

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

by Orell C. Anderson, MAI, Jack Williamson, PhD, and Alexander Wohl

Abstract

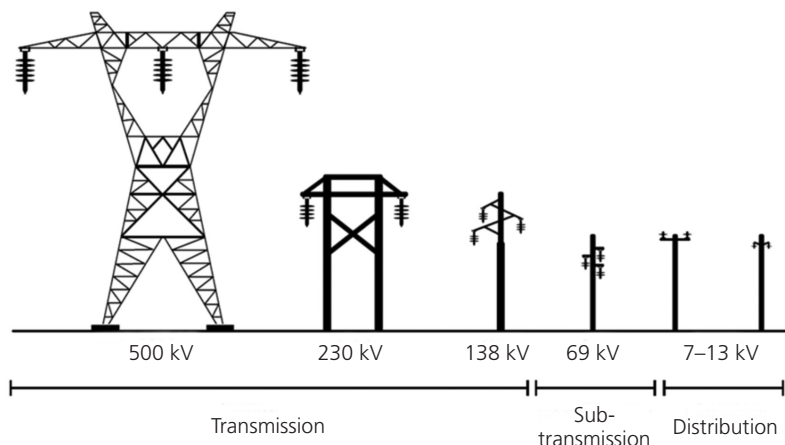
Renewable energy initiatives require modernization to the power grid. Renewable energy must be transported long distances by high-voltage overhead transmission lines (HVOTLs) from generation point to population centers. This article discusses the literature since 2010 regarding the impact of HVOTLs on 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. The article examines the developments within these three established empirical approaches and extends the literature review beyond the United States to studies in Europe and New Zealand.

Introduction

Recent changes in energy policy and infrastructure have continued to encourage research on the impact of high-voltage overhead transmission lines (HVOTLs) on property values.¹ The current transmission grid has its origins in the early- to mid-twentieth century during the modernization and electrification of the United States energy system. Investment declined for three decades between the 1960s and the 1990s. However, it has risen steadily since then. The original transmission infrastructure has been nearing the end of its intended useful life, and the recent shift towards renewables and more diverse energy generation has placed increasing demands on the aging system. Twenty-nine states have adopted Renewable Portfolio Stan-

dards that require them to generate a certain percentage or amount of their energy from renewable sources. But political demands for a more diverse energy production portfolio have been met with the sobering reality that a nation powered by renewable energy requires an expanded and updated transmission grid. Because of their dependence on regional climate and geography, renewable energy resources, such as hydroelectric, solar, and wind power, are often located far from final demand in dense population centers, often requiring high-capacity, efficient transmission across hundreds of miles. For example, California has adopted a Renewable Portfolio Standard requiring 33% of its energy to be generated from renewable sources by 2020, and 50% by 2030. The 173-mile Tehachapi Renewable Transmission Project,

1. There is not a widely accepted definition of the term *high-voltage overhead transmission line*. In the studies included here, when voltages are specified, voltages range from 110 kV to 500 kV. For the purposes of this review, HVOTL is used to distinguish transmission lines from distribution lines (see Exhibit 1). This distinction has resulted in the exclusion of research into the impact of distribution lines on property values, especially residential property values. For more on power lines and the power grid, see US Department of Energy, "Electric Power," <http://bit.ly/DOEInfo>.

Exhibit 1 Electric Power Transmission Line Types

developed by Southern California Edison, aims to connect wind farms in rural Kern County, California, to population centers in Los Angeles and San Bernardino counties. This pattern is seen across the United States, as large-scale transmission projects accommodate policy demands for a more reliable, more efficient, and higher-capacity transmission grid. As more large-scale projects break ground, the impacts of HVOTLs on surrounding property values continue to be an important consideration for appraisers of real property.

Previous reviews of HVOTL research, dating back to the early 1980s, have divided the literature on the impact of transmission lines on property values into three categories: statistical hedonic price models, survey-based research, and other valuation methods, such as paired sales and resale analyses. This article examines the developments in these three fields of HVOTL research since 2010. The studies reviewed here are not limited to the United States. Rather, the research includes studies conducted in the United Kingdom, Italy, Norway, and New Zealand. It is important to note that this literature does not generally apply to

the taking of an easement for an HVOTL, but rather only to the damages, if any, due to proximity to an existing HVOTL.

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 in 2010.² Jackson and Pitts find that the actual negative effects reported in the literature are either small or negligible. Survey-based research between the late 1960s and 2010 finds 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 concludes 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. These studies even find 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, report that any negative price effects ranged from approximately 2% to 9%, but 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 (Exhibit 2). 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

2. Thomas O. Jackson and Jennifer Pitts, "The Effects of Electric Transmission Lines on Property Values: A Literature Review," *Journal of Real Estate Literature* 18, no. 2 (2010): 239–260.

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.³

In a 2011 article, May, Corbin, and Hollins⁴ use a hedonic multiple regression model to study the price data for 1,251 homes sold between 2000 and 2009 over a 1.15-square-kilometer area of South London, United Kingdom. This study focuses 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 is proximity to an HVOTL. The authors consider the distance to the nearest pylon as well as the distance to the centerline of the HVOTL. In the United Kingdom, transmission lines can be built on residential property and lines may pass directly over homes, so the authors also consider whether the plot or home is over-sailed by a transmission line and whether a pylon is on the property. The authors claim this study is the first of its kind in that it analyzes the dynamic relationships—or “cross elasticities”—between these price determinants. For example, the authors measure the relationship between distance to a park and distance to an HVOTL and

find 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 decays everywhere at the same rate.⁵

While most of the literature focuses on the effects of transmission lines on residential properties, especially single-family homes, Jackson, Pitts, and Norwood⁶ study the effects on both commercial and industrial properties. They use the formal methods that have already been applied for decades to residential properties. The study analyzes the effects of HVOTLs on the sale prices of commercial and industrial properties between 2005 and 2010 in Madison, Wisconsin, 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 a control group of 145 unencumbered properties, and a treatment group of 42 properties either encumbered by or in proximity

3. Though not dealing with power lines specifically, the statistical research into the impact of views and impaired views on property values is relevant to the power line research. More sophisticated methods and data sets are generally included in view effects research, and therefore it may provide insight into the possibilities for the future of the HVOTL literature. A full review of view research is beyond the scope of this article. For a comprehensive literature review, readers are directed to Margaret Walls, Carolyn Kousky, and Ziyang Chu, “Is What You See What You Get? The Value of Natural Landscape Views,” *Land Economics* 91, no. 1 (2015): 1–19.

4. Daniel E. May, Adam R. Corbin, and Philip D. Hollins, “Identifying Determinants of Residential Property Values in South London,” *Review of Economic Perspectives* 11, no. 1 (2011): 3–11.

5. 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.

6. Thomas O. Jackson, Jennifer Pitts, and Stephanie Norwood, “The Effects of High Voltage Electric Transmission Lines on Commercial and Industrial Properties” (paper presented at the Annual Meeting of the American Real Estate Society, St. Petersburg, FL, April 19, 2012).

to a transmission line of 138 kV or more. The authors did not consider a range of possible distances. Rather, they enter one variable for whether or not the property was within 500 feet of an HVOTL. Results from the regression analysis do not show any significant negative effects on sale price. In fact, the effects reported are generally positive, possibly because of increased transportation access available to encumbered properties. Other property types included in this study, including office, retail, hotels, apartments, restaurants, vacant land, and other unspecified industrial properties, are analyzed with the paired sales method and no significant negative impact is found. These results are consistent with the findings of face-to-face and phone interviews with the parties involved in the transactions.

In a study published in 2013, Bottemiller and Wolverton⁷ analyze sales data for the period between 2005 and mid-2007 in the areas surrounding Portland, Oregon, and Seattle, Washington. The transmission lines considered in this study range from 115 kV to 500 kV. The Portland sample includes 538 home sales, with 152 HVOTL-abutting sales and 386 non-abutting control sales. The Seattle study includes 568 home sales, with 153 abutting sales and 415 control sales. The authors use a multiple regression analysis and find small but statistically significant price effects. Portland homes abutting HVOTLs show a negative impact of 1.67% and Seattle homes show a negative impact of 2.43%. This study is a refinement of a two earlier studies by the same authors that found no significant price effects. A richer data set 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 analyze the high-end Seattle homes, they find a significant neg-

ative 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, is 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 is due to the high-end homes 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 warn against generalizing these results beyond the respective geographical areas.

In a refinement of a 2005 study, Sims and Dent⁸ conduct a regression analysis of mid-priced homes sold in Blackwood, Scotland, between 1994 and 2010. The authors consider the sales of 620 properties, of which 483 have some view of the supporting pylons of a 275 kV transmission line running through the center of the neighborhood. Along with slight changes to the original 2005 data set, Sims and Dent add several variables. This study is the most ambitious of the five statistical HVOTL studies included in this review in its attempts to detect the subtleties of different view effects. Using property characteristics determined using plot maps and physical observation, the authors consider, 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, and homes with two pylons visible from the rear. They considered distance effects using 50 meter-wide distance bands.

7. Steven C. Bottemiller and Marvin L. Wolverton, "The Price Effects of HVOTLs on Abutting Homes," *The Appraisal Journal* 81, no. 1 (Winter 2013): 45–62.

8. Sally Sims and Peter Dent, "HVOTLs in the UK," in *Towers, Turbines and Transmission Lines: Impacts on Property Value*, ed. Sandy Bond, Sally Sims, and Peter Dent (West Sussex, UK: Wiley-Blackwell, 2013), 55–79.

The authors find that a view of a pylon from the rear of the home has 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 100 meters of a pylon shows a 21% discount compared to a similar house 400 meters away. All of these negative price effects diminish with distance. A side view of the HVOTL line, on the other hand, significantly increases value, presumably because of increased privacy. Sims and Dent argue that these findings suggest that implementing rights of way in the United Kingdom, as they exist in the United States, 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.

The literature generally estimates the impacts of existing HVOTLs on property, not their removal. A 2014 study by Callanan,⁹ however, uses a hedonic pricing model and a repeat sales analysis to attempt to measure the length of time that any market resistance remains after transmission lines are removed (the repeat sales analysis method is discussed later in this article). Callanan studies the low-income Newlands suburb of Wellington, New Zealand, in which two 110 kV lines were removed in the mid-1990s. A before-removal study included 330 homes sold between 1989 and 1995 and an after-removal study included 3,345 homes sold between 1995 and 2010. The author considers 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 20 meters of

the pylons; this impact decreases to 5% at 50 meters and is negligible at 100 meters. The lines themselves, rather than the pylons, did not have a significant negative impact. The model shows less than a 1% effect for homes directly under the line. After removal, the neighborhood as a whole, not just individual properties, improved in value, with a significant increase in sale prices in the three- to four-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. Therefore, 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.

In a 2016 article in *The Appraisal Journal*, researchers Tatos, Glick, and Lunt¹⁰ present a comprehensive new statistical study of the effects of transmission lines on residential property values. Citing the limited sample sizes of previous studies, this research compiles an unusually large and rich sample, using single-family residential sales in Salt Lake County, Utah, between 2001 and 2014. The study encompasses over 125,000 transactions and 250 home characteristics. The data in this study also includes location information for different line voltages, which allows the authors to separately study the effects of different voltages on nearby residential property values.

The authors' findings are generally consistent with the previous literature, though their results refine some areas in the literature that had previously been vague. For example, in differentiating between the impacts, if any, of different voltages, results indicate negative effects from 138 kV and 69 kV lines but no negative effects from 345 kV lines. Slightly positive impacts are observed for properties within 50 meters of 345 kV lines, confirming findings elsewhere in the literature. The medium-sized 138 kV lines display the most

9. Judith Marie Callanan, "Assessing the Property Market Impact of Stigma Removal: High Voltage Overhead Transmission Lines Removal in Wellington, NZ" (doctoral thesis, Queensland University of Technology, 2014), <https://eprints.qut.edu.au/71885/>.

10. Ted Tatos, Mark Glick, and Troy A. Lunt, "Property Value Impacts from Transmission Lines, Subtransmission Lines, and Substations," *The Appraisal Journal* (Summer 2016): 205–230.

Exhibit 2 Statistical Price Studies

Author (Report Year)	Study Period	Location	Property Type	Sample Size	Variables	Results
May, Corbin, & Hollins (2011)	2000 to 2009	South London, UK	Residential	1,251 houses, prices indexed up to 2009 prices using nationwide index	Freehold vs. leasehold, property type, plot oversailed by HVOTL, house oversailed by HVOTL, pylon on prop- erty, distance to centerline of HVOTL, distance to nearest pylon, distance to railway lines, distance to public park, distance to Wellington station	House values increase by 0.03% when distance to centerline of HVOTL increases by 1%. Proximity to park only had a positive effect for houses located away from HVOTLs.
Jackson, Pitts, & Norwood (2012)	2005 to 2010	Madison, Milwaukee, and other “generally urbanized areas” of Wisconsin	Commer- cial and industrial, including office, retail, hotels, apts, restaurants, vacant land, and others	187 (42 encumbered by or in proximity to line)	2005 sale, 2006 sale, 2007 sale, 2008 sale, 2009 sale, 2010 sale, total gross floor area, building age, size, number of high doors or loading docks, Dane County, Milwaukee County, Waukesha County, proximate (i.e. <500 ft.)	Effects are positive, possibly due to factors such as transportation access and utilities, though non- proximate properties shared these characteristics
Bottemiller & Wolver- ton (2013)	2005 to mid- 2007	Portland, Oregon, and Seattle, Washington	Suburban homes	Portland study area: 538 homes (152 abutting HVOTL) Seattle study area: 568 homes (153 abutting HVOTL)	State, county, sale year, living area, lot size, bedrooms, bathrooms, age, garage, fireplaces, pool, hot tub, deck, patio, shed, air conditioning, quality, condition, landscape, slope, lot shape, quarter	Portland study: discount of 1.65%. Seattle study: discount of 2.43%. When high-end homes separated in Seattle, discount is 11.23% for high-end homes and 0.64% for typical homes.

CONTINUED >

Exhibit 2 Statistical Price Studies (*continued*)

Author (Report Year)	Study Period	Location	Property Type	Sample Size	Variables	Results
Sims & Dent (2013)	1994 to 2010	Blackwell, Scotland	Mid-price range, mixed residential	620 properties (483 with some view of pylons)	Detached house, semi-detached house, terrace house, flat, bedrooms, garage, lake or countryside view, unadjusted selling price, inflation, inflation-adjusted price, distance from line to house (50-meter increments, distance to pylon (50-meter increments), line visible from front, line visible from rear, pylon not visible from front/rear, 1/4 pylon visible from front, 1/2 pylon visible from front, 3/4 pylon visible from front, 1 pylon visible from front/rear, 1 pylon and part of another visible, 2+ pylons visible from front/rear, screened line view (front), side view line (front), side-facing line view (front), facing line view (front), screened line view (rear), side line view (rear), side-facing line view (rear), facing line (rear)	Proximity and visual presence can have negative impact, whereas view of power line corridor from rear of house can significantly increase value (provided there is no view of the pylon). The greatest negative impact is from 3/4 view from rear, whereas a side view of the HVOTL significantly increased value. Property values within 100 meters of pylon reduced by 17%–24%, and impacts diminish with distance.
Callanan (2014)	Before removal: 1989 to 1995 After removal: 1995 to 2010	Newlands suburb, Wellington, New Zealand	Residential, lower socio-economic area	Before removal: 330 homes After removal: 3345 homes	Land area, floor area, exterior condition, roof condition, building condition, decade of construction, panoramic view, arterial road, location (1 to 8), year of sale, distance from each line, distance from each pylon, log of distance, reciprocal of distance x100, distance to line and pylon	Before removal: predominant effect is from towers, which have a -27% effect on value (adjacent to 20 meters), which drops to 5% at 50 meters and is negligible at 100 meters. The line itself has <1% effect for properties directly under line. After removal: Houses sold in 1997, 1998, and 1999 significant in regression analysis, increases of \$15,599, \$30,020, and \$40,182 respectively.
Tatos, Glick, & Lunt (2016)	2001 to 2014	Salt Lake County, Utah	Residential	Approximately 127,584 properties	Includes 450 explanatory variables described in published study.	No significant impact from 345 kV lines, except for a slight positive impact in 50-meter range, possibly due to open space amenity and one fewer neighbor. Significant impact from 138 kV and 69 kV lines. Most significant effects from 138 kV lines, with 5.1% diminution in 50-meter range, 2.9% at 50- to 100-meter range, and less than 1% at 400 meters.

significant effects, with homes within 50 meters of the 138 kV lines showing a 5.1% diminution, which dropped to 2.9% at 50 to 100 meters and to 1% after 400 meters. The smaller 46 kV lines appear to have no significant effects in the 50-meter range, but a 2.5% diminution in the 50- to 100-meter range. The authors suggest that this is attributable to the subtleties of the viewed impacts. Lines at a medium distance could potentially have a greater impact on the view versus lines that were directly adjacent. Interestingly, 2.9% diminution is seen for properties within 50 meters of substations. It is also important to note that the model did not find that effects dissipate over time. The authors posit that other studies may have been confounding macroeconomic factors with the passage of time and therefore were finding dissipation over time when in fact the observed effects were due to larger supply and demand factors.

Other Research 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 move away from transactional data altogether and rely on survey-based contingent valuation.

Three survey-based studies are reviewed here, as outlined in Exhibit 3. When survey-based research methods are used, they are generally combined with a hedonic regression model (see Jackson, Pitts, and Norwood, 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, Chalmers¹¹ in a 2012 article reports a case study analysis of rural properties located along transmission lines in Montana. This study uses the traditional appraisal methods of interviews, sales

comparison, and paired sales analysis. The study includes 49 individual transactions, along with 7 residential subdivisions in Sanders County. The properties are spread over 640 miles of rural Montana and represent a wide range of characteristics and uses—including agricultural, residential, recreational, and mixed uses. Chalmers identifies three general characteristics that make properties vulnerable to price effects: use, size, and uniqueness. The analysis finds that the more a property is used for residential purposes, the more vulnerable it is to a price effect. Strictly recreational properties are less vulnerable, and agricultural properties show no effects. In terms of size, larger properties are less vulnerable than smaller properties. Also, the study finds that the more unique a property is—or the less likely a buyer was to find a substitute—the less vulnerable it is to negative effects from transmission lines since for a unique property HVOTLs are but one of many differentiating factors.

In their 2012 article, Jackson, Pitts, and Norwood¹² supplement a multiple regression analysis of commercial and industrial properties in Wisconsin with a paired sales analysis. The paired sales study compares abutting and non-abutting properties sold between 2000 and 2010 in Dane and Milwaukee counties. The methodology includes three separate paired sales analyses, one for each property type—apartments, office buildings, and office land. The study considers three comparable apartments, four comparable office buildings, and five comparable office land sales. The paired sales analysis confirms the conclusion of the regression analysis, finding no evidence of any negative impact from the HVOTLs. This is consistent with the interviews of the market participants in each transaction.

The 2014 Callanan study¹³ includes a repeat sales analysis to supplement the multiple regression analysis of homes in a suburb of Wellington, New Zealand, before and after the removal of two 110 kV transmission lines. The repeat sales analysis considers six case study sales within 50

11. James A. Chalmers, "High-Voltage Transmission Lines and Rural, Western Real Estate Values," *The Appraisal Journal* 80, no. 1 (Winter 2012): 30–45.

12. Jackson, Pitts, and Norwood, "The Effects of High Voltage Electric Transmission Lines on Commercial and Industrial Properties." See also the discussion in the statistical studies section of this article.

13. Callanan, "Assessing the Property Market Impact of Stigma Removal." See also the discussion in the statistical studies section of this article.

Exhibit 3 Other Appraisal Methods

Author (Report Year)	Study Period	Location	Property Type	Methodology	Number of Observations	Findings
Chalmers (2012)	2000 to 2010	7 rural counties across Montana	Mix of agricultural, recreational, rural residential, cabin sites, mixed use	Personal interviews, sales comparison, and paired sales	49 individual transactions along with lot sales in 7 subdivisions	Properties with residential use more sensitive to HVOTL impact, recreational properties less sensitive, large properties less vulnerable than small, unique properties less vulnerable
Jackson, Pitts, & Norwood (2012)	2000 to 2010	Dane and Milwaukee Counties, Wisconsin	Separate analyses for apartments, office, and office land	Paired sales analysis with personal interviews to supplement regression analysis	Apartments: 3 comps, Office: 4 comps, Office land: 5 comps	There was no evidence of any negative impact from the HVOTLs. This was consistent with the interviews for each transaction.
Callanan (2014)	1983 to 2009 and 1992 to 2010	Newlands suburb in Wellington, NZ	Lower-priced single-family residential	Repeat sales analysis to supplement regression analysis	6 case study sales within 50 meters of pylons, 6 control sales	Contradicts results from regression. Study area properties move in price at a lower rate than the control area properties. One case study property with considerably higher resale price may have undergone renovations and skewed results.

meters of pylons, along with six comparable control sales. Like the sample used for the regression analysis, these homes are 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 shows that prices around HVOTLs increase more slowly than prices for comparable properties away from HVOTLs. In the repeat sales analysis, the case study properties increase 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 period, and therefore it 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 (Exhibit 4). The survey-based methods are used as alternatives to statistical price analyses 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 survey participants are not qualified as active market participants but are asked to pretend that they are participating in the market and that they are going to purchase a property with certain attributes.”¹⁴ Respondents are asked to choose

14. Randall Bell, Orell C. Anderson, and Michael V. Sanders, *Real Estate Damages: Applied Economics and Detrimental Conditions*, 2nd ed. (Chicago: Appraisal Institute, 2008), 43.

alternative scenarios, designed to elicit their preferences for environmental amenities and other nonmarket 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—and controversial—use of CV research in environmental litigation.

Giaccaria, Frontuto, and Dalmazzone¹⁵ estimate the willingness to pay for the removal of HVOTLs of households located 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 overlay 1,200-meter corridors along HVOTLs to guide in the selection of households. An online questionnaire was then administered in 2012. There are a total of 1,194 households in the final sample. The authors distinguish three different levels of perceived damage—ordinary, intermediate, and heavy damage. Households reporting ordinary impacts, such as landscape degradation and visual impacts, indicate a willingness to pay €189 (\$241)¹⁶ to remove the lines near their property. The average household income in the sample is €22,800 (\$29,045) per year. Those reporting an intermediate impact—defined as visual degradation, perceived health risks, environmental effects, and ecological risk—indicate a willingness to pay €576 (\$734) for removal. Finally, respondents with perceived property value effects in “extreme proximity” indicate a willingness to pay €3,753 (\$4,781) for removal.

Callanan¹⁷ conducts a CV study supplemented by an attitudinal survey and a sale price analysis to determine the willingness to pay for transmis-

sion line removal. The CV survey consists of mailed questionnaires and face-to-face interviews in Auckland, New Zealand. The final sample is 887 households in proximity to HVOTLs. In the attitudinal study, 70% of respondents state that HVOTLs have an effect on property values and 60% state they believe that the removal would increase property value by 10%. The CV survey results show that depending on the method of payment, 67% to 80.5% of respondents oppose any contribution to the removal. However, Callanan did not collect sufficient responses to reach a monetary estimate.

Tempesta, Vecchiato, and Girardi¹⁸ conduct a discrete choice experiment, or “conjoint valuation,” to estimate the benefits of undergrounding HVOTLs in rural areas of Italy. This study encompasses an online questionnaire survey conducted in 2012. There are 3,846 final observations chosen as representative of the Italian population. The survey results indicate that 88% of respondents value the landscape as an economic resource in Italy, and 55% think HVOTLs spoil the landscape. However, only 39.2% state they would be willing to pay for the burial of the power lines. The authors conclude that undergrounding lines is justified only in areas of environmental interest because of the high costs of undergrounding transmission lines. However, because undergrounding costs are decreasing, the authors expect these results to change.

Whereas much of the literature has attempted to observe subtle price effects using increasingly sophisticated hedonic models and data sets, Seiler¹⁹ 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

15. Sergio Giaccaria, Vito Frontuto, and Silvana Dalmazzone. “Who’s Afraid of Power Lines? Merging Survey and GIS Data to Account for Spatial Heterogeneity” (working paper, Department of Economics, University of Torino, Italy, 2010), <https://ideas.repec.org/p/uto/dipeco/201002.html>.

16. Euro amounts are converted to US dollar amounts using the yearly average IRS conversion rate for 2010. See http://bit.ly/firs_exchangerate.

17. Judith Callanan, “The Effect of High Voltage Transmission Lines on Property Values: A Contingent Valuation Approach,” *Pacific Rim Property Research Journal* 19, no. 2 (2013): 173–185.

18. Tiziano Tempesta, Daniel Vecchiato, and Pierpaolo Girardi, “The Landscape Benefits of the Burial of High Voltage Power Lines: A Study in Rural Areas of Italy,” *Landscape and Urban Planning* 126 (2014): 53–64.

19. Michael Seiler, “Power Lines and Perceived Home Prices: Isolating Elements of Easement Rights and Noise Pollution,” *Journal of Sustainable Real Estate* 6, no. 2 (2014): 47–61.

Exhibit 4 Survey Research

Author (Report Year)	Type of Study	Method	Location	Property Type	Survey Subjects	Findings
Giaccaria, Frontuto, & Dalmazzone (2010)	Contingent valuation (WTP), samples chosen using GIS data	Phone interviews	Piedmont, Italy	Residential	1,194 households within 1,200- meter corridors around HVOTLs	Households reporting ordinary impacts (landscape, visual) will pay € 189 (\$241) to remove lines near property. Households with intermediate impact (visual, perceived health, environmental, ecological) willing to pay €576 (\$734). Households claiming property value effects in “extreme proximity” willing to pay €3,753 (\$4,781).
Callanan (2013)	Contingent valuation (WTP), attitudinal survey, regression analysis	Mix of mailed questionnaires and face-to-face interviews	Auckland, New Zealand	Residential	887 households near HVOTLs	In the attitudinal study, 70% claim that HVOTLs have an effect on property values, 60% believe the removal would increase property value by 10%. 74% did not believe making multiple lines a single set would increase value. CV results were somewhat inconclusive. The majority (from 67.7% to 80.5%, depending on method) oppose any contribution, and those that not opposed are willing to pay a minimal amount.
Tempesta, Vecchiato, & Girardi (2014)	Discrete choice experiment (WTP)	Online questionnaire	Italy	Residential	3,846 people representative of Italian population	88% believe the landscape is an economic resource; 55% believe HVOTLs spoil the landscape; 50% in favor of the burial policy; 39% not willing to pay for the burial of the lines. Burial is only justified in areas of environmental interest.
Seiler (2014)	Contingent valuation	Live experiment showing pictures with and without powerlines	United States	Residential	82 eminent domain attorneys	Noise pollution lowers property values about 2%, while easements do not. Discount of 4.9% for power lines versus no power lines.

eminent domain attorneys from across the United States during a live experiment at an American Law Institute–American Bar Association conference. He isolates three factors: easement rights, noise pollution (the “humming” of HVOTLs), and proximity (near/far). The study consists of a questionnaire accompanied by pictures—one showing a house with a power line immediately behind it, another showing the power line farther away. Easement rights are 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 recent years, governments have pushed to upgrade the power grid to accommodate decentralized low-carbon generation. There has been much activity and 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, the 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 (Exhibit 5) find that local opposition is greater than general opposition, that the dislike of the pylons and lines 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, Devine-Wright, and Sherry-Brennan²⁰ assert that there exists a gap in the literature because there are few studies examining public beliefs about the power grid. In their study of 1,041 UK adults, they find 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-supply network. For new transmission line planning, respondents assume the government makes decisions, while locals have little influence. The surveys shows strong public support for putting new lines underground regardless of cost.

A study by Devine-Wright,²¹ reported in 2012, includes 503 residents of a rural town in South West England, where a new transmission line project proposed in 2009 was met with strong opposition. The study tries 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 finds that project-specific factors are the most influential and concludes that developers should improve access to information and increase local participation in the decision-making process.

Batel, Devine-Wright, and Tangeland,²² and Cohen, Reichl, and Schmidthaler²³ critique the very concept of “acceptance” as limiting the research so far.

Batel, Devine-Wright, and Tangeland propose doing away with the “acceptance” versus “opposition” framework. They 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.

20. Patrick Devine-Wright, Hannah Devine-Wright, and Fionnguala Sherry-Brennan, “Visible Technologies, Invisible Organisations: An Empirical Study of Public Beliefs about Electricity Supply Networks,” *Energy Policy* 38, no. 8 (2010): 4127–4134.

21. Patrick Devine-Wright, “Explaining ‘NIMBY’ Objections to a Power Line: The Role of Personal, Place Attachment and Project-Related Factors,” *Environment and Behavior* 45, no. 6 (2012): 761–781.

22. Susana Batel, Patrick Devine-Wright, and Torvald Tangeland, “Social Acceptance of Low Carbon Energy and Associated Infrastructures: A Critical Discussion,” *Energy Policy* 58 (2013): 1–5.

23. Jed J. Cohen, Johannes Reichl, and Michael Schmidthaler. “Re-Focussing Research Efforts on the Public Acceptance of Energy Infrastructure: A Critical Review,” *Energy* 76 (2014): 4–9.

Exhibit 5 Public Perception Research

Author (Report Year)	Location	Methodology	Number of Observations	Findings
Devine-Wright, Devine-Wright, & Sherry-Brennan (2010)	United Kingdom	Online survey	1,041 adults	Respondents identified HVOTLs with tangible elements (cables, pylons, etc.) rather than intangible systems or institutions. Lack of engagement, trust, and knowledge of planning process.
Devine-Wright (2012)	Small town of Nailsea in South West England, UK	Face-to-face interviews	503 mostly long-term residents of town	Individuals with higher levels of “place attachment” showed more opposition to lines. Beliefs that the planning process was unjust associated with opposition to power lines.
Batel, Devine-Wright, & Tangeland (2013)	United Kingdom & Norway	Two national surveys	1,515 (UK), 1972 (Norway)	57.5% both accept and support HVOTLs, 25.8% neither accept nor support, 16.5% accept but do not support. Therefore, accept and support perceptions are not the same and need to be separated in research.
Devine-Wright & Batel (2013)	United Kingdom	Online survey and regression analysis	1,519 adults	The T-pylon by far most preferred and seen as fitting in a rural landscape. Undergrounding preferred to all overhead designs. Involving locals in planning could mitigate opposition.

Cohen, Reichl, and Schmidthaler try to develop a new definition of “social acceptance” to inform future quantitative research. Their work 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 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 Batel²⁴ in their research observe the public preference for the T-pylon design. In a study of 1,519 UK adults, Devine-Wright and Batel find that the T-pylon design is by far the most preferred and perceived to fit the rural landscape, while undergrounding, not taking into account cost, is preferred to all overhead designs.

24. Patrick Devine-Wright and Susana Batel, “Explaining Public Preferences for High Voltage Pylon Designs: An Empirical Study of Perceived Fit in a Rural Landscape,” *Land Use Policy* 31 (2013): 640–649.

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. For example, new GIS and spatial econometric techniques allow researchers to attempt to measure, on a large scale, such subtle and hard-to-define 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, research will continue into the effects, if any, of

these possible disamenities on property values. Nevertheless, the most recent 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 prices. Stated preferences by market participants in this case generally do not translate into noticeable price effects as revealed in market data. All studies are difficult to generalize due to geographical, methodological, and other constraints. This is especially true of survey-based and statistical studies, which have faced intense scrutiny in the courts. Ultimately, the reliability, applicability, and integrity of every study must be judged based on the merits of its design and the quality of the data.

About the Authors

Orell C. Anderson, MAI, is president of Strategic Property Analytics, Inc., and specializes in real property damage economics. He has consulted on some of the world's largest disasters, such as Hurricane Katrina, the Bikini Atoll Nuclear Test Sites, the World Trade Center Site and Flight 93 Crash Site. He is chair of the American Bar Association's Litigation Subcommittee on Environmental Damages and Eminent Domain. His research on environmental contamination has been published in *The Appraisal Journal*, and he is the coauthor of *Real Estate Damages: An Analysis of Detrimental Conditions* and *Real Estate Damages: Applied Economics and Detrimental Conditions* (second edition) published by the Appraisal Institute. **Contact: orell@strategicpropertyanalytics.com**

Jack Williamson, PhD, is president of Almost Convex Economics, LLC. He has been a consulting economist for more than twenty years. He specializes damage analysis, particularly in property value diminution matters, econometrics and database development. He holds a BA degree in mathematics from UC Santa Cruz and a PhD in social science from Caltech. His previous affiliations include Carnegie-Mellon and McGill Universities, the California State Assembly Rules Committee, Arthur Anderson, Charles River Associates and LECG. He is the author and coauthor of papers published in the *Environmental Claims Journal*, *Journal of Real Estate Literature*, and *International Economic Review*. **Contact: jwmson@almostconvex.com**

Alexander Wohl is a research analyst at Strategic Property Analytics, Inc., a consulting firm specializing in litigation support, valuation, strategy, and econometrics. His research focuses on the influence of environmental contamination, geotechnical issues, energy infrastructure, and oil and gas operations on residential and commercial property values. **Contact: alex@strategicpropertyanalytics.com**

Additional Resources

Suggested by the Y. T. and Louise Lee Lum Library

Appraisal Institute

Lum Library, External Resources [Login required]

Information Files—Real estate damages/proximity impact

Electric Power Research Institute—Research

<https://www.epri.com/#/research/landing>

Federal Energy Regulatory Commission—Electric Smart Grid

<https://www.ferc.gov/industries/electric/indus-act/smart-grid.asp>

National Association of Regulatory Commissioners—Research Lab

<https://www.naruc.org/naruc-research-lab/>

US Department of Energy—Electric Power

<https://www.energy.gov/science-innovation/electric-power>

US Energy Information Administration—Electricity

<http://www.eia.gov/electricity>