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The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis

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Environmental Energy
Technologies Division

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The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis

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Abstract

With wind energy expanding rapidly in the U.S. and abroad, and with an increasing number of communities considering wind power development nearby, there is an urgent need to empirically investigate common community concerns about wind project development. The concern that property values will be adversely affected by wind energy facilities is commonly put forth by stakeholders. Although this concern is not unreasonable, given property value impacts that have been found near high voltage transmission lines and other electric generation facilities, the impacts of wind energy facilities on residential property values had not previously been investigated thoroughly. The present research collected data on almost 7,500 sales of single-family homes situated within 10 miles of 24 existing wind facilities in nine different U.S. states. The conclusions of the study are drawn from eight different hedonic pricing models, as well as both repeat sales and sales volume models. The various analyses are strongly consistent in that none of the models uncovers conclusive evidence of the existence of any widespread property value impacts that might be present in communities surrounding wind energy facilities. Specifically, neither the view of the wind facilities nor the distance of the home to those facilities is found to have any consistent, measurable, and statistically significant effect on home sales prices. Although the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, they are either too small and/or too infrequent to result in any widespread, statistically observable impact.

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Executive Summary

Overview

Wind power development in the United States has expanded dramatically in recent years. If that growth is to continue it will require an ever-increasing number of wind power projects to be sited, permitted, and constructed. Most permitting processes in the U.S. require some form of environmental impact assessment as well as public involvement in the siting process. Though public opinion surveys generally show that acceptance towards wind energy is high, a variety of concerns with wind power development are often expressed on the local level during the siting and permitting process. One such concern is the potential impact of wind energy projects on the property values of nearby residences.

Concerns about the possible impact of wind power facilities on residential property values can take many forms, but can be divided into the following non-mutually exclusive categories:

- Area Stigma: 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.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: 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.

Although concerns about the <u>possible</u> impact of wind energy facilities on the property values of nearby homes are reasonably well established, the available literature[1] that has sought to quantify the impacts of wind projects on residential property values has a number of shortcomings:

1) Many studies have relied on surveys of homeowners or real estate professionals, rather than trying to quantify real price impacts based on market data;
2) Most studies have relied on simple statistical techniques that have limitations and that can be dramatically influenced by small numbers of sales transactions or survey respondents;
3) Most studies have used small datasets that are concentrated in only one wind project study area, making it difficult to reliably identify impacts that might apply in a variety of areas;
4) Many studies have not reported measurements of the statistical significance of their results, making it difficult to determine if those results are meaningful;
5) Many studies have concentrated on an investigation of the existence of Area Stigma, and have ignored Scenic Vista and/or Nuisance Stigmas;
6) Only a few studies included field visits to homes to determine wind turbine visibility and collect other important information about the home (e.g., the quality of the scenic vista); and
7) Only two studies have been published in peer-reviewed academic journals.

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[1] This literature is briefly reviewed in Section 2 of the full report, and includes: Jordal-Jorgensen (1996); Jerabek (2001); Grover (2002); Jerabek (2002); Sterzinger et al. (2003); Beck (2004); Haughton et al. (2004); Khatri (2004); DeLacy (2005); Poletti (2005); Goldman (2006); Hoen (2006); Firestone et al. (2007); Poletti (2007); Sims and Dent (2007); Bond (2008); McCann (2008); Sims et al. (2008); and Kielisch (2009).

This report builds on the previous literature that has investigated the potential impact of wind projects on residential property values by using a hedonic pricing model and by avoiding many of the shortcomings enumerated above. The hedonic pricing model is one of the most prominent and reliable methods for identifying the marginal impacts of different housing and community characteristics on residential property values (see side bar). This approach dates to the seminal work of Rosen (1974) and Freeman (1979), and much of the available literature that has investigated the impacts of potential disamenities on property values has relied on this method.[2]

To seed the hedonic model with appropriate market data, this analysis collects information on a large quantity of residential home sales (i.e., transactions) ($n = 7,459$) from ten communities surrounding 24 existing wind power facilities spread across multiple parts of the U.S. (e.g., nine states). Homes included in this sample are located from 800 ft to over five miles from the nearest wind energy facility, and were sold at any point from before wind facility announcement to over four years after the construction of the nearby wind project. Each of the homes that sold was visited to determine the degree to which the wind facility was likely to have been visible at the time of sale and to collect other essential data.

To assess the potential impacts of all three of the property value stigmas described earlier, a base hedonic model is applied as well as seven alternative hedonic models each designed to investigate the reliability of the results and to explore other aspects of the data (see Table ES - 1 below). In addition, a repeat sales model is analyzed, and an investigation of possible impacts on sales volumes is

> **What Is a Hedonic Pricing Model?**
> Hedonic pricing models are frequently used by economists and real estate professionals to assess the impacts of house and community characteristics on property values by investigating the sales prices of homes. A house can be thought of as a bundle of characteristics (e.g., number of square feet, number of bathrooms). When a price is agreed upon by a buyer and seller there is an implicit understanding that those characteristics have value. When data from a large number of residential transactions are available, the individual marginal contribution to the sales price of each characteristic for an average home can be estimated with a hedonic regression model. Such a model can statistically estimate, for example, how much an additional bathroom adds to the sale price of an average home. A particularly useful application of the hedonic model is to value non-market goods – goods that do not have transparent and observable market prices. For this reason, the hedonic model is often used to derive value estimates of amenities such as wetlands or lake views, and disamenities such as proximity to and/or views of high-voltage transmission lines, roads, cell phone towers, and landfills. It should be emphasized that the hedonic model is not typically designed to appraise properties (i.e., to establish an estimate of the market value of a home at a specified point in time), as would be done with an automated valuation model. Instead, the typical goal of a hedonic model is to estimate the marginal contribution of individual house or community characteristics to sales prices.

conducted. Though some limitations to the analysis approach and available data are acknowledged, the resulting product is the most comprehensive and data-rich analysis to date in the U.S. or abroad on the impacts of wind projects on nearby property values.

Analysis Findings

Table ES - 1 describes the ten resulting statistical models that are employed to investigate the effects of wind facilities on residential sales prices, and the specific stigmas that those models investigate. Though all models test some combination of the three possible stigmas, they do so in different ways. For instance, the Base Model asks the question, "All else being equal, do homes near wind facilities sell for prices different than for homes located farther away?", while the All Sales Model asks, "All else being equal, do homes near wind facilities that sell after the construction of the wind facility sell for prices different from similar homes that sold before the announcement and construction of the facility?" Each model is therefore designed to not only test for the reliability of the overall results, but also to explore the myriad of potential effects from a variety of perspectives. Table ES-2 summarizes the results from these models.

Table ES - 1: Description of Statistical Models

Statistical Model	Description
Base Hedonic Model	Using only "post-construction" transactions (those that occurred after the wind facility was built), this model investigates all three stigmas in a straightforward manner
Alternative Hedonic Models	
View Stability	Using only post-construction transactions, this model investigates whether the Scenic Vista Stigma results from the Base Model are independent of the Nuisance and Area Stigma results
Distance Stability	Using only post-construction transactions, this model investigates whether the Nuisance and Area Stigma results from the Base Model are independent of the Scenic Vista Stigma results
Continuous Distance	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
All Sales	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
Temporal Aspects	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
Orientation	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
Overlap	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
Repeat Sales Model	Using paired transactions of homes that sold once pre-announcement and again post-construction, this model investigates the three stigmas, using as a reference transactions of homes located outside of five miles of the nearest wind turbine and that have no view of the turbines
Sales Volume Model	Using both pre-announcement and post-construction transactions, this model investigates whether the rate of home sales (not the price of those sales) is affected by the presence of nearby wind facilities

Table ES-2: Impact of Wind Projects on Property Values: Summary of Key Results

| Statistical Model | Is there statistical evidence of: | | | Section Reference |
	Area Stigma?	Scenic Vista Stigma?	Nuisance Stigma?	
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*

Base Model Results

The Base Model serves as the primary model and allows all three stigmas to be explored. In sum, this model finds no persuasive evidence of any of the three potential stigmas: neither the view of the wind facilities nor the distance of the home to those facilities is found to have any consistent, measurable, and statistically significant effect on home sales prices.

- Area Stigma: To investigate Area Stigma, the model tests whether the sales prices of homes situated anywhere outside of one mile and inside of five miles of the nearest wind facility are measurably different from the sales price of those homes located outside of five miles. No statistically significant differences in sales prices between these homes are found (see Figure ES-1).

- Scenic Vista Stigma: For Scenic Vista Stigma, the model is first used to investigate whether the sales prices of homes with varying scenic vistas - absent the presence of the wind facility - are measurably different. The model results show dramatic and statistically significant differences in this instance (see Figure ES-2); not surprisingly, home buyers and sellers consider the scenic vista of a home when establishing the appropriate sales price. Nonetheless, when the model tests for whether homes with minor, moderate, substantial, or extreme views of wind turbines have measurably different sales prices, no statistically significant differences are apparent (see Figure ES-3).

- Nuisance Stigma: Finally, for Nuisance Stigma, the model is used to test whether the sales prices of homes situated inside of one mile of the nearest wind energy facility are measurably different from those homes located outside of five miles. Although sample size is somewhat limited in this case,[3] the model again finds no persuasive statistical evidence that wind

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[3] 125 homes were located inside of one mile of the nearest wind facility and sold post-construction.

facilities measurably and broadly impact residential sales prices (see Figure ES-1 and later results).

Figure ES-1: Base Model Results: Area and Nuisance Stigma

The reference category consists of transactions for homes situated more than five miles from the nearest turbine, and that occured after construction began on the wind facility
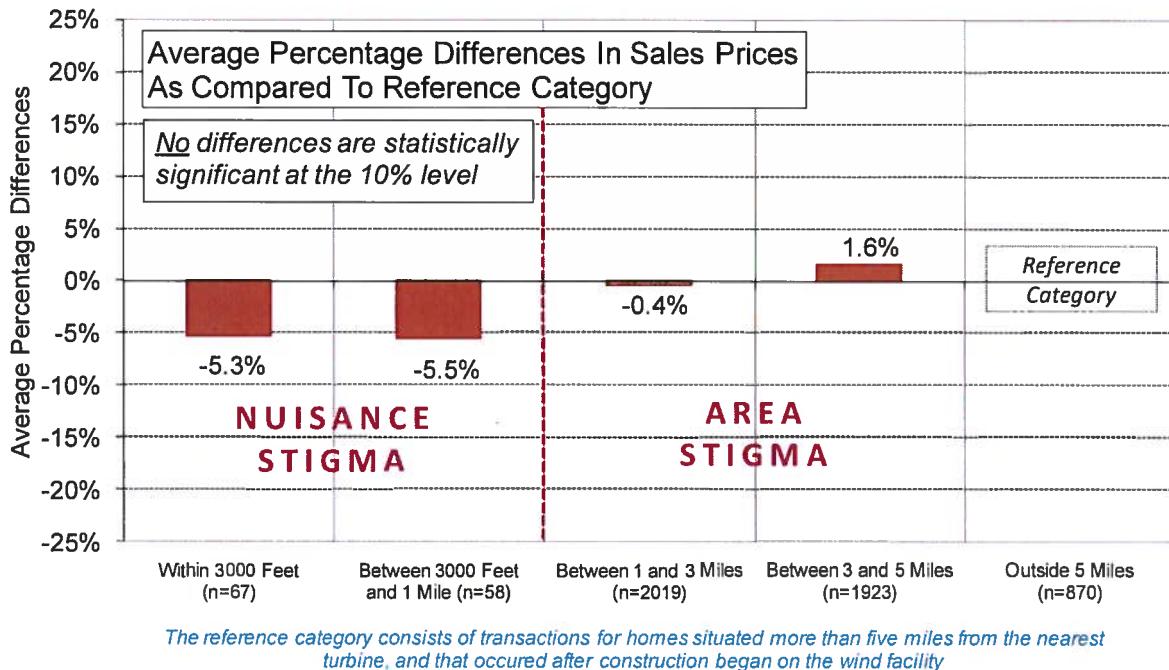
Figure ES-2: Base Model Results: Scenic Vista

The reference category consists of transactions for homes with an Average Vista, and that occured after construction began on the wind facility
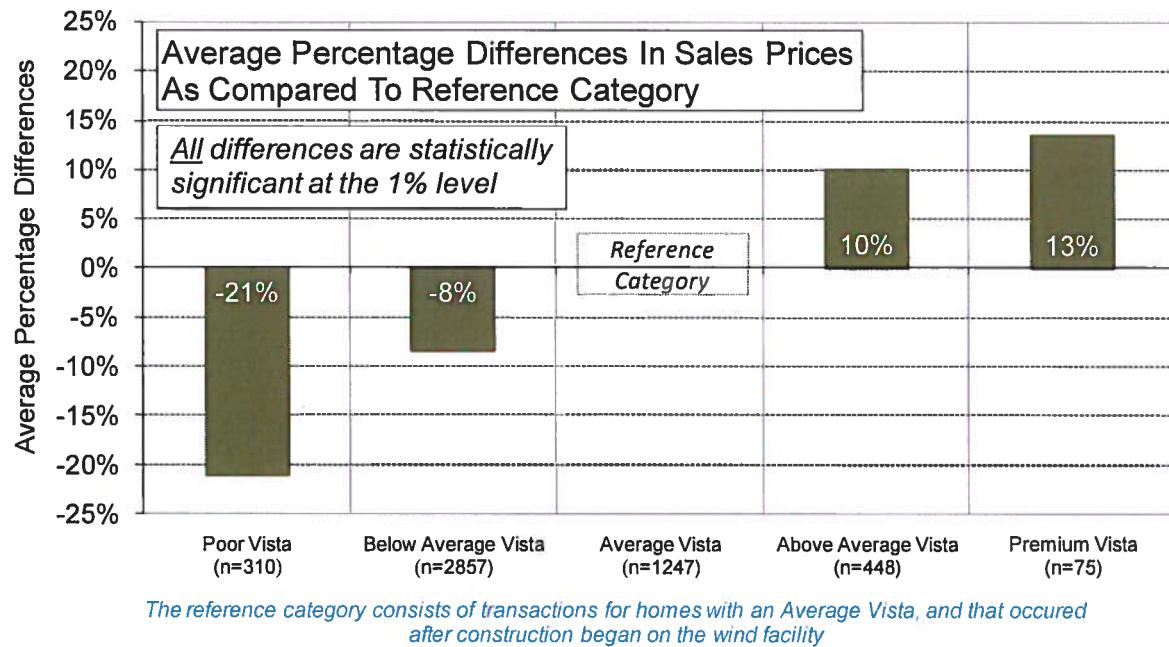
Figure ES-3: Base Model Results: Scenic Vista Stigma
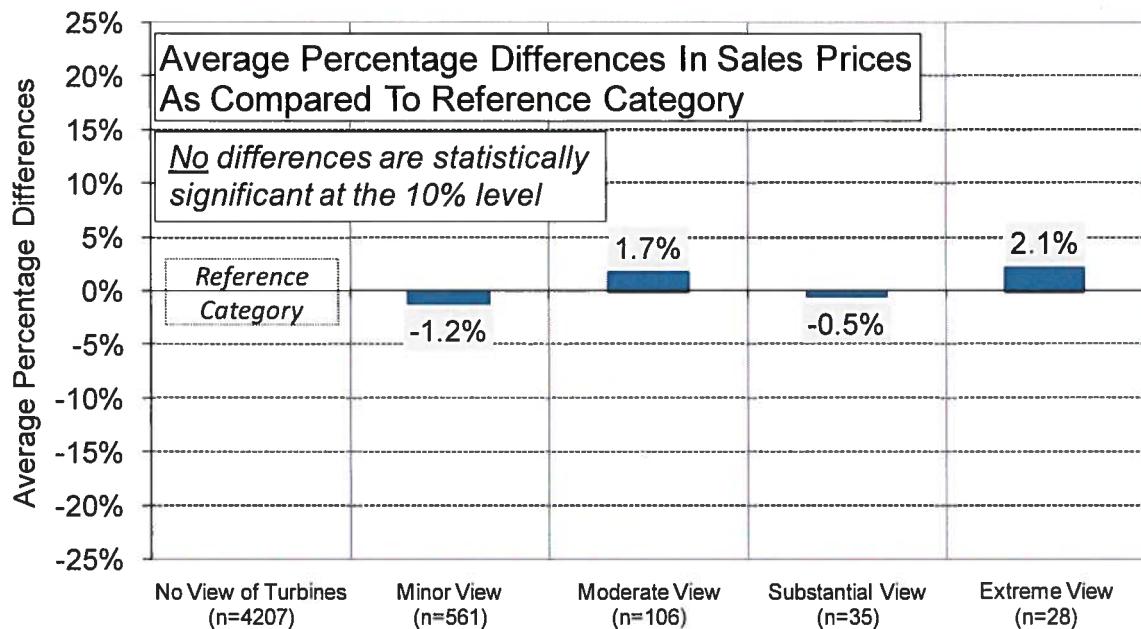
Average Percentage Differences In Sales Prices As Compared To Reference Category

No differences are statistically significant at the 10% level

Reference Category

-1.2%   1.7%   -0.5%   2.1%

| No View of Turbines (n=4207) | Minor View (n=561) | Moderate View (n=106) | Substantial View (n=35) | Extreme View (n=28) |

The reference category consists of transactions for homes without a view of the turbines, and that occured after construction began on the wind facility

The seven alternative hedonic models and the additional analysis contained in the Repeat Sales and Sales Volume Models (see Table ES-2) provide a fuller picture of the three stigmas and the robustness of the Base Model results.

Area Stigma: Other Model Results

Concentrating first on Area Stigma, the results from all of the models are similar: there is no statistical evidence of a widespread Area Stigma among the homes in this sample. Homes in the study areas analyzed here do not appear to be measurably stigmatized by the arrival of a wind facility, regardless of when those homes sold in the wind project development process and regardless of whether the homes are located one mile or five miles away from the nearest facility.

In the All Sales Model, for example, after adjusting for inflation,[4] homes that sold after wind facility construction and that had no view of the turbines are found to have transacted for higher prices - not lower - than those homes that sold prior to wind facility construction. Moreover, in the Temporal Aspects Model, homes that sold more than two years prior to the announcement of the wind facility and that were located more than five miles from where the turbines were eventually located are found to have transacted for lower prices - not higher - than homes situated closer to the turbines and that sold at any time after the announcement and construction of the wind facility (see Figure ES - 4). Further, in the Repeat Sales Model, homes located near the wind facilities that transacted more than once were found to have appreciated between those sales by an amount that was no different from that experienced by homes located in an area

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[4] All sales prices in all models are adjusted for inflation, but because this model (and the Temporal Aspects Model) deals with time explicitly, it is mentioned specifically here.

many miles away from the wind facilities. Finally, as shown in Table ES-2, none of the other models identified evidence of a broadly negative and statistically significant Area Stigma.

Scenic Vista Stigma: Other Model Results
With respect to Scenic Vista Stigma, the seven alternative hedonic models and the additional analysis contained in the Repeat Sales Model find little consistent evidence of a broadly negative and statistically significant impact. Although there are 730 residential transactions in the sample that involve homes that had views of a wind facility at the time of sale, 160 of which had relatively significant views (i.e., a rating higher than Minor), none of the various models finds strong statistical evidence that the view of a nearby wind facility impacts sales prices in a significant and consistent manner.

When concentrating only on the view of the wind facilities from a home (and not testing for Area and Nuisance Stigmas simultaneously), for example, the results from the View Stability Model are very similar to those derived from the Base Model, with no evidence of a Scenic Vista Stigma. Similarly, the All Sales Model finds that homes that sold after wind facility construction and that had a view of the facility transacted for prices that are statistically indistinguishable from those homes that sold at any time prior to wind facility construction. The Orientation Model, meanwhile, fails to detect any difference between the sales prices of homes that had either a front, back, or side orientation to the view of the wind facility. As shown in Table ES-2, the Continuous Distance and Temporal Aspects models also do not uncover any evidence of a broadly negative and statistically significant Scenic Vista Stigma.

In the Repeat Sales Model, some limited evidence is found that a Scenic Vista Stigma may exist, but those effects are weak, fairly small, somewhat counter-intuitive, and are at odds with the results of other models. This finding 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. Finally, in the Overlap Model, where the degree to which a view of the wind facility overlaps the primary scenic vista from the home is accounted for, no statistically significant differences in sales prices are detected between homes with somewhat or strongly overlapping views when compared to those homes with wind turbine views that did not overlap the primary scenic vista. Though this model produces some weak evidence of a Scenic Vista Stigma among homes with Minor views of wind facilities, the same model finds that the sales prices of those homes with views that barely overlap the primary scenic vista are positively impacted by the presence of the wind facility. When these two results are combined, the overall impact is negligible, again demonstrating no persuasive evidence of a Scenic Vista Stigma.

Nuisance Stigma: Other Model Results
Results for Nuisance Stigma from the seven alternative hedonic models and the additional analysis contained in the Repeat Sales and Sales Volume Models support the Base Model results. Taken together, these models present a consistent set of results: homes in this sample that are within a mile of the nearest wind facility, where various nuisance effects have been posited, have not been broadly and measurably affected by the presence of those wind facilities. These results imply that Nuisance Stigma effects are either not present in this sample, or are too small and/or infrequent to be statistically distinguished.

In the Distance Stability Model, for example, when concentrating only on the distance from homes to the nearest wind turbine (and not testing for Scenic Vista Stigma simultaneously), the results are very similar to those derived from the Base Model, with no statistical evidence of a Nuisance Stigma. These results are corroborated by the Continuous Distance, Orientation, Overlap, and Repeat Sales Models, none of which find a statistically significant relationship between distance and either sales prices or appreciation rates. Relatedly, the Sales Volume analysis finds no evidence that homes located within one mile of the nearest wind turbine are sold any more or less frequently than homes located farther away from the wind facilities.

In the All Sales Model, a weakly significant difference is found between the sales prices of homes located between 3000 feet and one mile of the nearest wind facility and the homes that sold before the announcement of the wind facility. This effect, however, is largely explained by the results of the Temporal Aspects Model, shown in Figure ES - 4. The Temporal Aspects Model finds that homes located within one mile of where the wind turbines would eventually be located sold for depressed prices well before the wind facility was even announced or constructed. In all time periods following the commencement of wind facility construction, however, inflation-adjusted sales prices increased - not decreased - relative to pre-announcement levels, demonstrating no statistical evidence of a Nuisance Stigma. The results from the All Sales Model (and, for that matter, the negative, albeit statistically insignificant coefficients inside of one mile in the Base Model, see Figure ES-1) are therefore an indication of sales price levels that preceded wind facility announcement construction, and that are not sustained after construction.

Figure ES - 4: Temporal Aspects Model Results: Area and Nuisance Stigma

The reference category consists of transactions of homes situated more than five miles from where the nearest turbine would eventually be located and that occurred more than two years before announcement of the facility
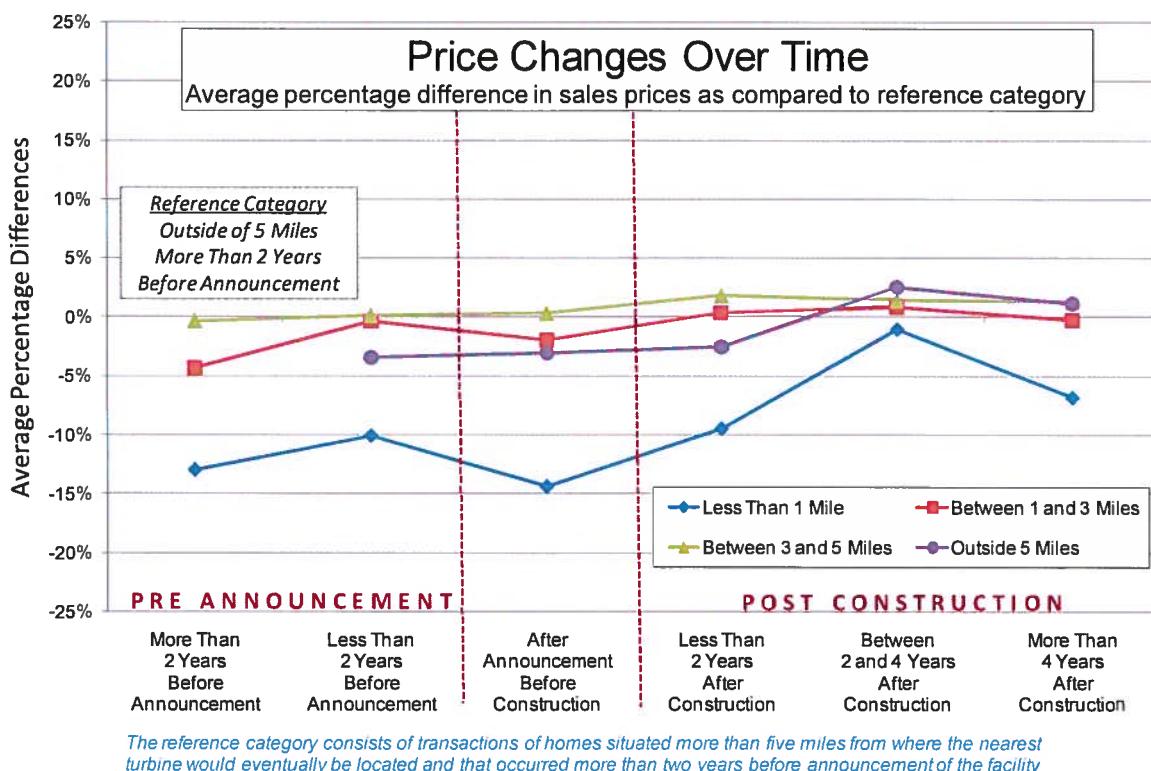
Conclusions and Further Research Needs

Though each of the analysis techniques used in this report has strengths and weaknesses, the results as a whole are strongly consistent in that none of the models uncovers conclusive evidence of the presence of any of the three property value stigmas that might be present in communities surrounding wind power facilities. Therefore, based on the data sample and analysis presented here, 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 homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, they are either too small and/or too infrequent to result in any widespread, statistically observable impact. Moreover, to the degree that homes and wind facilities in this sample are similar to homes and facilities in other areas of the United States, the results presented here are expected to be transferable to other areas.

This work builds on the existing literature in a number of respects, but 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 data sample herein was the most limited. 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. 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.

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Lawrence Berkeley National Laboratory

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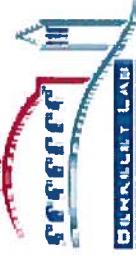
The Impact of Wind Power Projects on Residential Property Values in the U.S.

- Motivation and Study Methods

  – Motivation

  – Overview and Methods

  – Data Summary

- Summary of Analysis Results

- Conclusions and Further Research

Proximity to and Views of Environmental (Dis)Amenities Can Impact Property Values

Highway	Transmission Lines	Average Home	Green Space	Ocean Front
↓ $	↓ $	SOLD	↑ $	↑ $

This linkage is well studied generally, but not for wind power facilities

Aesthetics and Property Values Rank as Key Concerns for Wind Stakeholders

"Aesthetic perceptions, both positive and negative, are the strongest single influence on individuals' attitudes towards wind power projects."

(Warren, 2005, p. 853)

US developers rank aesthetics & property values as the #1 and #3 concerns of those in opposition to wind development (Paul, 2006)

100% and 85% of those opposed to offshore wind development believe aesthetics and property values, respectively, will be adversely impacted

(Firestone et. al., 2007)

Having structures on the Vermont hilltops was considered a "big disadvantage" by the majority of those surveyed before the Searsburg, VT wind facility was erected (Palmer, 1997)

Property Value Concerns for Wind Energy Fall Into Three Potential Categories

No one will move here!

1. **Area Stigma:** Concern that rural areas will appear more developed

It will ruin my view!

2. **Scenic Vista Stigma:** Concern over decrease in quality of scenic vistas from homes

I won't be able to live in my home!

3. **Nuisance Stigma:** Concern that factors that occur in close proximity will have unique impacts

Each of these effects could impact property values; none are mutually exclusive
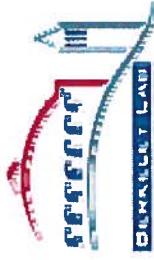
Relatively Few Existing Wind and Property Studies: A List of the Most Publicized

- **Variety of methods used,** from surveys to sales analyses, with varying levels of sophistication

- **Results are diverse,** and in many instances unpersuasive due to limitations in data and methodology

Document Type Author(s)	Year	Number of Transactions or Respondents	Before or After Wind Facility Construction Commenced	Area Stigma	Scenic Vista Stigma	Nuisance Stigma
Homeowner Survey						
Haughton et al.	2004	501	Before	-*	-*	
Goldman	2006	50	After	none		
Firestone et al.	2007	504	Before	-*	-*	
Bond	2008	~300	After		-?	-?
Expert Survey						
Grover	2002	13	After	none		none
Haughton et al.	2004	45	Before	-*	-*	
Khatri	2004	405	Before‡	-?		-?
Goldman	2006	50	After	none		none
Kielisch	2009	57	Before‡			-?
Transaction Analysis – Simple Statistics						
Jerabek	2001	25	After			none
Jerabek	2002	7	After			none
Sterzinger et al.	2003	24,000	After	none		
Beck	2004	2	After			none
Poletti	2005	187	After	none		
DeLacy	2005	21	Before†	none		
Goldman	2006	4	After	none		
Poletti	2007	256	After	none		none
McCann	2008	2	After			-?
Kielisch	2009	103	After			-?
Transaction Analysis – Hedonic Model						
Jordal-Jorgensen	1996	?	After			-?
Hoen	2006	280	After		none	
Sims & Dent	2007	919	After			-*
Sims et al.	2008	199	After		-/+*	

"none" indicates the majority of the respondents do not believe properties have been affected (for surveys) or that no effect was detected at 10% significance level (for transaction analysis)

"-?" indicates a negative effect without statistical significance provided

"-*" indicates statistically significant negative effect at 10% significance level

"-/+*" indicates positive and negative statistically significant effects at 10% significance level

† Sales were collected after facility announcement but before construction

‡ Some respondents had experience with valuations near facilities while others did not

Limitations of Existing Research

- **Many studies have relied on surveys** of homeowners or real estate professionals, rather than quantifying real impacts based on market data

- **Most studies have relied on simple statistical techniques** that have limitations and that can be dramatically influenced by small numbers of sales transactions or survey respondents

- **Most studies have used small datasets** that are concentrated in only one wind project study area, making it difficult to extrapolate findings

- **Many studies have not reported the statistical significance** of their results, making it difficult to determine if those results are meaningful

- **Many studies have concentrated on Area Stigma**, and have ignored Scenic Vista and/or Nuisance Stigma

- **Only a few studies have included field visits** to homes to determine wind turbine visibility and collect other important information

- **Only two studies have been published** in peer-reviewed journals
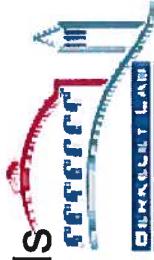
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- Motivation and Study Methods

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- Conclusions and Further Research

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Berkeley Lab Project Involves Most Data-Rich and Comprehensive Analysis To Date

Research Questions

1) Is there evidence that views of turbines measurably affect sales prices?

2) Is there evidence that proximity to turbines measurably affect sales prices?

3) Do the results change over time, and are there other observable impacts?

Relevance

Provides stakeholders in siting/permitting processes greater confidence in the likely effects of proposed wind energy facilities, allowing greater consensus on often-contentious setback requirements and viewshed valuations

Team

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Funder

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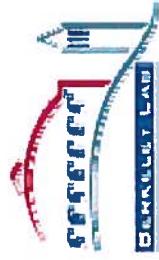
Research Approach Responds to Limitations of Previous Work

- **Conduct literature review** of previous wind / property value studies and wind facility public acceptance surveys, as well as potentially analogous studies on other disamenities (e.g. roads, power lines, power plants)

- **Collect large amount of data** on residential sales transactions occurring both pre- and post-construction surrounding a **representative sample** of wind facilities at **multiple locations** in the U.S.

- **Visit each home** to determine wind turbine visibility and to collect other important information about the home (e.g., the quality of the scenic vista)

- **Use multiple statistical models** to explore magnitude and statistical significance of potential effects, relying primarily on **hedonic model**

- **Test for the presence of all three stigmas** – Area Stigma, Scenic Vista Stigma, and Nuisance Stigma

- **Rigorously analyze** the data, culminating in an LBNL report and at least one journal paper

Collected Sales Data from 10 Study Areas Surrounding 24 Wind Facilities in 9 States

7,459 Residential Sales Transactions

1,754 Pre-Announcement, 4,937 Post-Construction, and 768 Post-Announcement-Pre-Construction

Madison Cnty, NY
Area 2: Fenner
20 WTG, 693 Sales

Wayne Cnty, PA
43 WTG,
551 Sales

Somerset Cnty, PA
3 Facilities: 34 WTG,
494 Sales

Madison Cnty, NY
Area 1: Madison
7 WTG, 463 Sales

Lee Cnty, IL
103 WTG,
412 Sales

Kewaunee Cnty, WI
2 Facilities: 31 WTG,
810 Sales

Custer Cnty, OK
2 Facilities: 98 WTG,
1,113 Sales

Buena Vista Cnty, IA
5 Facilities: 381 WTG,
822 Sales

3 Adjoining Counties
Washington & Oregon
7 Facilities: 582 WTG,
790 Sales

Howard Cnty, TX
46 WTG,
1,311 Sales

Legend:
- LBNL Study Areas
- Wind Facilities > 0.6 MW Completed Before 2006
- Represented States

500 Miles
0   125   250

Source
Energy Velocity, LLC
Lawrence Berkeley National Laboratory

Map Prepared By: LBNL

N

Research Relies on Hedonic Pricing Model in Addition to Other Models

What Is a Hedonic Pricing Model?

- **Well respected model** used by economists and real estate practitioners for over 40 years

- **Heterogeneous** residential sales data are used

- **Measures marginal price differences** between homes that vary by the variables of interest, after controlling for other characteristics

- **Controlling characteristics** include square feet, acres, bathrooms, fireplaces, age, condition and scenic vista of the home, location, etc.

- **Variables of interest** include view of turbines, distance from turbines, and development period (e.g. before or after construction began)

- **Results and significance levels** are important

Other Models Used in Analysis

Repeat Sales and Sales Volume Models

	Coef.	SE	p Value	n
Intercept	7.62	0.18	0.00	4,937
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

To Test for Scenic Vista Stigma, Scenic Vista Itself Is Controlled For

They might pull in two directions...

By separating out scenic vista, a potential bias is removed from measurements of the effects of the view of wind turbines
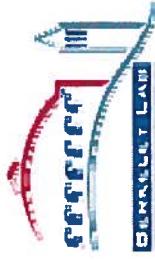
Five Qualitative Ratings Are Used for Quality of Scenic Vista

Premium

Above Average

Each home is given a scenic vista rating, based on field visits

Average

Poor

Below Average

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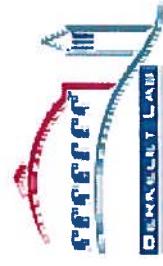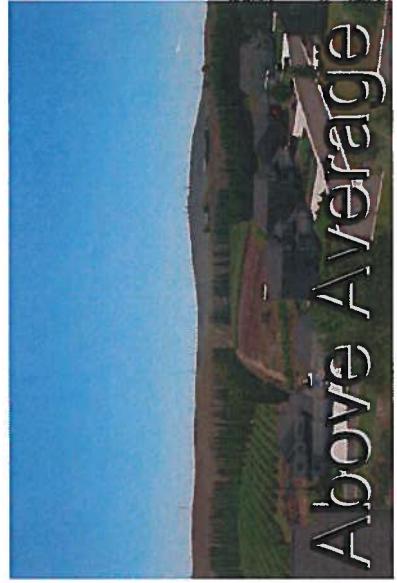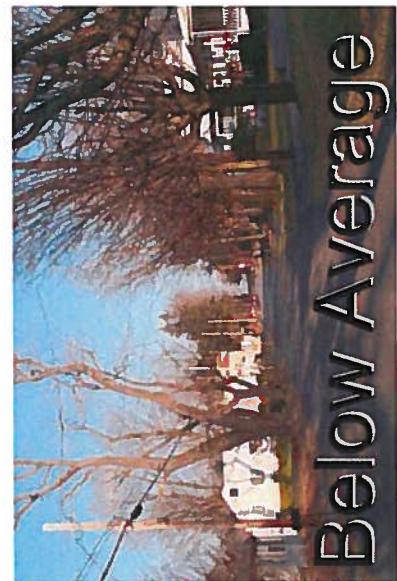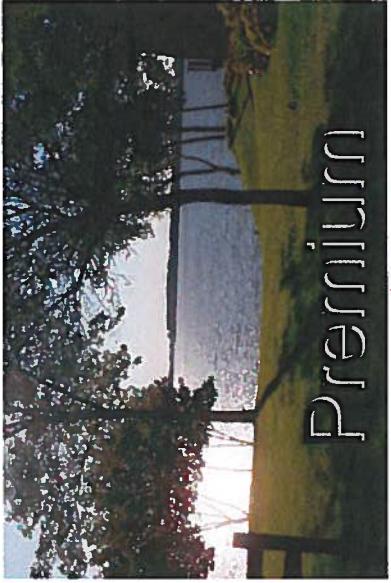
Four Qualitative Ratings Are Used for Dominance of View of Wind Turbines

Minor

Extreme

Each home is given a view of turbines dominance rating, based on field visits

Moderate

Substantial
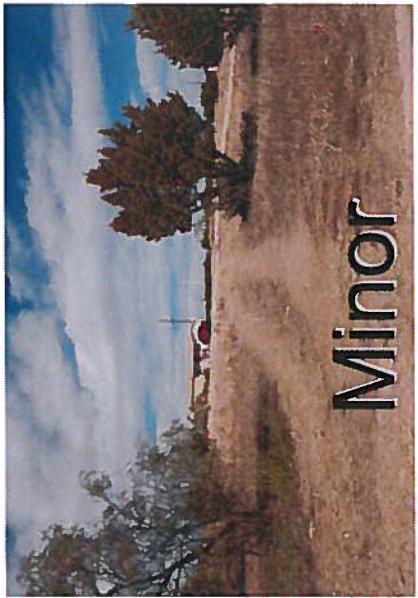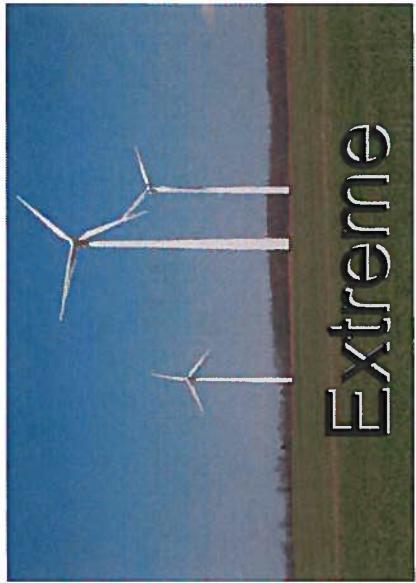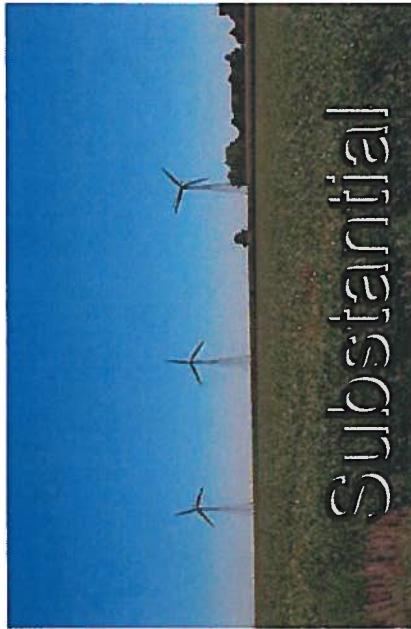
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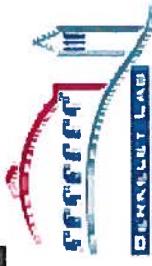
To Test for Area and Nuisance Stigmas,
Distance to Nearest Turbine at Time of Sale Is Determined

Five Distance Bands Are Created

Nuisance Stigma
- Inside of 3000 Feet
- Between 3000 Feet and 1 Mile

Area Stigma
- Between 1 and 3 Miles
- Between 3 and 5 Miles
- Outside of 5 Miles
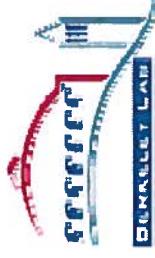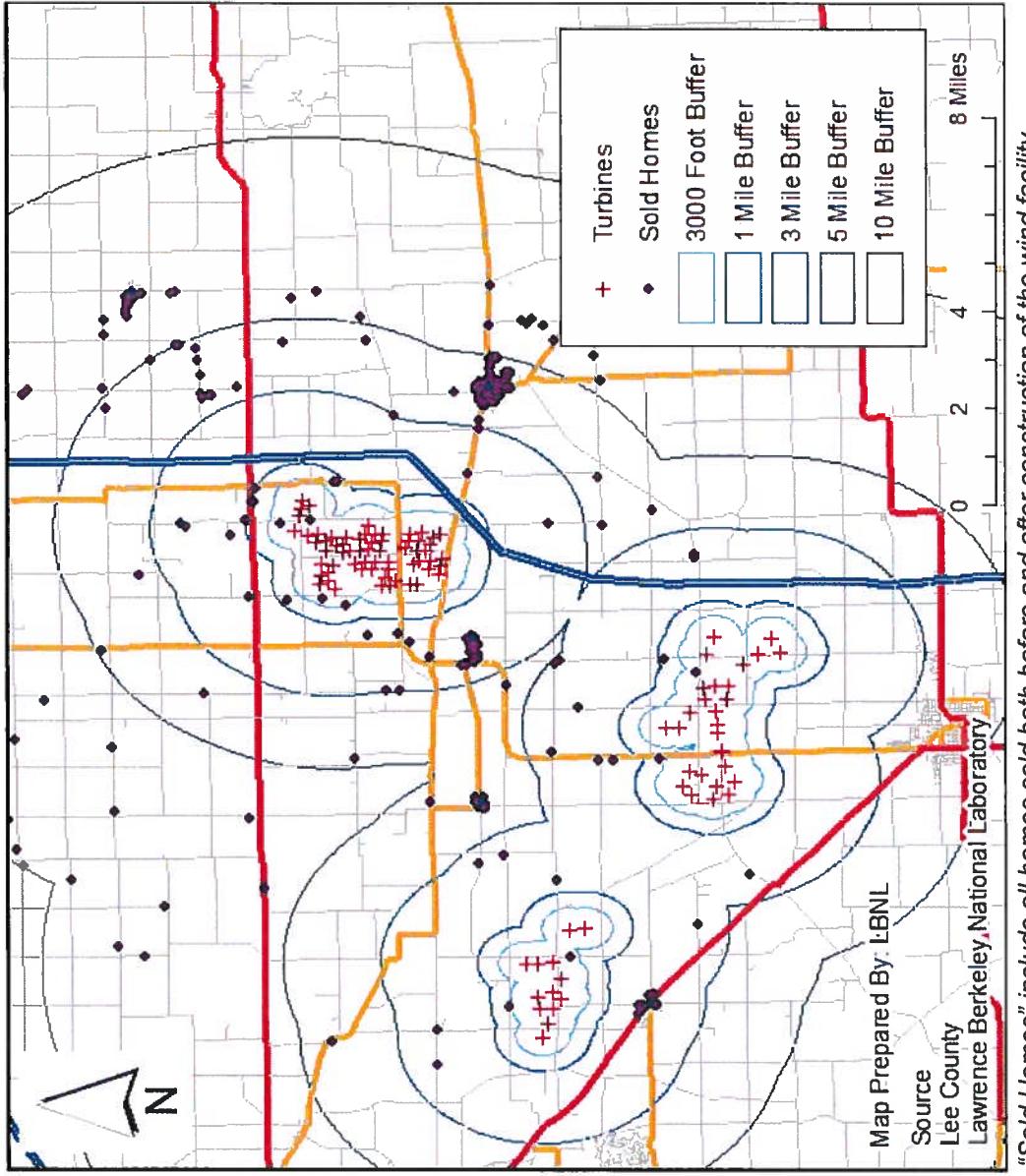
Map Prepared By: LBNL

Source
Lee County
Lawrence Berkeley National Laboratory

Legend:
- + Turbines
- • Sold Homes
- 3000 Foot Buffer
- 1 Mile Buffer
- 3 Mile Buffer
- 5 Mile Buffer
- 10 Mile Buffer

8 Miles

N

"Sold Homes" include all homes sold both before and after construction of the wind facility

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The Impact of Wind Power Projects on Residential Property Values in the U.S.

- Motivation and Study Methods

  - Motivation

  - Overview and Methods

  - Data Summary

- Summary of Analysis Results

- Conclusions and Further Research

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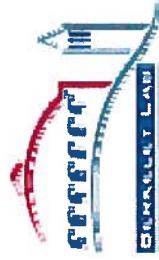
Summary of Transactions across Study Areas and Development Periods

	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	226	45	76	59	384	790
Howard, TX (TXHC)	169	71	113	131	827	1311
Custer, OK (OKCC)	484	153	193	187	96	1113
Buena Vista, IA (IABV)	152	65	80	70	455	822
Lee, IL (ILLC)	115	84	62	71	80	412
Kewaunee/Door, WI (WIKCDC)	44	41	68	62	595	810
Somerset, PA (PASC)	175	28	46	60	185	494
Wayne, PA (PAWC)	223	106	64	71	87	551
Madison/Oneida, NY (MYMCOC)	108	9	48	30	268	463
Madison, NY (NYMC)	59	165	74	70	325	693
TOTAL	1755	767	824	811	3302	7459

Frequency of DISTANCE Ratings for Post-Construction Transactions
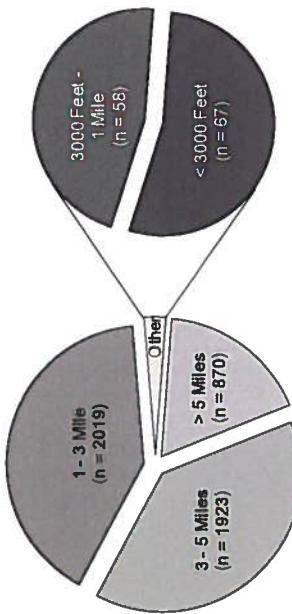
Frequency of VIEW Ratings for Post-Construction Transactions
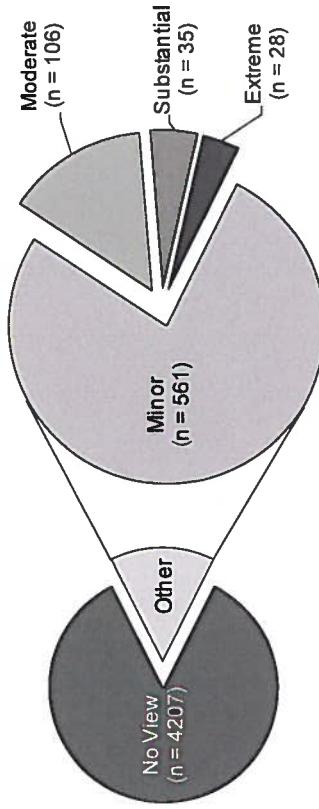
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The Impact of Wind Power Projects on Residential Property Values in the U.S.

- Motivation and Study Methods

- Summary of Analysis Results
  - Summary of Results of All Models
  - Key Model Results
    - Base Model - Scenic Vista, Area, and Nuisance Stigma
    - Temporal Aspects Model - Area and Nuisance Stigma
  - Summary of Results of Other Models

- Conclusions and Further Research

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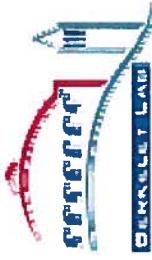
Eight Hedonic Models Used, as Well as Repeat Sales and Sales Volume Analyses

Variety of models used to investigate reliability of "Base Hedonic Model" results and to explore myriad of other potential effects from variety of perspectives

Data across study areas are pooled in this analysis; many other hedonic model specifications, including those with no pooling of data, are investigated

Statistical Model	Description
Base Hedonic Model	Using only "post-construction" transactions (those that occurred after the wind facility was built), this model investigates all three stigmas in a straightforward manner
Alternative Hedonic Models	
View Stability	Using only post-construction transactions, this model investigates whether the Scenic Vista Stigma results from the Base Model are independent of the Nuisance and Area Stigma results
Distance Stability	Using only post-construction transactions, this model investigates whether the Nuisance and Area Stigma results from the Base Model are independent of the Scenic Vista Stigma results
Continuous Distance	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
All Sales	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
Temporal Aspects	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
Orientation	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
Overlap	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
Repeat Sales Model	Using paired transactions of homes that sold once pre-announcement and again post-construction, this model investigates the three stigmas, using as a reference transactions of homes located outside of five miles of the nearest wind turbine and that have no view of the turbines
Sales Volume Model	Using both pre-announcement and post-construction transactions, this model investigates whether the rate of home sales (not the price of those sales) is affected by the presence of nearby wind facilities

Data collection, cleaning, validity, and regression tests are all discussed in detail in the full report

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Each Model Fails to Uncover Conclusive Evidence of Any of the Three Stigmas

Home Prices in Sample Are Not Measurably Impacted by Either the View of or Distance to Wind Facilities

Statistical Model	Is there statistical evidence of:			Section Reference
	Area Stigma?	Scenic Vista Stigma?	Nuisance Stigma?	
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

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The Impact of Wind Power Projects on Residential Property Values in the U.S.

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- Conclusions and Further Research

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Base Hedonic Model Results:

There Is Strong Statistical Evidence that the Quality of the Scenic Vista Affects Sales Prices
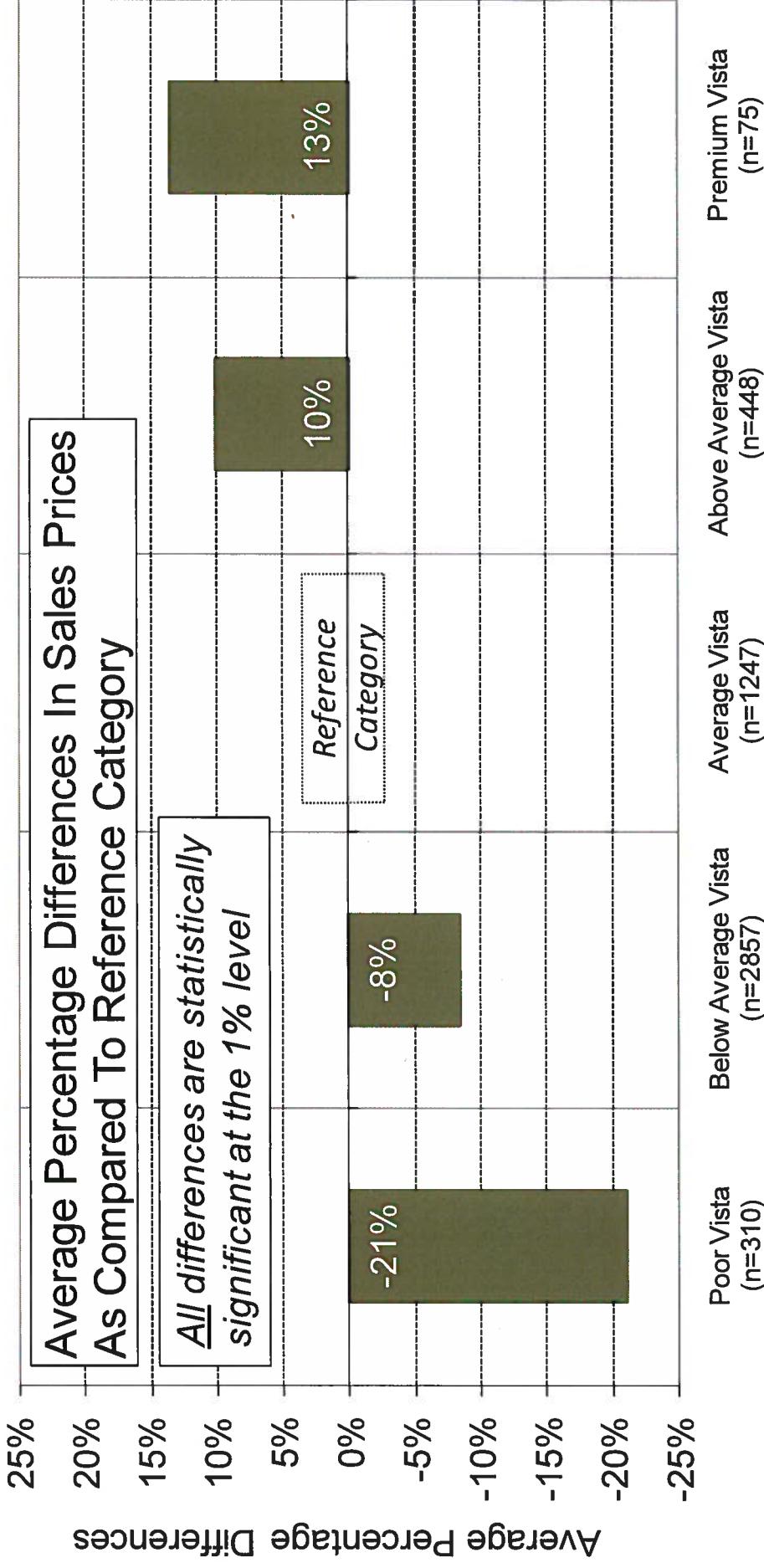
Average Percentage Differences In Sales Prices As Compared To Reference Category

All differences are statistically significant at the 1% level

Reference Category

13%

10%

-8%

-21%

Poor Vista (n=310)

Below Average Vista (n=2857)

Average Vista (n=1247)

Above Average Vista (n=448)

Premium Vista (n=75)

Average Percentage Differences

25% 20% 15% 10% 5% 0% -5% -10% -15% -20% -25%

The reference category consists of transactions for homes with an Average Vista, and that occured after construction began on the wind facility

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Base Hedonic Model Results:

There Is a Lack of Statistical Evidence that the Dominance of the Views of Turbines Affects Sales Prices
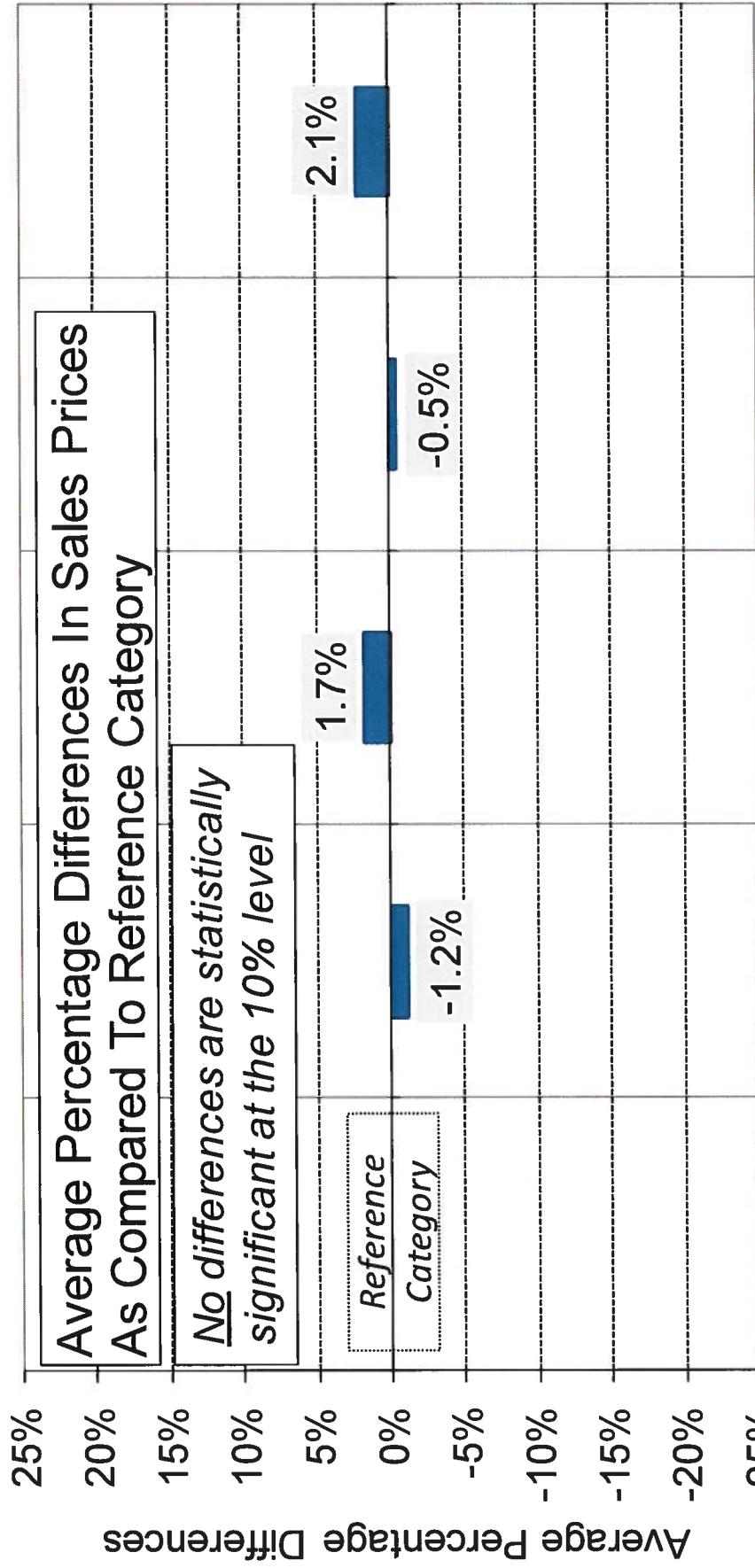
Average Percentage Differences In Sales Prices As Compared To Reference Category

No differences are statistically significant at the 10% level

Reference Category

Average Percentage Differences

25%
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
-25%

-1.2%

1.7%

-0.5%

2.1%

No View of Turbines (n=4207)

Minor View (n=561)

Moderate View (n=106)

Substantial View (n=35)

Extreme View (n=28)

The reference category consists of transactions for homes without a view of the turbines, and that occured after construction began on the wind facility

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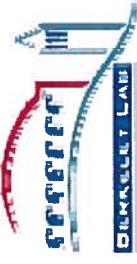
Base Hedonic Model Results:
There Is a Lack of Statistical Evidence that the Distance to the Nearest Turbine Affects Sales Prices
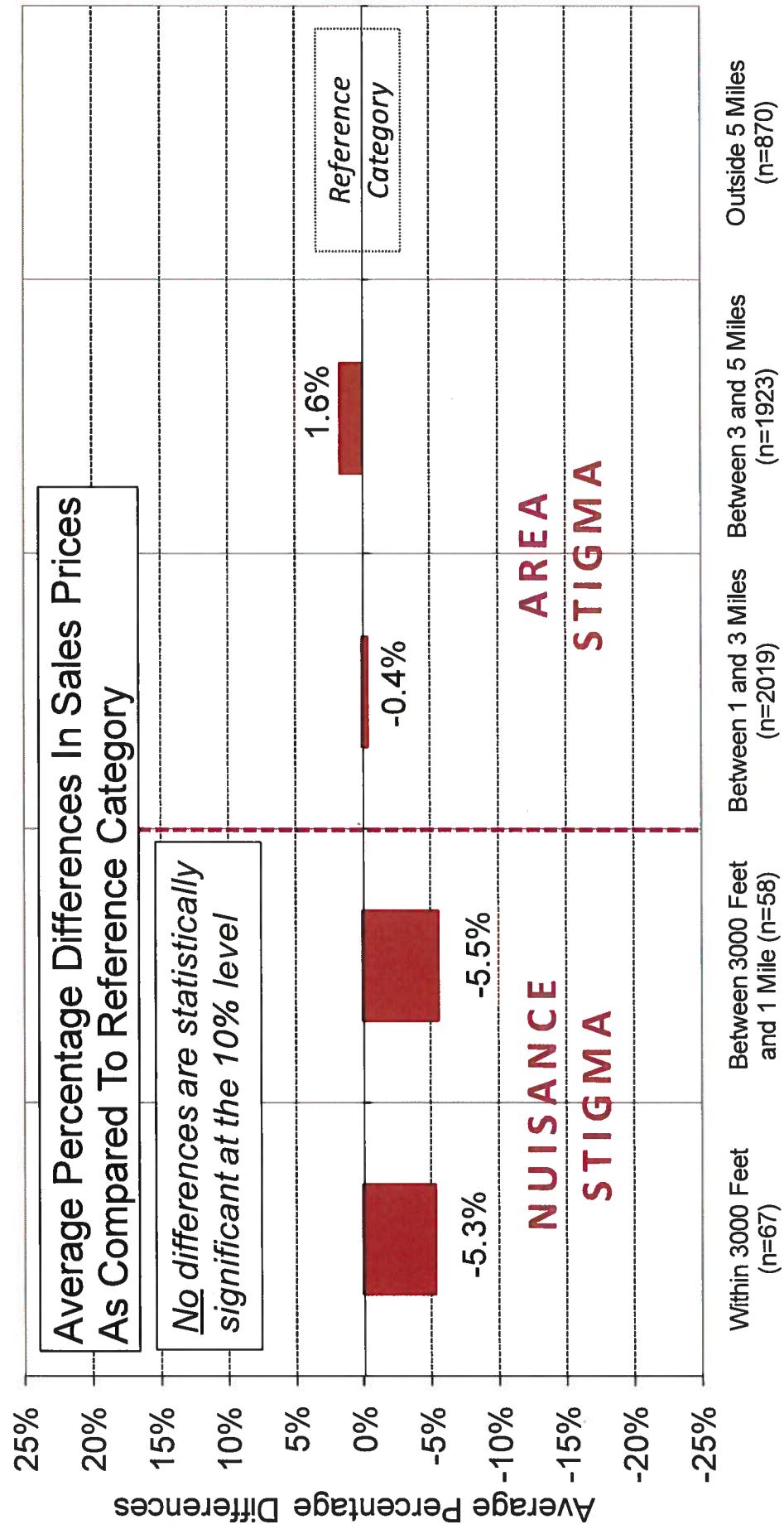
Average Percentage Differences In Sales Prices As Compared To Reference Category

No differences are statistically significant at the 10% level

Reference Category

1.6%

-0.4%

-5.5%

-5.3%

NUISANCE STIGMA

AREA STIGMA

| Within 3000 Feet (n=67) | Between 3000 Feet and 1 Mile (n=58) | Between 1 and 3 Miles (n=2019) | Between 3 and 5 Miles (n=1923) | Outside 5 Miles (n=870) |

Average Percentage Differences

25% 20% 15% 10% 5% 0% -5% -10% -15% -20% -25%

The reference category consists of transactions for homes situated more than five miles from the nearest turbine, and that occured after construction began on the wind facility

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The Impact of Wind Power Projects on Residential Property Values in the U.S.

- Motivation and Study Methods

- Summary of Analysis Results

  – Summary of Results of All Models

  – Key Model Results

    • Base Model - Scenic Vista, Area, and Nuisance Stigma

    • Temporal Aspects Model - Area and Nuisance Stigma

  – Summary of Results of Other Models

- Conclusions and Further Research
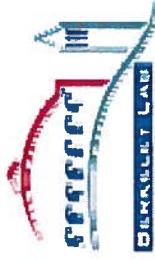
Temporal Aspects Model Results:

Homes Nearest the Turbines Were Depressed in Value Before Construction and Appreciated the Most After Construction While Homes Further Away Were Largely Unchanged Over Time

Price Changes Over Time

Average percentage difference in sales prices as compared to reference category

Reference Category
Outside of 5 Miles
More Than 2 Years
Before Announcement

Legend:
- Less Than 1 Mile
- Between 1 and 3 Miles
- Between 3 and 5 Miles
- Outside 5 Miles
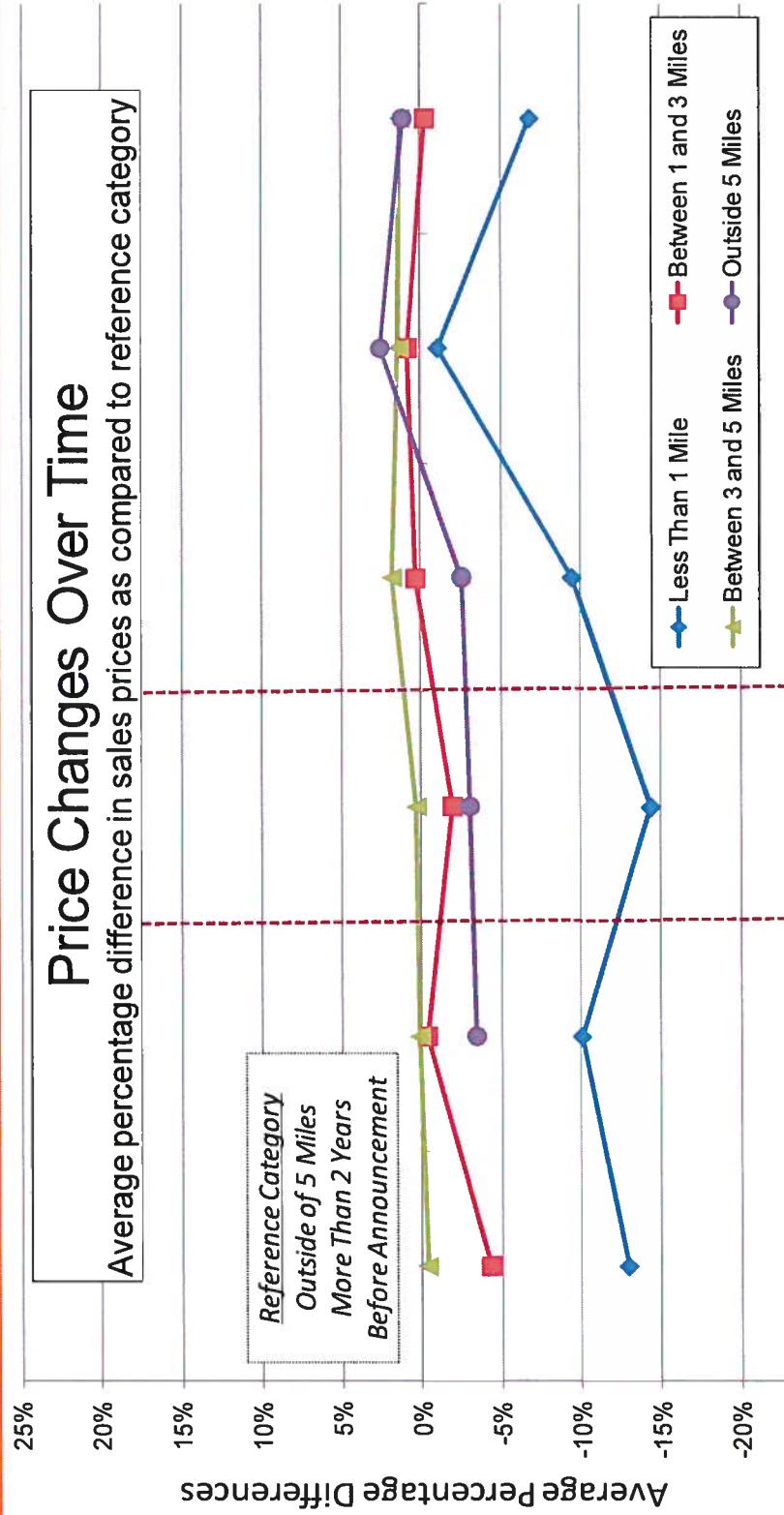
PRE ANNOUNCEMENT
- More Than 2 Years Before Announcement
- Less Than 2 Years Before Announcement
- After Announcement Before Construction

POST CONSTRUCTION
- Less Than 2 Years After Construction
- Between 2 and 4 Years After Construction
- More Than 4 Years After Construction

Y-axis: Average Percentage Differences (25% to -25%)

The reference category consists of transactions of homes situated more than five miles from where the nearest turbine would eventually be located and that occurred more than two years before announcement of the facility

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The Impact of Wind Power Projects on Residential Property Values in the U.S.

- Motivation and Study Methods

- **Summary of Analysis Results**
  - Summary of Results of All Models
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  - **Summary of Results of Other Models**

- Conclusions and Further Research

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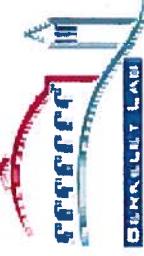
Results from Other Models Support Basic Conclusions from Base Hedonic Model

Some examples are...

Repeat Sales Model: Investigated appreciation rates between houses that sold twice with various views of and distances from turbines

Sales Volume Model: Investigated the numbers of homes that sold as a percentage of those that were available to sell at various distances from the turbines

Hedonic Orientation Model: Investigated whether a home's orientation to the view of turbines has an effect on selling price

Hedonic Overlap Model: Investigated whether the degree to which the view of the turbines overlaps the scenic vista has an effect

The results are consistent across all models in that none uncovers conclusive evidence of the existence of any widespread property value impacts for any of the three stigmas

The Impact of Wind Power Projects on Residential Property Values in the U.S.

- Motivation and Study Methods

- Summary of Analysis Results

- Conclusions and Further Research

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Conclusions

Although the analysis cannot dismiss the possibility that individual homes have been or could be negatively impacted, the Berkeley Lab research finds that if these impacts do exist in the sample of homes analyzed, they are either too small and/or too infrequent to result in any widespread, statistically observable effect

- **Area Stigma:** Homes in the study areas analyzed do not appear to be measurably stigmatized by the arrival of a wind facility

- **Scenic Vista Stigma:** None of the various models finds strong statistical evidence that the view of a nearby wind facility impacts sales prices in a significant and consistent manner

- **Nuisance Stigma:** Homes in the sample that are within a mile of the nearest wind facility, where various nuisance effects have been posited, have not been broadly and measurably affected by the presence of those wind facilities

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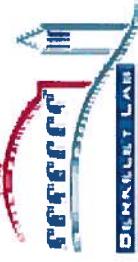
Further Research Recommendations

- **Complete "primer"** to summarize findings, place results into broader literature of disamenities, and outline options to measure, mitigate, and manage property value risks

- **Survey homeowners** living close to existing wind facilities especially those who have bought and sold homes in proximity to wind facilities after facility construction

- **Conduct more detailed analysis on sales volume** impacts including time on the market prior to sale

- **Revisit hedonic analysis** when more data are available for homes located particularly close to and having dominating view of wind facilities
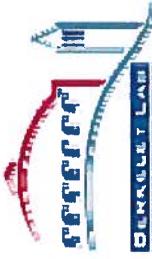
For More Information...

See full report for additional findings, a discussion of the sources of data used, etc.

- http://eetd.lbl.gov/ea/ems/re-pubs.html

To contact the primary authors

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