
Impacts on Residential Property Values Near Wind Turbines:

An Overview of Research Findings and Where to Go From Here

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Impacts on Residential Property Values Near Wind Turbines

- Wind Energy and Property Values
 - Overview of Subject
 - Previous Literature
 - Berkeley Lab Research
 - Other Disamenity Research
- Where To Go From Here

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



- This linkage is well studied generally, but not for wind facilities
- The home/land is often the largest asset in resident's portfolio
- Prior to wind facility construction, impacts (e.g., visual and auditory) to individual properties are difficult to quantify

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

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

No one will move here!

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

It will ruin my view!

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

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

Each of these effects could impact property values;
none are mutually exclusive

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Relatively Few Existing Wind and Property Studies

- **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
- Variety of methods and sample type makes **comparisons between results difficult**

| 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 |
| Crowley | 2007 | 42 | After | none | 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 | | 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 | | | - ? |
| Schneider | 2010 | 2,330 | Before | - */ none | | |
| Transaction Analysis - Hedonic Model | | | | | | |
| Jordal-Jorgensen | 1996 | ? | After | | | - ? |
| Hoen | 2006 | 280 | After | | none | |
| Sims & Dent | 2007 | 919 | After | | | - * |
| Sims et al. | 2008 | 199 | After | | -/+ * | |
| Hoen, Wiser et al. | 2009 | 7,459 | After | none | none | none |
| "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 | | | | | | |

Conclusions Drawn From Previous Literature on Wind Energy and Property Values

- Wind facilities have been **predicted to negatively impact property values** by some (e.g., Haughton; Firestone et al.), sometimes by as much as 24-43% (Kielisch)
- **Many experts** (e.g., appraisers, assessors, realtors) **have not experienced notable reductions** in value after construction (Grover; Goldman; Crowley)
- **Large impacts (e.g., >10%) have failed to materialize** when actual sales are investigated after construction (Poletti; Hoen; Sims & Dent; Sims et al.) **except for one study of land sales** (Kielisch)
- **Impacts**, to the degree that they exist, **are most likely very near turbines** (e.g., within ½ mile where they can be heard and seen) (McCann) and occur **after announcement but prior to construction** (Schnieder)

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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Berkeley Lab 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

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, viewshed valuations and non-participating landowner arrangements.

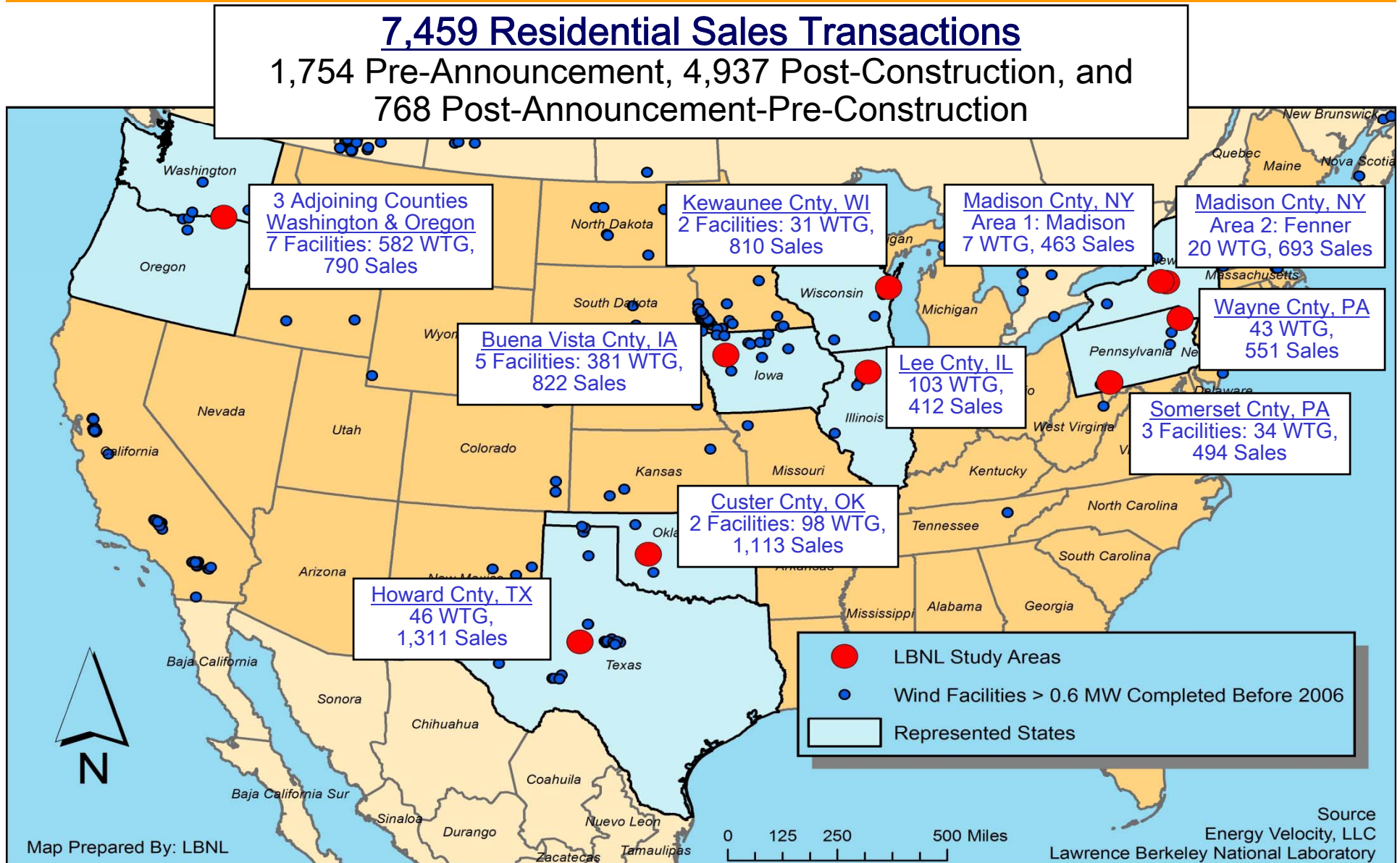
Team

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



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)
- **Estimates and significance levels** are important

Other Models Used in Analysis

Repeat Sales and Sales Volume Models

| | Coeff. | 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 |

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



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

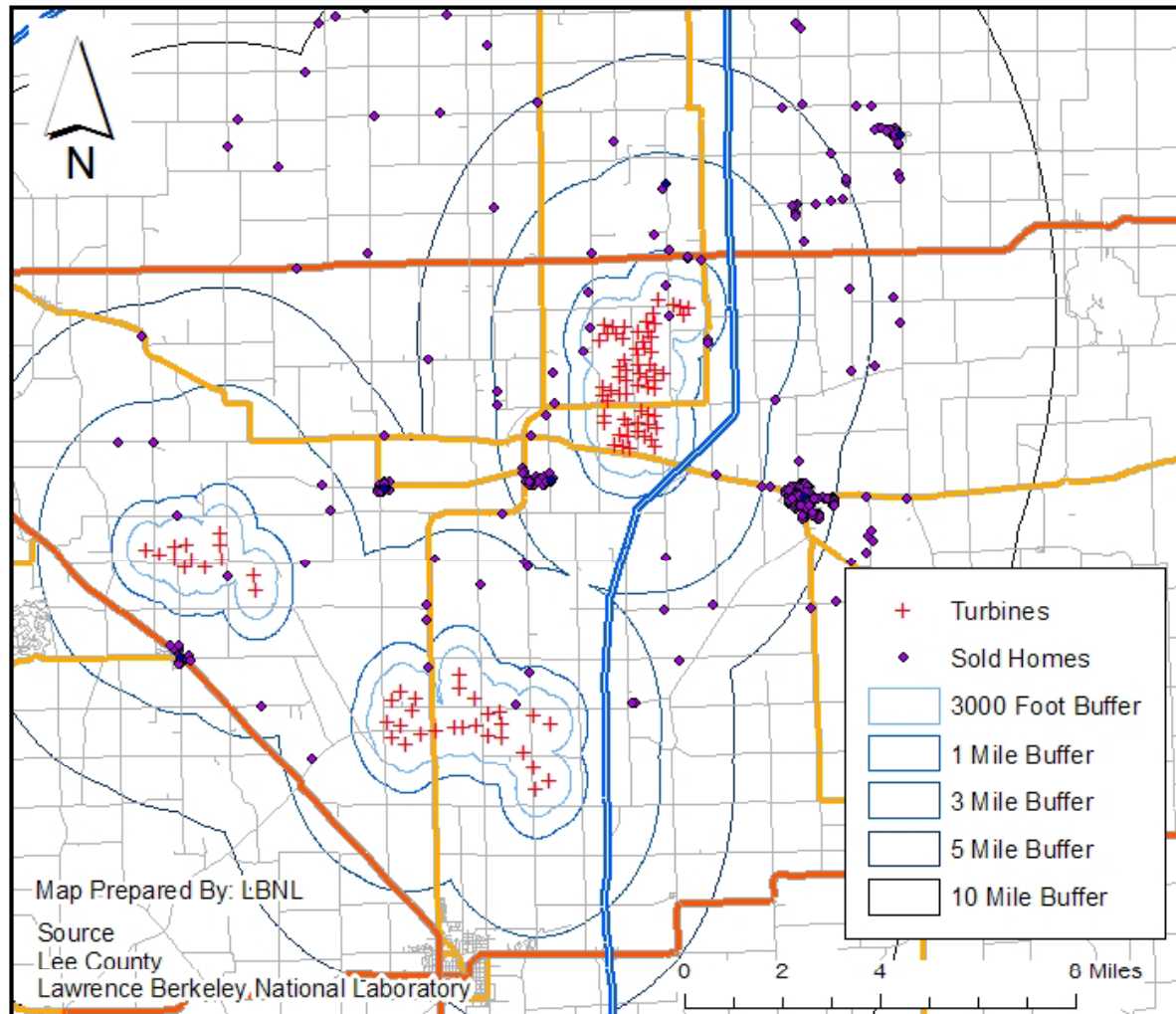
Four Qualitative Ratings Are Used for Dominance of View of Wind Turbines



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



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



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

Five Distance Bands Are Created

Nuisance Stigma

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

Area Stigma

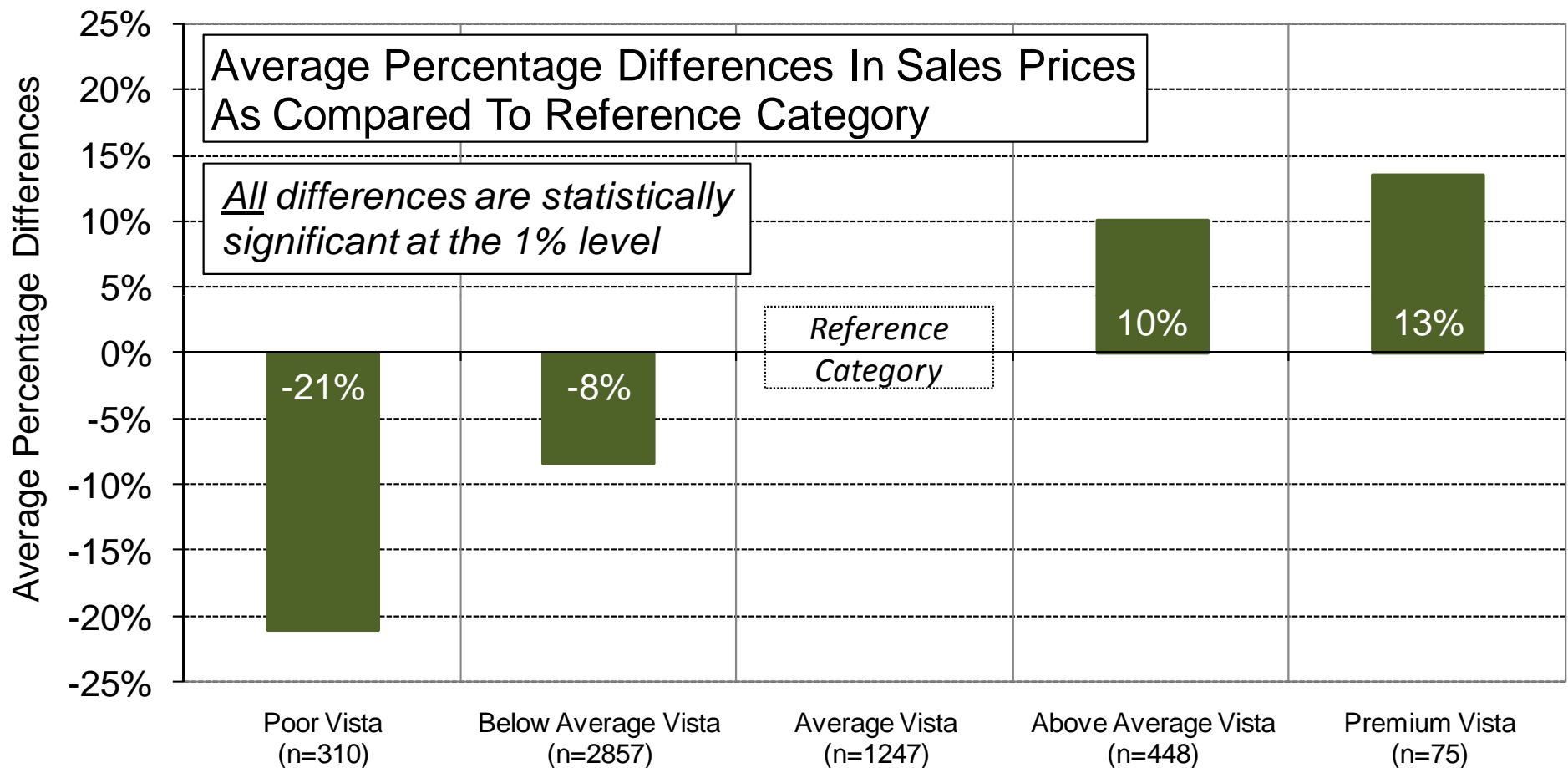
- Between 1 and 3 Miles
- Between 3 and 5 Miles
- Outside of 5 Miles

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Base Hedonic Model Results:

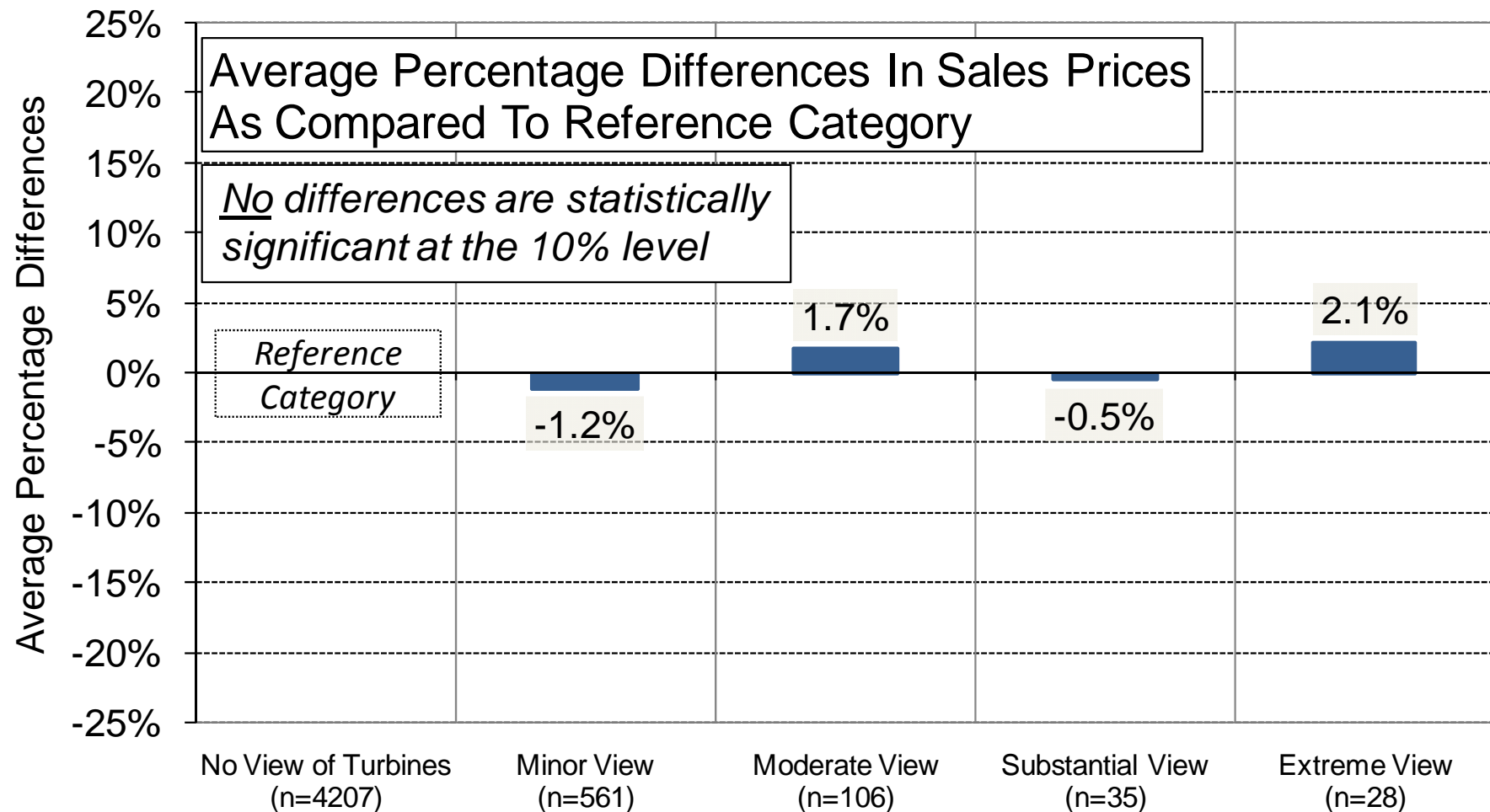
There Is Strong Statistical Evidence that the Quality of the Scenic Vista Affects Sales Prices



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

Base Hedonic Model Results:

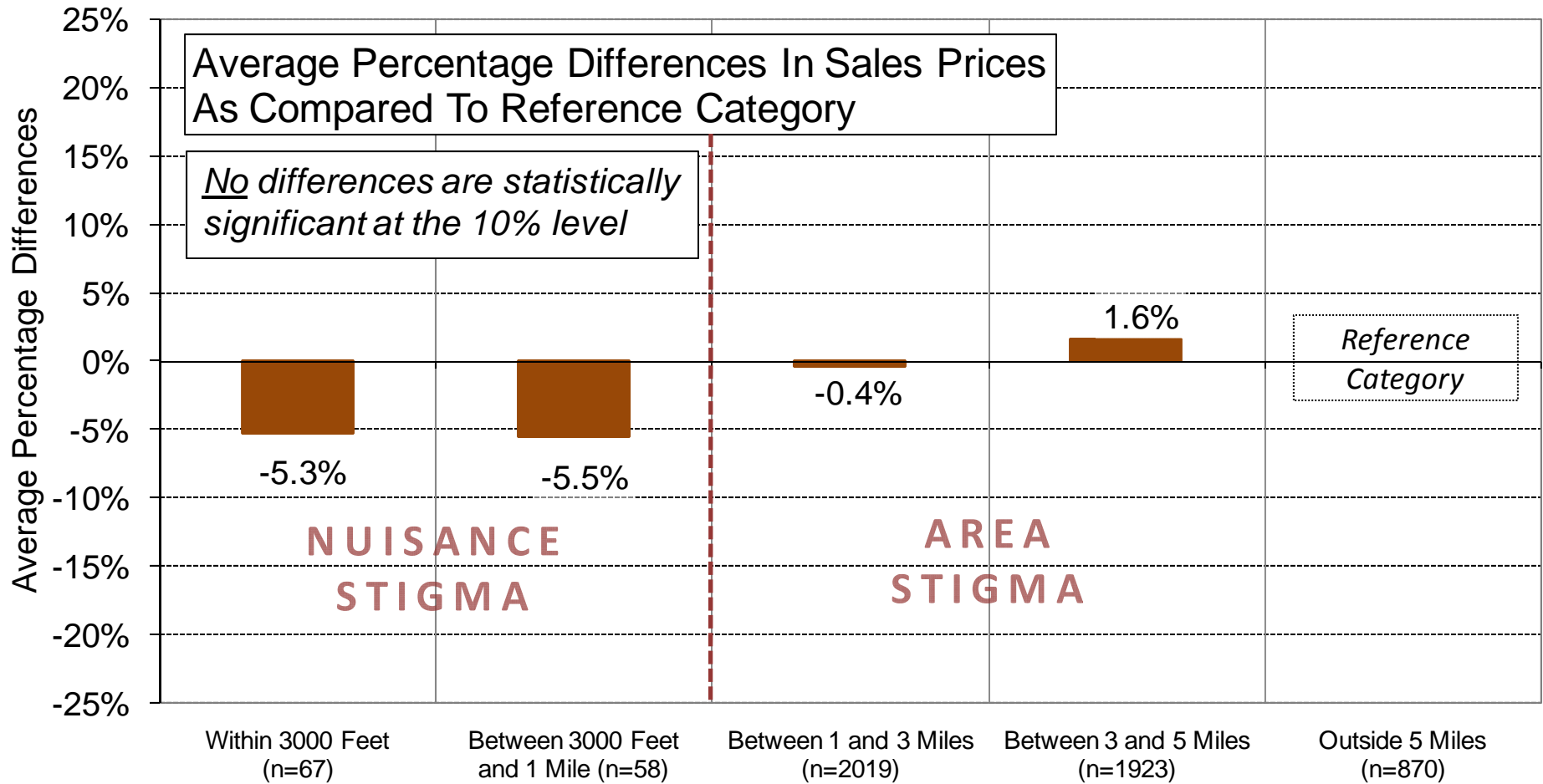
There Is a Lack of Statistical Evidence that the Dominance of the Views of Turbines Affects Sales Prices



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

Base Hedonic Model Results:

There Is a Lack of Statistical Evidence that the Distance to the Nearest Turbine Affects Sales Prices

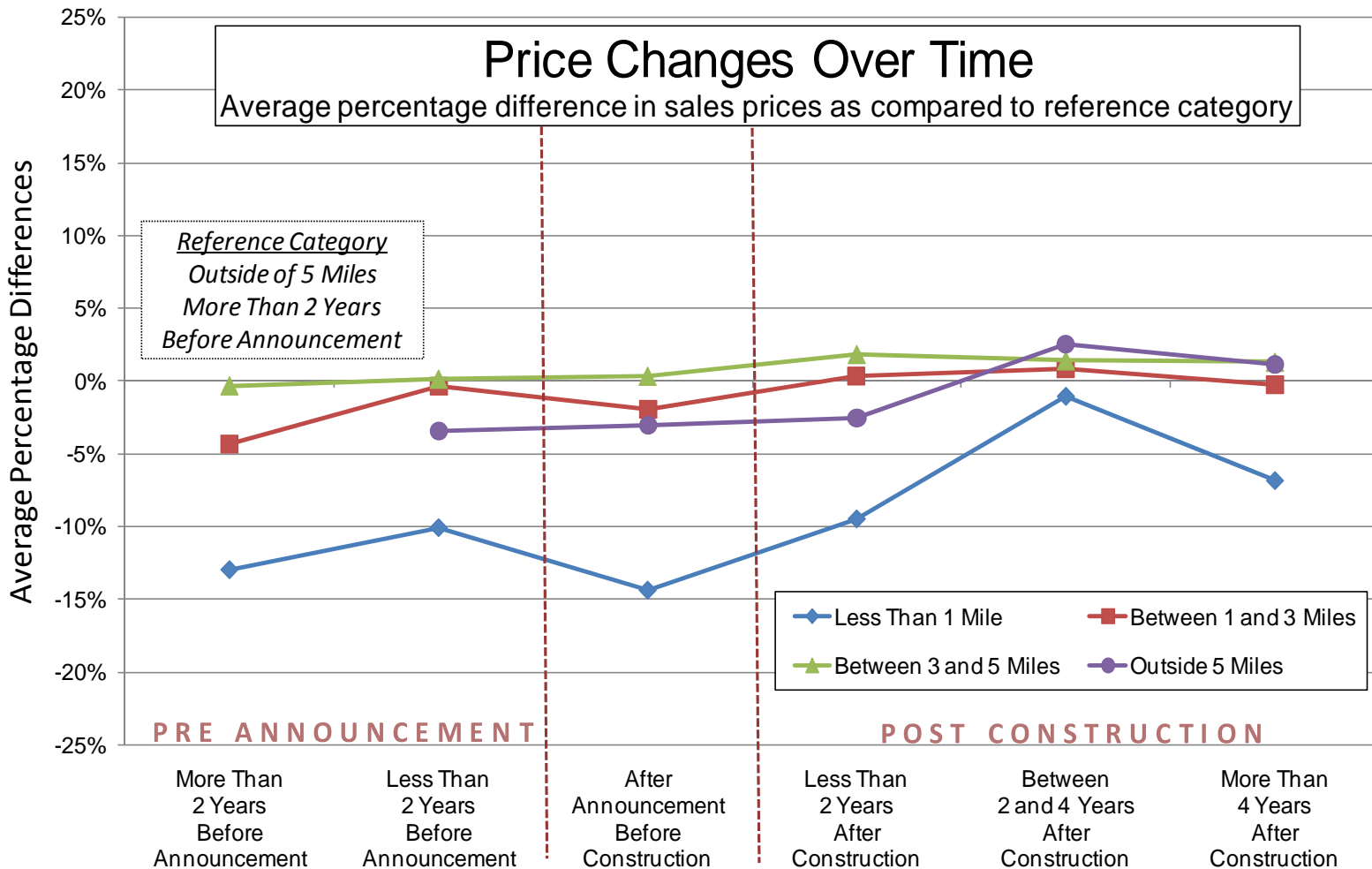


The reference category consists of transactions for homes situated more than five miles from the nearest turbine, and that occurred after construction began on the wind facility



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

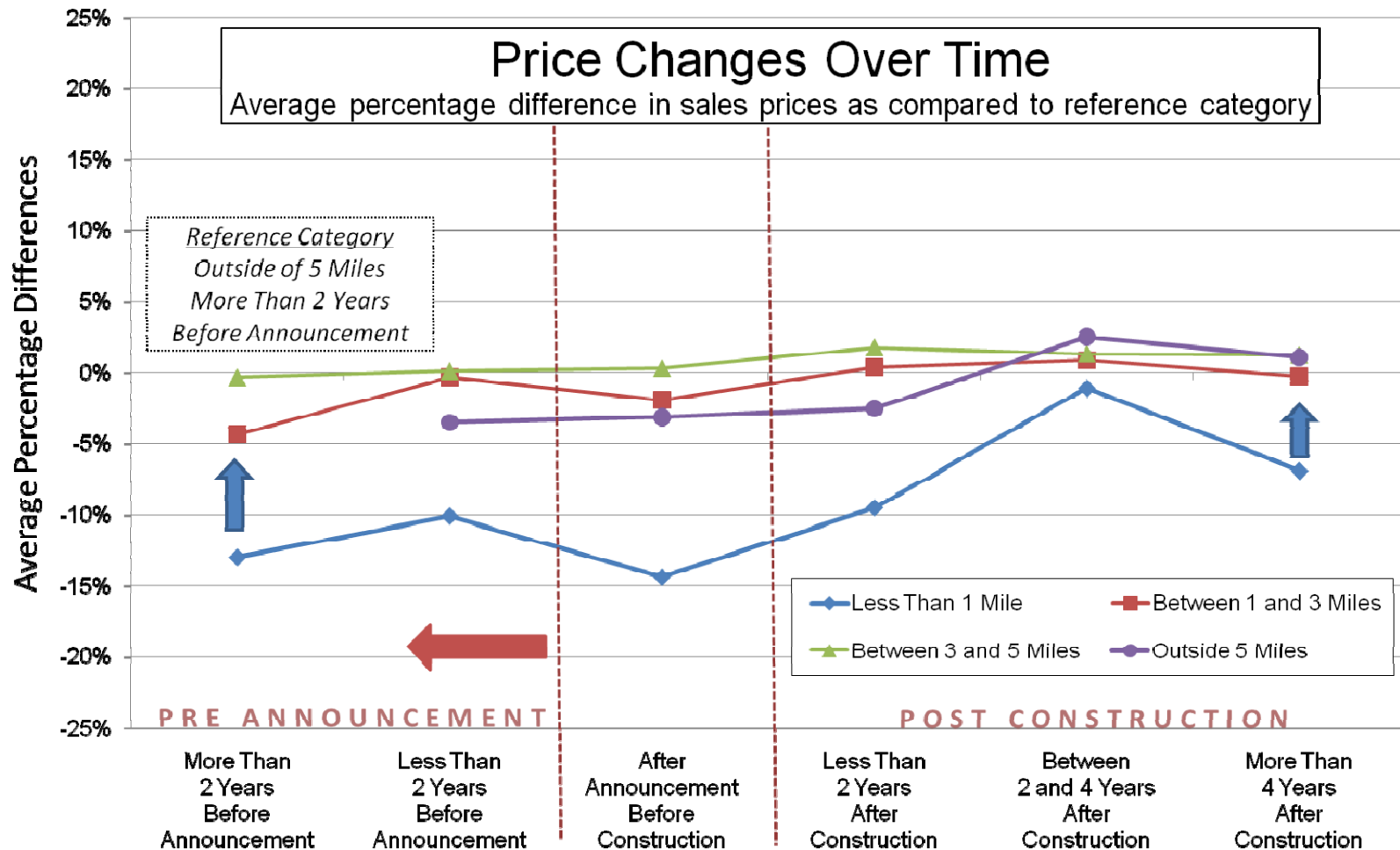


The reference category consists of transactions of homes situated more than five miles from where the nearest turbine would eventually be located and that occurred more than two years before announcement of the facility



Temporal Aspects Model Additional Sensitivity Results:

Potentially Sales Prices Are Affected in the Post Announcement Pre Construction Period and then Return to More Normal Levels Following Construction



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 Based on This Sample

- **Area Stigma:** There is an **absence of evidence** that sales prices of homes without views of turbines and further than one mile from the nearest turbine are stigmatized by the arrival of facility
- **Scenic Vista Stigma:** There is an **absence of evidence** that sales prices of homes with a view of the turbines are uniquely stigmatized even if that view is “dramatic”
- **Nuisance Stigma:** There is an **absence of evidence** that prices of sales occurring **after construction** of the facility for homes within a mile of the nearest wind turbine in this sample are affected and **some evidence** that sales occurring **prior to construction** are affected

“Absence of Evidence” does not equate to “Evidence of Absence”
But if effects do exist in this sample, they are either too small and/or too infrequent to result in any statistically observable effect

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Other Disamenity Research Have Conforming Results

| Disamenity | Study | Location | Percentage Change | Difference | Effect Limit |
|--|---------------------------|------------------------|---------------------------|---------------------------------|--------------|
| Crematory | Agee and Crocker (2008) | Rawlings, WY | -2% to -16%* | within a mile | |
| Superfund | Gayer et al. (2000) | Grand Rapids, MI | -4% to -6%* | within a mile | |
| Superfund | Kiel & Zabel (2001) | Woburn, MA | -15% | within a mile | |
| Groundwater Contamination Pre Remediation | Case et al. (2006) | Scottsdale & Tempe, AZ | -7% | in currently contaminated area | |
| Groundwater Contamination Post Remediation | Case et al. (2006) | Scottsdale & Tempe, AZ | no difference | in previously contaminated area | |
| Waste Transfer Station | Eshet et al. (2007) | Israel | -12% | within a mile | |
| Industrial - Superfund | Carroll et al. (1996) | Henderson, NV | -7% | within a mile | 2.5 miles |
| Lead Smelter | Dale et al. (1999) | Dallas, TX | -0.8% to -4% | within a mile | 2 miles |
| Power Plant | Davis (2008) | assorted | -3% to -5% | within 2 miles | |
| Landfill - High Volume | Ready (2005) | assorted | -13% | adjacent to landfill | 2 miles |
| Landfill - Low Volume | Ready (2005) | assorted | 0% to -3% | adjacent to landfill | 2 miles |
| Landfill | Reichert et al. (1992) | Cleveland, OH | -5% to -7% | within a few blocks | |
| Landfill | Thayer et al. (1992) | ? | -2% to -5% | within a mile | 4 miles |
| Transmission Line | Hamilton & Schwann (1995) | Vancouver, Canada | -6% | adjacent to tower | 330 feet |
| Transmission Line | Des Rosiers (2002) | Montreal, Canada | -10% | adjacent to tower | 150 feet |
| Road Noise | Batemen et al. (2001) | Glasgow, Scotland | -0.2% to -2% | increase of 5 dBA** | |
| Road Noise - 29 Study Review | Batemen et al. (2001) | assorted | 0% to -11% (2% median) | increase of 5 dBA** | |

* based on 2008 median house price (source: city-data.com)

** 10 dBA roughly represents the difference in noise between a busy road and a quiet street

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Where To Go From Here?

Do these results imply that property values effects near turbines do not exist? **NO!**

But rather, if effects do exist after construction, given current research, effects are likely to be relatively small and/or infrequent.

Further, where effects do exist in greater magnitude/frequency they are most likely to occur after announcement of the facility and prior to construction and in close proximity.

So, given these results, are property values something stakeholders should be concerned about?

OF COURSE!

Property Value Risks Will Persist Unless They Are Measured, Mitigated and Managed

Measure

Continue to Measure to Better Understand Effects,
to test the robustness of previous findings,
and explore nuances in effects (e.g., changes over time)

- Use other techniques (e.g., paired sales, surveys, appraisals)
- Use similar techniques with other data (e.g., new facilities)
- Test for other analogous effects (e.g., time on the market, sales volume)
- Publish results in journals

Modulate as knowledge and methods evolve!

Property Value Risks Will Persist Unless They Are Measured, Mitigated and Managed

Mitigate

Increase efforts to quantify risks for those living closest so as to reduce risk adverse actions, and **improve models** and resulting regulations

- Organize visits to other facilities; having discussions with nearby residents (both participating and non-participating);
- Model visual and audio aspects; Use video to better describe aesthetic impacts
- Improve models to better predict visual (e.g., via LIDAR) and audio impacts (e.g., take into account wind shear).
- Adjust regulations and maximum sound limits to take into account meteorological conditions and sound output under all operating conditions

Modulate as knowledge and methods evolve!

Property Value Risks Will Persist Unless They Are Measured, Mitigated and Managed

Manage

Manage risks in the short term for homeowners through tenable/workable measures

- Offer some combination of neighbor agreements/incentives and/or property value guarantees (e.g., Dekalb County, IL) to nearby homeowners as are economically tenable and legally workable
- Conduct follow up studies (e.g., surveys, appraisals)
- Realize that cumulative impacts may exist
- Realize that real or perceived risks may increase/decrease as more/better information become available

For More Information...

See full report LBNL report

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

To contact the primary authors of report and me

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