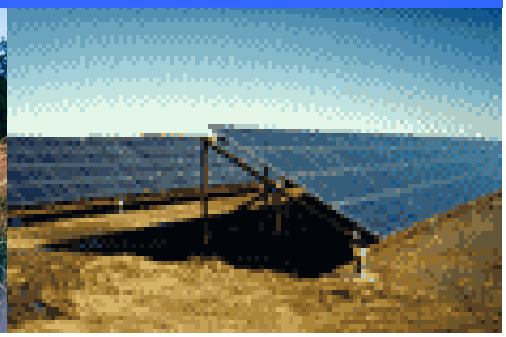


Tennessee Residential Electricity Consumers' Views on Electricity from Bioenergy and Other Renewable Sources





by

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Abstract

Production of bioenergy on a commercial scale could expand industrial consumption of agricultural commodities, adding rural jobs and increasing economic activity in rural regions. Bioenergy uses renewable resources such as fast growing agricultural crops and trees or forest products wastes to produce electricity. In 2001, biomass constituted about half of the nation's consumption of renewable energy, constituting about 3 percent of consumption. The purpose of the study is to ascertain residential electricity consumers' views on electricity from bioenergy and other renewable sources. The sources examined include: solar, wind, landfill gas, bioenergy from fast growing crops, and bioenergy from forest products wastes. Consumers' support and willingness to pay premiums for energy from renewable sources are evaluated. Differences in willingness to pay across sources of renewable energy are also investigated. The results from this study suggest that the percentage of residential electricity consumers who are willing to pay premiums for electricity is much lower than found in prior studies, at 38 percent compared with estimates as high as 60 percent. Findings from this suggest that there is a slightly lower preference for electricity from crops or forest wastes than for electricity from solar or wind sources. However, percents responding positively for crops and electricity from landfill wastes are not statistically different. Generally, those who would be willing to pay more for electricity from renewable sources are more highly educated, middle income individuals who have contributed time or money to environmental organizations.

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Tennessee Residential Electricity Consumers' Views on Electricity From Bioenergy and Other Renewable Sources

Background and Introduction

Production of bioenergy on a commercial scale could expand industrial consumption of agricultural commodities, adding rural jobs and increasing economic activity in rural regions. Bioenergy uses renewable resources such as fast growing agricultural crops and trees or forest products wastes to produce electricity. In 2001, biomass constituted about half of the nation's consumption of renewable energy, constituting about 3 percent of consumption. Biomass electricity generating capacity is currently about 1 percent of overall generating capacity (Source: DOE/EIA, 2003). In the future, sources will likely include co-firing of biomass in existing coal fired boilers and the introduction of high-efficiency gasification combined-cycle systems, fuel cell systems, and modular systems. Currently, the majority of new renewable energy projects are being focused on wind energy, rather than bioenergy sources (Source: Green Power Network).

Biomass generated electricity is not an emission free fuel source, producing CO_2, SO_2, and particulates emissions but it is carbon neutral. Hydroelectric, wind, and photovoltaic do not produce CO_2 or SO_2 emissions, but hydroelectric power faces environmental barriers related to construction of dams, wind machines can be noisy and have significant impacts on the landscape, and photovoltaic costs are relatively high. Compared with coal or natural gas, biomass generated electricity emits significantly fewer sulfur emissions, about $1/100^{th}$ that of coal.

Estimates of costs of generating electricity by renewable sources vary across studies and time frame under consideration. However, most estimates have shown photovoltaic to be least

cost competitive; while biomass generated sources is cost competitive with wind and landfill gas power. Guey-Lee (1998) evaluated the cost of renewable electricity generation compared with conventionally generated electricity for 1995. Utilities purchase about 53 percent of the renewable electricity generated by non-utilities. Most of this energy from non-utility generating sources is wood and wood waste (41.1 percent), while only a small portion is from other biomass (1.6 percent). Guey-Lee found that utility renewable energy prices paid by utilities to non-utilities were 8.78 cents per kWh relative to an average utility-to-utility price of 3.53 cents per kWh. Among renewable sources, prices paid by utilities to non-utilities were 6.86 cents per kWh for conventional hydro, 11.77 cents per kWh for landfill gas, 11.64 cents per kWh for wind, 15.80 cents per kWh for solar, 9.67 cents per kWh for wood/wood waste, 6.27 cents per kWh for municipal solid waste and landfills, and 12.31 for other biomass. Other estimates of electricity costs from biomass-fired plants are 9 cents per kWh (EREN, 2001) and 6.4 to 11.3 cents per kWh (ORNL, 2001). Thus, while bioenergy has significant environmental advantages over conventional methods of generating electricity, it is more expensive on a per unit basis.

Despite potentially higher power generation costs than conventional methods, the market for bioenergy will be economically sustainable if consumers are willing to pay green premiums for bioenergy. Many utility companies offer electricity consumers the opportunity to purchase blocks of electricity from renewable sources through green pricing programs, where participating consumers pay a premium on their electric bill to cover the added costs of the renewable energy. More than 300 utilities have either implemented or announced plans to offer a green pricing option (Source: Green Power Network).

The purpose of the study is to ascertain residential electricity consumers' views on electricity from bioenergy and other renewable sources. The sources examined include: solar,

wind, landfill gas, bioenergy from fast growing crops, and bioenergy from forest products wastes. Consumers' support and willingness to pay premiums for energy from renewable sources are evaluated. Differences in willingness to pay across sources of renewable energy are also investigated.

Prior Studies

Green Power and Bioenergy

Green power marketing is the sale of green power in competitive markets, while green pricing is an optional utility pricing system that enables consumers to support increased utility company investment in renewable energy technologies (Swezey and Bird, 2000). Examples of generating sources for green power products include wind power, photovoltaic, landfill gas, hydropower, biomass, SO_2 allowances, and landfill gas. Most of the planned green power capacity is in wind power (over 80 percent).

Biomass for bioenergy can include any organic matter that is available on a renewable or recurring basis (excluding old-growth timber), including dedicated energy crops and trees, agricultural food and feed crop residues, aquatic plants, wood and wood residues, animal wastes, and other waste materials. Example sources of biomass for electricity include combustion of switchgrasses or hybrid poplar. Sources of feedstocks for bioenergy can also include forestry or agricultural waste or by-products, such as wood chips, stalks of cotton, soyhusks, or sawdust. It has been estimated that as a waste or residue of forest products industries, biomass could provide about three to five percent of electricity generated in the United States. However, as an energy crop, grown on 20-60 million acres, along with the waste or residue uses, biomass could supply between seven and twenty percent of electricity generated in the United States (Hughes, 2000).

Pricing Programs for Green Power

When Farhar and Coburn (1999) asked consumers about pricing, their results suggest that 76 percent of consumers would be willing to pay $1 more on their monthly utility bill, 53 percent would pay $3 more, and 25 percent would pay $6 more. According to Farhar and Houston (1996), national poll samples indicate that 57 percent to 80 percent would be willing to pay more for electricity produced from sources producing less harm to the environment than conventional means. Farhar (1999) found from surveys in five Western/Southwestern states, that 70 percent would pay at least $5 per month more for electricity from renewable sources. Tarnai and Moore (1998) found that 30 percent of adults polled in the Midwest were willing to pay $5 more per month for energy from renewables. While the aforementioned studies' estimates of percentages of those who would pay ranges from 30 to 80 percent, actual customer participation in ongoing green power programs has been as high as 4 percent, but generally participation rates are closer to 1 percent (Swezey and Bird, 2000). The disparity in percentages of actual participation versus the WTP indicated in the studies suggests that previous studies may be seriously flawed in their assessment of the market for renewable energy

Bioenergy Compared With Other Renewables

Although bioenergy constitutes a source of renewable energy, consumers may be unfamiliar with the term "biomass" or "bioenergy". Findings from a previous study suggested that differences in preferences exist across renewable energy across fuel sources (Farhar, 1999). While 69 percent of the study respondents placed "Wind" in their top three choices, only 26 percent placed "Biomass" in their top three choices of renewable energy for their utility to develop. Among potential energy resources for their utility to use, 93 percent somewhat or strongly favored solar power; while 64 percent and 59 percent somewhat or strongly favored

landfill gas and forest waste, respectively. About 53 percent of the respondents stated that they would be willing to pay at least $4 a month more for electricity generated from biomass. In contrast, 65 percent said they would be willing to pay $6 per month more for wind power.

Farhar and Coburn (1999) studied Colorado homeowners' preferences for energy. The homeowners were provided the choices of solar cells, wind power, active solar (domestic hot water systems), passive solar houses, large scale hydropower, burning municipal solid waste, small-scale hydropower, landfill gas, landfill gas, biomass power, ground source heat pumps, or other. Given these choices, only 1.5 percent listed biomass as their top choice, while 33 percent listed solar cells as their top choice.

While both of these studies provided important insights into preferences across potential sources of renewables, they did not use modeling that would account for influences of socio-economic, demographic, or attitudinal factors on WTP for different types of renewable energy. Farhar (1999) used non-linear regression and the R^2 value to find the "best fit" curve for overall WTP for renewables, but not by renewable energy source. In the studies by Farhar (1999) and Farhar and Coburn (1999), only summaries of attitudinal questions and percentages willing to pay specified prices were provided for the potential sources of renewables.

'Yea-Saying' Bias and WTP

Wiser (1998) suggests that attitudinal surveys may tend to overestimate the market for renewables. Farhar and Houston (1996) note percentages expressing WTP tend to be higher in surveys than in reality when provision of a public good is involved, with incentives to "free ride" being expressed in the actual market for green power. Potential upward bias in WTP estimates may be ameliorated if study participants are asked to treat the hypothetical scenario as

realistically as possible and if they are reminded of their budget constraint (Kotchen and Reiling, 1999; Cummings and Taylor, 1999).

Upward bias in WTP for a public good, such as renewables, may also be diminished if participants are allowed to express support for renewables without having to pay a premium. By allowing respondents to express support for renewable energy without requiring a price premium, bias associated with 'yea saying' may be minimized (Blamey, Bennett, and Morrison, 1999). Perceived pressure to provide a "socially responsible" response of WTP a premium for renewables may be decreased, producing a more realistic estimate of consumers' behavior in the marketplace. Therefore, it is important to identify potential reasons why a consumer may not support use of green power of a particular type or may not be willing to pay a premium for it. Findings from recent research regarding WTP for environmentally certified hardwoods using methods to diminish 'yea saying' bias shows a percent of consumers willing to pay that is 20 to 40 percentage points lower than previous studies not using these methods (Jensen, Jakus, English, and Menard, 2001)

Wiser suggests that consumers may have concerns about the veracity of the claims of green marketers. Previous research in environmental certification suggests reasons why consumers may not support green products include that they do not believe environmental certification will work to improve the environment, other causes are of higher priority than the environment, companies should be regulated rather than using voluntary certification, or voluntary certification could lead to regulation (Jensen, Jakus, English, and Menard, 2001). Similar to the market for environmentally certified products, the reasons a person may support green power but being unwilling to pay a premium include an inability to pay more, a belief that it does not cost more to provide a green product, or a belief that manufacturers should not charge

higher prices even if it costs more to make certified products. As mentioned earlier, previous research has indicated that while consumers may be supportive of green power, they may not be supportive of power from bioenergy (Farhar, 1999; Farhar and Coburn, 1999). This lack of support may be in part due to perceived differences impacts on the environment across renewable energy sources.

Study Methods

The survey was conducted by mail in Spring/Summer of 2003. Prior to the field survey, a pretest survey of 50 randomly selected residents was conducted. The results from the pretest suggested no significant design problems. For the field survey, a sample of 3,000 Tennessee residents was randomly drawn. A survey, cover letter, and information sheet were mailed to individuals in the sample. About two to three weeks following the first mailing, a second mailing was sent to all non-respondents to the first mailing. Copies of the survey, cover letters, and information sheets are provided in the Appendix.

The survey contained three sections. First, respondents were asked about their support for and willingness to pay some positive amount for energy from renewable sources. Respondents were reminded that there may be many reasons why someone would be willing to pay more for electricity from renewable sources as well as many reasons why someone might not be willing to pay more for green power. Respondents were also reminded that their budget is allocated between many goods and many environmental and charitable cause, and that green power is but one. If a respondent indicated they supported and would pay some amount more for energy from renewable sources, he or she was asked questions regarding current participation in a green power program and willingness to pay for renewable energy from several sources. If a respondent indicated he or she supported electricity from renewable sources but would not pay

more, or that green power was not supported regardless of its cost, the respondent was instructed to skip forward to demographic questions.

The second section contained questions about consumers' willingness to pay for renewable energy from several sources, including solar, wind, landfill gas, bioenergy from fast growing crops, and bioenergy from forest products wastes. Respondents were asked to read an information sheet comparing land use, emissions, and other environmental impacts across the types of energy sources prior to responding. The sample was evenly divided among five premium levels for a 150kWh block of green power. These premium levels were $1.65, $3.75, $4.50, $6.00, and $13.00. These premium levels and the block of electricity sold were based on data from existing green power programs and did not differ by source of power. For each group, a referendum format was used, where respondents were asked to indicate whether they would be willing to purchase the block of power at that premium level.

The third section included questions about socioeconomics and demographics, including age, education, income, and home ownership. Respondents were also asked about recycling, contribution to environmental organizations, or home energy audits. Respondents were also asked to indicate their highest and lowest monthly bill during the past year.

The effect of demographic characteristics of respondents on the support for and willingness to pay for electricity from renewable sources was estimated using an ordered logit model. The possible outcomes (Support and Pay, Support but Not Pay, and Do Not Support) and their probabilities can be expressed as follows:

$$\Pr(\textit{Support and Pay} = 1) = \Phi(\alpha_1 + \beta X)$$
$$\Pr(\textit{Support and Pay} = 0) = \Phi(\alpha_2 + \beta X) - \Phi(\alpha_1 + \beta X)$$
$$\Pr(\textit{Do Not Support}) = 1 - \Phi(\alpha_2 + \beta X)$$

where α, and β are parameters to be estimated and Φ is the logistic distribution (Greene). The matrix *X* includes demographics and several other factors.

The effects of demographics on willingness to pay for renewable electricity from crops and from forest products wastes are modeled with binomial logit models. The matrix Z includes demographics. A variable measuring the price premium for renewable electricity, *R*, is included in each of the estimated equations for Crops and Forest Wastes. The probabilities of a respondent saying they would pay more for renewable energy from one of these sources, given they stated they supported and would pay more for electricity from renewables is

$$a.\ \Pr(Crops = 1 \mid Pay = 1) = \Phi(\delta_1 + \gamma_1 Z + \varphi_1 R)$$
$$b.\ \Pr(ForestWastes = 1 \mid Pay = 1) = \Phi(\delta_2 + \gamma_2 Z + \varphi_2 R).$$

While the magnitudes on coefficients from each logit model cannot be interpreted directly, the sign of each coefficient can. The significance of the overall model is evaluated with a chi-square likelihood ratio test (LLR).[1] The significance of the coefficients is evaluated with t-tests. The estimate of willingness to pay is calculated as

$$WTP = (\delta + \gamma Z) / -\varphi \quad .$$

The demographic characteristics included in each model are age of the respondent, gender, education level, and household income level. Variables indicating whether the respondents had ever contributed to an environmental organization and whether they had ever participated in an energy audit were also included. The average of the respondents' estimates of their highest and lowest electricity bills for the year was also included in the models.

[1] The Log-Likelihood Ratio Test (LLR) compares the log-likelihood function of the model if only the intercept were included with the log-likelihood of the model and is calculated as LLR (Restricted to Intercept)-LLR (Not Restricted).

Results

Assessing Sample Representativeness

A total of 3,000 surveys were mailed to Tennessee residents. Of these, 2,835 were deliverable. A total of 421 responses were received for a response rate of 14.85 percent. While socioeconomic data were not available for non-respondents, information about location was available. Chi-square tests were used to evaluate the association between urban/rural county and response and also region within the state and response. No significant degree of association was found between either of these location variables and response, suggesting no geographically related non-response bias. In comparing statistics from the respondents with state statistics (Table 1), it appears that the respondents were somewhat older than the state population, however, about the same percent fell into the 45 to 64 year old category (the sample mean was about 55 years old). A larger percent of the respondents were homeowners than in the state overall. The most common income category among the respondents was $35,001 to $45,000 while the state median family income was $43,517. About the same percent of the respondents held a college degree as in the state overall. The respondents were predominantly male while males make up less than 49 percent of the state's population. However, these results could reflect that the individuals who perceived themselves most responsible for paying the electric bill could be comprised by more males than females.

Table 1. Characteristics of Survey Respondents Compared with Overall State of Tennessee Population.

Characteristic	Survey respondents	State
Age:		
15 years to 44 years	29.61 %	45.21 %
45 to 64 years	37.62 %	34.29 %
65 or older	32.78 %	20.50 %
Homeownership	93.56 %	68 %
Income Level:		Median Family
Less than $15,000	7.77 %	Income=$43,517
$15,001-$25,000	10.46 %	
$25,001-$35,000	11.53 %	
$35,001-$45,000	9.92 %	
$45,001-$60,000	15.55 %	
$60,001-$75,000	13.94 %	
$75,001-$100,000	14.48 %	
$100,001-$125,000	8.58 %	
$125,001-$150,000	3.22 %	
greater than $150,000	4.56 %	
Education Level-College Graduate	19.71 %	19.6 %
Male	67.87 %	48.70 %

Sources: Tennessee Statistical Abstract and Census Bureau.

Characteristics of the Respondents

The respondents were on average 55.3 years in age (N=410). About 67.87 percent were male (N=414). Over 50 percent of the respondents held a college degree or higher (Table 2). About 90.45 percent were homeowners (Table 3). Nearly 44 percent of the respondents fell in the income range of $45,001 to $100,000 (Table 4).

Table 2. Highest Level of Education Completed.

Education Level	Percent (N=416)
Grade school or lower (8th grade or lower)	1.44
Some high school	3.13
High school graduate	16.11
Some college or technical school	27.64
College degree	31.97
Post graduate degree	19.71

Table 3. Type of Residence.

Resident Type	Percent (N=419)
Rental house	3.10
Owned house	90.45
Rental condominium or apartment	1.91
Owned condominium	3.10
Other	1.43

Table 4. Household Income from All Sources in 2002 (before taxes).

Income Level	Percent (N=373)
Less than $15,000	7.77
$15,001-$25,000	10.46
$25,001-$35,000	11.53
$35,001-$45,000	9.92
$45,001-$60,000	15.55
$60,001-$75,000	13.94
$75,001-$100,000	14.48
$100,001-$125,000	8.58
$125,001-$150,000	3.22
Greater than $150,000	4.56

About 65 percent of the respondents recycled waste once a month or more (Table 5). However, only about 21 percent had contributed time or money to an environmental organization (Table 6). About 44 percent had participated in a home energy audit (Table 7). The average highest monthly electric bill during the past year was estimated at $184.11, while the lowest was estimated at $74.95 (Table 8). About 73.56 percent of the respondents were located in a Metropolitan Statistical Area (N=416).

Table 5. Recycle Wastes Once a Month or More.

	Percent (N=418)
Yes	65.31
No	34.69

Table 6. Contributed Time/Money to an Environmental Organization.

	Percent (N=416)
Yes	20.91
No	79.09

Table 7. Participated in Home Energy Audit.

	Percent (N=421)
Yes	43.71
No	56.29

Table 8. Highest and Lowest Monthly Electricity Bill (2002).

	Average
Highest (N=402)	$184.11
Lowest (N=498)	$74.95

Opinions on Renewable Electricity

Respondents were asked to indicate their views on electricity from renewable sources. Respondents could select that they supported electricity from renewable sources and were willing to pay more, that they supported electricity from renewable sources but were not willing to pay more, or that they did not support electricity from renewable sources regardless of cost. The results are presented in Table 9. The majority of the respondents supported electricity from renewable sources but were not willing to pay any more for it (54.48 percent).

Table 9. Opinions on Electricity from Renewable Sources.

Opinions	Percent of Respondents (N=402)
I support electricity from renewable sources and am willing to pay more for it.	38.31
I support electricity from renewable sources but am not willing to pay more for it.	54.48
I do not support from renewable sources regardless of how much it costs.	7.21

Those who supported and would pay more were asked whether they currently purchased electricity from renewable sources (for example through a green power program). While these respondents had indicated a willingness to pay, less than 5 percent indicated they currently purchased electricity from renewable sources (Table 10). This number was quite low compared with actual availability of green power. About 70.53 percent of the respondents resided in areas where green power programs were available (N=414).

Table 10. Purchase of Electricity from Renewable Sources.

Purchase of Electricity from Renewable Sources	Percent of Respondents (N=147)
Yes	4.76
No	77.55
Don't Know	17.69

Those who stated they supported electricity from renewable sources and would pay more were then asked about willingness to pay more each month for specific types of renewable energy. As can be seen in Table 11, solar energy received the highest percent of "Yes" responses while bioenergy from forest products received the lowest percentage. However it is important to note that the difference between the two was less than 10 percentage points. In each

case, greater than 80 percent stated they would pay the premium provided. The responses in Table 11 are calculated across all premium levels presented to the respondents ($1.65, $3.75, $4.50, $6.00, and $13.00).

Table 11. Willing to Pay More on Electricity Bill Each Month.

Energy Source	Percent Responding Yes
Wind Energy (N=153)	90.85
Bioenergy from Crops (N=147)	84.35
Solar Energy (N=152)	91.45
Bioenergy from Forest Products Wastes (N=148)	82.43
Energy from Landfill Wastes (N=147)	89.12

As can be seen in Table 12, when the responses are disaggregated across premium level, no clear pattern of price responsiveness emerges. Chi-squared tests of association between percent willing to pay and premium levels did not reveal any significant degree of association for any of the energy sources.

Table 12. Willing to Pay More on Electricity Bill Each Month by Premium Vector.

	$1.65	$3.75	$4.50	$6.00	$13.00	
Energy Source	Percent Responding Yes (N)					Chi-Square
Wind Energy (N=153)	88.57	88.57	93.55	89.29	95.86	1.5081
Bioenergy from Crops (N=147)	85.29	84.38	83.87	88.89	78.26	1.096
Solar Energy (N=152)	94.29	88.24	93.55	92.59	88	1.4092
Bioenergy from Forest Products Wastes (N=148)	85.29	81.25	70.97	96.43	78.26	7.1008
Energy from Landfill Wastes (N=147)	85.71	93.75	90	88.89	86.96	1.2622

If the percentage of respondents who would pay more for electricity from renewable sources (38.31 percent) is multiplied by the percentages willing to pay for the various types of electricity from renewable source (Table 10), an overall percent who would be likely to pay (across the price ranges listed in Table 11) for each type of electricity from renewable sources

can be calculated. These percentages are 34.80 percent for wind energy, 32.31 percent for bioenergy from crops, 35.03 percent for solar energy, 31.58 percent for bioenergy from forest products wastes, and 34.14 percent for energy from landfill wastes.

Support and Willingness to Pay Across Characteristics

Tests of association between support and willingness to pay across characteristics revealed no significant degree of association between support and willingness to pay and gender, recycling, having had an energy audit, urbanization, or availability of green power programs to the respondent. However, significant association was found between support and willingness to pay and educational attainment, with more highly educated respondents being more likely to be willing to pay some amount more for electricity from renewable sources (Table 13).

Table 13. Support and Willingness to Pay Across Educational Attainment.

	Percent of Responses			
Educational Attainment	Support and Would Pay More	Support But Would Not Pay More	Do Not Support Regardless of Cost	Chi-Square
High School Graduate or Less (N=87)	21.84	64.37	13.79	22.1419***
Some College (N=105)	34.29	59.05	6.67	
College Graduate (N=130)	46.15	50.00	3.85	
Post Graduate Degree (N=80)	48.75	45.00	6.25	

As shown in Table 14, the income level at which support and willingness to pay was highest was in the $60,001-$75,000 category. In general, up to that point support levels rose and then declined after that income level. The Chi-square test of association revealed statistically significant association between support and willingness to pay and income.

Table 14. Support and Willingness to Pay Across Income.

	Percent of Responses			
Income Level	Support and Would Pay More	Support But Would Not Pay More	Do Not Support Regardless of Cost	Chi-Square
Less than $25,000 (N=64)	18.75	68.75	12.50	26.8431***
$25,001-$45,000 (N=76)	39.47	57.89	2.63	
$45,001-$60,000 (N=58)	39.66	51.72	8.82	
$60,001-$75,000 (N=51)	60.78	35.29	3.92	
$75,001-$100,000 (N=53)	39.62	50.94	9.43	
At Least $100,000 (N=59)	47.46	47.46	5.08	

Respondents who had contributed time or money to environmental organizations were more likely to support and be willing to pay more for electricity from renewable sources (Table 15). The Chi-square test revealed a significant degree of association between support and willingness to pay and contribution to environmental organizations.

Table 15. Support and Willingness to Pay Across Contribution to Environmental Organizations.

	Percent of Responses			
Contributed	Support and Would Pay More	Support But Would Not Pay More	Do Not Support Regardless of Cost	Chi-Square
No (N=314)	32.80	58.92	8.28	22.5384***
Yes (N=84)	60.71	36.90	2.38	

The average age of respondents was compared across support and willingness to pay (Table 16). An F-test was used to test for overall differences in the means. The test showed significant differences among the mean ages, therefore t-tests were used to assess differences between each pair of means. The t-test showed that the age of those who did not support electricity from renewable sources was statistically higher than the mean age of the respondents in the other two groups. No differences in means for lowest and highest electricity bills were found across support and willingness to pay.

Table 16. Mean Age, Highest Electricity Bill, and Lowest Electricity Bill Across Support and Willingness to Pay.

Characteristic	Support and Would Pay More	Support But Would Not Pay More	Do Not Support Regardless of Cost	F-Statistic
Age (N=393)	53.10 [a]	54.74[a]	64.38	6.53***
Highest Electricity Bill (N=386)	182.92	184.52	176.02	.11
Lowest Electricity Bill (N=381)	75.40	75.41	72.75	.97

[a] Not Significantly different at the .05 probability level, using a t-test.

The mean percents of individuals who would pay more for each of the types of renewable energy were compared. The results are shown in Table 17. For the purposes of comparison, only observations where responses were provided to each of the questions about renewable energy sources were used. A comparison of the means revealed that a higher percentage of the respondents would pay for solar and wind energy than bioenergy from crops or forest wastes. The mean percent of individuals who would pay more for landfill gas was not statistically different from the mean percent who would pay more for bioenergy from crops. Means with like letters beside them are not significantly different. For example, crops and forest wastes both have the letter "c" beside them. This indicates that these two means are not statistically different from each other.

Table 17. Willingness to Pay for Specific Sources Comparisons of Means.

Renewable Energy Source	Percent Responding Would Pay More (N=144)	
Solar	90.97	a
Wind	90.28	a
Landfill Gas	88.89	ab
Crops	84.03	bc
Forest Wastes	82.64	c

[a,b] Not Significantly different at the .05 probability level, using a t-test.

Effects of Demographic Characteristics on Support and Willingness to Pay

To evaluate how demographic characteristics might affect willingness to pay for renewable electricity from crops or forest wastes, three models were estimated. The first model estimated the effect of demographics on support for and willingness to pay a premium for electricity from renewable sources in general. The second and third models estimated the effect of demographics on willingness to pay for electricity from crops and electricity from forest wastes. The results from these models are presented in Tables 18-20.

Support for and Willingness to Pay for Green Energy

As shown in Table 18, the ordered logistic model for support and willingness to pay was significant using the LLR test. The model correctly predicted 68 percent of the responses. Educational attainment had a positive influence on support and willingness to pay for electricity from renewable sources. Respondents in the $60,000 to $75,000 income category were more likely than others to support and be willing to pay for renewable sources. If an individual had contributed time or money to an environmental organization, this also had a positive influence. Neither gender nor age significantly influenced support and willingness to pay. Having had a home energy audit or electricity bill level did no significantly influence support and willingness to pay.

Table 18. Ordered Logistic Model of Support and Willingness to Pay.

Variable	Estimated Parameter	Wald Chi-Square	
Intercept 1	-.7303	.2940	
Intercept 2	2.5931	3.6414	*
Age	-.0280	.2881	
Age Squared	.000204	.1829	
Male	.0523	.0424	
High School Graduate	.6999	3.8370	*
Some College	.9499	6.7154	***
College Graduate	1.1255	7.8280	***
Household Income $45,001-60,000	-.0187	.0029	
Household Income $60,001-75,000	.6774	3.3010	*
Household Income $75,001-100,000	-.2150	.3209	
Household Income Greater than $100,000	.1708	.2039	
Contributed to Environmental Organization	.9090	10.2766	***
Participated in Home Energy Audit	.3127	1.2926	
Average of Highest and Lowest Electricity Bill	-.00012	.0041	
N=339			
LLR Test	42.0435	***	
Percent Correctly Classified	68%		

Willingness to Pay for Green Power from Forest Wastes

The logistic model of willingness to pay for electricity from forest wastes is displayed in Table 19. The model was not significant overall, but correctly classified 79.6 percent of the observations. Neither premium level nor income significantly influenced willingness to pay for electricity from forest wastes. Age, gender, and education level affected willingness to pay. Being male or being a high school or college graduate had positive influences on willingness to

pay. All else equal, the likelihood of being willing to pay a positive premium increased with age until age 55.25 years when it began to decline.

Table 19. Logistic Model of Willingness to Pay for Electricity from Forest Wastes.

Variable	Estimated Parameter	Wald Chi-Square	
Intercept	-9.9204	7.2299	***
Premium	-.0676	.7730	
Age	.4232	8.0745	***
Age Squared	-.00383	7.5981	***
Male	1.4744	5.6929	**
High School Graduate	1.8382	2.6533	*
Some College	1.4744	1.9988	
College Graduate	2.4419	4.3775	**
Household Income $45,001-60,000	.0525	.0031	
Household Income $60,001-75,000	-.7519	.6970	
Household Income $75,001-100,000	-0.8614	.8311	
Household Income Greater than $100,000	-1.4266	2.0578	
Contributed to Environmental Organization	-0.6027	.7592	
Participated in Home Energy Audit	-0.5354	.6519	
Average of Highest and Lowest Electricity Bill	-0.00242	.2854	
N=127			
LLR Test	18.3726	*	
Percent Correctly Classified	79.2%		

Willingness to Pay for Green Power from Crop Sources

The estimated logistic model of willingness to pay for electricity from crops is displayed in Table 20. The model was significant overall and correctly classified 82.9 percent of the observations. Neither premium level nor gender significantly influenced willingness to pay for

electricity from crops. Age, education level, and income affected willingness to pay. Being a high school or college graduate had positive influences on willingness to pay. Incomes of $60,000 to $100,000 also had positive influences. Likelihood of being willing to pay increased with age until age 50.51 years when it began to decline. Contribution to an environmental organization had a negative effect on willingness to pay. Neither having had a home energy audit or average bill had a significant influence on willingness to pay for electricity from crops.

Table 20. Logistic Model of Willingness to Pay for Electricity from Crops.

Variable	Estimated Parameter	Wald Chi-Square	
Intercept	-9.3136	4.8091	**
Premium	-.0650	.6785	
Age	.4394	7.3432	***
Age Squared	-.00435	6.6973	***
Male	.5094	0.5424	
High School Graduate	2.7058	3.0892	*
Some College	1.4085	1.2883	
College Graduate	2.4006	2.8683	*
Household Income $45,001-60,000	-1.6292	2.0825	
Household Income $60,001-75,000	-2.0301	2.9246	*
Household Income $75,001-100,000	-2.6807	4.8570	**
Household Income Greater than $100,000	-1.5897	1.3171	
Contributed to Environmental Organization	-1.4673	4.2336	**
Participated in Home Energy Audit	-.9851	1.8470	
Average of Highest and Lowest Electricity Bill	-.00597	1.5045	
N=126			
LLR	23.0972	**	
Percent Correctly Classified	82.9		

Estimates of Willingness to Pay

The coefficients on the premiums in each of the models were not statistically different from zero. However, if the coefficients were used to calculate price willing to pay (among those stating they would be willing to pay more for energy from renewable sources) using the formula, then price for the 150kWh block of electricity from forest wastes would be $25.65 (N=127) and the price for electricity from crops would be $34.56 (N=126). If these conditional prices are then multiplied by the percent of respondents stating they would be willing to pay more for renewable energy (38.31) then the unconditional prices are $9.82 for electricity from forest wastes and $13.24 for electricity from crops per month. These estimates are equivalent to 6.51 cents per kWh and 8.83 cents per kWh respectively. Caution should be used with these estimates because the price coefficients were not significantly different from zero.

Conclusions

The results from this study suggest that the percentage of residential electricity consumers who are willing to pay premiums for electricity is much lower than found in prior studies, at 38 percent compared with estimates as high as 60 percent. Findings from this suggest that there is a slightly lower preference for electricity from crops or forest wastes than for electricity from solar or wind sources. However, percents responding positively for crops and electricity from landfill wastes are not statistically different. This finding is similar to those from prior studies.

Generally, those who would be willing to pay more for electricity from renewable sources are more highly educated, middle income individuals who have contributed time or money to environmental organizations. If male gender, income of $60,000-$75,000, and having

contributed to an environmental organization is used as a profile, this profile of respondent has over an 80 percent chance of stating they would be willing to pay more for electricity from renewable energy sources. It should be noted, however, that this profile constitutes are relatively small share of the sample (less than 5 percent).

Those who were willing to pay more for electricity from forest wastes are in their 50's, male, and a college graduate. Those who were willing to pay more for electricity from crops were in their 50's, high school or college graduates, of middle income ($60,000 to $100,00), and had not contributed time or money to an environmental organization.

The results from this study do suggest that there is a potential market demand for electricity from forest wastes and crops, however, the market likely smaller than that for wind or solar power. The results with regard to contribution of time or money to an environmental organization suggest that this may have a negative influence on potential consumers' views of bioenergy.

Because a significant price response was not found, a wider range of premiums should be used in future research. The premiums used in this study were based on premium levels currently used in the industry. Another explanation for the lack of price responsiveness is that the survey did not adequately control for the yea-saying bias despite the use of the Blamey *et al*. method successfully use din the past. In this case it is possible that those respondents self-selecting into the "support and willing-to-pay more" category simply did not focus on price. Subsequent research will examine the open-ended responses for the "why are you willing to pay?" and "why are you not willing to pay?" follow-up questions to ascertain the degree to which any bias may be present.

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Appendix

Your Views on Electricity from Renewable Sources

The purpose of this study is to measure your views on purchasing electricity from renewable sources. Renewable sources include sunshine, wind, vegetation, or wastes. Consumers can purchase energy from renewable sources through "green" power programs offered by their utilities. If you have any questions as you are completing the survey, please feel free to contact us, Dr. Kim Jensen or Dr. Burt English at 865-974-3716.

You may have many reasons for being willing to pay more for electricity from renewable sources or not being willing to pay more. You must make many choices between products and financially supporting important causes. Please keep in mind your ability to pay additional amounts for electricity from renewable sources given these choices and your budget.

1. Please circle the response that best reflects your views on electricity from renewable sources.

   a. I support electricity from renewable sources and am willing to pay more for it. (Please continue on to question 2).

   b. I support electricity from renewable sources but am not willing to pay more for it. (Please go to question 4).

   c. I do not support from renewable sources regardless of how much it costs. (Please go to question 4).

2. Do you currently purchase electricity from renewable sources (for example through a green power program)? (Go to question 3)

   a. Yes b. No c. Don't know

Please read the enclosed information sheet "Energy Sources and the Environment" that compares energy from renewable sources. *Information about coal is included for comparison purposes. The table to the right is provided as an example of a typical monthly bill with and without green power.*

3. Would you be willing to pay <u>$1.65 more on your electricity bill each month</u> for energy from the following sources? (*for 150 kWh of electricity or about 12-15% of a typical household's electricity needs).* Check the correct answer for each type of electricity source.

Example Monthly Bill With and Without Green Power

Type of Electricity	Use kWh	Price $/kWh	Total Amount
Typical Household:			
Conventional	1042	$.061	$63.56
*Buying One 150 kWh Block of Green Power:**			
Conventional	892	$.061	$54.41
Green	150	$.072	$10.80
			$65.21
Additional per Month for Green Power			*$1.65*

*The premium for Green Power is $.011/kWh. This amount is added to the conventional amount for each kWh of Green Power purchased. For the 150 kWh block, the added amount would be about $1.65.

Electricity Source	Yes	No	If No, Why?
a. Wind Energy			
b. Bioenergy from Crops			
c. Solar Energy			
d. Bioenergy from Forest Products Wastes			
e. Energy from Landfill Wastes			

This last set of questions is about you and your household. Answering these questions will help us compare how views on renewable energy may differ across electricity consumers.

4. What is the name of the company that provides your electricity service?_____

   _____

5. What is your age? _____.

6. What is your gender? Circle the answer.
   a. Male b. Female

7. What is the highest level of education you have completed? Circle the answer.

a. Grade school or lower (8th grade or lower)	d. Some college or technical school
b. Some high school	e. College degree
c. High school graduate	f. Post graduate degree

8. What type of residence do you live in? Circle the answer.
   a. Rental house
   b. Owned house
   c. Rental condominium or apartment
   d. Owned condominium
   e. Other (Please describe: _____).

9. What was your household's income from all sources before taxes in 2002? Circle the answer.

a. Less than $15,000	f. $60,001-$75,000
b. $15,001-$25,000	g. $75,001-$100,000
c. $25,001-$35,000	h. $100,001-$125,000
d. $35,001-$45,000	i. $125,001-$150,000
e. $45,001-$60,000	j. greater than $150,000

10. About how much was your highest monthly electricity bill last year (2002)? $ _____.

11. About how much was your lowest monthly electricity bill last year (2002)? $ _____.

12. Do you recycle wastes (for example, plastic, aluminum cans, or newspapers) once a month or more?

    a. Yes b. No

13. Have contributed time or money to an environmental organization in the past year?

    a. Yes b. No.

14. Have you ever participated in a home energy audit (either a trained professional visits your home or you use a check list provided by your utility) to determine ways to improve your household energy use?

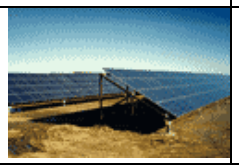
    a. Yes b. No.

Thank you for your participation. Please place the competed questionnaire in the postage paid envelope and return by mail.

_____Yes, I would like to receive information about the summarized results from this study.

ENERGY SOURCES AND THE ENVIRONMENT

The air emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx) are the primary causes of acid rain. Carbon dioxide or CO2 is a greenhouse gas. Scientific evidence points toward greenhouse gases contributing to global warming.

Electricity Source	How Does it Work?	How Many Pounds of Air Emissions Are Created to Supply Electricity to a Typical Household for a Year?*			How Many Acres of Land Are Needed to Supply Electricity to a Typical Household?*	Other environmental impacts
		Sulfur OxidesS Ox	Nitrogen Oxides NOx	Carbon Dioxide CO2		
Bioenergy from switchgrass or other fast growing crops or trees 	Switchgrass is a fast growing perennial grass native to N. America and can be grown on lands not suited for crops like soybeans or corn. Switchgrass can be burned directly to produce steam which is converted to electricity.	1	26	0 (No Net Emissions. Burning switch-grass releases CO2, but growing plants use CO2)	1.5	Can help reduce soil erosion. Requires use of pesticides and fertilizers in production, but less than traditional crops.
Solar electricity from photo-voltaic cells 	Solar panels contain materials that convert sunlight into electricity. Systems supply electricity back through the grid to the utility.	0	0	0	3/100	Toxic chemicals such as cadmium sulfide and gallium arsenide are used in manufacture of solar cells. Disposal of inoperative cells could become a long-term environmental problem.
Bioenergy from forest products wastes 	Forestry wastes are created when trees are logged. Mill residues are created when trees are made into products such as lumber and pulp. Forest products wastes can be burned to generate electricity.	1	26	0 (No Net Emissions. Burning of forest products wastes releases CO2 but forest growth uses CO2)	0 (Use of existing residues that would otherwise be landfilled)	Reduces the amount of solid waste sent to landfills. If market use exceeds the amount of available residues then about 7 acres of land planted in trees would be needed per household.
Wind electricity from wind turbines 	Wind electricity is captured by turbines. A rotor collects energy from the wind and a generator converts it into electricity. On flat areas, wind farms are used (many turbines). On hilltops, small numbers of turbines may be used.	0	0	0	4/1000	Visual clutter. Bird deaths in turbines.
Landfill gas 	Methane produced by decaying wastes in landfills is burned to produce electricity through a generator.	7/100	43	0 (No Net Emissions. The same amount of CO2 would be released as part of the decomposition process)	0 (Use of gases from existing landfills)	Decreases the amount of methane, a potent greenhouse gas (over 21 times stronger than CO2), from landfills by using it as an energy source.
Coal-fired plants 	Coal is mined and transported to the electricity plant where it is burned. A turbine captures the steam and a generator converts it into electricity. Coal can be mined from the surface or below the surface of the ground.	252	72	25,000	1/100	Surface mining destroys land surface from turning soil over, causes soil erosion, and potential pollution of ground water from waste water ponds. Surface mined areas are expensive to restore. Underground mining can cause land to sink (subside) and has potential for ground water pollution.

* Based on an average household use of 12,500 kilowatt hours per year. Production of emissions varies from facility to facility depending on the type of technologies used. These estimates are from studies which evaluated emissions using technologies commonly in place in this region.

6/4/2003

Dear Respondent:

As you are aware, issues regarding the environment are important to many consumers. Many electric utilities have either added or are considering adding a "green power" program so that consumers may purchase electricity from renewable sources. Renewable electricity may come from several sources, including sunshine, wind, vegetation, or wastes. As a consumer of electricity, your views on renewable energy and opinions about various types of renewable energy are of great importance.

Please take a few moments (about 5 minutes) to complete the enclosed questionnaire regarding your views on purchasing electricity from renewable sources. Your participation in this study is completely voluntary. All responses will be kept strictly confidential. Only summary statistics will be reported. The person responsible for paying the household electricity bill should complete this survey. Researchers at the University of Tennessee are conducting this study. When you have completed the survey, please place it in the postage paid envelope and return it to us by mail. If you have any questions as you are completing the survey, please feel free to contact us, Dr. Kim Jensen or Dr. Burt English at 865-974-3716.

Sincerely,

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6/18/03

Dear Respondent:

A few weeks ago we sent you a questionnaire regarding your views on electricity from renewable sources. We have not yet received your completed questionnaire. As you are aware, issues regarding the environment are important to many consumers. Many electric utilities have either added or are considering adding a "green power" program so that consumers may purchase electricity from renewable sources. Renewable electricity may come from several sources, including sunshine, wind, vegetation, or wastes. As a consumer of electricity, your views on the importance of renewable energy and opinions about various types of renewable energy are of great importance.

If you have already completed the questionnaire, we would like to take this opportunity to thank you. In that case, you may discard this questionnaire or keep it for your own records. If you have not completed the questionnaire, please take a few moments (about 5 minutes) to complete the enclosed questionnaire. Your participation in this study is completely voluntary. All responses will be kept strictly confidential. Only summary statistics will be reported. The person responsible for paying the household electricity bill should complete this survey. Researchers at the University of Tennessee are conducting this study. When you have completed the survey, please place it in the postage paid envelope and return it to us by mail. If you have any questions as you are completing the survey, please feel free to contact us, Dr. Kim Jensen or Dr. Burt English at 865-974-3716.

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