Relationship Between Wind Turbines and Residential Property Values in Massachusetts

A Joint Report of University of Connecticut and Lawrence Berkeley National Laboratory

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With Support From

Massachusetts Clean Energy Center

Boston, MA

Overview

1. Background on Land Economics
2. Valuing Amenities and Disamenities
3. Literature on Wind Turbines
4. Research Questions & Unique Contributions
5. Data and Methodology
6. Results
7. Conclusions

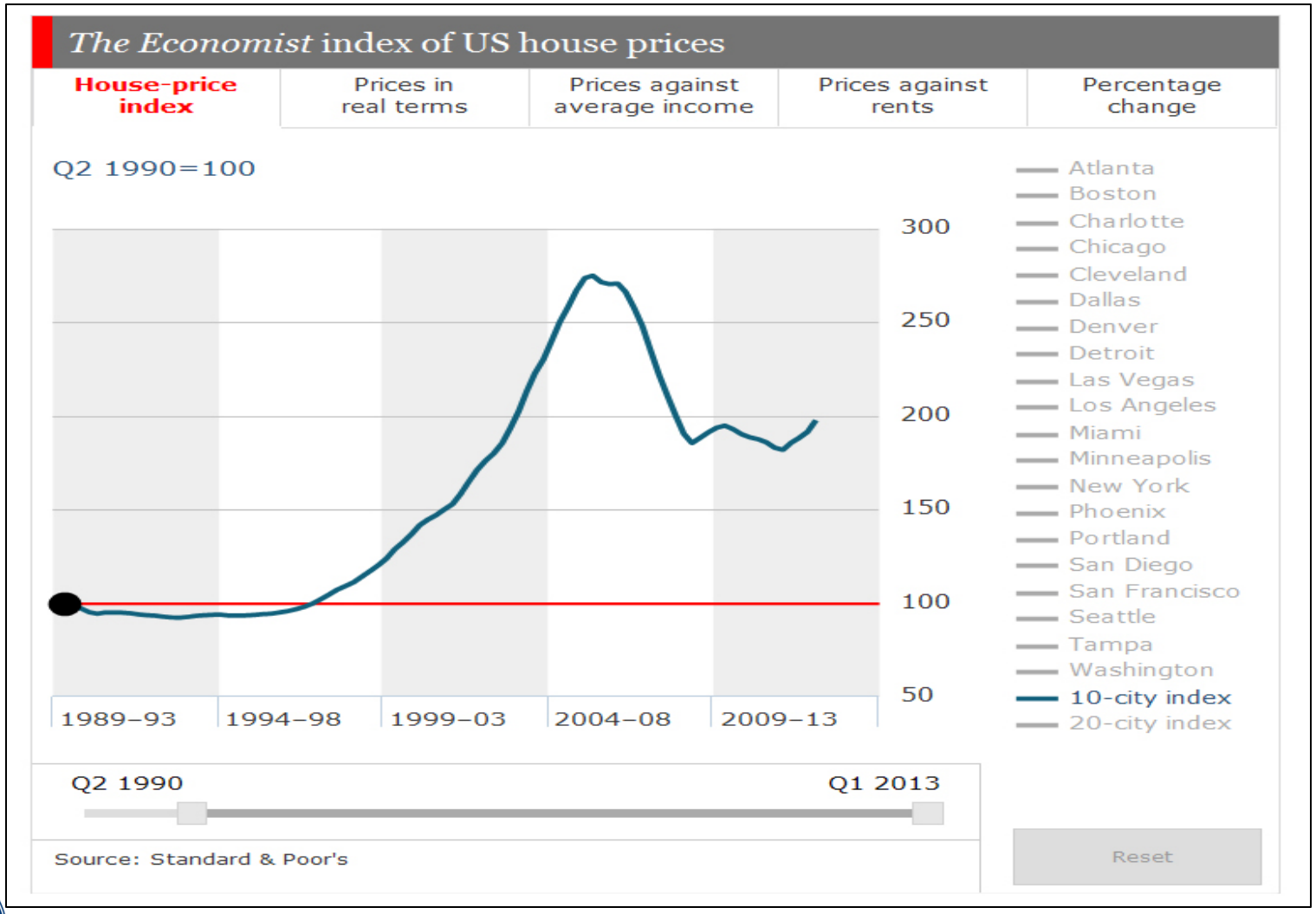
Determinants of House Prices

Characteristics of the Property

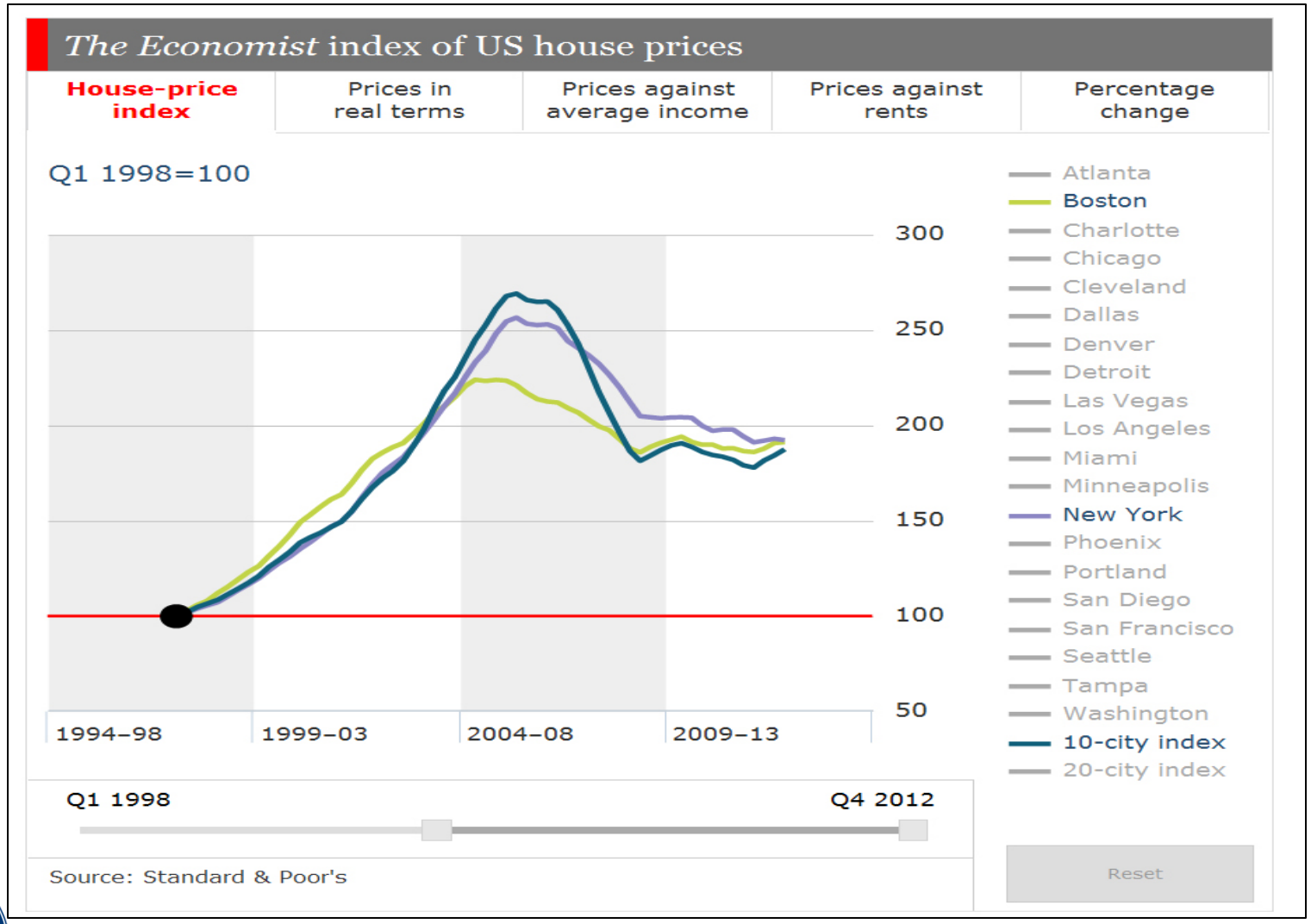
Locational Characteristics

Market Conditions

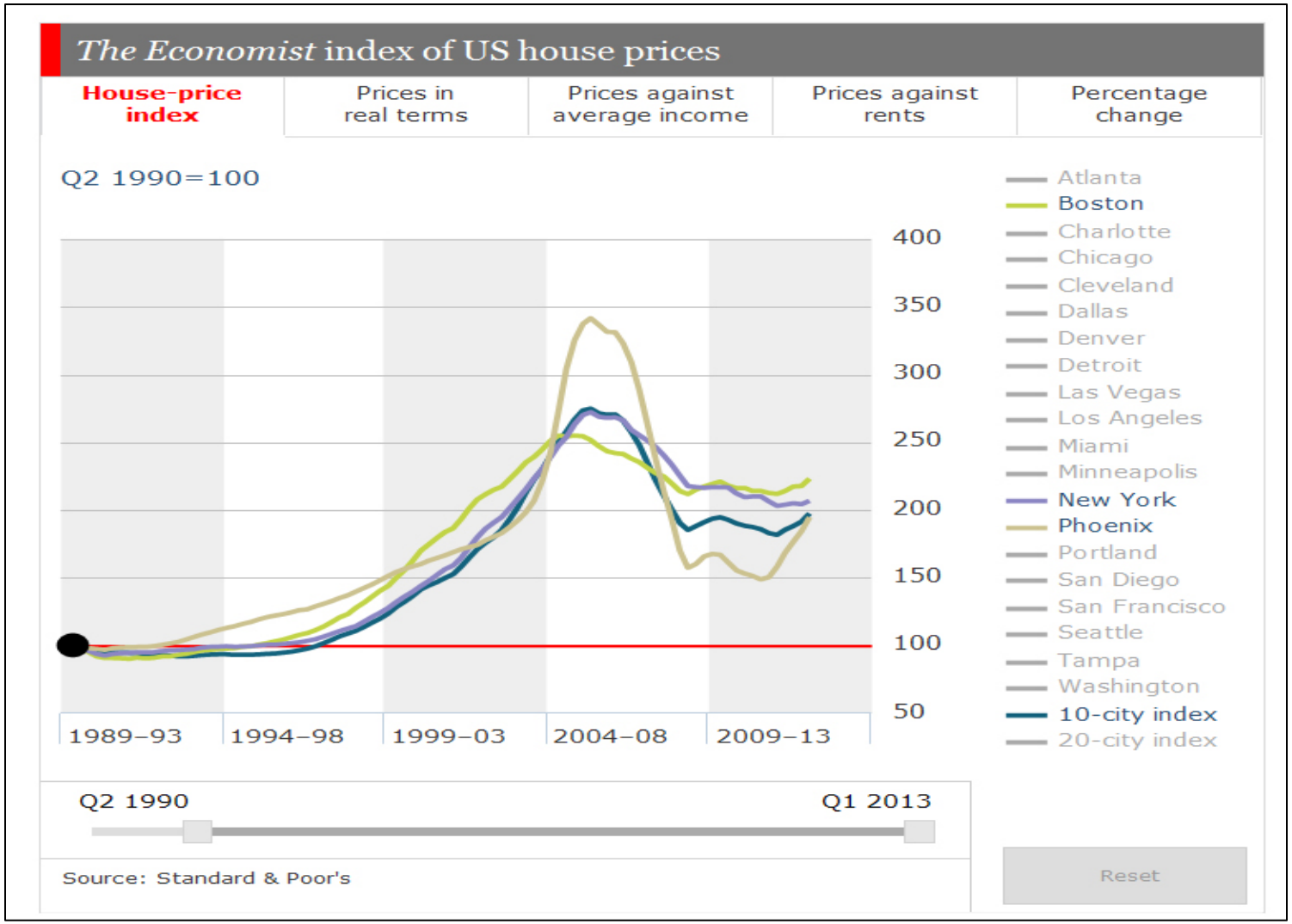
Variability over Time



Variability over Time by Location



Sunbelt versus NE



How do we measure effect of “treatment”?

What is a hedonic model?

$$P = f(L, N, A, E, T)$$

Where:

L = lot specific variables

N = Neighborhood variables

A = Amenities and Disamenties

E = Wind Turbine Variables

T = Time

How Hedonic Pricing Models Work

- Measures marginal price differences between homes that differ by the variables of interest while controlling for other variables.
- Controlling variables include square feet, acres, bathrooms, age of the home, year and season of sale, neighborhood, and (dis) amenities
- Variables of interest include if home was within ½ or ¼ mile from turbines, and wind facility development period (e.g., pre-announcement, post-construction, etc.)

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

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

Research For Disamenities Show Clear Evidence of Effects

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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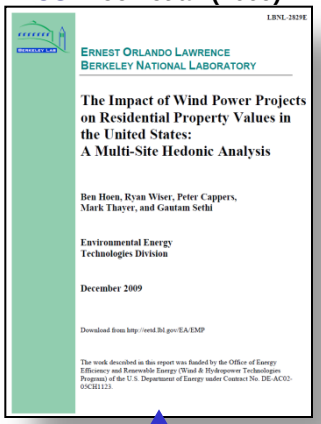
Potential Stigmas Associated with Wind Turbines

1. **Area Stigma:** Concern that area will appear more developed **.**
2. **Scenic Vista Stigma:** Concern over decrease in quality of scenic vistas from homes
3. **Nuisance Stigma:** Concern that factors that occur in close proximity will have unique impacts.

Academic & Peer-Reviewed Literature

US: Hoen et al. (2009)



LBNL-2029E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

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

Ben Hoen, Ryan Wiser, Peter Cappers, Mark Thayer, and Gautam Sethi

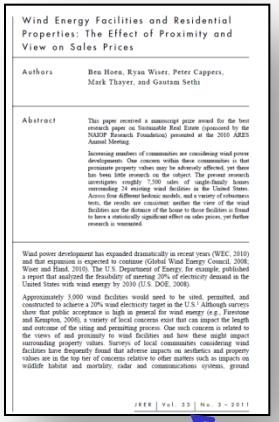
Environmental Energy Technologies Division

December 2009

Download from http://eetd.lbl.gov/EA/EMP

The work described in this report was funded by the Office of Energy Efficiency and Renewable Energy (Wind & Hydropower Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11123.

US: Hoen et al. (2011)



Wind Energy Facilities and Residential Properties: The Effect of Proximity and View on Sales Prices

Authors

Ben Hoen, Ryan Wiser, Peter Cappers, Mark Thayer, and Gautam Sethi

Abstract

This paper received a manuscript prize award for the best research paper on Sustainable Real Estate (sponsored by the NAIOP Research Foundation) presented at the 2010 ARES Annual Meeting.

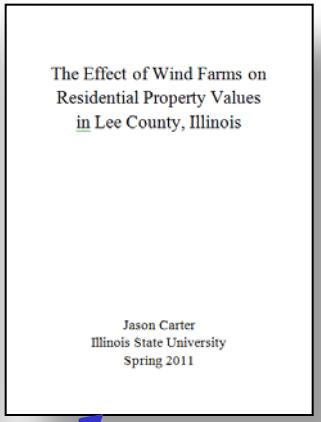
Increasing numbers of communities are considering wind power developments. One concern within these communities is that permanent property values may be adversely affected, yet there has been little research on the subject. The present research investigates roughly 7,500 sales of single-family homes surrounding 24 existing wind facilities in the United States. Across five different hedonic models, and a variety of robustness tests, the results are consistent: neither the view of the wind facilities nor the distance of the home to these facilities is found to have a statistically significant effect on sales prices, yet further research is warranted.

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

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

JERE | Vol. 33 | No. 3 - 2011

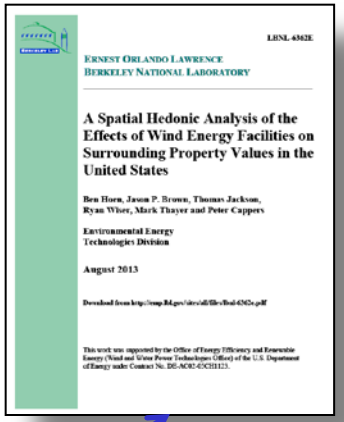
IL: Carter (2009)



The Effect of Wind Farms on Residential Property Values in Lee County, Illinois

Jason Carter
Illinois State University
Spring 2011

US: Hoen et al. (2013)



LBNL-6362E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States

Ben Hoen, Jason P. Brown, Thomas Jackson, Ryan Wiser, Mark Thayer and Peter Cappers

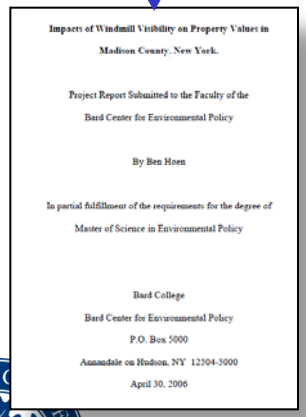
Environmental Energy Technologies Division

August 2013

Download from http://emp.lbl.gov/sites/all/files/lbnl-6362e.pdf

This work was supported by the Office of Energy Efficiency and Renewable Energy (Wind and Water Power Technologies Office) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

2006 2009 2010 2011 2012 2013



Impacts of Windmill Visibility on Property Values in Madison County, New York.

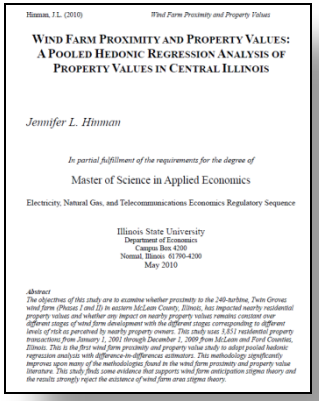
Project Report Submitted to the Faculty of the Bard Center for Environmental Policy

By Ben Hoen

In partial fulfillment of the requirements for the degree of Master of Science in Environmental Policy

Bard College
Bard Center for Environmental Policy
P.O. Box 5000
Annandale on Hudson, NY 12504-5000
April 30, 2006

NY: Hoen (2006)



Hinman, J.L. (2010) *Wind Farm Proximity and Property Values*

WIND FARM PROXIMITY AND PROPERTY VALUES: A POOLED HEDONIC REGRESSION ANALYSIS OF PROPERTY VALUES IN CENTRAL ILLINOIS

Jennifer L. Hinman

In partial fulfillment of the requirements for the degree of

Master of Science in Applied Economics

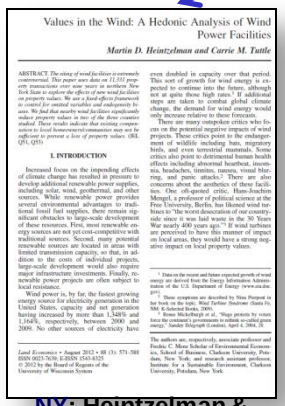
Electricity, Natural Gas, and Telecommunications Economics Regulatory Sequence

Illinois State University
Department of Economics
Campus Box 4200
Normal, Illinois 61790-4200
May 2010

Abstract

The objectives of this study are to examine whether proximity to the 149-turbine, Twin Groves wind farm (Phases I and II) in eastern McLean County, Illinois, has impacted nearby residential property values and whether any impact on nearby property values remains constant over different stages of wind farm development with the different stages corresponding to different levels of risk as perceived by nearby property owners. This study uses 3,851 residential property transactions from January 1, 2001 through December 1, 2009 from McLean and Ford Counties, Illinois. This is the first wind farm proximity and property value study to adopt pooled hedonic regression analysis with difference-in-differences estimators. This methodology significantly improves upon many of the methodologies found in the wind farm proximity and property value literature. This study finds some evidence that supports wind farm anticipation stigma theory and the results strongly reject the existence of wind farm area stigma theory.

IL: Hinman (2010)



Values in the Wind: A Hedonic Analysis of Wind Power Facilities

Martin D. Heintzelman and Carrie M. Tuttle

ABSTRACT. *The siting of wind facilities is extremely controversial. This paper uses data on 11,111 property transactions over nine years in northern New York State to explore the effects of new wind facilities on property values. We use a hard-effects framework to control for omitted variables and endogeneity bias. We find that nearby wind facilities significantly reduce property values in two of the three counties studied. These results indicate that existing compensation for local homeowners/communities may not be sufficient to prevent a loss of property values.* (JEL Q51, Q53)

I. INTRODUCTION

Increased focus on the impending effects of climate change has resulted in pressure to develop additional renewable power supplies, including solar, wind, geothermal, and other sources. While renewable power provides several environmental advantages to traditional fossil fuel supplies, there remain significant obstacles to large-scale development of these resources. First, most renewable energy sources are not yet cost-competitive with traditional sources. Second, many potential renewable sources are located in areas with limited transmission capacity, so that, in addition to the costs of individual projects, large-scale development would also require major infrastructure investments. Finally, renewable power projects are often subject to local resistance.

Wind power is, by far, the fastest growing energy source for electricity generation in the United States, capacity and net generation having increased by more than 1,340% and 1,164%, respectively, between 2000 and 2008. No other sources of electricity have

even doubled in capacity over that period. This sort of growth for wind energy is expected to continue into the future, although not at quite those high rates.[1] If additional steps are taken to combat global climate change, the demand for wind energy would only increase relative to those forecasts.

There are many outspoken critics who focus on the potential negative impacts of wind projects. These critics point to the endangerment of wildlife including bats, migratory birds, and even terrestrial mammals. Some critics also point to detrimental human health effects including abnormal heartbeat, insomnia, headaches, tinnitus, nausea, visual blurring, and panic attacks.[2] There are also concerns about the aesthetics of these facilities. One oft-quoted critic, Hans-Joachim Mengel, a professor of political science at the Free University, Berlin, has likened wind turbines to "the worst desecration of our countryside since it was laid waste in the 30 Years War nearly 400 years ago."[3] If wind turbines are perceived to have this manner of impact on local areas, they would have a strong negative impact on local property values.

[1] Data on the recent and future expected growth of wind energy are derived from the Energy Information Administration of the U.S. Department of Energy (www.eia.doe.gov).

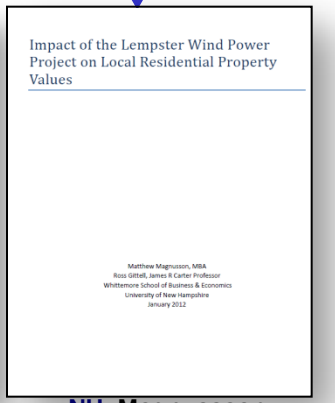
[2] These symptoms are described by Nina Pierpont in her book on the topic, *Wind Turbine Syndrome* (Santa Fe, NM: K-Selected Books, 2009).

[3] Rosa Mickenbergh et al., "Huge protests by voters force the continent's governments to rethink so-called green energy," Canada Telegraph (London), April 6, 2006.

The authors are, respectively, associate professor and Fredric C. Menz Scholar of Environmental Economics, School of Business, Clarkson University, Potsdam, New York; and research assistant professor, Institute for a Sustainable Environment, Clarkson University, Potsdam, New York.

Land Economics • August 2012 • 88 (3): 571–588
ISSN 0023-7639; E-ISSN 1543-8325

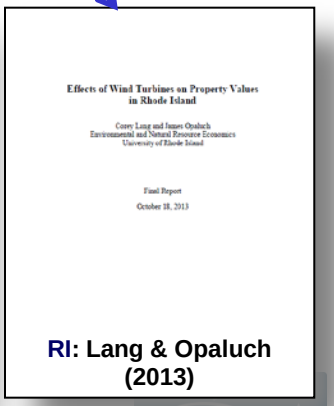
NY: Heintzelman & Tuttle (2012)



Impact of the Lempster Wind Power Project on Local Residential Property Values

Matthew Magnusson, MBA
Ross Gittell, James R Carter Professor
Whittemore School of Business & Economics
University of New Hampshire
January 2012

NH: Magnussson & Gittell (2012)



Effects of Wind Turbines on Property Values in Rhode Island

Corey Lang and James Opaluch
Environmental and Natural Resource Economics
University of Rhode Island

Final Report
October 18, 2013

RI: Lang & Opaluch (2013)

Other Non-US Academic Literature

UK: Sims & Dent (2007)

Property stigma: wind farms are just the latest fashion

Sally Sims and Peter Dent

Department of Real Estate and Construction, Oxford Brookes University, Oxford, UK

Germany: Sunak & Madlener (2013)

The Impact of Wind Farms on Property Values: A Geographically Weighted Hedonic Pricing Model

Y. Sunak* and R. Madlener

Canada: Vyn & McCullough (2013)

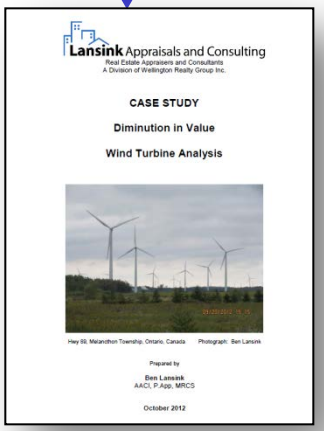
The Effects of Wind Turbines on Property Values in Ontario: Does Public Perception Match Empirical Evidence?

2006 2007 2008 2012 2013

UK: Sims et al. (2008)

MODELLING THE IMPACT OF WIND FARMS ON HOUSE PRICES IN THE UK

Sally SIMS [1,2], Peter DENT [3] and G. Reza OSKROCHI [4]



Canada: Lansink (2012)

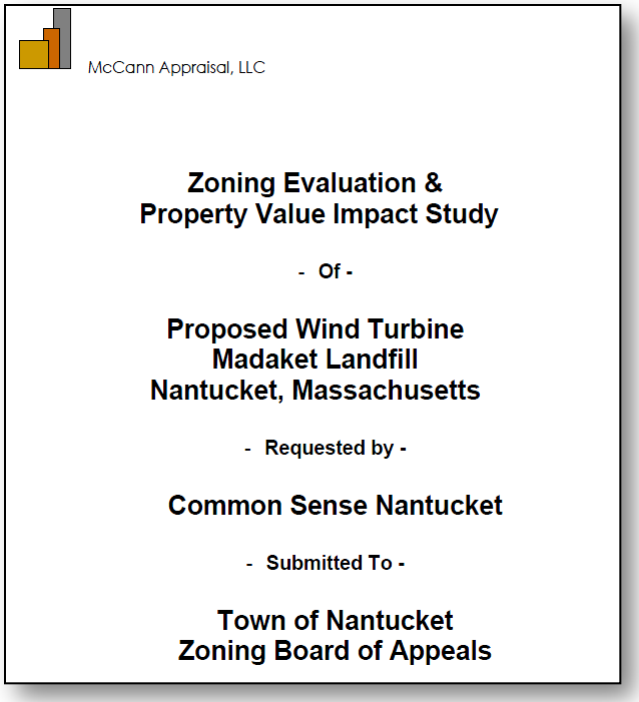
Appraisal Case Study

Most (But Not All) Of The Previous Academic and Peer-Reviewed Studies Of Turbines Have Not Found Effects

Document Type Author(s)	Year	Country	Study Location	Total Number of Transactions	Post-Construction Effects Found
Transaction Analysis - Simple Statistics					
Lansink	2012	Canada	Ontario, CA	4	**Yes**
Magnussson & Gittell	2012	US	Sullivan County, NH	2,593	No
Transaction Analysis - Hedonic Model					
Hoen	2006	US	Madison County, NY	280	No
Sims & Dent	2007	UK	3 Towns in UK	919	No
Sims et al.	2008	UK	1 Town in UK	199	No
Hoen et al.	2009/2011	US	9 US States	7,459	No
Hinman	2010	US	McLean County, IL	3,851	No
Carter	2011	US	Lee County, IL	1,298	No
Heintzelman & Tuttle	2012	US	3 NY Counties	9,393	Unclear
Sunak & Madlener	2012	Germany	North Rhine-Westphalia	1,405	**Yes**
Hoen et al.	2013	US	US	51,276	No
Vyn & McCullough	2013	Canada	Ontario	5,414	No
Lang & Opaluch	2013	US	RI	48,554	No

Claims Of Large Impacts Exist

2012 Appraisal Report



McCann Appraisal, LLC

Zoning Evaluation &
Property Value Impact Study

- Of -

Proposed Wind Turbine
Madaket Landfill
Nantucket, Massachusetts

- Requested by -

Common Sense Nantucket

- Submitted To -

Town of Nantucket
Zoning Board of Appeals

"reduction can be …forecast at 15% to 30%...

2013 News Article

MOTHER EARTH NEWS
THE ORIGINAL GUIDE TO LIVING WISELY

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Mother Earth News Blogs > Renewable Energy

RENEWABLE ENERGY

It's all about energy, from renewable sources to energy-efficient usage.

Property Value of Nearby Homes Hurt By Wind Turbines

3/20/2013 3:43:43 PM
Press Release
Tags: wind turbines, property value, renewable energy, wind power, wind energy

This press release was provided by PR Newswire.

Land-based wind turbines can cause property values within two miles of the 30 to 50 story high structures to plummet by 15 percent to 40 percent, according to comprehensive appraisal studies.

The individual real estate impact reports covered the towns of Falmouth, Nantucket, Shelburne, Dennis, and Brewster and are emblematic of similar studies in other states, according to Michael McCann, president of McCann Appraisals of Chicago.

"property values…plummet by 15 % to 40 %..."

There is also a website dedicated to impacts from turbines

www.windturbinepropertyloss.org

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Most Data-Rich Analysis To Date

Relevance

Provide 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.

Research Team

C. Atkinson-Palombo (U Conn), B. Hoen (LBNL)

Reviewers

T. Jackson (Appraiser, Professor, May's Business School, Texas A&M)

M. Thayer (Chair, Economics Dept, SDSU)

J. Zabel (Professor of Economics, Tufts University)

C. Lang (Assistant Professor, Env. & Nat. Res. Economics, U of RI)

Funders

MassCEC & USDOE (for Ben's time)

Five Distinct Research Questions

1. Have wind facilities in Massachusetts been located in areas where average home prices were lower than prices in surrounding areas (i.e., a “pre-existing price differential”)?
2. Are post-construction (i.e., after wind-facility construction) home price impacts evident in Massachusetts and how do Massachusetts results contrast with previous results estimated for more rural settings?
3. Is there evidence of a post-announcement/pre-construction effect (i.e., an “anticipation effect”)?
4. How do impacts near turbines compare to the impacts of amenities and disamenities also located in the study area, and how do they compare with previous findings?
5. Is there evidence that houses near turbines that sold during the post-announcement and post-construction periods did so at lower rates (i.e., frequencies) than during the pre-announcement period?

Unique Contributions of Current Study

- Uses largest and most comprehensive dataset ever assembled for a study linking wind facilities to nearby home prices, including the largest number of transactions close to turbines.
- Encompasses the largest range of home sale prices ever examined.
- Examines wind facilities in urban areas (with relatively high-priced homes), whereas previous analyses have focused on rural areas (with relatively low-priced homes).
- Focuses mainly on wind facilities that contain fewer than two turbines, while previous studies have focused on large-scale wind facilities (i.e., wind farms).
- Modeling approach controls for seven environmental amenities and disamenities in the study area, allowing the effect of wind facilities to be compared directly to the effects of these other factors.

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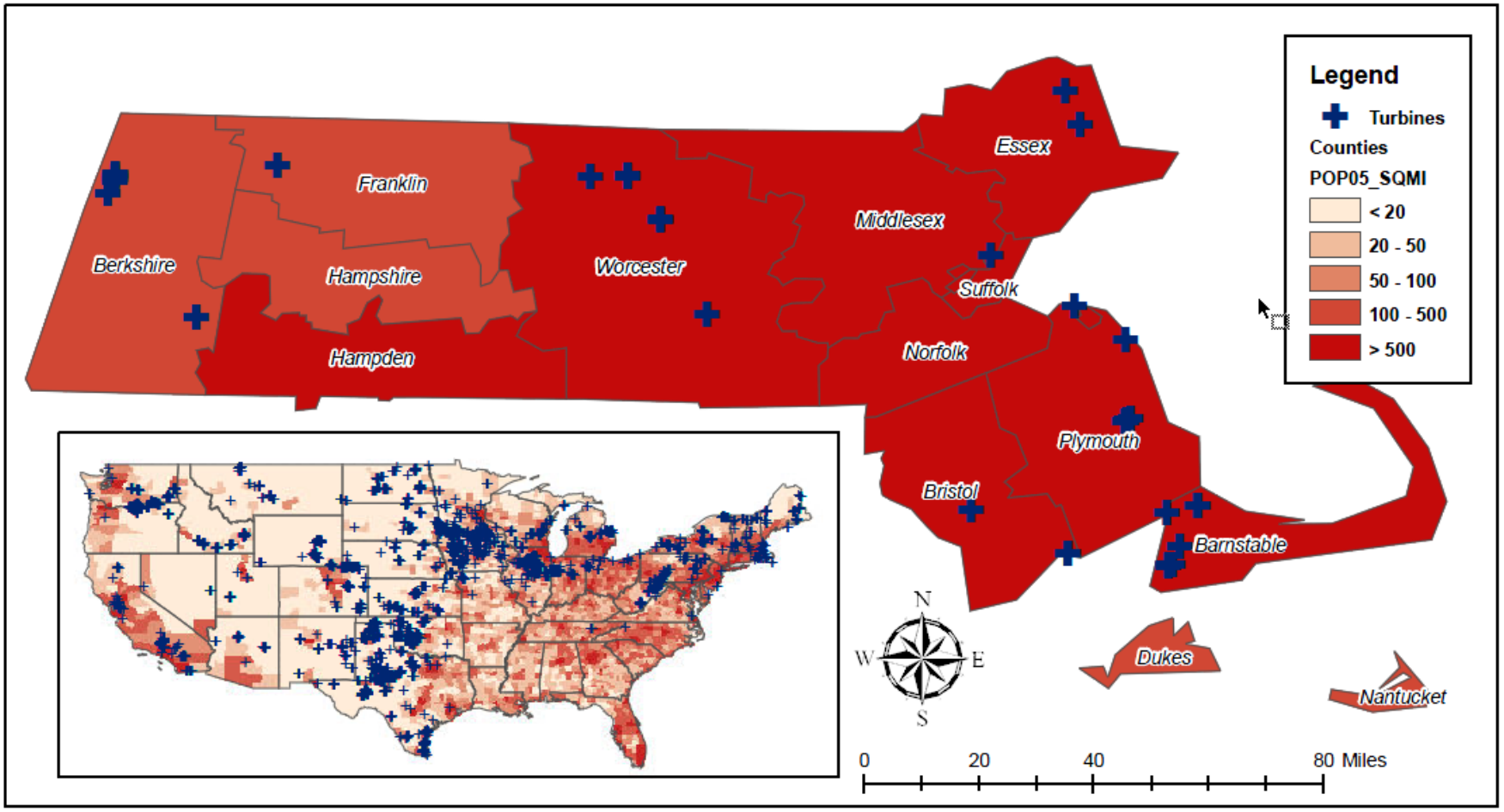
Four Different Data Sources

Dataset	Source
Wind Turbine Data *Note: Announcement, construction and commission dates were corroborated via internet searches*	MassCEC
Real Estate Data *Note: Warren provided data on single family home transactions that were arm's length and valid for analysis and between 1998 and 2012*	Warren Group
Census Data *Note: These data were used to identify the census block group in which the home was situated*	US Census Bureau
Amenity & Disamenity *Note: These data include GIS locations for landfills, prisons, major roads, electricity transmission lines, highways, beaches and open spaces.*	MassGIS

MA Has A Relatively Large Number Of Turbines For A Largely Urban State

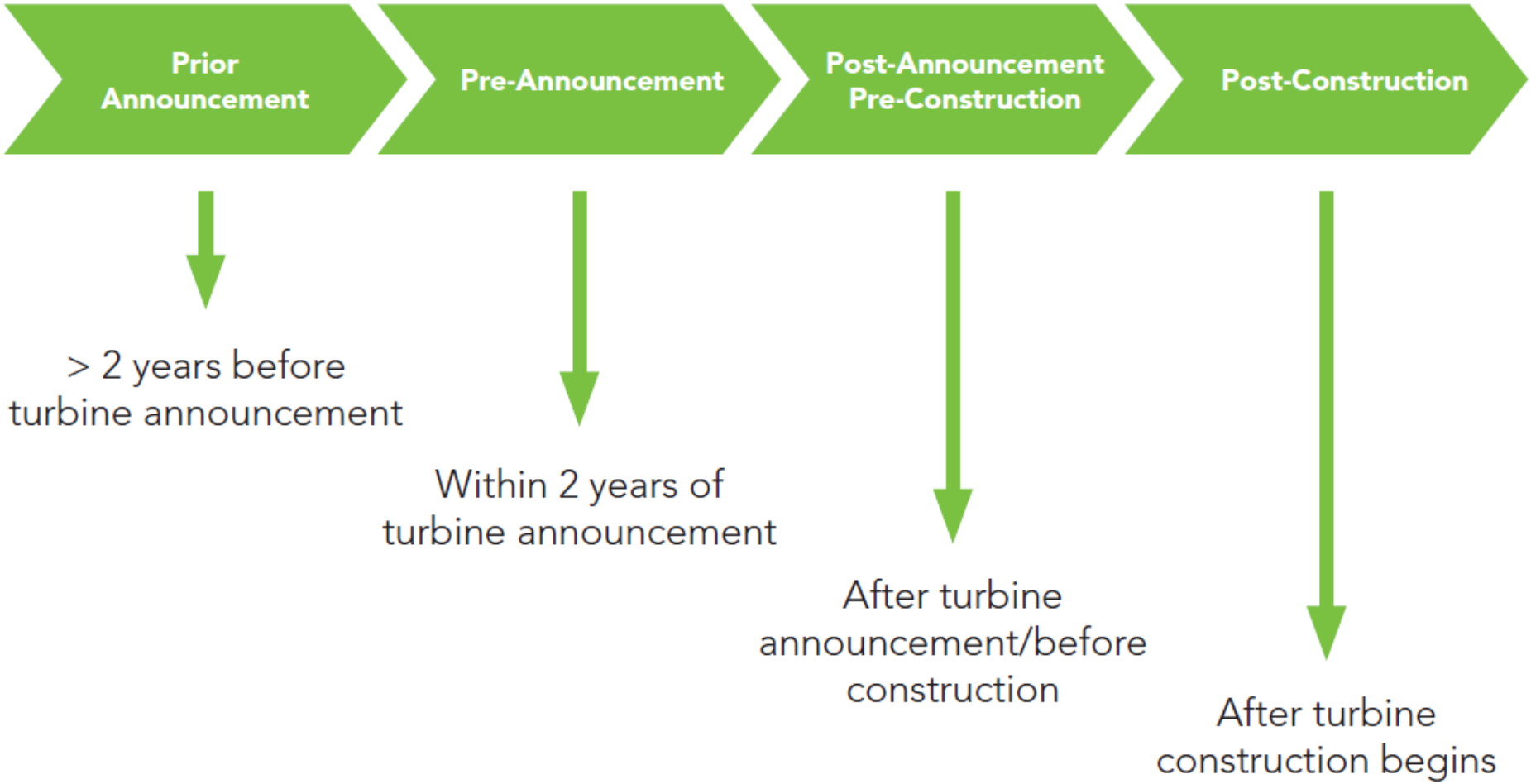
Project Name	Number of Turbines	Capacity per Turbine (kW)	Project Nameplate Capacity (MW)	Blade Tip Height (meters)	Announcement Date	Construction Date	Commission Date	Wastewater or Water Treatment	Industrial Site	Landfill
Berkshire East Ski Resort	1	900	0.9	87	12/16/08	7/12/10	10/31/10			
Berkshire Wind	10	1500	15	118.5	1/12/01	6/1/09	5/28/11			
Fairhaven	2	1500	3	121	5/1/04	11/1/11	5/1/12	X		
Falmouth Wastewater 1	1	1650	1.65	121	4/1/03	11/1/09	3/23/10	X		
Falmouth Wastewater 2	1	1650	1.65	121	11/1/09	4/5/10	2/14/12	X		
Holy Name Central Catholic Jr/Sr HS	1	600	0.6	73.5	9/21/06	3/21/08	10/4/08			
Hull 1	1	660	0.66	73.5	10/1/97	11/1/01	12/27/01			
Hull 2	1	1800	1.8	100	1/1/03	12/1/05	5/1/06			X
Ipswich MLP	1	1600	1.6	121.5	3/1/03	10/1/10	5/15/11			
Jiminy Peak Mountain Resort	1	1500	1.5	118.5	11/1/05	6/25/07	8/3/07			
Kingston Independence	1	2000	2	123	6/1/06	9/23/11	5/11/12			
Lightolier	1	2000	2	126.5	12/14/06	11/1/11	4/20/12		X	
Mark Richey Woodworking	1	600	0.6	89	11/10/07	11/1/08	2/22/09		X	
Mass Maritime Academy	1	660	0.66	73.5	1/31/05	4/12/06	6/14/06			
Mass Military Reservation 1	1	1500	1.5	118.5	11/8/04	8/1/09	7/30/10		X	
Mass Military Reservation 2	1	1500	1.5	121	10/1/09	10/1/10	10/28/11		X	
Mass Military Reservation 3	1	1500	1.5	121	10/1/09	10/1/10	10/28/11		X	
Mt Wachusett Community College	2	1650	3.3	121	8/18/08	1/28/11	4/27/11			
MWRA - Charlestown	1	1500	1.5	111	1/24/10	3/25/10	10/1/11	X		
MWRA - Deer Island	2	600	1.2	58.5	6/1/08	8/1/09	11/15/10	X		
No Fossil Fuel (Kingston)	3	2000	6	125	3/1/10	11/16/11	1/25/12		X	
NOTUS Clean Energy	1	1650	1.65	121	8/31/07	4/1/10	7/28/10		X	
Princeton MLP	2	1500	3	105.5	12/18/99	9/9/09	1/12/10			
Scituate	1	1500	1.5	111	3/15/08	2/15/12	3/15/12	X		
Templeton MLP	1	1650	1.65	118.5	7/24/09	2/1/10	9/1/10			
Williams Stone	1	600	0.6	88.5	1/11/08	5/1/08	5/27/09		X	
Total: 26 projects	**41**							**6**	**8**	**1**

Turbine Sample Covers Population Densities Not Studied Before

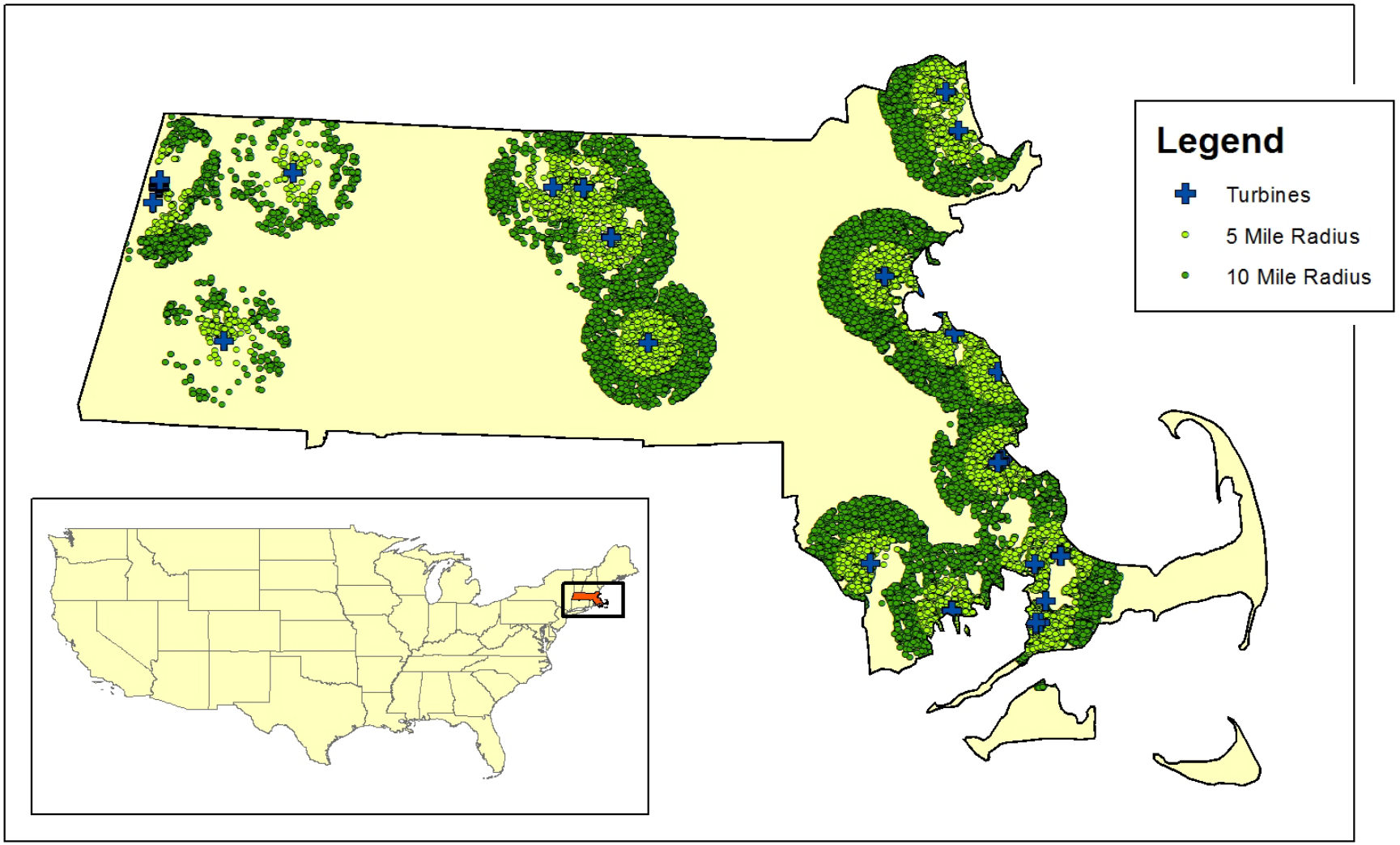


Population ('05) density near turbines: MA 416/mile^2; US 11/mile^2

Real Estate Dataset Covers Full Wind Facility Development Timeline (1998-2012)



Real Estate Data Are Limited To Homes Within 10 Miles Of Turbines (Yet Base Model Limited To Within 5 Miles)



Real Estate Data Are Well Arrayed Across Periods and Distances From Turbines

	prioranc	preanc	postanc-precon	postcon	all periods
0-0.25mile	60	9	14	38	121
	0.04%	*0.02%*	*0.03%*	*0.06%*	*0.04%*
0.25-0.5mile	434	150	210	192	986
	0.25%	*0.39%*	*0.47%*	*0.33%*	*0.32%*
0.5-1mile	3,190	805	813	1,273	6,081
	1.9%	*2.1%*	*1.8%*	*2.2%*	*1.9%*
1-5mile	62,967	14,652	17,086	20,305	115,010
	37%	*38%*	*38%*	*34%*	*37%*
5-10mile	104,188	22,491	26,544	37,256	190,479
	61%	*59%*	*59%*	*63%*	*61%*
Total	**170,839**	**38,107**	**44,667**	**59,064**	**312,677**
	100%	*100%*	*100%*	*100%*	*100%*

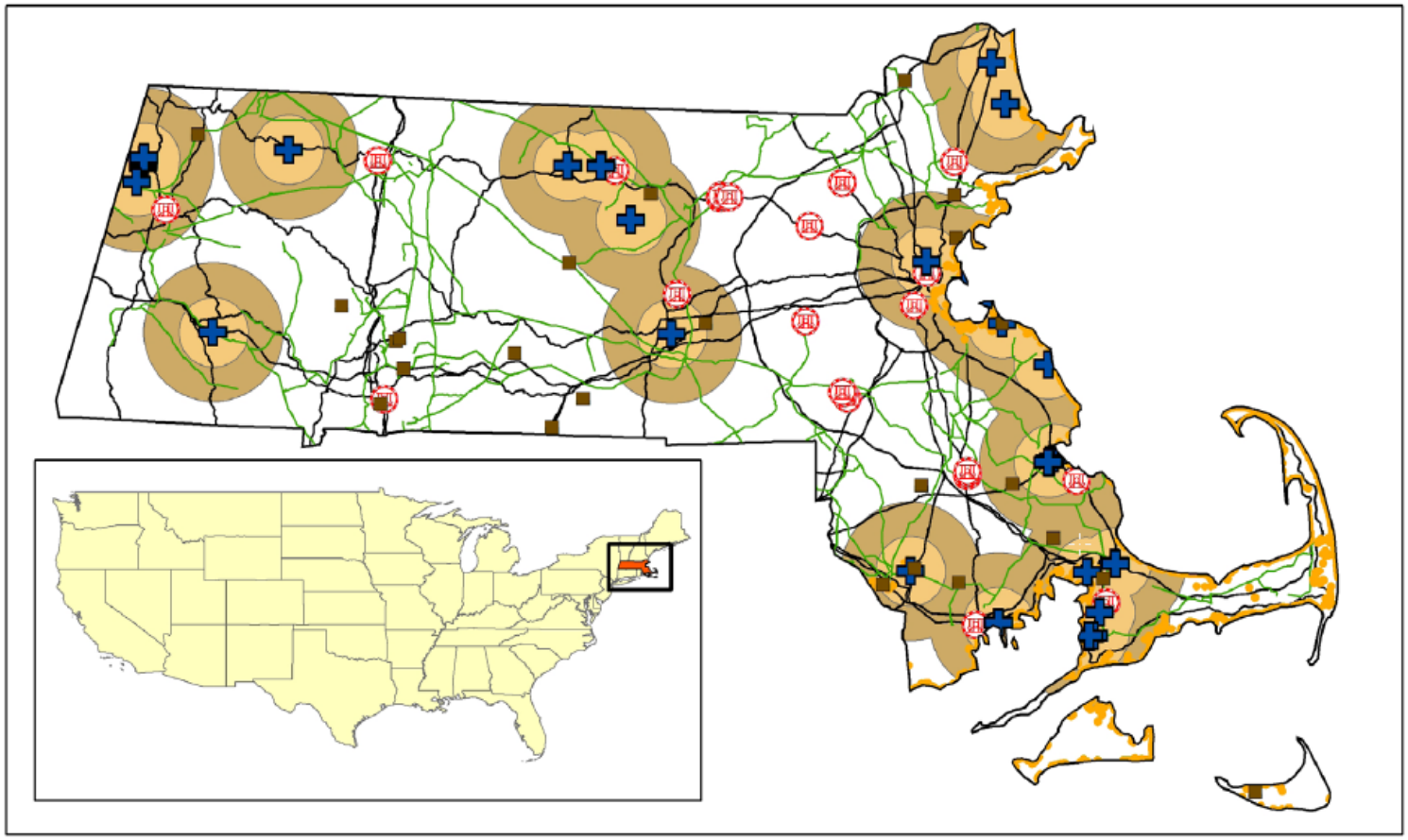
494 224 230

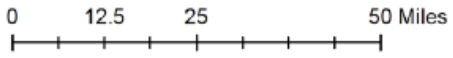
66,157 17,899 21,578

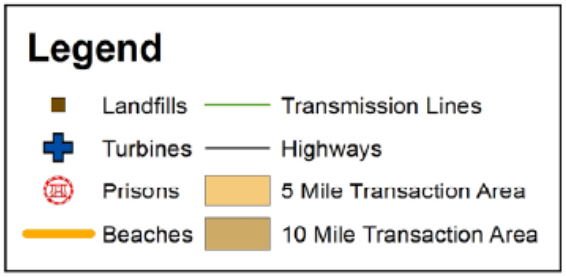
Dataset Is Well-Suited For Average Analysis Because It Contains A Well-Distributed Array Of Homes And Prices

Variable	Description	Mean	Std. Dev.	Min	Median	Max
sp	sale price	$322,948	$238,389	$40,200	$265,000	$2,495,000
lsp	log of sale price	12.49	0.60	10.6	12	14.72
sd	sale date	10/19/04	1522	3/3/98	2/6/05	11/23/12
sy	sale year	2004	4	1998	2004	2012
syq	sale year and quarter (e,g., 20042 = 2004, 2nd quarter)	20042	42	19981	20043	20124
sfla1000	square feet of living area (1000s of square feet)	1.72	0.78	0.41	1.6	9.9
acre*	number of acres	0.51	1.1	0.0054	0.23	25
acrelt1*	the number of acres less than one	-0.65	0.31	-0.99	-0.77	0
age	age of home at time of sale	54	42	-1	47	359
agesq	age of home squared	4671	4764	0	3474	68347
bath**	the number of bathrooms	1.9	0.79	0.5	1.5	10.5
wtdis	distance to nearest turbine (miles)	3.10	1.20	0.098	3.2	5
fdp	wind facility development period	1.95	1.18	1	1	4
annacre	average nearest neighbor's acres	0.51	0.93	0.015	0.25	32
annage	average nearest neighbor's age	53.71	30.00	-0.8	52	232
annagesq	average nearest neighbor's agesq	4672	4766	0	3474	68347
annsfla1000	average nearest neighbor's sfla1000	1.72	0.53	0.45	1.6	6.8

Analysis Tests Effects Of Multiple Amenities & Disamenities, Not Just Turbines







Disamenities

- Landfills*
- Prisons*
- Highways**
- Major Roads**
- Electricity Transmission Lines**

Amenities

- Beaches* and ^
- Open Spaces*

Distances Examined

** Within ½ mile*

*** Within 500 feet*

^ Between 500 feet and ½ mile

What is a hedonic model?

$$P = f(L, N, A, E, T)$$

Where:

L = lot specific variables

N = Neighborhood variables

A = Amenities and Disamenties

E = Wind Turbine Variables

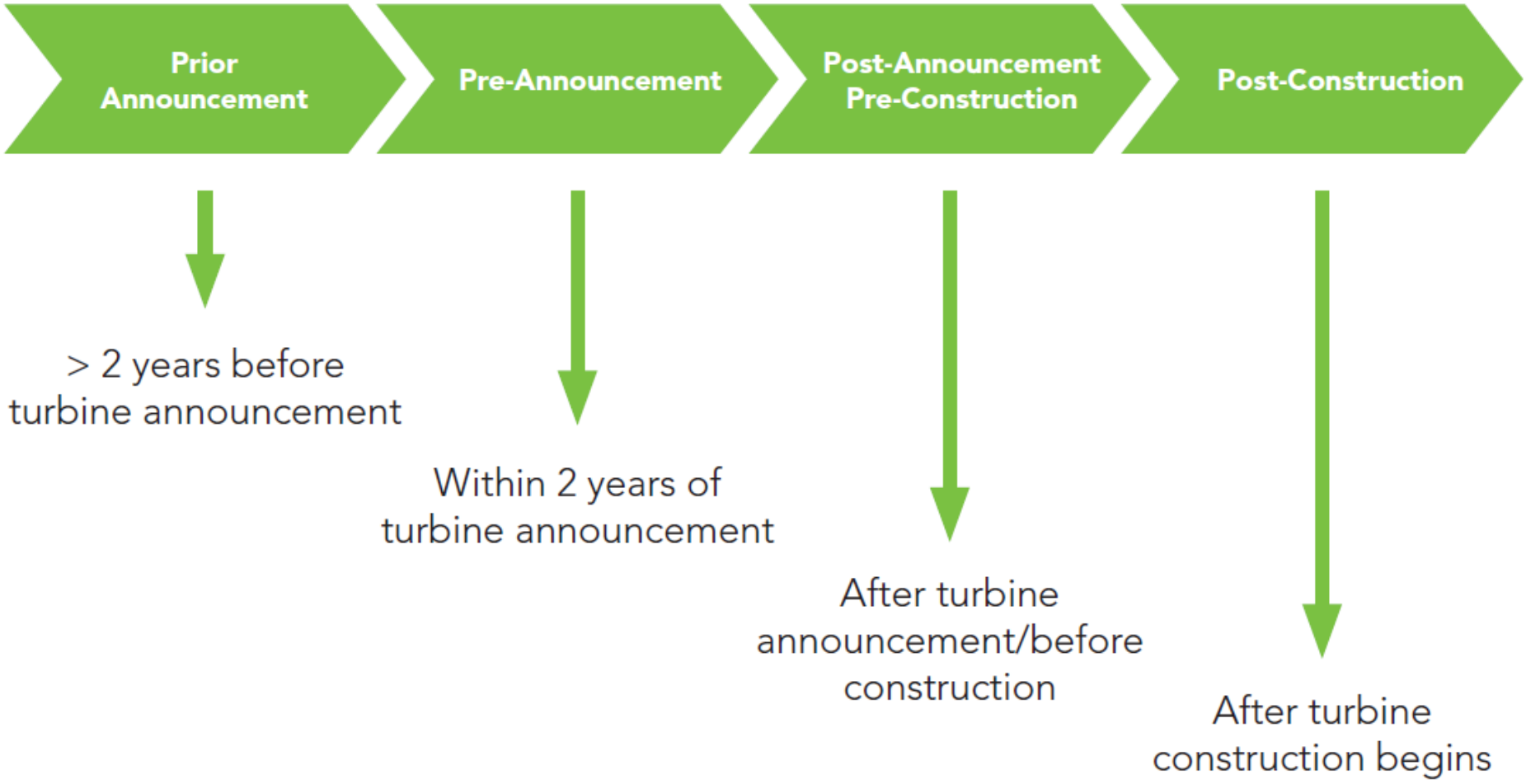
T = Time

Our Model Specification

$$\ln(P) = \beta_0 + \sum \beta_1 L \bullet D + \beta_2 N + \sum \beta_3 A \bullet D + \sum \beta_4 E \bullet D + \sum \beta_5 T + \varepsilon'$$

Variables of interest are the coefficients of E*D, the value associated with being within a certain distance of a wind turbine in the various facility development periods.

Real Estate Dataset Covers Full Wind Facility Development Timeline (1998-2012)



Difference-in-Difference Specification

- Focus on homes within ½ mile
- Compare them to homes outside of ½ mile (but inside 5 miles)
- Account for price differences between these two groups that existed before the announcement of the facilities
- Examine if the resulting “Net” price differences are statistically significant in either the post-announcement-pre-construction period OR in the post-construction/operation period

Key Concepts

Statistical Significance: Each estimated coefficient is accompanied by a standard error, which can be used to determine if the coefficient is statistically significant (unlikely to have occurred by chance) or not. If they are statistically significant, then more confidence can be placed in the estimated coefficient.

Robustness Test: A variety of sample sets and modelling assumptions are explored to examine if the base model results are robust to (i.e., are the same as/similar to) alternative specifications. If they are robust to alternative specifications then more confidence can be had in the results.

Overview

1. Background on Land Economics
2. Valuing Amenities and Disamenities
3. Literature on Wind Turbines
4. Research Questions & Unique Contributions
5. Data and Methodology
6. Results
7. Conclusions

Model Performed As Expected

		Wind Facility Development Period			
		prioranc	*preanc*	*postanc-precon*	*postcon*
Variables	**Description**	**coefficient**	**coefficient**	**coefficient**	**coefficient**
		p-value	*p*-value	*p*-value	*p*-value
sfla1000	living area in thousands of square feet	**22.9%*** **	**21.4%*** **	**22.6%*** **	**23.5%*** **
		0.000	*0.000*	*0.000*	*0.000*
acre	lot size in acres	**1.1%*** **	**1.9%*** **	**1.3%*** **	**-0.02%**
		0.000	*0.000*	*0.000*	*0.863*
acrelt1	lot size less than 1 acre	**21.7%*** **	**17.2%*** **	**14.7%*** **	**22.1%*** **
		0.000	*0.000*	*0.000*	*0.000*
age	age of the home at time of sale	**-0.2%*** **	**-0.2%*** **	**-0.2%*** **	**-0.2%*** **
		0.000	*0.000*	*0.000*	*0.000*
agesq*	age of the home at time of sale squared*	**0.6%*** **	**0.5%*** **	**0.6%*** **	**0.8%*** **
		0.000	*0.000*	*0.000*	*0.000*
bath	number of bathrooms	**6.4%*** **	**7.9%*** **	**8.4%*** **	**11.1%*** **
		0.001	*0.556*	*0.522*	*0.000*

- **Adjusted R^2 = 0.80**
- **Home and site characteristic variables are highly statistically significant**

statistical significance: *** highly significant (*p*-value <0.01); ** significant (*p*-value <0.05); * weakly significant (*p*-value <0.10; not significant (*p*-value >=0.1))

Time Trends

	Coef	SE	t	p-value
sale year				
1998	-0.52	0.007	-73.48	0.000
1999	-0.41	0.007	-58.44	0.000
2000	-0.26	0.007	-37.59	0.000
2001	-0.13	0.007	-18.03	0.000
2002	0.02	0.007	2.33	0.020
2003	0.14	0.007	21.26	0.000
2004	0.24	0.007	37.05	0.000
2005	0.31	0.006	49.32	0.000
2006	0.28	0.006	43.94	0.000
2007	0.23	0.006	37.58	0.000
2008	0.12	0.006	18.43	0.000
2009	0.04	0.006	7.29	0.000
2010	0.04	0.006	6.15	0.000
2011	-0.02	0.006	-3.74	0.000
2012	Omitted			
sale quarter				
1	-0.07	0.002	-28.05	0.000
2	-0.02	0.002	-9.56	0.000
3	Omitted			
4	-0.01	0.002	-3.03	0.002

- **Sale Prices are lowest in 1998, peak in 2005/2006 and return to 2002 levels by 2012**
- **Homes sold in winter are lower in value than those sold in late summer and the fall**

statistical significance:
*** highly significant (*p*-value <0.01);
** significant (*p*-value <0.05);
* weakly significant (*p*-value <0.10;
not significant (*p*-value >=0.1))

Amenity/Disamenity Variables Perform As Expected

		Wind Facility Development Period			
		prioranc	*preanc*	*postanc-precon*	*postcon*
Variables	**Description**	**coefficient**	**coefficient**	**coefficient**	**coefficient**
		p-value	*p*-value	*p*-value	*p*-value
beach500ft	within 500 feet of a beach	**20.8%*** **	**30.4%*** **	**25.3%*** **	**25.9%*** **
		0.000	*0.000*	*0.000*	*0.000*
beachhalf	within a half mile and outside of 500 feet of a beach	**5.3%*** **	**8.8%*** **	**8.7%*** **	**13.5%*** **
		0.000	*0.000*	*0.000*	*0.000*
openhalf	within a half mile of open space	**0.6%** **	**0.1%**	**0.1%**	**0.9%***
		0.021	*0.729*	*0.903*	*0.062*
line500ft	within 500 feet of a electricity transmission line	**-3%*** **	**-0.9%**	**-0.9%**	**-9.3%*** **
		0.001	*0.556*	*0.522*	*0.000*
prisonhalf	within a half mile of a prison	**-5.9%*** **	**2.6%**	**2.8%**	**-2.3%**
		0.001	*0.291*	*0.100*	*0.829*
hwy500ft	within 500 feet of a highway	**-7.3%*** **	**-5.2%*** **	**-3.7%*** **	**-5.3%*** **
		0.000	*0.000*	*0.000*	*0.000*
major500ft	within 500 feet of a major road	**-2.8%*** **	**-2.3%*** **	**-2.5%*** **	**-2%*** **
		0.000	*0.000*	*0.000*	*0.000*
fillhalf	within a half mile of a landfill	**1.8%**	**-0.9%**	**1%**	**-12.2%*** **
		0.239	*0.780*	*0.756*	*0.002*

statistical significance: *** highly significant (*p*-value <0.01); ** significant (*p*-value <0.05); * weakly significant (*p*-value <0.10; not significant (*p*-value >=0.1))

Pre-Turbine Announcement Effect Found But Not Post-Announcement or Post-Construction

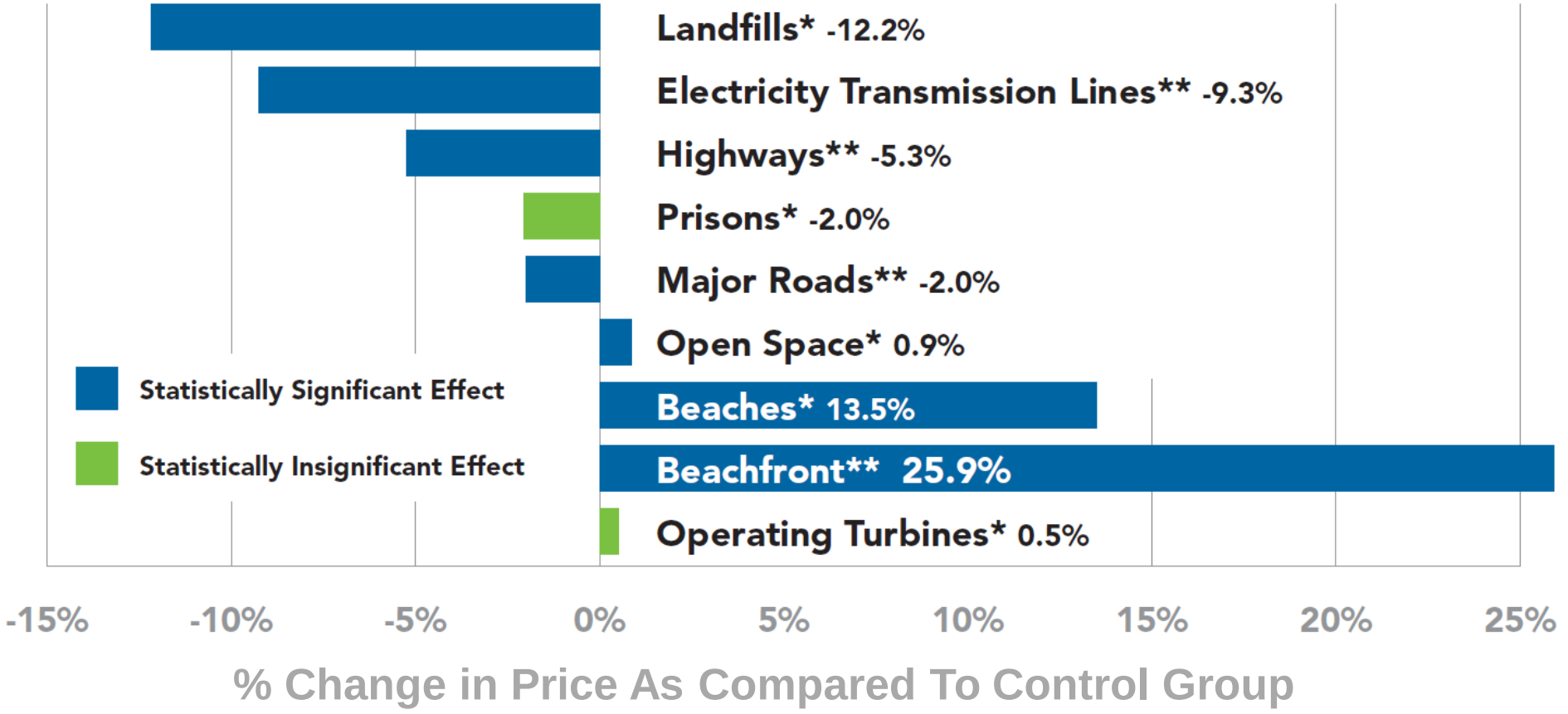
		Wind Facility Development Period			
		prioranc	*preanc*	*postanc-precon*	*postcon*
Variables	**Description**	**coefficient**	**coefficient**	**coefficient**	**coefficient**
		p-value	*p*-value	*p*-value	*p*-value
halfmile	within a half mile of a wind turbine	**-5.1%*** **	**-7.1%*** **	**-7.4%*** **	**-4.6%***
		0.000	*0.002*	*0.000*	*0.081*
	Net Difference Compared to *prioranc* Period			**-2.3%**	**0.5%**
				0.264	*0.853*

Results indicate

- Homes near turbines were lower in value before the development began (-5.1%, *p*-value 0.00)
- Values dipped further after announcement but effect was not statistically significant ("net effect" -2.3%, *p*-value 0.26)
- Values returned to pre-development levels after construction ("net effect" 0.5%, *p*-value 0.85)

statistical significance: *** highly significant (*p*-value <0.01); ** significant (*p*-value <0.05); * weakly significant (*p*-value <0.10; not significant (*p*-value >=0.1))

Home Prices Appear To Be Sensitive To Proximity To Some Amenities & Disamenities, But Not To The Turbines Studied in MA



*** within 500 feet *within ½ mile*

Robustness Tests Confirm Results

And Find Some Evidence Of Post-Announcement Effect

				Prior Announcement Turbine Effect			"Net" Post Announcement Pre Construction Turbine Effect			"Net" Post Construction Turbine Effect		
				inside 1/4 mile	*inside 1/2 mile*	*between 1/2 and 1 mile*	*inside 1/4 mile*	*inside 1/2 mile*	*between 1/2 and 1 mile*	*inside 1/4 mile*	*inside 1/2 mile*	*between 1/2 and 1 mile*
#	**Model Name**	*n*	*Adj R^2*	**coef**	**coef**	**coef**	**coef**	**coef**	**coef**	**coef**	**coef**	**coef**
				p-value	*p-value*	*p-value*	*p-value*	*p-value*	*p-value*	*p-value*	*p-value*	*p-value*
	Base Model	122,198	0.80		**-5.1%*** **			**-2.3%**			**0.5%**	
					0.000			*0.264*			*0.853*	
1	Inside 1/4 mile	122,198	0.80	**-5.3%**			**12.7%**			**0.7%**		
				0.260			*0.118*			*0.916*		
2	Between 1/2 and 1 Mile	122,198	0.80		**-5.0%*** **	**-0.4%**		**-2.0%**	**1.4%**		**1.0%**	**1.3%**
					0.000	*0.536*		*0.336*	*0.225*		*0.715*	*0.288*
3	All Sales Out to 10 Miles	312,677	0.82		**-5.8%*** **			**-3.0%**			**1.0%**	
					0.000			*0.886*			*0.724*	
4	Using Outside of 5 Miles as Reference	312,677	0.82		**-7.6%*** **			**1.6%**			**1.1%**	
					0.000			*0.435*			*0.695*	
5	Including Style & Heat Variables	120,292	0.81		**-3.8%*** **			**-3.3%**			**2.8%**	
					0.004			*0.114*			*0.336*	
6	Using Block Group	122,198	0.81		**-3.1%*** **			**-1.3%**			**-2.6%**	
					0.024			*0.554*			*0.324*	
7	No Screens	123,555	0.73		**-4.0%*** **			**-4.6%***			**-0.8%**	
					0.003			*0.072*			*0.800*	
8	Removing Outliers and Influencers	119,623	0.79		**-4.3%*** **			**-2.6%**			**0.04%**	
					0.001			*0.205*			*0.989*	
9	Including Spatial Variables	122,198	0.80		**-5.3%*** **			**-1.5%**			**1.4%**	
					0.000			*0.467*			*0.621*	

There Is Not Evidence That Homes Near Announced or Constructed Turbines Did So At Lower Volumes

	prioranc	*preanc*	*postanc-precon*	*postcon*	*all periods*
0-0.25mile	60	9	14	38	121
	0.04%	*0.02%*	*0.03%*	*0.06%*	*0.04%*
0.25-0.5mile	434	150	210	192	986
	0.25%	*0.39%*	*0.47%*	*0.33%*	*0.32%*
0.5-1mile	3,190	805	813	1,273	6,081
	1.9%	*2.1%*	*1.8%*	*2.2%*	*1.9%*
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	61%	*59%*	*59%*	*63%*	*61%*
Total	**170,839**	**38,107**	**44,667**	**59,064**	**312,677**
	100%	*100%*	*100%*	*100%*	*100%*

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Conclusions

- The report **analyzed more than 122,000 home sales**, near almost all turbines in densely-populated Massachusetts, with more than **1,500 sales within 1 mile** of operating turbines.
- The results **do not** support the claim that wind turbines affect nearby home prices.
- The study **did** find the effects from a variety of negative features (such as highways, major roads, and landfills) and positive features (such as open space and beaches)
- Weak evidence suggests that the announcement of the wind facilities had an adverse impact on home prices.
- The analysis **did not** find impacts on the rate of home sales near wind turbines.

Questions?

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