Research and Updates on Wind Property Value Impacts

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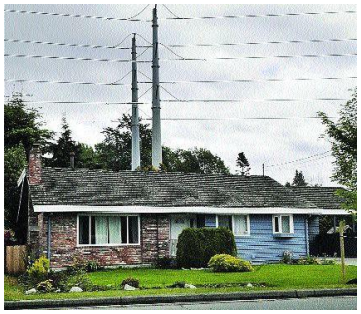
Schedule

0:00	Background & Methodology
0:05	Recent US Wind Property Value Studies
0:10	Recent EU Wind Property Value Studies
0:15	Comparisons

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

Vs.

Why Study Property Values?

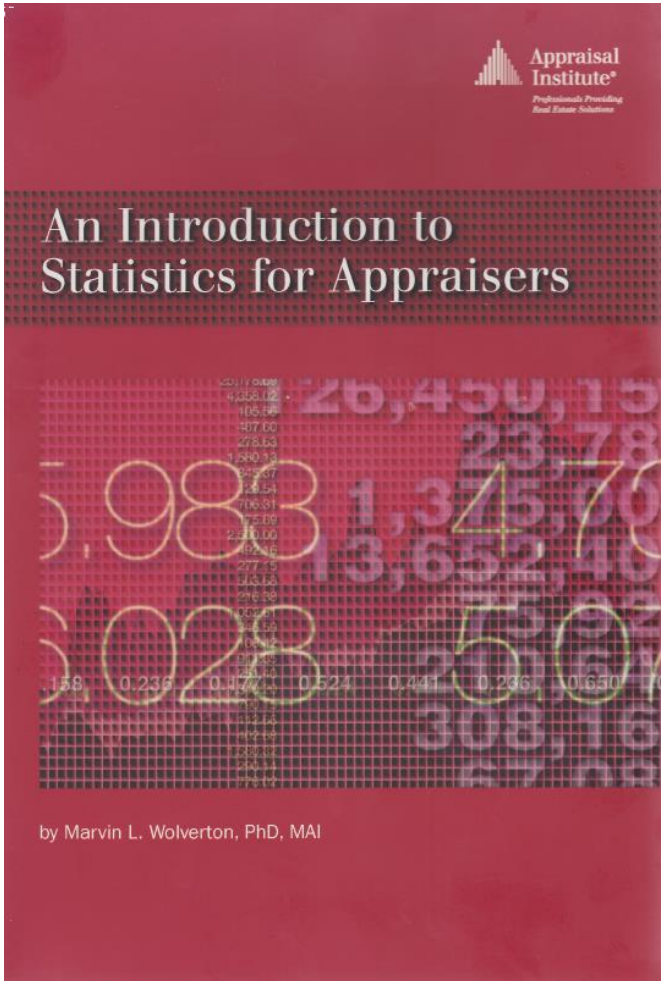
For many communities that are considering wind energyé

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

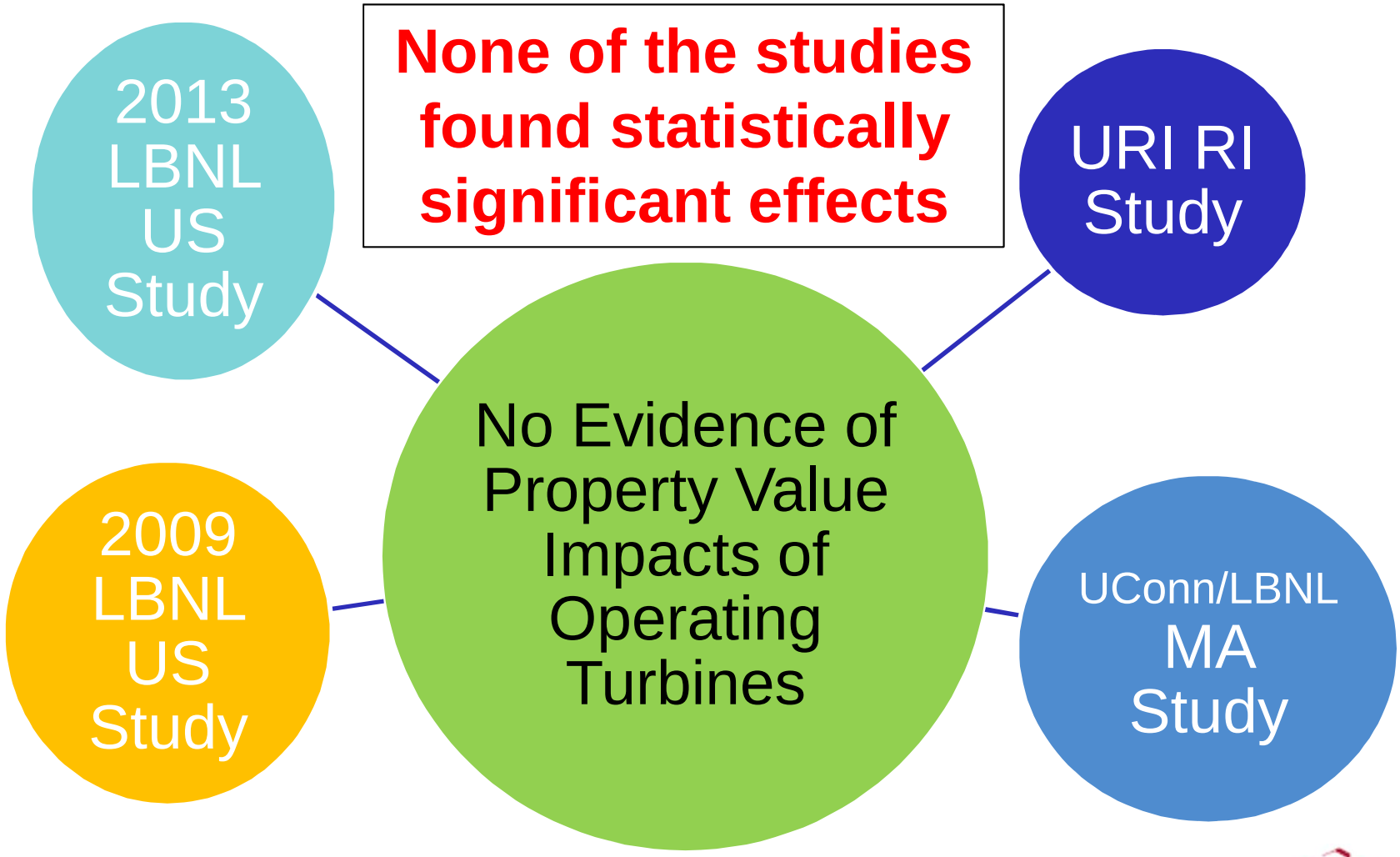
Wind Facility Development Periods	Distances to Nearest Turbine: Close to the Turbines	Moderate Distance From the Turbines	Far Away From the Turbines
Pre Announcement	A0	A1	Reference Category
Post-Announcement & Pre-Construction	B0	B1	B3
Post-Construction (Operation)	Interest Category	C1	C3

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

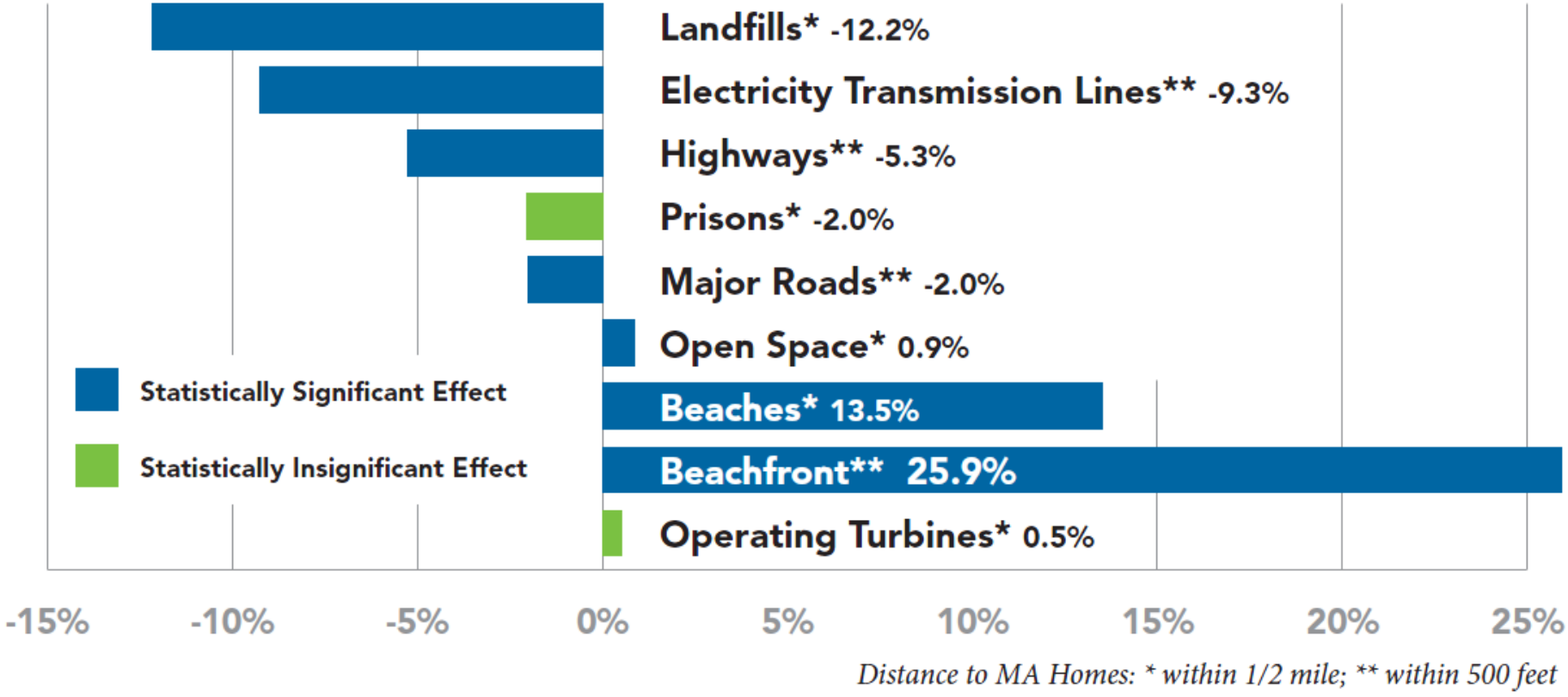
Authors	US Location	Date	Post-Con Sales W/in 1 Mile
LBNL	US Wide	2009	~ 125
LBNL	US Wide	2013	~376
University of RI	Rhode Island	2013	~412
U Conn/LBNL	Massachusetts	2014	~1,503

Four Studies = Four Distinct Research Efforts
But The Same Results



U Conn/LBNL 2014 Study Results

We Compared Impacts Across Amenities and Disamenities

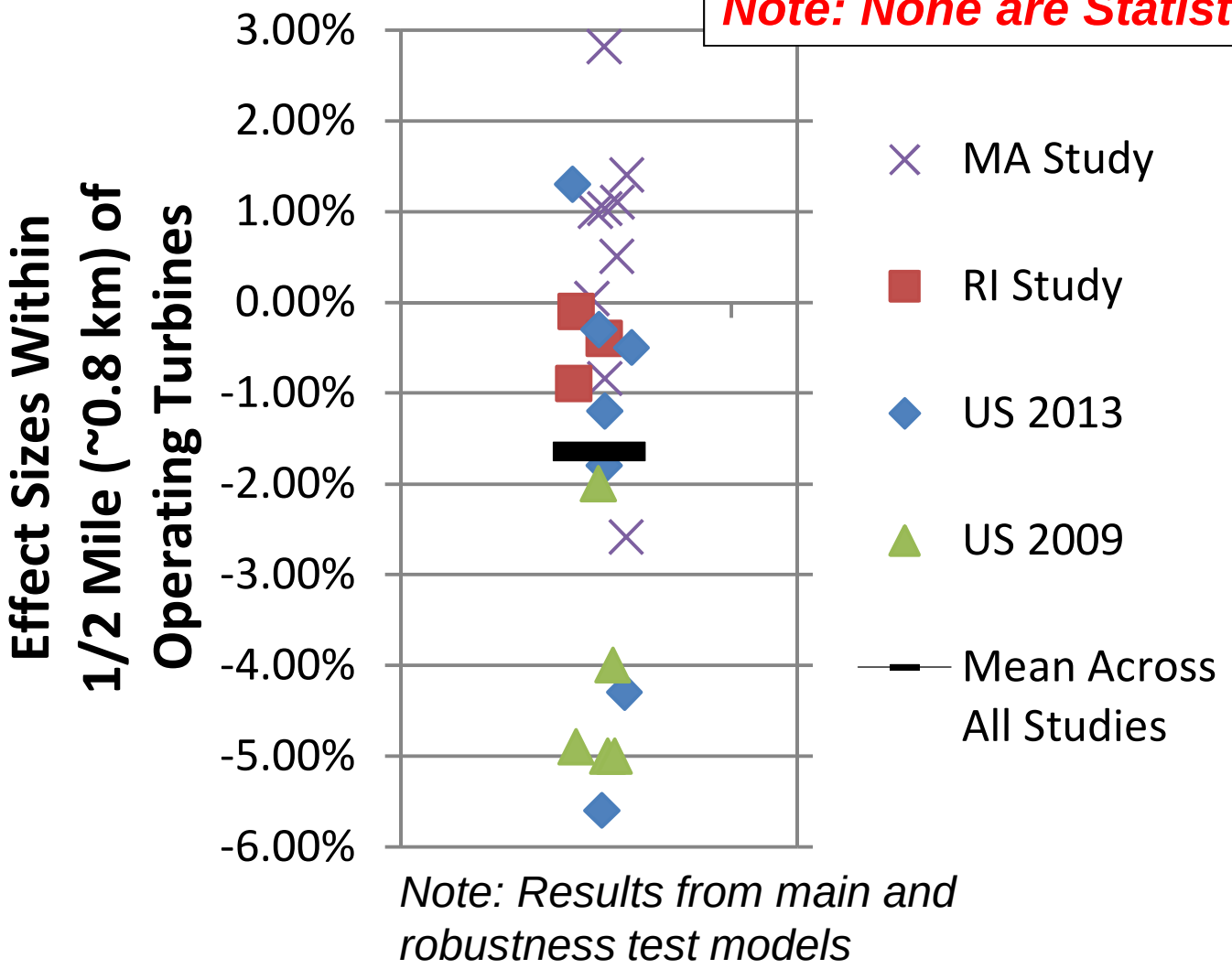


*Distance to MA Homes: * within 1/2 mile; ** within 500 feet*

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 ï 1.6%

Note: Results from main and robustness test models

These NA Results Contrast With Four Recent EU Studies

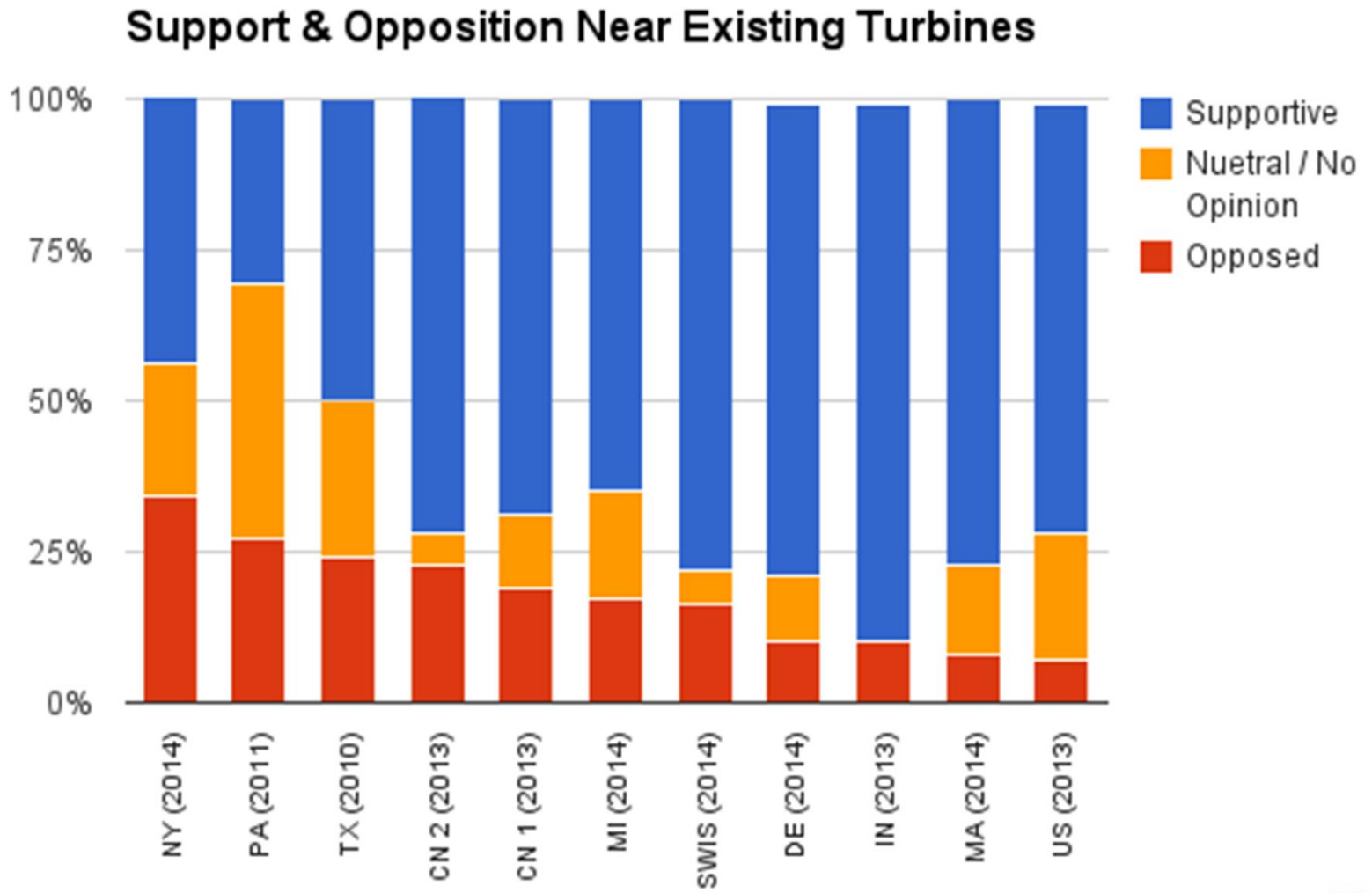
Studies Investigating Property Value Impacts of Surrounding Operating EU Turbines

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

Why Has Evidence Of Impacts Failed To Emerge In The US But Has In The EU?

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

Multiple Surveys Have Found High Levels Of Support Near US Turbines



Homeowner, Town, Schools And County Benefits Can Be Significant In The US

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

A PURE THEORY OF LOCAL EXPENDITURES[1]

CHARLES M. TIEBOUT
Northwestern University

ONE of the most important recent developments in the area of "applied economic theory" has been the work of Musgrave and Samuelson in public finance theory.[2] The two writers agree on what is probably the major point under investigation, namely, that no "market type" solution exists to determine the level of expenditures on public goods. Seemingly, we are faced with the problem of having a rather large portion of our national income allocated in a "non-optimal" way when compared with the private sector.

This discussion will show that the Musgrave-Samuelson analysis, which is valid for federal expenditures, need not apply to local expenditures. The plan of the discussion is first to restate the assumptions made by Musgrave and Samuelson and the central problems with which they deal. After looking at a key difference between the federal versus local cases, I shall present a simple model. This model yields a solution for the level of expenditures for local public goods which reflects the preferences of the population more adequately than they can be reflected at the national level. The assumptions of the model will then be relaxed to see what implications are involved. Finally, policy considerations will be discussed.

THE THEORETICAL ISSUE

Samuelson has defined public goods as "*collective consumption goods* ($X_n + 1, \ldots, X_n + n$) which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good, so that $X_n + j = X_n^i + j$ simultaneously for each and every ith individual and each collective good."[3] While definitions are a matter of choice, it is worth noting that "consumption" has a much broader meaning here than in the usual sense of the term. Not only does it imply that the act of consumption by one person does not diminish the opportunities for consumption by another but it also allows this consumption to be in another form. For example, while the residents of a new government housing project are made better off, benefits also accrue to other residents of the community in the form of the external economies of slum clearance.[4] Thus many goods that appear to lack the attributes of public goods may

[1] I am grateful for the comments of my colleagues Karl de Schweinitz, Robert Eisner, and Robert Strotz, and those of Martin Bailey, of the University of Chicago.

[2] Richard A. Musgrave, "The Voluntary Exchange Theory of Public Economy," *Quarterly Journal of Economics*, LII (February, 1939), 213–17; "A Multiple Theory of the Budget," paper read at the Econometric Society annual meeting (December, 1955); and his forthcoming book, *The Theory of Public Economy;* Paul A. Samuelson, "The Pure Theory of Public Expenditures," *Review of Economics and Statistics*, XXXVI, No. 4 (November, 1954), 387–89, and "Diagrammatic Exposition of a Pure Theory of Public Expenditures," *ibid.*, XXXVII, No. 4 (November, 1955), 350–56.

[3] "The Pure Theory . . . ," *op. cit.*, p. 387.

[4] Samuelson allows for this when he states that "one man's circus may be another man's poison," referring, of course, to public goods ("Diagrammatic Exposition . . . ," *op. cit.*, p. 351).

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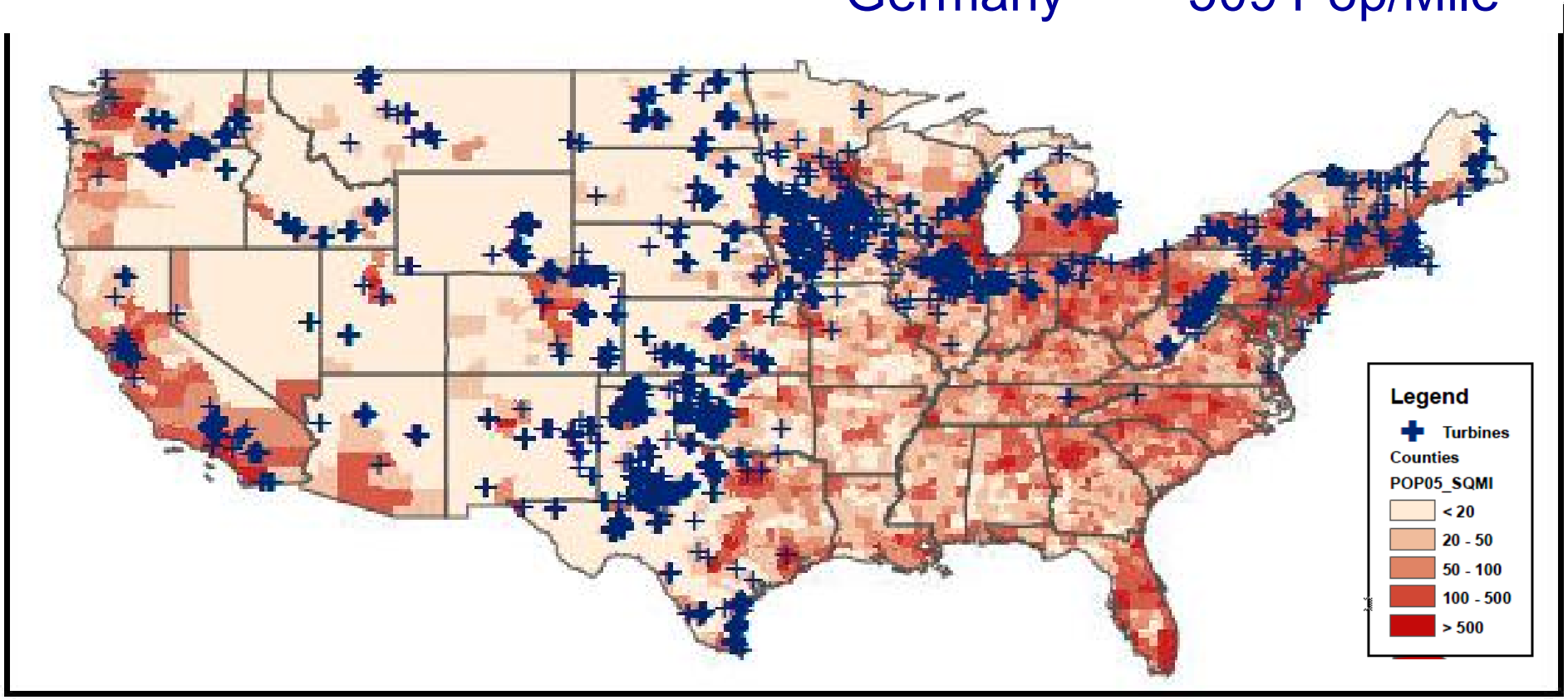
When consumers are mobile, over time they will sort themselves such that those living close to turbines are more supportive of turbines

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

- Property values can be useful to gauge levels of support/opposition and to determine impacts
- Statistically significant impacts have **not** emerged near US turbines but have near EUôs
- Reasons for these differences might be:
  - Significantly higher compensation for schools and local economies in the US
  - More sorting over time to more supportive communities in the US
  - Lower Population density in the US
  - Larger samples of sales in EU allowing a determination of smaller effects

Thank You & Questions?

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US Wide Study #1: LBNL 2009

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 proximate 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 four 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 those 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 Hand, 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

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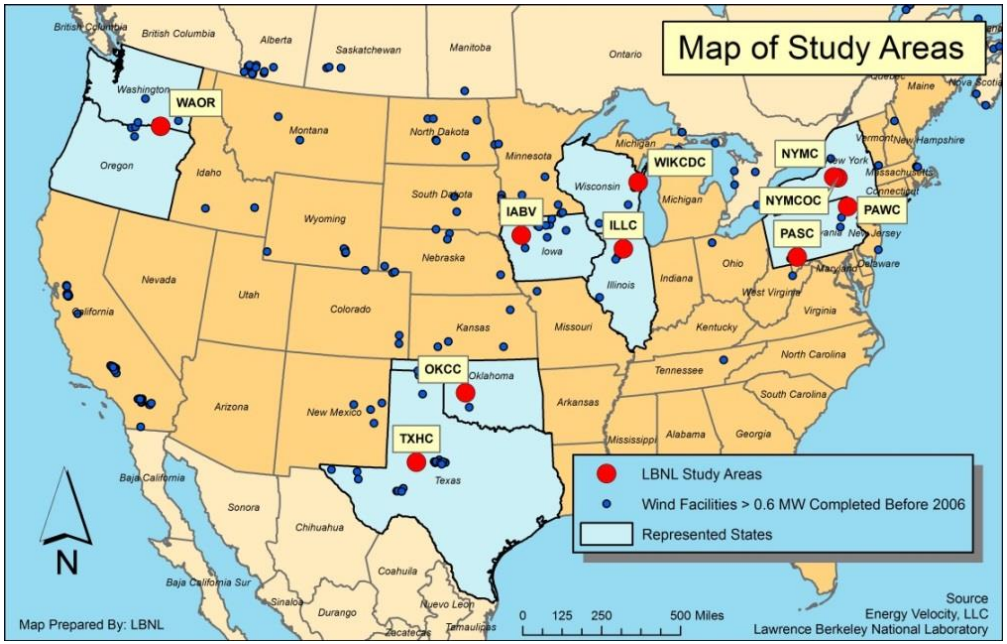

Summary

- 7,489 sales w/in 16 km of 11 facilities
- **125 post-construction sales** within 1.6 km
- Rural settings with large (50+ turbines) wind facilities

US Wide Study #2: LBNL 2013

J Real Estate Finan Econ
DOI 10.1007/s11146-014-9477-9

Spatial Hedonic Analysis of the Effects of US Wind Energy Facilities on Surrounding Property Values

Ben Hoen · 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 50,000 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-in-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

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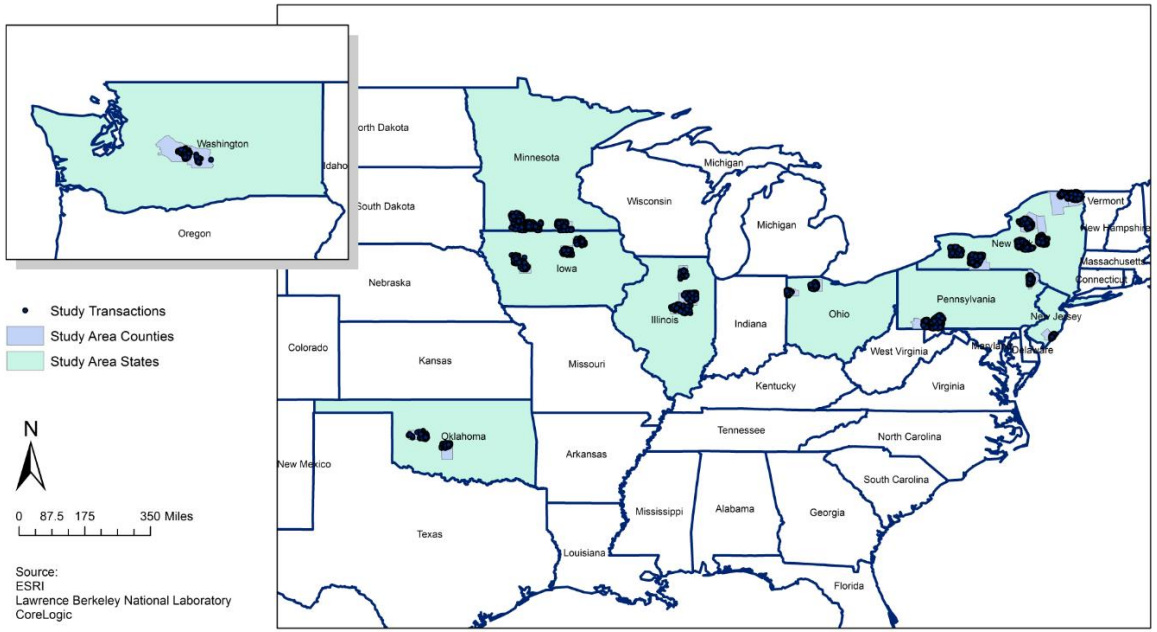
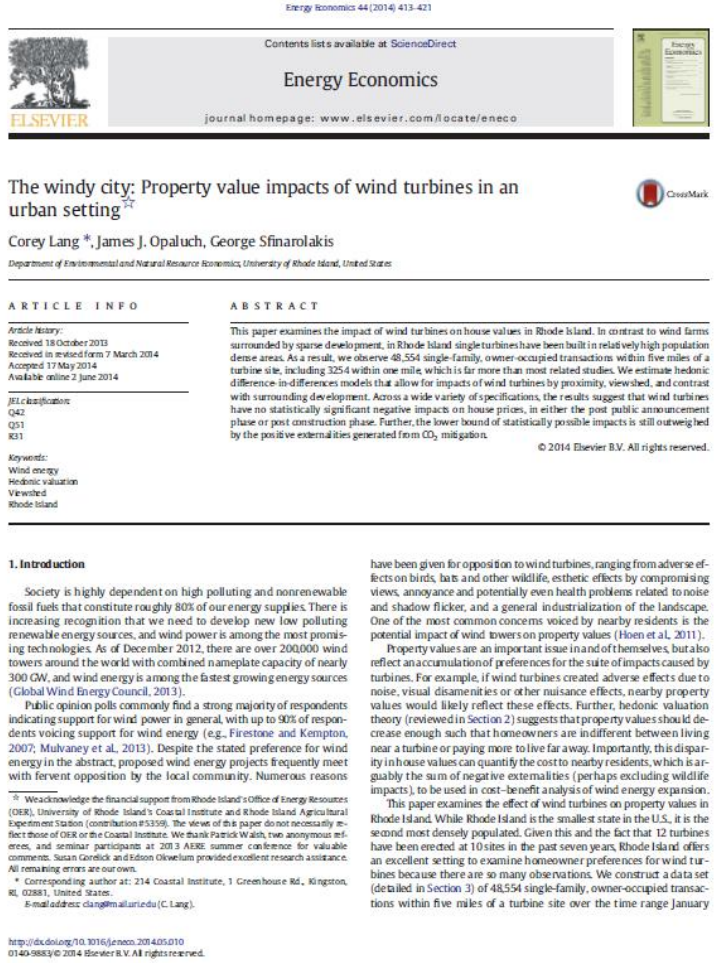


Summary

- 51,276 total sales, 9 states, 67 facilities
- **376 post-construction sales** within 1 mile
- Rural settings, large (50+ turbines) facilities

RI Based Study: URI 2013



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The windy city: Property value impacts of wind turbines in an urban setting☆

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ABSTRACT

This paper examines the impact of wind turbines on house values in Rhode Island. In contrast to wind farms surrounded by sparse development, in Rhode Island single turbines have been built in relatively high population dense areas. As a result, we observe 48,554 single-family, owner-occupied transactions within five miles of a turbine site, including 3254 within one mile, which is far more than most related studies. We estimate hedonic difference-in-differences models that allow for impacts of wind turbines by proximity, viewshed, and contrast with surrounding development. Across a wide variety of specifications, the results suggest that wind turbines have no statistically significant negative impacts on house prices, in either the post public announcement phase or post construction phase. Further, the lower bound of statistically possible impacts is still outweighed by the positive externalities generated from CO_2 mitigation.

1. Introduction

Society is highly dependent on high polluting and nonrenewable fossil fuels that constitute roughly 80% of our energy supplies. There is increasing recognition that we need to develop new low polluting renewable energy sources, and wind power is among the most promising technologies. As of December 2012, there are over 200,000 wind towers around the world with combined nameplate capacity of nearly 300 GW, and wind energy is among the fastest growing energy sources (Global Wind Energy Council, 2013).

Public opinion polls commonly find a strong majority of respondents indicating support for wind power in general, with up to 90% of respondents voicing support for wind energy (e.g., Firestone and Kempton, 2007; Mulvaney et al., 2013). Despite the stated preference for wind energy in the abstract, proposed wind energy projects frequently meet with fervent opposition by the local community. Numerous reasons have been given for opposition to wind turbines, ranging from adverse effects on birds, bats and other wildlife, esthetic effects by compromising views, annoyance and potentially even health problems related to noise and shadow flicker, and a general industrialization of the landscape. One of the most common concerns voiced by nearby residents is the potential impact of wind towers on property values (Hoen et al., 2011).

Property values are an important issue in and of themselves, but also reflect an accumulation of preferences for the suite of impacts caused by turbines. For example, if wind turbines created adverse effects due to noise, visual disamenities or other nuisance effects, nearby property values would likely reflect these effects. Further, hedonic valuation theory (reviewed in Section 2) suggests that property values should decrease enough such that homeowners are indifferent between living near a turbine or paying more to live far away. Importantly, this disparity in house values can quantify the cost to nearby residents, which is arguably the sum of negative externalities (perhaps excluding wildlife impacts), to be used in cost–benefit analysis of wind energy expansion.

This paper examines the effect of wind turbines on property values in Rhode Island. While Rhode Island is the smallest state in the U.S., it is the second most densely populated. Given this and the fact that 12 turbines have been erected at 10 sites in the past seven years, Rhode Island offers an excellent setting to examine homeowner preferences for wind turbines because there are so many observations. We construct a data set (detailed in Section 3) of 48,554 single-family, owner-occupied transactions within five miles of a turbine site over the time range January

☆ We acknowledge the financial support from Rhode Island's Office of Energy Resources (OER), University of Rhode Island's Coastal Institute and Rhode Island Agricultural Experiment Station (contribution #5359). The views of this paper do not necessarily reflect those of OER or the Coastal Institute. We thank Patrick Walsh, two anonymous referees, and seminar participants at 2013 AERE summer conference for valuable comments. Susan Gorelick and Edson Okwelum provided excellent research assistance. All remaining errors are our own.

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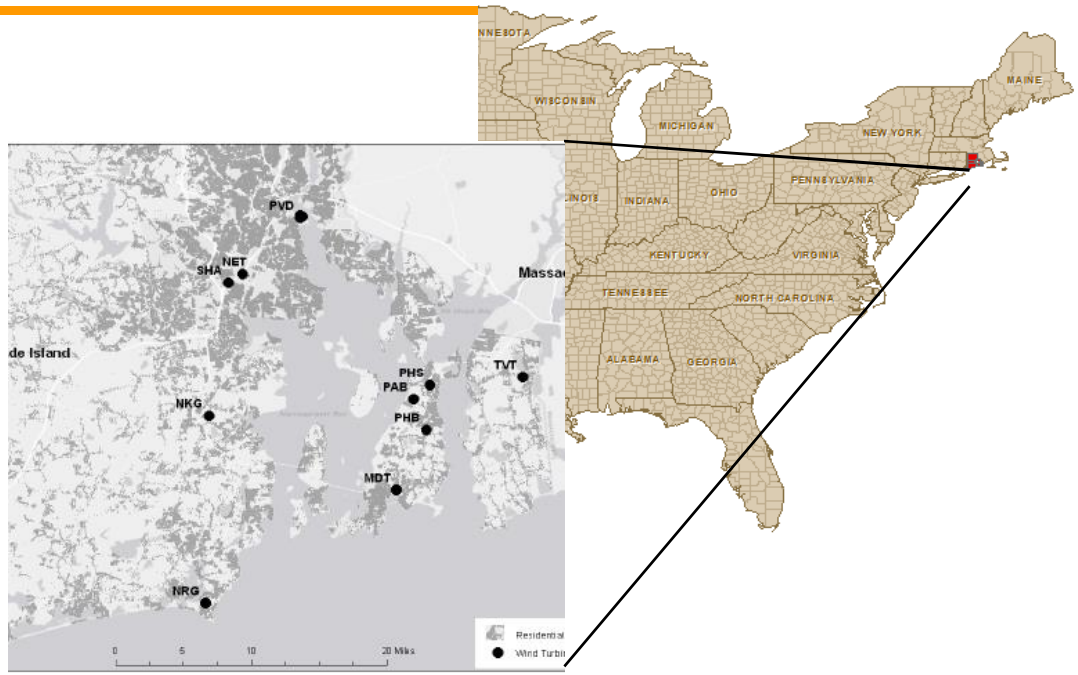
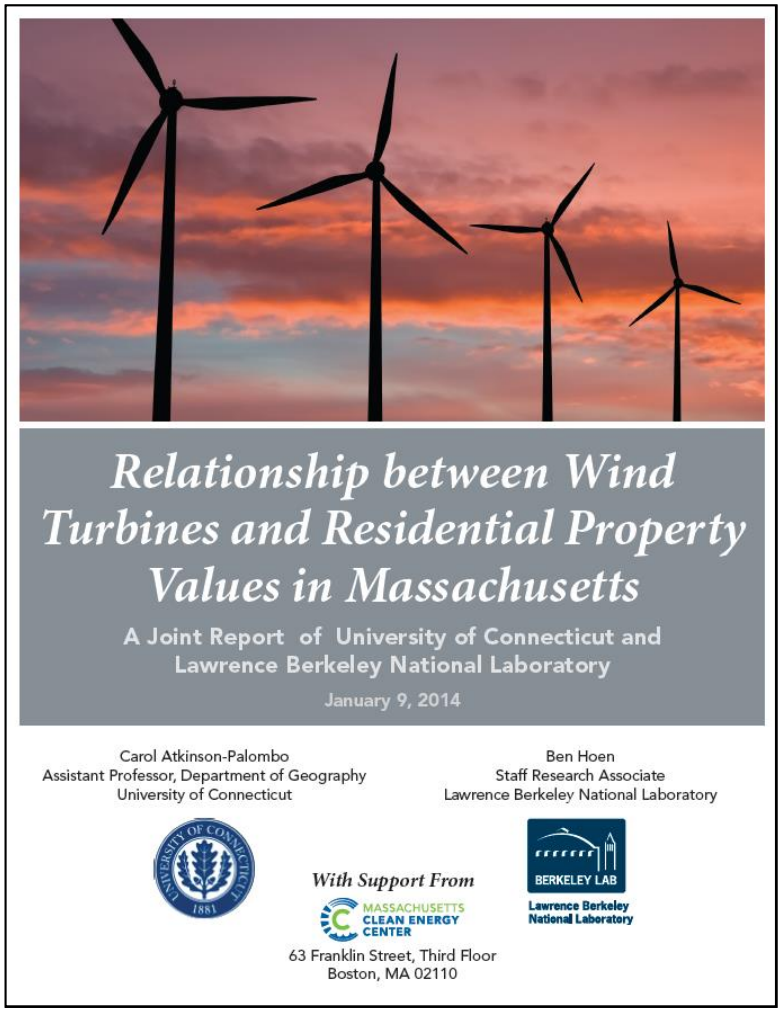
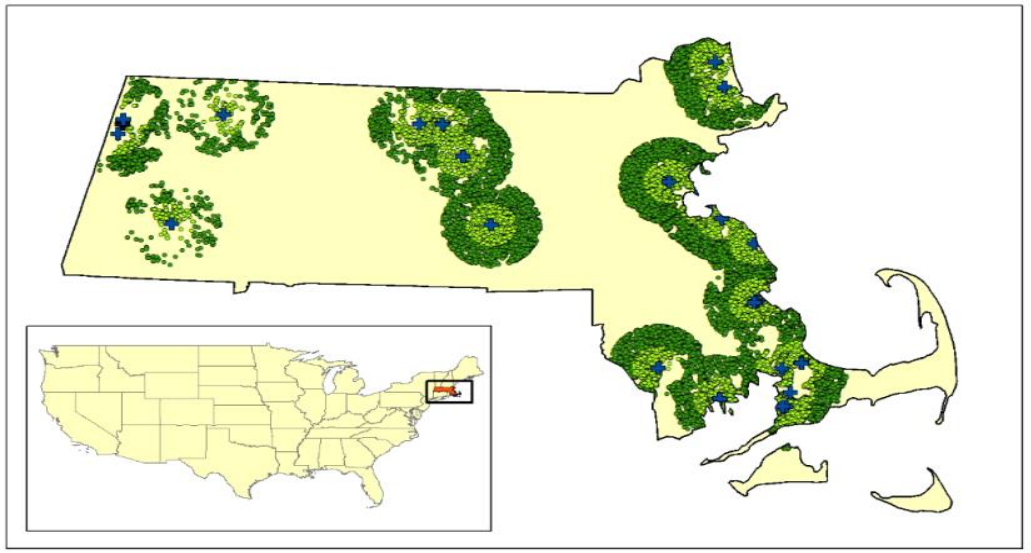


Summary

- 48,554 total sales, 10 facilities
- **412 post-construction sales** within 1 mile
- Mostly urban settings, small facilities

MA Based Study: UConn/LBNL 2014



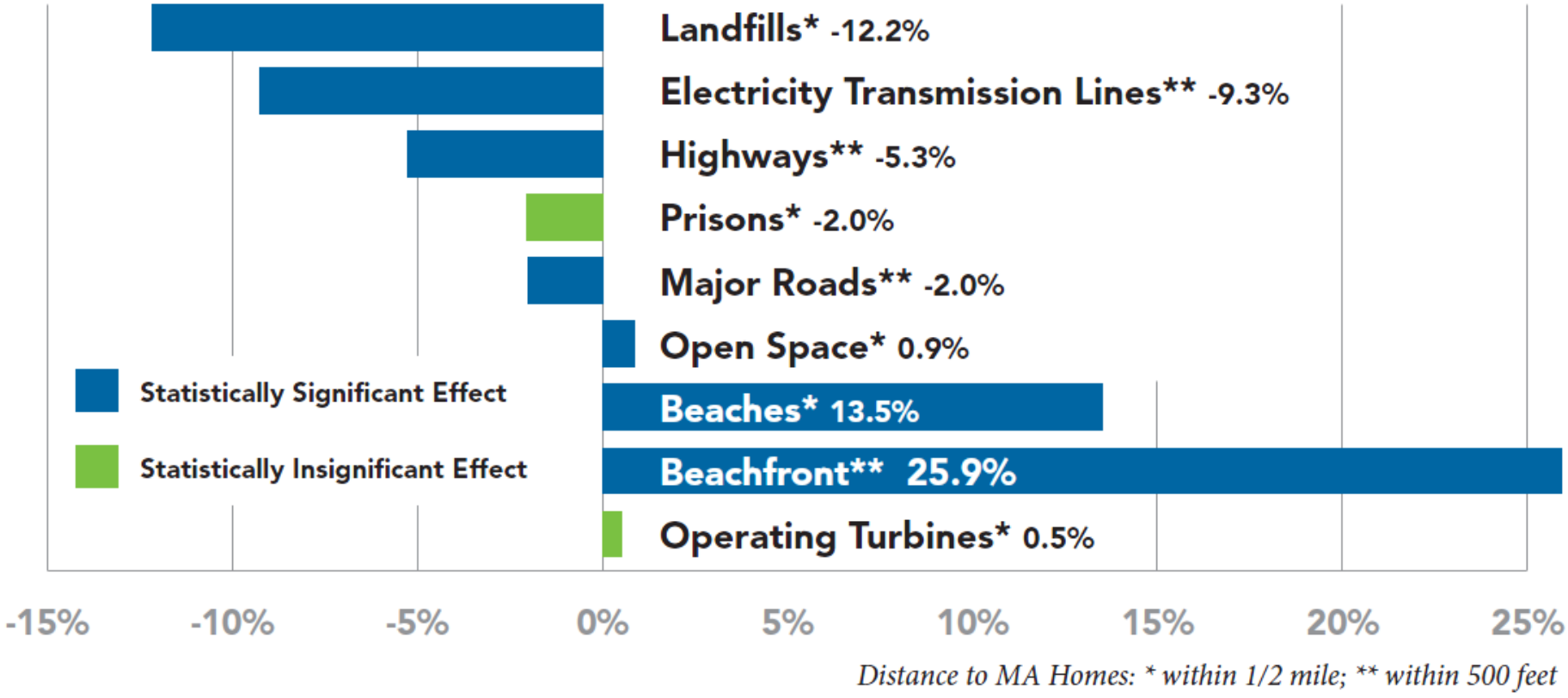


Summary

- 312,677 total sales, 26 facilities
- **1,503 post-construction sales** w/in 1 mile
- Urban settings, mostly small facilities
- First study to test wind turbine **and** other environmental amenities/disamenities together

Detailed MA Based Study Results

We Compared Impacts Across Amenities and Disamenities



*Distance to MA Homes: * within 1/2 mile; ** within 500 feet*

Despite the presence of effects for other environmental characteristics, no effects were discovered for turbines

Sunak & Madlener: Germany 2013

	When Did The Sales Occur?	
Effect Tested	**After Announcement and Before Construction of Wind Facility**	**After Construction and Operation of Wind Facility**
View of wind turbine	*not tested*	**effects found (~ -12%)**
Within a close distance (~0.8 km) of turbine	*not tested*	**strong effects found (~ -28%)**
Non-turbine landscape amenities	strong effects found	
Non-turbine landscape disamenities	strong effects found	

	Quando si sono verificate le vendite?	
Effetti Testati	**Dopo l'annuncio e prima della costruzione della Struttura Eolica**	**Dopo la costruzione e durante l'esercizio del struttura eolica**
Veduta di turbina eolica	*non testato*	**effetti trovati (~ -12%)**
A breve distanza (~ 0,8 km) di turbina	non testato	**forti effetti trovati (~ -28%)**
aspetti piacevoli del paesaggio in assenza della turbina eolica	forti effetti trovati	
aspetti spiacevoli del paesaggio in assenza della turbina eolica	forti effetti trovati	

Denmark Based Study: Jensen et al. 2013

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 up to about 3%, while noise pollution reduces the price between 3% and 7%.* (JEL Q18, Q38)

I. INTRODUCTION

In the sixteenth century, the fictional character Don Quixote thought that 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 (Wolsink 2000), which often takes the form of a "not in my back yard" argument. The general 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 1,800 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 (Borchers, 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 2009; Meyerhoff, Ohl, and Hartje 2010; Ladenburg and Möller 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 (Diamond and Hausman 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 succeeded (Sims and Dent 2007; Sims, Dent, and Oskrochi 2008; Hoen et al. 2011; Heintzelman and Tuttle 2012). Heintzelman and Tuttle (2012) find that nearby wind facilities

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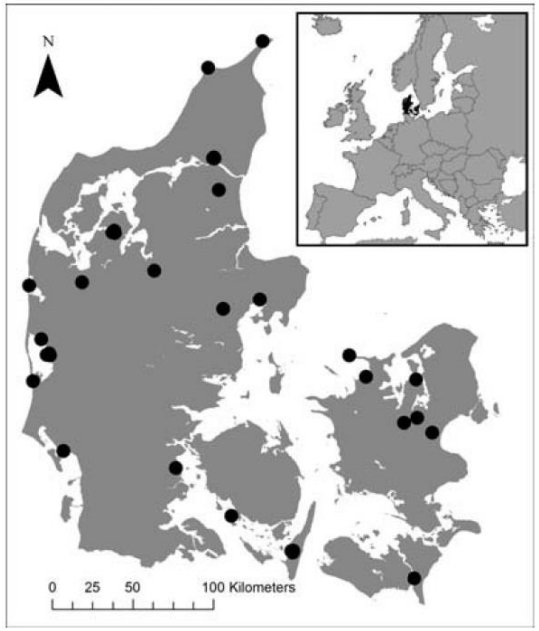
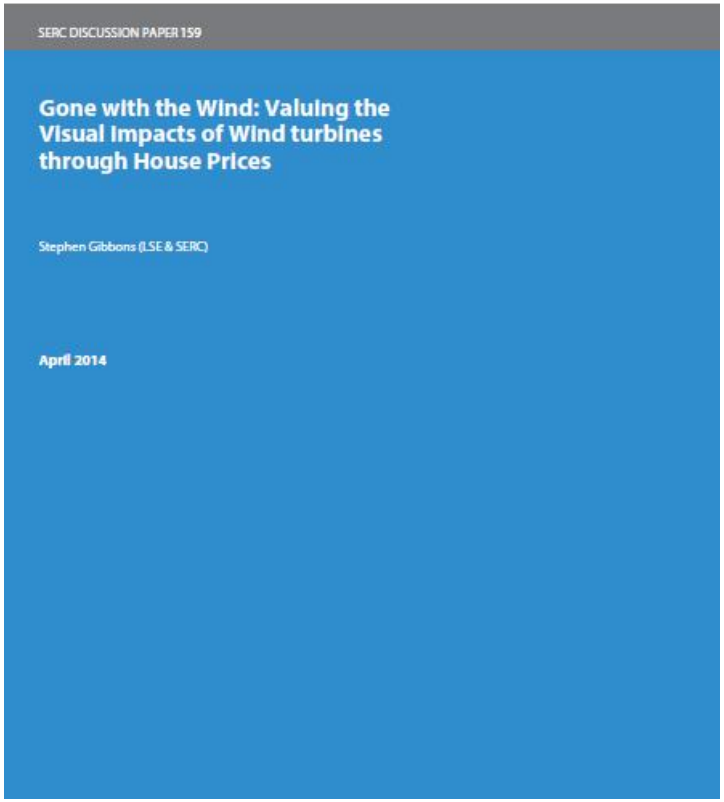


Summary

- 12,640 total sales, ~24 facilities
- **~400 post-construction sales** within 1 km
- First study of its kind in Denmark
- Explored impacts near a variety of disamenities
- Studied Scenic Vista and Nuisance Stigmas

UK Based Study: Gibbons 2014



Summary

- 1,710,293 total sales, >25 facilities
- **>8,000 post-construction sales** w/in 1 km
- First study of its kind in UK
- Focused on view of turbine effects
- Investigated Area Stigma, Scenic Vista Stigma, and Nuisance Stigma