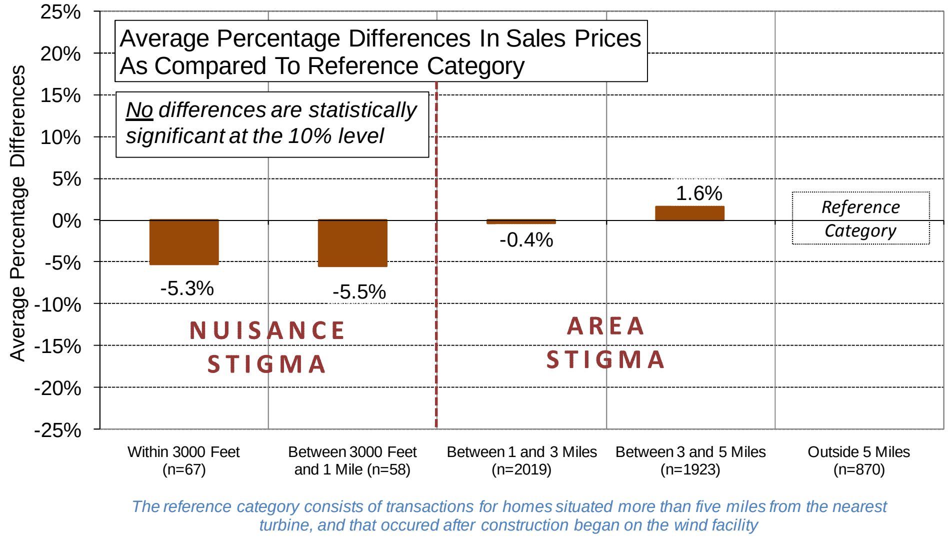
Figure 7: Results from the Base Model for DISTANCE



Looking at these results as a whole, a somewhat monotonic order from low to high is found as homes are situated further away from wind facilities, but all of the coefficients are relatively small and none are statistically different from zero. This suggests that, for homes in the sample at least, there is a lack of statistical evidence that the distance from a home to the nearest wind turbine impacts sales prices, and this is true regardless of the distance band.[69] As such, an absence of evidence of an Area or Nuisance Stigma is found in the Base Model. That notwithstanding, the -5% coefficients for homes that sold within one mile of the nearest wind turbine require further scrutiny. Even though the differences are not found to be statistically significant, they might point to effects that exist but are too small for the model to deem statistically significant due to the relatively small number of homes in the sample within 1 mile of the nearest turbine. Alternatively, these homes may simply have been devalued even before the wind facility was erected, and that devaluation may have carried over into the post construction period (the period investigated by the Base Model). To explore these possibilities, transactions that occurred well before the announcement of the wind facility to well after construction are investigated in the Temporal Aspects Model in the following "Alternative Models" section.

[69] It is worth noting that the number of cases in each of these categories (e.g., n = 67 for homes inside of 3000 feet and n = 58 between 3000 feet and one mile) are small, but are similar to the numbers of cases for other variables in the same model (e.g., LOW CONDITION, n = 69; PREMIUM VISTA, n = 75), the estimates of which were found to be significant above the 1% level.

Table 10: Results from the Base Model

	Coef.	SE	p Value	*n*
Intercept	7.62	0.18	0.00	
Nbr_LN_SalePrice96_hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale_Sqrd	0.00002	0.000003	0.00	4,937
Sqft_1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls_Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul_De_Sac	0.10	0.01	0.00	992
Water_Front	0.33	0.04	0.00	87
Cnd_Low	-0.45	0.05	0.00	69
Cnd_BAvg	-0.24	0.02	0.00	350
Cnd_Avg	Omitted	Omitted	Omitted	2,727
Cnd_AAvg	0.14	0.01	0.00	1,445
Cnd_High	0.23	0.02	0.00	337
Vista_Poor	-0.21	0.02	0.00	310
Vista_BAvg	-0.08	0.01	0.00	2,857
Vista_Avg	Omitted	Omitted	Omitted	1,247
Vista_AAvg	0.10	0.02	0.00	448
Vista_Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Post_Con_NoView	Omitted	Omitted	Omitted	4,207
View_Minor	-0.01	0.01	0.40	561
View_Mod	0.02	0.03	0.58	106
View_Sub	-0.01	0.07	0.94	35
View_Extrm	0.02	0.09	0.80	28
Mile_Less_0_57	-0.05	0.06	0.40	67
Mile_0_57to1	-0.05	0.05	0.30	58
Mile_1to3	0.00	0.02	0.80	2,019
Mile_3to5	0.02	0.01	0.23	1,923
Mile_Gtr5	Omitted	Omitted	Omitted	870

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**1**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**37**
F Statistic	**442.8**
Adjusted R Squared	**0.77**

5. Alternative Hedonic Models

The Base Hedonic Model presented in Section 4 found that residential property values have, on average, not been measurably affected by the presence of nearby wind facilities. To test the robustness of this result and to test for other possible impacts from nearby wind projects, the report now turns to a number of other hedonic models. These Alternative Models were created to investigate different approaches to exploring the impact of the variables of interest (#1 and #2, below) and to assess the presence of impacts that are not otherwise fully captured by the Base Model (#3 through #6, below).

1) **View and Distance Stability Models:** Using only post-construction transactions (the same as the Base Model) these models investigate whether the Scenic Vista Stigma (as measured with VIEW) results are independent of the Nuisance and Area Stigma results (as measured by DISTANCE) and vice versa.[70]
2) **Continuous Distance Model:** Using only post-construction transactions, this model investigates Area and Nuisance Stigmas by applying a continuous distance parameter as opposed to the categorical variables for distance used in the previous models.
3) **All Sales Model:** Using all transactions, this model investigates whether the results for the three stigmas change if transactions that occurred before the announcement and construction of the wind facility are included in the sample.
4) **Temporal Aspects Model:** Using all transactions, this model further investigates Area and Nuisance Stigmas and how they change for homes that sold more than two years pre-announcement through the period more than four years post-construction.
5) **Home Orientation Model:** Using only post-construction transactions, this model investigates the degree to which a home's orientation to the view of wind turbines affects sales prices.
6) **View and Vista Overlap Model:** Using only post-construction transactions, this model investigates the degree to which the overlap between the view of a wind facility and a home's primary scenic vista affects sales prices.

Each of these models is described in more depth in the pages that follow. Results are shown for the variables of interest only; full results are contained in Appendix H.

5.1. View and Distance Stability Models

The Base Model (equation 1) presented in Section 4 includes both DISTANCE and VIEW variables because a home's value might be affected in part by the magnitude of the view of a nearby wind facility and in part by the distance from the home to that facility. These two variables may be related, however, in-so-far as homes that are located closer to a wind facility are likely to have a more-dominating view of that facility. To explore the degree to which these two sets of variables are independent of each other (i.e. not collinear) and to further test the robustness of the Base Model results two alternative hedonic models are run, each of which includes only one of the sets of parameters (DISTANCE or VIEW). Coefficients from these models are then compared to the Base Model results.

[70] Recall that the qualitative VIEW variable incorporated the visible distance to the nearest wind facility.

5.1.1. Dataset and Model Form

The same dataset is used as in the Base Model, focusing again on post-construction transactions (n = 4,937). To investigate DISTANCE effects alone the following model is estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_s \beta_2 \mathrm{S} + \sum_k \beta_3 \mathrm{X} + \sum_d \beta_5 \mathrm{DISTANCE} + \varepsilon \quad (2)$$

where
P represents the inflation-adjusted sales price,
N is the spatially weighted neighbors' predicted sales price,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
DISTANCE is a vector of *d* categorical distance variables (e.g., less than 3000 feet, between one and three miles, etc.),
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 transactions of homes in the WAOR study area,
β_3 is a vector of *k* parameter estimates for the home and site characteristics,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to transactions of homes situated outside of five miles, and
ε is a random disturbance term.

The parameters of primary interest are β_5, which represent the marginal differences between home values at various distances from the wind turbines as compared to the reference category of homes outside of five miles. These coefficients can then be compared to the same coefficients estimated from the Base Model.

Alternatively, to investigate the VIEW effects alone, the following model is estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_s \beta_2 \mathrm{S} + \sum_k \beta_3 \mathrm{X} + \sum_v \beta_4 \mathrm{VIEW} + \varepsilon \quad (3)$$

where
VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),
β_4 is a vector of *v* parameter estimates for the VIEW variables, and
all other components are as defined in equation (2).

The parameters of primary interest in this model are β_4, which represent the marginal differences between home values for homes with varying views of wind turbines at the time of sale as compared to the reference category of homes without a view of those turbines. Again, these coefficients can then be compared to the same coefficients estimated from the Base Model.

Our expectation for both of the models described here is that the results will not be dramatically different from the Base Model, given the distribution of VIEW values across the DISTANCE values, and vice versa, as shown in Table 11. Except for EXTREME view, which is concentrated inside of 3000 feet, all view ratings are adequately distributed among the distance categories.

Table 11: Frequency Crosstab of VIEW and DISTANCE Parameters

	Inside 3000 Feet	Between 3000 Feet and 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles	Outside 5 Miles	Total
No View	6	12	1653	1695	841	**4207**
Minor View	14	24	294	202	27	**561**
Moderate View	8	13	62	21	2	**106**
Substantial View	11	9	10	5	0	**35**
Extreme View	28	0	0	0	0	**28**
TOTAL	**67**	**58**	**2019**	**1923**	**870**	**4937**

5.1.2. Analysis of Results

Summarized results for the variables of interest from the Base Model and the two Alternative Stability Models are presented in Table 12. (For brevity, the full set of results for the models is not shown in Table 12, but is instead included in Appendix H.) The adjusted R^2 for the View and Distance Stability Models is the same as for the Base Model, 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level and are similar in magnitude to the estimates presented earlier for the Base Model.

The DISTANCE and VIEW coefficients, β_5 and β_4, are stable, changing no more than 3%, with most (7 out of 8) not experiencing a change greater than 1%. In all cases, changes to coefficient estimates for the variables of interest are considerably less than the standard errors. Based on these results, there is confidence that the correlation between the VIEW and DISTANCE variables is not responsible for the findings and that these two variables are adequately independent to be included in the same hedonic model regression. As importantly, no evidence of Area, Scenic Vista, or Nuisance Stigma is found in the sample, as none of the VIEW or DISTANCE variables are found to be statistically different from zero.

Table 12: Results from Distance and View Stability Models

		Base Model			Distance Stability			View Stability		
Variables of Interest	***n***	**Coef**	**SE**	**p Value**	**Coef**	**SE**	**p Value**	**Coef**	**SE**	**p Value**
No View	4207	Omitted	Omitted	Omitted				Omitted	Omitted	Omitted
Minor View	561	-0.01	0.01	0.39				-0.02	0.01	0.24
Moderate View	106	0.02	0.03	0.57				0.00	0.03	0.90
Substantial View	35	-0.01	0.07	0.92				-0.04	0.06	0.45
Extreme View	28	0.02	0.09	0.77				-0.03	0.06	0.58
Inside 3000 Feet	67	-0.05	0.06	0.31	-0.04	0.04	0.25			
Between 3000 Feet and 1 Mile	58	-0.05	0.05	0.20	-0.06	0.05	0.17			
Between 1 and 3 Miles	2019	0.00	0.02	0.80	-0.01	0.02	0.71			
Between 3 and 5 Miles	1923	0.02	0.01	0.26	0.01	0.01	0.30			
Outside 5 Miles	870	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted			

"Omitted" = reference category for fixed effects variables. "n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**2**	**3**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**	**4937**
Number of Predictors (k)	**37**	**33**	**33**
F Statistic	**442.8**	**496.7**	**495.9**
Adjusted R Squared	**0.77**	**0.77**	**0.77**

5.2. Continuous Distance Model

The potential impact of wind facilities on residential property values based on Area and Nuisance effects was explored with the Base Model by using five ordered categorical DISTANCE variables. This approach was used in order to impose the least restriction on the functional relationship between distance and property values (as discussed in footnote 52 on page 25). The literature on environmental disamenities, however, more commonly uses a continuous distance form (e.g., Sims et al., 2008), which imposes more structure on this relationship. To be consistent with the literature and to test if a more rigid structural relationship might uncover an effect that is not otherwise apparent with the five distance categories used in the Base Model, a hedonic model that relies upon a continuous distance variable is presented here. One important benefit of this model is that a larger amount of data (e.g., *n* = 4,937) is used to estimate the continuous DISTANCE coefficient then was used to estimate any of the individual categorical estimates in the Base Model (e.g., *n* = 67 inside 3000 feet, *n* = 2019 between one and three miles). The Continuous Distance Model therefore provides an important robustness test to the Base Model results.

5.2.1. Dataset and Model Form

A number of different functional forms can be used for a continuous DISTANCE variable, including linear, inverse, cubic, quadratic, and logarithmic. Of the forms that are considered, an inverse function seemed most appropriate.[71] Inverse functions are used when it is assumed that any effect is most pronounced near the disamenity and that those effects fade asymptotically as distance increases. This form has been used previously in the literature (e.g., Leonard et al., 2008) to explore the impact of disamenities on home values, and is calculated as follows:

$$\mathrm{InvDISTANCE} = 1/\mathrm{DISTANCE} \tag{4}$$

where
DISTANCE is the distances to the nearest turbine from each home as calculated at the time of sale for homes that sold in the post-construction period.

For the purpose of the Continuous Distance Model, the same dataset is used as in the Base Model, focusing again on post-construction transactions (*n* = 4,937). InvDISTANCE has a maximum of 6.67 (corresponding to homes that were 0.15 miles, or roughly 800 feet, from the nearest wind turbine), a minimum of 0.09 (corresponding to a distance of roughly 11 miles), and a mean of 0.38 (corresponding to a distance of 2.6 miles). This function was then introduced into the hedonic model in place of the DISTANCE categorical variables as follows:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_{s}\beta_2\mathrm{S} + \sum_{k}\beta_3\mathrm{X} + \sum_{v}\beta_4\mathrm{VIEW} + \beta_5\mathrm{InvDISTANCE} + \varepsilon \tag{5}$$

where
$\mathrm{InvDISTANCE}_i$ is the inverse of the distance to the nearest turbine,
β_5 is a parameter estimate for the inverse of the distance to the nearest turbine, and

[71] The other distance functions (e.g., linear, quadratic, cubic & logarithmic) were also tested. Additionally, two-part functions with interactions between continuous forms (e.g., linear) and categorical (e.g., less than one mile) were investigated. Results from these models are briefly discussed below in footnote 72.

all other components are as defined in equation (1).

The coefficient of interest in this model is β_5, which, if effects exist, would be expected to be negative, indicating an adverse effect from proximity to the wind turbines.

5.2.2. Analysis of Results

Results for the variables of interest in the Continuous Distance Model and the Base Model are shown in Table 13. (For brevity, the full set of results for the model is not shown in Table 13, but is instead included in Appendix H.) The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at the one percent level. The coefficients for VIEW are similar to those found in the Base Model, demonstrating stability in results, and none are statistically significant. These results support the previous findings of a lack of evidence of a Scenic Vista Stigma.

Our focus variable InvDISTANCE produces a coefficient (β_5) that is slightly negative at -1%, but that is not statistically different from zero (*p* value 0.41), implying again that there is no statistical evidence of a Nuisance Stigma effect nor an Area Stigma effect and confirming the results obtained in the Base Model.[72]

Table 13: Results from Continuous Distance Model

	Base Model				Continuous Distance			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4,207	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.39	561	-0.01	0.01	0.32	561
Moderate View	0.02	0.03	0.57	106	0.01	0.03	0.77	106
Substantial View	-0.01	0.07	0.92	35	-0.02	0.07	0.64	35
Extreme View	0.02	0.09	0.77	28	0.01	0.10	0.85	28
Inside 3000 Feet	-0.05	0.06	0.31	67				
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58				
Between 1 and 3 Miles	0.00	0.02	0.80	2,019				
Between 3 and 5 Miles	0.02	0.01	0.26	1,923				
Outside 5 Miles	Omitted	Omitted	Omitted	870				
InvDISTANCE					-0.01	0.02	0.41	4,937

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	Continuous Distance
Model Equation Number	**1**	**5**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**34**
F Statistic	**442.8**	**481.3**
Adjusted R Squared	**0.77**	**0.77**

5.3. All Sales Model

The Base Model presented earlier relied on only those transactions that occurred after the construction of the relevant wind facility. This approach, however, leaves open two key questions. First, it is possible that the property values of all of the post-construction homes in the

[72] As mentioned in footnote 71 on page 36, a number of alternative forms of the continuous distance function were also explored, including two-part functions, with no change in the results presented here. In all cases the resulting continuous distance function was not statistically significant.

sample have been affected by the presence of a wind facility, and therefore that the reference homes in the Base Model (i.e., those homes outside of five miles with no view of a wind turbine) are an inappropriate comparison group because they too have been impacted.[73] Using only those homes that sold before the announcement of the wind facility (pre-announcement) as the reference group would, arguably, make for a better comparison because the sales price of those homes are not plausibly impacted by the presence of the wind facility.[74] Second, the Base Model does not consider homes that sold in the post-announcement but pre-construction period, and 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 more-protective and conservative stance (Wolsink, 1989). This subsection therefore presents the results of a hedonic model that uses the full set of transactions in the dataset, pre- and post-construction.

5.3.1. Dataset and Model Form

Unlike the Base Model, in this instance the full set of 7,459 residential transactions is included. The following model is then estimated:

$$\ln(P) = \beta_0 + \beta_1 N + \sum_s \beta_2 S + \sum_k \beta_3 X + \sum_v \beta_4 VIEW + \sum_d \beta_5 DISTANCE + \varepsilon \quad (6)$$

where

VIEW is a vector of *v* categorical view variables (e.g., NONE, MINOR, MODERATE, etc.),

DISTANCE is a vector of *d* categorical distance variables (e.g., less than 3000 feet, between one and three miles, outside of five mile, etc.),

β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to pre-construction transactions,

β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to pre-announcement transactions, and

all other components are as defined in equation (1).

It is important to emphasize that the VIEW and DISTANCE parameters in equation (6) have different reference categories than they do in the Base Model - equation (1). In the Base Model, DISTANCE and VIEW are estimated in the post-construction period in reference to homes that sold outside of five miles and with no view of the turbines respectively.[75] In the All Sales Model, on the other hand, the coefficients for VIEW (β_4) are estimated in reference to all <u>pre-construction</u> transactions (spanning the pre-announcement and post-announcement-pre-construction periods) and the coefficients for DISTANCE (β_5) are estimated in reference to all <u>pre-announcement</u> transactions. In making a distinction between the reference categories for VIEW and DISTANCE, it is assumed that awareness of the view of turbines and awareness of

[73] This might be the case if there is an Area Stigma that includes the reference homes.

[74] As discussed in footnote 47 on page 19, it is conceivable that awareness might occur prior to the "announcement" date used for this analysis. If true, this bias is likely to be sporadic in nature and less of an issue in this model, when all pre-announcement transactions are pooled (e.g., both transactions near and far away from where the turbines were eventually located) than in models presented later (e.g., temporal aspects model). Nonetheless, if present, this bias may weakly draw down the pre-announcement reference category.

[75] See Section 4.1 and also footnote 51 on page 24 for more information on why the post-construction dataset and five-mile-no-view homes reference category are used in the Base Model.

the distance from them might not occur at the same point in the development process. Specifically, it is assumed that VIEW effects largely occur after the turbines are erected, in the post-construction period, but that DISTANCE effects might occur in the post-announcement-pre-construction timeframe. For example, after a wind facility is announced, it is not atypical for a map of the expected locations of the turbines to be circulated in the community, allowing home buyers and sellers to assess the distance of the planned facility from homes. Because of this assumed difference in when awareness begins for VIEW and DISTANCE, the DISTANCE variable is populated for transactions occurring in the post-announcement-pre-construction period as well as the post-construction period (see Table 14 below), but the VIEW variable is populated only for transactions in the post-construction period – as they were in the Base Model.[76]

Table 14: Frequency Summary for DISTANCE in All Sales Model

	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Post-Construction	67	58	2019	1923	870	**4937**
Post-Announcement-Pre-Construction	13	7	340	277	130	**767**
TOTAL	**80**	**65**	**2359**	**2200**	**1000**	**5704**

One beneficial consequence of the differences in reference categories for the VIEW and DISTANCE variables in this model, as opposed to the Base Model, is that this model can accommodate all of the possible VIEW and DISTANCE categories, including NO VIEW transactions and transactions of homes outside of five miles. Because of the inclusion of these VIEW and DISTANCE categories, the tests to investigate Area, Scenic Vista, and Nuisance Stigmas are slightly different in this model than in the Base Model. For Area Stigma, for example, how homes with no view of the turbines fared can now be tested; if they are adversely affected by the presence of the wind facility, then this would imply a pervasive Area Stigma impact. For Scenic Vista Stigma, the VIEW coefficients (MINOR, MODERATE, etc.) can be compared (using a *t*-Test) to the NO VIEW results; if they are significantly different, a Scenic Vista Stigma would be an obvious culprit. Finally, for Nuisance Stigma, the DISTANCE coefficients inside of one mile can be compared (using a *t*-Test) to those outside of five miles; if there is a significant difference between these two categories of homes, then homes are likely affected by their proximity to the wind facility.

5.3.2. Analysis of Results

Results for the variables of interest for this hedonic model are summarized in Table 15, and Base Model results are shown for comparison purposes. (For brevity, the full set of results for the model is not shown in Table 15, but is instead included in Appendix H.) The adjusted R^2 for the model is 0.75, down slightly from 0.77 for the Base Model, and indicating that this model has slightly more difficulty (i.e. less explanatory power) modeling transactions that occurred pre-

[76] It is conceivable that VIEW effects could occur before the turbines are constructed. In some cases, for example, developers will simulate what the project will look like after construction during the post-announcement but pre-construction timeframe. In these situations, home buyers and sellers might adjust home values accordingly based on the expected views of turbines. It is assumed, however, that such adjustments are likely to be reasonably rare, and VIEW effects are therefore estimated using only post-construction sales.

construction.[77] All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level and are similar in sign and magnitude to the estimates derived from the post-construction Base Model.

The VIEW coefficients (β_4) are clearly affected by the change in reference category. All of the VIEW parameter estimates are higher than the Base Model estimates for the same categories. Of particular interest is the NO VIEW coefficient, which represents the values of homes without a view of the turbines and that sold in the post-construction period, as compared to the mean value of homes that sold in the pre-construction period, all else being equal. These homes, on average, are estimated to sell for 2% (*p* value 0.08) more than similar pre-construction homes. If an Area Stigma existed, a negative coefficient for these NO VIEW homes would be expected. Instead, a positive and statistically significant coefficient is found.[78] It is outside the ability of this study to determine whether the increase is directly related to the wind turbines, or whether some other factor is impacting these results, but in either instance, no evidence of a pervasive Area Stigma associated with the presence of the wind facilities is found.

To test for the possibility of Scenic Vista Stigma, the coefficients for MINOR, MODERATE, SUBSTANTIAL, and EXTREME views can be compared to the NO VIEW coefficient using a simple *t*-Test. Table 16 presents these results. As shown, no significant difference is found for any of the VIEW coefficients when compared to NO VIEW transactions. This reinforces the findings earlier that, within the sample at least, there is no evidence of a Scenic Vista Stigma.

The DISTANCE parameter estimates (β_5) are also found to be affected by the change in reference category, and all are lower than the Base Model estimates for the same categories. This result likely indicates that the inflation-adjusted mean value of homes in the pre-announcement period is slightly higher, on average, than for those homes sold outside of five miles in the post-construction period. This difference could be attributed to the inaccuracy of the inflation index, a pervasive effect from the wind turbines, or to some other cause. Because the coefficients are not systematically statistically significant, however, this result is not pursued further. What is of interest, however, is the negative 8% estimate for homes located between 3000 feet and one mile of the nearest wind turbine (*p* value 0.03). To correctly interpret this result, and to compare it to the Base Model, one needs to discern if this coefficient is significantly different from the estimate for homes located outside of five miles, using a *t*-Test.

The results of this *t*-Test are shown in Table 17. The coefficient differences are found to be somewhat monotonically ordered. Moving from homes within 3000 feet (-0.06, *p* value 0.22), and between 3000 feet and one mile (-0.08, *p* value 0.04), to between one and three miles (0.00, *p* value 0.93) and between three and five miles (0.01, *p* value 0.32) the DISTANCE coefficients are found to generally increase. Nonetheless, none of these coefficients are statistically significant except one, homes that sold between 3000 feet and one mile. The latter finding suggests the possibility of Nuisance Stigma. It is somewhat unclear why an effect would be found in this model, however, when one was not evident in the Base Model. The most likely

[77] This slight change in performance is likely due to the inaccuracies of home and site characteristics and the inflation adjustment for homes that sold in the early part of the study period. This is discussed in more detail in footnote 50 on page 23.

[78] For more on the significance level used for this report, see footnote 68 on page 30.

explanation is that the additional homes that are included in this model, specifically those homes that sold post-announcement but pre-construction, are driving the results. A thorough investigation of these "temporal" issues is provided in the next subsection.

In summation, no evidence is found of an Area or Scenic Vista Stigma in this alternative hedonic model, but some limited not-conclusive evidence of a Nuisance Stigma is detected. To further explore the reliability of this latter result, the analysis now turns to the Temporal Aspects Model.

Table 15: Results from All Sales Model

	Base Model				All Sales			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
Pre-Construction Sales	n/a	n/a	n/a	n/a	Omitted	Omitted	Omitted	2,522
No View	Omitted	Omitted	Omitted	4,207	0.02	0.01	0.08	4,207
Minor View	-0.01	0.01	0.39	561	0.00	0.02	0.77	561
Moderate View	0.02	0.03	0.57	106	0.03	0.03	0.41	106
Substantial View	-0.01	0.07	0.92	35	0.03	0.07	0.53	35
Extreme View	0.02	0.09	0.77	28	0.06	0.08	0.38	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.06	0.05	0.18	80
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.08	0.05	0.03	65
Between 1 and 3 Miles	0.00	0.02	0.80	2,019	0.00	0.01	0.80	2,359
Between 3 and 5 Miles	0.02	0.01	0.26	1,923	0.01	0.01	0.59	2,200
Outside 5 Miles	Omitted	Omitted	Omitted	870	0.00	0.02	0.78	1,000
Pre-Announcement Sales	n/a	n/a	n/a	n/a	Omitted	Omitted	Omitted	1,755

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	All Sales
Model Equation Number	**1**	**6**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**7459**
Number of Predictors (k)	**37**	**39**
F Statistic	**442.8**	**579.9**
Adjusted R Squared	**0.77**	**0.75**

Table 16: Results from Equality Test of VIEW Coefficients in the All Sales Model

	No View	**Minor View**	**Moderate View**	**Substantial View**	**Extreme View**
n	4,207	561	106	35	28
Coefficient	0.02	0.00	0.03	0.03	0.06
Coefficient Difference *	Reference	-0.02	0.00	0.01	0.04
Variance	0.0001	0.0003	0.0009	0.0030	0.0050
Covariance	n/a	0.00011	0.00010	0.00009	0.00008
Df	n/a	7419	7419	7419	7419
***t*-Test**	n/a	-1.20	0.17	0.23	0.58
Significance	n/a	0.23	0.87	0.82	0.57

** Differences are rounded to the nearest second decimal place.*
"n" = number of cases in category when category = "1"

Table 17: Results from Equality Test of DISTANCE Coefficients in the All Sales Model

	Inside 3000 Feet	Between 3000 Feet and 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles	Outside 5 Miles
n	80	65	2,359	2,200	1,000
Coefficient	-0.06	-0.08	0.00	0.01	0.00
Coefficient Difference *	-0.05	-0.08	0.00	0.01	Reference
Variance	0.0019	0.0015	0.0002	0.0002	0.0003
Covariance	0.00010	0.00013	0.00013	0.00015	n/a
Df	7419	7419	7419	7419	n/a
t Test	-1.23	-2.06	0.09	1.00	n/a
Significance	0.22	0.04	0.93	0.32	n/a

** Differences are rounded to the nearest second decimal place.*
"n" = number of cases in category when category = "1"

5.4. Temporal Aspects Model

Based on the results of the All Sales Model, a more thorough investigation of how Nuisance and Area Stigma effects might change throughout the wind project development period is warranted. As discussed previously, 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). The Temporal Aspects Model presented here allows for an investigation of how the different periods of the wind project development process affect estimates for the impact of DISTANCE on sales prices.

5.4.1. Dataset and Model Form

Here the full set of 7,459 residential transactions is used, allowing an exploration of potential property value impacts (focusing on the DISTANCE variable) throughout time, including in the pre-construction period. The following model is then estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_s \beta_2\mathrm{S} + \sum_k \beta_3\mathrm{X} + \sum_v \beta_4\mathrm{VIEW} + \sum_y \beta_5(\mathrm{DISTANCE}\cdot\mathrm{PERIOD}) + \varepsilon \qquad (7)$$

where
DISTANCE is a vector of categorical distance variables (e.g., less than one mile, between one and three miles, etc.),
PERIOD is a vector of categorical development period variables (e.g., after announcement and before construction, etc.),
β_5 is a vector of *y* parameter estimates for each DISTANCE and PERIOD category as compared to the transactions more than two years before announcement and outside of five miles, and
all other components are as defined in equation (1).

The PERIOD variable contains six different options:
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.

In contrast to the Base Model, the two DISTANCE categories inside of one mile are collapsed into a single "less than one mile" group. This approach increases the number of transactions in each crossed subcategory of data, and therefore enhances the stability of the parameter estimates and decreases the size of the standard errors, thus providing an increased opportunity to discover statistically significant effects. Therefore, in this model the DISTANCE variable contains four different options:

1) Less than one mile;
2) Between one and three miles;
3) Between three and five miles; and
4) Outside of five miles.[79]

The number of transactions in each of the DISTANCE and PERIOD categories is presented in Table 18.

The coefficients of interest are β_5, which represent the vector of marginal differences between homes sold at various distances from the wind facility (DISTANCE) during various periods of the development process (PERIOD) as compared to the reference group. The reference group in this model 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 and therefore are treated as controlling variables.[80]

Although the comparisons of these categorical variables between different DISTANCE and PERIOD categories is be interesting, it is the comparison of coefficients within each PERIOD and DISTANCE category that is the focus of this section. 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 the post-announcement-pre-construction period. For this comparison, a *t*-Test similar to that in the All Sales Model is used.

---

[79] For homes that sold in the pre-construction time frame, no turbines yet existed, and therefore DISTANCE is created using a proxy: the Euclidian distance to where the turbines were eventually constructed. This approach introduces some bias when there is more than one facility in the study area. Conceivably, a home that sold in the post-announcement-pre-construction period of one wind facility could also be assigned to the pre-announcement period of another facility in the same area. For this type of sale, it is not entirely clear which PERIOD and DISTANCE is most appropriate, but every effort was made to apply the sale to the wind facility that was most likely to have an impact. In most cases this meant choosing the closest facility, but in some cases, when development periods were separated by many years, simply the earliest facility was chosen. In general, any bias created by these judgments is expected to be minimal because, in the large majority of cases, the development process in each study area was more-or-less continuous and focused in a specific area rather then being spread widely apart.

[80] As discussed earlier, the VIEW variable was considered most relevant for the post-construction period, so delineations based on development periods that extended into the pre-construction phase were unnecessary. It is conceivable, however, that VIEW effects vary in periods following construction, such as in the first two years or after that. Although this is an interesting question, the numbers of cases for the SUBSTANTIAL and EXTREME ratings – even if combined – when divided into the temporal periods were too small to be fruitful for analysis.

Table 18: Frequency Crosstab of DISTANCE and PERIOD

	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	Total
Less Than 1 Mile	38	40	20	39	45	43	**225**
Between 1 and 3 Miles	283	592	340	806	502	709	**3,232**
Between 3 and 5 Miles	157	380	277	572	594	757	**2,737**
Outside of 5 Miles	132	133	130	218	227	425	**1,265**
TOTAL	**610**	**1,145**	**767**	**1,635**	**1,368**	**1,934**	**7,459**

5.4.2. Analysis of Results

Results for the variables of interest for this hedonic model are presented in Table 19; as with previous models, the full set of results is contained in Appendix H. Similar to the All Sales Model discussed in the previous section, the adjusted R^2 for the model is 0.75, down slightly from 0.77 for the Base Model, and indicating that this model has slightly more difficulty (i.e., less explanatory power) modeling transactions that occurred before wind facility construction. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model.

All of the DISTANCE / PERIOD interaction coefficients for distances outside of one mile are relatively small ($-0.04 < \beta_5 < 0.02$) and none are statistically significant. This implies that there are no statistically significant differences in property values between the reference category homes – homes sold more than two years before announcement that were situated outside of five miles from where turbines were eventually erected – and any of the categories of homes that sold outside of one mile at any other period in the wind project development process. These comparisons demonstrate, arguably more directly than any other model presented in this report that Area Stigma effects likely do not exist in the sample.

The possible presence of a Nuisance Stigma is somewhat harder to discern. For homes that sold inside of one mile of the nearest wind turbine, in three of the six periods there are statistically significant negative differences between average property values when compared to the reference category. Transactions completed more than two years before facility announcement are estimated to be valued at 13% less (*p* value 0.02) than the reference category, transactions less than two years before announcement are 10% lower (*p* value 0.06), and transactions after announcement but before construction are 14% lower (*p* value 0.04). For other periods, however, these marginal differences are considerably smaller and are not statistically different from the reference category. Sales prices in the first two years after construction are, on average, 9% less (*p* value 0.15), those occurring between three and four years following construction are, on average, 1% less (*p* value 0.86), and those occurring more than four years after construction are, on average, 7% less (*p* value 0.37).

Table 19: Results from Temporal Aspects Model

Variables of Interest		Temporal Aspects Coef	SE	p Value	*n*
Inside 1 Mile	More Than 2 Years Before Announcement	-0.13	0.06	0.02	38
	Less Than 2 Years Before Announcement	-0.10	0.05	0.06	40
	After Announcement Before Construction	-0.14	0.06	0.04	21
	2 Years After Construction	-0.09	0.07	0.11	39
	Between 2 and 4 Years After Construction	-0.01	0.06	0.85	44
	More Than 4 Years After Construction	-0.07	0.08	0.22	42
Between 1-3 Miles	More Than 2 Years Before Announcement	-0.04	0.03	0.18	283
	Less Than 2 Years Before Announcement	0.00	0.03	0.91	592
	After Announcement Before Construction	-0.02	0.03	0.54	342
	2 Years After Construction	0.00	0.03	0.90	807
	Between 2 and 4 Years After Construction	0.01	0.03	0.78	503
	More Than 4 Years After Construction	0.00	0.03	0.93	710
Between 3-5 Miles	More Than 2 Years Before Announcement	0.00	0.04	0.92	157
	Less Than 2 Years Before Announcement	0.00	0.03	0.97	380
	After Announcement Before Construction	0.00	0.03	0.93	299
	2 Years After Construction	0.02	0.03	0.55	574
	Between 2 and 4 Years After Construction	0.01	0.03	0.65	594
	More Than 4 Years After Construction	0.01	0.03	0.67	758
Outside 5 Miles	More Than 2 Years Before Announcement	Omitted	Omitted	Omitted	132
	Less Than 2 Years Before Announcement	-0.03	0.04	0.33	133
	After Announcement Before Construction	-0.03	0.03	0.39	105
	2 Years After Construction	-0.03	0.03	0.44	215
	Between 2 and 4 Years After Construction	0.03	0.03	0.44	227
	More Than 4 Years After Construction	0.01	0.03	0.73	424

"Omitted" = reference category for fixed effects variables.
"n" indicates number of cases in category when category = "1"

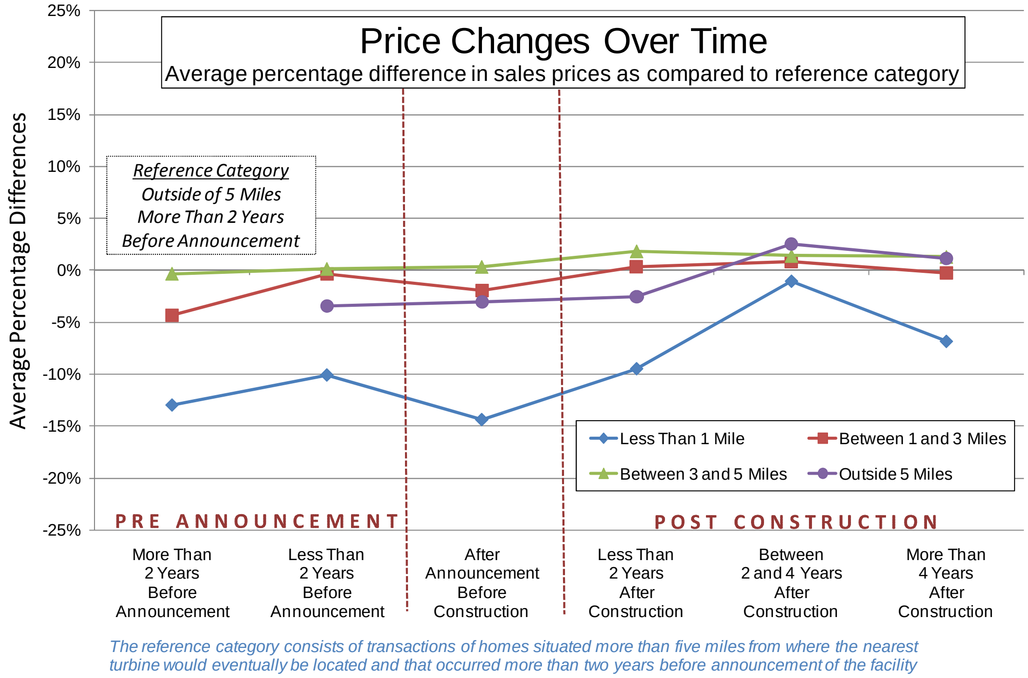
Model Information

Model Equation Number	7
Dependent Variable	LN_SalePrice96
Number of Cases	7459
Number of Predictors (k)	56
F Statistic	404.5
Adjusted R Squared	0.75

What these results suggest (as shown in Figure 8) is that homes inside of one mile in the sample, on average, were depressed in value (in relation to the reference category) before and after the announcement of the wind facility and up to the point that construction began, but that those values rebounded somewhat after construction commenced.[81] This conclusion also likely explains why a significant and negative effect for homes that sold between 3000 feet and one mile is found in the All Sales Model presented in Section 5.3: homes within this distance range that sold prior to facility construction were depressed in value and most likely drove the results for homes that sold after announcement. Regardless, these results are not suggestive of a pervasive Nuisance Stigma.

[81] As discussed in footnotes 47 (on page 19) and 74 (on page 38), the "announcement date" often refers to the first time the proposed facility appeared in the press. "Awareness" of the project in the community may precede this date, however, and therefore transactions occurring in the period "less than two years before announcement" could conceivably have been influenced by the prospective wind project, but it is considerably less likely that those in the period more than two years before announcement would have been influenced.

Figure 8: Results from the Temporal Aspects Model



To explore Nuisance Stigma further, the analysis again turns to the *t*-Test and compares the coefficients for transactions that occurred more than two years before wind facility announcement (during which time the future wind facility is not expected to have any impact on sales prices) to the estimates for the DISTANCE coefficients in the periods that follow. These results are shown in Table 20. Focusing on those transactions inside of one mile, it is found that all coefficients are greater in magnitude than the reference category except during the post-announcement-pre-construction period (which is 1% less and is not statistically significant; *p* value 0.90), indicating, on average, that home values are increasing or staying stable from the pre-announcement reference period onward. These increases, however, are not statistically significant except in the period of two to four years after construction (0.12, *p* value 0.08). With respect to Nuisance Stigma, the more important result is that, relative to homes that sold well before the wind facility was announced, no statistically significant adverse effect is found in any period within a one mile radius of the wind facility. Therefore, the -5% (albeit not statistically significant) average difference that is found in the Base Model, and the -8% (statistically significant) result that is found in the All Sales Model (for homes between 3000 feet and one mile) appear to both be a reflection of depressed home prices that preceded the construction of the relevant wind facilities. If construction of the wind facilities were downwardly influencing the sales prices of these homes, as might be deduced from the Base or All Sales Models alone, a diminution in the inflation adjusted price would be seen as compared to pre-announcement levels. Instead, an increase is seen. As such, no persuasive evidence of a Nuisance Stigma is evident among this sample of transactions.[82]

[82] It should be noted that the numbers of study areas represented for homes situated inside of one mile but in the periods "more than two years before announcement" and "more than four years after construction" are fewer ($n = 5$) than in the other temporal categories ($n = 8$). Further, the "more than two years before announcement – inside of one mile" category is dominated by transactions from one study area (OKCC). For these reasons, there is less

Turning to the coefficient differences for distances greater than one mile in Table 20, again, no statistical evidence of significant adverse impacts on home values is uncovered. Where statistically significant differences are identified, the coefficients are greater than the reference category. These findings corroborate the earlier Area Stigma results, and re-affirm the lack of evidence for such an effect among the sample of residential transactions included in this analysis.

Table 20: Results from Equality Test of Temporal Aspects Model 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 in parenthesis are t-Test statistics. Significance = *** 1% level, ** 5% level, * 10% level, <blank> below the 10% 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.

5.5. Orientation Model

All of the hedonic models presented to this point use a VIEW variable that effectively assumes that the impact of a view of wind turbines on property values will not vary based on the orientation of the home to that view; the impact will be the same whether the view is seen from the side of the home or from the back or front. Other literature, however, has found that the impact of wind projects on property values may be orientation-dependent (Sims et al., 2008). To investigate this possibility further a parameter for orientation is included in the model.

5.5.1. Dataset and Model Form

The same dataset is used as in the Base Model, focusing on post-construction transactions (*n* = 4,937). To investigate whether the orientation of a home to the turbines (ORIENTATION) has a marginal impact on residential property values, over and above that of the VIEW impacts alone, the following hedonic model is estimated:[83]

---

confidence in these two estimates (-13% and -7% respectively) than for the estimates for other temporal periods inside of one mile. Based on additional sensitivity analysis not included here, it is believed that if they are biased, both of these estimates are likely biased downward. Further, as discussed in footnote 47 on page 19, there is a potential for bias in the "announcement" date in that awareness of a project may precede the date that a project enters the public record (i.e., the "announcement" date used for this analysis). Taken together, these two issues might imply that the curve shown in Figure 8 for "less than one mile" transactions, instead of having a flat and then increasing shape, may have a more of an inverse parabolic (e.g., "U") shape. This would imply that a relative minimum in sales prices is reached in the period after awareness began of the facility but before construction commenced, and then, following construction, prices recovered to levels similar to those prior to announcement (and awareness). These results would be consistent with previous studies (e.g., Wolsink, 1989; Devine-Wright, 2004) but cannot be confirmed without the presence of more data. Further research on this issue is warranted. In either case, such results would not change the conclusion here of an absence of evidence of a pervasive Nuisance Stigma in the post-construction period.

[83] The various possible orientations of the home to the view of turbines will be, individually and collectively, referred to as "ORIENTATION" in this report.

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_s \beta_2\mathrm{S} + \sum_k \beta_3\mathrm{X} + \sum_v \beta_4\mathrm{VIEW} + \sum_d \beta_5\mathrm{DISTANCE} + \sum_o \beta_6\mathrm{ORIENTATION} + \varepsilon \qquad (8)$$

where
ORIENTATION is a vector of *o* ORIENTATION variables (e.g., SIDE, FRONT, and BACK),
β_6 is a vector of *o* parameter estimates for ORIENTATION variables, and
all other components are as defined in equation (1).[84]

The ORIENTATION categories include FRONT, BACK, and SIDE, and are defined as follows:

- SIDE: The orientation of the home to the view of the turbines is from the side.
- FRONT: The orientation of the home to the view of the turbines is from the front.
- BACK: The orientation of the home to the view of the turbines is from the back.

The orientation of the home to the view of the wind facilities was determined in the course of the field visits to each home. If more than one orientation to the turbines best described the home (e.g., back and side, or front, back, and side) they were coded as such (e.g., turbines visible from back and side: SIDE = 1; BACK = 1; FRONT = 0).[85]

Not surprisingly, ORIENTATION is related to VIEW. Table 21 and Table 22 provide frequency and percentage crosstabs of ORIENTATION and VIEW. As shown, those homes with more dramatic views of the turbines generally have more ORIENTATION ratings applied to them. For instance, 25 out of 28 EXTREME VIEW homes have all three ORIENTATION ratings (i.e., FRONT, BACK, and SIDE). Virtually all of the MINOR VIEW homes, on the other hand, have only one ORIENTATION. Further, MINOR VIEW homes have roughly evenly spread orientations to the turbines across the various possible categories of FRONT, BACK, and SIDE. Conversely, a majority of the MODERATE and SUBSTANTIAL VIEW ratings coincide with an ORIENTATION from the back of the house.[86]

---

[84] Ideally, one would enter ORIENTATION in the model through an interaction with VIEW. There are two ways that could be accomplished: either with the construction of multiple fixed effects ("dummy") variables, which capture each sub-category of VIEW and ORIENTATION, or through a semi-continuous interaction variable, which would be created by multiplying the ordered categorical variable VIEW by an ordered categorical variable ORIENTATION. Both interaction scenarios are problematic, the former because it requires increasingly small subsets of data, which create unstable coefficient estimates, and the latter because there are no *a priori* expectations for the ordering of an ordered categorical ORIENTATION variable and therefore none could be created and used for the interaction. As a result, no interaction between the two variables is reported here.

[85] An "Angle" orientation was also possible, which was defined as being between Front and Side or Back and Side. An Angle orientation was also possible in combination with Back or Front (e.g., Back-Angle or Front-Angle). In this latter case, the orientation was coded as one of the two prominent orientations (e.g., Back or Front). An Angle orientation, not in combination with Front or Back, was coded as Side.

[86] The prevalence of BACK orientations for MODERATE and SUBSTANTIAL VIEW homes may be because BACK views might more-frequently be kept without obstruction, relative to SIDE views.

Table 21: Frequency Crosstab of VIEW and ORIENTATION

		VIEW				
		Minor	Moderate	Substantial	Extreme	Total
ORIENTATION	Front	217	33	17	27	**294**
	Back	164	67	24	25	**280**
	Side	194	17	15	27	**253**
	Total	**561**	**106**	**35**	**28**	**730**

Note: Total of ORIENTATION does not sum to 730 because multiple orientations are possible for each VIEW.

Table 22: Percentage Crosstab of VIEW and ORIENTATION

		VIEW				
		Minor	Moderate	Substantial	Extreme	Total
ORIENTATION	Front	39%	31%	49%	96%	**40%**
	Back	29%	63%	69%	89%	**38%**
	Side	35%	16%	43%	96%	**35%**

Note: Percentages are calculated as a portion of the total for each VIEW ratings (e.g., 24 of the 35 SUBSTANTIAL rated homes have a BACK ORIENTATION = 69%). Columns do not sum to 100% because multiple orientations are possible for each VIEW.

The parameter estimates of interest in this hedonic model are those for ORIENTATION (β_6) and VIEW (β_4). β_6 represent the marginal impact on home value, over and above that of VIEW alone, of having a particular orientation to the turbines. In the Base Model the VIEW coefficients effectively absorb the effects of ORIENTATION, but in this model they are estimated separately. Because a home's surrounding environment is typically viewed from the front or back of the house, one would expect that, to the extent that wind facility VIEW impacts property values, that impact would be especially severe for homes that have FRONT or BACK orientations to those turbines. If this were the case, the coefficients for these categories would be negative, while the coefficient for SIDE would be to be close to zero indicating little to no incremental impact from a SIDE ORIENTATION.

5.5.2. Analysis of Results

Results for the variables of interest for this hedonic model are shown in Table 23; as with previous models, the full set of results is contained in Appendix H. The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model. The coefficients for DISTANCE and VIEW are stable, in sign and magnitude, when compared to the Base Model results, and none of the marginal effects are statistically significant.

The coefficients for the variables of interest (β_6) do not meet the *a priori* expectations. The estimated effect for SIDE ORIENTATION, instead of being close to zero, is -3% (*p* value 0.36), while BACK and FRONT, instead of being negative and larger, are estimated at 3% (*p* value 0.37) and -1% (*p* value 0.72), respectively. None of these variables are found to be even marginally statistically significant, however, and based on these results, it is concluded that there is no evidence that a home's orientation to a wind facility affects property values in a measurable way. Further, as with previous models, no statistical evidence of a Scenic Vista Stigma is found among this sample of sales transactions.

Table 23: Results from Orientation Model

	Base Model				Orientation Model			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4207	Omitted	Omitted	Omitted	4207
Minor View	-0.01	0.01	0.39	561	-0.01	0.06	0.88	561
Moderate View	0.02	0.03	0.57	106	0.00	0.06	0.96	106
Substantial View	-0.01	0.07	0.92	35	-0.01	0.09	0.85	35
Extreme View	0.02	0.09	0.77	28	0.02	0.17	0.84	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.04	0.07	0.46	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.05	0.05	0.26	58
Between 1 and 3 Miles	0.00	0.02	0.80	2019	0.00	0.02	0.83	2019
Between 3 and 5 Miles	0.02	0.01	0.26	1923	0.02	0.01	0.26	1923
Outside 5 Miles	Omitted	Omitted	Omitted	870	Omitted	Omitted	Omitted	870
Front Orientation					-0.01	0.06	0.72	294
Back Orientation					0.03	0.06	0.37	280
Side Orientation					-0.03	0.06	0.36	253

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	Orientation Model
Model Equation Number	**1**	**8**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**40**
F Statistic	**442.8**	**410.0**
Adjusted R Squared	**0.77**	**0.77**

5.6. Overlap Model

The Orientation Model, presented above, investigated, to some degree, how the potential effects of wind turbines might be impacted by how a home is oriented to the surrounding environment. In so doing, this model began to peel back the relationship between VIEW and VISTA, but stopped short of looking at the relationship directly. It would be quite useful, though, to understand the explicit relationship between the VISTA and VIEW variables. In particular, one might expect that views of wind turbines would have a particularly significant impact on residential property values when those views strongly overlap ("OVERLAP") the prominent scenic vista from a home. To investigate this possibility directly, and, in general, the relationship between VIEW and VISTA, a parameter for OVERLAP is included in the model.

5.6.1. Dataset and Model Form

Data on the degree to which the view of wind turbines overlaps with the prominent scenic vista from the home (OVERLAP) were collected in the course of the field visits to each home.[87] The categories for OVERLAP included NONE, BARELY, SOMEWHAT, and STRONGLY, and are described in Table 24: [88]

Table 24: Definition of OVERLAP Categories

OVERLAP - NONE	The scenic vista does not contain any view of the turbines.
OVERLAP - BARELY	A small portion (~ 0 - 20%) of the scenic vista is overlapped by the view of turbines, and might contain a view of a few turbines, only a few of which can be seen entirely.
OVERLAP - SOMEWHAT	A moderate portion (~20-50%) of the scenic vista contains turbines, and likely contains a view of more than one turbine, some of which are likely to be seen entirely.
OVERLAP - STRONGLY	A large portion (~50-100%) of the scenic vista contains a view of turbines, many of which likely can be seen entirely.

A crosstab describing the OVERLAP designations and the VIEW categories is shown in Table 25. As would be expected, the more dramatic views of wind turbines, where the turbines occupy more of the panorama, are coincident with the OVERLAP categories of SOMEWHAT or STRONGLY. Nonetheless, STRONGLY are common for all VIEW categories. Similarly, SOMEWHAT is well distributed across the MINOR and MODERATE rated views, while BARELY is concentrated in the MINOR rated views.

The same dataset is used as in the Base Model, focusing on post-construction transactions (*n* = 4,937). To investigate whether the overlap of VIEW and VISTA has a marginal impact on residential property values, over and above that of the VIEW and VISTA impacts alone, the following hedonic model is estimated:[89]

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_s \beta_2\mathrm{S} + \sum_k \beta_3\mathrm{X} + \sum_v \beta_4\mathrm{VIEW} + \sum_d \beta_5\mathrm{DISTANCE} + \sum_t \beta_6\mathrm{VISTA} + \sum_p \beta_7\mathrm{OVERLAP} + \varepsilon \quad (9)$$

where

VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),
VISTA is a vector of *t* categorical scenic vista variables (e.g., POOR, BELOW-AVERAGE, etc.),
OVERLAP is a vector of *p* categorical overlap variables (e.g., BARELY, SOMEWHAT, etc.),

87 Scenic vista was rated while taking into account the entire panorama surrounding a home. But, for each home, there usually was a prominent direction that offered a preferred scenic vista. Often, but not always, the home was orientated to enjoy that prominent scenic vista. Overlap is defined as the degree to which the view of the wind facility overlaps with this prominent scenic vista.

88 "…can be seen entirely" refers to being able to see a turbine from the top of the sweep of its blade tips to below the nacelle of the turbine where the sweep of the tips intersects the tower.

89 Although VISTA appears in all models, and is usually included in the vector of home and site characteristics represented by X, it is shown separately here so that it can be discussed directly in the text that follows.

β_4 is a vector of *v* parameter estimates for VIEW fixed effects variables as compared to transactions of homes without a view of the turbines,
β_6 is a vector of *t* parameter estimates for VISTA fixed effect variables as compared to transactions of homes with an AVERAGE scenic vista,
β_7 is a vector of *o* parameter estimates for OVERLAP fixed effect variables as compared to transactions of homes where the view of the turbines had no overlap with the scenic vista, and all other components are as defined in equation (1).

The variables of interest in this model are VIEW, VISTA and OVERLAP, and the coefficients β_4, β_6, and β_7 are therefore the primary focus. Theory would predict that the VISTA coefficients in this model would be roughly similar to those derived in the Base Model, but that the VIEW coefficients may be somewhat more positive as the OVERLAP variables explain a portion of any negative impact that wind projects have on residential sales prices. In that instance, the OVERLAP coefficients would be negative, indicating a decrease in sales price when compared to those homes that experience no overlap between the view of wind turbines and the primary scenic vista.

Table 25: Frequency Crosstab of OVERLAP and VIEW

		VIEW					
		None	**Minor**	**Moderate**	**Substantial**	**Extreme**	**Total**
OVERLAP	**None**	4,207	317	3	0	0	**4,527**
	Barely	0	139	10	1	0	**150**
	Somewhat	0	81	42	7	2	**132**
	Strongly	0	24	51	27	26	**128**
	Total	**4,207**	**561**	**106**	**35**	**28**	**4,937**

5.6.2. Analysis of Results

Results for the variables of interest for this hedonic model are shown in Table 26; as with previous models, the full set of results is contained in Appendix H. The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model.

As expected from theory, the VISTA parameters are stable across models with no change in coefficient sign, magnitude, or significance. Counter to expectations, however, the VIEW coefficients, on average, decrease in value. MINOR VIEW is now estimated to adversely affect a home's sale price by 3% (*p* value 0.10) and is weakly significant, but none of the other VIEW categories are found to be statistically significant. Oddly, the OVERLAP rating of BARELY is found to significantly increase home values by 5% (*p* value 0.08), while none of the other OVERLAP ratings are found to have a statistically significant impact.

Taken at face value, these results are counterintuitive. For instance, absent any overlap of view with the scenic vista (NONE), a home with a MINOR view sells for 3% less than a home with no view of the turbines. If, alternatively, a home with a MINOR view BARELY overlaps the prominent scenic vista, it not only enjoys a 2% increase in value over a home with NO VIEW of the turbines but a 5% increase in value over homes with views of the turbines that do not overlap with the scenic vista. In other words, the sales price increases when views of turbines overlap the prominent scenic vista, at least in the BARELY category. A more likely explanation for these results are that the relatively high correlation (0.68) between the VIEW and OVERLAP parameters is spuriously driving one set of parameters up and the other down. More importantly, when the parameters are combined, they offer a similar result as was found in the Base Model. Therefore, it seems that the degree to which the view of turbines overlaps the scenic vista has a negligible effect on sales prices among the sample of sales transactions analyzed here.[90]

Despite these somewhat peculiar results, other than MINOR, none of the VIEW categories are found to have statistically significant impacts, even after accounting for the degree to which those views overlap the scenic vista. Similarly, none of the OVERLAP variables are simultaneously negative and statistically significant. This implies, once again, that a Scenic Vista Stigma is unlikely to be present in the sample. Additionally, none of the DISTANCE coefficients are statistically significant, and those coefficients remain largely unchanged from the Base Model, reaffirming previous results in which no significant evidence of either an Area or a Nuisance Stigma was found.

[90] An alternative approach to this model was also considered, one that includes an interaction term between VIEW and VISTA. For this model it is assumed that homes with higher rated scenic vistas might have higher rated views of turbines, and that these views of turbines would decrease the values of the scenic vista. To construct the interaction, VISTA, which can be between one and five (e.g., POOR=1,…PREMIUM=5), was multiplied by VIEW, which can be between zero and four (e.g. NO VIEW=0, MINOR=1,…EXTREME=4). The resulting interaction (VIEW*VISTA) therefore was between zero and sixteen (there were no PREMIUM VISTA homes with an EXTREME VIEW), with zero representing homes without a view of the turbines, one representing homes with a POOR VISTA and a MINOR VIEW, and sixteen representing homes with either a PREMIUM VISTA and a SUBSTANTIAL VIEW or an ABOVE AVERAGE VISTA and an EXTREME VIEW. The interaction term, when included in the model, was relatively small (-0.013) and weakly significant (*p* value 0.10 – not White's corrected). The VISTA estimates were unchanged and the VIEW parameters were considerably larger and positive. For instance, EXTREME was 2% in the Base Model and 16% in this "interaction" model. Similarly, SUBSTANTIAL was -1% in the Base Model and 13% in this model. Therefore, although the interaction term is negative and weakly significant, the resulting VIEW estimates, to which it would need to be added, fully offset this negative effect. These results support the idea that the degree to which a VIEW overlaps VISTA has a likely negligible effect on sales prices, while also confirming that there is a high correlation between the interaction term and VIEW variables.

Table 26: Results from Overlap Model

Variables of Interest	Base Model				Overlap Model			
	Coef	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4,207	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.39	561	-0.03	0.02	0.10	561
Moderate View	0.02	0.03	0.57	106	-0.02	0.04	0.65	106
Substantial View	-0.01	0.07	0.92	35	-0.05	0.09	0.43	35
Extreme View	0.02	0.09	0.77	28	-0.03	0.10	0.73	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.05	0.06	0.32	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.05	0.05	0.27	58
Between 1 and 3 Miles	0.00	0.02	0.80	2,019	0.00	0.02	0.82	2,019
Between 3 and 5 Miles	0.02	0.01	0.26	1,923	0.02	0.01	0.26	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870	Omitted	Omitted	Omitted	870
Poor Vista	-0.21	0.02	0.00	310	-0.21	0.02	0.00	310
Below Average Vista	-0.08	0.01	0.00	2,857	-0.08	0.01	0.00	2,857
Average Vista	Omitted	Omitted	Omitted	1,247	Omitted	Omitted	Omitted	1,247
Above Average Vista	0.10	0.02	0.00	448	0.10	0.02	0.00	448
Premium Vista	0.13	0.04	0.00	75	0.13	0.04	0.00	75
View Does Not Overlap Vista					Omitted	Omitted	Omitted	320
View Barely Overlaps Vista					0.05	0.03	0.08	150
View Somewhat Overlaps Vista					0.01	0.03	0.66	132
View Strongly Overlaps Vista					0.05	0.05	0.23	128

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	Overlap Model
Model Equation Number	**1**	**9**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**40**
F Statistic	**442.8**	**409.7**
Adjusted R Squared	**0.77**	**0.77**

6. Repeat Sales Analysis

In general, the Base and Alternative Hedonic Models presented in previous sections come to the same basic conclusion: wind power facilities in this sample have no demonstrable, widespread, sizable, and statistically significant affect on residential property values. These hedonic models contain 29 or more controlling variables (e.g., house and site characteristics) to account for differences in home values across the sample. Although these models perform well and explain nearly 80% of the variation in sales prices among homes in the sample, it is always possible that variables not included in (i.e., "omitted from") the hedonic models could be correlated with the variables of interest, therefore biasing the results.

A common method used to control for omitted variable bias in the home assessment literature is to estimate a repeat sales model (Palmquist, 1982). This technique focuses on just those homes that have sold on more than one occasion, preferably once before and once after the introduction of a possible disamenity, and investigates whether the price appreciation between these transactions is affected by the presence of that disamenity. In this section a repeat sales analysis is applied to the dataset, investigating in a different way the presence of the three possible property value stigmas associated with wind facilities, and therefore providing an important cross-check to the hedonic model results. The section begins with a brief discussion of the general form of the Repeat Sales Model and a summary of the literature that has employed this approach to investigate environmental disamenities. The dataset and model used in the analysis is then described, followed by a summary of the results from that analysis.

6.1. Repeat Sales Models and Environmental Disamenities Literature

Repeat sales models use the annual sales-price appreciation rates of homes as the dependent variable. Because house, home site, and neighborhood characteristics are relatively stable over time for any individual home, many of those characteristics need not be included in the repeat sales model, thereby increasing the degrees of freedom and allowing sample size requirements to be significantly lower and coefficient estimates to be more efficient (Crone and Voith, 1992). A repeat sales analysis is not necessarily preferred over a traditional hedonic model, but is rather an alternative analysis approach that can be used to test the robustness of the earlier results (for further discussion see Jackson, 2003). The repeat sales model takes the basic form:

Annual Appreciation Rate (AAR) = *f* (TYPE OF HOUSE, OTHER FACTORS)

where
TYPE OF HOUSE provides an indication of the segment of the market in which the house is situated (e.g., high end vs. low end), and
OTHER FACTORS include, but are not limited to, changes to the environment (e.g., proximity to a disamenity).

The dependent variable is the adjusted annual appreciation rate and is defined as follows:

$$AAR = \exp\left[\frac{\ln\left(P_1 / P_2\right)}{t_1 - t_2}\right] - 1 \qquad (10)$$

where

P_1 is the adjusted sales price at the first sale (in 1996 dollars),
P_2 is the adjusted sales price at the second sale (in 1996 dollars),
t_1 is the date of the first sale,
t_2 is the date of the second sale, and
$(t_1 – t_2)$ is determined by calculating the number of days that separate the sale dates and dividing by 365.

As with the hedonic regression model, the usefulness of the repeat sales model is well established in the literature when investigating possible disamenities. For example, a repeat sales analysis was used to estimate spatial and temporal sales price effects from incinerators by Kiel and McClain (1995), who found that appreciation rates, on average, are not sensitive to distance from the facility during the construction phase but are during the operation phase. Similarly, McCluskey and Rausser (2003) used a repeat sales model to investigate effects surrounding a hazardous waste site. They found that appreciation rates are not sensitive to the home's distance from the disamenity before that disamenity is identified by the EPA as hazardous, but that home values are impacted by distance after the EPA's identification is made.

6.2. Dataset

The 7,459 residential sales transactions in the dataset contain a total of 1,253 transactions that involve homes that sold on more than one occasion (i.e., a "pair" of sales of the same home). For the purposes of this analysis, however, the key sample consists of homes that sold once before the announcement of the wind facility, and that subsequently sold again after the construction of that facility. Therefore any homes that sold twice in either the pre-announcement or post-construction periods were not used in the repeat sales sample.[91] These were excluded because either they occurred before the effect would be present (for pre-announcement pairs) or after (for post-announcement pairs). This left a total of 368 pairs for the analysis, which was subsequently reduced to 354 usable pairs.[92]

The mean AAR for the sample is 1.0% per year, with a low of -10.5% and a high of 13.4%. Table 27 summarizes some of the characteristics of the homes used in the repeat sales model. The average house in the sample has 1,580 square feet of above-ground finished living area, sits on a parcel of 0.67 acres, and originally sold for $70,483 (real 1996 dollars). When it sold a second time, the average home in the sample was located 2.96 miles from the nearest wind turbine (14 homes were within one mile, 199 between one and three miles, 116 between three and five miles, and 25 outside of five miles). Of the 354 homes, 14% (n = 49) had some view of the facility (35 were rated MINOR, five MODERATE, and nine either SUBSTANTIAL or EXTREME). Because of the restriction to those homes that experienced repeat sales, the sample is relatively small for those homes in close proximity to and with dramatic views of wind facilities.

[91] 752 pairs occurred after construction began, whereas 133 pairs occurred before announcement.

[92] Of the 368 pairs, 14 were found to have an AAR that was either significantly above or below the mean for the sample (mean +/- 2 standard deviations). These pairs were considered highly likely to be associated with homes that were either renovated or left to deteriorate between sales, and therefore were removed from the repeat sales model dataset. Only two of these 14 homes had views of the wind turbines, both of which were MINOR. All 14 of the homes were situated either between one and three miles from the nearest turbine (n = 8) or between three and five miles away (n = 6).

Table 27: List of Variables Included in the Repeat Sales Model

Variable Name	Description	Type	Sign	Freq.	Mean	Std. Dev.	Min.	Max.
SalePrice96_Pre	The Sale Price (adjusted for inflation into 1996 dollars) of the home as of the first time it had sold	C	+	354	$ 70,483	$ 37,798	$ 13,411	$ 291,499
SalePrice96_Pre_Sqr	SalePrice96_Pre Squared (shown in millions)	C	–	354	$ 6,393	$ 8,258	$ 180	$ 84,972
Acres	Number of Acres that sold with the residence	C	+	354	0.67	1.34	0.07	10.96
Sqft_1000	Number of square feet of finished above ground living area (in 1000s)	C	+	354	1.58	0.56	0.59	4.06
No View	If the home had no view of the turbines when it sold for the second time (Yes = 1, No = 0)	Omitted	n/a	305	0.86	0.35	0	1
Minor View	If the home had a Minor View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	35	0.10	0.30	0	1
Moderate View	If the home had a Moderate View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	5	0.01	0.12	0	1
Substantial/Extreme View	If the home had a Substantial or Extreme View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	9	0.03	0.12	0	1
Less than 1 Mile	If the home was within 1 mile (5280 feet) of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	14	0.02	0.13	0	1
Between 1 and 3 Miles	If the home was between 1 and 3 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	199	0.56	0.50	0	1
Between 3 and 5 Miles	If the home was between 3 and 5 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	116	0.33	0.47	0	1
Outside 5 Miles	If the home was outside 5 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	Omitted	n/a	25	0.07	0.26	0	1

"C" Continuous, "OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the "Omitted" category. This table does not include the study area fixed effects variables that are included in the model (e.g., WAOR, TXHC, NYMC). The reference case for these variables is the WAOR study area.

6.3. Model Form

To investigate the presence of Area, Scenic Vista, and Nuisance Stigmas, the adjusted annual appreciation rate (AAR) is calculated for the 354 sales pairs in the manner described in equation (10), using inflation adjusted sales prices. The following model is then estimated:

$$\text{AAR} = \beta_0 + \sum_{s} \beta_1 \text{S} + \sum_{k} \beta_2 \text{X} + \sum_{v} \beta_3 \text{VIEW} + \sum_{d} \beta_4 \text{DISTANCE} + \varepsilon \qquad (11)$$

where

AAR represents the inflation-adjusted Annual Appreciation Rate for repeat sales,

S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),

X is a vector of *k* home, site and sale characteristics (e.g., acres, square feet, original sales price),

VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),

DISTANCE is a vector of *d* categorical distance variables (e.g., less than one mile, between one and three miles, etc.),

β_0 is the constant or intercept across the full sample,

β_1 is a vector of *s* parameter estimates for the study area fixed effects as compared to sales that occurred in the WAOR study area,

β_2 is a vector of *k* parameter estimates for the home, site, and sale characteristics,

β_3 is a vector of *v* parameter estimates for the VIEW variables as compared to transactions of homes with no view of the turbines,

β_4 is a vector of *d* parameter estimates for the DISTANCE variables as compared to transactions of homes outside of five miles, and

ε is a random disturbance term.

Effectively, this model seeks to identify reasons that AARs vary among those sales pairs in the sample. Reasons for such differences in AARs might include variations in home and site characteristics, the study area in which the sale occurs, or the degree to which the home is in proximity to or has a dramatic view of a wind facility. As such, the model as shown by equation (11) has three primary groups of parameters: variables of interest; home, site, and sale characteristics; and study area fixed effects.

The variables of interest are VIEW and DISTANCE, and the coefficients β_3 and β_4 are therefore the primary focus of this analysis. Because of the small numbers of homes in the sample situated inside of 3000 feet and between 3000 feet and one mile, they are collapsed into a single category (inside one mile). For the same reason, homes with SUBSTANTIAL or EXTREME VIEWS are collapsed into a single category (SUBSTANTIAL/EXTREME). In this model, therefore, the influence on appreciation rates of the following variables of interest is estimated: MINOR, MODERATE, and SUBSTANTIAL/EXTREME VIEWS, and less than one mile, between one and three mile, and between three and five mile DISTANCES. For the VIEW fixed-effects variables, the reference category is NO VIEW; for DISTANCE, it is homes outside of five miles. As with previous models, if effects exist, it is expected that all of the coefficients would be negative and monotonically ordered.

The number of home, site, and sale characteristics included in a repeat sales model is typically substantially lower than in a hedonic model. This is to be expected because, as discussed earlier, the repeat sales model explores variations in AARs for sales pairs from individual homes, and home and site characteristics are relatively stable over time for any individual home. Nonetheless, various characteristics have been found by others (e.g., Kiel and McClain, 1995; McCluskey and Rausser, 2003) to affect appreciation rates. For the purposes of the Repeat Sales Model, these include the number of square feet of living space (SQFT_1000), the number of acres (ACRES), the inflation-adjusted price of the home at the first sale (SalePrice96_Pre), and that sales price squared (SalePrice96_Pre_Sqr). Of those characteristics, the SQFT_1000 and ACRES coefficients are expected to be positive indicating that, all else being equal, an increase in living area and lot size increases the relative appreciation rate. Conversely, it is expected that the combined estimated effect of the initial sales prices (SalePrice96_Pre and SalePrice96_Pre_Sqr) will trend downward, implying that as the initial sales price of the house increases the appreciation rate decreases. These expectations are in line with the previous literature (Kiel and McClain, 1995; McCluskey and Rausser, 2003).

Finally, the study-area fixed effects variables (β_1) are included in this model to account for differences in inflation adjusted appreciation rates that may exist across study areas (e.g., WAOR, TXHC, NYMC). The WAOR study area is the reference category, and all study-area coefficients therefore represent the marginal change in AARs compared to WAOR (the intercept represents the marginal change in AAR for WAOR by itself). These study area parameters provide a unique look into Area Stigma effects. Recall that the appreciation rates used in this model are adjusted for inflation by using an inflation index from the nearby municipal statistical area (MSA). These MSAs are sometimes quite far away (as much as 20 miles) and therefore would be unaffected by the wind facility. As such, any variation in the study area parameters (and the intercept) would be the result of local influences not otherwise captured in the inflation adjustment, and represent another test for Area Stigma; if effects exist, it is expected that the β_0 and β_1 coefficients will be negative.

As with the hedonic models presented earlier, the assumptions of homoskedasticity, absence of spatial autocorrelation, reasonably little multicollinearity, and appropriate controls for outliers are addressed as described in the associated footnote and in Appendix G.[93]

6.4. Analysis of Results

The results from the Repeat Sales Model are presented in Table 28. The model performs relatively poorly overall, with an Adjusted R^2 of just 0.19 (and an *F*-test statistic of 5.2). Other similar analyses in the literature have produced higher performance statistics but have done so with samples that are considerably larger or more homogenous than ours.[94] The low R^2 found here should not be cause for undue concern, however, given the relatively small sample spread across ten different study areas. Moreover, many of the home and site characteristics are found to be statistically significant, and of the appropriate sign. The coefficient for the adjusted initial sales price (SalePrice96_Pre), for example, is statistically significant, small, and negative (-0.000001, *p* value 0.00), while the coefficient for the adjusted initial sales price squared (SalePrice96_Pre_Sqr) is also statistically significant and considerably smaller (<0.000000, *p* value 0.00). These results imply, consistent with the prior literature, that for those homes in the sample, an increase in initial adjusted sales price decreases the average percentage appreciation rate. ACRES (0.002, *p* value 0.10) and SQFT_1000 (0.02, *p* value 0.00) are both positive, as expected, and statistically significant.

Of particular interest are the intercept term and the associated study-area fixed effect coefficients, and what they collectively say about Area Stigma. The coefficient for the intercept (β_0) is 0.005 (*p* value 0.81), which is both extremely small and not statistically significant. Likewise, the study-area fixed effects are all relatively small (less than 0.03 in absolute terms) and none are statistically significant. As discussed above, if a pervasive Area Stigma existed, it would be expected to be represented in these coefficients. Because all are small and statistically insignificant, it can again be concluded that there is no persuasive evidence of an Area Stigma among this sample of home transactions.

[93] All results are produced using White's corrected standard errors to control for heteroskedasticity. Spatial autocorrelation, with this small sample, is impossible to control. Because of the small sample, an even smaller number of neighboring sales exist, which are required to construct the spatial matrix. As such, spatial autocorrelation is not addressed in the repeat sales model. As with the hedonic models, some multicollinearity might exist, but that multicollinearity is unlikely to be correlated with the variables of interest. Outliers are investigated and dealt with as discussed in footnote 91 on page 56.

[94] McCluskey and Rausser (2003) had a sample of over 30,000 repeat sales and had an *F*-test statistic of 105; Kiel and McClain (1995) produced an R^2 that ranged from 0.40 to 0.63 with samples ranging from 53 to 145, but all sales took place in North Andover, MA.

Table 28: Results from Repeat Sales Model

	Coef.	SE	p Value	*n*
Intercept	0.005	0.02	0.81	354
WAOR	Omitted	Omitted	Omitted	6
TXHC	-0.01	0.02	0.63	57
OKCC	0.03	0.02	0.11	102
IABV	0.02	0.02	0.14	59
ILLC	-0.01	0.02	0.38	18
WIKCDC	0.02	0.03	0.50	8
PASC	-0.01	0.02	0.67	32
PAWC	0.02	0.02	0.16	35
NYMCOC	0.02	0.02	0.23	24
NYMC	0.03	0.02	0.13	13
SalePrice96_Pre	-0.000001	0.0000002	0.00	354
SalePrice96_Pre_Sqr	0.0000000	0.0000000	0.00	354
Acres	0.002	0.001	0.10	354
Sqft_1000	0.02	0.01	0.00	354
No View	Omitted	Omitted	Omitted	305
Minor View	-0.02	0.01	0.02	35
Moderate View	0.03	0.03	0.29	5
Substantial/Extreme View	-0.02	0.01	0.09	9
Less than 1 Mile	0.03	0.01	0.01	14
Between 1 and 3 Miles	0.01	0.01	0.59	199
Between 3 and 5 Miles	0.01	0.01	0.53	116
Outside 5 Miles	Omitted	Omitted	Omitted	25

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**11**
Dependent Variable	**SalePrice96_AAR**
Number of Cases	**354**
Number of Predictors (k)	**19**
F Statistic	**5.2**
Adjusted R2	**0.19**

Turning to the variables of interest, mixed results (see Figure 9 and Figure 10) are found. For homes with MINOR or SUBSTANTIAL/EXTREME VIEWS, despite small sample sizes, appreciation rates after adjusting for inflation are found to decrease by roughly 2% annually (*p* values of 0.02 and 0.09, respectively) compared to homes with NO VIEW. Though these findings initially seem to suggest the presence of Scenic Vista Stigma, the coefficients are not monotonically ordered, counter to what one might expect: homes with a MODERATE rated view appreciated on average 3% annually (*p* value 0.29) compared to homes with NO VIEW. Adding to the suspicion of these VIEW results, the DISTANCE coefficient for homes situated inside of one mile, where eight out of the nine SUBSTANTIAL/EXTREME rated homes are located, is positive and statistically significant (0.03, *p* value 0.01). If interpreted literally, these results suggest that a home inside of one mile with a SUBSTANTIAL/EXTREME rated view would experience a decrease in annual appreciation of 2% compared to homes with no views of turbines, but simultaneously would experience an increase of 3% in appreciation compared to homes outside of five miles. Therefore, when compared to those homes outside of five miles and with no view of the wind facilities, these homes would experience an overall increase in AAR by 1%. These results are counterintuitive and are likely driven by the small number of sales pairs that are located within one mile of the wind turbines and experience a dramatic view of those turbines.

Figure 9: Repeat Sales Model Results for VIEW

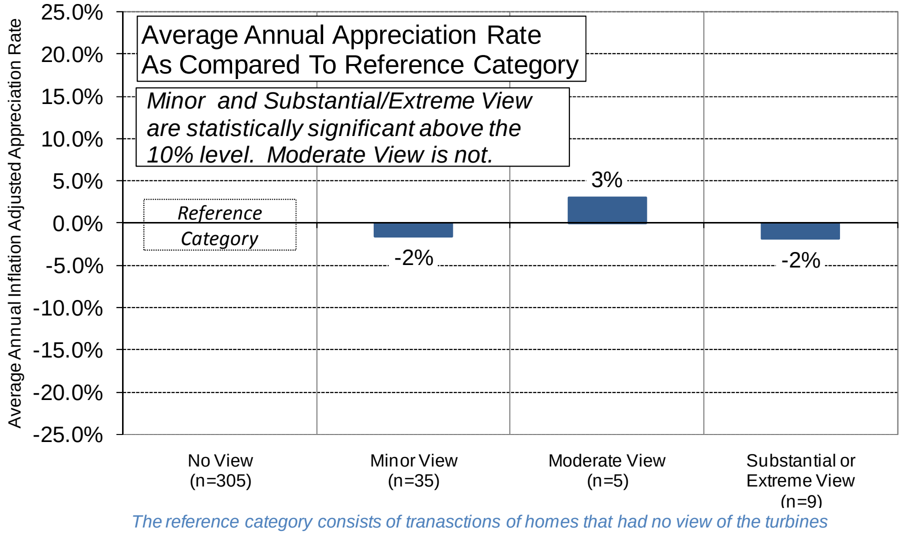
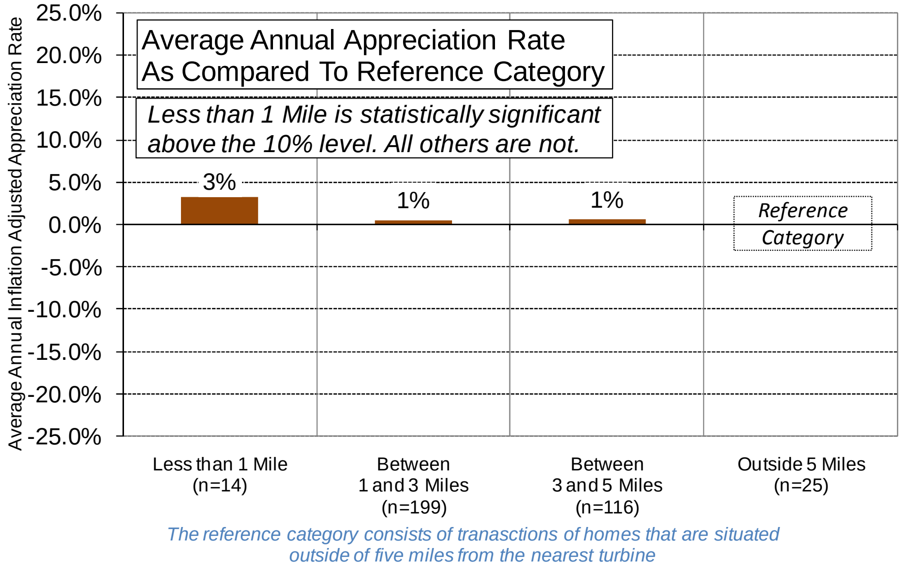


Figure 10: Repeat Sales Model Results for DISTANCE



Regardless of the reason for this result, again no persuasive evidence of consistent and widespread adverse effects is found from the presence of the wind facilities in the sample, reinforcing the findings from the previous hedonic analysis. Specifically, there is no evidence that an Area Stigma exists in that homes outside of one mile and inside of five miles do not appreciate differently than homes farther away. Similarly, there is no evidence of a Nuisance Stigma. Appreciation rates for homes inside of one mile are not adversely affected; in fact, significantly higher appreciation rates are found for these homes than for those homes located outside of five miles from the nearest wind facility. Finally, though some evidence is found that a Scenic Vista Stigma may exist in the sample of repeat sales, it is weak, fairly small, and somewhat counter-intuitive. This result is likely driven by the small number of sales pairs that are located within one mile of the wind turbines and that experience a dramatic view of those turbines.

7. Sales Volume Analysis

The analysis findings to this point suggest that, among the sample of sales transactions analyzed in this report, wind facilities have had no widespread and statistically identifiable impact on residential property values. A related concern that has not yet been addressed is that of sales volume: does the presence of wind facilities either increase or decrease the rate of home sales transactions? On the one hand, a decrease in sales volumes might be expected. This might occur if homeowners expect that their property values will be impacted by the presence of the wind facility, and therefore simply choose not to sell their homes as a result, or if they try to sell but are not easily able to find willing buyers. Alternatively, an increase in sales volume might be expected if homeowners that are located near to or have a dominating view of wind turbines are uncomfortable with the presence of those turbines. Though those homes may sell at a market value that is not impacted by the presence of the wind facilities, self-selection may lead to accelerated transaction volumes shortly after facility announcement or construction as homeowners who view the turbines unfavorably sell their homes to individuals who are not so stigmatized. To address the question of whether and how sales volumes are impacted by nearby wind facilities, sales volumes are analyzed for those homes located at various distances from the wind facilities in the sample, during different facility development periods.

7.1. Dataset

To investigate whether sales volumes are affected by the presence of wind facilities two sets of data are assembled: (1) the number of homes available to sell annually within each study area, and (2) the number of homes that actually did sell annually in those areas. Homes potentially "available to sell" are defined as all single family residences within five miles of the nearest turbine that are located on a parcel of land less than 25 acres in size, that have only one residential structure, and that had a market value (for land and improvements) above $10,000.[95] Homes that "did sell" are defined as every valid sale of a single family residence within five miles of the nearest turbine that are located on a parcel of land less than 25 acres in size, that have only one residential structure, and that sold for more than $10,000.

The sales data used for this analysis are slightly different from those used in the hedonic analysis reported earlier. As mentioned in Section 3.3, a number of study areas were randomly sampled to limit the transactions outside of 3 miles if the total number of transactions were to exceed that which could efficiently be visited in the field (*n* ~1,250). For the sales volume analysis, however, field data collection was not required, and all relevant transactions could therefore be used. Secondly, two study areas did not provide the data necessary for the sales volume analysis (WAOR and OKCC), and are therefore excluded from the sample. Finally, data for some homes that were "available to sell" were not complete, and rather than including only a small selection of these homes, these subsets of data were simply excluded from the analysis. These excluded homes include those located outside of five miles of the nearest wind turbine, and those available to sell or that did sell more than three years before wind facility announcement.[96] The resulting

[95] "Market value" is the estimated price at which a home would sell as of a given point in time.

[96] For instance, some providers supplied sales data out to ten miles, but only provided homes available to sell out to five miles. As well, data on homes that did sell were not consistently available for periods many years before announcement.

dataset spans the period starting three years prior to facility announcement and ending four years after construction. All homes in this dataset are situated inside of five miles, and each is located in one of the eight represented study areas.[97]

The final set of homes potentially "available to sell" and that actually "did sell" are then segmented into three distance categories: inside of one mile, between one and three miles, and between three and five miles. For each of these three distance categories, in each of the eight study areas, and for each of the three years prior to announcement, the period between announcement and construction, and each of the four years following construction, the number of homes that sold as a percentage of those available to sell is calculated.[98] This results in a total of 24 separate sales volume calculations in each study area, for a total of 192 calculations across all study areas. Finally, these sales volumes are averaged across all study areas into four development period categories: less than three years before announcement, after announcement but before construction, less than two years after construction, and between two and four years after construction.[99] The resulting average annual sales volumes, by distance band and development period, are shown in Table 29 and Figure 11.

Table 29: Sales Volumes by PERIOD and DISTANCE

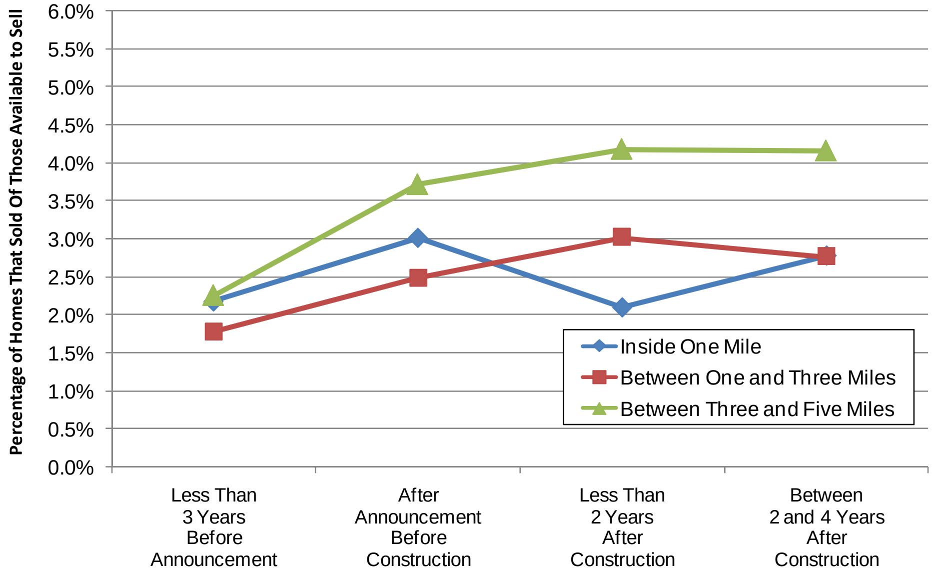
	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	2.2%	1.8%	2.3%
After Announcement Before Construction	3.0%	2.5%	3.7%
Less Than 2 Years After Construction	2.1%	3.0%	4.2%
Between 2 and 4 Years After Construction	2.8%	2.8%	4.2%

[97] The number of homes "available to sell" is constructed for each year after 1996 based on the year the homes in each study area were built. For many homes in the sample, the year built occurred more than three years before wind facility announcement, and therefore those homes are "available to sell" in all subsequent periods. For some homes, however, the home was built during the wind facility development process, and therefore becomes "available" some time after the first period of interest. For those homes, the build year is matched to the development dates so that it becomes "available" during the appropriate period. For this reason, the number of homes "available to sell" increases in later periods.

[98] For the period after announcement and before construction, which in all study areas was not exactly 12 months, the sales volume numbers are adjusted so that they corresponded to an average over a 12 month period.

[99] These temporal groupings are slightly different from those used in the hedonic Temporal Aspects Model. Namely, the period before announcement is not divided into two parts – more than two years before announcement and less than two years before announcement – but rather only one – less than three years before announcement. This simplification is made to allow each of the interaction categories to have enough data to be meaningful.

Figure 11: Sales Volumes by PERIOD and DISTANCE



7.2. Model Form

To investigate whether the rate of sales transactions is measurably affected by the wind facilities, the various resulting sales volumes shown above in Table 29 and Figure 11 are compared using a *t*-Test, as follows:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \tag{12}$$

where

$\bar{x}_1$ and $\bar{x}_2$ are the mean sales volumes from the two categories being compared,

s_1^2 and s_2^2 are variances of the sales volumes from the two categories being compared, and

n_1 and n_2 are numbers of representative volumes in the two categories.[100]

The degrees of freedom used to calculate the *p*-value of the *t* statistic equals the lower of $(n_1 - 1)$ or $(n_2 - 1)$.

Three sets of *t*-Tests are conducted. First, to test whether sales volumes have changed with time and are correlated with wind facility construction, the volumes for each DISTANCE group in later periods (x_1) are compared to the volume in that same group in the pre-announcement period (x_2). Second, to test whether sales volumes are impacted by distance to the nearest wind turbine, the volumes for each PERIOD group at distances closer to the turbines (x_1) are compared to the volume in that same group in the three to five mile distance band (x_2). Finally, for reasons that will become obvious later, the sales volumes for each PERIOD group at distances within one

[100] The number of representative volumes could differ between the two categories. For instance, the “less than three years before announcement” category represents three years – and therefore three volumes – for each study area for each distance band, while the “less than two years after construction” category represents two years – and therefore two volumes – for each study area for each distance band.

mile and outside of three miles of the turbines (x_1) are compared to the sales volume in that same group in the one to three mile distance band (x_2). These three tests help to evaluate whether sales volumes are significantly different after wind facilities are announced and constructed, and whether sales volumes near the turbines are affected differently than for those homes located farther away.[101]

7.3. Analysis of Results

Table 29 and Figure 11 above show the sales volumes in each PERIOD and DISTANCE category, and can be interpreted as the percentage of homes that are available to sell that did sell in each category, on an annual average basis. The sales volume between one and three miles and before facility announcement is the lowest, at 1.8%, whereas the sales volumes for homes located between three and five miles in both periods following construction are the highest, at 4.2%.

The difference between these two sales volumes can be explained, in part, by two distinct trends that are immediately noticeable from the data presented in Figure 11. First, sales volumes in all periods are highest for those homes located in the three to five mile distance band. Second, sales volumes at virtually all distances are higher after wind facility announcement than they were before announcement.[102]

To test whether these apparent trends are borne out statistically the three sets of *t*-Tests described earlier are performed, the results of which are shown in Table 30, Table 31, and Table 32. In each table, the difference between the subject volume (x_1) and the reference volume (x_2) is listed first, followed by the *t* statistic, and whether the statistic is significant at or above the 90% level ("*").

Table 30 shows that mean sales volumes in the post-announcement periods are consistently greater than those in the pre-announcement period, and that those differences are statistically significant in four out of the nine categories. For example, the post-construction sales volumes for homes in the three to five mile distance band in the period less than two years after construction (4.2%) and between three and four years after construction (4.2%) are significantly greater than the pre-announcement volume of 2.3% (1.9%, t = 2.40; 1.9%, t = 2.31). Similarly, the post-construction sales volumes between one and three miles are significantly greater than the pre-announcement volume. These statistically significant differences, it should be noted, could be as much related to the low reference volume (i.e., sales volume in the period less than

[101] An alternative method to this model would be to pool the homes that "did sell" with the homes "available to sell" and construct a Discrete Choice Model where the dependent variable is zero (for "no sale") or one (for "sale") and the independent variables would include various home characteristics and the categorical distance variables. This would allow one to estimate the probability that a home sells dependent on distance from the wind facility. Because home characteristics data for the homes "available to sell," was not systematically collected it was not possible to apply this method to the dataset.

[102] It is not entirely clear why these trends exist. Volumes may be influenced upward in areas farther from the wind turbines, where homes, in general, might be more densely sited and homogenous, both of which might be correlated with greater home sales transactions. The converse might be true in more rural areas, nearer the wind turbines, where homes may be more unique or homeowners less prone to move. The increasing sales volumes seen in periods following construction, across all distance bands, may be driven by the housing bubble, when more transactions were occurring in general.

three years before announcement), as they are to the sales volumes to which the reference category is compared. Finally, when comparing post-construction volumes inside of a mile, none are statistically different than the 2.2% pre-announcement level.

Table 30: Equality Test of Sales Volumes between PERIODS

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	Reference	Reference	Reference
After Announcement Before Construction	0.8% (0.72)	0.7% (0.99)	1.5% (1.49)
Less Than 2 Years After Construction	-0.1% (-0.09)	1.2% (2.45) *	1.9% (2.4) *
Between 2 and 4 Years After Construction	0.6% (0.54)	1% (2.24) *	1.9% (2.31) *

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Turning to sales volumes in the same development period but between the different distance bands, consistent but less statistically significant results are uncovered (see Table 31). Although all sales volumes inside of three miles, for each period, are less than their peers outside of three miles, those differences are statistically significant in only two out of eight instances. Potentially more important, when one compares the sales volumes inside of one mile to those between one and three miles (see Table 32), small differences are found, none of which are statistically significant. In fact, on average, the sales volumes for homes inside of one mile are greater or equal to the volumes of those homes located between one and three miles in two of the three post-announcement periods. Finally, it should be noted that the volumes for the inside one mile band, in the period immediately following construction, are less than those in the one to three mile band in the same period. Although not statistically significant, this difference might imply an initial slowing of sales activity that, in later periods, returns to more normal levels. This possibility is worth investigating further and is therefore recommended for future research.

Table 31: Equality Test of Volumes between DISTANCES using 3-5 Mile Reference

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	-0.1% (-0.09)	-0.5% (-0.88)	Reference
After Announcement Before Construction	-0.7% (-0.56)	-1.2% (-1.13)	Reference
Less Than 2 Years After Construction	-2.1% (-2.41) *	-1.2% (-1.48)	Reference
Between 2 and 4 Years After Construction	-1.4% (-1.27)	-1.4% (-1.82) *	Reference

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Table 32: Equality Test of Sales Volumes between DISTANCES using 1-3 Mile Reference

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	0.4% (0.49)	Reference	0.5% (0.88)
After Announcement Before Construction	0.5% (0.47)	Reference	1.2% (1.13)
Less Than 2 Years After Construction	-0.9% (-1.38)	Reference	1.2% (1.48)
Between 2 and 4 Years After Construction	0% (0.01)	Reference	1.4% (1.82) *

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Taken together, these results suggest that sales volumes are not conclusively affected by the announcement and presence of the wind facilities analyzed in this report. At least among this sample, sales volumes increased in all distance bands after the announcement and construction of the wind facilities. If this result was driven by the presence of the wind facilities, however, one would expect that such impacts would be particularly severe for those homes in close proximity to wind facilities. In other words, sales volumes would be the most affected inside of one mile, where views of the turbines are more frequent and where other potential nuisances are more noticeable than in areas farther away. This is not borne out in the data - no statistically significant differences are found for sales volumes inside of one mile as compared to those between one and three miles, and sales volumes outside of three miles are higher still. Therefore, on the whole, this analysis is unable to find persuasive evidence that wind facilities have a widespread and identifiable impact on overall residential sales volumes. It is again concluded that neither Area nor Nuisance Stigma are in evidence in this analysis.

8. Wind Projects and Property Values: Summary of Key Results

This report has extensively investigated the potential impacts of wind power facilities on the value (i.e., 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 projects on property values have been identified and analyzed: Area Stigma, Scenic Vista Stigma, and Nuisance Stigma. To assess these potential impacts, a primary (Base) hedonic model has been applied, seven alternative hedonic models have been explored, a repeat sales analysis has been conducted, and possible impacts on sales volumes have been evaluated. Table 33 outlines the resulting ten tests conducted in this report, identifies which of the three potential stigmas those tests were designed to investigate, and summarizes the results of those investigations. This section synthesizes these key results, organized around the three potential stigmas.

Table 33: Impact of Wind Projects on Property Values: Summary of Key Results

	Is there statistical evidence of:			
Statistical Model	**Area Stigma?**	**Scenic Vista Stigma?**	**Nuisance Stigma?**	**Section Reference**
Base Model	No	No	No	*Section 4*
View Stability	Not tested	No	Not tested	*Section 5.1*
Distance Stability	No	Not tested	No	*Section 5.1*
Continuous Distance	No	No	No	*Section 5.2*
All Sales	No	No	Limited	*Section 5.3*
Temporal Aspects	No	No	No	*Section 5.4*
Orientation	No	No	No	*Section 5.5*
Overlap	No	Limited	No	*Section 5.6*
Repeat Sales	No	Limited	No	*Section 6*
Sales Volume	No	Not tested	No	*Section 7*

"No"…………………. *No statistical evidence of a negative impact*
"Yes"………………… *Strong statistical evidence of a negative impact*
"Limited"…………… *Limited and inconsistent statistical evidence of a negative impact*
"Not tested"………… *This model did not test for this stigma*

8.1. 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 would be affected.

As summarized in Table 33, Area Stigma is investigated with the Base, Distance Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, and Overlap hedonic models. It is also tested, somewhat differently, with the Repeat Sales and Sales Volume analyses. In each case, if an Area Stigma exists, it is expected that the sales prices (and/or sales volume) of homes located near wind facilities would be broadly affected by the presence of those facilities, with effects decreasing with distance.

The Base Model finds little evidence of an Area Stigma, as the coefficients for the DISTANCE variables are all relatively small and none are statistically different from zero. For homes in this sample, at least, there is no statistical evidence from the Base Model that the distance from a home to the nearest wind turbine impacts sales prices, regardless of the distance band. Perhaps a more direct test of Area Stigma, however, comes from the Temporal Aspects Model. In this model, homes in all distance bands that sold after wind facility announcement are found to sell, on average, for prices that are not statistically different from those for homes that sold more than two years prior to wind facility announcement. Again, no persuasive evidence of an Area Stigma is evident.

The Repeat Sales and Sales Volume Models also investigate Area Stigma. The Repeat Sales Model's 354 homes, each of which sold once before facility announcement and again after construction, show average inflation-adjusted annual appreciation rates that are small and not statistically different from zero. If homes in all study areas were subject to an Area Stigma, one would expect a negative and statistically significant intercept term. Similarly, if homes in any individual study area experienced an Area Stigma, the fixed effect terms would be negative and statistically significant. Neither of these expectations is borne out in the results. The Sales Volume Model tells a similar story, finding that the rate of residential transactions is either not significantly different between the pre- and post-announcement periods, or is greater in later periods, implying, in concert with the other tests, that increased levels of transactions do not signify a rush to sell, and therefore lower prices, but rather an increase in the level of transactions with no appreciable difference in the value of those homes.

The All Sales, Distance Stability, Continuous Distance, Orientation, and Overlap Models corroborate these basic findings. In the All Sales and Distance Stability Models, for example, the DISTANCE coefficients for homes that sold outside of one mile but within five miles, compared to those that sold outside of five miles, are very similar: they differ by no more than 2%, and this small disparity is not statistically different from zero. The same basic findings resulted from the Orientation and Overlap Models. Further, homes with No View as estimated in the All Sales Model 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); an Area Stigma effect should be reflected as a negative coefficient for this parameter. Finally, despite using all 4,937 cases in a single distance variable and therefore having a correspondingly small standard error, the Continuous Distance Model discovers no measurable relationship between distance from the nearest turbine and the value of residential properties.

Taken together, the results from these models are strikingly similar: there is no evidence of a widespread and statistically significant Area Stigma among the homes in this sample. Homes in these study areas are not, on average, demonstrably and measurably stigmatized by the arrival of a wind facility, regardless of when they sold in the wind project development process and regardless of whether those homes are located one mile or five miles away from the nearest wind facility.

Drawing from the previous literature on environmental disamenities discussed in Section 2.1, one likely explanation for this result is simply that any effects that might exist may have faded to a level indistinguishable from zero at distances outside of a mile from the wind facilities. For other disamenities, some of which would seemingly be more likely to raise concerns, effects have been found to fade quickly with distance. For example, property value effects near a chemical plant have been found to 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). Further, homes outside of 300 feet (Hamilton and Schwann, 1995) or even as little as 150 feet (Des-Rosiers, 2002) from a high voltage transmission line have been found to be unaffected. A second possible explanation for these results could be related to the view of the turbines. In the sample used for this analysis, a large majority of the homes outside of one mile (n = 4,812) that sold after wind-facility construction commenced cannot see the turbines (n = 4,189, 87%), and a considerably larger portion have – at worst – a minor view of the turbines (n = 4,712, 98%). Others have found that the sales prices for homes situated at similar distances from a disamenity (e.g., HVTL) depend, in part, on the , view of that disamenity (Des-Rosiers, 2002). Similarly, research has sometimes found that annoyance with a wind facility decreases when the turbines cannot be seen (Pedersen and Waye, 2004). Therefore, for the overwhelming majority of homes outside of a mile that have either a minor rated view or no view at all of the turbines, the turbines may simply be out of sight, and therefore, out of mind.

8.2. Scenic Vista Stigma

Scenic Vista Stigma is defined as 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. It has as its basis an admission that home values are, to some degree, derived from the quality of what can be seen from the property and that if those vistas are altered, sales prices might be measurably affected. The Base, View Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, Overlap, and Repeat Sales Models each test whether Scenic Vista Stigma is present in the sample.

The Base Model, as well as subsequent Alternative Hedonic Models, demonstrates persuasively that the quality of the scenic vista – absent wind turbines – impacts sales prices. Specifically, compared to homes with an AVERAGE VISTA, those having a POOR or a BELOW AVERAGE rating are estimated to sell for 21% (p value 0.00) and 8% (p value 0.00) less, on average. Similarly, homes with an ABOVE AVERAGE or PREMIUM rating are estimated to sell for 10% (p value 0.00) and 13% (p value 0.00) more than homes with an AVERAGE vista rating. Along the same lines, homes in the sample with water frontage or situated on a cul-de-sac sell for 33% (p value 0.00) and 10% (p value 0.00) more, on average, than those homes that lack these characteristics. 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 report are able to clearly identify those impacts.[103]

[103] 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.

Despite this finding, those same hedonic models are unable to identify a consistent and statistically significant Scenic Vista Stigma associated with wind facilities. Home buyers and sellers, at least among this sample, do not appear to be affected in a measurable way by the visual presence of wind facilities. Regardless of which model was estimated, the value of homes with views of turbines that were rated MODERATE, SUBSTANTIAL, or EXTREME are found to be statistically indistinguishable from the prices of homes with no view of the turbines. 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 measurably different property values, and neither are the 31 homes with a SUBSTANTIAL view, where "the turbines are dramatically visible from the home."[104] The same finding holds for the 106 homes that were rated as having MODERATE views of the wind turbines. Moreover, the Orientation and Overlap Models show that neither the orientation of the home with respect to the view of wind turbines, nor the overlap of that view with the prominent scenic vista, have measurable impacts on home prices.

The All Sales Model compares homes with views of the turbines (in the post-construction period) to homes that sold before construction (when no views were possible), and finds no statistical evidence of adverse effects within any VIEW category. Moreover, when a *t*-Test is performed to compare the NO VIEW coefficient to the others, none of the coefficients for the VIEW ratings are found to be statistically different from the NO VIEW homes. The Repeat Sales Model comes to a similar result, with homes with MODERATE views appreciating at a rate that was not measurably different from that of homes with no views (0.03, *p* value 0.29). The same model also finds that homes with SUBSTANTIAL/EXTREME views appreciate at a rate 2% slower per year (*p* value 0.09) than their NO VIEW peers. Homes situated inside of one mile, however, are found to appreciate at a rate 3% more (*p* value 0.01) than reference homes located outside of five miles. Eight of the nine homes situated inside of one mile had either a SUBSTANTIAL or EXTREME view. Therefore, to correctly interpret these results, one would add the two coefficients for these homes, resulting in a combined 1% increase in appreciation as compared to the reference homes situated outside of five miles with no view of turbines, and again yielding no evidence of a Scenic Vista Stigma.

Although these results are consistent across most of the models, there are some individual coefficients from some models that differ. Specifically, homes with MINOR rated views in the Overlap and Repeat Sales Models are estimated to sell for 3% less (*p* value 0.10) and appreciate at a rate 2% less (*p* value 0.02) than NO VIEW homes. Taken at face value, these MINOR VIEW findings imply that homes where "turbines are visible, but, either the scope is narrow, there are many obstructions, or the distance between the home and the facility is large" are systematically impacted in a modest but measurable way. Homes with more dramatic views of a wind facility in the same models, on the other hand, are found to not be measurably affected. Because of the counterintuitive nature of this result, and because it is contradicted in the results of other models presented earlier, it is more likely that there is some aspect of these homes that was not modeled appropriately in the Overlap and Repeat Sales Models, and that the analysis is picking up the effect of omitted variable(s) rather than a systematic causal effect from the wind facilities.

---

[104] See Section 3.2.3 and Appendix C for full description of VIEW ratings.

Taken together, the results from all of the models and all of the VIEW ratings support, to a large degree, the Base Model findings of no evidence of a Scenic Vista Stigma. Although there are 160 residential transactions in the sample with more dramatic views than MINOR, none of the model specifications is able to find any evidence that those views of wind turbines measurably impacted average sales prices, despite the fact that those same models consistently find that home buyers and sellers place value on the quality of the scenic vista.

8.3. Nuisance Stigma

Nuisance Stigma is defined as a concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values. If these factors impact residential sales prices, those impacts are likely to be concentrated within a mile of the wind facilities. The Base, Distance Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, Overlap, Repeat Sales, and Sales Volume Models all investigate the possible presence of a Nuisance Stigma.

The Base Model 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, but that these differences are not statistically significant (*p* values of 0.40 and 0.30, respectively). These results remain unchanged in the Distance Stability Model, as well as in the Orientation and Overlap Models. Somewhat similarly, in the All Sales Model, when all transactions occurring after wind facility announcement are assumed to potentially be impacted (rather than just those occurring after construction, as in the Base Model), and a comparison is made to the average of all transactions occurring pre-announcement (rather than the average of all transactions outside of five miles, as in the Base Model), these same coefficients grow to -6% (*p* value 0.23) and -8% (*p* value 0.08) respectively. Although only one of these coefficients was statistically significant, they are large enough to warrant further scrutiny.

The Temporal Aspects Model provides a clearer picture of these findings. It finds that homes that sold prior to wind facility announcement and that were situated within one mile of where the turbines were eventually located sold, on average, for between 10% and 13% less than homes located more than five miles away and that sold in the same period. Therefore, the homes nearest the wind facility's eventual location were already depressed in value before the announcement of the facility. Most telling, however, is what occurred after construction. Homes inside of one mile are found to have inflation-adjusted sales prices that were either statistically undistinguishable from, or in some cases greater than, pre-announcement levels. Homes sold in the first two years after construction, for example, have higher prices (0.07, *p* value 0.32), as do those homes that sold between two and four years after construction (0.13, *p* value 0.06) and more than four years after construction (0.08, *p* value 0.24). In other words, there is no indication that these homes experienced a decrease in sales prices after wind facility construction began. Not only does this result fail to support the existence of a Nuisance Stigma, but it also indicates that the relatively large negative coefficients estimated in the Base and All Sales Models are likely caused by conditions that existed prior to wind facility construction and potentially prior to facility announcement.[105]

---

[105] See footnote 82 on page 46 for a discussion of possible alternative explanations to this scenario.

These results are corroborated by the Continuous Distance Model, which finds no statistically significant relationship between an inverse DISTANCE function and sales prices (-0.01, sig 0.46). Similarly, in the Repeat Sales Model, homes within one mile of the nearest turbine are not found to be adversely affected; somewhat counter-intuitively, they are found to appreciate faster (0.03, *p* value 0.01) than their peers outside of five miles. Finally, the Sales Volume analysis does not find significant and consistent results that would suggest that the ability to sell one's home within one mile of a wind facility is substantially impacted by the presence of that facility.

Taken together, these models present a consistent set of results: the sales prices of homes in this sample that are within a mile of wind turbines, where various nuisance effects have been posited, are not measurably affected compared to those homes that are located more than five miles away from the facilities or that sold well before the wind projects were announced. These results imply that widespread Nuisance Stigma effects are either not present in the sample, or are too small or sporadic to be statistically identifiable.

Though these results 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. As discussed earlier, studies of the property value impacts of high voltage transmission lines often find that effects fade towards zero at as little distance as 200 feet (see, e.g., Gallimore and Jayne, 1999; Watson, 2005). None of the homes in the present sample are 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 simply not noticeable outside of 800 feet. Additionally, almost half of the homes in the sample that are located within a mile of the nearest turbine have either no view or a minor rated view of the wind facilities, and some high voltage transmission line (HVTL) studies have found a decrease in adverse effects if the towers are <u>not</u> visible (Des-Rosiers, 2002) and, similarly, decreases in annoyance with wind facility sounds if turbines cannot be seen (Pedersen and Waye, 2004). 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, while studies of HVTLs have repeatedly found that effects fade over time (Kroll and Priestley, 1992) and studies of attitudes towards wind turbines have found that such attitudes often improve after facility construction (Wolsink, 1989). Regardless of the explanation, the fact remains that, in this sizable sample of residential transactions, no persuasive evidence of a widespread Nuisance Stigma is found, and if these impacts do exist, they are either too small or too infrequent to result in any widespread and consistent statistically observable impact.

9. Conclusions

Though surveys generally show that public acceptance towards wind energy is high, a variety of concerns with wind development are often expressed at the local level. One such concern that is often raised in local siting and permitting processes is related to the potential impact of wind projects on the property values of nearby residences.

This report has investigated the potential impacts of wind power facilities on the sales prices of residential properties that are in proximity to and/or that have a view of those wind facilities. It builds and improve on the previous literature that has investigated these potential effects by collecting a large quantity of residential transaction data from communities surrounding a wide variety of wind power facilities, spread across multiple parts of the U.S. Each of the homes included in this analysis was visited to clearly determine the degree to which the wind facility was visible at the time of home sale and to collect other essential data. To frame the analysis, three potentially distinct impacts of wind facilities on property values are considered: Area, Scenic Vista, and Nuisance Stigma. To assess these potential impacts, the authors applied a base hedonic model, explored seven alternative hedonic models, conducted a repeat sales analysis, and evaluated possible impacts on sales volumes. The result is the most comprehensive and data-rich analysis to date on the potential impacts of wind projects on nearby property values.

Although each of the analysis techniques used in this report has strengths and weaknesses, the results are strongly consistent in that each model fails to uncover conclusive evidence of the presence of any of the three property value stigmas. Based on the data and analysis presented in this report, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual or small numbers of homes have been or could be negatively impacted, if these impacts do exist, they are either too small and/or too infrequent to result in any widespread and consistent statistically observable impact. Moreover, to the degree that homes in the present sample are similar to homes in other areas where wind development is occurring, the results herein are expected to be transferable.

Finally, although this work builds on the existing literature in a number of respects, there remain a number of areas for further research. The primary goal of subsequent research should be to concentrate on those homes located closest to wind facilities, where the least amount of data are available. Additional research of the nature reported in this paper could be pursued, but with a greater number of transactions, especially for homes particularly close to wind facilities. Further, it is conceivable that cumulative impacts might exist whereby communities that have seen repetitive development are affected uniquely, and these cumulative effects may be worth investigating. A more detailed analysis of sales volume impacts may also be fruitful, as would an assessment of the potential impact of wind facilities on the length of time homes are on the market in advance of an eventual sale. Finally, it would be useful to conduct a survey of those homeowners living close to existing wind facilities, and especially those residents who have bought and sold homes in proximity to wind facilities after facility construction, to assess their opinions on the impacts of wind project development on their home purchase and sales decisions.

References

American Wind Energy Association (AWEA) (2008) Wind Energy Siting Handbook. American Wind Energy Association, Washington, DC. February, 2008. 183 pages.

Bateman, I., Day, B. and Lake, I. (2001) The Effect of Road Traffic on Residential Property Values: A Literature Review and Hedonic Pricing Study. Prepared for Scottish Executive and The Stationary Office, Edinburgh, Scotland. January, 2001. 207 pages.

BBC Research & Consulting (BBC R&C) (2005) Wind Power Facility Siting Case Studies: Community Response. BBC Research & Consulting. Prepared for National Wind Coordinating Committee, c/o RESOLVE, Washington, DC. June, 2005. 51 pages.

Beck, D. (2004) How Hull Wind "I" Impacted Property Values in Pemberton. Letter sent to C. McCabe. July 28, 2004.

Benson, E. D., Hansen, J. L. and Aurthur L. Schwartz, J. (2000) Water Views and Residential Property Values. *The Appraisal Journal.* 68(3): 260-270.

Bishop, I. (2002) Determination of Thresholds of Visual Impact: The Case of Wind Turbines. *Environment and Planning B: Planning and Design.* 29: 707-718.

Bond, S. (2008) Attitudes Towards the Development of Wind Farms in Australia. *Journal of Environmental Health Australia.* 8(3): 19-32.

Bond, S. and Wang, K. K. (2007) The Impact of Cell Phone Towers on House Prices in Residential Neighborhoods. *The Appraisal Journal.* 75(4): 362-370.

Bourassa, S. C., Hoesli, M. and Sun, J. (2004) What's in a View? *Environment and Planning.* 36(8): 1427-1450.

Boyle, M. A. and Kiel, K. A. (2001) A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities. *Journal of Real Estate Research.* 9(2): 117-144.

Buhyoff, G. J., Miller, P. A., Roach, J. W., Zhou, D. and Fuller, L. G. (1994) An AI Methodology for Landscape Visual Assessments. *AI Applications.* 8(1): 1-13.

Carroll, T. M., Clauretie, T. M., Jensen, J. and Waddoups, M. (1996) The Economic Impact of a Transient Hazard on Property Values: The 1988 PEPCON Explosion in Henderson, Nevada. *Journal of Real Estate Finance and Economics.* 13(2): 143-167.

Case, B., Clapp, J., Dubin, R. and Rodriguez, M. (2004) Modeling Spatial and Temporal House Price Patterns: A Comparison of Four Models. *The Journal of Real Estate Finance and Economics.* 29(2): 167-191.

Clark, D. E. and Allison, T. (1999) Spent Nuclear Fuel and Residential Property Values: The Influence of Proximity, Visual Cues and Public Information. *Papers in Regional Science.* 78(4): 403-421.

Crone, T. M. and Voith, R. P. (1992) Estimating House Price Appreciation: A Comparison of Methods. *Journal of Housing Economics.* 2(4): 324-338.

Dale, L., Murdoch, J. C., Thayer, M. A. and Waddell, P. A. (1999) Do Property Values Rebound from Environmental Stigmas? Evidence from Dallas. *Land Economics.* 75(2): 311-326.

Dale Rankin et al. v. FPL Energy LLC et al. (Dale Rankin v. FPL) (2008). 42nd District Court - Taylor County TX. August 21, 2008. 11-07-00074-CV.

Daniel, T. C. and Boster, R. S. (1976) Measuring Landscape Aesthetics: The Scenic Beauty Estimation Method. Forest Service - Rocky Mountian Forest and Range Experiment Station in Fort Collins Colorado. Prepared for U.S. Department of Agriculture, Washington, D.C. 66 pages.

Davis, L. W. (2008) The Effect Of Power Plants On Local Housing Values And Rents: Evidence From Restricted Census Microdata. Prepared for Center for Energy and Environmental Policy Research (CEEPR), Cambridge, MA. June 18, 2008. 34 pages. 08-009.

DeLacy, B. (2005) Technical Memorandum: Impacts of The Kittitas Valley Wind Power Project on Local Property Values. Cushman & Wakefield of Oregon. Prepared for Sagebrush Power Partners, LLC. December 29, 2005. 15 pages. File Number 06-34001-9012.

Des-Rosiers, F. (2002) Power Lines, Visual Encumbrance and House Values: A Microspatial Approach to Impact Measurement. *Journal of Real Estate Research.* 23(3): 275-301.

Devine-Wright, P. (2004) Beyond NIMBYism: Towards an Integrated Framework for Understanding Public Perceptions of Wind Energy. *Wind Energy.* 8(2): 125 - 139.

Dubin, R. A. (1998) Spatial Autocorrelation: A Primer. *Journal of Housing Economics.* 7(4): 304 -327.

Durbin, J. and Watson, G. S. (1951) Testing for Serial Correlation in Least-Squares Regression. *Biometrika.* 38(1-2): 159-178.

Espey, M., Fakhruddin, F., Gering, L. R. and Lin, H. (2007) Living on the Edge: Residential Property Values in the Urban-Rural Interface. *Journal of Agricultural and Applied Economics.* 39(3): 689-699.

Exeter-Enterprises-Ltd. (1993) Attitudes to Wind Power: A Survey of Opinion in Cornwall and Devon. Prepared for Department of Trade and Industry as Cited in Devine-Wright (2004). ETSU Report W/13/00354/038/REP.

Farber, S. (1998) Undesirable Facilities and Property Values: A Summary of Empirical Studies. *Ecological Economics.* 24(1): 1-14.

Firestone, J. and Kempton, W. (2006) Public Opinion about Large Offshore Wind Power: Underlying Factors. *Energy Policy.* 35(3): 1584-1598.

Firestone, J., Kempton, W. and Krueger, A. (2007) Delaware Opinion on Offshore Wind Power - Interim Report. University of Delaware College of Marine and Earth Studies, Newark, DE. January, 2007. 16 pages.

Freeman, A. M. (1979) Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues. *Scandinavian Journal of Economics.* 81(2): 154-173.

Gallimore, P. and Jayne, M. R. (1999) Public and Professional Perceptions of HVOTL Risks: The Problem of Circularity. *Journal of Property Research.* 16(3): 243-255. Cited by Elliott and Wadley, 2002.

Gipe, P. (2002) Design as if People Matter: Aesthetic Guidelines for a Wind Power Future. Section in Wind Power in View: Energy Landscapes in a Crowded World. Academic Press. Davis, CA. pp. 173-212 of 234 pages. ISBN 0-12-546334-0.

Global Wind Energy Council (GWEC) (2008) Global Wind Energy Outlook. Global Wind Energy Council, Brussels, Belgium, and Greenpeace, Amsterdam, The Netherlands. October, 2008. 60 pages.

Global Wind Energy Council (GWEC) (2009) Global Wind 2008 Report. Global Wind Energy Council, Brussels, Belgium, and Greenpeace, Amsterdam, The Netherlands. 60 pages.

Goldberger, A. S. (1991) A Course in Econometrics. Harvard University Press. Cambridge, MA. 178 pages.

Goldman, J. C. (2006) A Study in the Impact of Windmills on Property Values in Tucker County, West Virginia for the Proposed Beech Ridge Energy, L.L.C. project in Greenbrier County, West Virginia. Goldman Associates Inc. Prepared for Spilman Thomas & Battle, P.L.L.C., Charleston, WV. April, 2006. 51 pages. West Virginia Case No. 05-1590-E-CS.

Grover, D. S. (2002) Economic Impacts of Wind Power in Kittitas County, WA. ECONorthwest. Prepared for Phoenix Economic Development Group, Ellensburg, WA. November, 2002. 18 pages.

Gujarati, D. N. (2003) Basic Econometrics: Fourth Edition. McGraw-Hill/Irwin. New York, NY. 1002 pages. ISBN 0-07-233542-4.

Hamilton, S. and Schwann, G. (1995) Do High Voltage Electric Transmission Lines Affect Property Value? *Land Economics.* 71(4): 436-444.

Haughton, J., Giuffre, D., Barrett, J. and Tuerck, D. G. (2004) An Economic Analysis of a Wind Farm in Nantucket Sound. Beacon Hill Institute at Suffolk University, Boston, MA. May, 2004. 83 pages.

Hoen, B. (2006) Impacts of Windfarm Visibility on Property Values in Madison County, New York. Thesis Prepared for Masters Degree in Environmental Policy. Bard College, Annandale-On-Hudson, NY. April, 2006. 73 pages.

Jackson, T. O. (2001) The Effects of Environmental Contamination on Real Estate: A Literature Review. *Journal of Real Estate Research.* 9(2): 93-116.

Jackson, T. O. (2003) Methods and Techniques for Contaminated Property Valuation. *The Appraisal Journal.* 71(4): 311-320.

Jackson, T. O. (2005) Evaluating Environmental Stigma with Multiple Regression Analysis. *The Appraisal Journal.* 73(4): 363-369.

Jerabek, J. (2001) Property Values and their Relationship to the Town of Lincoln's Wind Turbine Projects. Letter sent to R. Bingen. January 30, 2001.

Jerabek, J. (2002) Property Values Respective to Wind Turbine Locations. Letter sent to Township of Lincoln Wind Turbine Moratorium Study Committee. January 29, 2002.

Jordal-Jorgensen, J. (1996) Visual Effect and Noise from Windmills - Quantifying and Valuation. Social Assessment of Wind Power in Denmark. J. Munksgaard and A. Larsen. Prepared for The Institute of Local Government Studies (AKF), Copenhagen, Denmark. April 1996.

Khatri, M. (2004) RICS Wind Farm Research: Impact of Wind Farms on the Value of Residential Property and Agricultural Land. Prepared for Royal Institute of Chartered Surveyors, London, UK. November 3, 2004. 11 pages.

Kiel, K. A. and McClain, K. T. (1995) The Effect Of An Incinerator Siting On Housing Appreciation Rates. *Journal of Urban Economics.* 37(3): 311-323.

Kielisch, K. (2009) Wind Turbine Impact Study: Dodge and Fond Du Lac Counties, WI. Appraisal Group One. Prepared for Calumet County Citizens for Responsible Energy (CCCRE), Calumet County, WI. September 9, 2009. 73 pages.

Kleinbaum, D. G., Kupper, L. L. and Muller, K. E. (1988) Applied Analysis and other Multivariate Methods, Second Edition. PWS-Kent. Boston, MA. 210 pages.

Kroll, C. A. and Priestley, T. (1992) The Effects of Overhead Transmission Lines on Property Values: A Review and Analysis of the Literature. Prepared for Edison Electric Institute, Washington, DC. July, 1992. 99 pages.

Leonard, T. and Murdoch, J. (forthcoming) The Neighborhood Effects of Foreclosure. *Journal of Geographical Systems*.

Leonard, T., Murdoch, J. and Thayer, M. (2008) The Price Effects of Environmental Disamenities in Residential Real-Estate Markets: A Review of the Literature. Working Paper. September, 2008: 14 pages.

LeSage, J. P. (1999) The Theory and Practice of Spatial Econometrics. University of Toledo. Toledo, Ohio. 284 pages.
Mahalanobis, P. C. (1936) On the Generalized Distance in Statistics. *Proceedings of the National Institute of Sciences of India.* 2(1): 49-55.
Mahan, B. L., Polasky, S. and Adams, R. M. (2000) Valuing Urban Wetlands: A Property Price Approach. *Land Economics.* 76(1): 100-113.
Maloy, M. A. and Dean, D. J. (2001) An Accuracy Assessment of Various GIS-Based Viewshed Delineation Techniques. *Photogrammetric Engineering and Remote Sensing.* 67(11): 1293-1298.
Malpezzi, S. (2003) Hedonic Pricing Models: A Selective and Applied Review. Section in Housing Economics and Public Policy: Essays in Honor of Duncan Maclennan. Wiley-Blackwell. Hoboken, NJ. pp. 67-85 of 328 pages. ISBN 978-0-632-06461-8.
McCann, M. S. (2008) Real Estate Impact Evaluation of the Horizon Wind Energy Proposed Rail Splitter Wind Farm. Prepared for Hinshaw & Culbertson, LLP, Rockford, IL. May, 2008. 24 pages.
McCann, R. J. (1999) A Review of the Literature on Property Value Impacts from Industrial Activities. *M. Cubed* (Working Paper): 16 pages.
McCluskey, J. J. and Rausser, G. C. (2003) Hazardous Waste Sites and Housing Appreciation Rates. *Journal of Environmental Economics and Management.* 45(2): 166-176.
National Academy of Sciences (NAS) (2007) Environmental Impacts of Wind-Energy Projects. Committee on Environmental Impacts of Wind Energy Projects - National Research Council. National Academy of Sciences. Washington, DC. 394 pages. ISBN: 0-309-10831-4.
Newman, J. (1956) The World of Mathematics, Volume 2. Simon & Schuster. New York. 1247 pages. ISBN# 0-486-41150-8.
Palmer, J. (1997) Public Acceptance Study of the Searsburg Wind Power Project - One Year Post Construction. Prepared for Vermont Environmental Research Associates, Inc., Waterbury Center, VT. December 1997. 58 pages.
Palmquist, R. B. (1982) Measuring Environmental Effects on Property Values Without Hedonic Regressions. *Journal of Urban Economics.* 11(3): 333-347.
Paul, T. (2006) Understanding and Predicting Community Responses to Wind Energy Development Applications. Thesis Prepared for Master of Science. Bard College, Annandale-on-Hudson, NY. April, 2006. 76 pages.
Pedersen, E. and Waye, K. P. (2004) Perception and Annoyance due to Wind Turbine Noise: A Dose-Response Relationship. *The Journal of the Acoustical Society of America.* 116(6): 3460-3470.
Pitt, D. G. and Zube, E. H. (1979). The Q-Sort Method: Use in Landscape Assessment Research and Landscape Planning. Presented at Applied Techniques for Analysis and Management of the Visual Resource, Incline Village, Nevada. April 23-25, 1979.
Poletti, P. (2005) A Real Estate Study of the Proposed Forward Wind Energy Center Dodge and Fond Du Lac Counties, Wisconsin. Poletti and Associates. Prepared for Invenergy Wind LLC, Chicago, IL. May, 2005. 106 pages.
Poletti, P. (2007) A Real Estate Study of the Proposed White Oak Wind Energy Center, Mclean & Woodford Counties, Illinois. Polleti and Associates. Prepared for Invenergy Wind LLC, Chicago, IL. January, 2007. 63 pages.

Ready, R. C. and Abdalla, C. W. (2005) The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model. *American Journal of Agricultural Economics.* 87(2): 314-326.

Riggs, P. D. and Dean, D. J. (2007) An Investigation into the Causes of Errors and Inconsistencies in Predicted Viewsheds. *Transactions in GIS.* 11(2): 175-196.

Rosen, S. (1974) Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy.* 82(1): 34-55.

Schwarz, G. E. (1978) Estimating the Dimension of a Model. *Annals of Statistics.* 6(2): 461-464.

Seiler, M. J., Bond, M. T. and Seiler, V. L. (2001) The Impact of World Class Great Lakes Water Views on Residential Property Values. *The Appraisal Journal.* 69(3): 287-295.

Simons, R. (2006a) When Bad Things Happen To Good Property. Environmental Law Institute Press. Washington DC. 350 pages. ISBN: 9781585761012.

Simons, R. (2006b) Peer Reviewed Evidence on Property Value Impacts by Source of Contamination. Section in When Bad Things Happen To Good Property. Environmental Law Institute Press. Washington DC. p. 350. ISBN: 9781585761012.

Simons, R. A. and Saginor, J. D. (2006) A Meta-Analysis of the Effect of Environmental Contamination and Positive Amenities on Residential Real Estate Values. *Journal of Real Estate Research.* 28(1): 71-104.

Sims, S. and Dent, P. (2007) Property Stigma: Wind Farms Are Just The Latest Fashion. *Journal of Property Investment & Finance.* 25(6): 626-651.

Sims, S., Dent, P. and Oskrochi, G. R. (2008) Modeling the Impact of Wind Farms on House Prices in the UK. *International Journal of Strategic Property Management.* 12(4): 251-269.

Sirmans, G. S., Lynn, M., Macpherson, D. A. and Zietz, E. N. (2005a). The Value of Housing Characteristics: A Meta Analysis. Presented at Mid Year Meeting of the American Real Estate and Urban Economics Association. May 2005.

Sirmans, G. S., Macpherson, D. A. and Zietz, E. N. (2005b) The Composition of Hedonic Pricing Models. *Journal of Real Estate Literature.* 13(1): 3-42.

Sterzinger, G., Beck, F. and Kostiuk, D. (2003) The Effect of Wind Development on Local Property Values. Renewable Energy Policy Project, Washington, DC. May, 2003. 77 pages.

Thayer, M., Albers, H. and Rhamation, M. (1992) The Impact of Landfills on Residential Property Values. *Journal of Real Estate Research.* 7(3): 265-282.

Thayer, R. L. and Freeman, C. N. (1987) Altamont: Public Perceptions of a Wind Energy Landscape. *Landscape and Urban Planning.* 14(1987): 379-398.

Torres-Sibillea, A., V. Cloquell-Ballester and Darton, R. (2009) Development and Validation of a Multicriteria Indicator for the Assessment of Objective Aesthetic Impact of Wind Farms. *Renewable and Sustainable Energy Reviews.* 13(1): 40-66.

United States Department of Agriculture (USDA) (1995) Landscape Aesthetics: A Handbook for Scenic Management. United States Department of Agriculture - Forest Service, Washington, DC. December 1995.

United States Department of Energy (US DOE) (2008) 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply. U.S. Department of Energy, Washington, DC. May, 2008. 248 pages.

Watson, M. (2005) Estimation of Social and Environmental Externalities for Electricity Infrastructure in the Northwest Sector. Reviewed by Martin Hill. Prepared for Prepared for Parsons Brinckerhoff by Integral Energy, Sydney, Australia. August 2005. 73 pages.

White, H. (1980) A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica.* 48(4): 817-838.

Wiser, R. and Bolinger, M. (2009) 2008 Wind Technologies Market Report. Lawrence Berkeley National Laboratory. Prepared for U.S. Department of Energy, Washington, DC. July, 2009. 68 pages. DOE/GO-102009-2868.

Wiser, R. and Hand, M. (2010) Wind Power: How Much, How Soon, and At What Cost? Section in Generating Electricity in a Carbon-Constrained World. Elsevier. Oxford, UK. p. 632. ISBN-13: 978-1-85617-655-2.

Wolsink, M. (1989) Attitudes and Expectancies about Wind Turbines and Wind Farms. *Wind Engineering.* 13(4): 196-206.

Wolsink, M. (2000) Wind Power and the NIMBY-Myth: Institutional Capacity and the Limited Significance of Public Support. *Renewable Energy.* 21(1): 49-64.

Zarem, K. L. (2005) Direct Testimony Regarding Forward Wind Project, Dodge and Fond Du Lac Counties, Wisconsin. Public Service Commission of Wisconsin, Madison, Wisconsin. June, 2005. 12 pages. Docket No. 9300-CE-100.

Appendix A: Study Area Descriptions

The analysis reported in the body of the report used data from ten different wind-project study areas, across nine different states and 14 counties, and surrounding 24 different wind facilities. Each of the study areas is unique, but as a group they provide a good representation of the range of wind facility sizes, hub heights, and locations of recent wind development activity in the U.S. (see Figure A - 1 and Table A - 1). This appendix describes each of the ten study areas, and provides the following information: a map of the study area; a description of the area; how the data were collected; statistics on home sales prices in the sample and census-reported home values for the towns, county, and state that encompass the area; data on the wind facilities contained within the study area; and frequency tables for the variables of interest (i.e., views of turbines, distance to nearest turbine ,and development period).

Figure A - 1: Map of Study Areas

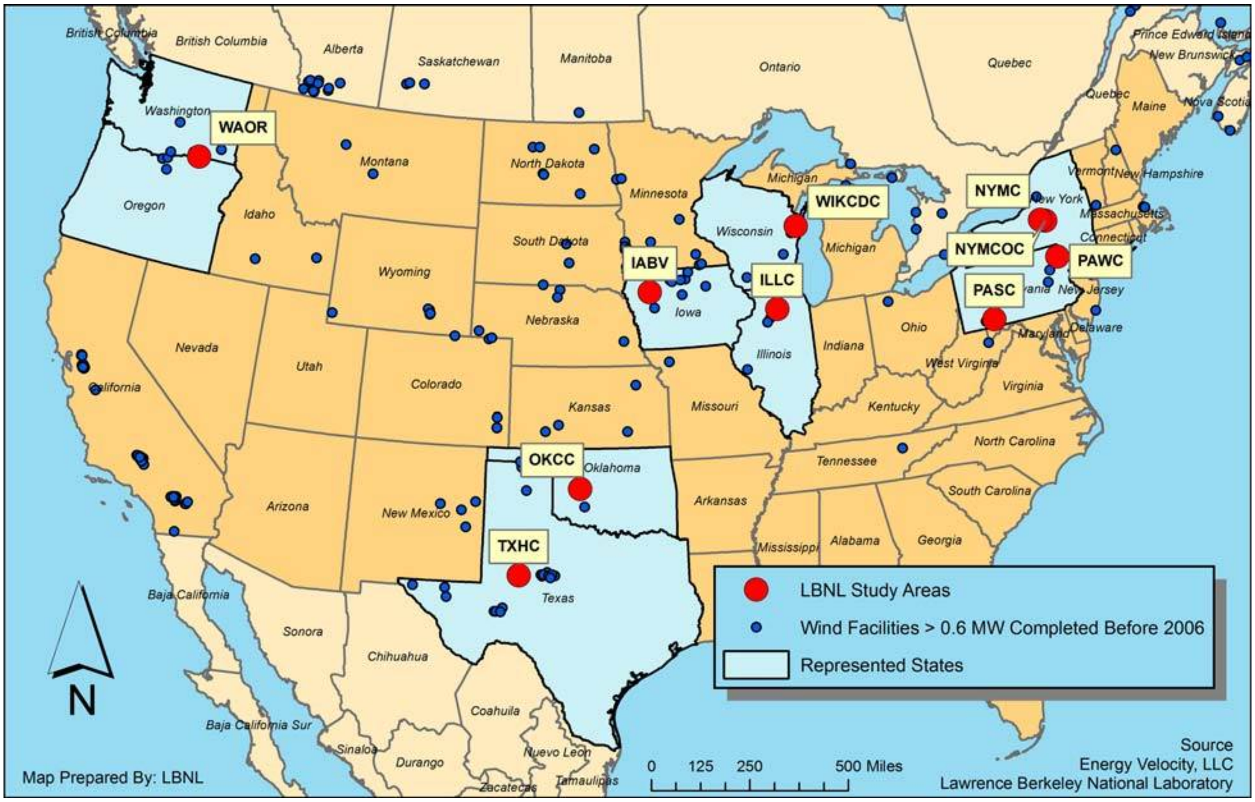
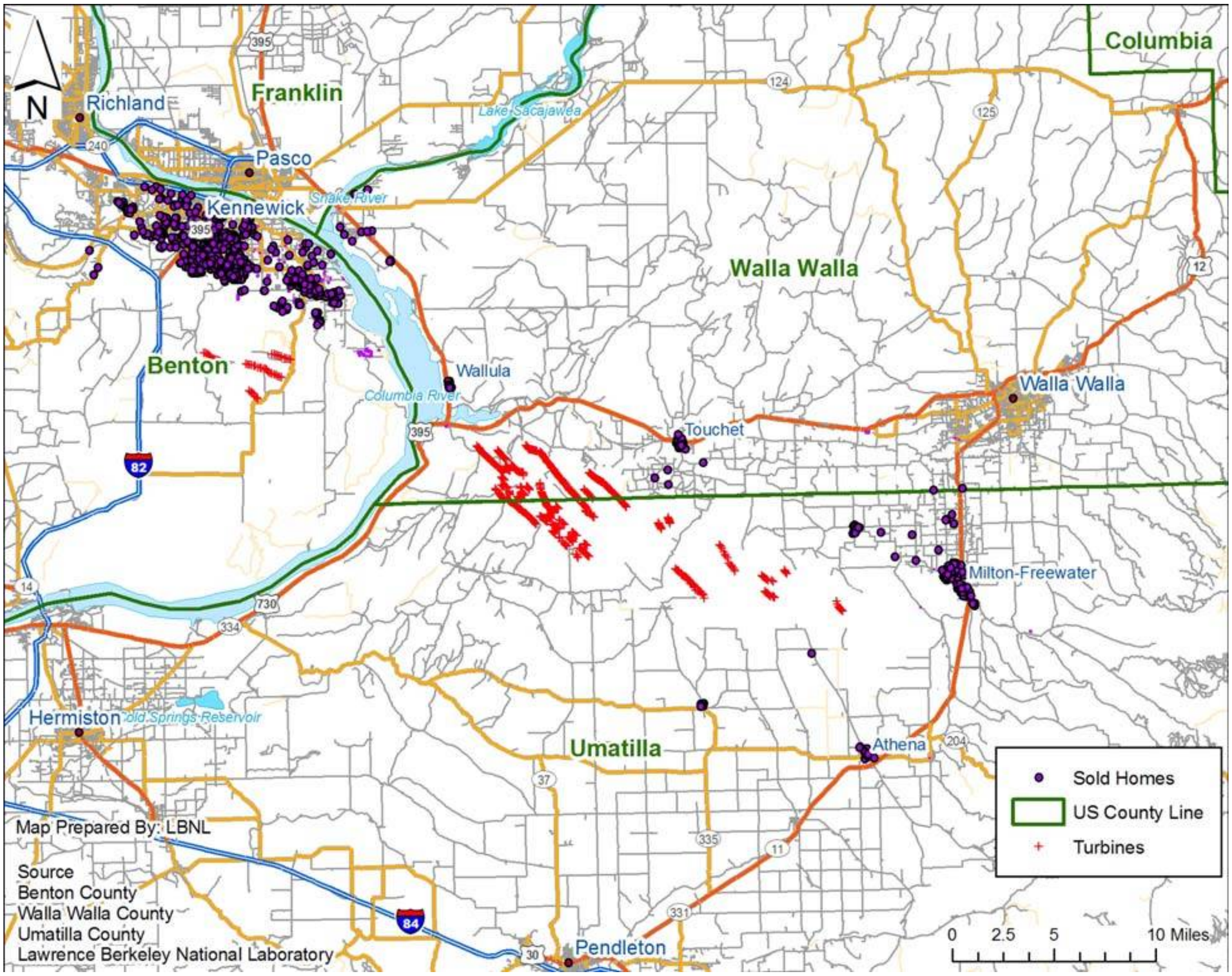


Table A - 1: Summary of Study Areas

Study Area Code	Study Area Counties, States	Facility Names	Number of Turbines	Number of MW	Max Hub Height (meters)	Max Hub Height (feet)
WAOR	Benton and Walla Walla Counties, WA and Umatilla County, OR	Vansycle Ridge, Stateline, Nine Canyon I & II, Combine Hills	582	429	60	197
TXHC	Howard County, TX	Big Spring I & II	46	34	80	262
OKCC	Custer County, OK	Weatherford I & II	98	147	80	262
IABV	Buena Vista County, IA	Storm Lake I & II, Waverly, Intrepid I & II	381	370	65	213
ILLC	Lee County, IL	Mendota Hills, GSG Wind	103	130	78	256
WIKCDC	Kewaunee and Door Counties, WI	Red River, Lincoln	31	20	65	213
PASC	Somerset County, PA	Green Mountain, Somerset, Meyersdale	34	49	80	262
PAWC	Wayne County, PA	Waymart	43	65	65	213
NYMCOC	Madison and Oneida Counties, NY	Madison	7	12	67	220
NYMC	Madison County, NY	Fenner	20	30	66	218
		TOTAL	**1345**	**1286**		

A.1 WAOR Study Area: Benton and Walla Walla Counties (Washington), and Umatilla County (Oregon)

Figure A - 2: Map of WAOR Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area combines data from the three counties - Benton and Walla Walla in Washington, and Umatilla in Oregon - that surround the Vansycle Ridge, Stateline, Combine Hills, and Nine Canyon wind projects. Wind development began in this area in 1997 and, within the sample of wind projects, continued through 2003. In total, the wind facilities in this study area include 582 turbines and 429 MW of nameplate capacity, with hub heights that range from 164 feet to almost 200 feet. The wind facilities are situated on an East-West ridge that straddles the Columbia River, as it briefly turns South. The area consists of undeveloped highland/plateau grassland, agricultural tracks for winter fruit, and three towns: Kennewick (Benton County), Milton-Freewater (Umatilla County), and Walla Walla (Walla Walla County). Only the first two of these towns are represented in the dataset because Walla Walla is situated more than 10 miles from the nearest wind turbine. Also in the area are Touchet and Wallula, WA, and Athena, OR, all very small communities with little to no services. Much of the area to the North and South of the ridge, and outside of the urban areas, is farmland, with homes situated on small parcels adjoining larger agricultural tracts.

Data Collection and Summary

Data for this study area were collected from a myriad of sources. For Benton County, sales and home characteristic data and GIS parcel shapefiles were collected with the assistance of county officials Eric Beswick, Harriet Mercer, and Florinda Paez, while state official Deb Mandeville (Washington Department of State) provided information on the validity of the sales. In Walla Walla County, county officials Bill Vollendorff and Tiffany Laposi provided sales, house characteristic, and GIS data. In Umatilla County, county officials Jason Nielsen, Tracie Diehl, and Tim McElrath provided sales, house characteristic, and GIS data.

Based on the data collection, more than 8,500 homes are found to have sold within ten miles of the wind turbines in this study area from January 1996 to June 2007. Completing field visits to this number of homes would have been overly burdensome; as a result, only a sample of these home sales was used for the study. Specifically, all valid sales within three miles of the nearest turbine are used, and a random sample of those homes outside of three miles but inside of five miles in Benton County and inside ten miles in Walla Walla and Umatilla Counties. This approach resulted in a total of 790 sales, with prices that ranged from $25,000 to $647,500, and a mean of $134,244. Of those 790 sales, 519 occurred after wind facility construction commenced, and 110 could see the turbines at the time of sale, though all but four of these homes had MINOR views. No homes within this sample were located within one mile of the nearest wind turbine, with the majority occurring outside of three miles.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/23/1996	6/29/2007	790	$ 125,803	$ 134,244	$ 25,000	$ 647,500

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Vansycle Ridge	25	38	Aug-97	Feb-98	Aug-98	Vestas	50
Stateline Wind Project, Phase I (OR)	83	126	Jun-00	Sep-01	Dec-01	Vestas	50
Stateline Wind Project, Phase I (WA)	177	268	Jun-00	Feb-01	Dec-01	Vestas	50
Stateline Wind Project, Phase II	40	60	Jan-02	Sep-02	Dec-02	Vestas	50
Nine Canyon Wind Farm	48	37	Jun-01	Mar-02	Sep-02	Bonus	60
Combine Hills Turbine Ranch I	41	41	Apr-02	Aug-03	Dec-03	Mitsubishi	55
Nine Canyon Wind Farm II	16	12	Jun-01	Jun-03	Dec-03	Bonus	60

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	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

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	271	409	106	4	0	0	790

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	271	0	0	20	277	222	790

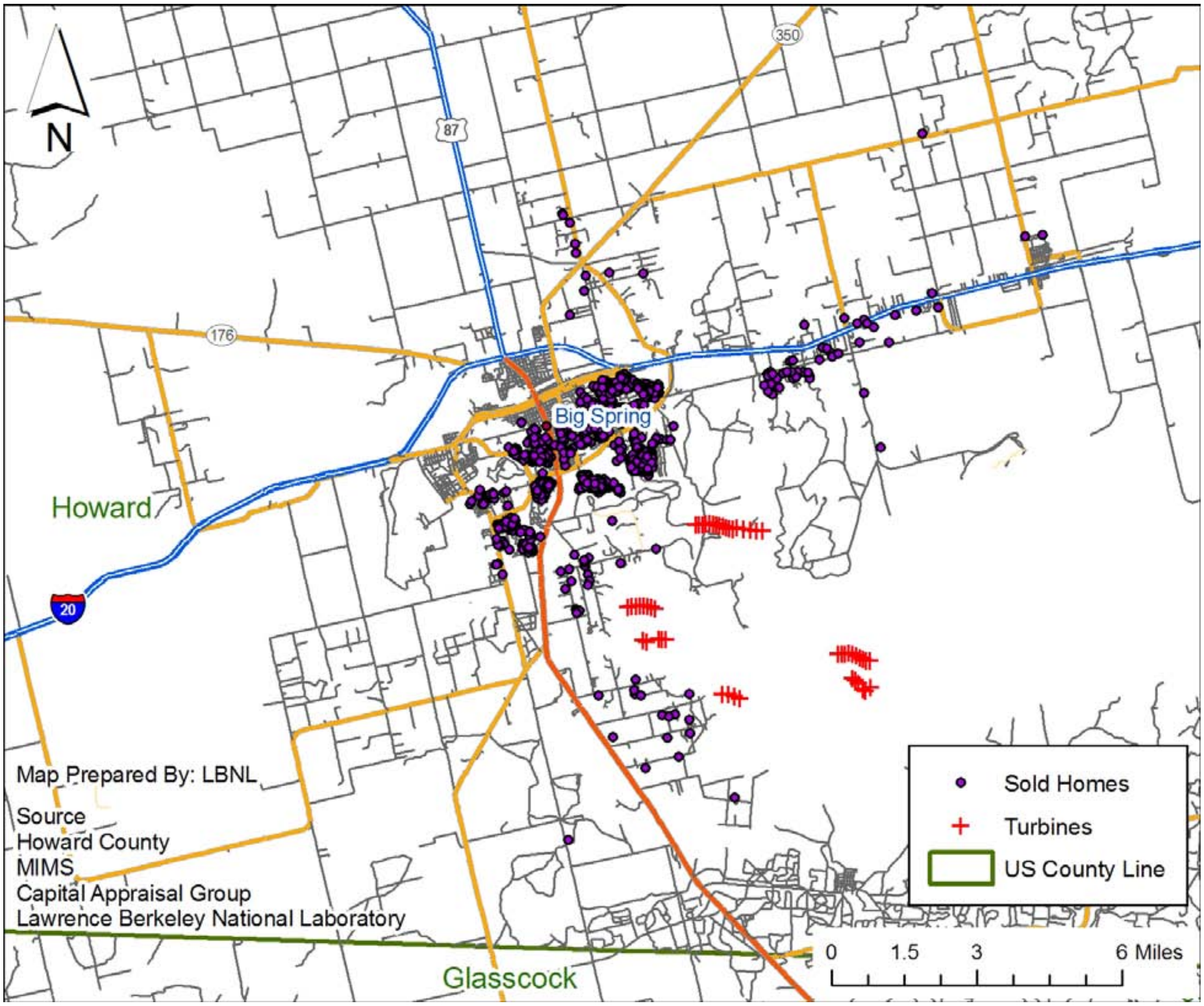
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Kennewich, WA	City	62,182	12.5%	2,711	32.3	$ 45,085	$ 155,531	46%
Walla Walla, WA	City	30,794	4.0%	2,847	33.8	$ 38,391	$ 185,706	91%
Milton Freewater, OR	Town	6,335	-2.0%	3,362	31.7	$ 30,229	$ 113,647	47%
Touchet, WA	Town	413	n/a	340	33.6	$ 47,268	$ 163,790	81%
Benton	County	159,414	3.6%	94	34.4	$ 51,464	$ 162,700	46%
Walla Walla	County	57,709	1.0%	45	34.9	$ 43,597	$ 206,631	89%
Umatilla	County	73,491	0.6%	23	34.6	$ 38,631	$ 138,200	47%
Washington	State	6,488,000	10.1%	89	35.3	$ 55,591	$ 300,800	79%
Oregon	State	3,747,455	9.5%	36	36.3	$ 48,730	$ 257,300	69%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.2 TXHC Study Area: Howard County (Texas)

Figure A - 3: Map of TXHC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area is entirely contained within Howard County, Texas, and includes the city of Big Spring, which is situated roughly 100 miles South of Lubbock and 275 miles West of Dallas in West Texas. On top of the Northern end of the Edwards Plateau, which runs from the Southeast to the Northwest, sits the 46 turbine (34 MW) Big Spring wind facility, which was constructed in 1998 and 1999. Most of the wind turbines in this project have a hub height of 213 feet, but four are taller, at 262 feet. The plateau and the wind facility overlook the city of Big Spring which, when including its suburbs, wraps around the plateau to the South and East. Surrounding the town are modest farming tracks and arid, undeveloped land. These lands, primarily to the South of the facility towards Forsan (not shown on map), are dotted with small oil rigs. Many of the homes in Big Spring do not have a view of the wind facility, but others to the South and East do have such views.

Data Collection and Summary

County officials Brett McKibben, Sally Munoz, and Sheri Proctor were extremely helpful in answering questions about the data required for this project, and the data were provided by two firms that manage it for the county. Specifically, Erin Welch of the Capital Appraisal Group provided the sales and house characteristic data and Paul Brandt of MIMS provided the GIS data.

All valid single-family home sales transactions within five miles of the nearest turbine and occurring between January 1996 and March 2007 were included in the dataset, resulting in 1,311 sales.[106] These sales ranged in price from $10,492 to $490,000, with a mean of $74,092. Because of the age of the wind facility, many of the sales in the sample occurred after wind facility construction had commenced (*n* = 1,071). Of those, 104 had views of the turbines, with 27 having views more dramatic than MINOR. Four homes sold within a mile of the facility, with the rest falling between one and three miles (*n* = 584), three to five miles (*n* = 467), and outside of five miles (*n* = 16).

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/2/1996	3/30/2007	1,311	$66,500	$74,092	$10,492	$490,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Big Spring I	27.7	42	Jan-98	Jul-98	Jun-99	Vestas	65
Big Spring II	6.6	4	Jan-98	Jul-98	Jun-99	Vestas	80

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Howard, TX (TXHC)	169	71	113	131	827	1311

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Howard, TX (TXHC)	240	967	77	22	5	0	1311

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Howard, TX (TXHC)	240	0	4	584	467	16	1311

[106] If parcels intersected the five mile boundary, they were included in the sample, but were coded as being outside of five miles.

Census Statistics

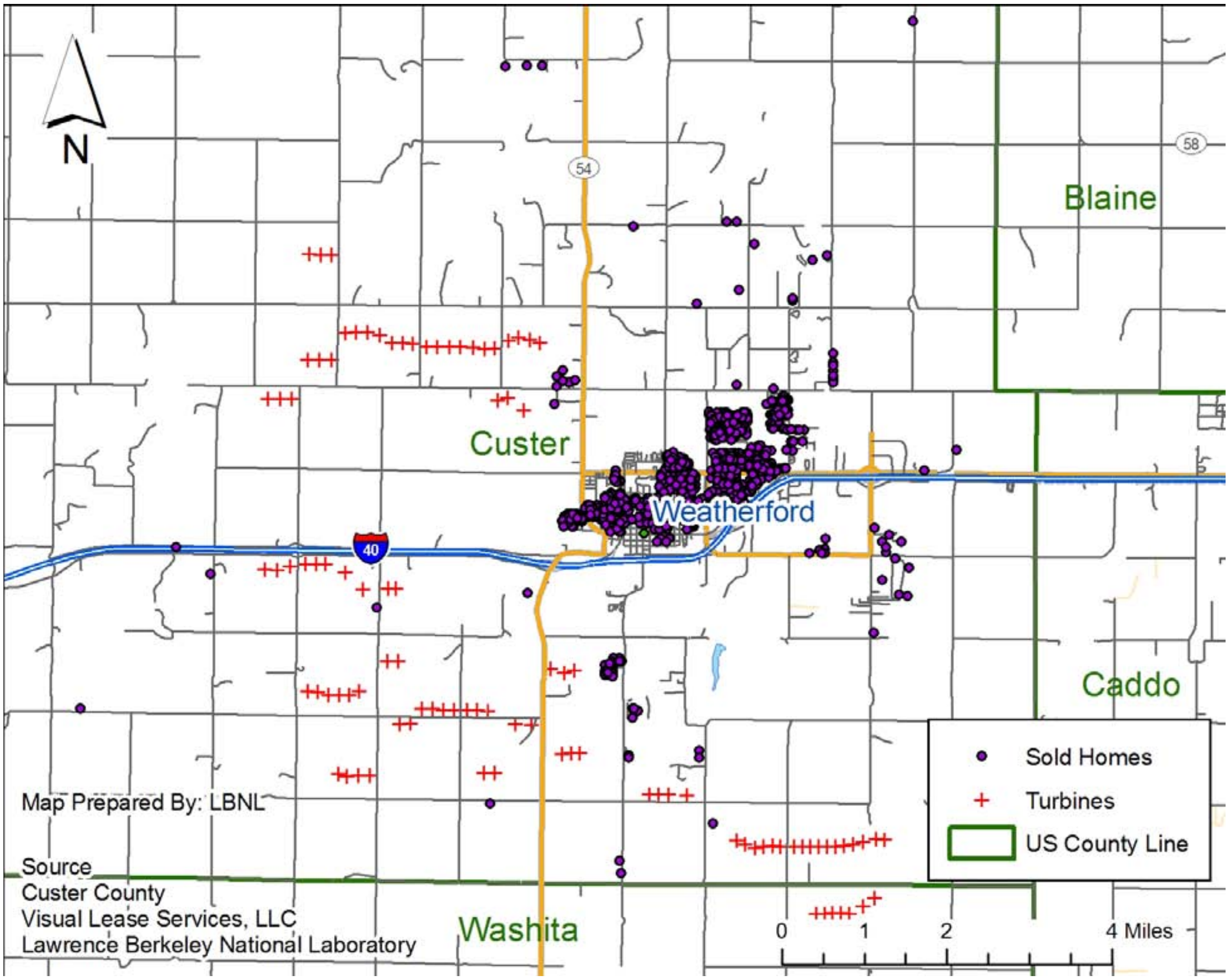
Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Big Spring	City	24,075	-5.4%	1,260	35.1	$ 32,470	$ 54,442	50%
Forsan	Town	220	-4.0%	758	36.8	$ 50,219	$ 64,277	84%
Howard	County	32,295	-1.9%	36	36.4	$ 36,684	$ 60,658	58%
Texas	State	23,904,380	14.6%	80	32.3	$ 47,548	$ 120,900	47%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

.

A.3 OKCC Study Area: Custer County (Oklahoma)

Figure A - 4: Map of OKCC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area is entirely contained within Custer County, Texas, and includes the Weatherford wind facility, which is situated near the city of Weatherford, 70 miles due west of Oklahoma City and near the western edge of the state. The 98 turbine (147 MW) Weatherford wind facility straddles Highway 40, which runs East-West, and U.S. County Route 54, which runs North-South, creating an "L" shape that is more than six miles long and six miles wide. Development began in 2004, and was completed in two phases ending in 2006. The turbines are some of the largest in the sample, with a hub height of 262 feet. The topography of the study area is mostly flat plateau, allowing the turbines to be visible from many parts of the town and the surrounding rural lands. There are a number of smaller groupings of homes that are situated to the North and South of the city, many of which are extremely close to the turbines and have dramatic views of them.