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Green vs. green: Measuring the compensation required to site electrical generation windmills in a viewshed

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ABSTRACT

Proponents of wind power note that wind is a green energy source. Yet locating electrical generating windmills has become difficult in some localities because of potential negative externalities. We address why the NIMBY syndrome may arise when choosing site locations by addressing the perceived property rights of a viewshed, the role of compensation in a NIMBY impasse, and how concerns for the environment might lessen the compensation required. We use a willingness to accept framework to measure the compensation required to allow wind generation windmills to be built in the mountains of North Carolina. We find that individuals who perceive wind energy as a clean source of power require less compensation. Those who retire to the mountains or individuals who have ancestors from Watauga County require more compensation to accept windmills in their viewshed. In addition, we find in a bivariate-probit analysis that individuals who are more likely to participate in a green energy program are also more likely to allow electrical generation windmills in their viewshed, suggesting that the green vs. green environmental debate is overstated.

1. INTRODUCTION

Wind electrical generation is becoming an economically viable technique. Proponents say that wind power is both a green and sustainable energy source. Green energy is defined as a source that does not contribute to global warming or other negative externalities such as acid rain or decreased visibility (Kahn, 2000). Roe et al. (2001) using a hedonic model find consumers are willing to pay a premium for renewable energy sources. Borchers et al. (2007), using a choice experiment, find that consumers are willing to pay more for green energy including wind, solar and biomass relative to conventional sources. Whitehead and Cherry (2007), using the contingent valuation method, find that individuals are willing to pay a premium to purchase green energy knowing that their choice leads to a cleaner environment.

Those who oppose wind energy, however, point out that electrical generation windmills can cause local negative externalities. Individuals who live near windmills have reported negative visual impact on the landscape, noise from the rotation of blades and shadow and light effects from the windmills (Warren et al., 2005). Ladenburg and Dubgaard (2007) find that individuals are willing to pay higher electrical bills to site coastal wind farms further from the coast. The two sides of the wind power debate can be labeled as a green vs. green environmental debate. Both sides of the debate claim the mantle of environmentalist. Proponents of wind power focus on the clean air and opponents focus on the local negative externalities (Warren et al., 2005). One recent example of the green vs. green debate is the Cape Cod coastal wind farms where a slim majority of respondents were opposed to wind farms (Coleman and Melo, 2004). Other examples are detailed in Pasqualetti (2004) where individuals argue that pristine landscapes will be damaged by windmills.

Local negative externalities from electrical generating windmills fall into the broad problem known as a locally undesirable land use, or LULU. In turn, LULUs lead to the NIMBY (not in my backyard) syndrome. Economists theorize that the NIMBY syndrome leads to inefficient allocation of resources because the external costs of a LULU are borne locally by the neighborhood surrounding the facility, while the benefits are distributed globally throughout the economy (O'Hare, 1977; Kunreuther et al., 1987). To address the problem of inefficiency and to encourage the placement of a LULU, those that receive the benefits could compensate the neighborhood around the site for bearing the external cost (O'Hare, 1977; Kunreuther et al., 1987).

To gain understanding of citizen's perceptions of wind power and their influence on mountain views we developed a contingent valuation (CV) survey. In our study, we explore the green vs. green debate by focusing on how various technologies influence a viewshed and how concern about the environment can influence the acceptance of windmills in ones neighborhood. In addition, our CV analysis provides insights on how to overcome the NIMBY syndrome by eliciting the willingness to accept (WTA) for changes in the county's viewshed amenities of electrical generation windmills.

Although the willingness to pay framework is the preferred question format in CV analysis, the WTA framework is more appropriate given the perceived property rights of individuals in the current context. Inhaber (1992) suggest that when choosing a location for a NIMBY politicians

concern for remaining in office makes the status quo the default property right due to a reluctance to infringe upon the perceived property rights. When individuals perceive that the status quo defines the property rights then the WTA becomes the appropriate measure of compensation. CV analysis has been used successfully in the past to measure the WTA (Groothuis et al., 1998; Carson et al., 2001).

2. SURVEY DATA

The eight page survey titled “Mountain View in Watauga County: What do you think?” was sent to Watauga County, NC, residents. Watauga County, located in the southern Appalachian highlands, offers an interesting case study because it has been identified as a potential wind farm location and is also noted for its scenic views (Grady, 2002). The Blue Ridge Parkway runs through the county. Many vacation homes are built in the area and tourism is a major industry. Watauga County also has had decreased visibility due to coal powered electrical generation plants and would benefit from the green energy that wind power would provide (Grady, 2002).

The survey was mailed in the spring of 2005 to a random sample of 1200 Watauga County residents. We used a primary mailing, a post card reminder and a second mailing to all non-respondents of the first wave. In the end, we had 901 useable addresses and 389 responses giving us a response rate of 43%. In Table 1, we provide a summary of the demographic variables. The average age of our respondent was 55.7 years, while the average age for the county of all residents over 20 was 43.5. The average income of survey respondents was $61,084,1 while the average income in Watauga County from the 2000 census was $50,300 in 2005. The average level of education for the respondents was 15 years and for the county it was 14 years. The respondents are older, slightly more educated and have higher income than the population.2 In addition, 11% of the respondents have retired to Watauga County and 33% report having ancestors who lived in Watauga County.

Table 1
Means of variables

Variable	Mean
Age	55.7 years (16.0)
Income	$61,321 (33.97)
Education	15.09 years (3.81)
Wind power should be allowed in Watauga County[a]	0.61 (0.48)
Ancestor from Watauga County	0.33 (0.47)
Retire to Watauga	0.16 (0.37)

Standard deviation in parentheses.
[a]Electrical generation windmills should be allowed in Watauga County. Strongly agree or agree equal one; strongly disagree or disagree equal zero; $n = 327$.

In order to compare respondent attitudes, in Table 2, Table 3 and Table 4, we summarize the opinions of the usefulness and impact on mountain views of various technologies that could cause externalities. We focus on technologies that provide benefits to society but might negatively influence the viewshed to illustrate the green vs. green debate. These technologies include cell phone towers, billboards and electrical generation windmills. We find that 46% of respondents find that billboards provide somewhat useful information and 42% use billboards to make decisions on where to shop and eat when they visit other locations. Yet around 80% either find that billboards are somewhat harmful to very harmful to the mountain views of Watauga County.

Table 2
Opinions about billboards

	1	2	3	4	5
Do you feel billboards provide useful information to tourists and residents?	Not at all useful 14.9%	22.5%	Somewhat useful 46.3%	7.8%	Very useful 8.3%
Do you feel that billboards are harmful to mountain views?	Not at all harmful 9.4%	8.9%	Somewhat harmful 32.5%	18.3%	Very harmful 30.9%
Do you use billboards to make decisions on where to shop and eat when you visit other locations?	Never 27.2%	16.2%	Some of the time 42.4%	6.8%	All the time 7.3%

$n = 327$.

Table 3
Opinions about cell phone towers

	1	2	3	4	5
Do you feel cell phone coverage provides useful service for cell phone owners such as convenience and safety?	Not at all useful 2.5%	6.3%	Somewhat useful 24.4%	25.2%	Very useful 41.6%
Do you feel that cell phone towers are harmful to the mountain views?	Not at all harmful 13.4%	18.9%	Somewhat harmful 39.7%	16.1%	Very harmful 11.7%

$n = 327$.

Table 4
Opinions about electrical generation windmills

	1	2	3	4	5
Do you feel electrical that generation windmills are a clean energy source that should be pursued in the future?	Should not be pursued 5.8%	5.8%	22.5%	18.1%	Should be pursued 48.0%
Do you feel that electrical generation windmills are harmful to the mountain views?	Not at all harmful 15.1%	20.8%	Somewhat harmful 42.2%	12.6%	Very harmful 9.3%

$n = 327$.

When it comes to cell phone towers, the vast majority, 91%, find that the cell phone service is somewhat useful to very useful. Yet, 67% feel that cell towers are somewhat harmful to very

harmful to mountain views. A majority of respondents also feel that wind energy is a clean energy that should be pursued. Yet, 64% feel that electrical generation windmills will harm mountain views.

This series of tables show respondents find that billboards, cell phone towers, and wind electrical power all provide benefits. Comparing the three technologies, we find some relation between how useful respondents find the technology and how harmful the technology is to the viewshed. For billboards, we find a negative correlation, $r=-0.61$, between those who state that billboards provide useful information and those who find billboards harmful to mountain views. For cell towers, we find a weaker negative correlation, $r=-0.30$, between those who feel cell phones provide useful service and those who find cell towers harmful to mountain views. Lastly, we find a negative correlation, $r=-0.42$, between those who feel electrical generation windmills is a clean energy source that should be pursued and those who find windmills harmful to mountain views. In all three cases, we find a negative correlation between the technologies usefulness and harm to mountain views. The negative correlations suggest that the usefulness of the technology dampens the potential NIMBY effect. Yet, a vast majority finds that these technologies harm mountain-view amenities, suggesting that tradeoffs need to be made.

3. PARTICIPATION IN GREEN ENERGY PROGRAMS

Wind energy provides benefits to citizens of the Appalachian Mountains. To help understand who receives the benefits, we ask about participation in a Green energy program. In the survey, the following statement was included:

> A Green Energy proposal has been implemented in North Carolina. Green Energy offers customers power generated from renewable sources such as wind or solar power at a higher price than electricity generated with coal or oil. Green energy reduces air pollution in the mountains and improves visibility. Do you participate or plan to participate in the Green Energy program in North Carolina? YES or NO

We find that 35.8% of respondents report that they participate or plan to participate in the green energy program. To further explore who participates, a logit analysis is used to determine the willingness to participate in the green energy program (Table 5). We find that older individuals are less likely to participate than younger individuals. We also find that individuals who report ancestors who lived in Watauga County are less likely to participate in a green energy program than individuals who did not have ancestors who lived in Watauga County. In terms of the attitudinal variables, we find that individuals who strongly agree or agree that wind power is clean and should be pursued were more likely to participate in the green energy program. The coefficient on the variables wind-power-is-harmful-to-mountain-views and wind-energy-should-be-allowed-in-Watauga County are both statistically insignificant. The results suggest that some individuals in Watauga County are willing to pay more to receive the benefits of green power.

Table 5
Logit model: determinants of willingness to participate in green energy program

Variable	Participate
Intercept	−0.816 (0.75)
Income	0.003 (0.70)
Education	−0.024 (0.62)
Age	−0.369** (3.88)
Wind power is clean and should be pursued	0.727** (4.33)
Wind power harmful to mountain views	−0.088 (0.59)
Wind power should be allowed in Watauga County	−0.060 (0.19)
Ancestor in Watauga	−1.12** (3.59)
Retired to Watauga	0.075 (0.18)
X^2	68.90**

$n = 327$.
*Statistically significant at 90% level.
**Statistically significant at 95% level.

4. WILLINGNESS TO ACCEPT FOR ELECTRICAL GENERATION WINDMILLS

Wind energy creates negative externalities for citizens of the Appalachian Mountains when the windmills are built in the viewshed. We analyze a CV question to provide insight on how to overcome the NIMBY syndrome by providing compensation to the affected parties. Using this technique we can elicit the willingness-to-accept (WTA) for changes in the county's viewshed amenities from wind turbines.

4.1. Theory

Consider a resident's utility function who receives utility from both a consumption good, z and a scenic view amenity, $x(q)$, where q represents quality of the scenic amenity that can be affected by the presence of windmills. Then a resident maximizes her utility, $u(x(q), z)$, subject to a budget constraint $y=px+z$ where the price of z is normalized to one. Solving for the indirect utility function yields $v(p, y, q)$, where p represents the price of the scenic amenity and y is income. The WTA, for lowering the quality of a scenic view amenity is found when

(1)

$$v(p^0,q^0,y)=v(p^0,q^1y+\text{WTA}),$$

where p^0 is the current price, q^1 is lowered quality and WTA is the willingness-to-accept compensating variation for lowering scenic view quality.

In our case, the CV question for the windmill proposal is:

Suppose, to generate Green electricity, windmill generators are to be built on four ridge tops throughout Watauga County. To compensate individuals in the county for accepting windmills, electric utility bills would be reduced by $A each month per household. Suppose that this proposal, approving the electrical payment reduction and allowing electrical windmills to be built, is on the next election ballot. How would you vote on this proposal?

FOR AGAINST DON'T KNOW

One problem that arises when estimating dichotomous choice CV questions is what to do with Don't Know responses. We follow the status quo approach and code all Don't Know responses as "Against" responses (Groothuis and Whitehead, 2002; Caudill and Groothuis, 2005). This becomes our variable that we label *Vote for*.

In Table 6, we report the percentage of votes by offer. We find for the lowest offer of $1 per month, only 42% would vote for the proposal but increasing the offer to $2.50 per month 53% were in favor of the wind proposal. For higher offer levels of $5.00, $10.00 and $50.00 over 60% would vote for the wind proposal. This result suggests that our respondents are behaving rationally in the hypothetical referendum.

Table 6
Percentage of respondents votes of wind proposal by offer

Offer	Votefor (%)	Total
$1.00	42	78
$2.50	53	64
$5.00	65	73
$10.00	67	64
$50.00	67	48

$n = 327$.

In Table 7 column 1, we report the results of two specifications on the wind proposal using the logit model

(2)

$$P(\text{Vote for}) = \frac{1}{1 + e^{-\beta' X}}.$$

Table 7
Logit model: determinants of willingness to accept electrical windmills

Variable	Votefor	Votefor[a]
Intercept	0.30 (1.04)	−0.93 (0.80)
Log of electrical bill reduction	0.272** (2.86)	0.440** (3.48)
Income	−0.0062* (1.85)	−0.0073 (1.58)
Education		0.008 (0.19)
Age		−0.003 (0.33)
Wind power is clean and should be pursued		0.600** (3.96)
Wind power harmful to mountain views		−0.542** (3.28)
Wind power should be allowed in Watauga County		1.35** (4.13)
Ancestor in Watauga		−1.06** (3.07)
Retired to Watauga		−0.914** (2.10)
Chi-squared	13.70**	149.21**
Median WTA (95% confidence interval)	$1.02 ($0.91–$1.13)	$1.84 ($0.43–$3.26)

$n = 327$.
*Statistically significant at 90% level.
**Statistically significant at 95% level.
[a]An intermediate model that does not include the attitudinal variables but includes income, age, education, retired to Watauga County and Ancestor in Watauga County was also estimated. The magnitudes, signs and significance and WTP were essentially the same as in the full model. These results are available from the authors by request.

The first specification includes only the policy cost and income variables:

(3)

$$\beta' X = \beta_0 + \beta_1 \log(A) + \beta_2 \text{Income}.$$

The second specification includes those variables in Eq. (2) and demographic and attitudinal variables:

(4)

$$\begin{aligned}\beta' X = {} & \beta_0 + \beta_1 \log(A) + \beta_2 \text{Income} + \beta_3 \text{Education} \\ & + \beta_4 \text{Age} + \beta_5 \text{Clean} + \beta_6 \text{Harm} + \beta_7 \text{Allowed} \\ & + \beta_8 \text{Ancestor} + \beta_9 \text{Retire}.\end{aligned}$$

In both specifications, as the log of payment *A* increases respondents are more likely to be in favor of the proposal. In the first specification, the coefficient on the income variable is found to be negative and statistically significant, indicating that landscape is a normal good. In the second specification, all three attitudinal variables are found to have statistically significant coefficients. Individuals who find wind power a clean source of power that should be pursued

are more likely to vote for the proposal. This result supports the conjecture that the green vs. green debate is overstated because individuals who perceive green energy as important require less compensation to locate a windmill in their viewshed. In addition, individuals who find wind power harmful to mountain views are less likely to vote for the proposal. Individuals who believe wind power should be allowed are more likely to vote in favor of the proposal.

Individuals who retire to Watauga County are less likely to vote for the proposal, while individuals with ancestors in the county are also less likely to vote for the proposal. The reason retirees require more compensation to allow windmills is that the viewshed amenity is likely one of the more important reasons one chooses to retire to Watauga County. In the second specification, we find that age, education and income all have statistically insignificant coefficients. The statistical insignificance on income may result from multicollinearity between age, education, and income. Overall, the results point to compensation playing a role in mitigating the NIMBY syndrome.

Using the Cameron (1988) technique, we calculate the median WTA using:

(5)

$$\mathrm{WTA} = \exp\left(\frac{\beta_0 + \beta_2\,\mathrm{Income} + \beta_3\,\mathrm{Education} + \beta_4\,\mathrm{Age} + \beta_5\,\mathrm{Clean} + \beta_6\,\mathrm{Harm} + \beta_7\,\mathrm{Allowed} + \beta_8\,\mathrm{Ancestor} + \beta_9\,\mathrm{Retire}}{\beta_1}\right)$$

We find that in the WTA is $1.90 per month or compensation of $23 per household per year.

To further explore the green vs. green environmental debate, where individuals focus on either the positive benefits or the local negative externalities of wind power, we analyze a bivariate-probit analysis of both the willingness to participate in a Green Energy program and the WTA windmills in Watauga County. In Table 8, the results mirror those of both univariate analyses. The interesting result is that the rho (ρ) coefficient that measures the unobserved correlation between the two equations is positive and statistically significant. Individuals who respond yes to the green energy participation equation are also more likely to vote in favor of the WTA windmills equation. This result indicates that the green vs. green conflict does not necessarily arise in the same individual. It suggests that individuals with genuine concern for the environment who are willing to pay more for green energy also require less compensation to allow windmills into their viewshed. This runs counter to the conventional wisdom that individuals who are concerned with the environment are willing to pay for clean air as long as the wind energy is not produced in their viewshed. On the contrary, individuals who are willing to pay more for green energy require less compensation to site windmills in their backyard suggesting that the NIMBY impasse is lessened by the positive benefits the windmills provide in air quality.

Table 8
Bivarite probit: willingness to accept electrical windmills and willingness to participate in green energy program

Variable	Vote for: accept windmills	Yes: participate green energy
Intercept	−0.53 (0.76)	−0.360 (0.55)
Log of electrical bill reduction	0.245** (3.51)	–
Income	−0.004 (1.49)	0.001 (0.38)
Education	−0.005 (0.21)	−0.011 (0.48)
Age	−0.002 (0.27)	−0.021** (3.78)
Wind power is clean and should be pursued	0.336** (3.94)	0.392** (4.33)
Wind power harmful to mountain views	−0.307** (3.57)	−0.062 (0.67)
Wind power should be allowed in Watauga County	0.805** (3.96)	0.008 (0.04)
Ancestor in Watauga	−0.619** (3.03)	−0.686** (3.59)
Retired to Watauga	−0.558** (2.16)	0.021 (0.08)
Rho (ρ)	0.411** (3.63)	
Log likelihood ratio	−320.66**	

$n = 327$.
*Statistically significant at 90% level.
**Statistically significant at 95% level.

5. CONCLUSIONS

Our results indicate that compensation could play a role to help eliminate the NIMBY syndrome when choosing sites for electrical generation windmills. We also find that individuals who are willing to participate in green energy programs require less compensation than individuals who do not participate. This result suggests that individuals with concern for the environment have less of a NIMBY reaction to windmills in their viewshed, ceteris paribus. Our results further suggest that the green vs. green environmental debate is not necessarily manifested in the same individual. In particular, we show that individuals who retire to the mountains require more compensation as do individuals who have ancestors in the county. Overall, we show that the landscape is important to citizens of Watauga County but they are willing to make tradeoffs to allow for wind power.

To gain an understanding of the total compensation required to site wind turbines in Watauga County, we can aggregate the household results of 23 dollars annually with a 95% confidence interval that includes a lower bound of $5 and an upper bound of $39. According to the 2000 census, there are 18,540 households in Watauga County giving an aggregate WTA of $426,400 per year with a 95% confidence interval that includes a lower bound of $95,200 and an upper bound of $724,900. This estimate can be thought as the amount that would be approved in a referendum election reflecting the preferences of a median voter. The result therefore is not as

much a welfare measure as the compensation required to locate a windmills through a referendum election.

NOTES

1 Income tends to have the most item non-response of all demographic questions. Following Whitehead (1994), we impute 18 missing wage values using a wage equation.

2 Using a t-test, we find that the sample age is statistically different than the population mean. The sample mean of education, however, is not significantly different than the population mean.

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