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1. Abstract

With increasing numbers of communities considering wind power developments, empirical investigations regarding related community concerns are needed. One such concern is that proximate property values may be adversely affected, yet relatively little research exists on the subject. The present research investigates roughly 7,500 sales of single-family homes surrounding 24 existing U.S. wind facilities. Across four different hedonic models, and a variety of robustness tests, the results are consistent: neither the view of the wind facilities nor the distance of the home to those facilities is found to have a statistically significant effect on sales prices, yet further research is warranted.

2. Introduction

Wind power development has expanded dramatically in recent years (GWEC, 2010) and that expansion is expected to continue (GWEC, 2008; Wiser and Hand, 2010). The U.S. Department of Energy, for example, published a report that analyzed the feasibility of meeting 20% of U.S. electricity demand with wind energy by 2030 (US DOE, 2008).

To achieve a 20% wind electricity target in the United States, about 3,000 wind facilities would need to be sited, permitted, and constructed.[1] Though surveys show that public acceptance is high in general for wind energy (e.g., Firestone and Kempton, 2006), a variety of local concerns exist that can impact the length and outcome of the siting and permitting process. One such concern is related to the views of and proximity to wind facilities and how these might impact surrounding property values. To that end, surveys of local communities considering wind facilities have frequently found that adverse impacts on aesthetics and property values are in the top tier of concerns relative to other matters such as impacts on wildlife habitat and mortality, radar and communications systems, ground transportation, and historic and cultural resources (e.g., BBC R&C, 2005; Firestone and Kempton, 2006).

Concerns about the possible impacts of wind facilities on residential property values can be categorized into three potential effects:

- Scenic vista stigma: A perception that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Area stigma: A perception that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Nuisance stigma: A perception that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have an adverse influence on home values.

Any combination of these three potential stigmas might affect a particular home. Consequently, each of the three potential impacts must be considered when analyzing the effects of wind facilities on residential sales prices.

This paper uses several hedonic pricing models to analyze a sample of 7,459 arms-length residential real estate transactions occurring between 1996 and 2007 for homes located near 24 existing wind facilities spread across nine U.S. states. In so doing, the paper investigates the degree to which views of and proximity to wind facilities affect sales prices.

The remainder of the paper is organized as follows. The next section contains a summary of the existing literature that has investigated the effects of wind energy on residential property values. Then the data used in the present analysis are described. Following that, a set of four hedonic models are described and estimated to test for the existence of property value impacts associated with the wind energy facilities. The findings regarding the existence and magnitude of the three stigmas mentioned above are described, as are a series of robustness tests intended to assess the reliability of the model results. The paper ends with a brief discussion of future research possibilities.

3. Previous Research

A variety of methods, including surveys of homeowners and real estate experts, simple analysis of sales transactions (e.g., t-test), and sophisticated empirical analysis of sales transactions (e.g., multiple regression), have been used to explore the relationship between residential property values and views of and proximity to wind facilities. One of the overall conclusions that can be drawn from this literature is that wind facilities are often *predicted* to negatively impact residential property values in pre-construction surveys (see Haughton et al., 2004; Khatri, 2004; Firestone et al., 2007; Kielisch, 2009), but negative impacts have largely failed to materialize post-construction when actual transaction data become available for analysis (see Jerabek, 2001; Sterzinger et al., 2003; Hoen, 2006; Poletti, 2007; Sims et al., 2008). In the only study using transaction data that did find a statistically significant adverse effect, the authors contend that the result was likely driven by variables omitted from their analysis, and not by the presence of wind facilities (Sims and Dent, 2007). Other studies that have relied on market data have sometimes found the possibility of negative effects, but the statistical significance of those results has not been reported (e.g., Kielisch, 2009).

Potentially more important, the existing literature leaves much to be desired. First, many of the studies have relied only on surveys of homeowners or real estate professionals, rather than trying to quantify impacts based on market data (e.g., Haughton et al., 2004; Goldman, 2006). Second, a number of the studies that used market data conducted rather simplified analyses of those data, potentially not controlling for the many drivers (e.g., size and/or condition of the home, and lot size) of residential sales prices (e.g., Sterzinger et al., 2003; McCann, 2008; Kielisch, 2009). Third, many of the studies have relied upon a very limited number of residential sales transactions, and therefore may not have had an adequate sample to statistically discern any property value effects, even if effects did exist (e.g., Jerabek, 2001). Fourth, and perhaps as a result, many of the studies did not conduct, or at least have not published, the statistical significance of their results. Fifth, when analyzed, there has been some emphasis on area stigma, and none of the studies has simultaneously investigated all three possible stigmas listed above. Sixth, only a few of the studies (Hoen, 2006; Sims and Dent, 2007; Sims et al., 2008; Kielisch, 2009) conducted field visits to the homes to assess the quality of the scenic vista from the home, and the degree to which the wind facility might impact that scenic vista. Finally, with two exceptions (Sims and Dent, 2007; Sims et al., 2008), none of the studies were peer-reviewed in the academic literature.

4. Data Overview

The methods applied in the present work are intended to overcome many of the limitations of the existing literature. First, a large amount of residential real estate transaction data was collected from within ten miles of 24 different existing wind facilities in the U.S., allowing for a robust statistical analysis across a pooled dataset that includes a diverse group of wind facility sites.

Second, all three potential stigmas were investigated by exploring the potential impact of wind facilities on home values based both on the distance to and view of the facilities from the homes. Third, field visits were made to every home in the sample, allowing for a reliable assessment of the scenic vista enjoyed by each home and the degree to which the wind facility was visible from the home, and to collect other value-influencing data from the field (e.g., if the home is situated on a cul-de-sac). Finally, a set of robustness tests, including the estimation of a number of different hedonic regression models, were conducted.

The 24 wind facilities included in the sample (see Figure 1 and Table 1) were chosen from a set of 241 wind facilities in the U.S. with a nameplate capacity greater than 0.6 megawatts (MW) and that were constructed prior to 2006.[2] These 24 facilities, encompassing 10 different study areas, were selected based on: (1) the number of available residential real estate transactions both before and, more importantly, after wind facility construction, and especially in close proximity (e.g., within 2 miles) to the facility; (2) the availability of comprehensive data on home characteristics, sales prices, and locations in electronic form from local assessors; and (3) the representativeness of the types of wind energy facilities being installed in the United States.

As indicated in Table 1, the ten study areas are located in nine separate states, include facilities in the Pacific Northwest, upper Midwest, the Northeast, and the South Central region, and total 1,286 MW, or roughly 13% of total U.S. wind power capacity installed at the time (the end of 2005). Turbine hub heights in the sample range from a minimum of 50 meters in the Washington/Oregon (WAOR) study area, to a maximum of 80 meters (TXHC, OKCC and PASC), with nine of the ten study areas having maximum hub heights of at least 65 meters. The sites include a diverse variety of land types, including combinations of ridgeline (WAOR, PASC, and PAWC), rolling hills (ILLC, WIKCDC, NYMCOC, and NYMC), mesa (TXHC), and windswept plains (OKCC, IABV).

Three primary sets of data are used in the analysis: tabular data, geographic information system (GIS) data, and field data, each of which is discussed below. Special attention is given to the field data collection process for the two qualitative variables, both of which are essential to the analysis that follows: scenic vista and views of turbines.

Tabular sales transaction data were obtained from assessors in the participating counties, and total 7,459 "valid"[3] transactions of single family residential homes, on less than 25 acres, which were sold for a price of more than $10,000, which occurred after January 1, 1996, and which had fully populated data on "core" home characteristics (number of square feet of the living area excluding finished basement, acres of land, number of bathrooms and fireplaces, year built, type of exterior walls, presence of central air conditioning and a finished basement, and the exterior condition of the home).[4] The 7,459 residential transactions in the sample consist of 6,194 unique homes (a number of the homes in the sample sold more than once in the selected study period) all of which are located within 10 miles of the nearest wind turbine. In addition to the home characteristic data, each county provided, at a minimum, the home's physical address and sales price. Finally, market-specific quarterly housing inflation indexes were obtained from Freddie Mac, which allowed nominal sales prices in each study area to be appropriately adjusted to 1996 dollars.[5]

GIS data on parcel location and shape were obtained from the individual counties and, as necessary, from the U.S. Department of Agriculture (USDA),[6] in addition to GIS layers for roads, water courses, water bodies, and in some cases wind turbines and house locations. Combined, these data allowed: (1) each home to be identified in the field; (2) the construction of a GIS layer of wind turbine locations for each facility; and (3) the calculation of the distance from each home to the nearest wind turbine. As a result, each transaction was assigned a unique distance ("DISTANCE")[7] that was determined as the distance between the home and nearest wind turbine at the time of sale. The empirical modeling used both actual distance and distances grouped into five categories: (1) inside of 3000 feet (0.57 miles); (2) between 3000 feet and one mile; (3) between one and three miles; (4) between three and five miles; and (5) outside of five miles. The GIS data were also used to discern if the home was situated on a cul-de-sac and had water frontage, both of which were corroborated in the field.

Two qualitative measures – scenic vista and view of the wind turbines – were collected through field visits to each home in the sample. The impact or severity of the view of wind turbines ("VIEW")[8] may be related to some combination of the number of turbines that are visible, the amount of each turbine that is visible (e.g., just the tips of the blades or all of the blades and the tower), the distance to the nearest turbines, the direction that the turbines are arrayed in relation to the viewer (e.g., parallel or perpendicular), the contrast of the turbines to their background, and the degree to which the turbine arrays are harmoniously placed into the landscape. Recent efforts have made some progress in developing quantitative measures of the aesthetic impacts of wind turbines (Torres-Sibillea et al., 2009), but, at the time this project began, few measures had been developed, and those that had been developed were difficult to apply in the field (e.g., Bishop, 2002). As a result, an ordered qualitative VIEW ranking system that consists of placing the view of turbines into one of five possible categories was used: (1) NO VIEW; (2) MINOR;

(3) MODERATE; (4) SUBSTANTIAL; and (5) EXTREME. These rankings were developed to encompass considerations of distance, number of turbines visible, and viewing angle into one ordered categorical scale (see Table 2).[9]

In addition to the qualitative VIEW measurements, a rating for the quality of the scenic vista ("VISTA")[10] from each home, absent the existence of the wind facilities, was also collected in the field. An assessment of the quality of the VISTA from each home was required because VIEW and VISTA are expected to be correlated; for example, homes with a PREMIUM VISTA are more likely to have a wide viewing angle in which wind turbines might also be visible. Therefore, to accurately measure the impacts of the VIEW of wind turbines on property values a concurrent control for VISTA (independent of any views of turbines) was required. Drawing heavily on the landscape-quality rating system developed by Buhyoff et al. (1994) and to a lesser degree on the systems described by others (Daniel and Boster, 1976; USDA, 1995), an ordered VISTA ranking system consisting of five categories was developed: (1) POOR; (2) BELOW AVERAGE; (3) AVERAGE; (4) ABOVE AVERAGE; and (5) PREMIUM (see Table 3).[11]

Field data collection was conducted on a house-by-house basis. Each of the 6,194 homes was visited by the same individual to avoid adding bias among field rankings. Data collection was conducted in the fall of 2006, and the spring, summer, and fall of 2007 and 2008. Each house was photographed and, when appropriate, so too were views of turbines and the prominent scenic vista.[12] Data on VIEW were collected only for those homes that sold after at least one wind energy facility had been erected in the study area. When multiple wind facilities, with different construction dates, were visible from a home, field rankings for VIEW were made by taking into account which turbines had been erected at the time of sale. Additionally, if the season at the time of sale differed from that of data collection an effort was made to modulate the VIEW rating accordingly.[13] Both VIEW and VISTA field rankings were arrived at through a Q-Sort method (Pitt and Zube, 1979), which is used to distinguish relatively similar rankings.[14]

The final dataset consists of 7,459 valid residential transactions occurring between January 2, 1996 and June 30, 2007, for homes that are within 10 miles of the nearest wind turbine. As summarized in Table 4, of the total, 1,755 of the transactions occurred prior to wind facility announcement, 764 occurred after announcement but before construction, and 4,937 occurred after facility construction. The transactions are arrayed across time and the ten wind facility study areas. A basic summary of the resulting dataset, including the many independent variables used in the hedonic models described below, is contained in Table 5: summary information for the full dataset as well as the post-construction (homes that sold after wind facility construction began) subset of the dataset is provided.[15]

As indicated in Table 5, the mean nominal residential transaction price in the full sample is $102,968, or $79,114 in 1996 dollars. The average (mean) house in the sample was 46 years old, situated on 1.13 acres, with 1,620 square feet of finished living area above ground, 1.74 bathrooms, and a slightly better than average condition. Of the 4,937 transactions in the sample that occurred after wind facility construction, 730 transactions involved homes that sold with a view of the turbines, with 169 of those transactions involving homes that had a view ranking higher than MINOR (e.g., MODERATE, SUBSTANTIAL, OR EXTREME). In addition, 125 transactions involved homes that sold after construction and that are located within a mile of the nearest turbine, with an additional 20 transactions involving homes located within a mile that sold after the facility was announced but before construction commenced.

5. Model Estimation

A series of hedonic models was estimated to assess whether residential sales prices were affected by views of and proximity to wind energy facilities in a statistically measurable way. In so doing, the presence of the three potential property value stigmas associated with wind energy facilities was simultaneously tested for: area, scenic vista, and nuisance. All of the estimated models have four sets of parameters. One of these sets is associated with the variables of interest (DISTANCE and VIEW), which test for the presence of the three stigmas as discussed later, while the other three sets are associated with controls that include home and site characteristics, study-area fixed effects, and spatial adjustments.[16] The models differ in their specification and testing of the variables of interest, but use the same three sets of controls.

The first of these sets of control variables account for home and site-specific characteristics such as age of the home (linear and squared), square feet, acres, number of bathrooms and fireplaces, the condition of the home,[17] the quality of the scenic vista from the home, the presence of central air conditioning, a stone exterior, and/or a finished basement, and whether the home is located in a cul-de-sac and/or on a waterfront (see Table 5). In the case of the condition (of the home) and scenic vista variables, the reference cases are average condition and average scenic vista, respectively.

The second set, the study-area fixed effects variables, include dummy variables that control for aggregated study area influences. The estimated coefficients for this group of variables capture the combined effects of school districts, tax rates, crime, and other location influences across an entire study area. Although this approach greatly simplifies the estimation of the model, interpreting the coefficients can be difficult because of the myriad of influences captured by these study-area fixed effects variables. The reference category is the Washington/Oregon (WAOR) study area. Because there is no intent to focus on the coefficients of the study area fixed effect variables, the reference case is arbitrary; further, the results for the other variables in the model are completely independent of this choice. Although models using study-area fixed effects are presented here, the hedonic results are robust to the alternative of including school district and census tract variables in addition to the study area fixed effects variables, as is discussed below in the robustness tests section.

The third set controls for spatial dependence. Since the sales price of a home is often influenced by the sales prices of homes in the same neighborhood, ignoring the underlying spatial dependence in the data could bias the OLS estimates (Espey et al., 2007). Spatial dependence among the prices of homes can take two forms: spatial autocorrelation and spatial heterogeneity. The former captures the direct effect of neighboring properties on the value of a given property, whereas the latter accounts for the correlation among unobservable factors that affect property values in a given neighborhood. The inclusion of study-area fixed effects likely reduces spatial heterogeneity, though further study of this issue is warranted.[18] Spatial autocorrelation, meanwhile, is addressed by including as a control variable a spatially weighted neighbor's sales price (N) for each transaction, which was calculated using the estimated (i.e., predicted) sales prices of the five nearest neighbors within the six preceding months. The predicted sales price is used to offset any potential endogeneity associated with the neighbor's price variable. The two stage estimation process is similar to that proposed in Kelejian and Prucha (1998). The definition of “nearest neighbors” was chosen to mimic the selection process of a set of comparables by appraisers and/or realtors.[19]

5.1. Model One

As noted earlier, the dataset consists of 7,459 residential transactions, of which 2,522 transactions occurred before the wind facility was constructed. The analysis begins with the simplest of the hedonic models in which only the 4,937 post-construction transactions are used. As is common in the literature (Malpezzi, 2003; Sirmans et al., 2005b; Simons and Saginor, 2006), a semi-log functional form is used where the dependent variable, the (natural log of) sales price (P), is measured in market-specific inflation-adjusted (1996) dollars.

The literature on environmental disamenities often uses a continuous variable for the distance from the home to the disamenity in question (e.g., Sims et al., 2008). A number of different functional forms can be used for a continuous DISTANCE variable, including linear, inverse, cubic, quadratic, logarithmic and spline. Of the forms that were considered, the linear spline seemed most appropriate for this purpose. Spline functions are used when it is assumed that a marginal change in sale price per unit of distance is not constant across all distances from a disamenity and that those effects should be estimated separately. This form dovetails well with area and nuisance stigma definitions, wherein an effect based on distance can be estimated across the entire sample of homes (area stigma) and separately for those homes inside of one mile (nuisance stigma).[20] Therefore, the following model is estimated:

$$\ln(\text{P}) = \beta_0 + \beta_1\text{N} + \sum_s \beta_2\text{S} + \sum_k \beta_3\text{X} + \sum_v \beta_4\text{VIEW} + \beta_5\text{DISTANCE} + \beta_6\left((\text{DISTANCE} - 1)\cdot\text{LT1MILE}\right) + \varepsilon \quad (1)$$

where N is the spatially weighted neighbors' predicted sales price, S is the vector of *s* study area fixed effects variables (e.g., TXHC, OKCC), X is a vector of *k* home and site characteristics, (e.g., acres, square feet), VIEW is a vector of *v* categorical turbine view variables (e.g., MINOR, MODERATE), DISTANCE is the measurement (in miles) from the home to the nearest turbine at the time of sale, and LT1MILE equals 1 when the DISTANCE is less than one mile, and 0 otherwise, β_0 is the constant or intercept across the full sample, β_1 is a parameter estimate for the spatially weighted neighbor's predicted sales price, β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to homes sold in the Washington/Oregon (WAOR) study area, β_3 is a vector of *k* parameter estimates for the home and site characteristics, β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines, β_5 is a parameter estimate for the effect DISTANCE has on sale price across all homes, β_6 is a parameter estimate for the additive effect DISTANCE has on sale price for those homes inside of one mile, and ε is a random disturbance term. Also note that both VIEW and DISTANCE appear in the model together because a home's value may be affected in part by the magnitude of the view of the wind turbines, and, in part by the distance from the home to those turbines; validation of this assumption is discussed later when summarizing various robustness tests that were preformed.

In this model, and all subsequent models, scenic vista stigma is tested for via the coefficients of the VIEW variable, which are expected to be negative, significant and monotonically decreasing from EXTREME to MINOR. The effect of area stigma is expected to be captured through the variable DISTANCE and the effect of nuisance stigma through the variable (DISTANCE-

1)*LT1MILE as it has been in the previous literature (e.g., Thayer et al., 1992). If these latter two stigmas exist, the coefficients of these variables are expected to be positive and significant, indicating an increase in selling prices for each mile the homes are further from the wind turbines.[21]

5.2. Model Two

Though the continuous form of DISTANCE, as used in Model One, is consistent with the previous literature, it imposes a rigid structure on the dataset that may lead to specification errors. Model Two relaxes this rigidity by measuring DISTANCE in categorical form. In this model, the reference category for DISTANCE is the set of transactions for homes that are situated outside of five miles from the nearest wind turbine. This reference category was because these homes are least likely to be affected by the presence of the wind facilities.[22] Other than this change, the dataset used for the estimation, the list of controls, and the specification of the VIEW variable remain unchanged relative to Model One. Therefore, the following model is estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_{\mathrm{s}} \beta_2\mathrm{S} + \sum_{\mathrm{k}} \beta_3\mathrm{X} + \sum_{\mathrm{v}} \beta_4\mathrm{VIEW} + \sum_{\mathrm{d}} \beta_5\mathrm{DISTANCE} + \varepsilon \qquad (2)$$

where DISTANCE is a vector of *d* categorical distance to turbine variables (e.g., less than 3000 feet, between 3000 feet and one mile), the reference category being homes situated outside of five miles. All other variables are as described in Model One.

Since the VIEW variable is unchanged, it is expected to capture the effect of scenic vista stigma in a manner identical to Model One. It is assumed that nuisance effects are largely concentrated within one mile of the nearest wind turbine, while area effects may occur to a varying degree all homes within a 5-mile radius of the wind facility. Therefore, property value effects as identified by the coefficients of the DISTANCE variables inside of one mile (e.g., inside 0.57 mile, and between 0.57 mile and 1 mile) can be interpreted as a combination of area and nuisance stigmas, while the coefficients of variables outside of one mile can be interpreted as only reflecting area sigma effects. All coefficients are expected to be negative and monotonically decreasing as the distance band increases.

5.3. Model Three

Though Model Two relaxes some of the structural rigidity of Model One, it implicitly assumes that the area stigma effects die out completely after a distance of five miles from a wind facility. The validity of this assumption can be tested by comparing the prices of homes sold before the construction of the wind facility to those sold after. Further, by using only the post-construction data, both Models One and Two ignore the possible *anticipated* effect of wind facility construction by not using data from the post-announcement pre-construction period. Previous research suggests that property value effects might be very strong during this period, during which an assessment of actual impacts is not possible and buyers and sellers may take a risk-adverse and conservative stance (Wolsink, 1989). Model Three addresses both of these issues by using the entire dataset (7,459 transactions), including homes that sold well before the facility was announced, through the period after announcement yet prior to construction, and continuing to well after construction. The following specification is used:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_{s} \beta_2 \mathrm{S} + \sum_{k} \beta_3 \mathrm{X} + \sum_{v} \beta_4 \mathrm{VIEW} \cdot \mathrm{POSTCON} + \sum_{d} \beta_5 \mathrm{DISTANCE} \cdot \mathrm{POSTANC} + \varepsilon \tag{3}$$

where POSTCON is one if the sale occurred after the wind facility was constructed (zero otherwise), POSTANC is one if the sale occurred after the wind facility was announced (zero otherwise), and all other variables are as defined in equation (2). In this model, all pre-construction sales serve as the reference category for VIEW, and all pre-announcement sales serve as the reference category for DISTANCE. This model, therefore, also serves as a robustness check on the reference categories used in Models Two and Three: by comparing the coefficients for the DISTANCE and VIEW variables from all three models, a comparison can be made between the reference categories and therefore their appropriateness for use.

In this model, the scenic vista stigma is expected to be captured via the variable VIEW*POSTCON, and the area and nuisance stigmas through the interaction variable DISTANCE*POSTANC. The coefficients of the VIEW and DISTANCE variables, as with previous models, are expected to be negative and monotonically ordered.

5.4. Model Four

Model Three allows all post-announcement sales to be potentially impacted by area and nuisance stigma, and therefore might be considered an improvement over Model Two, but it makes the assumption that the marginal effect of DISTANCE is constant across all time periods. As discussed previously, however, there is some evidence that property value impacts may be particularly strong after the announcement of a disamenity, but then may fade with time as the community adjusts to the presence of that disamenity (e.g., Wolsink, 1989). Model Four allows for an investigation of how different periods of the wind power development process affect estimates for the impact of DISTANCE on sales prices. The following specification is used:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_s \beta_2\mathrm{S} + \sum_k \beta_3\mathrm{X} + \sum_v \beta_4\mathrm{VIEW}\cdot\mathrm{POSTCON} + \sum_y \beta_5(\mathrm{DISTANCE}\cdot\mathrm{PERIOD}) + \varepsilon \quad (4)$$

where PERIOD is a vector of development periods. The PERIOD variable contains six categories: (1) more than two years before announcement; (2) less than two years before announcement; (3) after announcement but before construction; (4) less than two years after construction; (5) between two and four years after construction; and (6) more than four years after construction. Further, in contrast to Models Two and Three, Model Four collapses the two DISTANCE categories inside of one mile into a single "less than one mile" group to ensure that reasonably large numbers of transactions (e.g., ~>30) were used to estimate effects in each PERIOD.[23] Therefore, in this model, the DISTANCE variable contains four different levels: (1) less than one mile; (2) between one and three miles; (3) between three and five miles; and (4) outside of five miles. Consequently, the DISTANCE•PERIOD interaction created 24 distinct variables.

This model's reference case consists of transactions that occurred more than two years before the facility was announced for homes that were situated more than five miles from where the turbines were ultimately constructed. It is assumed that the value of these homes would not be affected by the future presence of the wind facility. The VIEW parameters, although included in the model, are not interacted with PERIOD.[24]

Although the comparisons of these categorical variables *between* different DISTANCE and PERIOD categories might be interesting, it is the comparison of coefficients *within* each

PERIOD and DISTANCE category that is the focus of this model. Such comparisons, for example, allow one to compare how the average value of homes inside of one mile that sold two years before announcement compare to the average value of homes inside of one mile that sold in later periods.

6. Results

The range of adjusted R^2 values for the four models is between 0.75 and 0.77 (see Table 6).[25] The sign and magnitudes of the site and home control variables are consistent with *a priori* expectations, are stable across all four hedonic models, and all are statistically significant at the 1% level (see Table 6). These results can be benchmarked to other research. Specifically, Sirmans et al. (2005a; 2005b) conducted a meta-analysis of 64 hedonic studies carried out in multiple locations in the U.S. during multiple time periods, and investigated the coefficients of ten commonly used characteristics, seven of which were included in our models. The similarities between the mean coefficients (i.e., the average across all 64 studies) reported by Sirmans el at. and those estimated in the present study are striking. For example, the effect of square feet (in 1000s) on log of sales price was estimated to be 0.28 across all four of the hedonic models presented here and Sirmans et al. provide an estimate of 0.34, while the effect of acres was similarly estimated (0.02 to 0.03, present study and Sirmans et al., respectively). Further, age at the time of sale (-0.006 to -0.009), bathrooms (0.09 to 0.09), central air conditioning (0.09 to 0.08), and fireplaces (0.11 to 0.09) all similarly compare. As a group, the estimates in the present study differ in all cases by no more than a third of the Sirmans et al. mean estimate's standard deviation.

The coefficients for the spatial control ("Spatial Control – Post Con" in Models One and Two, "Spatial Control – All Sales" in Models Three and Four) are also significant at the 1% level indicating a strong relationship between the predicted value of the neighbors' selling prices and those of the subject home. In addition, all the study-area fixed effects coefficients are significant at the one percent level. The omitted study-area category (WAOR), which had the highest overall median house prices (the WAOR value is $169,177 whereas the remainder of the sample is $120,256), was specifically chosen so that all of the study-area fixed effects coefficients would have negative signs. As noted earlier, this choice was arbitrary and has no impact on the remainder of the results.

Of particular interest are the coefficient estimates for scenic vista (VISTA). Homes with a scenic vista rated as poor are found to sell for 21% to 25% less on average than homes with an average rating, while homes with a premium vista sell for 9% to 13% more than homes with an average rating. In all four of the models, differences between homes with an average scenic vista and homes with other scenic vistas are significant at the 1% level. Based on these results, it is evident that the quality of the scenic vista is capitalized into sales prices, and that the qualitative VISTA variable is able to effectively capture these effects. To benchmark these results, they were compared to the few studies that have investigated the contribution of inland scenic vistas to sales prices. Benson et al. (2000) found that a mountain vista increases sales price by 8%, while Bourassa et al. (2004) found that wide inland vistas increase sales price by 7.6%. These both compare favorably to the results for above average and premium rated VISTA estimates presented in Table 6.

Next the discussion focuses on the three potential stigmas surrounding wind facilities.

6.1. Scenic Vista Stigma

Scenic vista stigma is defined as a concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista. This concern is premised on the notion that home values are, in part, derived from the quality of what can be viewed from the property.

As mentioned earlier, the results from all four models demonstrate persuasively that the quality of the scenic vista (the VISTA variable) does impact sales prices. Along the same lines, homes in the sample with water frontage or situated on a cul-de-sac sell for 33% to 35% more and 9% to 10% more, on average, respectively, than those homes that lack these characteristics, differences that are significant at or above the 1% level. Taken together, these results demonstrate that home buyers and sellers consistently take into account what can be seen from the home when sales prices are established, and that the models presented in this paper are able to clearly identify those impacts when they exist.[26]

Despite this finding, the models are unable to identify any evidence of a scenic vista stigma associated with the wind facilities in the sample (see Table 7). Specifically, the 25 homes with extreme views in the sample, where the home site is "unmistakably dominated by the [visual] presence of the turbines," are not found to have statistically different selling prices than either those that sold in the same period but which did not have a view (Models One and Two) or that sold prior to the wind facility's construction (Models Three and Four). The same finding holds for the 106 and 561 homes that were rated as having either moderate or minor views of the wind turbines, respectively.

6.2. Area Stigma

Area stigma is defined as a concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines. Though these impacts might be expected to be especially severe at close range to the turbines, the impacts could conceivably extend for a number of miles around a wind facility. Modern wind turbines are visible from well outside of five miles in many cases, so if an area stigma exists, it is possible that all of the homes in the study areas inside of five miles could be affected. To distinguish this generalized area stigma effect from nuisance effects, we focus on transactions of homes located outside of one mile.

The presence of area stigmas was tested in each of the four models (see Table 7). Model One uses a continuous linear distance function and finds a relatively small (0.004) and non-significant (*p* value 0.25) relationship between distance (in miles) from the nearest turbine and the value of residential properties for the 4,937 transactions occurring after construction commenced. Similarly, Model Two finds no statistical difference between the sales prices of homes located more than five miles from the turbines and those located in any nearer distance band. Likewise, in Model Three, the coefficients of DISTANCE for homes that sold outside of one mile after announcement are essentially no different to those that sold prior to announcement, with coefficients ranging between 0.00 and 0.01, none of which are statistically significant. Further, homes that sold after facility construction but that had No View of the turbine are found to appreciate in value, after adjusting for inflation, when compared to homes that sold before wind facility construction (0.02, *p* value 0.06); any area stigma effect that impacts the general area surrounding wind facilities should be reflected as a negative coefficient for this parameter. It should also be noted that the stability of the DISTANCE coefficients across Models Two and Three, where different reference cases are used, reinforces both the stability of the models and the appropriateness of the reference case selection.

Perhaps a more direct test of area stigma comes from Model Four. In this model, homes in all distance bands outside of one mile and that sold after wind facility announcement are found to sell, on average, for prices that are not statistically different from sales that occurred more than two years prior to wind facility announcement.

To summarize, there is little evidence of the existence of an area stigma among the homes in this sample. On average, homes in these study areas are not demonstrably and measurably stigmatized by the arrival of a wind facility based on area stigma, regardless of when they sold in the wind power development process and regardless of whether those homes are located one mile or five miles away from the nearest wind facility.

6.3. Nuisance Stigma

Nuisance stigma is defined as any adverse impacts, such as sound and shadow flicker, which might uniquely affect residents of homes in *close* proximity to wind turbines, thereby leading to a potential reduction of home sales prices.

The results of Model One (see Table 7), where a continuous linear function is estimated for only those homes within one mile, imply a 4.1% reduction in the values of homes located one half mile away from the wind facility, and a 6.4% reduction for those within one quarter of a mile, though these results are not statistically significant.[27] Similarly, Model Two finds that those homes within 3000 feet and those between 3000 feet and one mile of the nearest wind turbine sold for roughly 5% less than similar homes located more than five miles away that sold in the same post-construction period. Again, these differences are not statistically significant (*p*-values 0.40 and 0.30, respectively). In Model Three, when all transactions occurring after wind facility announcement are assumed to potentially be impacted, and a comparison is made to the average of all transactions occurring pre-announcement, the adverse impacts are estimated to be -6% (*p* value 0.23) and -8% (*p* value 0.08), respectively.

Though none of these results are statistically significant, they are possibly consistent with the presence of a nuisance stigma. Model Four, however, provides the clearest picture of these findings, and demonstrates that these effects are not likely to have been caused by the presence of the wind facilities. As is illustrated in Figure 2, homes that sold prior to wind facility announcement, but situated within one mile of the eventual location of the turbines, sold, on average, for between 10% and 13% less than homes that sold in the same time period but located more than five miles away. Therefore, the homes nearest the wind facility's eventual location were depressed in value, in comparison to homes further away, *prior* to the announcement of the facility. Moreover, comparing the sales prices of the homes located within a mile of the turbines between those that transacted more than two years prior to the facilities' announcement and those that sold in later periods (e.g., after announcement or after construction), as is shown in Table 8, differences were statistically indistinguishable from pre-announcement levels. In other words, relative prices did not fall after the announcement and eventual construction of the wind facility for this sample of homes.

The weak (i.e., not statistically significant) evidence of a nuisance stigma found in Models One, Two, and Three therefore appear to be a reflection of depressed home prices that preceded the construction of the relevant wind facilities, rather than a reaction to the turbines. If construction of the wind facilities were downwardly influencing the sales prices of these homes, as might be deduced from Models One, Two, or Three alone, a diminution in the inflation adjusted price would be seen as compared to pre-announcement levels in Model Four. Instead, an increase (albeit not-statistically significant) is observed. As such, no persuasive evidence of a nuisance stigma is apparent in this sample.

7. Robustness Tests

The results reported in Table 7, Table 8, and Figure 2 suggest that wind facilities in this sample do not demonstrably cause scenic vista, area, or nuisance stigmas. Because this result is somewhat counter-intuitive and possibly controversial, several alternative model specifications to the four presented earlier were estimated to determine whether or not the results were robust. These alternative specifications included: (1) interacting the study-area fixed effects variables with the home and site characteristics to mimic the estimation of separate regressions for each study area; (2) replacing the study-area fixed effects variables with alternative location measures (specifically, census tract and school district delineations, the importance of which is discussed in Seo and Simons (2009)); (3) including additional micro-spatial variables in the models (specifically, distance to nearest highway ramp and proximity to a major road); (4) omitting either VIEW or DISTANCE from the model to explore potential colinearity between these variables; (5) removing the variable for the spatially weighted sales price of the five nearest neighbors (Spatial Control – Post Con) ; (6) including five outlier and influential observations that had previously been removed from the dataset (as discussed in Hoen at al., 2009); (7)

including a quantitative measurement of VIEW (pct_vis) constructed from the total number of turbines visible and the distance of the home to the nearest wind turbine[28] rather than using the qualitative VIEW categories; and (8) adding fixed effects variables for the year in which the home sold.

Key results for these robustness checks are presented in Table 9. In the interest of brevity, only Model Two is used with these alternative specifications, and only the estimated coefficients on two VIEW categories (SUBSTANTIAL and EXTREME) and two DISTANCE categories (within 3000 feet and 3000 feet to one mile) are reported (although all were investigated). The re-estimated models, unless otherwise noted, include all of the same control variables and variables of interest as Model Two specified above.

Table 9 reveals that the estimated coefficients for the robustness models are similar in magnitude to the baseline Model Two estimates (presented at the top of Table 9 for comparison purposes) and *none* are statistically different from zero (this also holds for the other variables that are not presented). The results are therefore robust to pooling the data across study areas; alternative location measures; the inclusion/exclusion of additional micro-spatial, neighbor's price, and/or year fixed effects variables; the omission of either set of variables of interest (DISTANCE or VIEW); the inclusion of previously omitted outliers and influential observations; and an alternative, quantitative measure of the VIEW variable. In addition, although not shown here, the results of Model One are robust to various DISTANCE functions, and the full set of results are consistent with repeat sales and sales volume models (all of which are presented in Hoen et al., 2009, along with several other robustness tests not otherwise mentioned here).

8. Concluding Remarks

This paper has investigated the potential impacts of wind energy facilities on the sales prices of residential properties that are in proximity to and/or that have a view of those wind facilities. In so doing, three different potential impacts of wind facilities on property values have been identified and analyzed: scenic vista stigma, area stigma, and nuisance stigma. The results are based on the most comprehensive data on and analysis of the subject to date. Across various model specifications and after a number of robustness tests were conducted no statistical evidence of the presence of these stigmas was found for the 24 wind facilities and 7,459 residential real estate transactions included in the sample. Consistent with the location of existing wind facilities in the United States, the sample described herein is dominated by rural areas with relatively low median home prices. Therefore, although we would expect that these results would be relevant to new wind facilities located in similar areas, the relevance of these results to situations much different from those studied cannot be determined without additional research.

Though the results of the present study may appear counterintuitive, it may simply be that property value impacts fade rapidly with distance, and that few of the homes in the sample are close enough to the subject wind facilities to be substantially impacted. Previous assessments have found that property value effects near a chemical plant fade outside of two and a half miles (Carroll et al., 1996), near a lead smelter (Dale et al., 1999) and fossil fuel plants (Davis, 2008) outside of two miles, and near landfills and confined animal feeding operations outside of 2,400 feet and 1,600 feet, respectively (Ready and Abdalla, 2005; Ready, 2010). Further, homes outside of 300 feet (Hamilton and Schwann, 1995) or even as little as 150 feet (Des-Rosiers, 2002) from high voltage transmission lines have been found to be unaffected (see also e.g., Gallimore and Jayne, 1999; Watson, 2005). None of the homes in the dataset used in the present study is closer than 800 feet to the nearest wind turbine, and all but eight homes are located outside of 1000 feet of the nearest turbine. It is therefore possible that, if any effects do exist, they exist at very close range to the turbines, and that those effects are of small magnitude outside of 800 feet. Finally, effects that existed soon after the announcement or construction of the wind facilities might have faded over time. More than half of the homes in the sample sold more than three years after the commencement of construction, and studies of transmission lines have found that effects fade with time (Kroll and Priestley, 1992), while studies of attitudes towards wind turbines have found that such attitudes are the most negative after facility announcement, but often improve after facility construction (Wolsink, 1989). Further, even during the post-announcement-pre-construction period, effects on property values are difficult to detect (Laposa and Mueller, 2010). Finally, some effects, such as periodic effects of turbine noise, might be difficult to quantify for a buyer, and therefore might not be accurately priced into the market. Regardless of the possible explanation, if impacts do exist, they are either too small or too infrequent to result in any statistically observable impact among this sample.

Subsequent research should concentrate on homes located closest to wind facilities that sold shortly after wind facility announcement and/or construction since during this period effects are most likely, and the sample used for this analysis included very few such homes. Further, it is conceivable that cumulative impacts might exist whereby communities in which multiple wind facilities are constructed are affected uniquely, and these cumulative effects may be worth investigating. Although the present analysis finds no statistically significant effects on property values, it is unable to identify why this might be the case. A particularly useful investigation could therefore be a comparative attitudinal analysis of buyers and sellers.

Future research might also analyze the possible impact of wind facilities on the amount of time it takes to sell a home, a factor that was not considered in the present work, but that can influence price (McGreal et al., 2009). Alternative measures of the physical impact of wind facilities could also be considered because the distance variable used in the research presented here may not adequately reflect either the perceived or actual impact of wind facilities on noise levels, or other potential effects. Further, because this study has focused on the overall *net* effect of wind facilities on property values, it did not seek to understand the possible separate negative and positive impacts that might exist; for example, wind facilities might be expected to increase property values if they lead to improved job opportunities, an increased tax base, or improved community image. Future work might seek to unpack the possible positive and negative property value impacts that may exist.

Finally, the results of Model Four (see the shape of the line for homes within one mile of the nearest wind turbine in Figure 2) may suggest that sales prices relative to "pre-announcement" levels were depressed in the period after awareness began of the facility but before construction commenced, and then, following construction, prices recovered to levels more similar to those prior to announcement (and awareness). These results would be consistent with previous studies (e.g., Wolsink, 1989; Devine-Wright, 2004) that find that community members are likely to take a risk averse stance during the post-announcement, pre-construction period when the impact on property values is difficult to quantify. Future research could focus on the factors that might explain the initially lower prices (topography, land productivity, access, etc.), why prices seem to respond positively (appreciate) to wind development, and how relative prices are affected in subsequent time periods.

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10.Figures and Tables

Table 1: Summary of Study Areas

Study Area Code	Study Area Counties, States	Facility Names	Number of Turbines	Number of MW	Max Hub Height (meters)
WAOR	Benton and Walla Walla Counties, WA and Umatilla County, OR	Vansycle Ridge, Stateline, Nine Canyon I & II, Combine Hills	582	429	60
TXHC	Howard County, TX	Big Spring I & II	46	34	80
OKCC	Custer County, OK	Weatherford I & II	98	147	80
IABV	Buena Vista County, IA	Storm Lake I & II, Waverly, Intrepid I & II	381	370	65
ILLC	Lee County, IL	Mendota Hills, GSG Wind	103	130	78
WIKCDC	Kewaunee and Door Counties, WI	Red River, Lincoln	31	20	65
PASC	Somerset County, PA	Green Mountain, Somerset, Meyersdale	34	49	80
PAWC	Wayne County, PA	Waymart	43	65	65
NYMCOC	Madison and Oneida Counties, NY	Madison	7	12	67
NYMC	Madison County, NY	Fenner	20	30	66
		TOTAL	1,345	1,286	

The ten study areas are located in nine separate states, and total 1,286 MW, or roughly 13% of total U.S. wind power capacity installed as of the end of 2005. The 24 wind facilities are comprised of 1,345 turbines which have hub heights that range from a minimum of 50 meters to a maximum of 80 meters.

Table 2: Definition of VIEW Categories

NO VIEW	The turbines are not visible at all from this home.
MINOR VIEW	The turbines are visible, but the scope (viewing angle) is narrow, there are many obstructions, or the distance between the home and the facility is large.
MODERATE VIEW	The turbines are visible, but the scope is either narrow or medium, there might be some obstructions, and the distance between the home and the facility is most likely a few miles.
SUBSTANTIAL VIEW	The turbines are dramatically visible from the home. The turbines are likely visible in a wide scope and most likely the distance between the home and the facility is short.
EXTREME VIEW	This rating is reserved for sites that are unmistakably dominated by the presence of the wind facility. The turbines are dramatically visible from the home and there is a looming quality to their placement. The turbines are often visible in a wide scope or the distance to the facility is very small.

An ordered qualitative VIEW (of turbines) ranking system was developed by the authors to encompass considerations of multiple characteristics (e.g., distance to turbines visible, number of turbines visible, and viewing angle of the turbines visible) into one ordered categorical scale to be used in conjunction with the VISTA rankings at each home.

Table 3: Definition of VISTA Categories

POOR VISTA	These vistas are often dominated by visually discordant man-made alterations (not considering turbines), or are uncomfortable spaces for people, lack interest, or have virtually no recreational potential.
BELOW AVERAGE VISTA	These scenic vistas contain visually discordant man-made alterations (not considering turbines) but are not dominated by them. They are not inviting spaces for people, but are not uncomfortable. They have little interest or mystery and have minor recreational potential.
AVERAGE VISTA	These scenic vistas include interesting views that can be enjoyed often only in a narrow scope. These vistas may contain some visually discordant man-made alterations (not considering turbines), are moderately comfortable spaces for people, have some interest, and have minor recreational potential.
ABOVE AVERAGE VISTA	These scenic vistas include interesting views that often can be enjoyed in a medium to wide scope. They might contain some man-made alterations (not considering turbines), yet still possess significant interest and mystery, are moderately balanced and have some potential for recreation.
PREMIUM VISTA	These scenic vistas would include "picture postcard" views that can be enjoyed in a wide scope. They are often free or largely free of any discordant man made alterations (not considering turbines), possess significant interest, memorable qualities, and mystery and are well balanced and likely have a high potential for recreation.

Drawing heavily on the landscape-quality rating system developed by Buhyoff et al. (1994) and to a lesser degree on the systems described by others (Daniel and Boster, 1976; USDA, 1995), a qualitative ordered (scenic) VISTA ranking system, consisting of five categories, was developed to be used in conjunction with the VIEW rankings at each home.

Table 4: Summary of Transactions across Study Areas and Development Periods

	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	226	45	76	59	384	790
Howard, TX (TXHC)	169	71	113	131	827	1,311
Custer, OK (OKCC)	484	153	193	187	96	1,113
Buena Vista, IA (IABV)	152	65	80	70	455	822
Lee, IL (ILLC)	115	84	62	71	80	412
Kewaunee/Door, WI (WIKCDC)	44	41	68	62	595	810
Somerset, PA (PASC)	175	28	46	60	185	494
Wayne, PA (PAWC)	223	106	64	71	87	551
Madison/Oneida, NY (MYMCOC)	108	9	48	30	268	463
Madison, NY (NYMC)	59	165	74	70	325	693
TOTAL	1,755	767	824	811	3,302	7,459

The final dataset consists of 7,459 valid residential transactions occurring between January 2, 1996 and June 30, 2007, for homes that are within 10 miles of the nearest wind turbine. Transactions spanned the period prior to the announcement of the decision to build the wind facility to well after the facility's construction and are spread across all ten study areas.

Table 5: Summary Statistics

		All Sales		Post-Construction Sales	
Variable Name	Description	Mean	Standard Deviation	Mean	Standard Deviation
SalePrice	Unadjusted sale price of the home (in US dollars)	102,968	64,293	110,166	69,422
SalePrice96	Sale price of the home in 1996 US dollars	79,114	47,257	80,156	48,906
LN_SalePrice96	Natural log of sale price of the home in 1996 US dollars	11.117	0.58	11.12	0.60
AgeatSale	Age of the home at the time of sale	46	37	47	36
AgeatSale_Sqrd	Age of the home at the time of sale squared	3,491	5,410	3,506	5,412
Sqft_1000	Number of finished square feet of above grade (in 1000s)	1.623	0.59	1.628	0.589
Acres	Number of acres sold with the residence	1.128	2.42	1.10	2.40
Baths	Number of bathrooms (full bath = 1, half bath = 0.5)	1.738	0.69	1.75	0.70
ExtWalls_Stone	Home has exterior walls of stone, brick or stucco (Yes = 1, No = 0)	0.307		0.301	
CentralAC	Home has a central AC unit (Yes = 1, No = 0)	0.507		0.522	
Fireplace	Number of fireplace openings	0.390	0.55	0.40	0.55
Cul_De_Sac	Home is situated on a cul-de-sac (Yes = 1, No = 0)	0.133		0.136	
FinBsmt	Finished basement square feet > 50% first floor square feet (Yes = 1, No = 0)	0.197		0.201	
Water_Front	Home shares property line with body of water or river (Yes = 1, No = 0)	0.014		0.018	
Cnd_Low	Condition of the home is Poor (Yes = 1, No = 0)	0.014		0.014	
Cnd_BAvg	Condition of the home is Below Average (Yes = 1, No = 0)	0.070		0.073	
Cnd_Avg	Condition of the home is Average (Yes = 1, No = 0)	0.584		0.552	
Cnd_AAvg	Condition of the home is Above Average (Yes = 1, No = 0)	0.274		0.293	
Cnd_High	Condition of the home is High (Yes = 1, No = 0)	0.059		0.068	
Vista_Poor	Scenic Vista from the home is Poor (Yes = 1, No = 0)	0.063		0.063	
Vista_BAvg	Scenic Vista from the home is Below Average (Yes = 1, No = 0)	0.577		0.579	
Vista_Avg	Scenic Vista from the home is Average (Yes = 1, No = 0)	0.256		0.253	
Vista_AAvg	Scenic Vista from the home is Above Average (Yes = 1, No = 0)	0.088		0.091	
Vista_Prem	Scenic Vista from the home is Premium (Yes = 1, No = 0)	0.016		0.015	
SaleYear	Year the home was sold	2002	2.9	2004	2.3
View_None	Home sold post-construction with no view of turbines (Yes = 1, No = 0)	0.564		0.852	
View_Minor	Home sold post-construction with Minor View (Yes = 1, No = 0)	0.075		0.114	
View_Mod	Home sold post-construction with Moderate View (Yes = 1, No = 0)	0.014		0.021	
View_Sub	Home sold post-construction with Substantial View (Yes = 1, No = 0)	0.005		0.007	
View_Extrm	Home sold post-construction with Extreme View (Yes = 1, No = 0)	0.004		0.006	
DISTANCE †	Distance to nearest turbine for post-announcement homes, otherwise 0	2.53	2.59	3.57	1.68
Mile_Less_0.57 †	Home sold post-announcement and was located within 0.57 miles (3000 feet) from nearest turbine (Yes = 1, No = 0)	0.011		0.014	
Mile_0.57to1 †	Home sold post-announcement and was located between 0.57 miles (3000 feet) and 1 mile from nearest turbine (Yes = 1, No = 0)	0.009		0.012	
Mile_1to3 †	Home sold post-announcement and was located between 1 and 3 miles from nearest turbine (Yes = 1, No = 0)	0.316		0.409	
Mile_3to5 †	Home sold post-announcement and was located between 3 and 5 miles from nearest turbine (Yes = 1, No = 0)	0.295		0.390	
Mile_Gtr5 †	Home sold post-announcement and was located at least 5 miles from nearest turbine (Yes = 1, No = 0)	0.134		0.176	

† "All Sales" mean and standard deviation DISTANCE and DISTANCE fixed effects variables (e.g., Mile_1to3) include transactions that occurred after facility "announcement" and before "construction" as well as those that occured post-construction

The mean residential transaction price in the full sample is $102,968 (nominal) and $79,114 ($1996), which represents a house over 46 years old, situated on 1.13 acres, with 1,620 square feet of finished living area above ground, 1.74 bathrooms, and a slightly better than average condition.

Table 6: Model Summary and Control Variable Results

	Model 1	Model 2	Model 3	Model 4
Number of Cases	4,937	4,937	7,459	7,459
Number of Predictors	35	37	39	56
F Statistic	468	443	580	404
Adjusted R2	0.77	0.77	0.75	0.75

Intercept	7.63 (0.18)**	7.62 (0.18)**	9.08 (0.14)**	9.11 (0.14)**
Spatial Control - Post Con	0.29 (0.02)**	0.29 (0.02)**		
Spatial Control - All Sales			0.16 (0.01)**	0.16 (0.01)**
AgeatSale	-0.0059 (0.00)**	-0.0059 (0.00)**	-0.007 (0.00)**	-0.007 (0.00)**
AgeatSale_Sqrd	0.00002 (0.00)**	0.00002 (0.00)**	0.00003 (0.00)**	0.00003 (0.00)**
Sqft_1000	0.28 (0.01)**	0.28 (0.01)**	0.28 (0.01)**	0.28 (0.01)**
Acres	0.02 (0.00)**	0.02 (0.00)**	0.02 (0.00)**	0.02 (0.00)**
Baths	0.09 (0.01)**	0.09 (0.01)**	0.08 (0.01)**	0.08 (0.01)**
ExtWalls_Stone	0.21 (0.02)**	0.21 (0.02)**	0.21 (0.01)**	0.21 (0.01)**
CentralAC	0.09 (0.01)**	0.09 (0.01)**	0.12 (0.01)**	0.12 (0.01)**
Fireplace	0.11 (0.01)**	0.11 (0.01)**	0.11 (0.01)**	0.12 (0.01)**
FinBsmt	0.08 (0.02)**	0.08 (0.02)**	0.09 (0.01)**	0.09 (0.01)**
Cul_De_Sac	0.1 (0.01)**	0.1 (0.01)**	0.09 (0.01)**	0.09 (0.01)**
Water_Front	0.34 (0.04)**	0.33 (0.04)**	0.35 (0.03)**	0.35 (0.03)**
Cnd_Low	-0.44 (0.05)**	-0.45 (0.05)**	-0.43 (0.04)**	-0.43 (0.04)**
Cnd_BAvg	-0.24 (0.02)**	-0.24 (0.02)**	-0.21 (0.02)**	-0.21 (0.02)**
Cnd_Avg	Omitted	Omitted	Omitted	Omitted
Cnd_AAvg	0.13 (0.01)**	0.14 (0.01)**	0.13 (0.01)**	0.13 (0.01)**
Cnd_High	0.23 (0.02)**	0.23 (0.02)**	0.22 (0.02)**	0.22 (0.02)**
Vista_Poor	-0.21 (0.02)**	-0.21 (0.02)**	-0.25 (0.02)**	-0.25 (0.02)**
Vista_BAvg	-0.08 (0.01)**	-0.08 (0.01)**	-0.09 (0.01)**	-0.09 (0.01)**
Vista_Avg	Omitted	Omitted	Omitted	Omitted
Vista_AAvg	0.1 (0.02)**	0.1 (0.02)**	0.1 (0.01)**	0.1 (0.01)**
Vista_Prem	0.13 (0.04)**	0.13 (0.04)**	0.09 (0.03)**	0.09 (0.03)**
WAOR	Omitted	Omitted	Omitted	Omitted
TXHC	-0.75 (0.03)**	-0.75 (0.03)**	-0.82 (0.02)**	-0.82 (0.02)**
OKCC	-0.44 (0.02)**	-0.44 (0.02)**	-0.53 (0.02)**	-0.52 (0.02)**
IABV	-0.24 (0.02)**	-0.24 (0.02)**	-0.31 (0.02)**	-0.3 (0.02)**
ILLC	-0.09 (0.03)**	-0.09 (0.03)**	-0.05 (0.02)*	-0.04 (0.02)*
WIKCDC	-0.14 (0.02)**	-0.14 (0.02)**	-0.17 (0.01)**	-0.17 (0.02)**
PASC	-0.3 (0.03)**	-0.31 (0.03)**	-0.37 (0.03)**	-0.37 (0.03)**
PAWC	-0.07 (0.03)**	-0.07 (0.03)**	-0.15 (0.02)**	-0.14 (0.02)**
NYMCOC	-0.2 (0.03)**	-0.2 (0.03)**	-0.25 (0.02)**	-0.25 (0.02)**
NYMC	-0.14 (0.02)**	-0.15 (0.02)**	-0.15 (0.02)**	-0.15 (0.02)**

*Significant at or above the: ** 1% level, * 5% level. Standard Errors shown in parenthesis.*

The sign and magnitudes of the home and site, study area, and spatial control variables are consistent with a priori expectations, are stable across all four hedonic models, and all are statistically significant at the 1% level. Of note are the scenic vista and cul-de-sac coefficients, indicating strong relationships between visual and proximate characteristics (not considering turbines) and sale prices.

Table 7: Results for Variable of Interest

		Model 1	Model 2	Model 3	Model 4
No View		Omitted	Omitted	0.02 (0.01)	Omitted
Minor View		-0.01 (0.01)	-0.01 (0.01)	0.00 (0.02)	-0.02 (0.01)
Moderate View		0.01 (0.03)	0.02 (0.03)	0.03 (0.03)	0.00 (0.03)
Substantial View		-0.01 (0.07)	-0.01 (0.07)	0.03 (0.07)	0.01 (0.07)
Extreme View		0.04 (0.1)	0.02 (0.09)	0.06 (0.08)	0.04 (0.07)
Pre-Construction Sales				Omitted	
Inside 3000 Feet			-0.05 (0.06)	-0.06 (0.05)	
Between 3000 Feet and 1 Mile			-0.05 (0.05)	-0.08 (0.05)	
Between 1 and 3 Miles			0.00 (0.02)	0.00 (0.01)	
Between 3 and 5 Miles			0.02 (0.01)	0.01 (0.01)	
Outside 5 Miles			Omitted	0.00 (0.02)	
Pre-Announcement Sales				Omitted	
DISTANCE		0.004 (0.00)			
DISTANCE*LT1MILE		0.086 (0.11)			
Inside 1 Mile	Gtr2Yr_PreAnc				-0.13 (0.06)*
	Lt2Yr_PreAnc				-0.10 (0.05)
	PostAnc_PreCon				-0.14 (0.06)*
	Lt2Yr_PostCon				-0.09 (0.07)
	Btw2_4Yr_PostCon				-0.01 (0.06)
	Gtr4Yr_PostCon				-0.07 (0.08)
Between 1-3 Miles	Gtr2Yr_PreAnc				-0.13 (0.06)*
	Lt2Yr_PreAnc				0.00 (0.03)
	PostAnc_PreCon				-0.02 (0.03)
	Lt2Yr_PostCon				0.00 (0.03)
	Btw2_4Yr_PostCon				0.01 (0.03)
	Gtr4Yr_PostCon				0.00 (0.03)
Between 3-5 Miles	Gtr2Yr_PreAnc				0.00 (0.04)
	Lt2Yr_PreAnc				0.00 (0.03)
	PostAnc_PreCon				0.00 (0.03)
	Lt2Yr_PostCon				0.02 (0.03)
	Btw2_4Yr_PostCon				0.01 (0.03)
	Gtr4Yr_PostCon				0.01 (0.03)
Outside 5 Miles	Gtr2Yr_PreAnc				Omitted
	Lt2Yr_PreAnc				-0.03 (0.04)
	PostAnc_PreCon				-0.03 (0.03)
	Lt2Yr_PostCon				-0.03 (0.03)
	Btw2_4Yr_PostCon				0.03 (0.03)
	Gtr4Yr_PostCon				0.01 (0.03)

*Significant at or above the: ** 1% level, * 5% level. Standard Errors shown in parenthesis.*

Across four different hedonic models, the results are consistent: neither the view of the wind facilities nor the distance of the home to those facilities is found to have a statistically significant effect on home sales prices. These results are strengthened in light of the statistically significant relationships found for non-turbine related visual and proximate characteristics.

Table 8: Results from Equality Test of Model Four Coefficients

	More Than 2 Years Before Announcement	Less Than 2 Years Before Announcement	After Announcement Before Construction	Less Than 2 Years After Construction	Between 2 and 4 Years After Construction	More Than 4 Years After Construction
Less Than 1 Mile	Reference	0.03 (0.45)	-0.01 (-0.13)	0.04 (0.56)	0.12 (1.74)	0.06 (0.88)
Between 1 and 3 Miles	Reference	0.04 (1.92)	0.02 (0.86)	0.05 (2.47)*	0.05 (2.27)*	0.04 (1.82)
Between 3 and 5 Miles	Reference	0.01 (0.37)	0.01 (0.34)	0.02 (0.77)	0.02 (0.78)	0.02 (0.79)
Outside of 5 Miles †	Reference	-0.04 (-0.86)	-0.03 (-0.91)	-0.03 (-0.77)	0.03 (0.81)	0.01 (0.36)

Numbers represent the differences between coefficients in the target temporal category and those in the reference temporal category (more than 2 years before announcement) for the same distance band.

*Numbers in parenthesis are t-Test statistics. Significance = ** 1% level, * 5% level, and <blank> below the 5% level.*

† *For homes outside of 5 miles, the coefficient differences are equal to the coefficients in the Temporal Aspects Model, and therefore the t-values were produced via the OLS.*

A comparison of the sales prices for the homes located within a mile of the turbines which transacted more than two years prior to the facilities' announcement and those that sold in later periods (e.g., after announcement or after construction) produced differences that were statistically indistinguishable from pre-announcement levels. In other words, relative prices did not fall after the announcement and eventual construction of the wind facility for this sample of homes.

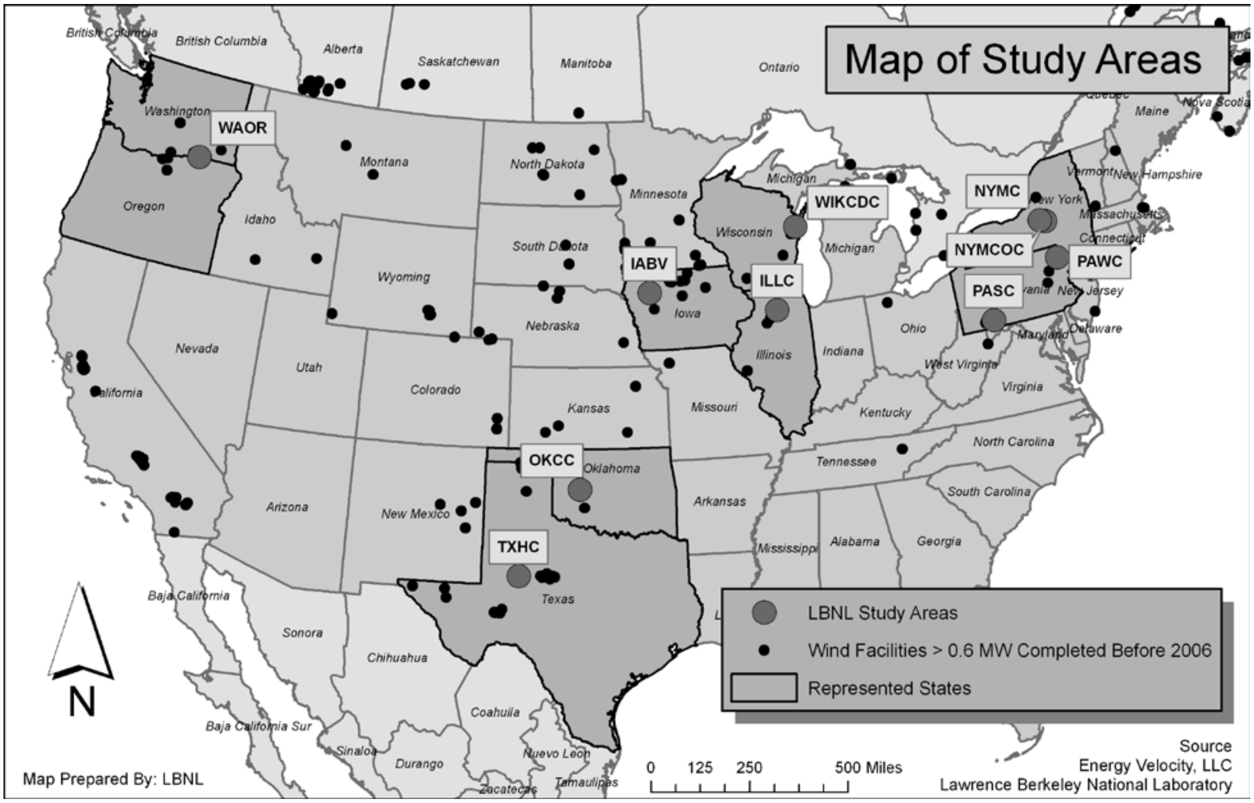
Table 9: Robustness Test Results

	Substantial View	Extreme View	Inside 3000 Feet	Between 3000 Feet and 1 Mile	pct_vis
Model Two	-0.01 (0.07)	0.02 (0.09)	-0.05 (0.06)	-0.05 (0.05)	
Robustness Models					
Interactions Between Study Area and Home and Site Characteristics Included	0.002 (0.07)	0.01 (0.09)	-0.05 (0.06)	-0.06 (0.05)	
Census Tract and School District Delineations Included	0.03 (0.06)	0.03 (0.08)	-0.07 (0.06)	-0.02 (0.05)	
Micro Spatial Effects - Ramp Distance and Major Roads Included	0.02 (0.06)	0.02 (0.08)	-0.02 (0.06)	0.03 (0.05)	
Spatial Control (Nearest Neighbor) Omitted	-0.03 (0.07)	-0.006 (0.09)	-0.07 (0.06)	-0.06 (0.05)	
View Variables Omitted			-0.04 (0.04)	-0.06 (0.05)	
Distance Variables Omitted	-0.04 (0.06)	-0.03 (0.06)			
Five Outlier and Influencer Cases Included	-0.03 (0.06)	0.02 (0.09)	-0.02 (0.06)	-0.05 (0.05)	
Percent Visible (Quantitative View Variable) Tested			-0.09 (0.06)	-0.06 (0.04)	0.43 (0.23)
Year Dummies Included	-0.01 (0.07)	0.02 (0.09)	-0.05 (0.06)	-0.05 (0.05)	

*Significant at or above the: ** 1% level, * 5% level. Standard Errors shown in parenthesis.*

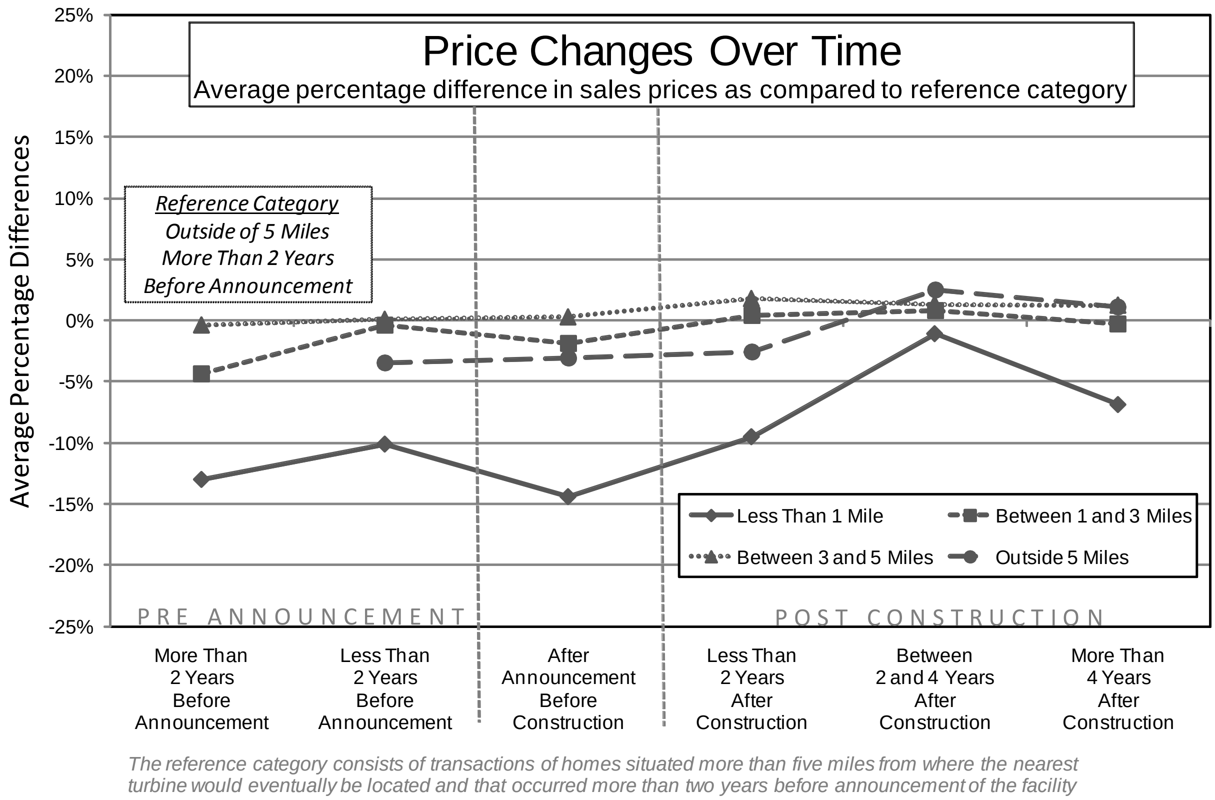
The results are consistent across a variety of model and sample specifications. The estimated coefficients for the robustness models are similar in magnitude to the baseline Model Two estimates (presented at the top of this table for comparison purposes) and none are statistically different from zero (this also holds for the other variables that are not presented in this table).

Figure 1: Map of Study Areas and Potential Study Areas



The 24 wind facilities, selected from 241 potential facilities, were included in the sample, and encompassed 10 different study areas.

Figure 2: Results from Model Four



Homes that sold prior to wind facility announcement, but situated within one mile of the eventual location of the turbines, sold, on average, for between 10% and 13% less than homes that sold in the same time period but located more than five miles away. Therefore, the homes nearest the wind facility's eventual location were depressed in value prior to the announcement of the facility in comparison to homes further away.

11. Endnotes

[1] The average size of wind power facilities built in the U.S. from 2007 through 2009 was approximately 100 MW (Wiser and Bolinger, 2010) and the total amount of capacity required to reach 20% wind electricity is roughly 300,000 MW (US DOE, 2008). Therefore, to achieve 20% wind electricity by 2030, a total of about 3,000 wind facilities may need to be sited and permitted; by the end of 2009, the installed wind power capacity in the U.S. stood at 35,000 MW.

[2] The wind facility data set was obtained from Energy Velocity, LLC, later purchased by Ventyx. The dataset is available as the Velocity Suite from Ventyx.

[3] "Validity" was determined, in all cases, by local assessors. Additionally, calls were made to the wind facility developers to ensure that none of the homes in our sample had received compensation related to the facility (e.g., payments that run with the deed), and that no property value guarantees associated with the wind facilities were in place at the time of sale.

[4] In some cases, county officials extracted data from their database directly, while in other cases a company engaged to manage a county's data provided the necessary information. In either case, the provider is referred to as "county." Also, January 1996 was used so that all study areas had sales that preceded the announcement of the wind facility. Detailed descriptions of the providers, the data collection process, and how the data are arrayed across the variables of interest are described more fully in Hoen et al. (2009).

[5] Freddie Mac Conventional Mortgage Home Price Index: municipal statistical area (MSA) series data are available from the following site: http://www.freddiemac.com/finance/cmhpi/. Because most of the study areas do not fall within the MSAs, a collection of local experts was relied upon, including real estate agents, assessors, and appraisers, to decide which MSA most-closely matched that of the local market. In all cases, the experts had consensus as to the best MSA to use. In one case (NYMCOC), the sample was split between two MSAs.

[6] These data were sourced from the USDA Geospatial Data Gateway: http://datagateway.nrcs.usda.gov

[7] Distance measures are collectively and individually referred to as "DISTANCE" from this point forward. The variable DISTANCE was constructed using the Euclidean distance between each property and the nearest turbine at the time of sale. A full description of the method for deriving distance to the nearest turbine for each home is detailed in Hoen et al. (2009).

[8] View of turbines rankings are collectively and individually referred to as "VIEW" from this point forward.

[9] In addition to the qualitative ratings, a variety of quantitative data were collected that might describe the nature of the view of wind turbines, including the total number of turbines visible, the distance of the home to the nearest wind turbine, and the view scope (i.e., the degree to which the turbines are spread out in front of the home: narrow, medium, or wide). A *post hoc* Multinomial Logistic Regression model relating the qualitative rankings and the quantitative measures, and to test their similarity, produced high Pseudo R^2 statistics (Cox and Snell 0.88, Nagelkerke 0.95, and McFadden 0.79) and values (qualitative vs. those predicted from the quantitative model) that

were highly correlated (Pearson's 0.88). Additionally, a test using off-site raters, who were shown pictures of the views of the turbines that had been rated on-site, produced high correlations (Pearson's 0.81) between both on and off-site ratings, with 97% or the rankings differing by no more than one category between the two groups. Both tests - the details of which are provided in Hoen et al. (2009) - substantiated the choice of the simpler qualitative ranking system.

[10] Scenic vista rankings are individually and collectively referred to as "VISTA" from this point forward.

[11] See Hoen et al. (2009) for details regarding validity testing of the VISTA rankings.

[12] View and Vista ratings were often ascertained from the road. When this proved problematic (e.g., long driveways, obscured views from the road) other methods were used such as accessing neighboring property, or by obtaining permission from the homeowner to gain access to the views from their property. Photographic examples of each VIEW and VISTA rating are provided in Hoen et al. (2009).

[13] This "modulation" involved establishing a rating while assuming the leaves in the fore-ground and middle-ground trees matched those at the time of sale. For example, if large fore-ground and middle-ground trees would have obscured views of the turbines at the time of sale, but did not do so when the field data were collected, the View rating was adjusted appropriately to consider what the view would have been like at the time of sale, with full foliage.

[14] For a full discussion of the field ranking system for View and Vista see Hoen et al. (2009).

[15] Pre and post-construction and pre and post-announcement are determined by the dates provided by Energy Velocity, LLC. The announcement date corresponds to the first time the facility appears in the public record, which was often the permit application date. The construction date corresponds to the date on which site construction began. For a full discussion of potential biases associated with these dates see Hoen et al. (2009).

[16] It should be emphasized that in the four primary hedonic models estimated in this paper all variables of interest, spatial adjustments, and home and site characteristics are pooled, and therefore their estimates represent the average across all study areas. Ideally, one would have enough data to estimate a model at the study area level - a fully unrestricted model - rather than pooled across all areas. This fully unrestricted model form, along with 15 other model forms (with some variables restricted and others not) were investigated in Hoen et al. (2009). These 16 different models were estimated to explore which model was the most parsimonious (had the fewest parameters), performed the best (e.g., had the highest adjusted R^2 and the lowest Schwarz information criterion), and had the most stable coefficients and standard errors. The pooled model (as best described by equation 2) was found to be the highest ranking model. By making this choice, the present research concentrates on identifying the presence of potential property value impacts across all of the study areas in the sample as opposed to any single study area. Because effects might vary between study areas, and the models estimate an average across all study areas, the full range of effects in individual study areas are undetermined. That notwithstanding, there is no reason to suspect that effects will be completely "washed out." For that to occur, an effect in one study area would have to be positive while in another area it would have to be negative, and there is no reason to suspect that this would occur.

[17] Condition of the home was determined by the local assessor.

[18] Verifying the existence, or lack thereof, of spatial heterogeneity (via Moran's I) was not possible given the computing power available for this research and the large dataset involved.

[19] A full discussion of how this variable was created is contained in Hoen at al. (2009).

[20] Other distance functions (e.g., linear, quadratic, cubic, logarithmic and inverse) were also tested, as discussed in Hoen et al. (2009).

[21] The distance variables are a proxy for a variety of effects. As is discussed below, future research should attempt to disentangle these individual effects (e.g., sound, flicker) and test them directly.

[22] It is worth noting that these reference homes are situated in both rural and urban locales and therefore are not uniquely affected by influences from either setting. This further reinforces their worthiness as a reference category. Nonetheless, the question as to whether these homes are appropriate as a reference category group is addressed further in Models Three and Four.

[23] Although the results are not presented here, a specification where the two categories were not collapsed was estimated. The results from this alternative version do not differ from those presented here and are available upon request.

[24] The VIEW variable was considered most relevant for the post-construction period when turbines could actually be seen, so delineations based on development periods that extended into the pre-construction phase were unnecessary. It is conceivable that VIEW effects vary within the periods following construction. . Although an interesting area of further research, the numbers of cases of SUBSTANTIAL and EXTREME view rankings in our sample – even if combined – when divided into temporal periods were too small to conduct analysis on.

[25] All models were estimated with White's corrected standard errors (White, 1980) using the PROC REG procedure of SAS Version 9.2 TS1M0. It should also be noted that all Durbin-Watson (Durbin and Watson, 1951) test statistics were within the acceptable range of 1.89 and 2.53 (Gujarati, 2003), there was little multicollinearity associated with the variables of interest, and all results were robust to the removal of any cases with a Mahalanobis Distance statistic greater than 150 (Mahalanobis, 1936) and/or standardized residuals greater than four.

[26] Of course, cul-de-sacs and water frontage bestow other benefits to the home owner beyond the quality of the scenic vista, such as safety and privacy in the case of a cul-de-sac, and recreational potential and privacy in the case of water frontage.

[27] Effects for homes within a mile are calculated as follows from the estimated coefficients as reported in Table 7 for Model One: DISTANCE*0.004 + 0.086 - (DISTANCE*0.086).

[28] Pct_vis (i.e., Percent Visible) was constructed by dividing the total area of turbines visible from each home (as determined by the distance to the nearest turbine and the numbers of turbines visible), by the total viewing area possible.