Research and Updates on Wind Property Value Impacts

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Lawrence Berkeley National Laboratory

German Federal Ministry For Economy & Energy
June 3, 2015
<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>0:00</td>
<td>Background &amp; Methodology</td>
</tr>
<tr>
<td>0:05</td>
<td>Recent US Wind Property Value Studies</td>
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<tr>
<td>0:10</td>
<td>Recent EU Wind Property Value Studies</td>
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<tr>
<td>0:15</td>
<td>Comparisons</td>
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</tbody>
</table>
Why Study Property Values?

House prices are sensitive to location and the surrounding environment.

- Highway: $↓
- Transmission Lines: $↓
- Average Home: $↑
- Green Space: $↑
- Ocean Front: $↑
Why Study Property Values?

House prices can:
- Reveal preferences that some surveys cannot
- Clarify appropriate compensation
- Can be house specific or averaged over many homes
Why Study Property Values?

For many communities that are considering wind energy:

Protection of property values is #1 issue

Because the home is the largest asset for most residents
Hedonic Pricing Model
(Also Known As A Multiple Linear Regression Model)

- **Well respected model** used by practitioners (appraisers, assessors, academics) for over 40 years.

- **Uses sale prices of homes** as dependent variables to examine environmental effects

- **Measures marginal price differences** between homes that differ by the variables of interest while controlling for other variables

- **Many Controlling variables** include square feet, acres, bathrooms, age of the home, year and season of sale, and neighborhood

- **Robustness tests** allow assumptions to be tested in a variety of ways to ensure results are consistent

- **Estimates and Significance Levels (aka margins of error)** are important
A Difference-In-Difference Model Can Be Used To Control For Pre-Existing Price Differences

<table>
<thead>
<tr>
<th>Wind Facility Development Periods</th>
<th>Distances to Nearest Turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Announcement</td>
<td>Close to the Turbines</td>
</tr>
<tr>
<td></td>
<td>A0</td>
</tr>
<tr>
<td></td>
<td>Moderate Distance From the Turbines</td>
</tr>
<tr>
<td>Post-Announcement &amp; Pre-Construction</td>
<td>Far Away From the Turbines</td>
</tr>
<tr>
<td></td>
<td>B0</td>
</tr>
<tr>
<td></td>
<td>B1</td>
</tr>
<tr>
<td>Post-Construction (Operation)</td>
<td>Interest Category</td>
</tr>
<tr>
<td></td>
<td>C1</td>
</tr>
<tr>
<td></td>
<td>Far Away From the Turbines</td>
</tr>
<tr>
<td></td>
<td>C3</td>
</tr>
</tbody>
</table>

A Difference - In - Difference Model Can Be Used To Control For Pre-existing Price Differences.
Three Major New US Studies Were Released In Late 2013 / Early 2014 Adding To 2009 Study

Recent Studies Investigating Property Value Impacts of Surrounding Operating Turbines In North America

<table>
<thead>
<tr>
<th>Authors</th>
<th>US Location</th>
<th>Date</th>
<th>W/in 1 Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBNL</td>
<td>US Wide</td>
<td>2009</td>
<td>~ 125</td>
</tr>
<tr>
<td>LBNL</td>
<td>US Wide</td>
<td>2013</td>
<td>~376</td>
</tr>
<tr>
<td>University of RI</td>
<td>Rhode Island</td>
<td>2013</td>
<td>~412</td>
</tr>
<tr>
<td>U Conn/LBNL</td>
<td>Massachusetts</td>
<td>2014</td>
<td>~1,503</td>
</tr>
</tbody>
</table>
Four Studies = Four Distinct Research Efforts
But The Same Results

None of the studies found statistically significant effects

No Evidence of Property Value Impacts of Operating Turbines

2009 LBNL US Study

2013 LBNL US Study

URI RI Study

UConn/LBNL MA Study

LBNL US Study

2009 LBNL US Study

UConn/LBNL MA Study

URI RI Study
We Compared Impacts Across Amenities and Disamenities

Despite the presence of effects for other environmental characteristics, no effects were discovered for turbines.
After Construction Effects Within 0.8 Km Fall Within A Narrow Range Across All Studies

Note: None are Statistically Significant

Mean Effect Across All Studies is −1.6%

Note: Results from main and robustness test models

Effect Sizes Within 1/2 Mile (~0.8 km) of Operating Turbines
These NA Results Contrast With Four Recent EU Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>EU Location</th>
<th>Date</th>
<th>Post-Con Sales W/in 1 km</th>
<th>1 km Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunak &amp; Madlener</td>
<td>Germany</td>
<td>2013</td>
<td>~ 40</td>
<td>-12% (with view)</td>
</tr>
<tr>
<td>Jensen et al.</td>
<td>Denmark</td>
<td>2013</td>
<td>~200</td>
<td>-10% (with view)</td>
</tr>
<tr>
<td>Gibbons</td>
<td>UK</td>
<td>2013</td>
<td>~3,000</td>
<td>-5.4% (with view)</td>
</tr>
<tr>
<td>Droes &amp; Koster</td>
<td>Netherlands</td>
<td>2014</td>
<td>~3,000?</td>
<td>-2.3% (assumed with view)</td>
</tr>
</tbody>
</table>

Studies Investigating Property Value Impacts of Surrounding Operating EU Turbines
Why Has Evidence Of Impacts Failed To Emerge In The US But Has In The EU?

<table>
<thead>
<tr>
<th>Highway</th>
<th>Transmission Lines</th>
<th>Average Home</th>
<th>Green Space</th>
<th>Ocean Front</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓ $</td>
<td>↓ $</td>
<td>↑ $</td>
<td>↑ $</td>
<td>↑ $</td>
</tr>
</tbody>
</table>
Multiple Surveys Have Found High Levels Of Support Near US Turbines
Homeowner, Town, Schools And County Benefits Can Be Significant In The US

Â Knapp, 2009: $18 million/year for 112 MW wind farm in NY for 20 years

Â Loomis et al., 2011: Estimated effect of 100 MW wind farm on annual school district budget of: $450,000 to $600,000/year for the first 3 years!

Â Loomis et al., 2012: Estimated the 23 largest wind facilities in IL produce an economic benefit of $5.98 billion over the life of the wind projects or ~$9 million/year/100 MW
Buyers Could Be Sorting Themselves Into Supporters And Objectors

When consumers are mobile, over time they will sort themselves such that those living close to turbines are more supportive of turbines.

Tiebout, 1956
Development Often Occurs In Relatively Rural Areas In The US (But Not Always)

Average Population Density Near:  
US Turbines  11 Pop/Mile$^2$  
Germany  509 Pop/Mile$^2$
Overall Conclusions

Å Property values can be useful to gauge levels of support/opposition and to determine impacts
Å Statistically significant impacts have **not** emerged near US turbines but have near EU's
Å Reasons for these differences might be:
  1. Significantly higher compensation for schools and local economies in the US
  2. More sorting over time to more supportive communities in the US
  3. Lower Population density in the US
  4. Larger samples of sales in EU allowing a determination of smaller effects
Thank You & Questions?

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References


**US Wide Study #1: LBNL 2009**

**Summary**
- 7,489 sales within 16 km of 11 facilities
- 125 post-construction sales within 1.6 km
- Rural settings with large (50+ turbines) wind facilities
Spatial Hedonic Analysis of the Effects of US Wind Energy Facilities on Surrounding Property Values

Ben Hoek · Jason P. Brown · Thomas Jackson ·
Mark A. Thayer · Ryan Wiser · Peter Cappers

Abstract Rapid, large-scale U.S. deployment of wind turbines is expected to continue in the coming years. Because some of that deployment is expected to occur in relatively populous areas, concerns have arisen about the impact of turbines on nearby home values. Previous research on the effects of wind turbines on surrounding home values has been limited by small home-sale data samples and insufficient consideration of confounding home-value factors and spatial dependence. This study examines the largest set of turbine-proximal sales data to date: more than 30,000 home sales including 1,198 within 1 mile of a turbine (331 of which were within a half mile). The data span the periods well before announcement of the wind facilities to well after their construction. We use ordinary least squares and spatial-process difference-to-difference hedonic models to estimate the home-value impacts of the wind facilities, controlling for value factors existing prior to the wind facilities’ announcements, the

Summary

$51,276$ total sales, 9 states, 67 facilities

$376$ post-construction sales within 1 mile

Rural settings, large (50+ turbines) facilities
**Summary**

Å48,554 total sales, 10 facilities
Å412 post-construction sales within 1 mile
Mostly urban settings, small facilities
MA Based Study: UConn/LBNL 2014

Relationship between Wind Turbines and Residential Property Values in Massachusetts
A Joint Report of University of Connecticut and Lawrence Berkeley National Laboratory
January 9, 2014

Carol Atkinson-Falombe
Assistant Professor, Department of Geography
University of Connecticut

Ben Hoan
Staff Research Associate
Lawrence Berkeley National Laboratory

Summary
Å312,677 total sales, 26 facilities
Å1,503 post-construction sales w/in 1 mile
ÅUrban settings, mostly small facilities
ÅFirst study to test wind turbine and other environmental amenities/disamenities together
Detailed MA Based Study Results
We Compared Impacts Across Amenities and Disamenities

Despite the presence of effects for other environmental characteristics, no effects were discovered for turbines.
## Sunak & Madlener: Germany 2013

<table>
<thead>
<tr>
<th>Effect Tested</th>
<th>When Did The Sales Occur?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After Announcement and Before Construction of Wind Facility</td>
</tr>
<tr>
<td>View of wind turbine</td>
<td><em>not tested</em></td>
</tr>
<tr>
<td>Within a close distance (~0.8 km) of turbine</td>
<td><em>not tested</em></td>
</tr>
<tr>
<td>Non-turbine landscape amenities</td>
<td></td>
</tr>
<tr>
<td>Non-turbine landscape disamenities</td>
<td></td>
</tr>
</tbody>
</table>

### Italian Translation

<table>
<thead>
<tr>
<th>Effetti Testati</th>
<th>Quando si sono verificate le vendite?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veduta di turbina eolica</td>
<td>Dopo l'annuncio e prima della costruzione della Struttura Eolica</td>
</tr>
<tr>
<td>A breve distanza (~ 0,8 km) di turbina</td>
<td>non testato</td>
</tr>
<tr>
<td>aspetti piacevoli del paesaggio in assenza della turbina eolica</td>
<td>non testato</td>
</tr>
<tr>
<td>aspetti spiacevoli del paesaggio in assenza della turbina eolica</td>
<td></td>
</tr>
</tbody>
</table>
The Vindication of Don Quixote: The Impact of Noise and Visual Pollution from Wind Turbines

Cathrine Ulla Jensen, Toke Emil Panduro, and Thomas Hedemark Lundhede

Abstract.
In this article, we quantify the marginal external effects of nearby land-based wind turbines on property prices. We succeed in separating the effect of noise and visual pollution from wind turbines. This is achieved by using a dataset consisting of 12,640 traded residential properties located within 2,500 meters of a turbine, sold in the period 2000–2011. Our results show that wind turbines have a significant negative impact on the price schedule of neighboring residential properties. Visual pollution reduces the residential sales price by around 3%, while noise pollution reduces the price between 3% and 7%. (JEL Q18, Q5).

1. Introduction
In the sixteenth century, the fictional character Don Quixote thought windmills were alien to the landscape. Many people have similar views about wind turbines today. The installation of land-based wind turbines is controversial and is often met with opposition from the local community (Welsink 2000), which often takes the form of a “not in my yard” argument. The need to increase renewable energy and install wind turbines in particular, is acknowledged, but at the same time, the location of local wind turbine projects is opposed. Denmark has experienced a massive growth in wind power capacity. In the mid-1990s, less than 2% of the domestic power supply was derived from wind. Today, 5,000 onshore and offshore turbines make up more than one-fifth of the domestic power supply. The Danish government plans to increase the share of onshore turbines by an additional 1,300 megawatt-hours before 2020. In addition, large offshore wind turbine projects have been initiated. It is expected that offshore projects will dominate the expansion of wind turbine energy production in the coming years.

The noise and visual appearance of wind turbines make them very unattractive neighbors (Devine-Wright 2005). The stated preference literature has shown that people in general have a positive attitude toward wind turbines (Boschker, Duke, and Parsons 2007), while at the same time, they are able to put a value on the negative externalities related to noise and visual pollution (Ladenburg 2006; Meyerhoff, Ohl, and Hartje 2010; Ladenburg and Møller 2011). The stated preference results are compelling, but a number of questions follow in their wake. For example, when respondents have to relate to a hypothetical scenario, are they cognitively able to distinguish between their opinions on noise and visual pollution? If not, are conclusions based on hypothetical payments as reliable as results based on observed, actual payments (Diamand and Hamman 1994)?

The externalities related to wind turbines are restricted to local residents, which makes the hedonic house price method the obvious valuation technique to choose. Only a handful of hedonic studies have attempted to estimate the local negative impacts of wind turbines, and only the most recent publications have proceeded (Sim and Donn 2007; Sim and Ozbek 2008; Roen et al. 2011; Heinzelman and Tuttle 2012). Heinzelman and Tuttle (2012) find that nearby wind facilities

Summary
Å12,640 total sales, ~24 facilities
Å400 post-construction sales within 1 km
ÅFirst study of its kind in Denmark
ÅExplored impacts near a variety of disamenities
ÅStudied Scenic Vista and Nuisance Stigmas
UK Based Study: Gibbons 2014

Summary
Å1,710,293 total sales, >25 facilities
Å>8,000 post-construction sales w/in 1 km
ÅFirst study of its kind in UK
ÅFocused on view of turbine effects
ÅInvestigated Area Stigma, Scenic Vista Stigma, and Nuisance Stigma