The Effect of High-Voltage Overhead Transmission Lines on Property Values
A Review of the Literature Since 2010

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Abstract

This paper examines the literature since 2010 regarding the impact of high voltage overhead transmission lines (HVOTLs) on property values. Previous reviews have divided the literature into three categories: statistical price models, survey-based research, and other appraisal methods, such as paired sales and resale analyses. This paper examines the developments in these three established empirical approaches during the past five years. Also included is a brief overview of the more sophisticated research on impaired viewsheds, which can offer insight into the future of the HVOTL literature.
Introduction

In the past five years, changes in energy policy and infrastructure, along with the application of more sophisticated statistical methods, have continued to encourage research on the impact of high voltage overhead transmission lines (HVOTLs) on property values. With the recent updates to existing energy transmission corridors and the siting of new projects to accommodate solar and wind power, this research is increasingly relevant for appraisers of real property. Previous reviews, dating back to the early 1980s, divide the literature on the impact of transmission on property values into three categories: statistical hedonic price models, survey-based research, and other appraisal methods, such as paired sales and resale analyses. This review examines the developments in these three fields of HVOTL research since 2010 and provides an overview of recent developments in the research into the impact of impaired viewsheds on property values. Because of the more sophisticated data and methods used in the view literature, these recent articles may provide insight into possibilities for the future of the HVOTL literature.

The research into the effects of HVOTLs on property values is a mature area of research and has been extensively reviewed, notably by Jackson and Pitts\(^1\) in 2010. Jackson and Pitts found that

negative effects observed in the literature were either small or negligible. Survey-based research between late 1960s and 2010 found persistent adverse perceptions of HVOTLs, primarily because of perceived health risks and aesthetic concerns. However, negative perceptions held by market participants did not necessarily translate into observable price differences. Though mixed, most of the statistical research before 2010 concluded that properties near HVOTLs generally do not show a significant negative impact on value and that any observed impacts diminish with distance from the lines. Studies even found a premium for houses located near the lines, presumably because of increased views, increased privacy, and the recreational value of the transmission corridors. Jackson and Pitts, in summarizing the literature, found that any negative price effects ranged from approximately 2% to 9%, but that generally there were no effects and any effects decreased with distance.

Statistical Price Studies

Researchers since 2010 have continued to produce hedonic regression studies of the impact of transmission lines on property values (See Table 1). Hedonic regression is a statistical method for decomposing the price of real property, or some other good, into the prices of its component characteristics such as lot size, square footage and age—even though these characteristics may not be unbundled in the marketplace. The assumption is that the prices of goods in the market are affected by their characteristics. To estimate the value of real property using a hedonic regression analysis, a researcher will identify the characteristics or independent variables that contribute to market value such as view, lot size and shape, topography, location, utility, and entitlements. By including proximity or view of an HVOTL as a variable in the regression, the researcher in
theory can estimate the negative or positive contribution to price that the HVOTL has on the value of the property.

In a 2011 article, May et al. used a hedonic multiple regression model to study the price data for 1,251 homes sold between 2000 and 2009 over a 1.15km-squared area of South London, UK. This study focused on the effects of certain determinants—including house characteristics, psychological and health conditions, aesthetic factors, and services—on residential property values. One of the factors considered was proximity to an HVOTL. The authors considered the distance to the nearest pylon, as well as the distance to the centerline of the HVOTL. In the UK, transmission lines can be built on property and lines may pass directly over homes, so the authors also considered whether the plot or home was over-sailed by a transmission line and whether a pylon was on the property. The authors claim this study to be the first of its kind in that it analyzes the dynamic relationships—or “cross elasticities”—between these price determinants. For example, the authors measured the relationship between distance to a park and distance to an HVOTL and found that proximity to a park only had a positive effect for houses located away from HVOTLs.

This model shows that house values increase by 0.03% when distance from the centerline of the HVOTL increases by 1%. This claim, however, must be interpreted with caution. While most statistical studies of transmission line effects have used distance bands to measure changes in price impacts over various distances, the authors in this study entered these multiple distance variables into the regression as continuous variables. Expressing distance as a continuous variable, however, constrains the regression and imposes the assumption that the distance effect

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decays everywhere at the same rate.\textsuperscript{3} In addition, the authors commented on the homogeneity of their housing sample, largely a single development from the 1930s, as one of the advantages of their study, yet they reported a percentage of variation (R-squared = 0.44) that compares poorly with hedonic results reported elsewhere in the literature.

Most of the literature focuses on the effects of transmission lines on residential properties, especially single-family homes. Jackson et al.\textsuperscript{4} conducted a study of both commercial and industrial properties using the formal methods that have already been applied for decades to residential properties. The authors analyzed the effects of HVOTLs on the sales prices of commercial and industrial properties between 2005 and 2010 in Madison and other “generally urbanized areas” of Wisconsin using a combination of five regression models, a paired sales analysis, and interviews. The sample size was 187 commercial and industrial properties, with control group of 145 unencumbered properties, and a treatment group of 42 properties either encumbered by or in proximity to a transmission line of 138kV or more. The sample included office, retail, hotels, apartments, restaurants, vacant land, and other unspecified industrial properties. The authors did not consider a range of possible distances. Rather, they enter one variable for whether or not the property was within 500ft of an HVOTL line. Results from the regression analysis did not show any significant negative effects on sales price. In fact, effects were generally positive, possibly because of increased transportation access available to

\textsuperscript{3} The use of continuous variables is a minority position among researchers. A single distance variable forces any proximity to be constant with respect to distance—a situation at odds with common sense and empirical observation. Some researchers include ad hoc terms such as distance squared in hedonic models to allow greater freedom in estimation. There is a legitimate question concerning the best definition of distance bands. If defined too narrowly, observation counts may be low and finding statistically significant distance zone coefficients may be made too difficult. On the other hand, if distance bands are made too wide, close-by effects may be obscured by more distant observation where effects may not be present. The choice of distance bands is a matter of professional judgment and depends on the particular situation being investigated.

encumbered properties. These results were consistent with the face-to-face and phone interviews with the parties involved in the transactions.

In an study published in 2013, Bottemiller and Wolverton\(^5\) analyzed the sales data of a 2.5-year period between 2005 and mid-2007 in the areas surrounding Portland and Seattle. The transmission lines considered in this study ranged from 115kV to 500kV. The Portland sample included 538 home sales, with 152 HVOTL-abutting sales and 386 non-abutting control sales. The Seattle study included 568 home sales, with 153 abutting sales and 415 control sales. The authors used a multiple regression analysis and found small but statistically significant price effects. Portland homes abutting HVOTLs showed a negative impact of 1.67% and Seattle homes showed a negative impact of 2.43%. The Portland study was a refinement of an earlier study by the same authors, which found no significant price effects. A richer dataset in this project allowed the authors to control for neighborhood and school district.

The authors note that 25% of the Seattle homes have a mean price of about $1 million. When the authors separately analyzed the higher-end Seattle homes, they found a significant negative impact of 11.23%, which would translate to a $130,882 decrease in price for a typical home in the group. The price effect for a typical home in Seattle, on the other hand, showed a mere 0.65% negative impact, which is not statistically significant. This suggests that nearly all of the 2.49% negative impact in the Seattle area was due to the high-end homes included in the study.

Bottemiller and Wolverton are conservative in their language and quick to acknowledge the limitations of this kind of study. They point out that the huge trees in the Northwest largely cover

HVOTLs, so this study is not applicable outside the Northwest. The smaller lot sizes in Portland suggest that there is less room for trees and so the HVOTLs are more visible. This could explain the higher negative impact for a typical home in Portland (1.67%) when compared to a typical home in Seattle (0.65%). The authors wisely warn against generalizing these results beyond their respective geographical areas.

In a refinement of a 2005 study, Bond et al.\textsuperscript{6} conducted a regression analysis of mid-priced homes sold in Blackwood, Scotland, between 1994 and 2010. The authors considered the sales of 620 properties, of which 483 had some view of the supporting pylons of a 275kV transmission line running through the center of the neighborhood. Along with slight changes to the original 2005 dataset, Sims and Dent added a number of variables. This study is the most ambitious of the five statistical HVOTL studies included in this review in its attempts to tease out the subtleties of different view effects. Using property characteristics determined using plot maps and physical observation, the authors considered, among many other possibilities, homes with one-fourth of a pylon visible from the front, homes with half a pylon visible from the front, homes with side views of an HVOTL, homes with two pylons visible from the rear. They considered distance effects using 50m-wide distance bands.

The authors found that a view of a pylon from the rear of the home had a significant price impact, which decreased with distance. The greatest negative impact resulted from a three-fourths view of a pylon from the rear of the home. The value of a property within 100m of a pylon showed a 21% discount compared to a similar house 400m away. All of these negative

price effects diminished with distance. A side view of the HVOTL line, on the other hand, significantly increased value, presumably because of increased privacy. Sims and Dent argue that these findings suggest that implementing ROWs in the UK, as they exist in the US, could mitigate effects from HVOTLs. The authors echo Bottemiller and Wolverton in noting that the results from this kind of research are difficult to generalize. In the UK, for example, HVOTLs can be built on property, so results from the US and Canada are not applicable to the UK.

The literature generally estimates the impacts of existing HVOTLs on property, not their removal. In a 2014 study, Callanan\(^7\) attempted to measure the length of time that any market resistance remains after transmission lines are removed using a hedonic pricing model and a repeat sales analysis (see appraisal methods section for a discussion of the repeat sales analysis). Callanan studied the low-income Newlands suburb of Wellington, NZ, in which two 110kV lines were removed in the mid-1990s. The before-removal study included 330 homes sold between 1989 and 1995 and the after-removal study included 3,345 homes sold between 1995 and 2010. The author considered the distance from each line and the distance from each pylon, as well as various other property characteristics. Distance variables in this study, are entered into the regression as continuous variables. Callanan explicitly criticizes the distance bands method, noting that price effects are often subtle and can be lost within the distance bands.

Before removal, the analysis showed a negative impact of 27% for properties within 20m of the pylons, which reduced to 5% at 50m and at 100m was negligible. The lines themselves did not have a significant negative impact. The model showed less than 1% effect for homes directly

\(^7\) Callanan, Judith Marie. "Assessing the property market impact of stigma removal: high voltage overhead transmission lines removal in Wellington, NZ." (2014).
under the line. After removal, the neighborhood as a whole, not just individual properties, improved in value, with the significant increase in the 3 to 4 year period after removal. However, post-removal results were impeded by significant demographic changes in the study area and wide price swings in the New Zealand real estate market at the time. The 27% figure must be interpreted with care. It is most likely an artifact of the close siting of towers allowed in New Zealand. For example, there was a home used in the study with a pylon directly on the lot.

Other Appraisal Methods

Few scholars have turned to case-by-case sales comparisons as a more reliable alternative to these hedonic pricing methods. Typically, researchers either improve upon the existing hedonic models or get away from transactional data altogether and rely on survey-based contingent valuation. As outlined in Table 2, three appraisal studies are reviewed here. If these appraisal methods are used, they are generally combined with a hedonic regression model (see Jackson et al. and Callanan above). However, hedonic regressions require a large amount of data, so they are most suited for densely populated urban areas.

Citing this criticism of the hedonic approach, Chalmers\(^8\) in a 2012 study conducted a case study analysis of rural properties located along transmission lines in Montana using more the traditional appraisal methods of interviews, sales comparison, and paired sales analysis. The study included 49 individual transactions, along with 7 residential subdivisions in Sanders County. The properties were spread over 640 miles of rural Montana and represented a wide range of characteristics and uses—including agricultural, residential, recreational, and mixed

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uses. Chalmers identified three general characteristics that make properties vulnerable to price effects: use, size, and uniqueness. The study found that the more a property was used for residential purposes, the more vulnerable it was to a price effect. Strictly recreational properties were less vulnerable, and agricultural properties showed no effects. In terms of size, larger properties were less vulnerable than smaller properties. The more unique a property was—or the less likely a buyer was to find a substitute—the less vulnerable it was to negative effects from transmission lines since for a unique property HVOTLs are but one of many differentiating factors.

In their 2012 article, Jackson et al.\textsuperscript{9} supplemented a multiple regression analysis of commercial and industrial properties in Wisconsin (see statistical studies section) with a paired sales analysis. The paired sales study compared abutting and non-abutting properties sold between 2000 and 2010 in Dane and Milwaukee counties. There are three separate paired sales analyses, one for each property type—apartments, office buildings, and office land. Jackson considered three comparable apartments, four comparable office buildings, and five comparable office land sales. The paired sales analysis confirmed the conclusion of the regression analysis, finding no evidence of any negative impact from the HVOTLs. This was consistent with the interviews of the market participants in each transaction.

In the 2014 study discussed above, Callanan\textsuperscript{10} included a repeat sales analysis to supplement her own multiple regression analysis of homes in a suburb of Wellington, New Zealand, before and


\textsuperscript{10} Callanan, Judith Marie. "Assessing the property market impact of stigma removal: high voltage overhead transmission lines removal in Wellington, NZ." (2014).
after the removal of two 110kV transmission lines (see statistical studies section). The repeat sales analysis considered six case study sales within 50m of pylons, along with six comparable control sales. Like the sample used for the regression analysis, these homes were lower-priced single-family residential homes sold between 1993 and 2009. The repeat sales analysis contradicts the results obtained with the regression model. The regression model showed that prices around HVOTLs increased more slowly than prices for comparable properties away from HVOTLs. In the repeat sales analysis, the case study properties increased in price at a higher rate when compared to the control area properties. Callanan notes that one property with a considerably higher resale price underwent renovations during the study time period and therefore may have skewed the results obtained from this analysis.

Survey Research

Survey-based research into the potential price impacts of transmission lines consists primarily of contingent valuation (CV) experiments. These survey-based methods (See Table 3) are used as alternatives to statistical price analyses as ways to estimate the value of environmental amenities and potential detrimental conditions. A CV survey, considered a Type III Survey within appraisal literature, is an interview in which subjects, who are not qualified as active market participants, are asked to pretend that they are participating in the market and that they are going to purchase a property with certain attributes. Respondents are asked to choose alternative scenarios, designed to elicit their preferences for environmental amenities and other non-market goods. CV surveys often estimate a monetary value for respondents’ willingness to pay (WTP) for the preservation or removal of a certain environmental amenity or disamenity. This has not
been a particularly active area of power line research since 2010, but it is of interest because of the frequent use of CV research in environmental litigation.

Giaccaria et al.\textsuperscript{11} estimated the willingness to pay for the removal of HVOTLs of households locating along transmission line corridors in Piedmont, Italy. The novelty of this CV study is its use of GIS data in the sampling of survey subjects. The authors overlaid 1200m corridors along HVOTLs to guide in the selection of households. An online questionnaire was then administered in 2012. There were a total of 1,194 households in the final sample. The authors distinguished three different levels of perceived damage—ordinary, intermediate, and heavy damage. Households reporting ordinary impacts such as landscape degradation and visual impacts were willing to pay €189 to remove the lines near their property. Those reporting an intermediate impact—defined as visual degradation, perceived health risks, environmental effects, and ecological risk—were willing to pay €576 for removal. Finally, respondents with perceived property value effects in “extreme proximity” were willing to pay €3753 for removal.

Callanan\textsuperscript{12} conducted a CV study supplemented by an attitudinal survey and a sales price analysis to determine the WTP for transmission line removal. The CV survey consisted of mailed questionnaires and face-to-face interviews in Auckland, New Zealand. The final sample was 887 households in proximity to HVOTLs. In the attitudinal study 70\% of respondents claimed that HVOTLs have an effect on property values and 60\% believed that the removal would increase property value by 10\%. The CV survey results showed that depending on the method of


payment, 67% to 80.5% of respondents opposed any contribution to the removal. However, Callanan received did not collect sufficient responses to reach a monetary estimate.

Tempesta et al.\textsuperscript{13} conducted a so-called discrete choice experiment, or “conjoint valuation,” to estimate the benefits of undergrounding HVOTLs in rural areas of Italy. This study consisted of an on-line questionnaire conducted in 2012. There were 3,846 final observations chosen to be representative of the Italian population. The survey showed that 88% of respondents valued the landscape as an economic resource in Italy and 55% thought the HVOTLs spoiled the landscape. However, only 39.2% were willing to pay for the burial of the power lines. The authors concluded that undergrounding was justified only in areas of environmental interest because of the high costs of undergrounding transmission lines. However, because undergrounding costs are decreasing, the authors expected these results to change.

Whereas much of the literature has attempted to tease out subtle price effects using increasingly sophisticated hedonic models and datasets, Seiler\textsuperscript{14} criticizes hedonic modeling as inherently limited when it comes to measuring the impact of power lines because “no study is able to control for everything.” Seiler conducted a survey of eminent domain attorneys from across the United States during a live experiment at an American Law Institute-American Bar Association conference. Seiler isolated three factors: easement rights, noise pollution (the “humming” of HVOTLs), and proximity (near vs. far). The study consisted of a questionnaire accompanied by pictures—one showing a house with a power line immediately behind it, another showing the

\textsuperscript{13} Tempesta, T., D. Vecchiato, and P. Girardi. "The landscape benefits of the burial of high voltage power lines: A study in rural areas of Italy." \textit{Landscape and Urban Planning} 126 (2014): 53-64.

power line further away. Easement rights were found to have no significant effect. Noise pollution led to a 2% diminution, while siting HVOTLs immediately behind a house led to a 2.5% diminution.

Public Perception Research

In the past five years, as governments have pushed to upgrade the power grid to accommodate decentralized low-carbon generation, there has been much activity in the attention given to the public acceptance of new and existing transmission line projects. These are not studies of price impacts, per se. Rather, they are attitudinal studies of public perception and the “social acceptance” of power lines. Though they do not attempt to estimate price effects, these studies may inform, for instance, the choice of variables in statistical studies or the sample selections and questionnaire designs used in CV studies. These studies (See Table 4) find that local opposition is greater than general opposition, that the dislike of the pylons and lines themselves is influenced by the belief that local communities have no say in the HVOTL planning process, and that respondents favor undergrounding. At the very least, these studies may provide insight into any price effects observed in more rigorous large-scale statistical studies.

Devine-Wright et al. claim there exists a gap in the literature because there are few studies examining public beliefs about the power grid. This study of 1,041 UK adults found that electricity supply networks are understood largely in terms of physical technologies rather than organizations—the visible and tangible cables and wires, rather than the concept of an energy

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supply network. For new transmission line planning, respondents assumed the government made decisions, while locals had little influence. The surveys showed strong public support for putting new lines underground regardless of cost.

Devine-Wright\textsuperscript{16} conducted a 2010 study of 503 residents of a rural town in South West England in which a new transmission project proposed in 2009 was met with strong opposition. The study tried to examine the relative influence of personal factors, place attachment, and project-specific factors in the local opposition to the new power line project. The study found that project-specific factors were the most influential and concluded that that developers should improve access to information and increase local participation in the decision-making process.

Batel et al.\textsuperscript{17} and Cohen et al.\textsuperscript{18} critique the very concept of “acceptance” as limiting the research so far. Batel et al. propose doing away with the “acceptance” vs. “opposition” framework. The authors suggest that the idea of local “opposition” perpetuates a top-down, passive, condescending narrative about people’s relationships to new energy infrastructures and ignores other possible responses such as support, uncertainty, resistance, and apathy. Cohen et al.\textsuperscript{19} try to develop a new definition of “social acceptance” to inform future quantitative research. The paper discusses the social acceptance of wind farms, transmission lines, and pump hydro-storage facilities. The authors offer suggestions on how to improve acceptance rather than simply trying

\textsuperscript{16} Devine-Wright, Patrick. "Explaining “NIMBY” Objections to a Power Line The Role of Personal, Place Attachment and Project-Related Factors." *Environment and Behavior* 45, no. 6 (2013): 761-781.
\textsuperscript{19} Ibid.
to identify the origins of opposition. In addition to improving local participation in the planning process, the authors recommend locating pylons near existing pylons and using T-pylon designs for rural landscapes. Devine-Wright and Batel\(^\text{20}\) also observed the public preference for the T-pylon design. In a study of 1,519 UK adults, Devine-Wright and Batel found that the T-pylon design was by far the most preferred and perceived to fit the rural landscape, while undergrounding, not taking into account cost, was preferred to all overhead designs.

**Impaired Viewshed Research**

Walls et al.\(^\text{21}\) provide a comprehensive review of the view literature. A full review is beyond the scope of this paper, but a brief overview is presented here. Like several of the HVOTL-specific studies reviewed above, early viewshed studies used a single distance measure for whether or not a property had a view of a certain amenity. These studies collected view data from tax records or, often, by direct observation. Such methods clearly limited the potential of any large-scale viewshed study. Nevertheless, these studies (See Table 5) consistently found large positive price effects from certain types of views, especially ocean views. By the 2000s, researchers began using GIS and topographical data. In the past five years, the period covered by this literature review, viewshed research has embraced even more sophisticated methods, including LiDAR, which constructs high-resolution maps by illuminating targets with a laser and measuring reflected light. These methods are still rare in HVOTL research, which in general simply controls


for whether or not a property is near or in viewing range of a power line or tower. The view literature’s methodological advances may show the way for the future of a more systematic and precise large-scale statistical HVOTL research.

Hamilton and Morgan\textsuperscript{22} present a study in Pensacola Beach, Florida, that belongs to this new generation of view literature. Using GIS data, the authors measured distance between each property in the study to the nearest public beach access point. Then, using LiDAR data, they measured the ocean view from each property and integrated this distance and view data into a semi-log hedonic pricing model. They found that buyers were willing to pay $1,119 for a 1m decrease in distance to the shoreline and $1,627 for a 1-degree increase in viewshed of the ocean. (Effects of this magnitude, however, would not be expected to be linear over a sizeable domain.)

Baranzini and Schaerer\textsuperscript{23} provide a large-scale study of 13,000 observations in urban areas of Geneva, Switzerland, using three-dimensional GIS-based view variables. They found that the rent premium for proximity to water is up to 3%, while a view of water can be up to 57% of rent. The GIS data used in this study accounted for both the natural environment and the built environment. The authors constructed a three-dimensional layer that allowed them to calculate the view in a 1km-cubed radius at the ground floor, middle of the building, and attic level. They determined that the size and view of natural environments increases rents, while the view of built environments decreases rents.


Hindsley et al.\textsuperscript{24} examine the impact of Gulf of Mexico views on residential property values in Pinellas County, Florida, by using LiDAR data to construct four measures of view—total view, maximum view segment, mean view segment, and proximity to view content—and assessing their relative influence on value. Using GIS and LiDAR data, they were able to more precisely value both the scope of the view and the proximity to the view content. They found that buyers paid $1,300 for a 1 degree increase in view scope and that the proximity to the view content increased buyers’ willingness-to-pay.

Walls et al.\textsuperscript{25} examine the value of a view by applying a hedonic pricing model to GIS data and 25 years of transactional data from St. Louis, Missouri. Using 25 years of data allowed the researchers to watch property values react to a changing landscape as it transitioned from farmland to developed property. They found that although the more sophisticated GIS techniques have allowed for a more precise measurement of views, researchers have not used large enough sample sizes and have not matched the precision of the data with equally sophisticated hedonic models. View researchers, the authors claim, often do not control for omitted variable bias, which is now standard in hedonic studies. The fixed-effects model used here minimized bias from the omission of time-constant variables. The authors found that not all pristine natural views are associated with positive price effects. In fact, forest views have generally negative effects and grassland views have no significant effects.


Conclusion

Changes in energy policy and infrastructure continue to encourage research into the effects of HVOTLs on property values. Meanwhile, more sophisticated research methods continue to inform the literature. New GIS and spatial econometric techniques, for example, have allowed researchers to attempt to measure on a large scale such subtle and hard-to-defined factors as impaired viewsheds. There has been increased interest in the sociological research as it relates to local opposition of HVOTLs and other perceived energy infrastructure disamenities. As efforts to curb carbon emissions and decentralize the power grid continue, no doubt research will continue into the effects, if any, of these possible disamenities on property values. Nevertheless, the conclusions remain the consistent with the literature before 2010. Survey-based research finds adverse perceptions and general dislike for HVOTLs, but sales data reveals little to no diminution in home prices. Stated preferences by market participants in this case generally do not translate into noticeable price effects as revealed in market data.

Bibliography


