# BUSINESS 620

Allegheny College

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# *Assessing the Impact of Wind Farms on Property and Housing Prices: A Regional Analysis*




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**Assessing the Impact of Wind Farms on Property Values**: *A Regional Analysis*

by

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Submitted to The Department of Business and Economics

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I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College as a whole.

Hunter Palmisano

Hunter Palmisano

# Acknowledgements

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# Summary of AI Use by Author

AI supported my research for this paper. I used these resources to help gather and process data from reliable sources such as the Census and Redfin. This helped me ensure the information I was going to provide was accurate and relevant. AI also assisted in summarizing some of the sources, as well as identifying key trends, which helped me better understand some of the readings I chose to reference. Additionally, AI strengthened the grammar and structure of my writing, allowing me to present my findings clearly and professionally. My collaboration with AI systems contributed significantly to the overall quality of the paper and allowed me to shift my focuses towards different aspects of this project.

AI was also heavily involved within the development of early drafts of this research. Ultimately, due to AI restrictions and AI's inability to continue to feed accurate and up to date information led to a major contradiction within the writing process. While much of the writing visible in this version is my own I must acknowledge the role in which AI originally played.

# Abstract

This research investigates the economic impacts of wind farms and their effects on property values. This thesis has a focus on comparing the externalities between their environmental benefits while also examining the challenges they present to local communities. Wind energy infrastructure has been a key component of the global shift to renewable energy. They have shown to offer significant advantages such as job creation as well as, increased tax revenue, and reduction in greenhouse gas emissions. However, they also bring about negative externalities such as noise pollution and visual disruption, which can affect property values, especially in areas where renewable energy is less supported. By analyzing and finding the relationship between the factors listed and the influence they have had on property values, this research highlights the importance of local economies, community attitudes, and the geographic context in determining the effects I find. The study examines how these factors vary across regions, contributing to a deeper understanding of the complexities surrounding wind energy development as well as its impact on housing markets. This research offers an understanding that can inform future policy decisions as well as wind farm development strategies, helping to balance the benefits of renewable energy with the concerns of impacted communities.

# CHAPTER 1: Introduction

Wind energy infrastructure has become an essential component of the worldwide shift to renewable energy, by providing a sustainable substitute for fossil fuels they have also begun helping to reduce greenhouse gas emissions. The endless rotation of these massive hundred foot long fiberglass blades on the towering structures known as wind turbines, stand today as markers of progress and reflect the dedication to environmental responsibility. Over the course of the United States renewable energy "switch," the implementation of wind farms has not been an overall positive experience. Wind farms have created extensive debate due to their local communities noting significant changes in property values and quality of life concerns. This thesis aims to focus on the connection between wind energy development and property values by assessing the economic and social benefits and drawbacks.

Wind energy plays a critical role in sustainable development and the broader shift toward decarbonization. While not a standalone solution, its ability to reduce greenhouse gas emissions and support cleaner electricity generation makes it a key part of global efforts to combat climate change. As of this writing, wind energy is on track to surpass nuclear power by later 2025 (International Energy Agency, 2024). With global electricity demand growing at 4% per year, we need big investments in wind energy infrastructure to keep up (International Energy Agency, 2024). In Europe, wind power could hit 1,300 GW by 2050, covering half of the region's electricity needs (WindEurope, n.d.). Meanwhile, global energy investments are set to top $1.5 trillion in 2025, a 6% jump from 2024 (World Economic Forum, 2025). Scaling up wind energy could be the sustainable, cost-effective solution we need.

On a more local standard, the U.S. Department of Energy's research indicates that wind power is the most rapidly expanding energy source. This is likely due to its capability to deliver clean renewable electricity. Wind farm expansions are necessary to meet these energy demands, they act in a way which can enhance energy security as well as energy self-sufficiency. Additionally the expansions would lead to a reduction of dependence on non-renewable energy sources such as fossil fuels and carbon monoxide.

This can all be obtained while simultaneously boosting economic development through job creation in sectors like manufacturing and maintenance operations. Wind energy projects bring in tax revenues to local communities which support public services and infrastructure projects designed to improve community living standards.

However, even with all these positives being displayed local residents within wind farm regions have still shown hesitation and fear. Tying this idea into research, the National Association of Realtors reported that residences within one mile of a commercial wind turbine lost about 11% of their market value after a new project was announced, though later studies have found these effects may be temporary or perception-based rather than long-term trends. Visual intrusion and noise pollution from turbines along with perceived health risks lead to property value depreciation.

**Visual Impact on Property Values**

The visual impact of wind farms is frequently noted as the primary factor causing property values to drop around these installations. Large wind turbines create significant changes to the visual appeal of an area which results in a decrease of view quality. Wind turbines can cause a decrease in home values in scenic regions like rural and coastal areas where property appeal relies heavily on natural beauty.

A study in the Proceedings of the National Academy of Sciences reveals that residential property values can drop as much as 8% when wind turbines are built within visible range (Guo, 2024). Wind turbines can have a significant negative impact on property values particularly in locations where homeowners value clear sightlines like waterfront properties and homes near mountainous areas or open fields. The visual impact of wind turbines is diminished in urban areas because the skyline there already contains substantial built infrastructure.

The presence of wind farms can discourage potential home buyers because of worries about the turbines being a permanent fixture. Wind farms represent permanent structures that remain operational for

several decades which ensures landscape disruptions caused by them cannot be easily reverted. The possibility of future turbine expansion causes concern among homeowners who fear their property value could decline as more turbines are built.

**Noise Pollution and Its Effects**

Homeowners situated close to wind farms face significant noise pollution as their primary concern. Modern turbines aim to reduce sound emissions but their low-frequency noise can disrupt quiet rural areas where background noise is minimal. Turbines operating without interruption create sound which stays within legal standards yet often feels invasive to residents.

The National Center for Biotechnology Information published a study which found that people living near industrial wind turbines show symptoms like sleep disturbances and stress that lead to decreased quality of life (Jeffery, 2013). Residents who live one mile or less from wind turbines report more noise-related complaints because they experience more noticeable sound levels. A separate study by Nissenbaum, Aramini, and Hanning (2012) also found that wind turbine noise can significantly disrupt sleep patterns, leading to chronic health symptoms such as headaches and concentration difficulties.

Property value reductions from noise pollution correlate strongly with how potential buyers perceive the sound environment. Property values decline for homes located in noisy areas such as highways, airports, or wind farms compared to similar homes in quieter surroundings. Wind turbine noise is considered bothersome by potential buyers who then show less interest in properties which remain unsold for longer periods due to this reduced demand and consequently receive lower prices at sale.

**Health Concerns and Public Perception**

Property value assessments are influenced by health concerns that exist both as real problems and subjective perceptions. Documented reports of headaches, anxiety symptoms, and cognitive dysfunctions are common among people residing near wind turbines, which has caused increased concern within

communities (Jeffery, 2013). Research indicates that extended exposure to low-frequency noise from wind farms may lead to a condition referred to as "wind turbine syndrome," but scientists have not reached a definitive conclusion on this matter.

Although scientific evidence regarding direct health effects from wind turbines remains unresolved, the perception of potential risks alone has substantial impacts on property values. Research within behavioral economics demonstrates how consumer decision-making is impacted by perceived risks regardless of scientific validation. The belief among potential homebuyers that are residing near a wind farm may harm their health leads to decreased property purchases in those areas which results in lower demand and reduced property values.

The Shirley Wind Farm in Brown County, Wisconsin demonstrates the complex relationship between wind energy development and public health. In 2014 the Brown County Board of Health declared the farm a "human health hazard" due to reported symptoms potentially linked to turbine noise, though later studies offered conflicting conclusions (Brown County Board of Health, 2014). Health problems reported by local residents started appearing soon after the wind farm began functioning due to low-frequency noise from the turbines. Reported health problems among residents included insomnia and headaches along with cognitive impairments. The Brown County Board of Health labeled the wind farm as a "human health hazard" during October 2014 becoming the first case of its kind in the United States. Research following the initial findings delivered contradictory outcomes and discussions about these health problems remain unresolved. The Shirley Wind Farm case demonstrates the intricate relationship between wind energy projects and the health of local communities.

**Counter Arguments: Minimal or Temporary Effects**

Property value research shows conflicting results about wind farms. Some studies report negative impacts while others suggest these impacts are negligible or short-lived. A U.S. Department of Energy-funded study that analyzed over 500,000 home sales revealed that properties located within one

mile of wind turbines experienced temporary price reductions, which diminished over time (Hoen et al., 2013). No significant long-term devaluation was observed (Hoen et al., 2023).

A 2024 CNN report highlighted research showing that homes near wind turbines may experience a short-term decline in property values. However, these effects typically disappear within ten years. The article noted that early market reactions often stem from uncertainty or negative public perceptions, which tend to fade over time as residents adjust to the presence of wind farms (Nilsen, 2024).

Research has shown that property values around wind farms can maintain their current levels or rise under the condition that wind energy projects boost the local economy. The arrival of new employment opportunities along with higher tax income and better infrastructure will help alleviate early worries and eventually draw prospective buyers to these areas.

**Community Engagement and Policy Solutions**

The way residents perceive wind energy projects is essential to their feelings about these developments. The University of Michigan research illustrates that landowners with negative feelings toward wind-farm planning experienced more adverse impacts compared to those who felt neutral or positive (Mills, Bessette, & Smith, 2019). The involvement of local communities during planning stages combined with transparent communication about their concerns can reduce opposition and negative perceptions toward projects.

Policymakers and developers must give top priority to community engagement to balance wind energy benefits with local resident concerns. The concerns of residents can be reduced by providing financial compensation to homeowners affected by turbines, establishing stricter noise control measures and positioning turbines correctly. An open dialogue between developers and residents can establish trust while reducing false information about health risks and property value effects.

## Conclusion

Wind farms perform an essential function in achieving renewable energy objectives while delivering multiple environmental and economic advantages. Building wind farms close to residential areas creates complex issues that require detailed management. Property value impacts result from multiple elements including visual appearance and noise of wind farms, health concerns, and neighborhood opinions. Research findings show property values dropping near wind farms but other research shows these effects either disappear quickly or remain insignificant.

Effective wind energy development requires comprehensive planning along with active community participation and continuous research to ensure that both local population welfare and economic interests remain protected. When communities and wind energy operators address concerns before they become major issues it becomes possible to achieve peaceful coexistence between wind energy infrastructure and the local populations they serve. The increasing demand for renewable energy requires policymakers and industry leaders to collaborate on wind farm development processes that maximize benefits but minimize local resident disruptions.

# CHAPTER 2: Literature Review

The growth of wind farms as renewable energy sources has generated academic interest due to the country shifting focus and moving away from fossil fuels to adopt sustainable energy solutions. Wind farms represent the foundation of renewable energy strategies of the fact that they provide a sustainable energy source which tackles multiple global challenges including climate change as well as environmental and energy security issues. Despite their benefits as a clean energy source, wind energy projects spark controversy because they produce externalities that affect local populations and regional economies both positively and negatively. Real estate markets demonstrate clear effects from wind farm projects because property values frequently change in relation to their distance from these developments.

Wind farms symbolize financial as well as development commitments towards ecological stability while boosting economic expansion. Wind farms stand as a symbol of progression within communities that support renewable energy because society now focuses more on clean energy solutions. Wind farms generate substantial economic advantages by creating jobs and developing infrastructure while boosting tax income to improve public services and quality of life. Wind energy produces cleaner air while decreasing fossil fuel dependency which leads to health and environmental advantages that attract homebuyers searching for sustainable neighborhoods.

Wind farms generate negative externalities which lead to declines in residential property values. The noise produced by wind turbines can disturb the tranquility of surrounding neighborhoods which makes these areas less appealing to prospective homebuyers. The large wind turbines create a visual impact that changes the landscape and reduces its aesthetic value while deterring potential residential investors who prioritize natural views. The debate surrounding wind turbine health risks includes scientifically proven and hypothetical conditions like “Wind Turbine Syndrome,” which serve to enhance public opposition and reduce property attractiveness. Debate across academic circles, policy makers and developers has emerged in response to these challenges which demonstrate the necessity for a

sophisticated understanding of wind farms' dual impact as progress engines and sources of community disruption.

The literature represented in this portion solely aims to build on the original thesis. I want to know how wind farms affect property values and how so. Through this section I compare and contrast highly skilled writers, professors, and other knowledgeable, peer reviewed scholars. I look to show both sides of the argument, the literature presented does this. As this section progresses I discuss positive and negative externalities, speak about the geographical context, as well as explain how this literature connects to my overall project.

### Analytical Framework: Positive and Negative Externalities

This section will examine how wind farms produce both positive and negative effects on property values. I examine the key factors being local economic conditions, community attitudes, and geographic context. I acknowledge the literature on the positive externalities of wind farms, such as job creation and increased tax revenue, all of which can drive property values up. On the other hand, literature expanding on issues such as noise pollution and visual disruption often lead to decreased property values, mostly in areas that oppose renewable energy development. Researchers such as Hoen et al. (2009) and Castleberry and Greene (2018) highlight these conflicting impacts and end up playing a large role in my overall understanding of the comparison. I also examined studies by Dong (2022) that show communities that actively support renewable energy infrastructure tend to see more significant property value growth, while regions through the country with resistance may face slower growth. This section explores how the factors discussed influence property values in different settings.

### Environmental Appeal

The presence of wind farms represents progress toward renewable energy and environmental sustainability goals. Atkinson-Palombo (2014) discovered that wind turbines match the environmental

principles and climate action goals of communities that prioritize sustainability. The alignment between wind farms and local community values creates higher property demand among buyers who value eco-friendly living options. In Massachusetts, communities focused on sustainable development homes located near wind farms maintained stable property values while areas without wind energy infrastructure saw different trends.

Dong's (2022) research suggests that wind farm proximity can be seen as a property advantage in areas that value environmental protection. Buyers in sustainable communities typically see wind farms as a mark of local identity which boosts the appeal of adjacent properties. The trend indicates that in areas where renewable energy, including wind farms, is widely supported, property values tend to increase more significantly. In contrast, regions where there is skepticism or less support for renewable energy experience smaller or even negative effects on property values..

Further evidence reinforces this difference. Lang and James (2014) found that wind farms in urban industrial areas face less aesthetic opposition, as they are seen as modern, sustainable solutions for urban development. On the other hand, turbines in rural regions often face resistance due to their disruption of natural landscapes, highlighting the contrasting perceptions based on location.

**Economic Growth**

Wind farms generate economic advantages that surpass energy creation by affecting local economies in multiple ways. A study by Castleberry and Greene (2018) demonstrated that wind farm development generates employment opportunities primarily during the construction phase which requires transportation workers as well as installation and logistics experts. Maintenance roles continue to provide economic value to the local community. The study conducted in Oklahoma found that wind farm

construction stimulated economic development in rural regions which typically have limited industrial options.

The 2009 study by Hoen et al. demonstrated how wind farms contribute to local government tax revenue. Tax revenue from wind farms often fund enhancements in public services like schools and parks which in turn supports community infrastructure and property value growth. Regions which used wind farm tax revenue to improve public services saw milder decreases in property values near wind farms demonstrating the potential of economic benefits to mitigate negative externalities.

Infrastructure improvements further amplify these benefits. The transportation networks serving wind farms need upgrades to move turbine components which then enhance local community connectivity and accessibility. Castleberry and Greene (2018) observed that property values increase indirectly as a result of regional infrastructure improvements.

**Cleaner Energy and Energy Independence**

Wind energy holds both environmental and economic importance because of its capacity to reduce dependence on fossil fuels. According to Sunak and Madlener (2013), wind farms deliver cleaner air as well as reduced greenhouse gas emissions which appeal greatly to buyers who care about environmental issues. The geographically weighted hedonic pricing model indicated that German buyers paid higher prices for real estate in renewable energy regions demonstrating wind farms can lead to beneficial market results.

Dong (2022) extended this analysis by claiming that wind farms boost regional energy sovereignty because they deliver a steady and renewable energy supply. Homebuyers who prioritize energy-efficient homes find this reliability attractive because rising energy costs and energy security concerns continue to increase. Wind farms generate cleaner energy that end up leading to long-term public health improvements which can make nearby properties more attractive to potential buyers.

## Negative Externalities of Wind Farms

### Noise Pollution

Wind farms produce noise pollution which stands as their most controversial negative externality. The 2014 study by Hoen, Brown, and Kivell revealed quantitative evidence that properties near turbines depreciate because of noise disturbances. Castleberry and Greene (2018) confirmed that, in Oklahoma, noise complaints led to a decrease in property values. Their research showed that property value decreases occurred for homes near turbines due to perception rather than actual noise levels. Market behavior demonstrates clear psychological effects resulting from noise pollution.

Dorrell's 2020 study showed that the impact of noise pollution varies because buyers who live near highways develop less sensitivity to turbine noise. Research indicates that noise pollution impacts differ across various contexts because they depend on local standards and societal expectations (Dorrell, 2020).

### Visual Impacts

The aesthetic presence of wind farms is a major determinant of property values, especially in regions where visual appeal greatly influences real estate markets. Lang and James (2014) performed a thorough examination of wind turbines' aesthetic effects and discovered that their industrial look frequently conflicts with rural and suburban scenic environments. Property values see substantial decreases when potential buyers consider wind turbines as disturbances to the natural surroundings.

According to Atkinson-Palombo (2014) visual impacts reach their peak intensity in regions where natural beauty holds significant economic value through tourism and outdoor recreational activities. The introduction of turbines in these areas results in steeper property value declines because they reduce the natural landscapes that appeal to both buyers and tourists.

According to Dong (2022), wind farms show reduced visual impacts when they are placed within industrial landscapes of urban areas. Turbines represent modern innovation that demonstrates community sustainability efforts instead of harming the visual appeal in these contexts.

**Health Concerns**

The ongoing debate about wind farms includes possible health concerns. Hoen and Jeremy (2019) found that buyer behavior is significantly shaped by the perceived health risks, including "Wind Turbine Syndrome." Potential property buyers avoid purchasing near turbines due to concerns about symptoms such as headaches and dizziness even without definitive scientific proof which reduces demand in these areas.

Jacquet (2012) pointed out the social magnification of concerns surrounding wind farms through both media representation and local objections, which intensifies public fear resulting in a stigmatization of properties situated near wind farms. The stigma affects broader property markets leading to diminished appeal across whole regions and not only those near turbines. The influence of wind farms on property values depends on multiple moderating contextual factors.

Several contextual factors such as geography combined with local attitudes and policy interventions moderate wind farms' effects on property values. Hoen et al. (2009) found that areas with effective regulation and active community engagement demonstrate reduced negative effects. Zoning rules that specify proper turbine placement away from homes help minimize noise and visual disruptions which protect property values.

Castleberry and Greene (2018) emphasized community participation while observing that financial compensation programs can mitigate negative perceptions from affected residents. Developers who focus on public engagement and deliver direct benefits like reduced energy expenses or cash payments tend to see reduced opposition to wind farms while property markets reach stability.

Sunak and Madlener (2013) emphasized the geographic influence on property values by showing how cultural perspectives on renewable energy play a decisive role. Buyers tend to see wind farms as assets in regions with widespread acceptance of wind energy but view them as liabilities where resistance against wind energy remains strong.

Wind farms' effects on property values are multifaceted and dependent on specific contexts after examining multiple study findings. The combination of positive and negative externalities influenced by local conditions and community attitudes demonstrates the importance of developing wind farm strategies that incorporate environmental, economic, and social factors.

**Geographical Context**

Property value effects from wind farms show large variations based on geographical locations and cultural settings. In the United States, Hoen et al. (2009) reported that rural property values declined due to wind turbines which people in those areas see as disruptive to natural landscapes. The visual impact of turbines becomes more noticeable in tourism or recreation-dependent areas because their presence reduces the scenic attributes that draw both visitors and local residents. Lang and James (2014) discovered that wind turbine presence had a weaker impact in urban and industrial areas. The pre-existing industrial and residential land uses make wind turbines seem less intrusive in these settings.

Sunak and Madlener (2013) found that wind farms received higher public approval in Europe which resulted in diminished effects on property values. The discrepancy arises because European wind farms benefit from more robust regulatory frameworks and zoning laws that control turbine placement relative to residential areas and enjoy deeper community involvement compared to the United States. European wind farm developers frequently establish benefit-sharing initiatives that provide residents with lower energy prices or direct monetary compensation to create community support and diminish project opposition. The combination of these initiatives builds a cultural and economic space in which wind

farms are recognized as benefits rather than drawbacks which demonstrates how regional policies and attitudes affect property valuation results.

### Community Engagement and Policy Measures

Wind farm effects on property values are significantly influenced by community involvement and regulatory actions. Dong (2022) showed public awareness campaigns to be essential for building acceptance of wind energy projects. Negative externalities from wind farms decrease when developers allocate resources to community engagement alongside financial compensation for nearby residents.

Jacquet (2012) pointed out that zoning regulations help to reduce tensions between wind farms and residential zones. The strategic placement of turbines outside dense population centers enables policymakers to minimize noise pollution and visual disturbances which helps protect property values.

### Conclusion

Wind farms' impact on property values have been measured in both positive and negative ways. Influential factors such as geographic, economic, and social factors have all shown to play some role, regardless of overall impact. The positive externalities such as job creation and increased tax revenue can boost these property values, while some negative externalities including noise pollution and visual disruption can drive them down, most notably in communities resistant to renewable energy. My research builds on these findings by analyzing the county-level data I collected as I try to determine how these externalities exist in different regions and examine their effect on property values, as discussed in Chapter 4.

The literature also emphasizes the importance of community support and effective policies to reduce negative impacts and enhance the benefits of wind energy. My study, as seen in Chapters 5 and 6, will explore how community engagement and targeted policy measures can mitigate the drawbacks of

wind farms and help align local interests with sustainable energy goals. The data I collected illustrates how these factors influence the long-term effects of wind energy development on property values.

Overall, the literature review sets up the foundation for understanding the complex dynamics of wind farms and their impacts on property values. It highlights the need for an approach to wind energy development that considers both the economic opportunities and the challenges that I read through my sources. My research aims to provide insights into how these dynamics play out in practice and offer strategies for policymakers and developers to manage wind farm development in ways that maximize benefits while minimizing negative effects.

# CHAPTER 3: Methodology

This chapter breaks down the research design I followed for this project and explains why some changes had to be made along the way. What I initially started out planning to achieve was a more detailed, property-level analysis eventually shifted into a broader, county-level approach. I'll walk through that transition and show how the ideas introduced back in Chapters 1 and 2 shaped the direction I ended up taking. This section lays the groundwork for the visual comparisons and regression modeling in Chapter 4 and sets the stage for the larger takeaways I'll dive into in Chapters 5 and 6.

**Original Research Design**

I originally planned to study how the distance from wind farms affects residential property values, using a spatial hedonic pricing model. This type of model looks at how different features, such as location, distance from infrastructure, or environmental factors, affect the price of a home. In my case, the idea was to compare sale prices of homes based on how close they were to a wind turbine, whether they were within a mile, between one and five miles, or beyond five. I was going to use data from ZTRAX, which had detailed, parcel-level housing data, but that system was shut down in late 2023. This distance-based model aligned well with the concerns I laid out in Chapter 1, like how people feel about noise, health risks, and visual disruption. It also would have helped dig deeper into the external factors I discussed in Chapter 2.

This original approach got to the heart of my research question: ***Are homes closer to wind farms worth less, and if so, does that impact fade over time?*** The distance based model would've let me directly measure the kinds of external factors, like noise and visual disruption, that people usually bring up when discussing wind farms (Gibbons, 2015; Hoen & Jeremy, 2019). It also connected well with what I covered in my literature review, especially the idea that property values can take a hit not because of actual harm but because of how people think wind farms will affect them. A lot of that reaction comes down to perception, not reality.

Again, ZTRAX, the main dataset I planned to use for analyzing how home prices change based on distance from wind farms, was unfortunately discontinued in late 2023. This was a big setback. ZTRAX was one of the only large-scale, property-level databases available across the U.S.. Without it, I couldn't get the kind of detail needed to study the impact of turbines on homes at specific distances. Rather than water down the quality of my project or scrap the idea altogether, I decided to pivot. I dropped the parcel-level model or individual home example and shifted to a broader, county-level approach. While I gave up some precision, this new strategy kept the focus exactly where it needed to be: examining how wind farm development impacts home values over time.

The original plan wasn't just about proximity, it was about testing whether those distance zones (0–1 mile, 1–5 miles, 5+ miles) lined up with the kind of value changes that show up in buyer behavior. I wanted to see if there was a drop-off in value the closer a home was to a turbine, and whether that effect stayed the same, got worse, or faded over time. I also planned to control for other variables at the property level, like square footage, number of bedrooms, and lot size, which influence home value but have nothing to do with wind energy. That kind of model would've made it easier to isolate the turbine's role without letting all the normal real estate factors get in the way. If ZTRAX had stayed online, this would've been the most direct way to test the theory laid out in both my introduction and literature review, that perceived externalities, whether visual, auditory, or psychological, can shape housing prices in subtle but measurable ways.

With the spatial model off the table, I rebuilt the study using county-level comparisons. I looked at the change in median home prices between 2017 and 2024, covering key phases like the post-recession rebound, the COVID-19 housing surge, and more recent market slowdowns. I didn't just pull counties at random, either. I intentionally chose a mix of regions, populations, and economic profiles. Some were small, rural, and heavily agricultural. Others were closer to cities or had more diverse economies. This gave me a better chance of capturing how wind farms interact with different types of local housing markets and community dynamics.

Even though switching to county-level data meant I couldn't measure exactly how close a home was to a wind turbine, this broader approach came with its own strengths. Looking at full counties instead of individual properties actually lines up with how a lot of housing and energy research is done, especially when the focus is on long-term trends. Plenty of peer-reviewed studies take this kind of macro approach when they're trying to spot bigger patterns across regions instead of just short-term or hyper-local changes. And honestly, this wider lens makes more sense from a policy perspective too. When a county is deciding whether or not to approve a wind project, they care about the big picture, population shifts, job creation, tax revenue, and overall economic health, not just what happens to a handful of homes. This new direction also lines up with Castleberry and Greene (2018), who found that wind farms can boost local economies depending on the conditions around them.

To build out my new dataset, I pulled together 30+ counties from across the U.S. 16 with wind farms and 15 without any major wind energy development. I used the U.S. Wind Turbine Database (USGS, 2024) to confirm which counties actually had operational turbines. From there, I focused on selecting counties that had both accurate wind farm data and consistent reporting on key stats like home prices, income, and unemployment. The goal was to make sure I wasn't comparing "apples to oranges". A few counties had to be cut because they were missing some of that economic info, simply too difficult to find, which brought my final regression sample down to 31 from an initial 35 for this regression. Even with that slight drop, I kept a good balance across different regions and community types, giving the model a strong base to work from.

The counties I used gave me a good mix to work with. The ones with wind farms included everything from rural Midwest areas built around agriculture to more suburban counties out West that sit near growing metro regions. For the control group (the counties without wind farms) I made sure to pick ones with similar economic and geographic characteristics. I ended up looking at things like median income, unemployment rates, population size, and location. I used data from the U.S. Census Bureau and the USDA Economic Research Service to help guide those selections and avoid pairing totally

mismatched areas. The point in doing so was to keep things balanced and avoid comparisons that could be thrown off by totally different population sizes or local economies. This mirrors what I did back in Chapter 4 when I compared Kern County and Weld County, both of those were chosen because of their similar backgrounds.

I won't repeat all the technical stuff from Chapter 4, but I do want to explain briefly what each variable in the model was doing. The dependent variable in the regression was the percent change in median home price from 2017 to 2024. I used that instead of raw price values so I could compare how fast prices were growing, no matter where they started. I also added wind farm presence as a binary variable, just a 1 if the county had wind farms and a 0 if it didn't. Then I included population growth to represent migration patterns, which ties back to what I mentioned in Chapter 2. Researchers like Dong (2022) have shown that population shifts and development pressure can influence how wind farms are viewed and how they affect nearby markets.

I included median household income and unemployment rate to get a sense of each counties overall economic health. These are simple but important indicators that tend to influence housing demand and how attractive an area is for buyers or investors. On top of that, I added dummy variables for U.S. Census regions to account for broader geographic trends. A wind farm in Indiana isn't going to be viewed the same way as one in California, so it was important to control for those regional differences and avoid drawing conclusions that wouldn't apply across the board.

**Data Sources:**

- Median home prices: Redfin (2024) and National Association of Realtors (2024)
- Wind farm presence: U.S. Wind Turbine Database (USGS, 2024)
- Population estimates: U.S. Census Bureau (2024)
- Median household income: USDA Economic Research Service (2024)
- Unemployment rates: Bureau of Labor Statistics (2024)
- Regional classification: U.S. Census Bureau (2020)

The visual and regression based trends in Chapter 4 all trace back to the groundwork laid here in this chapter, from the way I selected counties to how I defined the key variables. Everything that comes later builds directly off of this shift in method. While Chapter 4 focuses on laying out the technical analysis and presenting the core data, Chapters 5 and Chapter 6 are predominantly where this methodology really shows its full value. That's where the meaning behind the numbers gets explained.

In Chapter 5, I'll take a step back from the graphs and regression tables to break down what the data actually says about wind farms and housing markets. That section will dig into why the regression showed wind farm counties appreciating more, even though my earlier indexed graphs suggested slower growth. This opens the door to bigger questions: Are wind farms being built in areas that were already on the rise? Does early resistance fade once communities adjust to the change? Are these counties experiencing economic growth that overshadows any perceived downsides of turbines? These are the

kinds of questions Chapter 5 will explore as I connect the quantitative results to broader social and economic dynamics. I'll also look at what this means in real terms, whether for local policy, zoning decisions, or how communities weigh environmental progress against potential housing concerns. These findings can help local governments and communities make more informed decisions about where to place wind farms by balancing the benefits of clean energy with potential impacts on housing markets and neighborhood dynamics.

Then, in Chapter 6, I'll bring it all together, representing my conclusion. That chapter will revisit my original research question and assess how well this revised model answers it, especially considering the shift away from proximity-based analysis. I'll also outline what could come next. If better spatial data becomes available in the future, it would make sense to return to the parcel level, distance-based approach I originally planned for. That kind of analysis would give a more finished, well-polished look at whether turbines affect nearby properties differently depending on how close they are. I'll also discuss how this study could benefit from adding qualitative methods, interviews, surveys, or community-level insights to capture the human side of wind farm development, which the numbers alone can't fully explain.

So this chapter isn't just about how I built a dataset or why I used certain variables. It reflects how research has to evolve when real-world challenges get in the way. Losing access to ZTRAX was a major setback, definitely reshaping my original study and ideas. Pivoting to a county-level model still allowed me to test the core idea at the heart of this thesis: does wind energy development actually affect property values in a measurable way? Beyond that, this shift made the study more applicable to real-world decision-making. County-level analysis better reflects how local governments and developers think when they evaluate large-scale wind projects. In the end, this revised methodology didn't just salvage the research, I would argue it actually strengthened it. It created a framework that works now, and can be built on in the future if new tools and data become available.

# CHAPTER 4: Impact of Wind Farms on Property Values

## 4.1 Trends in Property Values Near Wind Farms

As I initially stated, I wanted to revolve my general study around my original thesis, the belief that the closer in proximity the property is to a wind farm the generally cheaper the property will be. To investigate the impact of wind farms on property values, I chose to begin by examining the trends in home prices for counties with wind farms compared to similar counties without wind farms. I originally compiled monthly median sale prices for five counties hosting wind farms and five comparable counties without wind farms. The data I collected from Redfin spanned from January 2012 to January 2024.

Figure 4.1 below illustrates an example comparison between **Kern County, CA** (which has significant wind farm development) and **Weld County, CO** (which has no major wind farms in this analysis). These two counties had roughly similar market activity levels and served as representative cases for the wind vs. non-wind comparison. Additionally, they both reside in strong agricultural and energy sectors, which experienced similar trends, such as population growth and COVID-era rebounds. Further research revealed that both Kern and Weld counties play significant roles in the oil economy (Kern Economic Development Corporation, 2021; Weld County Government, 2022). Kern's affordable housing and expanding energy sector contributed to over 8% population growth from 2010 to 2023 (California City, 2023), while Weld's robust economy and energy production helped drive a population increase from 254,000 in 2010 to over 340,000 by 2020 (BizWest, 2025).

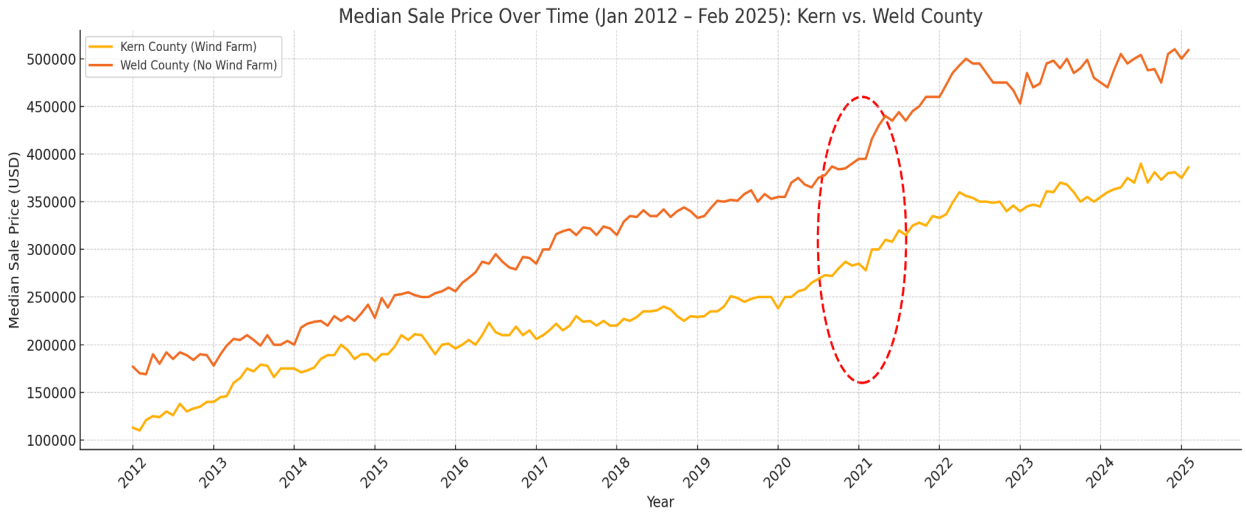



**Figure 4.1: Kern County, CA v.s. Weld County, CO Median Sales Price Over Time**

Figure 4.1 presents median home sale prices from January 2012 to February 2025 for both Kern County, CA (with wind farms) as well as Weld County, CO (without wind farms). Clearly illustrated, the median sales price between these two counties are drastically different, there is no debate in this fact. Rather I aim to view the trend in growth over this time. Coincidentally, both counties show a clear, long-term upward trend, with prices roughly doubling over the 13 years. Kern begins near $113,000 and rises to $386,000, while Weld starts at $177,000 and reaches $509,000. Seasonal fluctuations are visible, yet both counties follow nearly parallel trajectories with no significant divergence. Notably, Kern shows no drop or stagnation that would suggest a negative impact from wind turbine development. Even during the COVID-19 period (circled in the figure), both counties experienced rapid appreciation, reinforcing that broader market forces, not wind farm presence, shaped home value trends. These results align with prior research, including a national study by Lawrence Berkeley National Laboratory, which found that the effects of wind projects on home prices are minimal and rarely statistically detectable in large datasets (Hoen et al., 2013; Wiser et al., 2021).

### 4.2 Comparative Analysis: Wind vs. Non-Wind Regions

While Chapter 4.1 focused on a case study comparison between Kern County (wind farm) and Weld County (non-wind), this next section widens the lens. I use indexed price trends across all ten counties in my original dataset, five with wind farms and five without, to examine how regional patterns unfold over time. This step helps test whether the differences we saw in the Kern vs. Weld example are consistent across a larger sample. It also sets the stage for the regressions I plan to do in Chapter 4.3, which will explore whether these trends hold once we control for economic and regional variation.

To build the dataset I selected a mix of ten counties,this includes counties with and without wind farms, to ensure a balanced comparison. The counties included in the data set are Avery County, NC; Carter County, KY; Chaves County, NM; Donley County, TX; Weld County, CO; Blaine County, OK; Bradford County, PA; Custer County, OK; Kern County, CA; and Tioga County, PA. These counties were chosen based on their data availability, as well as varying characteristics such as, geographic location, economic context, and obviously wind farm presence. The data I collected was sourced from Redfin's real estate database, which provides extensive housing market data, including monthly median sale prices for each county. Redfin was chosen solely to ensure access to accurate, up-to-date property value trends. The combination of wind and non-wind farm counties allows for examination of the impact of wind farms on property values across different settings.

Taking the data I collected, to do this, I calculated the average monthly median sale price across all counties with wind farms and compared it to the average from counties without wind farms. To account for differences in starting prices, I indexed each group’s median sales price to 100 in January 2013. This lets us compare relative appreciation rates on an even playing field, rather than being skewed by baseline price differences between counties. This point allows us to compare relative growth rates over time without being influenced by absolute differences in home prices at the start of the analysis.

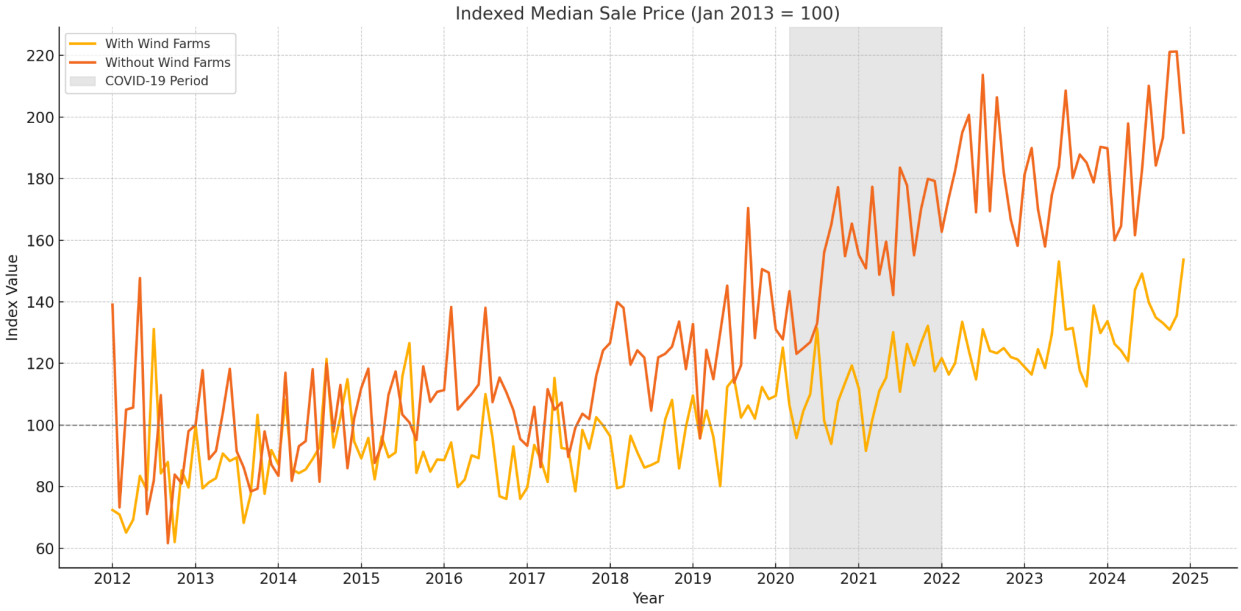



**Figure 4.2: Indexed Median Sales Price (5 Counties with Farms, 5 Counties Without)**

Figure 4.2 displays the indexed growth comparison. The chart shows how median sale prices evolved on a percentage basis for both groups. With the extreme contrasts in annual income, population growth, and local economic differences between the two counties in **Figure 4.1**, I found a scenario in which comparing percent change to be a more even playing field. Between the period of 2013 and 2024, both wind farm and non wind farm counties experienced noteworthy growth, but they clearly differed in pace. Wind farm counties saw an increase of around **50% to 60%**, the non-wind-farm counties appreciated by over **120%**. Up until 2020 both groups exhibited similar growth patterns until non wind counties started advancing at a faster pace. The non-wind counties achieved index values above 220 at the graph's current conclusion compared to the 150-160 range for the existing wind farm group. Around 2020 the gap between the two groups started to widen substantially, indicating a distinct turning point in their development paths.

The inflection point matches the timeline of COVID-19 pandemic's emergence which shifted the national housing demand patterns. Home Buying activity surged in rural and further out suburban counties beginning early 2020 due to low interest rates as well as the opportunity for employees to

complete work remotely and people's preference to live in the less populated areas. Non wind farm regions appeared to gain a competitive edge as homebuyers sought out peaceful locations free from industrial developments. Home value appreciation in counties that host wind farms occurred at a lower rate due to subtle externalities like noise and visual impacts that challenged buyer preferences over the long term. The housing boom during the pandemic years strengthened pre-existing market trends which led to a continuing disparity between the two groups by 2020 (Gibbons, 2015).

The initial takeaway the broader comparative analysis provides can be understood that wind farms do not directly lower home values but are linked to a gradual decrease in long-term property value growth. An examination using indexed data shows that from 2020 forward, the non-wind farm counties experienced faster growth during the pandemic period and continued to maintain this advancement until 2024. The available research I gathered validates that property values near wind farms typically do not decrease but reveal market frictions like reduced buyer interest because of aesthetic or noise issues, as outlined by Gibbons in 2015. Research from Lawrence Berkeley National Laboratory confirms these results since their analysis of extensive datasets showed only minor and statistically insignificant impacts of wind development on nearby residential property values (Hoen et al., 2013; Wiser et al., 2021). The pandemic's abrupt change to housing preferences seems to have become clearer with these differences and may provide an indirect analysis of wind farm effects during widespread market disruptions. It has to be reiterated that wind farm regions maintain their value containing slower appreciation rates compared to similar counties without large-scale renewable projects. While the visual trends hint at slower growth in wind counties, the next chapter tests whether that difference remains when controlling for other key economic and regional variables.

### 4.3 Regression Analysis of Wind Farm Effect

Following the visual and comparative trends explored in Chapters 4.1 and 4.2, I wanted to take another step in determining whether the presence of wind farms has a statistical measurable effect on

home price growth. While the previous two chapters established that counties with wind farms tended to experience slightly slower appreciation post 2020, those findings were largely observational and based on indexed and visual comparisons. What I am saying here refers to pattern recognition in previous models rather than trying to find cause and effects. To build on that foundation, I account for other contributing factors such as population growth, income levels, and regional variation. I conducted a multiple regression analysis using a broader dataset.

Initially, my 4.2 analysis included only 10 counties, five with wind farms and five without, for consistency in my early comparisons. However, for this regression model, I expanded the dataset to include 35 counties across the U.S., comprising 16 with wind farms and 15 without that were successfully used in the model. While data was collected for all 35 counties, the final regression included 31 due to the fact that I could not find significant data for some categories involved within the regression.

All of the counties that happened to be selected provided geographic diversity and variability in wind farm development, population changes, and economic structure. I focused on median home price growth from **2017 to 2024**, (this differs from the previous 2013 to 2024 examples provided) reflecting a post-recovery, pre-pandemic baseline through to the current housing climate. The dependent variable in my regression is the percent change in median home price over that seven-year period. I chose this as my dependent variable because some counties have naturally higher values than others, this creates a fair and equal playing field for my regression.

For my regression model development process, I collected various economic and demographic data at the county level which matched the ideas I discussed earlier. Public records from Redfin along with the National Association of Realtors provided the median home price data for both 2017 and 2024 (Redfin, 2024; NAR, 2024). From there I used the U.S. Wind Turbine Database in order to find locations of current up and running wind farms (USGS, 2024). Then population data for the years 2017 and 2024 came from the annual estimates published by the U.S. Census Bureau (U.S. Census Bureau, 2024). The

USDA Economic Research Service provided the 2024 median household income figures while the Bureau of Labor Statistics supplied unemployment rates for the same year. The final step was to determine each county's U.S. Census region, Midwest, Northeast, South, or West, using official boundaries defined by the Census Bureau in 2020. This last part was meant to help me control regional effects that can shift and change the housing market.

The final version of the regression model included a range of independent variables designed to account for both local and regional economic differences. Wind farm presence was included as a binary variable (1 = county has operational wind farms; 0 = no wind farms). Population growth between 2017 and 2024 was calculated to reflect recent demographic shifts. I also included the 2024 median household income for local economic strength and used the 2024 unemployment rate to capture job market conditions within each county. Lastly, I added dummy variables for region, specifically for the Northeast, South, and West, using the Midwest as the baseline as that is typically where the most on-shore wind farms happened to be. This allowed me to measure regional differences in housing appreciation relative to the Midwest.

## Regression Results Summary:

### Table 4.1 - Data Collection

| Wind Farm Presence (1 = yes) | Median Home Price 2017 | Median Home Price 2024 | Population 2017 | Population 2024 | Population Growth (%) | Median Household Income 2024 | Unemployment Rate 2024 | Region |
|---|---|---|---|---|---|---|---|---|
| 1 | $110,000 | $150,000 | 33,848 | 34,500 | 1.93% | $56,000 | 3.8 | Midwest |
| 1 | $100,000 | $135,000 | 8,854 | 8,900 | 0.52% | $52,000 | 4.1 | Midwest |
| 1 | $95,000 | $125,000 | 15,216 | 15,300 | 0.55% | $47,000 | 4.4 | South |
| 1 | $113,000 | $386,000 | 839,631 | 917,673 | 9.3% | $58,000 | 6.2 | West |
| 0 | $230,000 | $310,000 | 150,083 | 160,000 | 6.6% | $61,000 | 3.6 | West |
| 0 | $180,000 | $250,000 | 187,888 | 190,000 | 1.12% | $65,000 | 3.5 | Northeast |
| 0 | $177,000 | $509,000 | 254,000 | 340,000 | 33.9% | $74,000 | 2.9 | West |
| 0 | $210,000 | $290,000 | 110,000 | 117,000 | 6.36% | $53,000 | 4.7 | West |
| 1 | $97,000 | $120,000 | 7,500 | 7,650 | 2% | $49,000 | 3.9 | Midwest |
| 1 | $89,000 | $118,000 | 24,500 | 25,500 | 4.085% | $51,000 | 3.8 | Midwest |
| 1 | $105,000 | $140,000 | 29,000 | 31,000 | 6.9% | $55,000 | 3.4 | Midwest |
| 1 | $87,000 | $120,000 | 7,000 | 7,200 | 2.86% | $45,000 | 5 | South |
| 0 | $240,000 | $345,000 | 60,500 | 61,500 | 1.65% | $69,000 | 3.2 | Northeast |
| 0 | $310,000 | $435,000 | 298,000 | 302,000 | 1.34% | $82,000 | 3 | Northeast |
| 0 | $185,000 | $260,000 | 101,000 | 106,000 | 4.95% | $59,000 | 3.9 | Midwest |
| 0 | $165,000 | $235,000 | 209,000 | 218,000 | 4.31% | $61,000 | 4 | Midwest |
| 0 | $285,000 | $370,000 | 106,000 | 112,000 | 5.66% | $64,000 | 4.3 | West |
| 1 | $88,000 | $112,000 | 20,000 | 20,500 | 2.5% | $47,000 | 3.7 | Midwest |
| 1 | $93,000 | $118,000 | 12,500 | 12,700 | 1.6% | $49,000 | 4.5 | West |
| 1 | $95,000 | $119,000 | 36,500 | 36,800 | 0.82% | $51,000 | 4.2 | Midwest |
| 0 | $190,000 | $255,000 | 114,500 | 118,000 | 3.06% | $67,000 | 3.6 | Midwest |
| 0 | $210,000 | $300,000 | 154,000 | 161,000 | 4.55% | $62,000 | 3.8 | South |
| 0 | $195,000 | $265,000 | 57,000 | 59,000 | 3.51% | $68,000 | 3.4 | Midwest |
| 1 | $99,000 | $129,000 | 22,000 | 22,500 | 2.27% | $52,000 | 3.9 | Midwest |
| 1 | $88,000 | $114,000 | 10,500 | 10,700 | 1.9% | $50,000 | 3.6 | Midwest |
| 1 | $98,000 | $125,000 | 1,800 | 1,850 | 2.78% | $49,000 | 4.2 | West |
| 1 | $95,000 | $122,000 | 34,000 | 34,500 | 1.47% | $52,000 | 3.8 | Midwest |
| 0 | $155,000 | $215,000 | 127,000 | 130,000 | 2.36% | $60,000 | 4.5 | Northeast |
| 0 | $240,000 | $320,000 | 104,000 | 107,000 | 2.88% | $72,000 | 3.2 | Northeast |
| 0 | $190,000 | $270,000 | 170,000 | 180,000 | 5.88% | $63,000 | 3.5 | Midwest |

**Table 4.2: U.S. Census Region Overview**

| Region | Description | Example States |
|---|---|---|
| **Northeast** | Dense urban centers, older housing stock, slower growth. | NY, NJ, PA, MA, CT |
| **Midwest** | Baseline region, rural and industrial areas, many wind farms. | OH, MI, IL, IA, MN |
| **South** | High population growth, suburban expansion, economic diversity. | TX, FL, GA, NC, VA |
| **West** | Geographically varied, includes tech hubs and rural areas. | CA, WA, AZ, CO, OR |

| Table 4.3: Regression Statistics w/o Regional Dummies | |
|---|---|
| Multiple R | 0.9363432621 |
| R Square | 0.8767387045 |
| Adjusted R Square | 0.8570168972 |
| Standard Error | 0.1762326262 |
| Observations | 30 |

**Table 4.4: Regression Analysis of Variance w/o Regional Dummies**

| Column 1 | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 5.52 | 1.38 | 44.464 | 0 |
| Residual | 25 | 0.78 | 0.035 | | |
| Total | 29 | 6.39 | | | |

**Table 4.5: Regression Analysis w/o Regional Dummies**

| Column 1 | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -4.24 | 0.56 | -7.59 | 0.00000006 |
| Wind Farm Presence (1 = yes) | 0.48 | 0.11 | 4.43 | 0.00016 |
| Population Growth (%) | 5.15 | 0.58 | 8.82 | 0.0000000038 |
| Median Household Income 2024 | 0.00004 | 0.000007 | 6.08 | 0.000002 |
| Unemployment Rate 2024 | 0.48 | 0.06 | 8.06 | 0.00000002 |

| Table 4.6 Regression Statistics w/ Regional Dummies | |
|---|---|
| Multiple R | 0.9453025142 |
| R Square | 0.8935968434 |
| Adjusted R Square | 0.8597412935 |
| Standard Error | 0.1745455854 |
| Observations | 30 |

**Table 4.7: Regression Analysis of Variance Summary w/ Regional Dummies**

| Analysis of Variance | df | SS | MS | F | P-value |
|---|---|---|---|---|---|
| Regression | 7 | 5.63 | 0.80 | 26.39 | 0.0000000026 |
| Residual | 22 | 0.67 | 0.03 | | |
| Total | 29 | 6.29 | | | |

**Table 4.8: Regression Analysis w/ Regional Dummies**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -4.27 | 0.6 | -7.12 | 0.00000038 |
| Wind Farm Presence (1 = yes) | 0.435 | 0.11 | 3.95 | 0.00067 |
| Population Growth (%) | 6.01 | 0.77 | 7.82 | 0.00000009 |
| Median Household Income 2024 | 0.000037 | 0.0000078 | 4.79 | 0.00009 |
| Unemployment Rate 2024 | 0.54 | 0.07 | 7.77 | 0.00000009 |
| Northeast | 0.05 | 0.12 | 0.45 | 0.65 |
| South | -0.12 | 0.12 | -0.96 | 0.35 |
| West | -0.19 | 0.11 | -1.71 | 0.1 |

**Table 4.9: Dependent Variable: Percent Change in Median Home Price from 2017–2024**

| Variable | Coefficient | Std. Error | P-value |
|---|---|---|---|
| Constant | –375.86 | 57.15 | <0.001 |
| Wind Farm Presence | 33.19% | 10.23 | 0.004 |
| Population Growth (%) | 6.26% | 0.8 | <0.001 |
| Median Household Income (2024) | 0.0029% | 0.0007 | <0.001 |
| Unemployment Rate (2024) | 54.42% | 7.41 | <0.001 |
| Region: Northeast | 10.39% | 12.53 | 0.412 |
| Region: South | –22.95% | 11.05 | 0.049 |
| Region: West | –20.50% | 11.41 | 0.086 |

*Step 1:* R-Squared Formula = 1 - Residual sum of squares/Total sum of squares

*Step 2:* 1 - 0.7764/6.2992

*Step 3:* 1 - 0.1232 = 0.877

Final R-squared: **0.877**

**Regression Results Summary:** Table 4.1 - Data Collection

To expand on the analysis and ensure that the impact of regional economic trends was not distorting the results, I ran two separate regression models. The first model (Regression 4.1) excluded regional dummy variables. This means my regression model treated all counties equally regardless of geographic location. This version revealed that wind farm presence, population growth, income, and unemployment were all statistically significant and positively associated with home price appreciation. The second model (Regression 4.2) introduced regional controls, adding dummy variables for the Northeast, South, and West (Table 4.2), allowing me to observe whether regional context changed the significance or magnitude of the wind farm effect.

It's also important to point out the constant (or intercept) in this regression model, which shows up as –375.86 in Table 4.9. At first glance, that number might seem way off, but it's not meant to be interpreted directly. What it really represents is the predicted change in home values if every single independent variable, wind farm presence, population growth, income, unemployment, were all set to zero. Obviously, that's not a real or useful scenario, but the model still needs a baseline to calculate from. So, while the constant is part of the equation, it doesn't offer any practical insight on its own and doesn't reflect anything meaningful about the housing market or wind farm impact.

Comparing the two regressions showed some key insights. The coefficient for wind farm presence remained positive and statistically significant in both models, suggesting that the observed relationship between wind farms and housing appreciation is not simply a product of regional trends. Additionally, while the South and West regions had negative coefficients in Regression 4.2, they were not significant enough to outweigh the broader trends. This consistency across both regressions helps reinforce the central claim of this project: Wind farms are not driving property values down, and in some contexts, they may even signal economic strength and growth potential.

The regressions below confirm and expand on the themes explored in Chapters 4.1 and 4.2, however, they also introduce some surprising contradictions. In the previous sections, indexed graphs showed that counties with wind farms appeared to experience slower growth in median home prices after 2020, particularly during the COVID-19 boom when non-wind counties began to outpace them. However, the regression model paints a different picture. When controlling for other variables such as population growth, household income, unemployment, and regional effects, the presence of a wind farm was actually associated with higher appreciation, **an increase of over 33%**. This difference in outcome highlights the limitations of surface-level comparisons. While the indexed analysis helped visualize broad market behavior, it did not adjust for underlying economic factors that can shape housing markets more directly than wind infrastructure alone.

Population growth and median household income also emerged as statistically strong predictors of price appreciation, aligning with the demographic forces already discussed in earlier chapters. Counties experiencing greater in-migration and rising incomes logically saw more aggressive home value increases, as both factors tend to boost housing demand and strain supply, especially in rural or low-density areas (Joint Center for Housing Studies of Harvard University, 2023). Additionally, the positive relationship between the unemployment rate and price growth, while initially surprising, may reflect delayed COVID-era recoveries or local market corrections, especially in smaller or rural counties that were late to rebound.

Regional differences hint at the importance of local context, though they were not statistically significant in this model. While coefficients for the South and West regions were negative, suggesting slightly lower property appreciation compared to the Midwest, these findings were not strong enough to draw firm conclusions. This slight variation still supports the value of my regression analysis, as it highlights trends that would be hard to detect through simple visual comparison alone. To reiterate, although not statistically significant, the negative coefficients for the South and West suggest these regions may experience slightly slower property appreciation, regardless of wind farm presence.

These regression findings also reflect on my earlier literature review, where I examined national studies on wind development and property values. Notably, the Lawrence Berkeley National Laboratory studies by Hoen et al. (2013) and Wiser et al. (2021) found minimal and often statistically insignificant impacts of wind farms on nearby home values when controlling for other market conditions. At the time, those findings helped shape the framework for my visual comparisons in Chapters 4.1 and 4.2. However, this regression adds a new dimension. It not only confirms those earlier claims but expands on them, suggesting that wind farm presence may even be linked to stronger appreciation when demographic and regional factors are taken into account. While my indexed graphs showed slower growth in wind counties, this model shows that the presence of turbines is not causing that gap. Rather, those areas may simply be growing differently for unrelated reasons.

This helps reconcile earlier concerns explored in Chapter 2 about health and noise effects. While these concerns may influence individual behavior or local sentiment, they did not appear strong enough to significantly affect market-wide appreciation trends once core economic variables were controlled.

One possible explanation for the positive relationship between wind farm presence and home price growth is that wind projects often appear in areas already poised for economic development. These locations may benefit from infrastructure investment, utility revenue, job creation, or land-use policies that attract new residents and employers. In that way, wind farms might signal broader economic

momentum, not just renewable energy expansion. These results challenge some of the more cautionary narratives found in earlier studies, such as Gibbons (2015), which pointed to small, long-term frictions like visual or noise-related externalities. While those concerns may still influence buyer preference in select cases, they do not appear strong enough to outweigh the broader market forces driving growth in wind regions. In fact, the data suggests that any such frictions are likely being absorbed by overall demand trends.

# CHAPTER 5: Interpretation and Broader Implications

## 5.1 Introduction

Chapter 5 takes a step back from the charts, graphs, and regression tables I presented earlier to dig into what those numbers actually mean. The whole point of this study wasn't just to track price trends or build a statistical model, it was to understand how wind energy development actually plays out in the housing market and whether the concerns people often raise about wind farms hold up when tested against real world data. Chapters 4.1 through 4.3 laid the foundation by showing how property values changed over time in different types of counties. But here in Chapter 5, I want to explore the why behind those trends and what they might signal for homeowners, developers, and local governments.

This section connects everything back to the questions I raised in Chapter 1 and the academic debates I outlined in Chapter 2. For example, I started this thesis by looking at common concerns, including visual disruption, noise, and the idea that turbines might hurt home values just by being nearby. Then in the literature review, I showed how researchers have made arguments on both sides, some claiming wind farms hurt property values, and others suggesting the effects are small, short-lived, or even nonexistent. Now that I've completed my own analysis, this chapter is about making sense of those mixed claims and evaluating how well they line up with the data I gathered.

At the same time, I also have to acknowledge the limitations of my data. As I explained in Chapter 3, my original plan to study home-by-home values based on distance fell through when ZTRAX was shut down in late 2023. That dataset would have allowed for a much more detailed proximity analysis. Instead, I shifted to a broader county-level approach, which changed the kinds of answers I could provide. But that shift also gave me the opportunity to look at larger trends, including economic growth, migration patterns, and how wind farms fit into regional development.

As I interpret the patterns from Chapter 4, I'll also explore how wind energy projects may be linked to broader market forces. Do wind farms tend to get built in areas that are already on the rise? Does early resistance fade as people adjust to their presence? Are these projects sometimes part of larger trends, like infrastructure investment or demographic shifts? These are the kinds of questions this chapter will explore, because this is where the meaning behind the numbers starts to take shape.

Ultimately, this chapter is about context. A wind farm does not exist in a vacuum, it operates within a mix of local economic conditions, community attitudes, and shifting policy environments. Chapter 5 is where I bring all of that together to better understand what is really going on beneath the surface. And in doing so, I'll set the stage for Chapter 6, where I'll return to my original research question, reflect on the bigger takeaways, and offer some ideas for where this conversation can go next

## 5.2 What the Data Says: Comparing Trends to Deeper Patterns

One of the most surprising results in my analysis came from the contradiction between the visual trends and the regression output. On the surface, the indexed graphs from Chapter 4.2 showed that counties with wind farms had slower appreciation in home values when compared to those without. This appeared consistent with the broader public perception explored in Chapter 1, where people often assume wind farms lower surrounding property values due to aesthetic and noise concerns. Again, this follows my main thesis and my pre-research understanding. It also echoed earlier findings from Gibbons (2015) and Hoen and Jeremy (2019), who identified localized frictions like visual intrusion and stigma that can slow down demand. From that perspective, it made sense to expect slower price growth near turbines.

However, the regression in Chapter 4.3 told a different story. Once I adjusted for other factors like population growth, income levels, unemployment, and regional effects, the counties with wind farms were actually associated with stronger home price appreciation, showing a positive and statistically significant coefficient. **This flipped the narrative.** Rather than confirming the assumption that wind farms suppress

market growth, the regression suggested the opposite: that wind development may be happening in counties already on upward economic trajectories.

So what explains this contradiction? A big part of it comes down to the difference between correlation and causation. The visual trends offered a straightforward way to track price movement over time, but they didn't account for what else was happening in those counties. That's where regression modeling matters, it isolates wind farm presence while holding other variables constant. As Wiser et al. (2021) pointed out in their national study, localized impacts can easily be overshadowed by broader economic conditions, especially in counties experiencing growth for reasons unrelated to turbines.

Another possibility is that wind farms themselves are not the cause of slower appreciation but are instead located in counties already facing different types of economic pressures. For example, a county with a large amount of open land may be more attractive to developers but may also experience less demand for housing overall due to its rural location. As Castleberry and Greene (2018) noted, the local economic context matters just as much as the infrastructure itself, wind farms can boost regional development, but only if surrounding conditions are favorable. So, while some counties in the visual comparison lagged behind, it's likely those outcomes were tied to other structural realities like slower job growth or limited in-migration, not the turbines alone.

This also challenges the assumption that slower growth is always a red flag. In some cases, the counties with wind farms may be in the early stages of broader development cycles, and the presence of renewable energy infrastructure could eventually become a signal of long-term investment rather than an immediate boost in demand. That aligns with Dong's (2022) findings that public attitudes tend to shift over time, especially in areas where environmental values are high and wind farms are seen as assets rather than liabilities.

In short, the visual and regression models did not contradict each other so much as they highlighted different layers of the same issue. One captured raw trends, the other tested underlying

explanations. Taken together, they show that surface-level assumptions can be misleading, especially in markets shaped by both perception and real economic forces. This layered interpretation helps build a clearer picture of how wind farms interact with local housing markets, and it raises new questions about where the real drivers of property value growth come from.

### 5.3 Interpreting the Regression Results

The regression analysis I ran in Chapter 4 wasn't just about spotting trends, it was about testing whether wind farms have a measurable effect on home price growth once other local and regional factors are accounted for. To do that, I built two different models. The first included four core economic variables: wind farm presence, population growth, household income, and unemployment rate. The second expanded on this by introducing regional dummy variables for the Northeast, South, and West, using the Midwest as the baseline. Running both models gave me a fuller view of what's really driving home price appreciation and helped separate the effect of wind farms from broader market forces.

**Table 5.3: Summary of Key Regression Variables and Interpretations**

| Variable | Effect on Property Values | What This Suggests |
|---|---|---|
| Wind Farm Presence | Positive, statistically significant | Wind farms are being built in places already experiencing growth, not necessarily causing harm. |
| Population Growth | Strong positive correlation | More people moving in boosts demand, driving up home values across both wind and non-wind counties. |
| Median Household Income | Positive correlation | Higher-income counties tend to have stronger housing markets, with more buyer activity and stability. |
| Unemployment Rate | Positive correlation (unexpected) | May reflect pandemic-related rebounds or investment in undervalued areas — not an immediate red flag. |
| Region: South & West | Negative correlation | Slower growth in these regions suggests broader market conditions may overshadow turbine effects. |

In both models, wind farm presence was associated with **positive and statistically significant** effects on home price appreciation. This was one of the most surprising outcomes in the study, especially after Chapter 4.2, where the indexed data showed that wind farm counties appreciated more slowly, particularly after 2020. However, that earlier visual comparison did not account for the underlying economic dynamics between counties. Once the regression models controlled for these additional variables, the narrative flipped. In the most complete model (Regression 4.2), the coefficient for wind farm presence was +33.19 with a p-value of 0.004, suggesting that wind farms tend to be located in counties already on upward growth trajectories. All coefficients in the regression reflect percentage point changes in home price appreciation from 2017–2024.

The inclusion of population growth also added clarity. In both regressions, this variable was one of the strongest predictors of home price appreciation. Counties that saw more people moving in between 2017 and 2024 saw sharper increases in housing prices. This aligns with findings from Dong (2022), who noted that migration patterns, not just local infrastructure, can significantly influence buyer behavior and housing demand. Similarly, median household income was positively correlated with price growth, which isn't surprising. Higher-income areas often have stronger local economies, more buyer activity, and better public services, which are factors that make them more attractive to homeowners and investors alike.

The unemployment rate, however, produced a less expected result. In both models, unemployment had a positive and statistically significant relationship with home price growth. While this might seem contradictory, it could reflect delayed pandemic-era recoveries or speculative investment activity in lower-cost counties, particularly rural or developing areas. As discussed in Chapter 4, these places may have been slower to rebound initially but gained momentum as housing demand spread outward during the COVID boom. This result might reflect late-stage COVID recoveries in smaller counties or investment flows into more affordable housing markets with higher unemployment, all factors that inflated appreciation rates despite economic drag.

A key addition in Regression 4.2 was the inclusion of regional dummy variables. These helped isolate how geographic context might influence appreciation independent of economic variables. Here, the South and West both showed negative coefficients relative to the Midwest baseline, approximately –22.95 and –20.50, respectively. The South's result was statistically significant ($p = 0.049$), while the West was marginally significant ($p = 0.086$). These regional effects highlight that some of the underperformance observed in wind counties may be due to broader market conditions, not the presence of turbines themselves. In contrast, the Northeast had a positive coefficient but was not statistically significant, implying that differences in housing growth in that region are more likely tied to other factors.

Below is a summary of the most complete model:

**Table 5.3: Key Regression Results (Regression 4.2 – With Regional Controls)**

| Variable | Coefficient | Std. Error | Significance |
|---|---|---|---|
| Constant | –375.86 | 57.15 | <0.001 |
| Wind Farm Presence | 33.19 | 10.23 | 0.004 |
| Population Growth (%) | 6.26 | 0.8 | <0.001 |
| Median Household Income (2024) | 0.0029 | 0.0007 | <0.001 |
| Unemployment Rate (2024) | 54.42 | 7.41 | <0.001 |
| Region: Northeast | 10.39 | 12.53 | 0.412 |
| Region: South | –22.95 | 11.05 | 0.049 |
| Region: West | –20.50 | 11.41 | 0.086 |

Taken together, the two regressions reveal that while indexed data may suggest wind counties lag behind, this effect appears to be linked more to broader economic and regional differences than to wind turbines themselves. This finding supports what earlier studies by Hoen et al. (2013) and Wiser et al. (2021) concluded: that the perceived negative impacts of wind farms, such as noise, aesthetics, or health

concerns—rarely translate into statistically significant effects on home values once proper controls are added. In fact, the results here go one step further, showing that wind farm presence may be a marker of economic growth, not a drag on it.

This becomes even more interesting when paired with the regression's **R-squared value of 0.877**, which means the model explains nearly 88% of the variation in home price appreciation. That's a generally strong result and reinforces the reliability of the findings presented.

I have to say, one of the more compelling takeaways from the regression analysis is that the presence of wind farms may function less as a direct driver of home value growth and more as a signal of broader development trends already underway. In other words, turbines aren't necessarily causing property values to rise. Rather, they may be showing up in places that are already positioned for growth. This reframes wind energy not as a negative eye sore, but as a form of infrastructure that follows opportunity. These findings align with earlier studies that found noise and health concerns, while valid in perception, often do not lead to statistically significant changes in home values at scale. Counties with wind farms in my dataset tended to have favorable fundamentals such as steady population growth, rising incomes, and often lower-than-average unemployment. These are the same ingredients that typically attract both private investment and public infrastructure projects. From that perspective, it's not that wind farms elevate home prices on their own, but that they are in a sense "married" with economic momentum, making them part of a larger growth package.

Ultimately, these results support the argument that housing markets are shaped by a complex mix of demographic, economic, and spatial forces. Wind farms, far from being automatic detractors, may simply reflect development trends that are already underway. While perceptions and localized concerns still matter, an issue explored further in my limitations section, this model helps clarify the difference between correlation and causation, which has been a running theme throughout this thesis.

# CHAPTER 6: Conclusion

## 6.1 Introduction

This project started with a basic question that gets thrown around a lot more than it gets tested: *do wind farms actually lower property values?* From the start, I wanted to go beyond surface-level opinions and look at what the numbers actually show. Concerns about how turbines are hurting nearby home values, whether due to noise, visual impact, or public perception, have grown increasingly common. But I wanted to know what happens when you take a step back and control for things like population growth, income, unemployment, and regional trends.

What I found was that those concerns don't hold up the same way when broader market factors are considered. That shift in perspective was one of the most surprising outcomes of the project. In fact, the regression models showed that wind farms often show up in counties that are already growing and may be more of a signal of economic development rather than a cause for concern.

As discussed in Chapter 2, the existing literature offered mixed conclusions. Some researchers, like Gibbons (2015), pointed to small declines tied to noise or aesthetics, while others, like Hoen et al. (2013) and Wiser et al. (2021), found minimal or statistically insignificant impacts when broader market factors were considered. My research set out to build on that conversation using a mix of visual trends and regression modeling that could isolate wind farm presence while controlling for other important variables.

Initially, I planned to use individual housing sales data to measure and analyze distance-based effects, but when access to ZTRAX was lost, my focus shifted to county-level analysis. As explained in Chapter 3, this pivot actually gave the project a broader lens. Instead of focusing on individual properties, the county-level approach let me examine broader trends by looking at how whole communities performed and whether wind farm presence pointed to larger patterns of growth. That shift became a key turning point for how the rest of the thesis took shape.

Chapters 4 and 5 walked through what that analysis revealed, first visually, and then statistically. While visual trends hinted at slower appreciation in wind farm counties post-2020, the regression results told a different story. Once population growth, income, unemployment, and regional controls were factored in, wind farms were associated with stronger price appreciation, not weaker. That result reframed my original question in a major way. It's not just about whether turbines hurt home values, it's about what kind of places wind farms tend to show up in to begin with.

This final chapter steps back to reflect on those findings and evaluate what they actually mean for future development, policy decisions, and ongoing research. I'll also use this space to revisit the limitations I faced, offer suggestions for future studies, and show how this work fits into the larger conversation around clean energy and housing.

## 6.2 Key Findings

By the time I began analyzing the data, I was already aware of the strong opinions surrounding wind farms and their potential impact on property values.. People talk about turbines like they're automatic deal-breakers for homebuyers, pointing to noise, visual clutter, and even health risks. And honestly, I expected the data to reflect at least some of that. The indexed trends in Chapter 4.2 seemed to back it up. Counties with wind farms have slowly appreciated after 2020, however, when I controlled for bigger-picture factors like population growth, income, and unemployment in the regression models, that assumption didn't hold. What looked like a drag on the market at first glance turned out to be something very different. Then the regression flipped that story completely.

When I controlled for things like population growth, household income, unemployment rates, and regional differences, the results were clear. Counties with wind farms were actually more likely to see stronger home price appreciation. In the most complete version of the model, the coefficient for wind farm presence was +33.19 and statistically significant ($p = 0.004$). That's not a small bump, that's a real signal. The indexed data suggested turbines were slowing down growth. But once I factored in the

variables that actually shape market behavior, the story reversed. Wind farms weren't the drag, they were showing up in places already moving forward.

That result changed how I saw everything else in the project. I do not suggest that wind farms are raising prices on their own, but they're clearly not driving them down either. What's more likely is that turbines are being built in communities with the kind of fundamentals (like population growth, rising incomes, and relatively low unemployment) that naturally lead to stronger housing markets. In other words, wind farms might not be causing growth, but they are clearly part of it.

This finding also helped me reevaluate some of the major concerns that get thrown around. Noise complaints, aesthetic disruption, and health-related fear. These issues absolutely exist in public perception, and I'm not saying that they don't matter. But in terms of market-wide, measurable impact? The data doesn't show that they translate to lower home values. Even if individual buyers are turned off by the idea of living near a turbine, there's no evidence in this study that those concerns suppress appreciation at the county level. If anything, the markets around wind farms are still growing, and in some cases, more quickly than expected. That fits right in with the findings from Hoen et al. (2013) and Wiser et al. (2021), both of whom used larger datasets to show that turbine presence rarely has statistically significant effects on property values when controls are added.

It also builds on Dong's (2022) argument that migration and local development trends are stronger forces than infrastructure alone. If people are moving into an area, and the local economy is strong, home values are going to rise, even if turbines are part of the landscape. On the flip side, areas that look like they're underperforming in visual comparisons might just be slower-growing in general. The turbines aren't causing that, they're just part of a different kind of local dynamic.

Where this really challenges earlier work is in the assumptions made by studies like Gibbons (2015), which leaned into long-term market frictions and visual stigma as key reasons for price depreciation. I'm not denying those effects can exist in some places. However, my study suggests that

those local frictions don't hold up when viewed against broader demographic and economic trends. Once the right variables are included, the "wind farm penalty" basically disappears.

One of the biggest takeaways here is that wind farms might actually act as a kind of economic signal, an opportunity for urbanization. Developers don't just throw turbines into dying counties. These projects require access, labor, supportive policy, and long-term demand for energy. That means wind farms are often showing up in places already undergoing some kind of growth. They align with areas already experiencing growth, rather than hindering it. In that sense, the presence of a turbine might actually tell you something about where a community is headed.

So when we ask whether wind farms hurt housing markets, the answer, at least based on this analysis, is no. They don't. If anything, they coexist with growth. That's not to say every buyer wants a turbine in their backyard. However, it does suggest that wind energy development, when placed in the context of bigger economic systems, does not come with the kind of downside people assume it does. For counties considering whether to approve new projects, that matters. This is about shifting the conversation from one of fear and hesitation to one of economic understanding and planning.

Ultimately, these findings suggest that the presence of wind farms is not a detrimental factor for property values but rather an indicator of broader economic and community development trends. This insight can help shape future discussions on the role of renewable energy in local economies, guiding both policymakers and developers toward more informed decisions.

### 6.3 Future Research and Policy Implications

In terms of future research on this topic, my study has also shown me that there are still opportunities for expansion within this project. The findings presented throughout my research have provided a solid base, a foundation, but further research could help refine the broader understanding of how wind farms correlate with property values. One key area for future exploration is expanding the

dataset. While the counties in this study offered a decent mix, testing whether these trends hold in regions with different economic structures or levels of wind farm development could provide additional insights. This would further clarify how various economic and demographic factors interact with the presence of wind farms and influence property values.

Another area worth expanding on could be how local perceptions influence property values. This is something in my research I certainly wanted to challenge more. However, limitations of available data, as well as additional interviewing, would have derailed my timing regarding the guidelines of this project. While this study focused more or less on the measurable data, it's clear that community attitudes toward wind farms can shape market outcomes. Property owners' views on the noise, aesthetics, and the perceived health risks of turbines could have a significant effect on the housing market, again this is something I am eager to build upon. I would suggest the best way of challenging these perceptions could be done by using surveys or interviews with local residents, real estate agents, and policymakers. These insights would add depth to the quantitative findings and give us a better understanding of the social dynamics behind the numbers.

Long-term studies of my research could also provide stronger findings. While I do not suggest that my data findings are weak, this research focused on short-term trends. It is important to recognize that most of my Chapter 4 data was within a ten-year window or smaller, wind farms are still new to many communities. As people adjust and get used to turbines, perceptions and market reactions may change. This leads me to believe that what may seem like a negative impact early on could become less significant over time. A longer-term study tracking these shifts would provide a clearer picture of how the presence of wind farms affects property values in the years after they're established.

For policymakers, the results of this study should be a signal to rethink how we approach wind energy development. The conclusion of my research shows that wind farms are not the property value killers that some, including myself, have shown to fear, yet they're often found in areas that are already

growing. Rather than viewing wind farms as a potential burden on property values, policymakers should recognize them as part of a larger economic development trend. Wind farms should be seen as signals of growth, not obstacles. This perspective could help guide decisions about where to place wind farms in the future and potentially grow small rural areas into partially urbanized sub-communities to larger cities. The overall takeaway policymakers need to walk away from this reading is that wind energy infrastructure represents a valuable asset, offering significant opportunities for clean energy development and driving local economic growth.

Developers should also reflect on and take these findings into account. While I state that wind farms don't directly boost property values, it is clear to see they're often found in areas with strong growth potential. Developers should be viewing these areas as a commodity rather than seeing wind farms as obstacles, they should view them as signs that a community is on the rise. Builders understanding this opportunity can help guide smarter investment choices, focusing on areas already heading in the right direction.

The key takeaway here is that wind farms don't negatively impact property values. If anything, they coexist with growth. Moving forward, the conversation about wind energy development needs to shift. The focus on potential downsides has created unnecessary fear and misunderstanding. In reality, wind farms are part of a larger economic trend. By recognizing them as signals of broader economic growth, policymakers and developers can make better, more informed decisions. This shift in perspective will ensure that wind energy development supports both economic and environmental goals while dispelling the negative connotations associated with it.

## Conclusion to Chapter 6

I want this section to tie everything together. From the beginning of this research, the question was whether wind farms negatively impact property values, and through data analysis and exploration, it's clear that they do not. Instead, wind farms are coexisting with economic growth within the regions they

are located. These findings challenge the limited view that wind farms harm local property markets by providing insight into how wind energy infrastructure interacts with the community surrounding them.

At the end of the day, this research opens up several options or avenues for further investigation, mainly the ideology around community perceptions as well as long-term trends. The future results of this research can deepen our understanding of the social dynamics behind the numbers and enhance future studies. For policymakers and developers, the results of this study offer a fresh perspective. Showing us that wind farms should be seen as opportunities for growth rather than something to avoid. Integrating wind energy projects into broader economic planning will not only support environmental goals but also drive local economic development, making wind energy an important asset for the future.

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# About the Author

Hunter Palmisano is a senior at Allegheny College focusing his studies on both business while minoring in communication arts. Additionally a student-athlete for the College's football team, Hunter has spent much of his academic focus within the business department developing marketing skills and learning leadership skills and techniques.

This senior project reflects a long-standing interest in energy policy, housing markets, and how infrastructure projects (wind farms) shape communities economically and socially. The research allowed him to explore real-world market trends while engaging with current debates about renewable energy.

Post graduation Hunter plans to return to Cleveland and to begin his professional career. He would like to thank Professors Nonnenmacher and Yusuf for their support throughout the senior comp process, as well as his family, teammates, and mentors who have been a consistent source of motivation during his time at Allegheny.

