

The Effects of Electric Transmission Lines on Property Values: A Literature Review

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Abstract

This paper presents a review of empirical studies on the effects of electric transmission lines on property values. The primary purpose of these studies is to address the effects of the presence of transmission lines on the value of surrounding properties. The studies range from survey-based research that provides important context to regression analyses of sales data to less formal appraisal-based sales analyses. The surveys of market participants and real estate professionals found evidence of concern and at least in one survey, an assumption that such concern would impact property values. Others noted the unattractiveness of the transmission lines and structures. However, most of the regression-based sales price analyses found little or no effects on price. What effects that were found tended to dissipate with time and distance. Lastly, price analyses based on less formal paired sales and other techniques failed to find any effects.

The literature on the effects of electric transmission lines on property values can be divided into three general categories. The first category presents several survey-based studies of opinions and perceptions concerning the impacts of transmission lines, although some of these studies also analyze sales prices. While “stated preferences” in surveys do not provide an adequate basis for estimating price effects, surveys can and do provide important insights into the market’s perception of these structures and their potential impacts on certain types of real property. Although adverse perceptions by the market can lead to sales price effects, potential effects may be offset or mitigated by other factors influencing the pricing decisions and this likely accounts for the lack of such findings when the preferences “revealed” in sales data are analyzed. The second literature category presents empirical studies of sales price effects using multiple regression analysis or other closely related multivariate statistical techniques such as analysis of covariance. Like the survey research, these studies primarily address single-family residential properties, although two studies address impacts on rural land and agricultural properties. The third literature category contains a mix of study types, including paired sales analyses, case studies, and sale /resale analyses. Many of these studies were conducted by appraisers.

EMFs and Health Effects

While not the primary focus of the research reviewed herein, the issue of health effects has received some attention due to the market’s purported “fear” of harmful exposure to electromagnetic fields (EMFs). Numerous studies have been conducted around the

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world to determine what health effects, if any, are caused by EMF exposure. This research has employed numerous methodologies, and the findings are largely inconclusive. In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID), a six-year “program of research and analysis with the purpose of providing scientific evidence to clarify the potential for health risks from exposure to extremely low frequency electric and magnetic fields (ELF-EMF).” This research was led by the National Institute of Environmental Health Sciences (NIEHS). At the conclusion of this project in 1999, the NIEHS reported that scientific evidence linking EMF exposure to health risks is weak. Overall, epidemiological EMF studies show a pattern of small, increased risk of two types of cancers: childhood leukemia and chronic lymphocytic leukemia in adults with occupational EMF exposure. However, laboratory research fails to provide any consistent evidence of this connection. The NIEHS determined that while EMF exposure cannot be ruled as entirely safe, the scientific evidence of health risks is “insufficient to warrant aggressive regulatory concern.” Since there has been scant evidence of any actual health effects from EMFs, any measured effects on property values would, then, likely be due to other factors such as visual encumbrance or the physical encumbrance of the easement area through which the transmission lines pass. This point is generally borne out in the studies reviewed below.

Survey Research

Kinnard (1967) was one of the first to undertake a comprehensive study concerning the effects of electric transmission lines on the value of residential property. Kinnard conducted a year-long survey of 17 subdivisions located in nine suburban towns in Metropolitan Hartford, Connecticut. All of these subdivisions, developed between 1954 and 1964, were either intersected by or abutted a tower line right-of-way. Questionnaires were sent to property owners and those who influence residential sales (lending institutions, home builders, Realtors, appraisers, and assessors) to determine their attitudes and opinions. Most homeowners reported that they did not mind living near a tower line. Over 85% said that they would purchase again in the same location. Screening a tower or line from view through landscaping, at least partially, did tend to considerably reduce any negative reactions by adjacent homeowners. The owners of higher priced or custom homes had a slightly more negative reaction to the proximity of the tower line than the owners of lower-end homes. In general, the attitudes of those who influence residential sales were more negative about the effects of a power line than the attitudes of the homeowners.

Morgan et al (1985) conducted a survey of 116 alumni of Carnegie-Mellon University to research the risk perception of 50/60 Hz electromagnetic fields from both high voltage transmission lines and electric blankets. The questionnaire consisted of two parts. In the first part, participants were asked to evaluate the risk of large power lines, electric blankets, and 14 other common hazards, such as automobiles, pesticides, caffeine, and cigarette smoking. Participants were then asked to rank the hazards from least to most risky and assign each a score based on how risky they viewed the hazards to be. The second part of the questionnaire provided additional information on electromagnetic fields (EMFs), their possible health effects, and how fields from

transmission lines compare in strength to other 60 Hz fields. They were then asked a variety of questions concerning appropriate regulatory responses to EMFs, willingness to pay for exposure control, etc.

The participants in this study did not view either electric blankets or transmission lines as particularly risky. Both were ranked among the least risky of the 16 hazards considered. Transmission lines were ranked as slightly more risky than electric blankets. As a whole, those surveyed believe that only modest regulatory control is needed for EMFs from transmission lines. When specific information about EMFs was provided in part two, participants had a statistically significant change in perception, and they became more concerned about the risk of EMFs.

Solum (1985) conducted an opinion study of the impacts of transmission line easements on rural land in northwest Wisconsin. He presented a questionnaire to landowners whose properties had been encumbered by a transmission line ranging from 69 kV to 161 kV. The 180 respondents owned encumbered property that fell into three categories: agricultural, recreational, or residential. When asked how the transmission line had affected their property, a majority of agricultural property owners responded that the line had no effect. The most frequently cited effect for agricultural property was the inconvenience of working around transmission structures in areas that were being actively farmed. Recreational property owners were primarily concerned with the loss of future timber value from clearing the easement area, while residential landowners named the loss of aesthetic beauty as the predominant effect. Some landowners were also concerned that the transmission line would have a negative impact on future sales price. To examine this further, Solum conducted personal interviews with buyers and sellers of encumbered properties. According to these interviews, all but one of the encumbered properties sold at a market price comparable to non-encumbered properties, and none of the buyers reduced their offer to purchase the property due to the presence of the power line. Solum concluded that despite some concerns and inconveniences, the resale price of all three property types was not reduced due to the transmission line easement.

Surveys of appraisers by Delaney and Timmons (1992) found that this group believed that the value of a property near a high voltage overhead transmission line (HVOETL) is, on average, 10% lower than the market value for comparable properties not subject to the influence of these lines. The initial mailing of the survey was sent to a random sample of 500 Appraisal Institute members holding the Residential Member (RM) designation, and there was a 43.8% useable response rate. Approximately 84% of respondents indicated that the market value of residential property near a HVOETL is negatively affected, and the average estimate of the decline in value was 10%. The most commonly cited reason for this decline in value was the visual unattractiveness of the power lines, followed by potential health hazards, disturbing sounds, and safety concerns. Most of the appraisers surveyed used matched pairs or paired sales analysis to determine the decrease in value due to the proximity of HVOETLs. About 10% of appraisers surveyed believed that HVOETLs have no significant impact on value, while 6% believed these lines increase the value of a property due to larger yards and additional privacy.

Kung and Seagle (1992) analyzed perceptions regarding the spatial relationships between power transmission lines and property values in Memphis and Shelby Counties, Tennessee. In this study, neighborhoods with high tension lines were identified, and homes under or adjacent to these lines were surveyed to determine the real or perceived influences on the value and marketability of these properties. A questionnaire was developed to survey homeowners living adjacent to the power lines. Of 80 homeowners in two adjacent neighborhoods, 47 responded to the survey. About 50% of the respondents said they consider the transmission lines an eyesore, while 47% do not. About 72% of those who saw the lines as an eyesore said the lines had no effect on the purchase price. There has been some evidence that has linked electromagnetic fields to health problems such as cancer, but these findings are debated, and no direct causal relationship has been discovered. None of the homeowners surveyed saw the lines as a potential health hazard. However, 87% claimed that if they had known of potential health risks, they would have paid less for their home or looked elsewhere.

Priestley and Evans (1996) conducted a survey based on a large sample of people living near a power line about 28 miles north of San Francisco who were surveyed using psychometrically developed scales. The line had recently been rebuilt to carry more power and consisted of three high-voltage circuits ranging from 120 to 160 feet in height. There were 445 questionnaires mailed to residents of two adjacent suburban neighborhoods located within 900 feet of this power line. A 60% response rate was achieved. The survey results indicated that many of the nearby residents feel this line is a negative element in their neighborhood and that it has moderately negative impacts on health and safety, property values, and aesthetics; 87% of respondents indicated that the lines have an adverse effect on the attractiveness of their neighborhood. Negative perceptions were greater for older people and those with higher status jobs, and less for those who use the right-of-way for recreational purposes. Those who lived in the neighborhood prior to the line upgrade had the most strongly negative views about the lines. Physical factors such as distance from the line and visibility did not appear to affect perceptions.

The results of the foregoing studies are summarized in Exhibit 1. As discussed, Kinnard (1967) found that most homeowners surveyed were not averse to living in proximity to transmission lines. Interestingly, the attitudes of realtors were more negative than the homeowners. The adverse perceptions of real estate professionals were also depicted in the Delaney and Timmons (1992) research on Appraisal Institute members. Kung and Seagle (1992) found that while half of those surveyed considered transmission lines an "eyesore," most (72%) said they have no effect on sales price, although if they had known of any actual health risks, they might have paid less for their homes. Perceptions of health risks from EMFs were put in perspective by Morgan et al. (1995), who found that transmission line EMFs were perceived as the least risky of 16 potential hazards. Lastly, Priestly and Evans (1996) found that most (87%) San Francisco residents they surveyed perceived an effect on the attractiveness of their neighborhood. The extent to which negative perceptions influence sales prices and market values will be more directly addressed in the next two sections.

Exhibit 1
The Effects of Electric Transmission Lines on Property Values
Summary of Survey Based Research

Papers	Who was Surveyed	Number of Respondents	Response Rate	Effects Found
Kinnard (1967)	Residential property owners in subdivisions containing a power line right of way in Metropolitan Hartford, CT & people who influence residential sales in this area (lenders, home builders, Realtors, appraisers, assessors)	377 home owners, 648 total	43.6%	Most homeowners surveyed did not mind living near a power line. Over 85% said they would purchase again in the same location. Screening a tower or line from view through landscaping reduced any negative reactions by homeowners. The owners of higher priced or custom homes had a slightly more negative reaction to the lines. In general, the attitudes of those who influence residential sales were more negative than the attitudes of the homeowners.
Morgan, et al. (1985)	Alumni of Carnegie-Mellon University	116	70%	Participants did not view either electric blankets or transmission lines as particularly risky relative to other common hazards. Both were ranked among the least risky of the 16 hazards considered. Those surveyed believe that only modest regulatory control is needed for EMFs from transmission lines. When specific information about EMFs was provided, participants perceived the transmission lines as riskier.
Solum (1985)	Landowners whose properties had been encumbered by a transmission line easement in Northwest Wisconsin & buyers and sellers of these encumbered properties	180	43%	The majority of agricultural property owners believed the line had no effect on their property. Recreational property owners were primarily concerned with the loss of future timber value, while residential landowners thought the lines had a negative effect on the property's aesthetic beauty. Of the 23 encumbered properties that sold, all but one sold at market value, and none of the buyers reduced their offer to purchase the property due to the presence of the power line.

Exhibit 1 (continued)
The Effects of Electric Transmission Lines on Property Values
Summary of Survey Based Research

Papers	Who was Surveyed	Number of Respondents	Response Rate	Effects Found
Delaney & Timmons (1992)	Appraisal Institute members holding the RM designation	268	43.8%	Approximately 84% of respondents indicated that the market value of residential property near an HVTL is negatively affected, and the average estimate of the decline in value was 10%. The most commonly cited reason for the decline in value was the visual unattractiveness of the lines. About 10% of appraisers surveyed believed the HVTLs had no significant impact on value, and 6% believed that the lines increase the value of a property due to larger yards and additional privacy.
Kung & Seagle (1992)	Homeowners living adjacent to power lines in 2 neighborhoods in Memphis and Shelby Counties, Tennessee	47	58.5%	About 50% of respondents said they consider the transmission lines an eyesore. About 72% of those who consider the lines an eyesore said the lines had no effect on purchase price. 87% of respondents claimed that if they had known of potential health risks from the lines, they would have paid less for their home or looked elsewhere.
Priestly & Evans (1996)	People living near a power line in 2 suburban neighborhoods about 28 miles north of San Francisco	266	60%	87% of respondents indicated that the lines have an adverse effect on the attractiveness of their neighborhood. Negative perceptions were greater for older people and those with higher status jobs, and less for those who use the right-of-way for recreational purposes. Those who lived in the neighborhood prior to the line upgrade had the most strongly negative views.

Statistical Sales Price Analyses

The second literature category summarizes studies of statistical analyses of the impacts of transmission lines on sales prices. While the surveys can elicit stated preferences, the analysis of actual sales data yields what is termed “revealed preferences.” The preferences represent the actual behavior of the real estate market as revealed in transactional data. Through an analysis of such data, research can provide evidence concerning the translation of stated concerns or perceptions into measurable price effects. Most of the studies reviewed utilize multivariate analysis whereby important determinants of pricing such as the detailed physical characteristics of the properties are held statistically constant in order to isolate the effects, if any, of the presence of the transmission lines. As will be seen, these effects are not found to be uniform. As with the survey research, most of the studies focus on single-family residential properties, although two studies address rural acreage and agricultural land.

One of the two studies not focusing on residential properties is provided by Brown (1976), who uses regression analysis to analyze sales of farm land in south-eastern Saskatchewan, Canada that occurred between 1965 and 1970. The study included sales of “quarter section” (136–199 acre) and “half section” (200–350 acre) parcels. Parcels with significant improvements were excluded from the analysis. The relationship of land value to the number of power line structures was not found to be statistically significant. To further examine the effects of power lines and easements, very similar parcels, with the main difference being that one had a power line and one did not, were paired and analyzed. Overall, the properties with power lines sold for higher prices than their pairs without power lines. It is unreasonable to conclude that this higher price was due to the power lines and easements, but it appears that the lines did not negatively affect land value.

From these results, as well as a limited review of previous studies, Brown (1976) concludes that power lines do not have an effect on market value as a whole. However, the easement required to build the line does reduce the rights of the property owner, and power line structures normally have an adverse impact on the efficiency of farming operations. Therefore, there is a need for an analytical approach that will take into account the extent of ownership rights taken away and determine a reasonable compensation for affected property owners. When determining fair compensation, several components of loss must be identified, such as rights of ownership lost, increased operating costs, reduced gross returns, costs due to risk, damages to machinery and equipment, value of area out of production, and other factors.

Colwell and Foley (1979) hypothesize that there are costs imposed on residential property stemming from close proximity to electric transmission lines. Although previous research found that the value of residential property was not affected by the close proximity of these lines, other important factors, particularly lot size, were not held constant in those studies. Holiday Hills and Windsor Village, two neighborhoods in Decatur, Illinois, were chosen for this research. The sample consists of 200 sales during the ten-year study period from January 1968 to October 1978. Within 400 feet of all properties in the sample is an electric transmission line of double-circuit 137,000-volt conductors supported by steel towers.

The model consists of an equation that relates selling price, the dependent variable, to ten independent or explanatory variables, including lot size. Lot size is an important variable to include because residential lots abutting an electric transmission line tend to be larger than other lots in the subdivision. The results of this study show that selling price becomes higher as distance from the transmission line increases. The selling price increases at a decreasing rate and quickly approaches an asymptote. The most substantial impacts, of approximately 6%, are observed between 50 and 200 feet from the line, but the lines seem to have little or no effect at distances beyond 200 feet.

In a follow-up study, Colwell (1990) measures the impacts of power lines and towers on the selling price of residential land with a hedonic price index in which the selling price is a Cobb-Douglas function of a number of property characteristics. Some previous studies ignore the potential premium for larger lot size and the use of right-of-way land, which both offset the negative impacts of power lines. This study avoids this problem by using a sample of properties proximate to a power line located on an easement instead of a fee right-of-way. The data used in this study is identical to the data used in Colwell and Foley (1979), with additional variables added for distance to a tower and the presence of an easement. The models show that the selling price of residential property increases as distance from the power line increases. The selling price increases at a decreasing rate and quickly approaches an asymptote. The negative impacts tend to diminish or disappear over time.

Rigdon (1991) analyzes the impact of a 138 kV transmission line on vacant recreational land in Marquette County, Michigan using multiple regression techniques. Forty-six sold properties ranging from 10 to 160 acres were selected in two large "neighborhoods" during the study period of January 31, 1986 to January 30, 1991. Results indicated no statistically significant relationship between sales price and proximity to a power line easement. The author found only a few previous studies that point to any negative property value effects from power line proximity. Far more research has been conducted on the impacts of power lines on residential properties than on agricultural and recreational acreage. In one study, landowners affected by the construction of a power line in northwest Wisconsin were interviewed to determine their reaction to the easement and the lines. These landowners believe that the effects on recreational property are less than any effects on residential property. The major concern of the owners was loss of future timber value caused by clearing the right-of-way. Rigdon concludes from his literature review that transmission line effects, in general, are not significant and not easily measurable.

Hamilton and Schwann (1995) review previous literature concerning the effects of high voltage transmission lines on property values and also present new research on this topic. Previous studies reviewed by them found that overhead transmission lines can, in some instances, reduce the values of nearby properties, but these effects are generally less than 5% of property value. The impacts are observed in the immediate area of the transmission line and diminish quickly with distance, usually disappearing at 200 meters. Neither height of the lines nor voltage is found to have a significant impact. When a new line is constructed, the impacts may be larger initially but tend

to dissipate quickly. In a few studies, a positive impact is found, which is generally associated with a right-of-way that's accessible for recreational use, is attractively landscaped or provides added privacy. In all of the literature reviewed, other neighborhood factors dominate the explanation of variations in property values. The authors' own study analyzes 12,907 arms-length sales of single-family detached homes in four neighborhoods in the Vancouver area between 1985 and 1991. The neighborhoods are in close proximity to existing transmission lines. The authors find that properties adjacent to a line lose 6.3% of value due to proximity and visual impact. Properties more distant from a line lose on average only 1% of their value.

Des Rosiers (1998) looks at the impact of high-voltage transmission lines (HVTLs) on surrounding property values using a microspatial approach. The research is based on a sample of 507 single-family houses in the city of Brossard, in the greater Montreal area, Canada; 257 of these town cottages sold during the study period between February 1991 and November 1996. The study area includes three distinct neighborhoods (R, S, and T) with a 315 kV transmission line running through the center. The data bank includes 25 property descriptors pertaining to physical, environmental, neighborhood, access, fiscal, and sales time attributes, as well as a series of HVTL-related descriptors. Standard and stepwise regression procedures are successively used in the analysis.

This model shows that a residential property both adjacent to an HVTL easement and facing a pylon experiences a drop in value due to the visual encumbrance (on average the decrease was 9.6% of the mean house price). Properties located 1 to 2 lots away from a pylon usually benefit from a market premium due to increased visual clearance and privacy. This premium is, on average, between 7.4% and 9.2% of the mean house price. A property located at mid-span will experience a decrease in value because the low minimal clearance of the lines causes a visual obstruction. This decrease is smaller, on average 4.7% of the mean home price. Properties with a moderate or limited, rear or side view on an HVTL structure but not adjacent to the easement usually experience a market premium of 2.8% to 3.8% due to the improved visual clearance these properties enjoy. The net visual encumbrance (difference between proximity drawbacks and advantages) reaches a maximum between 50 and 100 meters from the easement external boundary, and diminishes quickly thereafter to fade away entirely beyond 150 meters. Luxury home prices are more sensitive to the visual encumbrances of HVTL structures.

Wolverton and Bottemiller (2003) offer a confirmatory study of an earlier article by Cowger, Bottemiller, and Cahill (1996). This more recent study investigates whether the results of the original study hold using more rigorous analytical methods. The original study used a paired sales analysis to determine any difference in sales price between properties abutting transmission line right-of-ways in Portland, Vancouver, and Seattle, and properties located in the same cities but away from a transmission line. However, the original study did not control for differences between the subject properties and the comparables. This study attempted to overcome that problem using regression analysis.

Analysis of covariance (ANCOVA) was used to test for an “abutting transmission line” effect on sales price. The data from these models does not support any price effect on residential property from being located adjacent to an HVTL. This confirms the results of the original study, that prices are not significantly affected by the presence of an HVTL. The data also shows no difference in appreciation rates between homes along an HVTL right-of-way and homes located further away from the HVTL.

Lastly, Chalmers and Voorvaart (2009) also addressed the issue of impacts on residential property values and prices using a multiple regression framework. Based on a study of residential properties in Connecticut and Massachusetts sold from 1999 to 2007 and located in proximity to 345 kV transmission lines, the authors analyzed the effects of proximity (distance to the lines) and encumbrance (area on a property encumbered by the easement) and found proximity to have an insignificant effect on sales price. They concluded that “the only variable that appears to have any kind of systematic effect is the encumbrance variable,” although its statistical significance varied and the effect was “generally small.” The authors also addressed potential effects due to the visibility of the transmission line structures and found a lack of any significant impacts on sales prices.

These studies point to a mix of conclusions regarding the effects of transmission lines on sales prices and property values. A summary is presented in Exhibit 2. Many of the studies found no statistically significant or systematic impacts (Brown, 1976; Rigdon, 1991; Wolverton and Bottemiller, 2003; Chalmers and Voorvardt, 2009) while others found impacts or lack of impacts under certain conditions. For example, researchers that found effects also generally found that impacts diminish with distance from the lines (Colwell and Foley, 1979; Colwell, 1990; Hamilton and Schwann, 1995; Des Rosiers, 2002). The distance at which the effects dissipate varied from 150 meters, or approximately 450 feet (Des Rosiers, 2002) to 200 feet (Colwell and Foley, 1979). Some researchers found a relationship between the placement of the structure in relation to the house, or visual encumbrance, and in some cases found a positive effect due to increased visual clearance and privacy (Des Rosiers, 2002). Some research suggests a lessening of effects over time (Colwell, 1990; Des Rosiers, 2002). Most of the effects, when measurable were less than 5% of unimpaired value, although some research suggests that depending on placement effects can range up to 9%. The two researchers that addressed rural properties with generally large tracts of land did not find any effects on price and value (Brown, 1976; Rigdon, 1991).

Other Studies and Techniques

The third literature category contains a variety of sales price analyses not generally using the regression-based hedonic pricing analyses. Rather, these sales price analyses, many of which were done by real estate appraisers, used a variety of sales-based techniques, including sale and resale analysis, average sales price per square foot comparisons, case studies, and paired sales analysis. While these techniques may omit certain variables that the multivariate analyses account for directly, the conclusions and findings from the two sets of studies are generally consistent and similar. The studies in this category, though, are perhaps less detailed in offering

Exhibit 2
The Effects of High Voltage Transmission Lines on Property Values
Summary of Statistical Sales Price Analyses

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Dependent Variable	Independent Variables	Effects Found
Brown (1976)	1965 to 1970	Saskatchewan, Canada	Farm Land	Transmission lines varying in voltage	Sales Price per Cultivated Acre, converted to a 1970 base and adjusted for the existence of waste land, pasture land, or improvements.	Non-arable acres as a percentage of total acres, Weighted land productivity index, Distance in miles from shipping point, # of power lines per parcel sold.	Power line structures and easements do not have a significant effect on the selling price of farm land.
Colwell & Foley (1979)	1968 to 1978	Decatur, IL	Single-Family Residential	138 kV transmission line	Sales Price	Distance from center of transmission line easement (feet), Presence of tower on property, Neighborhood, Month of sale, Presence of deck or porch, Lot area (thousands of SF), Living area (thousands of SF), # of bathrooms, Basement (none, half, full), Size of garage (thousands of SF).	Diminished property values are associated with proximity to a transmission line. Substantial differences in selling price exist between 50 and 200 feet from the line, but disappear beyond 200 feet.

Exhibit 2 (continued)
The Effects of High Voltage Transmission Lines on Property Values
Summary of Statistical Sales Price Analyses

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Dependent Variable	Independent Variables	Effects Found
Colwell (1990)	1968 to 1978	Decatur, IL	Single-Family Residential	138 kV transmission line	Sales price or natural log of sales price	Distance from center of transmission line easement (feet), Distance to a tower (feet), Presence of an easement, Presence of a tower on property, Neighborhood, Month of sale, Presence of deck or porch, Lot area (thousands of SF), Living area (thousands of SF), # of bathrooms, Basement (none, half, full), Size of garage (thousands of SF).	Selling price increases at a decreasing rate as distance to a power line increases. These negative impacts typically diminish with time. Proximity to a tower may have a negative impact that does not diminish with time. The presence of an easement also negatively affects property value.
Rigdon (1991)	1986 to 1991	Marquette County, Michigan	Unimproved Recreational	138 kV transmission line	Sales price	Size of acreage parcels, Topography rating (1 to 10), Reciprocal of distance to a plowed and county maintained road, Reciprocal of distance to a 138 kV transmission line easement, Month of sale.	Distance to a power line was not found to be correlated with sales price. Thus, there is no evidence of a relationship between sales price and the proximate distance of recreational properties to a transmission line.

Exhibit 2 (continued)
The Effects of High Voltage Transmission Lines on Property Values
Summary of Statistical Sales Price Analyses

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Dependent Variable	Independent Variables	Effects Found
Hamilton & Schwann (1995)	1985 to 1991	Metropolitan Vancouver	Single-Family Residential	Transmission lines varying in voltage from 60 kV to 500 kV	Sales price	Distance to center of transmission line right-of-way, Adjacent to right-of-way, Partially within right-of-way, # of towers visible from property, Transmission lines visible from property, Garage, Pool, Sewer, Curb, Sidewalk, Corner lot, Age, # of fireplaces, # of basement rooms, # of bedrooms, # of full baths, # of partial baths, # of other rooms, Width of lot, Depth of lot, Sale date (categorized by quarter).	Properties adjacent to a line lose 6.3% of value due to proximity and visual impact. More distant properties are scarcely affected, losing on average only 1% of value.

Exhibit 2 (continued)
The Effects of High Voltage Transmission Lines on Property Values
Summary of Statistical Sales Price Analyses

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Dependent Variable	Independent Variables	Effects Found
Des Rosiers (1998)	1991 to 1996	City of Brossard, Canada (Greater Montreal Area)	Single-Family Residential	315 kV transmission line	Sales price or natural log of sales price	Apparent age (years), Lot size (square meters), Living area (square meters), Finished basement area (square meters), Siding other than stone or brick, Above average landscaping, Laminated kitchen cabinets, Hardwood floors, Central air, # of built-in features in the kitchen, Excavated swimming pool, # of garage places, Electric garage door, Type of house (one-story, attached, row house, split-level), Neighborhood sector, Effective tax rate, Months elapsed between 1/1/91 & sale date, Located in a service area, Adjacent to HVTL easement, Linear distance to HVTL easement & line, Optimal distance from HVTL easement & line, Natural log of distance to HVTL easement & line, Inverse of distance to line, Square root of distance to HVTL easement & line, Discrete distance from HVTL easement, View on HVTL structures, Location along line relative to pylons.	A property both adjacent to an HVTL easement and facing a pylon will see, on average, a drop in value of 9.6% of mean house price. Adjacent properties 1 to 2 lots away from a pylon usually benefit from a market premium between 7.4% & 9.2% due to increased visual clearance and privacy. An adjacent property located at mid-span will experience a decrease in value, on average 4.7%, due to the low minimal clearance of the lines. Properties not directly adjacent but with a limited or moderate, rear or side view on the HVTL structure usually experience a market premium between 2.8% & 3.8%, due to improved visual clearance. The net visual encumbrance (difference between proximity drawbacks & advantages) reaches a maximum between 50 and 100 m from the easement boundary, with values dropping between 5% and 12% of mean price, and disappears entirely beyond 150 m.

Exhibit 2 (continued)
The Effects of High Voltage Transmission Lines on Property Values
Summary of Statistical Sales Price Analyses

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Dependent Variable	Independent Variables	Effects Found
Wolverton & Bottemiller (2003)	1989 to 1992	King County, WA; Clark County, WA; Washington County, OR; Clackamas County, OR	Single-Family Residential	Varies from 115 kV to 500 kV	Sales price and Natural log of sales price	Date of sale (quarter and year), age of house, lot size, type of lot (corner, cul-de-sac, flag shaped lot), landscaping, house condition, sloping topography, bedrooms, bathrooms, carport floor area, garage floor area, additional improvements (patio, deck, greenhouse, hot tub), county in which property is located, indicator variable for lots abutting transmission line by county.	None of the measures of the effects of abutting an HTVL line are statistically significant. However, results from King county show an average impact of -1.4% and results from Clackamas County show an effect of -3.2%. Washington and Clark County results show a near zero difference.
Chalmers & Voorvardt (2009)	1998 to 2007	Connecticut and Massachusetts	Single-Family Residential	345 kV	Natural log of sales price	Year of sale, livable area, lot size, age, air conditioning, bathrooms, basement area, deck, garage, patio, porch, and subarea location.	Proximity not found to have a statistically significant effect on price. Encumbrance (square feet of area encumbered by easement) had a significant effect in some models.

explanations and analyses of why and under what circumstances impacts may occur and then diminish.

Carll (1956) addresses the issues and procedures involved in conducting an appraisal for condemnation purposes. He specifically outlines the steps he took in appraising a fee right-of-way that was to be acquired in the City of Los Angeles for the construction of electric HVTLs on steel towers. This right-of-way was a portion of a larger tract that was being developed as a residential subdivision. The owners of the larger tract expressed a concern that the presence of the HVTLs would have a negative impact on the market value of the new homes they would build along the right-of-way. To address this concern, Carll conducted interviews with buyers, sellers, and brokers in the Los Angeles area who had actually bought or sold properties along a similar transmission line right-of-way. These interviews revealed, without exception, that residential properties adjoining a right-of-way have not sold at a discount. This was confirmed by comparing the prices paid for these properties with other comparable properties not in the vicinity of a transmission line right-of-way. Interviews with developers confirmed that lots along a right-of-way did not sell for any discount, and that lenders did not make any adjustments to the loan amount offered for right-of-way lots.

Bigras (1964) analyzes several case studies in Ste. Foy (Quebec), Three Rivers, and Montreal to determine the effects of HVTLs on property values. Overall, 1,956 deeds of sale and mortgages were analyzed, and a statistical study was made that brought out the price of the vacant land, the proportion of mortgage-to-sale price, and the municipal assessment of buildings. This study indicates that prices for vacant land adjacent to the lines were generally higher than the average price of all transactions. Municipal assessment values of buildings were also higher for properties adjacent to the lines. The proportion of mortgage amount-to-sales price was about the same for both groups. Land adjacent to the power lines sold faster and was developed to a higher degree than land away from the lines.

Bigras (1964) also conducted interviews with principal officers of the Central Mortgage and Housing Corporation concerning their policies of granting mortgage loans to properties adjacent to a power line. From these interviews, it appears that the presence of a line does not deter buyers from purchasing properties in close proximity, and the line does not affect the loan amount granted to these owners. The author believes that the Canadian public is inclined to exaggerate the disadvantages of living close to a high power transmission line.

Kinnard (1967), in his seminal study of these issues, conducted surveys of market participants (see survey research section) and analyzed over 1,200 sales and resales of residential properties in the same 17 subdivisions located in nine suburban towns in Metropolitan Hartford, Connecticut. All of these subdivisions, developed between 1954 and 1964, were either intersected by or abutted a tower line right-of-way. Kinnard found that sales prices did not vary significantly based on proximity to a tower line right-of-way. However, the lots closest to the right-of-way were generally larger, which means that more land area can be obtained closer to a power line for

the same price as a smaller, more distant lot. The rate of absorption and financing terms of properties close to a power line were not significantly different from those of more distant properties. Over time, negative market impacts decreased substantially. Overall, Kinnard concluded that the value of residential property is not significantly affected by proximity to a tower line. Although negative attitudes toward these lines do exist, market evidence shows that properties near tower lines are readily salable on competitive market terms.

In addition to their survey research concerning power transmission lines and property values in Memphis and Shelby Counties, Tennessee, as previously reviewed, Kung and Seagle (1992) analyzed sales data that was used to formulate a computerized map and database using a GIS system. The average price-per-square-foot for properties next to (adjacent to) transmission lines were compared to similar measures for homes further away. The prices of homes adjacent to the power transmission lines are very similar to prices of other homes in the same neighborhood. Any slight differences in price are attributable to the differences in property condition, style, buyer preference, and seller motivation. There was no evidence to indicate that the power transmission lines had any significant impact on the sales prices of the residential properties.

Cowger, Bottemiller, and Cahill (1996) analyze a market-based study that was conducted by the Bonneville Power Administration (BPA). Utilizing a paired sales analysis technique, this study compares the prices of improved residential properties bordering overhead HVTLs to similar properties away from the lines. Residential properties in four counties were chosen for this study, including Washington and Clackamas Counties (Portland, OR), Clark County (Vancouver, WA), and King County (Seattle, WA). All 1990 and 1991 home sales that abutted BPA HVTLs in these counties were identified and paired with comparable home sales further away from the lines.

On average, homes adjoining a power line in Portland sold for a 0.95% premium, in Vancouver a 1.03% discount, and in Seattle a 1.82% discount. None of these price differences were statistically significant from zero at the 95% probability level. Therefore, it is assumed that proximity to a transmission line has no substantial effect on the sales prices of these homes. Other factors, such as location, type and condition of improvements, and real estate market conditions, are far more important in determining the value of residential property. The sales data for this study was subsequently analyzed with the use of multivariate statistical techniques with similar findings (see Wolverton and Bottemiller, 2003).

A summary of these studies is presented in Exhibit 3. As noted, while these analyses are less detailed and do not in most cases control for the range of variables the regression-based studies account for, the conclusions and findings here do not generally conflict with the overall findings of the statistical sales price analyses. None of the five studies found any effect on sales price due to proximity to a transmission line. In the statistical studies, small effects were found under some conditions, but these dissipated with distance, time or placement of the transmission line structures.

Exhibit 3
The Effects of High Voltage Transmission Lines on Property Values
Summary of Other Studies

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Effects Found	Additional Comments
Bigras	1948 to 1961	Ste. Foy (Quebec), Three Rivers & Montreal, Canada	Residential	230 kV, 69 kV & 180 kV transmission lines	No Effect	The sales price of vacant land adjacent to a transmission line was generally higher than the average price of all transactions. Municipal assessment values of buildings were also higher for properties adjacent to a line. The proportion of mortgage to sale price was about the same for both groups. Land adjacent to the power lines sold faster and was developed to a higher degree than land away from the line.
Carll	1954	Los Angeles	Residential subdivision land	220 kV transmission line	No Effect	Market interviews revealed, without exception, that residential properties adjoining a transmission line right of way have not sold at a discount. This was confirmed by comparing the prices paid for these properties with other comparable properties away from a transmission line right of way. Interviews with developers revealed that lenders did not make any loan adjustments for right of way lots.
Kinnard	1954 to 1964	Metropolitan Hartford, Connecticut	Residential	Transmission lines varying in voltage	Larger lots near ROW sold for the same price as smaller lots more distant from the ROW	In general, sales prices did not vary significantly based on proximity to a tower line right of way. However, the lots closest to the right of way were generally larger. The rate of absorption and financing terms of properties close to a power line were not significantly different from those of more distant properties.

Exhibit 3 (continued)
The Effects of High Voltage Transmission Lines on Property Values
Summary of Other Studies

Author(s)	Year(s) of Study	Location of Study	Property Type	Power Line Type	Effects Found	Additional Comments
Kung & Seagle	1989 to 1990	Memphis and Shelby Counties, Tennessee	Residential	Unknown	No Effect	The sales prices of homes adjacent to a power transmission line were very similar to prices of other homes in the same neighborhood. Any slight differences in price are attributable to the differences in property condition, style, buyer preference and seller motivation. There was no evidence to indicate that the power transmission lines had any significant impact on the sales prices of residential properties.
Cowger, Bottemiller & Cahill	1990 to 1991	Washington & Clackamas Counties (Portland, OR), King County (Seattle, WA) & Clark County (Vancouver, WA)	Residential	6 BPA transmission lines varying in voltage from 115 kV to 500 kV	No Effect	On average, homes adjoining a power line in Portland sold for a 0.95% premium, in Vancouver a 1.03% discount, and in Seattle a 1.82% discount. None of these price differences were statistically significant from zero at the 95% probability level. Therefore, it is assumed that proximity to a transmission line has no substantial effect on the sales prices of these homes. Other factors, such as location, type and condition of improvements, and real estate market conditions, are far more important in determining the value of residential property.

Conclusion

The studies on transmission line impacts reviewed herein ranged in time from 1964 to 2009. All of these studies have been published and deal with empirical data, either survey-based data or actual real estate sales data. Excluded were publications that reviewed other studies, publications not based on the direct analysis of data, conference papers, and industry reports. The studies reviewed, while having some inconsistencies in their detailed results, generally pointed to small or no effects on sales price due to the presence of electric transmission lines. Some studies found an effect but this effect generally dissipated with time and distance. The effects that were found ranged from approximately 2% to 9%. Most studies found no effect and in some cases a premium was observed. This was attributed to the additional open area usually behind the residence created by the transmission line easement. These relatively small effects are somewhat in contrast to concerns and adverse perceptions expressed in the surveys reviewed here. To put this in perspective, Kinnard and Dickey (1995) authors note that the regression-based sales price analyses “reflect what buyers and sellers actually do, opposed to what potential buyers say they might do, under specified hypothetical circumstances.” Citing a court case, they also note that “fear (whether reasonable or not) is admissible as an explanation of why diminution in property value has occurred. It is not a measure of the diminution in market value.” Nevertheless, surveys can and do provide context and an explanation for observed differences in price and as such they have a place in real estate research.

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