 1425 Psuedo R – Squared = 0.412 Chi – Squared (11 d.f.) = 1282.62		N = 1425 Psuedo R – Squared = 0.414 Chi – Squared (11 d.f.) = 1288.58	

***, **, * = Significance at the 1%, 5%, and 10% levels

Table E4: Parameter Estimates of All Models with "Distance" Effects Coded

	ML1		ML2		ML3	
Variable	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error
Random Parameters						
Neither	-4.080**	1.587	-3.210	2.676	-7.733***	2.984
Distance_Near	-0.237***	0.062	-0.179**	0.080	-0.200**	0.090
Non – Random Parameters						
Cost	-0.056***	0.007	-0.059***	0.009	-0.067***	0.012
Parameters on Heterogeneity in Status Quo Utility						
NXIncounty	0.692	0.476	0.893	0.615	1.298*	0.752
NXFemale	0.726**	0.315	1.688***	0.396	1.316***	0.459
NXAge	0.153**	0.068	0.192*	0.113	0.285**	0.131
NXAgeSquared	-0.001	0.001	-0.002	0.001	-0.002	0.001
NXCollege	0.424	0.361	0.005	0.430	0.425	0.557
NXGrad	0.694	0.428	1.345**	0.528	1.601***	0.579
Standard Deviation of Random Parameters						
Neither	2.869***	0.242	3.466***	0.322	3.516***	0.350
Distance_Near	0.630***	0.131	0.713***	0.177	0.645***	0.147
	N = 2039		N = 2039		N = 1425	
	Psuedo R- Squared = 0.352		Psuedo R-Squared = 0.499		Psuedo R – Squared = 0.412	
	Chi – Squared (11.d.f) = 1556.48		Chi – Squared (11 d.f.) = 2206.51		Chi – Squared (11 d.f.) = 1282.62	

***, **, * = Significance at the 1%, 5%, and 10% levels

Table E5: Parameter Estimates of All Models with "Distance" Dummy Coded

	ML1		ML2		ML3	
Variable	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error
			Random Parameters			
Neither'	-4.168**	1.923	-3.997	2.589	-7.242***	2.776
Near_ HydFracturing	-0.624***	0.143	-0.546***	0.163	-0.600***	0.175
			Non – Random Parameters			
Cost	-0.056***	0.007	-0.058***	0.009	-0.068***	0.012
			Parameters on Heterogeneity in Status Quo Utility			
N'XIncounty	0.650	0.504	0.692	0.597	1.098	0.781
N'XFemale	0.717**	0.324	1.729***	0.436	1.300***	0.445
N'XAge	0.146*	0.078	0.197*	0.113	0.281***	0.117
N'XAgeSquared	-0.001	0.001	-0.002	0.001	-0.002**	0.001
N'XCollege	0.368	0.356	0.284	0.512	0.132	0.495
N'XGrad	0.403	0.498	1.478***	0.563	1.367**	0.594
			Standard Deviation of Random Parameters			
Neither'	2.803***	0.246	3.380***	0.294	3.472***	0.349
Near_HydFracturing	1.236***	0.267	1.197***	0.357	1.380***	0.280
	N = 2039		N = 2039		N = 1425	
	Psuedo R- Squared = 0.352		Psuedo R- Squared = 0.497		Psuedo R – Squared = 0.414	
	Chi – Squared (11 d.f.) =1555.74		Chi – Squared (11 d.f.) = 2195.66		Chi – Squared (11 d.f.) = 1288.58	

***, **, * = Significance at the 1%, 5%, and 10% levels

Table E6: ML3 Estimates in LIMDEP vs. STATA

	LIMDEP		STATA	
Variable	Parameter Estimates	Std. Error	Parameter Estimates	Std. Error
	Random Parameters			
Neither	-7.733***	2.94	-7.843**	3.781
Distance_Near	-0.200**	0.090	-0.205*	0.117
	Non – Random Parameters			
Cost	-0.066***	0.012	-0.069***	0.015
	Parameters on Heterogeneity in Status Quo Utility			
NXIncounty	1.298*	0.752	1.246***	0.464
NXFemale	1.316***	0.459	1.313**	0.601
NXAge	0.285**	0.131	0.290**	0.160
NXAgeSquared	-0.002	0.001	-0.002	0.002
NXCollege	0.425	0.557	0.469	0.756
NXGrad	1.601***	0.580	1.737**	0.804
	Standard Deviation of Random Parameters			
Neither	3.516***	0.350	3.591***	0.463
Distance_Near	0.645***	0.147	0.765***	0.255

***, **, * = Significance at the 1%, 5%, and 10% levels

Table E7: WTP Estimates of ML1 and ML3 with “Distance” Effects Coded

	WTP per HH within shale counties				WTP per HH outside shale counties			
	Effects: Model 1 (ML1)							
Distance	Mean	Std. Dev.	10%	90%	Mean	Std. Dev.	10%	90%
Near	($40.79)	4.03	($46.30)	($35.30)	($28.68)	3.84	($33.87)	($23.95)
Far	($32.16)	4.08	($37.56)	($23.95)	($20.05)	3.79	($25.11)	($15.36)
	Effects: Model 3 (ML3)							
Distance	Mean	Std. Dev.	10%	90%	Mean	Std. Dev.	10%	90%
Near	($47.63)	4.16	($53.32)	($42.08)	($27.76)	3.93	($32.96)	($22.78)
Far	($41.71)	4.21	($47.28)	($36.16)	($21.84)	3.89	($26.94)	($17.10)

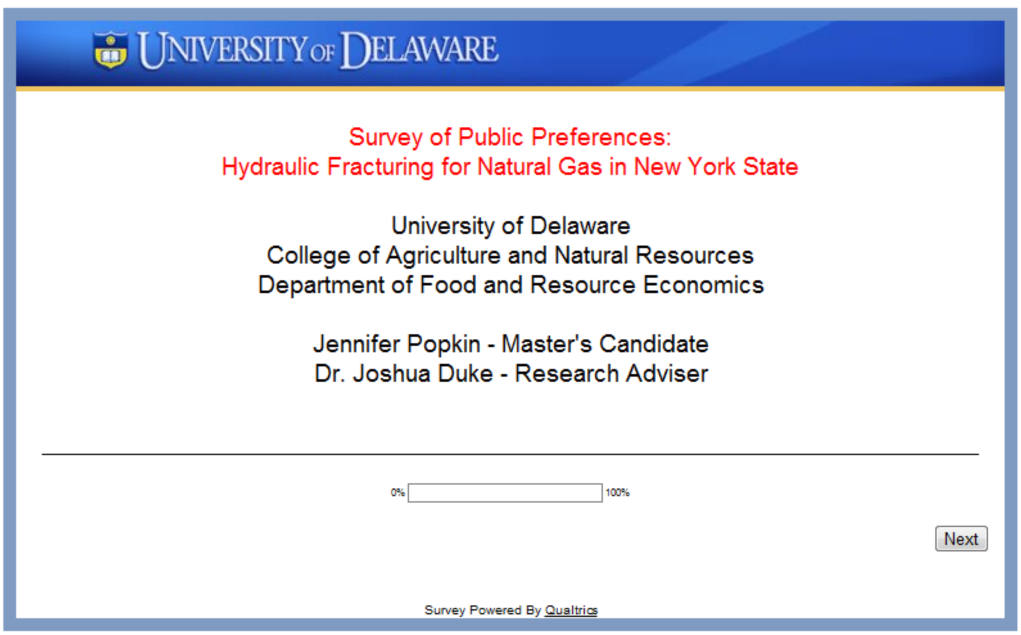
Table E8: WTP Estimates of ML1 and ML3 with "Distance" Dummy Coded

	WTP per HH within shale counties				WTP per HH outside shale counties			
	Dummy: Model 1 (ML1)							
Distance	Mean	Std. Dev.	10%	90%	Mean	Std. Dev.	10%	90%
Near	($41.49)	4.15	($47.03)	($35.59)	($30.18)	3.92	($35.45)	($25.22)
Far	($30.06)	3.93	($35.59)	($24.89)	($18.75)	3.63	($23.47)	($14.35)
	Dummy: Model 3 (ML3)							
Distance	Mean	Std. Dev.	10%	90%	Mean	Std. Dev.	10%	90%
Near	($47.13)	4.16	($53.80)	($41.37)	($31.06)	4.04	($36.44)	($26.09)
Far	($38.16)	3.99	($43.34)	($32.96)	($22.08)	3.69	($26.79)	($17.50)

Appendix F

SAMPLE SURVEY

The following is a sample of the survey as seen by a respondent who lived in a county outside the Marcellus Shale region. The only answer that forced a response was when asked their monthly electric bill, as it was necessary to produce the % change to their bill in the choice sets.



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Hydraulic Fracturing for Natural Gas in New York State

This questionnaire investigates the attitudes of New York State residents toward hydraulic fracturing of natural gas. The study is being conducted by **Ms. Jennifer Popkin** and **Dr. Joshua Duke** of the **Department of Food and Resource Economics at the University of Delaware**. Survey results will be published in summary form only. This study will seek the results of approximately 500 adults.

The questionnaire will take you approximately **10- 15 minutes** to complete.

Individual responses will be collected on a secure web server. This data will remain **confidential and anonymous**, and will be viewed only by the study team. No personally identifiable information will be collected.

Your participation is entirely voluntary. To leave the study at any time, close the web browser before you press the final submission button at the end of the survey. Any responses you previously made will not be saved.

If you have any questions concerning the study, please contact the principal investigator, Ms. Jennifer Popkin, Department of Food and Resource Economics, University of Delaware at **Jpopkin@udel.edu**. For questions about your rights as a subject or about any issues concerning the use of human subjects in research, please contact Chair, Institutional Review Board, University of Delaware, (302) 831-2137.

Are you a decision maker of your household's electric bill?

- Yes
- No

0% 100%

Next

Survey Powered By Qualtrics

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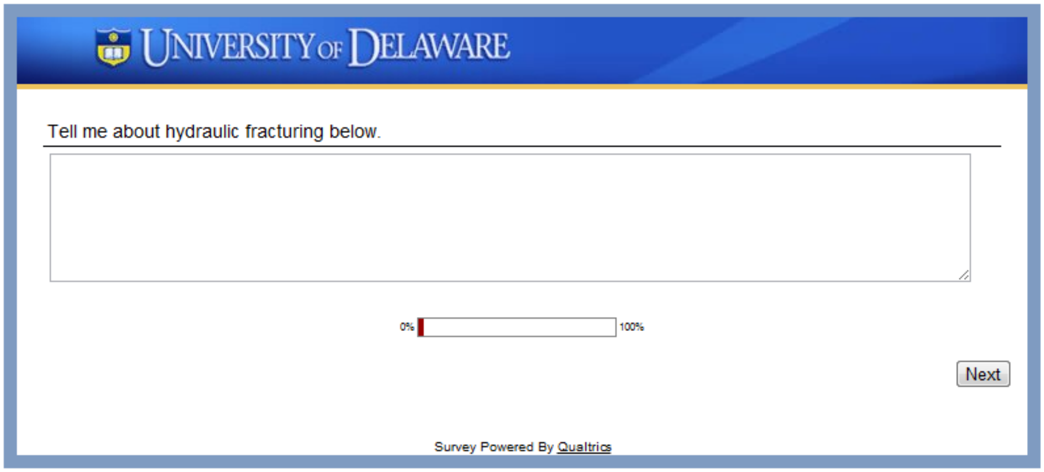
Have you ever heard of ***hydraulic fracturing*** (also known as hydro-fracking and fracking)?

- Yes
- No

0% 100%

Next

Survey Powered By Qualtrics



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Tell me about hydraulic fracturing below.

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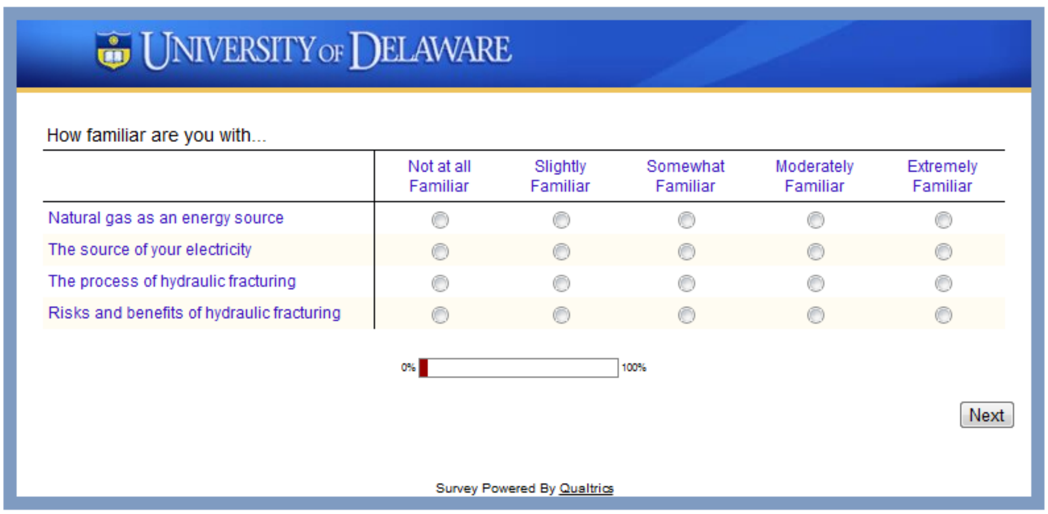

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How familiar are you with...

	Not at all Familiar	Slightly Familiar	Somewhat Familiar	Moderately Familiar	Extremely Familiar
Natural gas as an energy source					
The source of your electricity					
The process of hydraulic fracturing					
Risks and benefits of hydraulic fracturing					

0% 100%

Next

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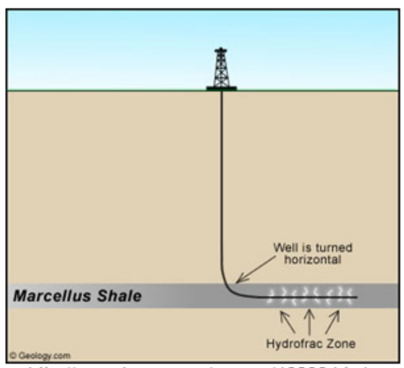
About Hydraulic Fracturing

- Hydraulic Fracturing is also known as hydro-fracking, fracking, and frack-jobs.
- In this study, it will be referred to as **Hydraulic Fracturing**.
- Hydraulic Fracturing is a method of extracting natural gas from the Marcellus Shale formation that is naturally found in the Appalachian Mountains.
- Residents of New York may be affected by Hydraulic Fracturing.

The Process

- A vertical well is dug, on average, between 4,000 – 8,500 feet underground.
- A horizontal well then extends outwards for up to 1 mile below the earth.
- A mixture that is made up of 99.5% water and sand and 0.5% chemicals is injected into the well creating cracks in the rock.
- Natural gas is then able to be collected from the shale. Natural gas is a type of fossil fuel that is considered more environmentally friendly than other fossil fuels (coal and oil).



http://www.dec.ny.gov/energy/46288.html

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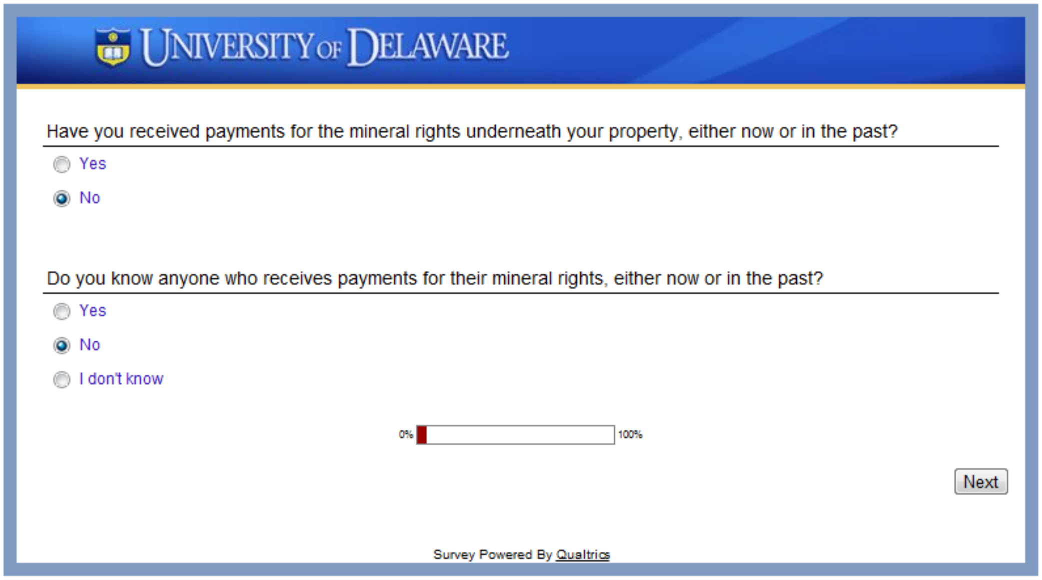

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Have you received payments for the mineral rights underneath your property, either now or in the past?

- Yes
- No

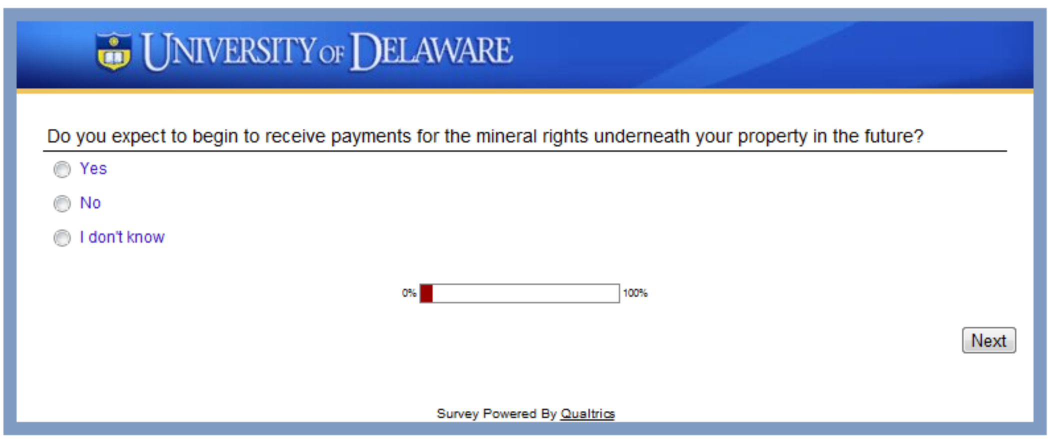
Do you know anyone who receives payments for their mineral rights, either now or in the past?

- Yes
- No
- I don't know

0% 100%

Next

Survey Powered By Qualtrics



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Do you expect to begin to receive payments for the mineral rights underneath your property in the future?

- Yes
- No
- I don't know

0% 100%

Next

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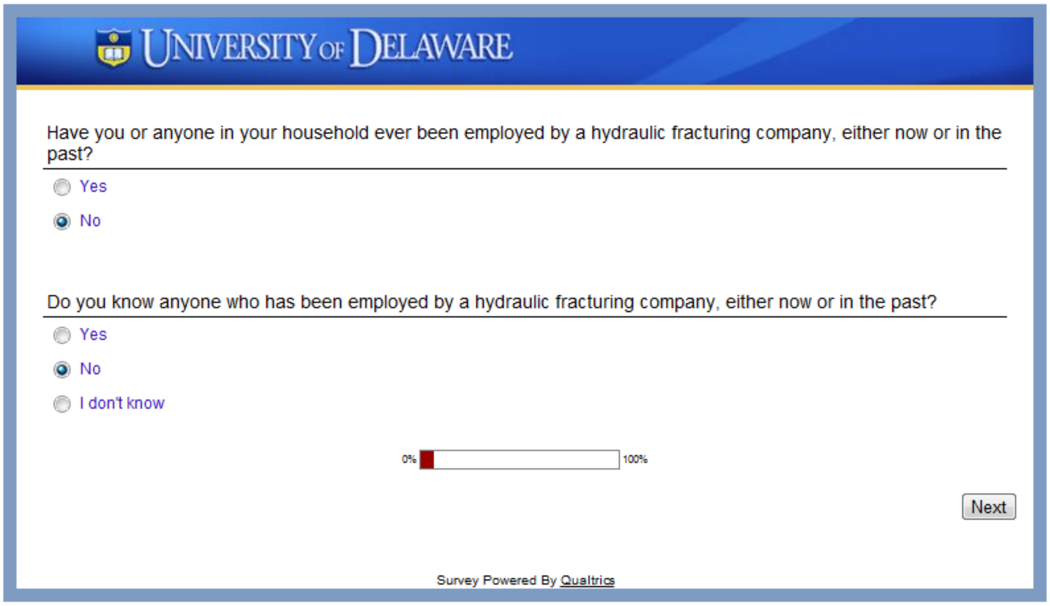

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Have you or anyone in your household ever been employed by a hydraulic fracturing company, either now or in the past?

- Yes
- No

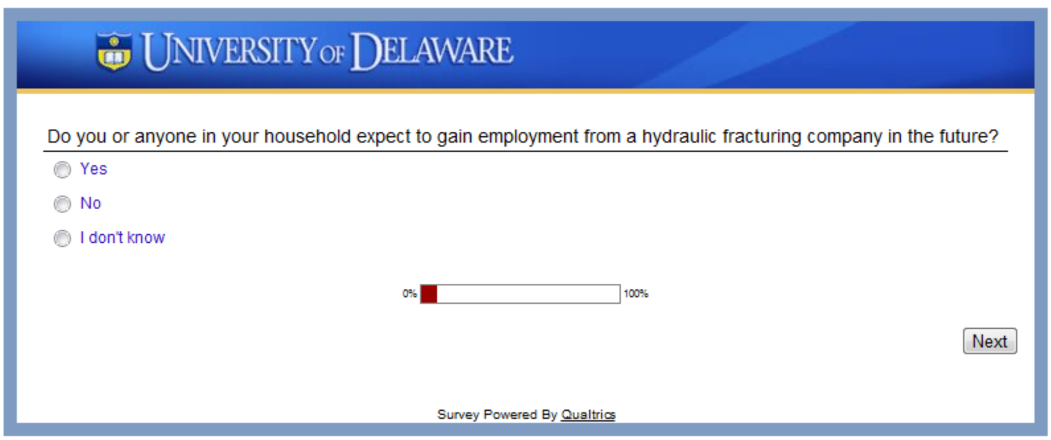
Do you know anyone who has been employed by a hydraulic fracturing company, either now or in the past?

- Yes
- No
- I don't know

0% 100%

Next

Survey Powered By Qualtrics



UNIVERSITY OF DELAWARE

Do you or anyone in your household expect to gain employment from a hydraulic fracturing company in the future?

- Yes
- No
- I don't know

0% 100%

Next

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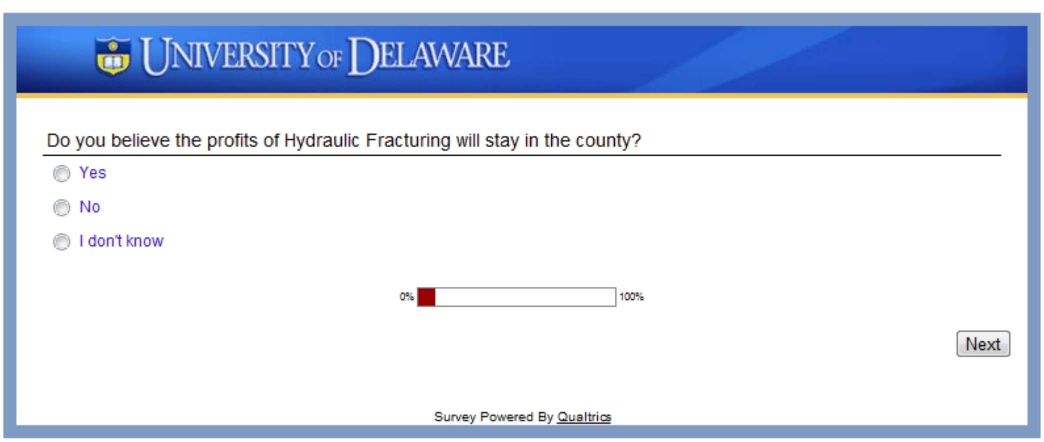

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Do you believe the profits of Hydraulic Fracturing will stay in the county?

- Yes
- No
- I don't know

0% 100%

Next

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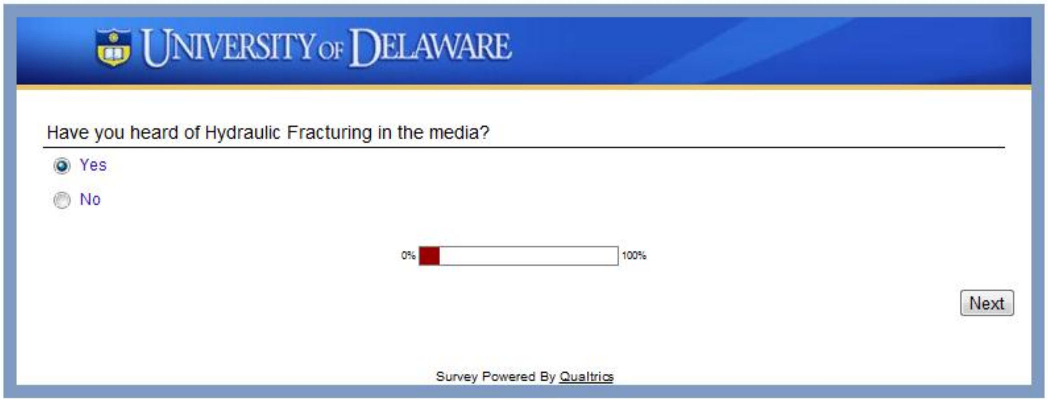
UNIVERSITY OF DELAWARE
Have you heard of Hydraulic Fracturing in the media?
Yes
No
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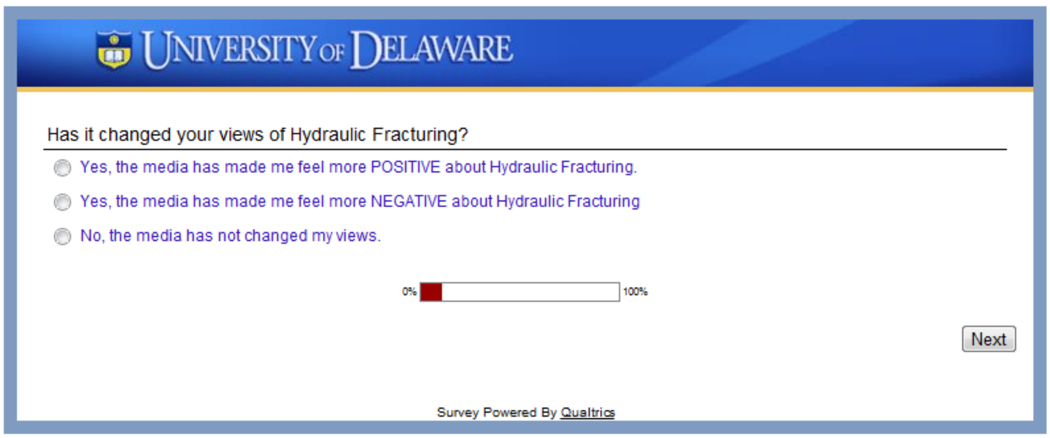
UNIVERSITY OF DELAWARE
Has it changed your views of Hydraulic Fracturing?
Yes, the media has made me feel more POSITIVE about Hydraulic Fracturing.
Yes, the media has made me feel more NEGATIVE about Hydraulic Fracturing
No, the media has not changed my views.
0%
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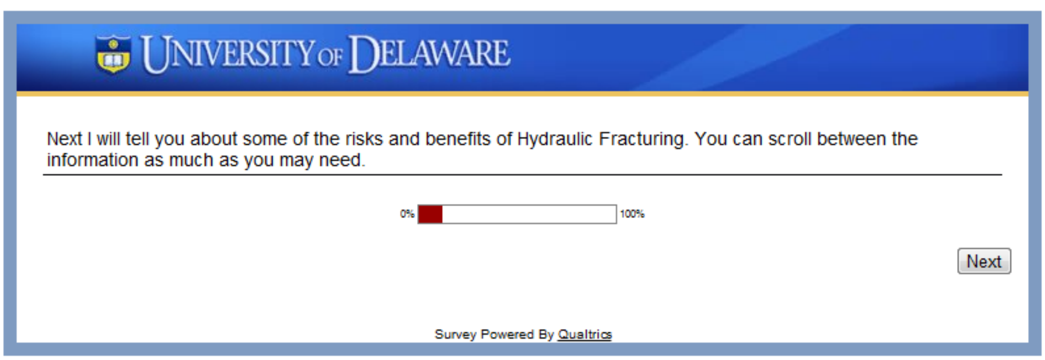
UNIVERSITY OF DELAWARE
Next I will tell you about some of the risks and benefits of Hydraulic Fracturing. You can scroll between the information as much as you may need.
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Benefits	Risks
Money for Mineral Rights	**Increased Truck Traffic**
Landowners whose property lies above a natural gas deposit may be approached by an energy company to lease, receive royalties, or receive other forms of payment for the mineral rights to drill beneath their property. (New York Dept. of Environmental Conservation, 1992)	Hydraulic Fracturing will lead to increased truck traffic in the community, and may require the construction of additional roads in order to accommodate the heavier truck traffic. (United States Environmental Protection Agency, 2011)
Regional Development	**Water Contamination**
Hydraulic Fracturing development creates jobs and increases state revenue through regional development, and taxes and fees from energy companies. (Pennsylvania Dept. of Environmental Protection, 2010)	Chemicals used during the hydraulic fracturing process as well as methane, a gas naturally found in the shale, may leak into your water source as a result of hydraulic fracturing. (Pennsylvania Dept. of Environmental Protection, 2009)
Domestic Energy Source	**Earthquakes**
The Marcellus Shale formation is estimated to have 168-516 trillion cubic feet of natural gas. That is the equivalent of approximately 28-88 billion barrels of oil. New York State currently uses 1.1 trillion cubic feet of natural gas a year. (New York Dept. of Environmental Conservation, 2010)	The fracturing process may cause small earthquakes that could be felt at the surface. (New York Dept. of Environmental Conservation, 2009)
Clean Energy	**Water Requirements**
Natural gas is considered a “clean energy”, producing less than a third of the nitrogen, half of the carbon dioxide, and 1% of the sulfur oxide emissions of coal and oil. (United States Environmental Protection Agency, 2007)	The fracturing process of a single well requires between 2.4 and 7.8 million gallons of water. (New York Dept. of Environmental Conservation, 1992)

Sources (from left to right):<http://www.dec.ny.gov/energy/45912.htm>; <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-81979/5500-FS-DEP2834.pdf>; <http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/HFStudyPlanDraft_SAB_020711.pdf>; <http://www.library.dep.state.pa.us/etc/etc/etc/>; <http://www.dec.ny.gov/energy/46288.html>; <ftp://ftp.dec.state.ny.us/dmn/download/OGdSGEISFull.pdf>; <http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html>

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The following are **reasons some may support** Hydraulic Fracturing.
Please state their level of importance to you.

	Extremely Important	Very Important	Somewhat Important	Somewhat Unimportant	Very Unimportant	Not at all Important
It is a domestic source of energy	○	○	○	○	○	○
Natural gas is good for the environment	○	○	○	○	○	○
It has brought jobs to the county	○	○	○	○	○	○

The following are **reasons some may NOT support** Hydraulic Fracturing.
Please state their level of importance to you.

	Extremely Important	Very Important	Somewhat Important	Somewhat Unimportant	Very Unimportant	Not at all Important
It may lead to contamination of local ground water	○	○	○	○	○	○
The process uses a lot of water	○	○	○	○	○	○
It may increase truck traffic	○	○	○	○	○	○

Taking all this into consideration, do you support Hydraulic Fracturing?

Yes	No	I don't know
○	○	○

0% 100%

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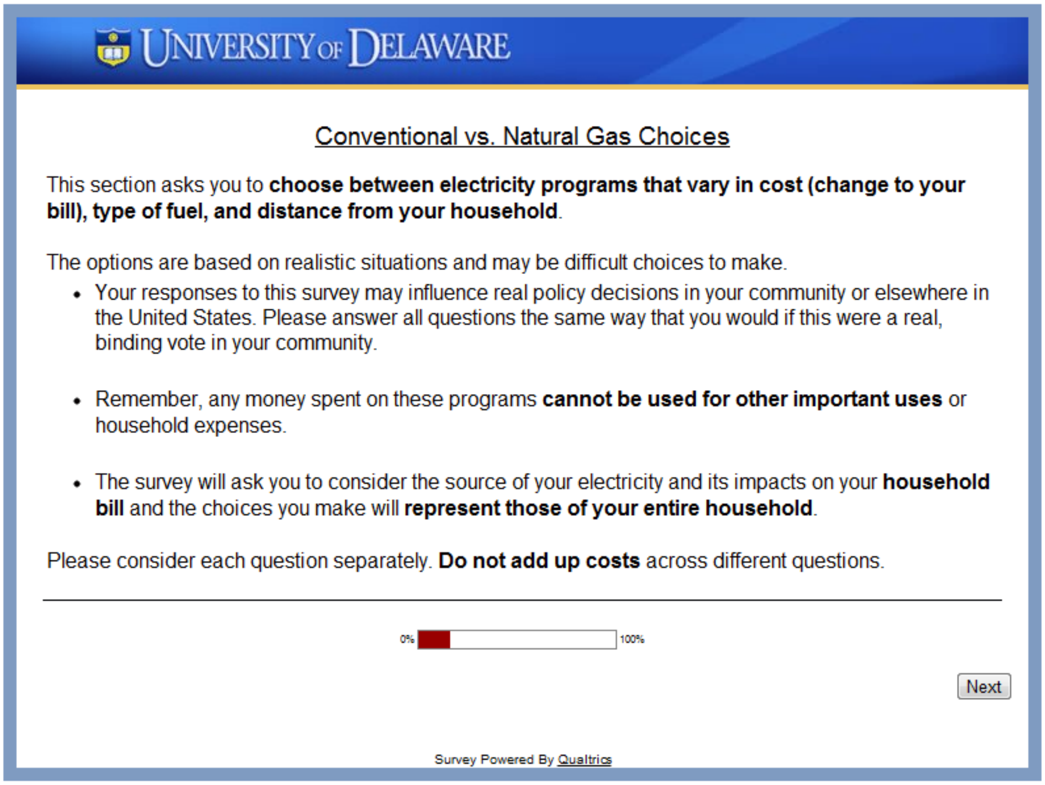

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Conventional vs. Natural Gas Choices

This section asks you to **choose between electricity programs that vary in cost (change to your bill), type of fuel, and distance from your household**.

The options are based on realistic situations and may be difficult choices to make.

- Your responses to this survey may influence real policy decisions in your community or elsewhere in the United States. Please answer all questions the same way that you would if this were a real, binding vote in your community.
- Remember, any money spent on these programs **cannot be used for other important uses** or household expenses.
- The survey will ask you to consider the source of your electricity and its impacts on your **household bill** and the choices you make will **represent those of your entire household**.

Please consider each question separately. **Do not add up costs** across different questions.

0% 100%

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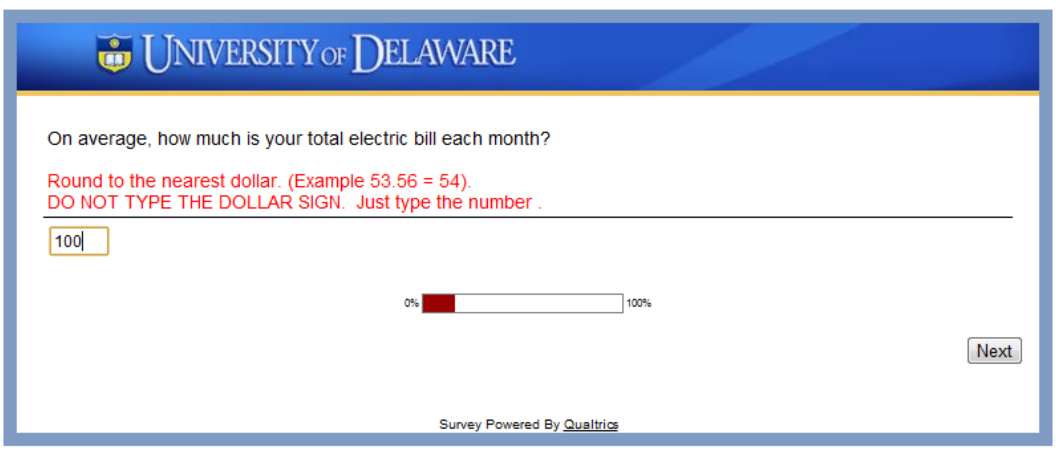

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On average, how much is your total electric bill each month?

Round to the nearest dollar. (Example 53.56 = 54).
DO NOT TYPE THE DOLLAR SIGN. Just type the number .

100

0% 100%

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You said that you pay $100. Your current electricity source is largely fossil fuel. Now consider only the following options, as proposed for your county. How would your household vote?

	Option A	Option B	Option C
Source	Natural gas from Hydraulic Fracturing	Natural gas from Hydraulic Fracturing	Largely Fossil Fuel
Your new monthly electric bill	$ 150 *(50% more)*	$ 125 *(25% more)*	$ 100 *(No change)*
Distance of drill site from your household	50 miles	250 miles	No Drilling

- ◯ I would choose Option A and pay 50% more on my household electric bill
- ◯ I would choose Option B and pay 25% more on my household electric bill
- ◯ I would choose Option C

How certain are you that the option you chose would be the one you would make if you had to make a real decision that involved your real energy source and real money?

- ◯ 1 I am completely unsure which option I would choose
- ◯ 2
- ◯ 3
- ◯ 4 I think I would choose my choice, but I am not completely sure
- ◯ 5
- ◯ 6
- ◯ 7 I am fairly sure that I would choose my choice
- ◯ 8
- ◯ 9
- ◯ 10 I am 100% certain that I would choose my choice

0% 100%

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UNIVERSITY OF DELAWARE

You said that you pay $100. Your current electricity source is largely fossil fuel. Now consider only the following options, as proposed for your county. How would your household vote?

	Option A	Option B	Option C
Source	Natural gas from Hydraulic Fracturing	Natural gas from Hydraulic Fracturing	Largely Fossil Fuel
Your new monthly electric bill	$ 90 *(10% less)*	$ 90 *(10% less)*	$ 100 *(No change)*
Distance of drill site from your household	250 miles	50 miles	No Drilling

- ◯ I would choose Option A and pay 10% less on my household electric bill
- ◯ I would choose Option B and pay 10% less on my household electric bill
- ◯ I would choose Option C

How certain are you that the option you chose would be the one you would make if you had to make a real decision that involved your real energy source and real money?

- ◯ 1 I am completely unsure which option I would choose
- ◯ 2
- ◯ 3
- ◯ 4 I think I would choose my choice, but I am not completely sure
- ◯ 5
- ◯ 6
- ◯ 7 I am fairly sure that I would choose my choice
- ◯ 8
- ◯ 9
- ◯ 10 I am 100% certain that I would choose my choice

0% 100%

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UNIVERSITY OF DELAWARE

You said that you pay $100. Your current electricity source is largely fossil fuel. Now consider only the following options, as proposed for your county. How would your household vote?

	Option A	Option B	Option C
Source	Natural gas from Hydraulic Fracturing	Natural gas from Hydraulic Fracturing	Largely Fossil Fuel
Your new monthly electric bill	$ 75 *(25% less)*	$ 125 *(25% more)*	$ 100 *(No change)*
Distance of drill site from your household	50 miles	250 miles	No Drilling

- I would choose Option A and pay 25% less on my household electric bill
- I would choose Option B and pay 25% more on my household electric bill
- I would choose Option C

How certain are you that the option you chose would be the one you would make if you had to make a real decision that involved your real energy source and real money?

- 1 I am completely unsure which option I would choose
- 2
- 3
- 4 I think I would choose my choice, but I am not completely sure
- 5
- 6
- 7 I am fairly sure that I would choose my choice
- 8
- 9
- 10 I am 100% certain that I would choose my choice

0% 100%

Next

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UNIVERSITY OF DELAWARE

You said that you pay $100. Your current electricity source is largely fossil fuel. Now consider only the following options, as proposed for your county. How would your household vote?

	Option A	Option B	Option C
Source	Natural gas from Hydraulic Fracturing	Natural gas from Hydraulic Fracturing	Largely Fossil Fuel
Your new monthly electric bill	$ 75 *(25% less)*	$ 90 *(10% less)*	$ 100 *(No change)*
Distance of drill site from your household	250 miles	50 miles	No Drilling

- I would choose Option A and pay 25% less on my household electric bill
- I would choose Option B and pay 10% less on my household electric bill
- I would choose Option C

How certain are you that the option you chose would be the one you would make if you had to make a real decision that involved your real energy source and real money?

- 1 I am completely unsure which option I would choose
- 2
- 3
- 4 I think I would choose my choice, but I am not completely sure
- 5
- 6
- 7 I am fairly sure that I would choose my choice
- 8
- 9
- 10 I am 100% certain that I would choose my choice

0% 100%

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In making decisions, there are certain attributes that people consider more important than others. In making your choices, which attribute was <u>of least importance to you</u>?

- Source
- Change to your household electric bill
- Distance of Drill Site from your household

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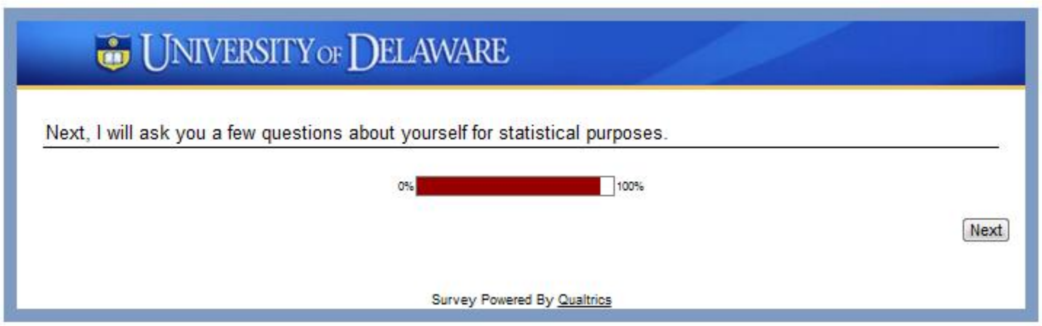

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Next, I will ask you a few questions about yourself for statistical purposes.

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In what year were you born? (yyyy)

What is your gender?

- Male
- Female

How many people live in your household (including yourself?)

What county do you live in?

How many years have lived in your county? (##)

What is the highest level of education that you have completed?

- Less than high school
- High school
- One or more years of college
- Associates degree
- Bachelor's degree
- Graduate degree or beyond

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This space provided is for any additional comments you may have regarding the content of this survey...

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THANK YOU!

If you have questions or concerns regarding this survey you may contact Dr. Joshua Duke (Duke@Udel.edu) or Ms. Jennifer Popkin (JPopkin@Udel.edu or 302-831-1310).

Preview Results *will not be displayed to the recipient*

- Saved Response. Response Id: R_bK1crOhksCDwUL2
- Quota "Obtained 250 electric decision-maker's responses" count: 520

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Appendix G

HUMAN SUBJECTS PERMISSION LETTER: EXEMPT

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RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	April 11, 2012
TO:	Jennifer Popkin
FROM:	University of Delaware IRB
STUDY TITLE:	[241751-2] Willingness to Pay for Natural Gas from Hydraulic Fracturing in New York State
SUBMISSION TYPE:	Continuing Review/Progress Report
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	April 11, 2012
REVIEW CATEGORY:	Exemption category # 2

Thank you for your submission of Continuing Review/Progress Report materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Jody-Lynn Berg at (302) 831-1119 or jlberg@udel.edu. Please include your study title and reference number in all correspondence with this office.