

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

Prepared for Antrim Wind Energy, LLC  
By Seacoast Economics  
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## Contents

<b>1 Executive Summary</b>	<b>3</b>
<b>2 Introduction</b>	<b>4</b>
2.1 Lempster Wind Power Project . . . . .	5
2.2 Potential Residential Property Value Impacts of Wind Power Projects . . . . .	6
<b>3 Analysis</b>	<b>7</b>
3.1 Literature Review . . . . .	8
3.2 Single Family Home Sales in Communities Surrounding the Lempster Wind Power Project . . . . .	10
<b>4 Conclusion</b>	<b>13</b>
<b>A Study Update Background</b>	<b>14</b>
<b>B Figures</b>	<b>15</b>
<b>C Tables</b>	<b>21</b>
<b>D Review of Studies of Property Value Impacts Related to Wind Power Projects</b>	<b>25</b>
<b>E Methodology</b>	<b>28</b>
<b>F Study Author</b>	<b>30</b>

## List of Figures

1	Town of Lempster with wind turbine locations . . . . .	15
2	Lempster Wind Power Project (September 2008) . . . . .	16
3	Graph of annual sales for each city and town in Sullivan County (excluding Sunapee) . . . . .	17
4	Single family home sales from September 2008 to November 2011 . . . . .	18
5	Box plot of pre-sale assessed value by view from September 2008 to November 2011 . . . . .	19
6	Box plot of difference of sales price and pre-sale assessed value by view from September 2008 to November 2011 . . . . .	19
7	Correlation of sales price to distance from nearest wind turbine from September 2008 to November 2011 . . . . .	20
8	Correlation of sales price to square footage from September 2008 to November 2011 . . . . .	20

## List of Tables

1	Summary statistics for the Lempster Wind Power Project compared to the State of NH . . . . .	21
2	Studies reviewed that examined the relationship between residential property values and commercial wind power projects . . . . .	21
3	Sales of single family homes in Sullivan County (excluding Sunapee) from January 2005 to November 2011 . . . . .	22
4	Frequency of post-construction sales transactions(September 2008 to November 2011 ) by distance from nearest turbine . . . . .	22
5	Single family home sales from September 2008 to November 2011 by view of the Lempster Wind Power Project . . . . .	23
6	ANOVA test of pre-sale assessed value by view from September 2008 to November 2011 . . . . .	23
7	ANOVA test of difference between sales price and pre-sale assessed value by view from September 2008 to November 2011 . . . . .	23
8	Correlation of sales price to distance from nearest wind turbine from September 2008 to November 2011 . . . . .	24
9	Correlation of sales price to square footage from September 2008 to November 2011 . . . . .	24

## 1. Executive Summary

This is an update to the study *Impact of the Lempster Wind Power Project on Local Residential Property Values* which was originally released in January 2012. The purpose of the study update was to determine if there might be any potential economic impact from the proposed Antrim Wind Energy Project on the local real estate market based on observations of the real estate market surrounding the Lempster Wind Power Project. The 24-megawatt (12 turbine) Lempster Wind Power Project, located in Sullivan County, is the first significant wind power project in New Hampshire which began operating in the 3<sup>rd</sup> quarter of 2008.

The original study concluded:

*While this study does not exclude the possibility of isolated cases of property value impacts attributable to the Lempster Wind Power Project, this study has found no evidence that the Project has had a consistent, statistically-significant impact on property values within the Lempster region. This is consistent with the near unanimous findings of other studies—based their analysis on arms-length property sales transactions—that have found no conclusive evidence of wide spread, statistically-significant changes in property values resulting from wind power projects.*

Since that time, new studies examining the relationship between residential property values and commercial wind power projects at the local, regional and national level have been released. This includes a study by the update author titled *The Impact of the Wild Meadows Wind Farm on Local Residential Property Values* which included property sales near the Lempster Wind Power Project through July 2013.

Single family homes surrounding the Lempster Wind Power Project have not shown an overall change in their assessed values nor have they been observed to sell for a value that was consistently different from their expected value.

In other words, there has been no overall change observed in the residential real estate market value surrounding the Lempster Wind Power Project that differs from overall area real estate market trends. This observation holds true even when considering the types of residential properties that would be expected to be the most impacted by the presence of a wind power project—including properties that are in close proximity to a turbine and/or that have direct views of one or more turbines.

This study update supports the original conclusion that the Lempster Wind Power Project has not had any consistent, statistically-significant impact on property values. Furthermore, the findings from this study update agree with the substantial body of evidence from international, national, and regional studies that also have not found evidence of systematic, wide-spread changes in property values associated with wind power projects.

Therefore, it is not expected there will be a decrease in the value of the overall residential market around the proposed Antrim Wind Energy Project—including those properties that would be in close proximity to a turbine and/or that would have direct views of one or more turbines—if it is developed.

## 2. Introduction

New Hampshire has experienced growth in the number of wind power projects over the last decade. To date, three separate commercial wind power projects rated at a total of 171-megawatts capacity are active in NH.

- The 24-megawatt (12 turbine) Lempster Wind Power Project, located in Sullivan County, is the first significant wind power project in New Hampshire which began operating in the 3<sup>rd</sup> quarter of 2008.
- The 99-megawatt (33 turbine) Granite Reliable Power Windpark located in Coos County is NH's second commercial-scale wind power project. The facility began operations in the 4<sup>th</sup> quarter of 2011.
- The 48-megawatt (24 turbine) Groton Wind Farm located in Grafton County is NH's third commercial-scale wind power project. The facility began operations in the 4<sup>th</sup> quarter of 2012.

The Lempster Wind Power Project serves as a case study of an operating wind power project in NH. The real estate market activity around the Lempster Wind Power Project can indicate what would be experienced by other real estate markets that are located around potential new wind power projects in NH if they are developed.

## 2.1. Lempster Wind Power Project

The Lempster Wind Power Project—owned by Iberdrola Renewables, LLC—is New Hampshire’s first modern, commercial-scale wind farm. The project is a 24 megawatt (MW) wind farm that came on-line in November 2008. The wind farm is located in the eastern portion of the Town of Lempster in Sullivan County on approximately 1,500 acres of privately owned land. The farm consists of 12 Gamesa G87 (2 MW) wind turbines stretching over several connected ridgelines on Lempster Mountain and Bean Mountain whose summit is 2,326 feet above sea level. In fig. 1 on page 15 there is a map of the turbine locations in the Town of Lempster. In fig. 2 on page 16 there is a photograph of two turbines of the Lempster Wind Power Project.

The Town of Lempster has a total area of 33 square miles and had a population of 1,150 in 2010. The population density is 36 people per square mile and the median age is 46. There are approximately 700 housing units that had a total assessed valuation of \$71 million in 2012. The average assessed value of a housing unit was \$104,300. Refer to table 1 on page 21 for a summary of demographic information for the Town of Lempster.

The region is rural, heavily forested, and features hilly terrain. The town also has several bodies of water that account for 1.2 percent of the total area of the town and include: Dodge Pond, Long Pond and Sand Pond. There are two settlement areas in Lempster: the town center (Lempster village) and the village of East Lempster. The northernmost wind turbine is just south of the Town of Goshen and nearby to the east is Pillsbury State Park in the Town of Washington. Pillsbury Park is heavily wooded and covers 8,135 acres which significantly limits the number of residential properties immediately east of the Project. The Town of Washington is located to the east and south east of the Lempster Wind Power Project. The town of Marlow is south of the Lempster Wind Power Project and the Town of Unity is north-west of the Lempster Wind Power Project.

The major road routes in the Town of Lempster are: Route 10 (runs north to south through the center of the Town of Lempster), Second New Hampshire Turnpike (runs northwest to southeast up to the center of the Town of Lempster) and Mountain Road (runs northwest to southeast from the center of the Town of Lempster). Commercial establishments are primarily located along Route 10 and residential housing units are dispersed throughout the Town of Lempster.

The Gamesa G87 turbines stand 398 feet to the tip of blade and have a tower hub height of 256 feet and a blade length of 139 feet. Each of the turbines is located within 700 to 850 feet of another turbine and the turbines are accessible via 5 miles of gravel surfaced roads. The Lempster Wind Power Project is interconnected to the Public Service of New Hampshire (PSNH) Newport substation by a 10.5-mile 34.5 kilovolt (kV) distribution line and features a 34.5 kV switchyard with pole mounted equipment and a 34.5 kV underground collector feeder system.<sup>1</sup> PSNH has a power purchase agreement with Iberdrola for 100 percent of the electricity generated from the Lempster Wind Power Project. PSNH resells a portion of the power purchased to the New Hampshire Electric Cooperative, a local electric service provider that includes the Town of Lempster in its service territory.<sup>2</sup>

<sup>1</sup> “Lempster Wind Power Project Fact Sheet,” Iberdrola Renewables, Available on-line at [http://www.iberdrolarenewables.us/cs\\_lempster.html](http://www.iberdrolarenewables.us/cs_lempster.html)

<sup>2</sup> “Twelve New Wind Turbines Nearing Completion at New Hampshire’s First Wind Project,” Iberdrola Renewables, October 7, 2008, Available on-line at [http://www.iberdrolarenewables.us/rel\\_08.10.07.html](http://www.iberdrolarenewables.us/rel_08.10.07.html)

## 2.2. Potential Residential Property Value Impacts of Wind Power Projects

The construction of wind power projects can create concerns about local impacts. Host communities of wind power projects may have concerns about the potential visual impacts and potential nuisances from turbines including noise and shadow flicker. Property owners may be fearful that potential negative impacts from a wind power project will cause the value of their home to decrease.<sup>3</sup>

To investigate these concerns, research has typically focused on four possible negative impact categories of wind power projects on residential property values.

**Area** A general negative image of the wind power project may adversely affect property values in the local community regardless of whether or not any specific property has a view of the wind turbines or is located in close proximity to a wind turbine.

**View** The view from a property is a characteristic that has been shown to have positive value when it is perceived to be pleasant or desirable (such as waterfront property or mountain vista) and negative value when it is perceived to be unpleasant or undesirable (such as a view of a landfill). Related to the electrical power sector, reductions in residential property values have been found for properties in relation to power transmission lines and conventional power generation facilities.<sup>4</sup> Property values with views of the turbines may be devalued because the quality of their view has been diminished.

**Nuisance** Property values in close proximity of the turbines may be devalued due to factors, such as turbine noise, and shadow flicker. Shadow flicker occurs when a specific set of conditions (location, wind direction, sun height) combine to cause the turbine blades to cast shadows.

**Anticipation** Property values in the local community may decline before, during, and immediately after construction of the wind project due to existing property owners' fear that the project will negatively impact the area. This impact would occur before the actual operating characteristics of the wind project are known.

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<sup>3</sup> "Wind power sometimes hurts property values, Clarkson study says," Watertown Daily Times, July 20, 2011, Available on-line at <http://www.watertowndailytimes.com/article/20110720/NEWS03/707209999>

<sup>4</sup> Simons, R. A. and Saginor, J. D., "A Meta-Analysis of the Effect of Environmental Contamination and Positive Amenities on Residential Real Estate Values," *Journal of Real Estate Research*. 2006, 28(1): 71-104. Available on-line at [http://business.fullerton.edu/finance/journal/papers/pdf/past/vol28n01/05.71\\_104.pdf](http://business.fullerton.edu/finance/journal/papers/pdf/past/vol28n01/05.71_104.pdf)

### 3. Analysis

To help understand any potential relationship between residential real estate values and the presence of the Lempster Wind Power Project, two separate approaches were taken to investigate the subject.

**Literature Review** The first approach was to review research that has investigated the relationship between residential property values and commercial wind power projects.

The primary finding from the literature review was that there is no wide-spread, statistically-significant changes change in residential property values after the construction of wind power projects. This finding was found to hold across a wide variety of properties and locations.

**Single Family Home Sales** The next approach was to review actual single family home property transactions in the communities surrounding the Lempster Wind Power Project.

Single family homes surrounding the Lempster Wind Power Project have not shown an overall change in their assessed values nor have they been observed to sell for a value that was consistently different from their expected value.

### 3.1. Literature Review

The relationship between residential property values and commercial wind power projects has been an area of active investigation. Studies have reviewed property transactions at wind power projects in foreign countries and the United States. Past studies have used a variety of research techniques including: surveys, case studies, and statistical analysis of real estate property transactions.

For this study update, twenty studies were identified that had applied statistical analysis to property transactions to investigate the relationship between residential property values and commercial wind power projects. These studies used a methodology that is non-biased as they base their conclusions on actual market transactions.

Therefore, these studies are the most reliable source of information on the relationship between residential property values and commercial wind power projects. In these twenty studies, collectively over 250,000 property transactions have been reviewed. Furthermore, these studies included properties that had clear views of wind turbines and ones that were located in close proximity to wind turbines (under a half mile). In table 2 on page 21, there is a table of the studies reviewed in this study update.

To date, two studies performed by the Lawrence Berkley National Laboratory have been among the most noteworthy investigations of the topic in the United States in terms of the sophistication of the statistical analysis and the number of property transactions: (1) *A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States* (2013), and (2) *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis* (2009).

Both of these studies reviewed a large number of property transactions near wind power projects—51,276 and 7,459 respectively—in Illinois, Iowa, Minnesota, New Jersey, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Texas, Washington, and Wisconsin. Neither found any relationship between residential property values and commercial wind power projects after the construction of wind power projects.

Regionally, three studies: one in Massachusetts, *Relationship between Wind Turbines and Residential Property Values in Massachusetts* (2014); one in Rhode Island, *Effects of Wind Turbines on Property Values in Rhode Island* (2013); and one that included Vermont, *The Effect of Wind Development on Local Property Values* (2003) reviewed the relationship between residential property values and commercial wind power projects. The study of residential properties near wind power projects in Massachusetts reviewed 122,198 properties; the study in Rhode Island reviewed 48,554 property transactions; and the study in Vermont reviewed 2,788 property transactions. These three New England-based studies of residential property transactions found no relationship between residential property values and commercial wind power projects after the construction of wind power projects.

Within New Hampshire, two studies have examined the relationship between residential property values and commercial wind power projects. The *Impact of the Lempster Wind Power Project on Local Residential Property Values* (2012) reviewed 2,593 single family home sales (88 post-construction) from January 2005 to November 2011 in communities surrounding the Lempster Wind Power Project. *The Impact of the Wild Meadows Wind Farm on Local Residential Property Values* (2013) reviewed 382 single family home sales (132 post-construction) from January 2008 to July 2013 in communities surrounding both the Lempster Wind Power Project and the Groton Wind Farm. These two studies concluded that there was no evidence of a relationship between residential property values and commercial wind power projects after the construction of wind power projects in New Hampshire.

The pattern that has emerged across these studies is that there is no wide-spread, statistically-significant changes in residential property values after the construction of wind power projects. This has been shown to hold at the international, national, regional, and state level. This differs from other types of facilities—such as landfills

and high voltage power lines—that have been associated with having negative impacts on residential property values using statistical techniques.<sup>5</sup>

In appendix D *Review of Studies of Property Value Impacts Related to Wind Power Projects* starting on page 25, there is additional discussion of some noteworthy studies that have investigated the relationship between residential property values and commercial wind power projects.

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<sup>5</sup>Simons, R. A. and Saginor, J. D, "A Meta-Analysis of the Effect of Environmental Contamination and Positive Amenities on Residential Real Estate Values," *Journal of Real Estate Research*, 28(1), 2006.

### 3.2. Single Family Home Sales in Communities Surrounding the Lempster Wind Power Project

Single family home sales surrounding the Lempster Wind Power Project from January 2005 to November 2011 were reviewed in this study update. The purpose was to determine if there was evidence that residential real estate property values had changed after the construction of the Lempster Wind Power Project. When conducting real estate analysis of local markets, it is important to compare the activity in the local market with the broader trends of the overall housing market. In this study, the real estate activity in the communities that immediately bordered the Lempster Wind Power Project was compared to the overall real estate market in Sullivan County. Sunapee was excluded from the analysis. The methodology and rationale for excluding Sunapee are discussed in appendix E *Methodology* starting on page 28.

The following questions were posed and answered during the analysis in this study update.

1. Did single family home sales volume in communities surrounding the Lempster Wind Power Project change in a way that appeared different from the overall market trend after construction?
2. Were there single family home sales in communities surrounding the Lempster Wind Power Project that were located in in close proximity to a turbine and/or that had direct views of one or more turbines after construction?
3. Did single family home sales that had views of the Lempster Wind Power Project sell for less than properties that did not have a view of the Lempster Wind Power Project?
4. Did single family home sales that were close to the Lempster Wind Power Project sell for less than properties that were further from the Lempster Wind Power Project?

#### **Did single family home sales volume in communities surrounding the Lempster Wind Power Project change in a way that appeared different from the overall market trend after construction?**

A review of 2,593 property transactions in Sullivan County did not reveal a difference between the communities surrounding the Lempster Wind Power Project and the overall residential real estate market .

The change in single family home sales from 2005 to 2011 across all the cities and towns in Sullivan County ranged between -100% to +21% with the median decline at -70%. The towns of Goshen, Lempster, Marlow, Unity, and Washington surrounding the Lempster Wind Power Project ranged between -100% to -67% per town with the average decline at -82%. While this average was slightly lower than the median for the overall region, there were other markets in the region, such as the City of Claremont—which is far from the Lempster Wind Power Project—that showed a similar decline at -81%.

This steep decline was not unique to Sullivan County as both New Hampshire and the overall U.S. housing market experienced a similar decline during this time period.<sup>6</sup> In fig. 3 on page 17, there is a graph of the number of arms-length single family home sales for each town or city in Sullivan County (excluding Sunapee) from January 2005 to November 2011 . In table 3 on page 22, there is a list of the number of arms-length single family home sales for each town or city in Sullivan County (excluding Sunapee) from January 2005 to November 2011 .

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<sup>6</sup>“Home Value and Homeownership Rates: Recession and Post-Recession Comparisons From 2007-2009 to 2010-2012,” U.S. Census Bureau, available on-line at <http://www.census.gov/prod/2013pubs/acsbr12-20.pdf>

**Were there single family home sales in communities surrounding the Lempster Wind Power Project that were located in in close proximity to a turbine and/or that had direct views of one or more turbines after construction?**

Overall, 88 arms-length single family home sales transactions were recorded in the towns of Goshen, Lempster, Marlow, Unity, and Washington after the construction of the Lempster Wind Power Project (the Lempster Wind Power Project became operational in the 3<sup>rd</sup> quarter of 2008). Three (3%) were within a 1-mile radius of the nearest turbine, sixteen (18%) were within a 3-mile radius of the nearest turbine, and fifty-two (59%) were within a 5-mile radius of the nearest turbine. In table 4 on page 22, there is a list of the frequency of post-construction property transactions by distance from the nearest turbine.

Out of the 88 property transactions, five had a clear view of the wind turbines and four had an obscure view. The remaining seventy-nine homes did not have any view of the wind turbines.

In fig. 4 on page 18, there is a map that shows the location of each of the 88 single family homes sales that occurred after the construction of the Lempster Wind Power Project. The color of the markers indicates the type of view that the single family home had of the Lempster Wind Power Project. In table 5 on page 23, there are summary statistics that provides the number of sales and average sales price for each town surrounding the Lempster Wind Power Project segmented by type of view and by year.

**Did single family home sales that had views of the Lempster Wind Power Project sell for less than properties that did not have a view of the Lempster Wind Power Project?**

It was found that the average value of assessed properties with a view was not different from the average value of assessed properties without a view. In fig. 5 on page 19, there is a box plot for the pre-sale assessed value for each type of view. The box plot visually demonstrates that there wasn't a difference between the three view groups. In table 6 on page 23, there is the results of an ANOVA statistical test that demonstrates that there wasn't a statistically-significant difference between the three view groups for this metric.

There also wasn't a statistically-significant difference between the sales price and the pre-sale valuation for properties with no view, an obscure view, or a clear view of one or more turbines. In fig. 6 on page 19, there is a box plot for the difference between the sales price and the pre-sale assessed value for each type of view. The box plot visually demonstrates that there wasn't a difference between the three view groups. In table 7 on page 23, there is the results of an ANOVA statistical test that demonstrates that there wasn't a statistically-significant difference between the three view groups for this metric.

In reviewing sales of single family homes surrounding the Lempster Wind Power Project from January 2005 to November 2011, there was no evidence to suggest that an obscure or clear view of one or more wind turbines negatively impacts residential property values.

**Did single family home sales that were close to the Lempster Wind Power Project sell for less than properties that were further from the Lempster Wind Power Project?**

The study update examined the relationship between sales price and distance from a wind turbine. In fig. 7 on page 20, there is a scatter plot with the distance a single family home was from the nearest wind turbine on the x-axis and the sales price of the home on the y-axis. A best-fit line is drawn on the plot. The best-fit line visually demonstrates that there was not a relationship between these two variables. In table 8 on page 24, there is the results of a linear regression statistical test that demonstrates that there wasn't a relationship between the distance a single family home was from a turbine and its sale price.

For comparison, square footage is a housing characteristic that does show a relationship to the sales price. In fig. 8 on page 20, there is a scatter plot with the square footage of a single family home on the x-axis and the sales price of the home on the y-axis. A best-fit line is drawn on the plot. The best-fit line visually demonstrates that there was a positive relationship between these two variables. In table 9 on page 24, linear regression statistically demonstrates that there was a positive relationship between the square footage of a single family home and its sale price.

In reviewing sales of single family homes surrounding the Lempster Wind Power Project from January 2005 to November 2011, there was no evidence to suggest that a property being located in close proximity to a wind power projects negatively impacts its property value.

## 4. Conclusion

This is an update to the original study *Impact of the Lempster Wind Power Project on Local Residential Property Values* which was released in 2012. The purpose of this study update was to answer the question “are there expected to be any negative impacts on residential property values surrounding the proposed Antrim Wind Energy Project if it is developed?” To answer this question, both a review of existing research on the relationship between residential property values and commercial wind power projects and a review of single family home property transactions in the communities surrounding the Lempster Wind Power Project located in Sullivan County, NH was undertaken.

In performing the literature review, studies that had been released since the time of the original study were considered. The results of the previously performed analysis of single family homes surrounding the Lempster Wind Power Project in the original study were reviewed and replicated.

This study update supports the original conclusion that the Lempster Wind Power Project has not had any consistent, statistically-significant impact on property values. Furthermore, the findings from this study update agree with the substantial body of evidence from international, national, and regional studies that also have not found evidence of systematic, wide-spread changes in property values associated with wind power projects.

The experience of other New England states supports this finding. Studies reviewing wind power projects in Massachusetts, Rhode Island, and Vermont also have not found evidence of a consistent difference in property values associated with the presence of wind power projects.

Additionally, the study *The Impact of the Wild Meadows Wind Farm on Local Residential Property Values* released in December 2013 reviewed 382 single family home property transactions with 132 post-construction (January 2008 to July 2013 ) around both the Lempster Wind Power Project and the Groton Wind Farm located in Grafton County, NH. It found that there was no consistent difference found between the sales price and pre-sale assessed value for NH homes within 0-1 mile of a turbine, 1-3 miles of a turbine, and 3-10 miles of a turbine of the two wind power projects. The Wild Meadows study also found that was no consistent change observed in the assessed values of properties sold in these regions from 2008 through 2013 that differed from the trends observed in the overall regional market.

Therefore, it is not expected there will be a decrease in the value of the overall residential market around the proposed Antrim Wind Energy Project—including those properties that would be in close proximity to a turbine and/or that would have direct views of one or more turbines—if it is developed.

## A. Study Update Background

Antrim Wind Energy, LLC (AWE) is a Delaware limited liability company formed in 2009 to develop, build, own and operate the proposed Antrim Wind Energy Project.

In 2011, AWE approached Professor Ross Gittell, P.h.D and Matthew Magnusson, M.B.A. from the University of New Hampshire's Whittemore School of Business and Economics to independently examine the impact of the Lempster Wind Power Project on the value of residential properties surrounding the facility. The intent of the study was to inform the members of the New Hampshire Site Evaluation Committee and other stakeholders of any potential impacts there may be on residential property values associated with the proposed Antrim Wind Energy Project.

In performing the study, the authors conducted an extensive review of studies, reports, articles, and websites that discussed the impacts that may be associated with wind power projects and residential property values. The authors also reviewed the sales of single family homes in the communities surrounding the Lempster Wind Power Project before and after the facility was constructed and operational. The report titled *Impact of the Lempster Wind Power Project on Local Residential Property Values* was issued in January 2012. Matthew Magnusson was primary author and Ross Gittell was secondary author.

In 2014, AWE approached Matthew Magnusson of the consulting firm Seacoast Economics to review the study and its findings and conclusions, to review any new research that may influence its findings, and to update the study as necessary. Ross Gittell was not available to participate in the study update. The intention of the update to the study was to inform the members of the New Hampshire Site Evaluation Committee of the potential impacts on local property values for the re-filed application for the proposed Antrim Wind Energy Project utilizing the most currently available research.

The following activities were undertaken to update the original study:

1. Review the study *Impact of the Lempster Wind Power Project on Local Residential Property Values*.
2. Replicate the original statistical results of the study using the same property transaction data set.
3. Conduct an extensive literature review of studies, reports, articles, and web sites that have discussed or analyzed the relationship between residential property values and commercial wind power projects including any new studies that have been released since the original study was released..

During the course of the study update, the original statistical results were replicated. Although no new property transaction data was collected for the study update, the update does reference the more recent study *The Impact of the Wild Meadows Wind Farm on Local Residential Property Values*, which does include more recent NH property transaction data, including properties surrounding the Lempster Wind Power Project.

B. Figures

Figure 1: Town of Lempster with wind turbine locations

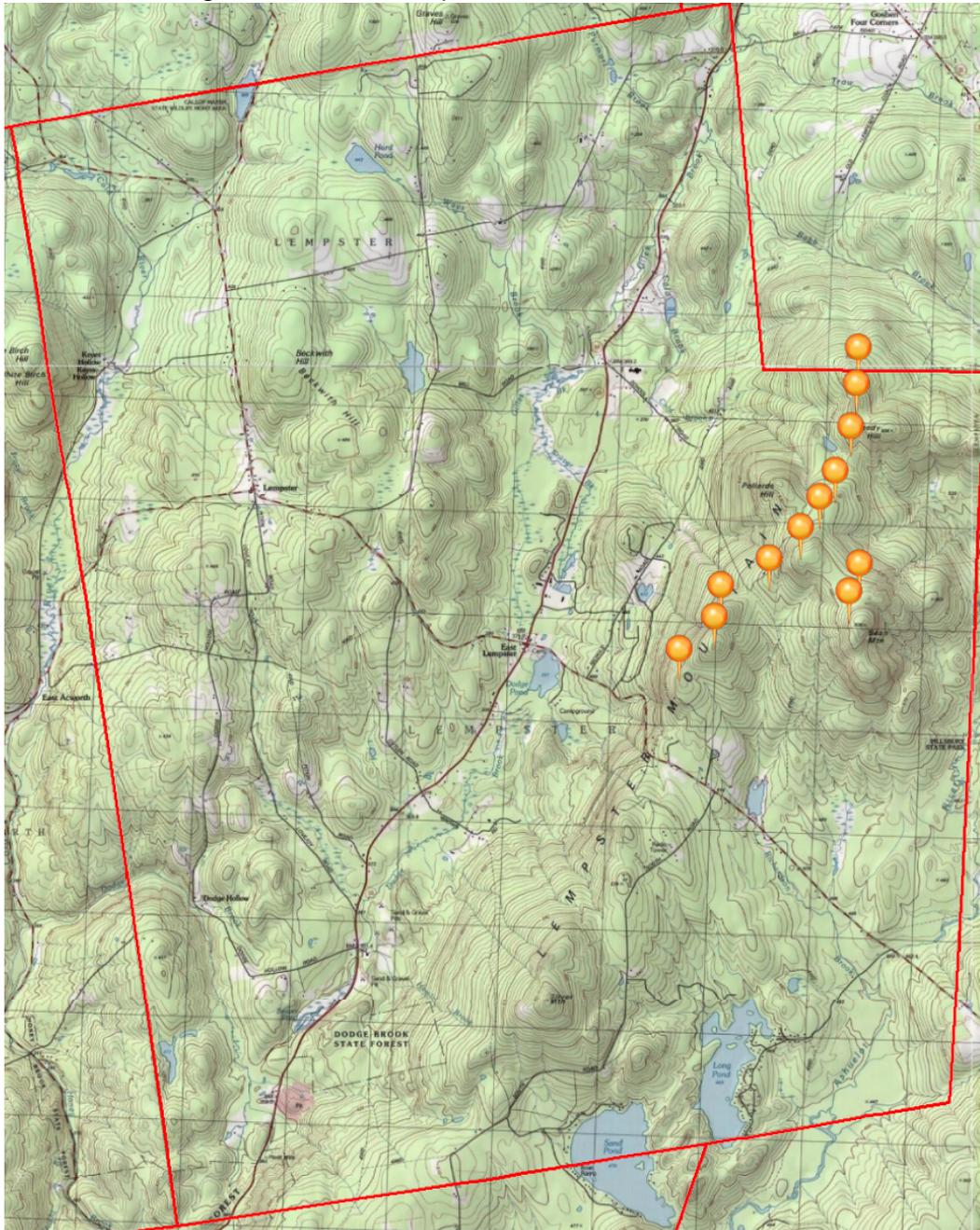


Figure 2: Lempster Wind Power Project (September 2008)



Figure 3: Graph of annual sales for each city and town in Sullivan County (excluding Sunapee)

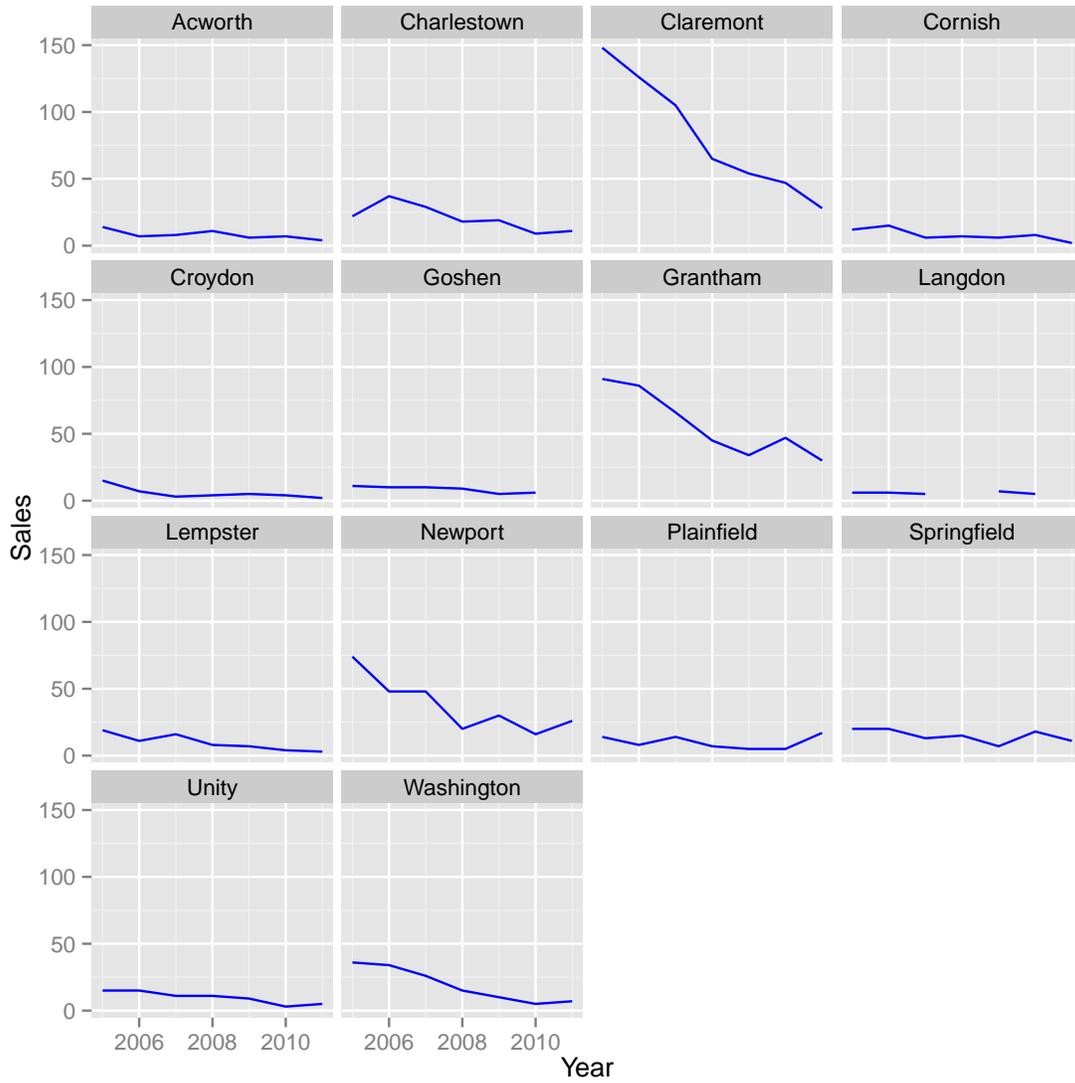


Figure 4: Single family home sales from September 2008 to November 2011

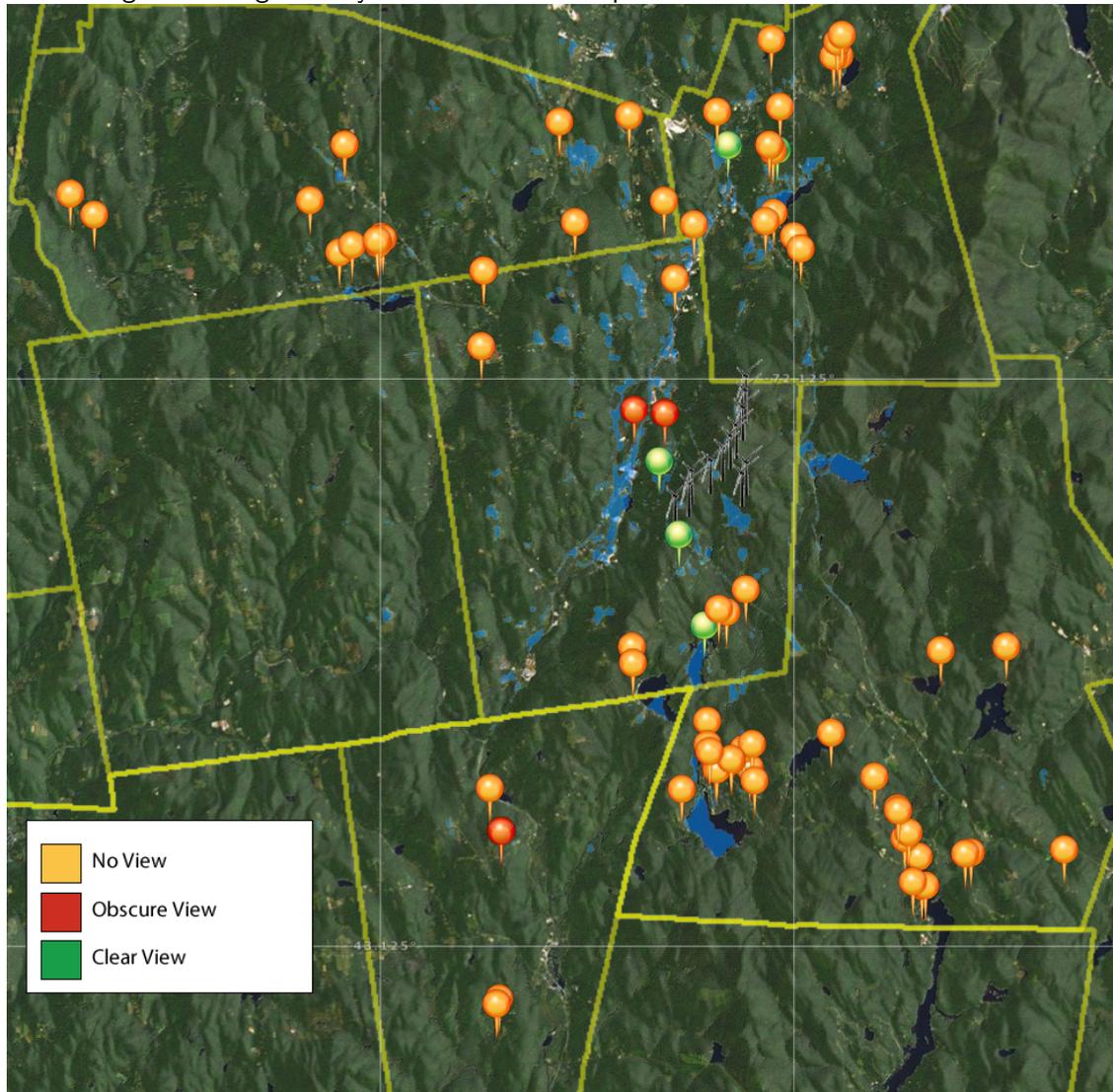


Figure 5: Box plot of pre-sale assessed value by view from September 2008 to November 2011

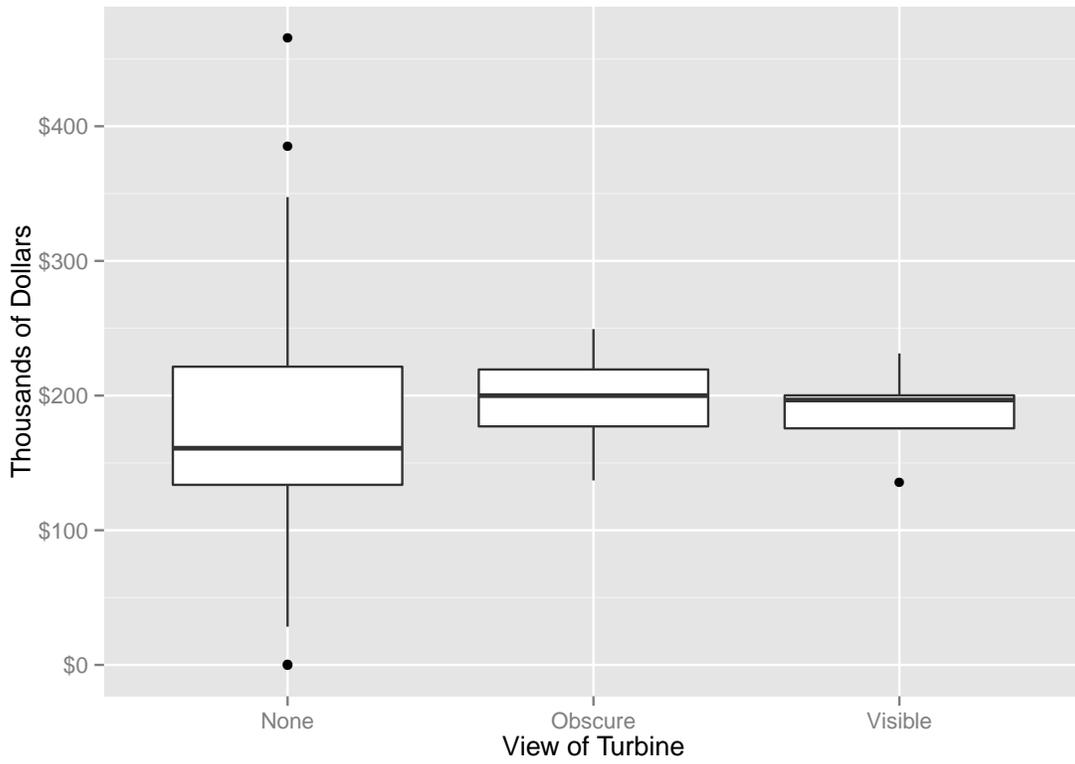


Figure 6: Box plot of difference of sales price and pre-sale assessed value by view from September 2008 to November 2011

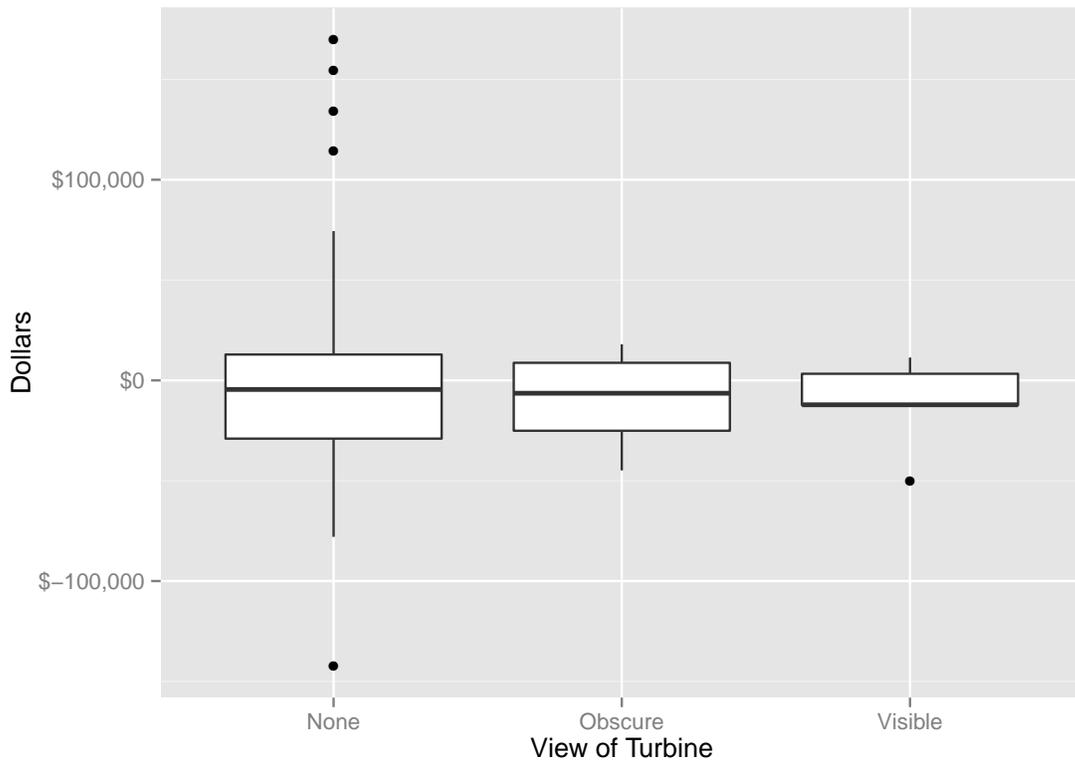


Figure 7: Correlation of sales price to distance from nearest wind turbine from September 2008 to November 2011

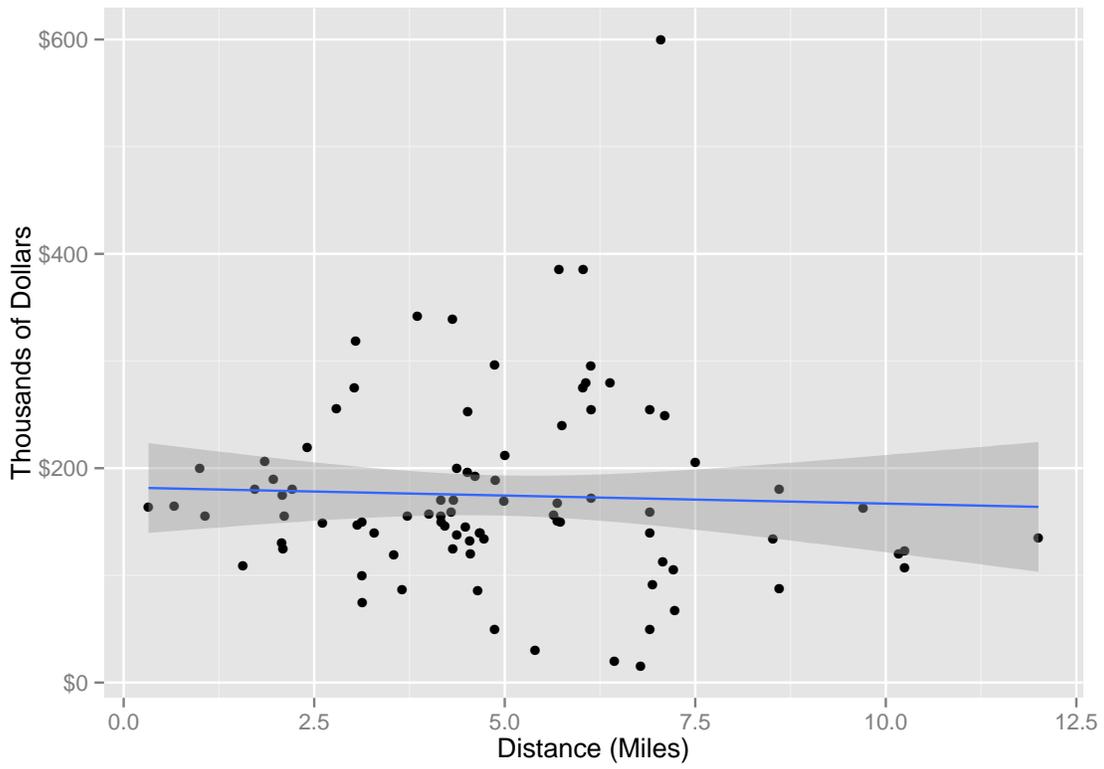
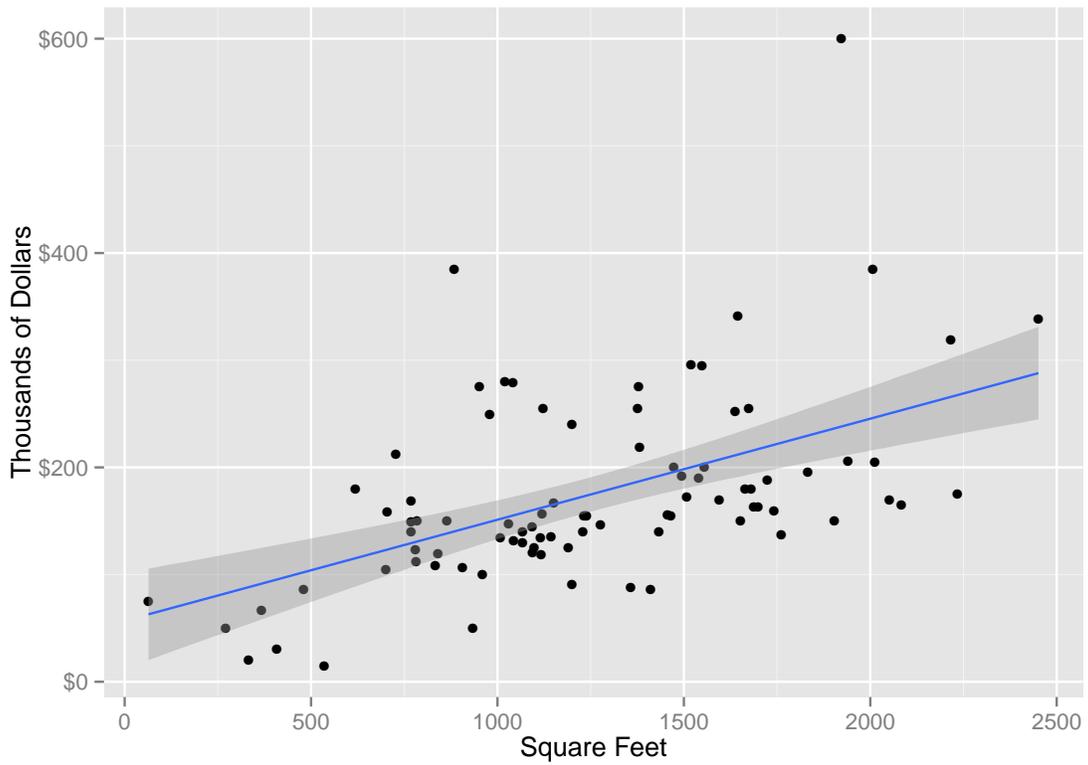


Figure 8: Correlation of sales price to square footage from September 2008 to November 2011



## C. Tables

Table 1: Summary statistics for the Lempster Wind Power Project compared to the State of NH

	Town	Town of Lempster	State of NH Totals
	County	Sullivan	n/a
	Population (2010)	1,154	1,316,470
	Land Area (SQ Miles)	32	8,932
	Density (People per SQ MI)	36	147
	Median Age (2010)	46	41
	Percentage of population 18 or older (2010)	81%	78%
	Housing units (2010)	679	614,754
	Income (2007-2011)	\$58,594	\$64,664
	Total Assessed Residential and Manufactured Housing Value (2012)	\$70,855,500	\$76,046,711,137
	Average Assessed Residential and Manufactured Housing Value per housing unit	\$104,353	\$123,703

Table 2: Studies reviewed that examined the relationship between residential property values and commercial wind power projects

Study	Geographic	Number of Property Transactions
Sterzinger et al. (2003)	(10 States), US	24,346
Delacy (2005)	Washington, US	21
Poletti (2005)	Wisconsin, US	187
Hoen(2006)	New York, US	280
Poletti (2007)	Illinois, US	256
Sims and Dent (2007)	UK	919
Sims et al. (2008)	UK	199
Hoen et al. (2009)	(9 States), US	7,459
Canning and Simmons (2010)	Canada	83
Hinman (2010)	Illinois, US	3,851
Laposa and Miller (2010)	Colorado, US	2,910
Carter(2011)	Illinois, US	1,298
Heintzelman and Tuttle (2012)	New York, US	11,331
Magnusson and Gittell (2012)	New Hampshire, US	2,593
Sunak and Madlener (2012)	Germany	1,405
Hoen et al. (2013)	(9 States), US	51,276
Lang and Opaluch (2013)	Rhode Island, US	48,554
Magnusson (2013)	New Hampshire, US	382
Atkinson-Palombo and Hoen (2014)	Massachusetts, US	122,198
Vyn and McCullough(2014)	Canada	7,004

Table 3: Sales of single family homes in Sullivan County (excluding Sunapee) from January 2005 to November 2011

Town/City	2005	2006	2007	2008	2009	2010	2011
Acworth	14	7	8	11	6	7	4
Charlestown	22	37	29	18	19	9	11
Claremont	148	126	105	65	54	47	28
Cornish	12	15	6	7	6	8	2
Croydon	15	7	3	4	5	4	2
Goshen	11	10	10	9	5	6	
Grantham	91	86	66	45	34	47	30
Langdon	6	6	5		7	5	
Lempster	19	11	16	8	7	4	3
Newport	74	48	48	20	30	16	26
Plainfield	14	8	14	7	5	5	17
Springfield	20	20	13	15	7	18	11
Unity	15	15	11	11	9	3	5
Washington	36	34	26	15	10	5	7

Table 4: Frequency of post-construction sales transactions(September 2008 to November 2011 ) by distance from nearest turbine

Distance (Miles)	Count	Percentage	Cumulative
0-1	3	3%	3%
1-2	5	6%	9%
2-3	8	9%	18%
3-4	11	13%	31%
4-5	25	28%	59%
5-6	8	9%	68%
6-7	14	16%	84%
7-8	6	7%	91%
8-9	3	3%	94%
9-10	1	1%	95%
10-11	3	3%	99%
11-12	0	0%	99%
12-13	1	1%	100%
Total	88		

Table 5: Single family home sales from September 2008 to November 2011 by view of the Lempster Wind Power Project

	2008 (Q4 only)		2009		2010		2011 (thru Nov.)		Total	
	Sales	Average Price	Sales	Average Price	Sales	Average Price	Sales	Average Price	Sales	Average Price
<b>Goshen</b>	5	\$126,146	5	\$153,200	6	\$198,333			16	\$161,625
No View	4	\$120,950	4	\$154,000	6	\$198,333			14	\$163,143
Clear View	1	\$146,933	1	\$150,000					2	\$148,6.5
<b>Lempster</b>	2	\$167,500	7	\$174,857	4	\$171,300	3	\$122,333	16	\$163,625
No View	1	\$180,000	3	\$158,333	4	\$171,300	3	\$122,333	11	\$155,545
Obscure View	1	\$155,000	1	\$164,533					2	\$159,766
Clear View			3	\$194,667					3	\$194,667
<b>Marlow</b>	2	\$223,500	4	\$130,000	1	\$255,000	2	\$134,000	9	\$165,556
No View	1	\$275,000	4	\$130,000			2	\$134,000	7	\$151,143
Obscure View	1	\$172,000			1	\$255,000			2	\$213,500
<b>Unity</b>	1	\$139,933	9	\$227,778	3	\$165,333	5	\$151,387	18	\$191,667
No View	1	\$139,933	9	\$227,778	3	\$165,333	5	\$151,387	18	\$191,667
<b>Washington</b>	7	\$251,000	10	\$161,6.5	5	\$142,3.2	7	\$163,857	29	\$180,207
No View	7	\$251,000	10	\$161,6.5	5	\$142,3.2	7	\$163,857	29	\$180,207
<b>Total</b>	17	\$194,118	35	\$176,714	19	\$175,789	17	\$149,941	88	\$174,580

Table 6: ANOVA test of pre-sale assessed value by view from September 2008 to November 2011

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
TURBINE_VIEW	2	2.263e+09	1.132e+09	0.171	0.843
Residuals	85	5.611e+11	6.602e+09		

Table 7: ANOVA test of difference between sales price and pre-sale assessed value by view from September 2008 to November 2011

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
TURBINE_VIEW	2	7.121e+08	3.561e+08	0.165	0.848
Residuals	85	1.837e+11	2.162e+09		

Table 8: Correlation of sales price to distance from nearest wind turbine from September 2008 to November 2011

Residuals:

Min	1Q	Median	3Q	Max
-156793	-44378	-19854	25132	428605

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	182001	22292	8.164	2.46e-12 ***
NEAREST_TOWER	-1505	4094	-0.367	0.714

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Signif. codes: 0 \*\*\* 0.001 \*\* 0.01 \* 0.05 . 0.1 1

Residual standard error: 88600 on 86 degrees of freedom

Multiple R-squared: 0.001568, Adjusted R-squared: -0.01004

F-statistic: 0.1351 on 1 and 86 DF, p-value: 0.7142

Table 9: Correlation of sales price to square footage from September 2008 to November 2011

Residuals:

Min	1Q	Median	3Q	Max
-103384	-40014	-18255	32816	361913

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	56905.82	22406.49	2.540	0.0129 *
BLDG_EFFECTIVE_AREA	94.27	16.74	5.631	2.21e-07 ***

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Signif. codes: 0 \*\*\* 0.001 \*\* 0.01 \* 0.05 . 0.1 1

Residual standard error: 75790 on 86 degrees of freedom

Multiple R-squared: 0.2694, Adjusted R-squared: 0.2609

F-statistic: 31.7 on 1 and 86 DF, p-value: 2.214e-07

## D. Review of Studies of Property Value Impacts Related to Wind Power Projects

The impact of wind energy projects on residential properties has been explored in both the United States and in other countries. In this appendix, there is some additional discussion of studies that were considered to be noteworthy.

### *A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States (2013)*

A study released in 2013 by the Lawrence Berkley National Laboratory (LBNL) by Hoen et al. represents one of the most comprehensive studies of this topic to date and features statistical analysis of more than 50,000 property transactions from 27 different counties across 9 states ( Illinois, Iowa, Minnesota, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, and Washington). The data set also contains 1,200 sales transactions that occurred within 1-mile of a turbine. The study incorporated two different hedonic statistical models; one model had a coefficient of determination of 0.64 and the other had a coefficient of determination of 0.67. This means that the model developed had a reasonably good fit to the data and explained 64% to 67% of the variation observed.

The 2013 LBNL study reported no statistically significant difference in the sales price for transactions at any distance, including within bands of 0.5-miles and 1-mile of a wind turbine. This study provides strong statistical evidence that there is no relationship between residential property values and commercial wind power projects.

The study also found no evidence that home values near turbines were affected in either the period of time between when a project was announced through the construction period or the period of time post-construction. This finding was based on a sample-size adequate to detect even small differences in selling prices for properties located closer to wind turbines.

### *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis (2009)*

Hoen et al. (2009) analyzed almost 7,500 single family home sales within a 10 mile range of 24 existing wind projects in 9 U.S. states (Illinois, Iowa, New York, Oklahoma, Oregon, Pennsylvania, Texas, Washington, and Wisconsin). Sales occurred between January 1996 and June 2007.

Hoen et al. developed a base hedonic model which showed no statistically significant difference attributable to the presence of wind turbines. The model had a good fit to the actual property transactions observed with a coefficient of determination of 0.77; this means that the model explained 77% of the variation in housing prices observed.

Also in this study, statistical modeling was employed to investigate whether the sales prices of homes were impacted with varying wind turbine views, based on a data set of just under 5,000 property transactions (730 transactions with views of turbines)—it was found that there was no statistically significant difference in selling prices between homes with minor, moderate, substantial, or extreme views of wind turbines.

## *The Impact of the Wild Meadows Wind Farm on Local Residential Property Values* (2013)

Magnusson (2013) reviewed 382 single family home sales in the towns of Goshen, Lempster, and Washington surrounding the Lempster Wind Power Project and the Towns of Groton, Hebron, and Rumney and the City of Plymouth surrounding the Groton Wind Farm from January 2008 to July 2013. Linear regression showed a very strong relationship between sales price and pre-sale assessed value for these properties with a coefficient of determination of 0.92. This means that assessed values explained 92% of the variation observed in sales prices and among all of the studies reviewed in this study, showed the best fit of any statistical model constructed.

From January 2008 to July 2013, at the Lempster Wind Power Project and the Groton Wind Farm in New Hampshire, there have been 132 arms-length single family home property transactions at a value of \$22.5 million in the immediate communities surrounding the wind farms. For these property transactions, there was no statistically significant difference found between the sales price and pre-sale assessed value for NH homes within 0-1 mile of a turbine, 1-3 miles of a turbine, and 3-10 miles to a turbine. There also was no statistically significant change observed in the assessed values of properties sold in these regions from 2008 through 2013.

Since the completion of the two wind farms, there have been 14 arm's-length single family home transactions totalling \$6.1 million for waterfront residential properties located on bodies of water that are within 10 miles of a turbine and that feature visibility of a turbine from areas on the body of water and areas of the shoreline. In general, these properties have sold at assessed value; which is noteworthy, as the overall trend in Grafton and Sullivan counties has been for properties to sell on average slightly below assessed value since 2008.

A separate analysis of real estate market value based on total assessed residential values did not indicate that the real estate market activity of the communities surrounding the Lempster Wind Farm or the Groton Wind Farm was different from that experienced throughout Grafton or Sullivan counties overall.

## *Relationship between Wind Turbines and Residential Property Values in Massachusetts* (2014)

Atkinson-Palombo and Hoen (2014) performed a study that reviewed 122,198 residential property transactions located within 5 miles of a turbine location between 1998 and 2012 in Massachusetts. This study examined communities that spanned a wide range of land use and zoning types from rural to urban. There were 121 transactions that were in less than a quarter mile from a turbine location, 986 that were between a quarter and half mile from a turbine location, and 6,081 that were between a half mile and mile from a turbine location. Their base hedonic statistical model had a coefficient of determination of 0.80 which means the model explained 80% of the variation in housing prices observed and therefore had a high level of explanatory power. The study concluded that there was no support for the claim that wind turbines affect nearby home prices and that no evidence emerged of a post-construction impact.

This study also addressed the question "is there evidence that houses that sold during the post-announcement and post-construction periods did so at lower rates than during the pre-announcement period?" To test for a sales-volume effect, Atkinson-Palombo and Hoen (2014) examined the differences in sales rate in fixed distances from the turbines over the various development periods. They did not find any changes in rate of sales near the turbines during the announcement period or post-construction period of the turbines leading to the conclusion that there was an absence of evidence to support the claim that sales rate was affected by the turbines.

*Values in the Wind: A Hedonic Analysis of Wind Power Facilities (2012)*

Heintzelmen and Tuttle (2012) performed a study that had mixed results. Their analysis included 9,414 arms-length property transactions in Franklin and Clinton County, NY and it considered 5 wind power projects. They stated that in Clinton and Franklin counties of NY, proximity to turbines had a usually negative and often statistically significant impact on property values, while, in Lewis County, turbines appear to have had little effect or even a statistically significant positive effect. This would mean that proximity to wind farms increased property values.

Heintzelmen and Tuttle developed two models and the coefficient of determination for the models across the three counties ranged from 0.28 to 0.33. This means that their hedonic models only explained about 28% to 33% of the variation observed in the data. This indicates that while the model did help explain some of the variation observed, it was not as strong a predictor of property transaction values as seen in other studies of property values and wind farms.

Hoehn et al. (2013) discusses some flaws with the methodology of the Heintzelmen and Tuttle (2012) study. Specifically, there was a low number of transactions within 1-mile (35 transactions) and very few to none in areas of estimates (1/10 and 1/4 mile). Their model also uses the inverse of continuous distance. This is problematic as it causes the model to estimate effects at the average distance, which in the case of their model is greater than 10 miles from the turbines. This approach weakens the ability of the model to quantify effects near the turbines where they would be expected to be stronger if present.

While Heintzelmen and Tuttle did report some instances of statistically significant negative impacts on property values, they also showed statistically significant positive impacts on property values. From a common sense perspective, this seems to be an unlikely situation where sometimes wind power projects reduce property values and other times it raises them. Furthermore, there are noteworthy flaws and limitations of their hedonic model that draw into question the quality and reliability of the findings and conclusions reached by Heintzelmen and Tuttle in their study.

*Wind Farm Proximity And Property Values: A Pooled Hedonic Regression Analysis Of Property Values In Central Illinois (2010)*

Hinman (2010) found evidence that housing values in areas of close proximity to wind turbines can temporarily decline during the period between when a project is announced up until when the project is completed. Hinman analyzed 3,851 total property transactions from 2001 to 2009 in 25 townships in McLean and Ford Counties, Illinois around the Twin Groves Wind Farm—a 240 Vestas V82 (1.65 MW) MW project covering 22,000 acres that was constructed in 2007 and 2008. Hinman found up to an 18% decline in property values between project announcement and project completion for nearby properties. However, Hinman also found that during the operational stage of the wind farm project, as the actual visual and noise impacts of the wind turbines become known, property values rebounded higher in real terms than they were prior to the wind power project approval.

An explanation for the decline in property values that occurred around Twin Groves Wind Farm in Illinois could be anticipation, or that some homeowners were fearful of negative impacts from the wind farm and, as a result, property sales transacted at lower values than would otherwise be expected. Hinman's finding of wind farm anticipation may explain the difference between what has been shown in some past surveys where people expect a decrease in prices due to wind farm projects and the actual property transaction data for properties sold after the construction phase of the project. Hinman's study indicates that if there is a temporary decline in property values, it is also possible that they can rebound once the uncertainty surrounding how home owners are affected by the development disappears.

## E. Methodology

This study update utilized two different statistical tests: simple linear regression and analysis of variance (ANOVA). Simple linear regression models the relationship between a dependent variable  $y$  for one explanatory variable  $x$  and is a widely-used statistical test. The ANOVA statistical test was selected for this analysis because it is well-established and specifically tests for differences among the averages of groups. ANOVA tests are robust statistical tests that have been specifically applied to evaluating factors that may have an impact on property values.<sup>7</sup>

This study update follows the approach in the original study of utilizing assessed value as the “expected” value to compare to sales price. Assessors would be viewed as local market experts with in-depth knowledge of the unique characteristics and dynamics of the properties in the communities they assess and the expectation is that assessed value should show a strong relationship to fair market value.

This study took a three step approach.

1. The first step was to determine if pre-sale assessed values showed a relationship to sales prices using simple linear regression for all arms-length sales in Sullivan County from January 2005 to November 2011 . Statistical analysis showed a strong correlation ( $0.73 R^2$ ) between the deed price (price of sale) and the pre-sale assessed valuation. This support the use of the pre-sale assessed value as the “expected” deed price.
2. View impact was tested using an ANOVA statistical analysis to see if there was a statistically-significant difference between properties with no view, an obscured view, and a clear view of the turbines.
3. Nuisance was tested by looking at the correlation between a property’s distance to the nearest turbine and the deed price using simple linear regression. If distance was a significant factor, then some form of relationship would be expected to be observable.

The authors obtained property sales and parcel records for all of the fifteen towns and cities in Sullivan County, NH including the Town of Lempster. Real Data Corporation—located in Manchester, NH—provided property transaction data occurring from January 2005 to November 2011 . Real Data Corp provides summaries of New Hampshire and Vermont real estate sales and other public records.

*Please note that the data provided by Real Data Corp was purchased by the authors for the purpose of this study and the terms and conditions of the purchase specifically do not allow the purchased data to be shared with other entities. Therefore the underlying property data used in this study is not available from the author. Property transaction data is public information, so entities interested in replicating the findings of this study are able to collect this information through public sources or they can purchase the data directly from Real Data Corp or other commercial providers of NH real estate transaction data.*

Property transactions were filtered to only include warranty deed sales transactions of single-family homes. Warranty deed sales are arms-length transactions and are deemed to be the best overall indicator of residential property market prices. An arms-length transaction is one in which the parties are independent, have no relationship to each other, and are on equal footing (meaning the parties have equal bargaining power and equal information about the transaction). This type of transaction reveals the true and fair market value of a real estate property. An arms-length transaction—in this study—is defined as one that was a warranty deed transaction that did not have any of the

<sup>7</sup>Examples include: Mulley, C. and Chi-Hong, T., “How much does new transport infrastructure add to land values? Evidence from the bus rapid transit system in Sydney, Australia” Institute Of Transport And Logistics Studies, September 2013; McGrew, Jr., J C., and Monroe, C. B., “An introduction to statistical problem solving in Geography,” Waveland Press, Inc., Second Edition, 2009.

exclusion codes listed by the NH Department of Revenue associated with the transaction. This is a similar process to that which the NH Department of Revenue uses in calculating equalization rates of town property taxes. A total of 2,593 arms-length property sales transactions were included in the analysis.

These properties were geocoded utilizing Google Earth from the address provided. In several cases, Google Earth did not correctly map the property location or the address information was not matched. In these circumstances, town tax maps were consulted to identify or verify the geographic coordinates of property sales locations.

All fifteen towns and cities in Sullivan County were included in this portion of the analysis with the exception of Sunapee. Sunapee was excluded as its average property sales price was above the regional average and therefore would not be useful for comparison with the communities surrounding the Lempster Wind Power Project.

## F. Study Author

Matthew Magnusson is a graduate of the University of New Hampshire's Whittemore School of Business and Economics with a Masters of Business Administration. Matthew Magnusson has performed economic research on each of the three commercial wind farms currently operating in New Hampshire as well as the previously-proposed 30 MW wind farm by Antrim Wind Energy, LLC.

Previous research experience while employed as a Data Scientist at the University of New Hampshire (UNH) includes economic modeling for a study sponsored by NRDC and Protect Our Winters "Climate Impacts on the Winter Tourism Economy in the United States," "New Hampshire's Green Economy and Industries: Current Employment and Future Opportunities" performed for the Rockingham Economic Development Committee (REDC), "Economic Impact of Granite Reliable Power Wind Power Project in Coos County, New Hampshire" performed for Granite Reliable Power, LLC and the economic analysis of policies proposed in "The New Hampshire Climate Action Plan" performed for the NH Climate Change Task Force.