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PUBLIC ATTITUDES TOWARD CONSTRUCTION OF NEW POWER PLANTS

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Abstract Increased demand for U.S. electricity generation will require the construction of hundreds of new power plants in the coming decades. We examine attitudinal data from the 2008 MIT Energy Survey to measure public support for and opposition to the local siting of power plants. Substantial majorities of Americans oppose the location of coal, natural gas, and nuclear power plants in their area, although a majority supports local siting of wind facilities. We find that attitudes about plant siting depend heavily on perceptions of the environmental harm and costs of specific facilities; the effects of these attributes are similar across different types of fuel sources, suggesting that there is a common underlying structure to an individual's attitude. That is, people view all power sources in the same framework and differentiate them on perceived endowments, the most important of which is environmental harm.

Expansion of electric power generation over the coming decades presents a major political challenge for the United States. The U.S. Energy Information Agency projects a 40 percent rise in electricity demand over the next 30 years. To meet rising demand with the current mix of energy sources will require approximately 230 new coal-fired power plants, 160 wind farms, and 10 nuclear power facilities (U.S. EIA 2007).[1] Given the inefficiency of electricity transmission, most of these facilities will need to be located near population centers, raising the prospects that local opposition to such facilities may significantly delay or even prevent the development of sufficient numbers of power plants to

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1. These estimates are based on "back of the envelope" calculations, using projections of future generation and current generation capacities for producing electricity from each energy source.

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meet electricity demand. It is widely thought that public opposition will limit the ability of the United States to meet future demand. Efforts to locate new power plants will evoke a knee-jerk reaction of opposition: Not in My Backyard (or NIMBY).

A long literature examines public attitudes toward the location of environmentally hazardous facilities, including toxic waste handling facilities, nuclear waste repositories, and solid waste landfills (Kraft and Clary 1991; Portney 1991; Easterling 1992; Pollock, Vittes, and Lilie 1992; Hunter and Leyden 1995; Jenkins-Smith and Kunreuther 2001). Opposition to power plants is thought to be particularly pronounced because coal, nuclear, natural gas, and other power plants are complex chemical processing facilities that emit or produce toxic wastes locally. Survey organizations have, since the mid-1970s, gauged public attitudes about the local construction of new nuclear power plants (Rosa and Dunlap 1994; Bolsen and Cook 2008), and, more recently, public attitudes toward the local siting of wind power facilities (Krohn and Damborg 1999; Wolsink 2000, 2007; Devine-Wright 2005; Warren et al. 2005).

The central question concerning public attitudes toward power plant location is whether the NIMBY reaction is a strong, constant reaction, or whether it is variable and depends on characteristics of the public and of the facilities in question. And, if attitudes about plant location vary, on what do they depend? The most significant stream of research concerning opposition to power plants concerns individuals' risk attitudes. Risk-taking individuals express greater willingness to accept potentially dangerous technologies (e.g., Slovic 1987), and some technologies trigger more severe aversion to risk (Kahneman, Slovic, and Tversky 1982). Individuals' risk attitudes and trust in government and energy companies further correlates with the acceptability of nuclear power plants (Tanaka 2004). And, attitudes about global warming have been found to have some influence on people's preferences on energy alternatives (Krosnick, Holbrook, and Visser 2000; Bannon et al. 2007).

This article measures attitudes about the location of coal, natural gas, nuclear, and wind power facilities. We gauge overall levels of opposition to power plants generally and the relative public support for each technology. Most studies focus on one power source at a time, making it unclear whether opinions reflect the characteristics of the plants or public attitudes toward *any* development. We show that individuals' preferences about plant location vary across power sources and depend systematically on perceptions of environmental harm and economic cost from each type of facility, as well as individual's personal risk attitudes.

A Model of Opinions

We model opinions about plant location as a function of perceived attributes of a fuel source, especially environmental harm and cost, and of an individual's

characteristics. Recent work examining attitudes about power generation from nuclear power and coal has shown the importance of perceptions of environmental harm and costs (MIT 2003, 2007). A simple model expresses the relative importance of these considerations:

$$\begin{aligned} Y_{ij}[\text{Power plant opposition}] &= \alpha_j + \beta_1 E_{ij}[\text{Energy attributes}] \\ &+\beta_2 I_i[\text{Individual characteristics}] + \varepsilon_{ij} \end{aligned} \tag{1}$$

where i indexes individuals, j indexes the four types of power plants (coal, natural gas, nuclear power, and wind), α is a power plant-specific intercept, E is a vector of power plant attributes, I is a vector of personal characteristics including an individual's risk orientation, electricity consumption, socioeconomic status, political attributes, and other demographics, and ε is an error term.

Three effects can account for differences in attitudes about plant location. The first factor, an endowment effect, reflects the values of the attributes of a fuel source, i.e., the average perceived costs and perceived environmental harms. Respondents might favor one power source over another because the favored power source is perceived, on average, as cheaper or less harmful to the environment. A second factor is a discrimination effect, arising from differences in the weights of a particular attribute (i.e., price or harm) across power sources. Two power sources might be seen as equally bad for the environment, but individuals might think about the environment when considering one source but not the other. A third component, a characteristic effect, corresponds to differential effects of individual characteristics across power plants. Education or risk attitude or political orientation might have more pronounced effects on one power source than they do on others.

To estimate the contribution of these effects, we proceed in three steps. First, we estimate Equation (1) for each type of power plant. Second, we evaluate each regression at its average (average of Y and of E and I). Third, we compute the difference in the regressions evaluated at their averages between pairs of power plants. This yields

$$\bar{Y}_1 - \bar{Y}_2 = \alpha_1 - \alpha_2 + \hat{\beta}_{11}\bar{E}_1 - \hat{\beta}_{12}\bar{E}_2 + \hat{\beta}_{21}\bar{I} - \hat{\beta}_{22}\bar{I} \tag{2}$$

$$= (\alpha_1 - \alpha_2) + (\hat{\beta}_{11} - \hat{\beta}_{12})\bar{E}_1 + \hat{\beta}_{12}(\bar{E}_1 - \bar{E}_2) + (\hat{\beta}_{21} - \hat{\beta}_{22})\bar{I} \tag{3}$$

This method is commonly used in labor economics to calculate endowment and discrimination effects in labor markets (Blinder 1973; Oaxaca 1973).

Equation (3) parses differences in attitudes across fuels into four components. First, differences in the intercepts measure the extent to which people favor one fuel source over another, regardless of the fuel's attributes or individuals' characteristics. Second, differences in the coefficients on attributes across fuel types correspond to discrimination effects, i.e., $(\hat{\beta}_{11} - \hat{\beta}_{12})\bar{E}_1$. Third, differences in average levels of the perceived attributes, assuming people give that attribute the same weight, measure endowment effects, i.e., $\hat{\beta}_{12}(\bar{E}_1 - \bar{E}_2)$.

Fourth, individual characteristics might matter more for some fuels than for others, i.e., $(\hat{\beta}_{21} - \hat{\beta}_{22})\bar{I}$.

Methods

The 2008 MIT Energy Survey was designed to examine whether attitudes about a particular type of power plant reflect characteristics of the plant itself, or attitudes about nearby development in general.[2] This web-based survey, conducted by Knowledge Networks (KN), asked a sample of 1,430 U.S. residents their perceptions of different energy sources and their willingness to accept a new coal, gas, nuclear power, or wind facility near their homes. The survey was conducted during January 2008, and consists of a nationally representative, randomly selected sample of U.S. adults. Members of the KN panel are recruited through random digit dialing and then contacted to participate in surveys through email; panel members without internet access are provided it for free in exchange for completing surveys.[3]

The key variable we wish to measure and explain is attitude about plant location. The survey asked: "To meet new electricity demand, utilities will have to build additional power plants. How would you feel if a new natural gas-fired power plant were built within 25 miles of your home?" The question was asked for a natural gas plant, a coal-fired power plant, a nuclear power plant, and a large wind power facility (100- to 250-foot towers).[4] As table 1 shows, there is a strong tendency for the public to oppose new power plants nearby, but these preferences clearly vary across individuals and types of facilities, and some types of power, notably wind, receive majority support.

We also measure perceptions of the attributes of individual energy sources—their costs and environmental harms—and the characteristics of individuals—especially their risk attitudes. To measure perceptions of harm, the survey asks: "Some ways of generating electricity may be harmful to the environment we live in because they produce air pollution, water pollution, or toxic wastes. How harmful do you think each of these power sources is?"[5] To measure perceptions

2. The 2008 MIT Energy Survey is available at the MIT PORTL website: http://web.mit.edu/polisci/portl/index.html.

3. KN contacted 2,312 panelists for this survey; 1,430 finished the survey, for a completion rate of 61.9 percent. KN reported a recruitment rate of 25.1 percent and a profile rate of 55.7 percent, yielding a cumulative response rate of 8.7 percent. The recruitment rate computed by KN uses the AAPOR Response Rate 3 for telephone surveys. See Callegaro and DiSogra (2008) for additional details on computing response rates for online panels.

4. The order of these questions was not randomized, so order effects are possible.

5. Rather than drop "not sure" responses and lose observations, we recode these responses to the middle category ("somewhat harmful"). The results are robust when these individuals are excluded. We also recode "not sure" responses for the perceptions of energy cost variables below the middle category ("moderately priced"), which again does not substantively change the results. We include a dummy variable in the regression analyses to capture whether individuals responding not sure are systematically more likely to express more/less opposition to local power plant siting.

Table 1. Public Attitudes about Siting a New Power Plant within 25 Miles of Home

Type of plant	Coal-fired power plant (%)	Natural gas-fired power plant (%)	Nuclear power plant (%)	Wind power facility (%)
Strongly oppose	45.0	25.7	55.3	11.2
Somewhat oppose	32.1	32.3	21.2	14.3
Support	20.2	38.3	18.5	48.8
Strongly support	2.7	3.7	5.0	25.7
n	1,417	1,415	1,422	1,416

NOTE.—Data from 2008 MIT Energy Survey. Response to question: To meet new electricity demand, utilities will have to build additional power plants. How would you feel if a new [type of plant] were built within 25 miles of your home: strongly oppose, somewhat oppose, support, or strongly support?

Table 2. Descriptive Statistics

Attributes of energy type	Mean	Standard deviation	Minimum	Maximum
Perceived environmental harm				
Coal	0.71	1.15	−2	2
Natural gas	−0.52	1.02	−2	2
Nuclear power	0.16	1.39	−2	2
Wind	−1.68	0.73	−2	2
Perceived cost				
Coal	0.04	1.00	−2	2
Natural gas	0.34	0.89	−2	2
Nuclear power	0.40	1.10	−2	2
Wind	−0.65	1.12	−2	2

NOTE.—Data from 2008 MIT Energy Survey. The scale of these variables ranges from very harmful (very costly) which takes a value of 2 to not harmful at all (very cheap) which takes a value of −2.

of cost, the survey asked respondents to indicate how expensive it is to produce electricity from each type of energy source. We expect that people will be less favorable toward power plants that they perceive produce electricity more expensively. Table 2 presents descriptive statistics for these measures.

In addition to the measures of energy attributes described above, we include in the analysis a variety of measures of individual characteristics. The most important such characteristic cited in the literature is risk attitude. Risk-averse individuals are less likely to support a power plant of any kind in their community. To measure personal risk, the survey asked respondents to place themselves on an 11-point scale where higher values reflect higher risk tasking (Dohmen et al. 2005; Bonin et al. 2007). Other potentially relevant characteristics of individuals include economic circumstances and opinions, residency,

and political orientation. We also include measures that we expect or have been shown to correlate with preferences on environmental issues: energy consumption (measured in terms of the amount of money spent on electricity last month), confidence individuals have in companies responsible for building and operating power plants and the government agencies that monitor the performance of power plants (Kraft and Clary 1991; Kunreuther, Fitzgerald, and Aarts 1993; Hunter and Leyden 1995; Jenkins-Smith and Kunreuther 2001), and political attitudes (e.g., Guber 2003; Konisky, Milyo, and Richardson 2008). We also control for several socioeconomic and demographic attributes, including income, education, race, age, and gender, as well as region and living in a city, suburb, or rural area.[6] Such factors are conjectured to explain attitudes about development. Previous work has produced mixed findings regarding demographic and political characteristics, so we do not have strong expectations about the effects of these variables.

Results: Explaining Attitudes toward Power Plants

To assess the determinants of attitudes about power plants, we estimate Equation (1) for each type of power plant—coal, natural gas, nuclear power, and wind. We use a seemingly unrelated regression model because we expect a correlation between the residuals in the four models.[7] Results are presented in table 3.

The most striking feature of these estimates is their similarity. The table presents the unstandardized coefficients, but the standardized coefficients indicate that, for each power source, perceived environmental harm has the strongest effect, followed by perceived cost, and then the effects of risk attitude (any comparison of the size of effects below reflect the standardized coefficients).[8] The coefficient on perceived environmental harm is approximately .30 in the cases of coal, nuclear power, and wind, but close to .18 for natural gas. The difference between seeing a fuel source as very harmful and not harmful at all is about 1.2 points on a scale of -2 to 2. Perceptions of the cost of producing electricity from a specific energy source are also positively associated with attitudes toward the local siting of a new power plant. The more expensive people perceive electricity production from a power source to be, the more they oppose such a plant as a means to produce electricity in their area. Risk-averse individuals are much more likely to oppose the siting of each type of power plant, and the

6. Perceptions of the health risks and costs associated with different energy sources used in electricity generation, as well as an individual's personal risk orientation, are not very well explained by the demographic and political attributes included in the model. In regressions not reported, we estimated the effects of these attributes, and the *R*-squares in the models typically were about .05.

7. A Breusch–Pagan test of independence confirms that this is the case. We also estimated single-equation models using both OLS and ordered logistic regression, and the results are substantively similar.

8. Wald tests confirm that the coefficient on perceived environmental harms for each power source has a larger effect on opposition to power plant siting than do cost or general risk attitudes.

Table 3. Linear Regression Coefficients of the Determinants of Opposition to New Power Plants

	Coal-fired power plant		Natural gas-fired power plant		Nuclear power plant		Wind power facility	
Perceived environmental harm	.298**	.107	.179**	.020	.307**	.019	.308**	.037
Perceived energy cost	.041*	.019	.109**	.023	.092**	.022	.051*	.021
Personal risk	−.035**	.010	−.044**	.011	−.050**	.011	−.056**	.011
Income	.001	.006	−.002	.007	.007	.006	−.006	.007
Education	.015	.014	−.032*	.015	−.023	.014	.005	.015
Electricity bill	.001	.012	−.005	.013	.015	.012	.015	.013
Democrat	.106	.057	.137*	.061	.086	.059	−.008	.060
Independent	.058	.053	.057	.057	.044	.055	.008	.057
Trust in government	.012	.022	−.026	.023	.023	.022	−.002	.023
Confidence in companies	−.076**	.021	−.038	.022	−.092**	.021	.072**	.022
Female	.172**	.044	.276**	.047	.134**	.046	.158**	.046
Age	−.019	.014	−.058**	.015	−.033*	.015	.022	.015
Nonwhite	.118*	.055	.217**	.059	.016	.057	.310**	.059
City	.052	.055	.018	.059	.105	.057	.055	.058
Suburb	.159*	.054	.070	.058	−.009	.055	.140*	.058
Home owner	−.020	.055	−.041	.066	.024	.057	−.047	.059
Intercept	2.20**	0.149	2.35**	0.158	2.38**	0.16	1.42**	0.17
n	1,165		1,165		1,165		1,165	
R^2	.28		.21		.42		.21	

NOTE.—Data from 2008 MIT Energy Survey. Dependent variable: level of opposition to power plant built within 25 miles of respondent's home, where 0 is strongly support, 1 is support, 2 is somewhat oppose, and 3 is strongly oppose. Coefficients and their corresponding standard errors are from seemingly unrelated regression models. All models also include regional dummies and dummy variables for "not sure" response to environmental harm and energy cost questions. According to the Breusch–Pagan test of independence, $\chi^2 = 603.7$; $p < .000$. Significance levels: *.05, and **.01.

effects are quite similar across fuel sources. This pattern suggests that there is a common, underlying structure to the public's attitudes about new power plant construction.

Demographic, economic, and political characteristics had uneven and much smaller effects. Contrary to expectations, an individual's electricity consumption is not a good predictor of their attitudes toward the construction of a new power plant within 25 miles of their home. Democratic respondents were somewhat more likely to oppose natural gas and coal power plants, although the coefficient for coal plants had only marginal statistical significance. Women and minorities express more opposition to the construction of any new power plants, except in the case of nuclear power, which evokes equal opposition from whites and nonwhites. Older individuals have more favorable views of natural gas and nuclear power plants, while those in suburbs express more opposition to coal and wind power facilities. Except for the case of wind power, people who are more confident in energy companies express less opposition to local siting of a power plant.

Using these results, we can assess the relative importance of endowment, discrimination, and individual characteristic effects. Table 4 presents our partitioning of these effects. Coal is treated as the baseline case, and we compare it with nuclear power, natural gas, and wind (see Equation 3).

By far, the largest component of the differences in attitudes comes from the endowment effect for environmental harm. Endowment effects account for nearly a .4 difference in preferences about location in the comparison of natural gas and coal, a .2 difference in the comparison of nuclear power and coal, and a .9 difference in the comparison of wind and coal. Endowment effects for prices of electricity do not contribute significantly to differential assessments of plant location, and discrimination effects matter only in the comparison of natural gas versus coal. Individual characteristics did not affect the comparative assessment of location of different sorts of power plants in a consistent way.

Although risk attitudes matter for each fuel source individually, they show no differential effects when comparing preferences about alternative fuel sources. This finding is particularly striking in the case of nuclear power, as the dread of a nuclear catastrophe has long been thought to be the obstacle to wider public support. If dread indeed was the problem, then risk attitudes ought to have weighed much more heavily for that fuel source. The absence of discrimination and individual characteristic effects suggests that people think about each power source in similar ways and that environmental concerns are paramount in their assessments of plant location.

There is one very important caveat to this assessment. The intercepts indicate that people discriminate among the fuels in ways not captured by attributes of fuels or risk attitudes and other characteristics. Significant differences in the intercepts remain. The large positive intercept in the comparison of nuclear power and coal means that *a priori* people favor coal over nuclear power. Only after considering the environmental implications of coal does nuclear power

Table 4. Components of Differences in Attitudes across Power Plants

Variable	Endowment effect $\hat{\beta}_{12}(\bar{E}_1 - \bar{E}_2)$	Discrimination effect $(\hat{\beta}_{11} - \hat{\beta}_{12})\bar{E}_1$	Characteristic effect $(\hat{\beta}_{21} - \hat{\beta}_{22})\bar{I}$
Natural gas compared to coal			
Perceived environmental harm	−.360**	.070**	
Perceived energy cost	.009	.027**	
Personal risk			−.061
Female			.051*
Nonwhite			.012
Democrat			.011
Intercept		.205	
Nuclear power compared to coal			
Perceived environmental harm	−.179**	−.001	
Perceived energy cost	.006	.013	
Personal risk			−.092
Female			−.018
Nonwhite			−.011
Democrat			−.008
Intercept		.408**	
Wind compared to coal			
Perceived environmental harm	−.942**	.150	
Perceived energy cost	−.012	−.029	
Personal risk			−.141
Female			−.009
Nonwhite			.024**
Democrat			−.026
Intercept		−.581**	

Significance levels of coefficient: *.05, and **.01.

rise in that comparison, and even then (as reflected in table 1), it is still at a slight disadvantage. The large negative intercept in the comparison of wind and coal means that people favor wind, *a priori*, over coal, nuclear power, and natural gas, and the perceived environmental attributes translate into an even larger advantage for wind over more traditional power sources.

Conclusion

Local resistance to power plants and other facilities has long been described as a knee-jerk opposition to any development—Not in My Back Yard. Preferences about power plant location are clearly more nuanced. We analyzed public attitudes toward the local construction of new coal, natural gas, nuclear power, and wind-based power generation units to assess the relative effects of the

attributes of the fuel source (endowment effects), the weights of these attributes (discrimination effects), and individual characteristics (characteristic effects).

People view location of any facility through the same lenses, weighing environmental harms and economic benefits as most important. An individual's risk attitude, gender, and race also explain preferences about plant location, but to a lesser extent than the perceived harms and costs of the fuels. In this regard, our results carry an important practical lesson. Efforts to site any type of new power plant must reassure the public on perceived environmental harms, and information campaigns may help reduce opposition (Berrens et al. 2004; Jenkins-Smith and Herron 2007). Compensation schemes may also lessen opposition (Kunreuther et al. 1990; Kunreuther and Easterling 1996), though people appear less sensitive to economic benefits than environmental harms. It is also possible that perceptions will change as individuals update their personal risk-benefit tradeoffs. For example, attitudinal shifts toward more support for converting the nation's energy mix from fossil fuels to alternatives to address climate change or to secure a domestic energy supply, may lead to changes in preferences about the siting of different types of power plants.

Our findings point to a major long-term political problem for the electricity generation industry in the United States. Coal, natural gas, and nuclear power account for 90 percent of U.S. electricity generation, and represent the main sources to meet future power demand. Respondents in our survey expressed overwhelming opposition to siting such facilities nearby, and, thus, to any major expansion of these power sources. The politics of plant siting will likely push the electricity sector in the direction of alternative power sources, which are today more expensive and less well established. One silver lining: the American public appears willing to accept a substantial expansion of wind power, even in their backyards.

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