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Transmission Lines and Property Values: State of the Science

Technical Report

Transmission Lines and Property Values: State of the Science

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PRODUCT DESCRIPTION

Growing energy demand and an aging electricity infrastructure underscore the need for new and upgraded transmission lines. Despite system failures and seasonal symptoms such as rolling brownouts, efforts to expand or improve transmission systems invariably meet with strong opposition. A primary source of this opposition comes from landowners who feel that the presence of a nearby transmission line may cause their property to decrease in value. A significant factor contributing to the contentious nature of routing efforts is an inadequate understanding of the influence of power corridors on property values. This report reviews studies investigating the relationship between transmission lines and property values, assesses the current state of the science, and discusses needs for future research.

Results & Findings

Research methods used to study the effects of transmission lines on property values are divided into surveys and opinion-based studies and quantitative studies that are either market-data comparisons or econometric approaches. The report describes these research options and highlights their strengths and weaknesses. A review of recent studies reveals that results are mixed: in some cases small decreases in property values are associated with proximity to a transmission line; in other cases there are no changes in property values; and in some cases there are even increases in property values. The report discusses and summarizes pertinent findings, identifies gaps in knowledge, and identifies current research needs.

Challenges & Objectives

Research publications support seemingly diametrically opposed positions regarding the existence and magnitude of property-value effects. Variation in study design and presentation of findings, especially when aggregate effects are used, can produce average effects that mask a large degree of value change for individual properties. Furthermore, variability in sample selection, analytical techniques employed, and study subjects have rendered each study an island unto itself, greatly limiting opportunities for generalization to other situations or locales. Improvements in experimental design have helped investigators make progress in fine-tuning their methods, but research needs identified more than a decade ago are still largely unmet. This report will help set the agenda for the next stage of research by identifying the stumbling blocks that hampered previous efforts and promoting coordination of results for improved transferability and understanding of the interaction between transmission lines and property values. Using multiple research methods in concert to harness the strengths of each is the next step to improved understanding.

Applications, Values & Use

The undersized and overtaxed electricity transmission infrastructure must undergo upgrades and expansions in the near future. Lengthy battles over routing drain the resources of developers and

landowners alike. Improved understanding of issues associated with these conflicts and actual demonstrated market effects will help make progress more efficient and help promote equitable solutions when conflicts arise. This report provides useful information to energy companies preparing for public meetings related to routing a transmission line and for individual negotiations with property owners.

EPRI Perspective

EPRI has a longstanding involvement with electric transmission research, EMF issues, and risk communication. It is in a unique position to expand the knowledge base on transmission lines and property values and help guide its members through the impending expansion of the transmission system. EPRI members can expect the next stage of research to improve understanding of public sentiment in relationship to actual effects of transmission lines on property values. As a result, they will be able to overcome public opposition and accomplish transmission line routing in the most efficient manner, enabling system growth to meet customer demand.

Approach

The goals of this project were to assess the current state of understanding of the relationship between electrical transmission facilities and property values. Investigators examined recent studies of perceived and actual effects and provided a discussion of the research techniques employed. They identified the strengths and weaknesses of each study and highlighted innovative approaches to improve research design and statistical analysis. Looking at the research literature and reading press coverage of current routing battles, it is clear that these valuation issues are far from resolved. The report suggests that the future of investigation on this topic lies in using a variety of research techniques, harnessing the strengths of each to characterize significant relationships. Pursuing research as a dynamic process that integrates surveys and opinion-based studies with quantitative methods will further our understanding of the effect of transmission lines on property values.

Keywords

Transmission Lines
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INTRODUCTION AND OVERVIEW

Over the past 50 years, energy-company professionals have worked with real estate specialists, appraisers, environmental planners, statisticians, and others to try to determine whether the location of transmission lines has an effect on property values, and if so, to measure that effect. Despite the long history, and an abundance of data, companies intending to construct or upgrade transmission lines continue to be faced with complications of routing a line caused by the hostility of homeowners who feel the investment in their property may be threatened by the presence of a power line (e.g., Berquist 1999; Rouse 2001). What have we learned in all that time, and why is there still confusion about this issue? One difficulty concerns access to accurate and reliable information; studies vary not only in design and measurement, but reports are scattered throughout the published and so-called gray literature.[1] A second difficulty has arisen with the practice of separating perceptions from actual market impacts and operating solely on one or the other. This project addresses both issues by presenting an overview of significant studies prior to 1992 and a more-detailed analysis of research carried out since that time, and reinforces an argument for the integration of perception surveys with investigations of property values.

The report is organized into four sections: review of research methods, discussion of key studies, statement of conclusions, and analysis of research needs. It concentrates on investigations carried out in the United States and Canada over the past 12 years. A comprehensive review and analysis of the literature prior to that time was produced by Cynthia Kroll and Thomas Priestley (1992) in their report *The Effects of Overhead Transmission Lines on Property Values*.[2] Their summaries of these early research projects are reproduced in the Appendices for the reader's convenience. The focus of their report was to examine the prevailing methodologies used to investigate the issue, summarize the significant outcomes of key studies, and determine future research needs. This project also focuses on those three areas, picking up where they left off. Advances in research design and the use of more sophisticated statistical techniques can be seen in much of the current research, although progress has been slow and many questions remain unanswered.

[1] Studies carried out by energy companies in-house and not published are frequently referred to as "gray area literature," defined as open source material that usually is available only through specialized channels.

[2] This report will be available as a pdf file at http://staff.haas.berkeley.edu/kroll/pubs/tranline.pdf

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RESEARCH METHODS

The primary methods of research on transmission lines and property values fall into two categories: 1. Studies based on surveys or opinion, and 2. Studies based on actual property transactions. These approaches, and the advantages and disadvantages of each, are described in the following sections. The review makes it clear that variations in research design and data analysis continue to make direct comparisons of findings problematic, as they did ten years ago.

Survey and Opinion-Based Studies

One method of estimating the effect of transmission lines on property values is to survey real estate and appraisal professionals who regularly estimate property values, as well as property owners, and ask their opinion about the relationship. Kroll and Priestley (1992) called these "attitudinal studies," because questionnaires and interviews typically are used to survey attitudes and perceptions of power-line impacts. A second survey method is to question market participants (i.e., prospective homebuyers) about potential influences, such as the location of a transmission line, on their purchasing decisions.

In general, surveys of real estate professionals and market participants both have the advantage of being direct and timely—questions are posed directly to individuals regarding their values at the current time and answers are given in present-day dollars. They also minimize problems related to interpretation of answers and isolation of effects due to transmission lines from other effects represented in real estate prices. In addition, survey methods may be employed in situations when market sales data are not available. But most importantly, no other method can address directly the preferences of individuals in the face of little or no difference in quality of properties.

Surveys do, however, have numerous disadvantages, many of which were discussed in Kroll and Priestley (1992), and continue to make surveys problematic. Studies based on opinions do not represent actual market behavior, and respondents may not be able or inclined to give realistic or truthful responses. Furthermore, data from opinion surveys tend to document only the negative effects, painting an overly pessimistic picture. There are certainly situations in which individuals are indifferent to the presence of a transmission line on their property, or even are attracted by the increased open space, but these attitudes are difficult to document in a survey. Surveys also tend to miss people who have already moved because of their opposition to living near a transmission line.

Another significant shortcoming of surveys is often overlooked. It is in the nature of a questionnaire that by asking a question on a topic, the importance of that topic is highlighted. Simply conducting a survey on the relationship between transmission lines and property values

indicates to respondents that it is an issue of concern. The structure and content of the questions can also easily influence responses; thus, it is imperative that surveys be conceived, written, and conducted with the utmost care, if responses are to be reliable.

Finally, opinion surveys of prospective homebuyers often involve some form of contingent valuation, meaning interviewees are asked to place a monetary value on a hypothetical situation, (also known as "willingness to pay"). These surveys are notoriously difficult to construct, and do not necessarily reflect opinions of actual purchasers (Kroll and Priestley 1992; Kinnard and Dickey 1995).

Considering the advantages and disadvantages of surveys, they do have a place in current research. A survey is the only qualitative method available to assess the perception of transmission line effects on property values. When constructed carefully and used properly, a survey can serve as an effective adjunct to quantitative studies. Although surveys historically were analyzed with simple descriptive statistical techniques, which limited interpretation and generalizability, this is no longer the case for some. As will be outlined below, recent surveys are beginning to employ sophisticated data analysis and tests of significance based on actual hypothesis formulation, which has increased their usefulness.

Quantitative Sales-Price Studies

Analysis of real estate sales has been generally viewed as the preferred strategy for identifying factors affecting property valuation because actual market behavior is observed. This type of study yields quantitative data, which lend themselves to more informative statistical approaches.

Two types of quantitative sales-price studies seek to identify the extent to which proximity to a transmission line affects property values by gathering evidence on revealed preferences of buyers through sales transaction data. These are: 1. Market-data comparisons, and 2. Econometric approaches.

Market-Data Comparisons

Market-data comparison, often called paired-sales analysis, uses standard real estate appraisal techniques to match sales (or in some cases, assessed values) of individual study properties with sales of equivalent control properties. The control properties must be nearly identical to the study properties in every respect other than proximity to a transmission line. For all pairs of properties, price differentials, and sales patterns are analyzed. The advantages of paired market-sales studies are that actual data are used and intervening variables are minimized. On the other hand, this method generally employs fairly small data sets, so results do not have the statistical power of studies using larger samples (Hamilton and Carruthers 1993; Kinnard and Dickey 1995). In addition, it depends upon the ability of the investigator or appraiser to identify matching properties, a subjective judgement, at best.

Gallimore and Jayne (1997) presented another shortcoming of market-data comparison studies that they discuss in terms of circularity. Circularity is a potential risk whenever evidence of effects of transmission lines on property values comes from actual sales transactions of

properties. Sales transactions are based in part upon appraisal valuations of properties, which take into account the proximity to a transmission line. At the present time, this involves a relatively high level of informational and behavioral uncertainty on the part of the appraiser. Unless appraisers perceive the impact of the transmission line in the same way the public views the impact, there exists the potential for circularity between appraisal valuation and market prices. In fact, there is some evidence that appraisers view the impact to be greater than actual owners of property near a transmission line do (e.g., Delaney and Timmons 1992; Sims and Dent 2003).

Econometric Approaches

Econometric approaches typically use multiple regression analysis, most often in the form of an hedonic pricing model. Observational studies using an hedonic pricing model attempt to estimate the economic costs associated with qualities of the local environment. For example, the model allows researchers to derive an estimate of changes in property values associated not only with an environmental characteristic, such as proximity to a transmission line, but also with specific attributes of that characteristic (e.g., pylon design, view, setback). From a sample of real estate sales data, some portion of which pertains to properties in the proximity of a transmission line, an attempt is made to identify the proportion of variability in sales prices attributable to that proximity. This type of study has been widely used to estimate the effects that qualities of the environment have on market prices (see Boyle and Kiel 2001, for a review).

A transmission line is only one of a number of potential factors that may influence real estate values (and ultimate selling prices); the challenge lies in identifying that portion of variability in sales prices that can be attributed to the transmission line. A key factor is the selection of variables and their operational definitions. Not only are there numerous characteristics of transmission lines, rights-of-way (ROW), and properties that vary, there is also a wide range of interactions among those characteristics.[3] Consequently, there is extensive variation in research design, which limits the ability to generalize findings. With the use of sophisticated statistical techniques comes the qualification that the results are only as good as the reliability of the data. In addition, complexities of advanced analysis arise from the use of cross-sectional and time-series data, and likely heteroscedasticity of the data.[4] As a result, the necessity of finding a compromise between investigating useful questions and insuring technical precision, mentioned by Kroll and Priestley (1992), continues to be a major issue.

Despite the limitations, quantitative sales-price studies can provide beneficial information for energy-company professionals. Not only have these studies advanced in methodology in recent years, but reliability has improved with the use of larger and better data sets. The key is to piece together significant findings from quantitative studies with results from methodologically sound perception surveys to begin to form the broad picture of the transmission line/property value

[3] Issues discussed in this report are similar whether the corridor in question is a purchased ROW or an easement. For the sake of simplicity, all corridors discussed are referred to as ROWs.

[4] Heteroscedasticity, or unequal variance, arises when variance in property values is greater for larger properties than smaller, for more expensive properties than less-expensive, or for different types of land use. Econometric analyses require "homoscedasticity," or equal variances.

issue. Then, with the specific audience in mind, one can call upon results as necessary—perhaps using quantitative data for public information sessions, with understanding gleaned from surveys, and survey data for negotiations with individual property owners, with back-up from quantitative studies.

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KEY STUDIES

Research design and data analysis have continued to develop since 1992. A number of literature reviews have briefly covered recent articles on transmission lines and property values (e.g., Bolton and Sick 1999; Kinnard and Dickey 1995; Jaconetty 2001). Other reviews are more extensive but concentrate on the pre-1992 literature (e.g., Gregory and von Winterfeldt 1996; Haider and Haroun unpublished; Hamilton and Carruthers 1993). This section covers the key findings from recent surveys and quantitative studies available in published form or from the sponsoring company.

Survey and Opinion-Based Studies

A number of investigators have surveyed real estate and appraisal professionals who regularly estimate property values, and asked their opinion about the relationship between transmission lines and property values. Results have shown that these professionals tend to overestimate the impact of transmission lines on residential property values relative to findings from actual market activity. Surveys of property owners present a more accurate picture of perceptions of individuals who may have a direct influence on transmission line routing.

Table 1 in Appendix A is a summary of the attitudinal studies discussed in Kroll and Priestley (1992). As can be seen, results of these early surveys are decidedly mixed. Kroll and Priestley concluded that, although the data are not directly comparable among the studies, in many of them approximately 50 percent of respondents felt that transmission lines had little effect on property values. Recent surveys also reveal mixed results.

Delaney and Timmons (1992) surveyed real estate appraisers to determine whether they viewed the market value of residential properties proximate to transmission lines to be significantly lower than comparable distant properties. They analyzed responses from 219 appraisers (a 43.8% response rate) throughout the United States. A majority (84%) of respondents felt market value of residential property was negatively affected by proximity to transmission lines, 10 percent felt there was no impact, and 6 percent said property value increased. Visual unattractiveness of the line was given most often as the reason for the decrease in value.

Appraisers who had experience valuing property proximate to a transmission line estimated the mean value decrease to be 10.0 percent (range = 7.7%–15.5%). In comparison, appraisers who lacked experience working with properties bordering a transmission line predicted a mean value decrease of 11.9%—a statistically significant difference. Interestingly, Sims and Dent (2003) found the opposite was true for surveyors and real estate agents in the UK; the more experienced the professional, the greater the estimated negative effect, although this finding was based on a very small number of respondents.

Although 69 percent of respondents stated that they primarily used paired-sales analysis to measure the impact of transmission lines on property values, no attempt was made in this study to investigate that variable. In fact, data used by appraisers were said to come mainly from public sources, such as the Multiple Listing Service, and matching of properties seems to have been done only informally. Consequently, interpretation of results should be limited to perceptions of appraisers, and not to actual decreases in property values. The findings point out the caution about circularity expressed by Gallimore and Jayne (1997) that was discussed earlier. If it is the case that appraisers perceive that properties proximate to transmission lines suffer a decline in value, then their valuations will most likely reflect that perception, which in turn could affect sales prices.

Even more troublesome are the results of a survey by Kung and Seagle (1992), who questioned 80 residential property owners in Memphis and Shelby County Tennessee to measure impacts on residential property values of proximity to "high tension" power lines and knowledge of possible links between exposure to electric and magnetic fields (EMF) and health problems. They received 47 responses (53% response rate) from residents living adjacent to, and some directly beneath, power lines. The survey included questions about how the presence of the power lines and potential health effects influenced their decision to purchase the property. As part of the survey questionnaire, respondents were told that some evidence exists linking "these types of power lines" and some forms of cancer, and were then asked whether awareness of this prior to purchase would have influenced their decision to buy the property. The authors found that residents were generally unaware (prior to the survey) of potential health effects from high-voltage transmission lines, and that they typically believed any effects on property values to be due only to aesthetics. (Delaney and Timmons (1992) found that appraisers also felt the greatest impact from transmission lines was because of the visibility of the line.) Once informed of the potential health effects, 87 percent of respondents said having that knowledge would have influenced their purchasing decisions.

From their survey, Kung and Seagle (1992) concluded that when property owners and potential homebuyers become more informed through media reports about the potential health effects of EMF, then the value of properties near transmission lines will plummet. As an adjunct to the survey, sales transactions of 11 properties were examined using average price per square foot, but no evidence of devaluation was found for properties that were adjacent to power lines. The authors interpreted this finding as further evidence that there is a “lack of public knowledge about any health risks associated with power transmission lines.” This study points out another caution discussed earlier, that asking leading questions can influence survey participants’ responses; in fact, merely conducting the survey can cause great concern and heighten awareness of issues that are the subject of the questions.

A survey conducted for Kansas City Power and Light highlights the caution of limited generalizability. Surveys sponsored by an energy company and carried out to evaluate the effects of a particular line provide information that is pertinent only to that area and findings cannot be extrapolated to other geographical regions, or even to similar non-surveyed properties.

Right of Way Associates (2001) interviewed owners, leasing agents and managers of 30 commercial properties in Kansas City to determine whether transmission line proximity adversely affected the value of commercial real estate. The indicators considered were rent levels, marketing time, and a tenant's desire to rent space. For cases in which property sales had

occurred, the owners were also asked about perceived sales-price effects. Analysis of the data was limited to calculating the proportion of participants responding yes to each of four questions. Based on the survey data, the authors found no quantifiable economic impact associated with the presence of the transmission line. Because these were commercial properties, the easement space was either used for parking or was kept as green space. As mentioned above, these results are only valid for the specific line, properties, and geographic region surveyed; potential differences in any of these variables rules out generalization.

The final survey to be discussed provides an example of the use of more sophisticated statistical techniques, such as multiple regression and factor analysis, to develop explanatory models. This is the type of study that can add value to the research on sales prices by identifying significant variables to be investigated further.

Priestley and Evans (1996) conducted a survey of 266 residents of two neighborhoods in a suburban area in California regarding a newly rebuilt high-voltage 230kV-transmission line. The line was built on a 100-foot wide ROW; 60-foot high lattice steel towers were replaced with tubular steel towers 120 to 160 feet in height that carried both the old 115kV circuit and the new 230kV double-circuit line. The authors questioned residents about their perceptions of line impacts on health and safety, property values, and aesthetics; line visibility; ROW use; design mitigation (e.g., tubular steel versus steel lattice towers, tower color options, landscaping of ROW); and pre-upgrade attitudes and behaviors toward the line. Overall, 87 percent of respondents felt the transmission line had a negative effect on the attractiveness of their neighborhood, and the impact of the line on health and safety was perceived more negatively than the impact on property values or aesthetics. Interestingly, respondents' reports of the view of the line from their property were at odds with an objective assessment of line visibility from each land parcel. Those who used the ROW tended to underestimate their view. In contrast, about 60 percent of respondents who lived in the neighborhood prior to construction were extremely opposed to the line being built, and exaggerated line visibility from their property significantly more than did those who were not opposed to the line. Commonly used mitigation measures were not judged positively by all residents. Forty-seven percent of respondents felt the tubular steel towers were more attractive than the steel lattice towers, although 21 percent felt they were less attractive. Similar responses were given regarding use of green paint on the towers (i.e., 43% said it made them better and 22% said it made them worse). On the question of landscaping used when transmission lines intersected with neighborhoods, 66 percent felt it had a positive effect and seven percent believed it was worse.

Priestley and Evans used psychometrically developed rating scales to improve the reliability of single-item indicators. They also applied multiple regression analysis to identify significant predictor variables to model the line-impact scores. In addition, discriminant analysis was used to model some of the subjective assessments of respondents. As a consequence, they were able to present detailed results about "individual characteristics and individual relationships with the line as predictors of opposition to the construction of the rebuilt transmission line and perceptions of its effects once in place." This study is an example of the quality of survey research that is necessary to begin modeling the individual and environmental concomitants of perceptions of transmission line impacts on property values.

Summary of Survey and Opinion-Based Studies

Not many surveys have been carried out in the last 12 years—only one of real estate appraisers, and three of property owners or potential purchasers—which precludes forming a valid summary of results. Individual results from these four studies show:

1. Experienced appraisers estimated a 10 percent reduction in value for residential properties proximate to a transmission line; inexperienced appraisers estimated a significantly greater reduction;

2. A majority of property owners whose residence is in proximity of a transmission line said the knowledge of potential health effects would have influenced their decision to purchase the property;

3. The presence of a transmission line did not influence the value of 30 commercial properties in Kansas City;

4. Modeling of response patterns to perceived negative impacts of a transmission line on residential property values emphasized the importance of identifying conceptually relevant variables as predictors of opposition behavior.

With so few studies, these results should be interpreted as tentative, at best, although the Priestley and Evans article offers optimism for the future of survey research on this topic. Summaries of these studies are included in Table A-2 in Appendix A.

Quantitative Sales-Price Studies

Market-Data Comparisons

Comparisons between similar properties most often use property transactions as data. In addition to sales price, time-on-market and sales volume may also be measured. The first two investigations presented used paired-sales data of residential properties from the same region and the third study used assessed property values. The results highlight the importance of careful matching between study properties and controls and the limitations that choice of the dependent variables such as sales price, time-on-market, or assessed value may impose. Table B-1 in Appendix B reproduces Kroll and Priestley's (1992) summary of appraiser studies, which combines some surveys and paired-sales methodologies, recent studies of market-data comparisons are included in Table C-2: Summary of Recent Quantitative Sales-Price Studies.

Cowger, Bottemiller, and Cahill (1996) conducted a matched-pairs study of properties near transmission lines in the Pacific Northwest region of the United States for Bonneville Power Administration. The authors selected properties adjoining 16 different transmission lines that range in voltage from 115 to 500kV and have a variety of pylon designs. Sales of these properties from 1990 to 1991 were matched with sales of comparable properties in the same communities but not in the proximity of a transmission line. The study did not find any significant difference in sales price that was related to distance from a transmission line.

Bottemiller, Cahill, and Cowger (2000) gathered updated, paired-sales data from 1994 to 1995 in those same regions. This follow-up study confirmed findings of the earlier study (i.e., minimal price effects for proximate properties). The authors did find, however, that properties near transmission lines averaged 1 to 1.5 months longer selling time (i.e., days-on-market) over the nine-month period of data collection.

Bolton (1993) collected data on assessed values, not sales prices, for 200 properties in Houston, Texas. He compared the assessed values of 100 properties adjacent to a "major power line corridor" with an equivalent number of similar properties further away from the line, and found an average difference in assessed values of about 21 percent. No attempt was made to control for intervening variables such as characteristics of the properties. Although the type of towers, line voltage, and ROW width are not mentioned, the author suggests that "this overhead power transmission line corridor may be considered typical to those corridors in many other single family detached residential neighborhoods."

These data are in agreement with findings from other surveys in which real estate professionals and appraisers were more likely to perceive a decrease in value for properties near a transmission line than were property owners. For example, Kinnard, Geckler, Geckler, Kinnard, and Mitchell (1984) found that real estate professionals were more negative about property values near transmission lines than were buyer-owners, or than appeared to be justified by market data.

Econometric Approaches

Most econometric approaches to the topic under review use multiple regression analysis with the hedonic pricing method to estimate the costs associated with proximity to a transmission line. The resulting hedonic regression reflects the desirability or quality of otherwise non-priced aspects of the environment, which in this case would be the willingness to pay for not living near a transmission line. Summaries of early econometric studies are reproduced in Table C-1 in Appendix C.

Ignelzi and Priestley (1991) conducted a study of 1,816 sales records (over 14 years) of 1,230 residential properties in eight neighborhoods in California: six transected by transmission lines, of which three experienced upgrades, and two comparison neighborhoods without a line. Overall, there was less than a one-percent reduction in sales prices as an effect of having a transmission line in a neighborhood, although there was wide variation; estimated effects on individual properties ranged from a 12 percent reduction to a 10 percent increase in sales prices. Table 3-1 lists the estimated average price effects for each neighborhood with a line.

Table 3-1
Estimated Average Change in Property Value by Neighborhood

Neighborhood	Pre-upgrade Impact % of Sales Price	Post-upgrade Impact % of Sales Price
1	+1.2	-4.2
2	+.2	-5.5
3	+.7	-8.9
4	-.4	no upgrade
5	-.4	no upgrade
6*	+2.8	no upgrade

Source: Ignelzi and Priestley 1991.
*The right-of-way was integrated into the neighborhood design.

Lower sales prices were related to passage of a transmission line through an *adjacent* property (i.e., not through the property with the price drop) and to upgrading the line after development of a neighborhood. Higher premiums on sales prices were related to integration of the ROW design into the neighborhood with unobstructed access and planned landscaping (e.g., see neighborhood 6 in Table 3-1 above). The authors also found that adverse impacts from line upgrades diminished over time, disappearing within five years.

This study used descriptive analyses and multiple regression to determine statistical estimates of relationships between property values and other factors that were measured. An hedonic price model was developed and several variables were tested for their contribution to explaining sales prices. The multi-faceted methodology the authors used avoided many weaknesses inherent in previous research of this type. The following studies also benefit from improved design and more reliable data analysis.

Hamilton and Carruthers (1993) studied records of 16,000 residential property sales that occurred over the seven-year period from 1985 to 1991 in the Vancouver, British Columbia metropolitan area. Using a series of regression models, they found that properties within 400 feet of the transmission line had adverse price effects in the range of 1.5 to 4 percent. There was no statistically significant difference in price for properties adjacent to the transmission line compared to those within 400 feet, or for properties with a view of a transmission structure compared to those without a view. Properties partially within the transmission line ROW (i.e., intersected by it) appeared to get a modest positive benefit relative to those in close proximity but not within the ROW. The authors failed to find a significant difference in proximity effects when comparing transactions before and after local press announcements suggested that prolonged proximity to power lines was a health hazard. Finally, results of unstructured interviews with seven real estate experts active in development in the study area reported that three felt transmission lines had no effect, while four felt they resulted in a property value reduction in the range of 5 to 10 percent.

Hamilton and Schwann (1995) studied a sample of 12,907 transactions of single-family residential properties in four Vancouver, British Columbia neighborhoods. In addition to looking for a link between transmission lines with voltage levels of 60kV or higher and residential property values, the authors also sought clearer econometric understanding of the hedonic price function (which has implications for econometric modeling and analysis). They discovered that the hedonic functional form was different for properties adjacent to transmission lines and properties farther removed, so they carried out separate regressions for three different distance zones (adjacent, mid-range, far) for the separate effects of tower visibility and distance from the tower and the joint effect of both. The authors found that properties adjacent to the line tended to lose 6.3 percent of their value on average, due to the interaction effect of proximity and tower visibility, and properties more distant had little if any devaluation, losing roughly one percent. They also estimated the impact of tower visibility alone for properties adjacent to the towers to be about 5.7 percent of sales price. The tower view did not significantly affect prices for mid-range or far residences (i.e., those greater than 328 feet from the line). Estimates of the effect of distance from the tower ranged from a decrease of 5.8 percent for adjacent properties to a decrease of 2.8 percent for mid-range properties. They stressed the importance of accounting for the extreme variability among groups and correcting for heteroscedasticity when attempting to model these types of relationships.

Mitchell and Kinnard (1996) studied sales data for vacant improved residential land in two rural townships in Orange County, New York. The goal was to determine whether land values were adversely affected by the construction of a 345kV overhead transmission line. They examined 376 transaction records over the period of January 1983 through December 1987. Sales prices per acre of land parcels were measured and were adjusted for inflation. The authors used hedonic linear regression models to perform time-trend analyses but found no measurable impact on the value of land adjacent to the transmission line over that time period.

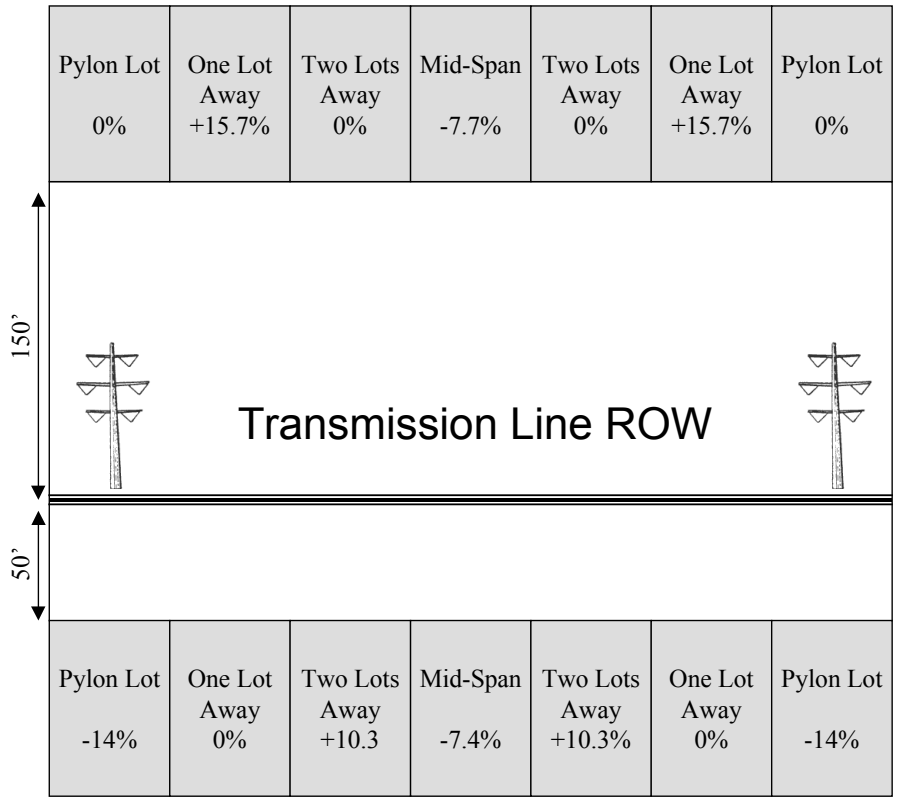
Kinnard, Geckler, and DeLottie (1997) (see also Kinnard, Bond, Syms, and DeLottie 1997) studied property sales, days-on-market, and changes in sales volume in Sun City, Nevada, and St. Louis and St. Charles Counties in Missouri. They looked at Nevada sales from 1990 through mid-1996, and Missouri sales from roughly 1989 through early 1996. These periods of sales records were chosen to capture any effect the 1992 announcements of the findings from Swedish studies on EMF and human health may have had on property values. Sales records were analyzed using multiple regression analysis and hedonic price models were produced for the data from both locations. Because of the vegetation and topographic conditions in Sun City, all households in the sample had a view of 90-foot concrete poles with 138kV-transmission lines and/or one of two substations. A 138kV-transmission line with 90-foot steel poles and four substations crossed the Missouri counties. The authors did not find a consistent relationship between proximity to, or visibility of, transmission lines (or substations) and declines in property values in either data set. Also, there was no evidence that release of the findings from the Swedish EMF studies had any consistent negative market-wide effect on prices of properties closest to the transmission lines. Visibility of structures (as opposed to "proximity") produced a 10 to 11 day increase in days-on-market in the Missouri study areas.

Haider and Haroun (unpublished) studied a sample of 27,400 single-family residence sales that took place from 1987 to 1995 in the Greater Toronto Area for properties up to 1.9 miles from a transmission line. Using spatial autoregressive techniques to incorporate unique characteristics of neighborhoods, their models indicated a 4.0 to 6.2 percent decrease in property values for

those located within 0.6 miles of a transmission line. They also found that as the distance from the transmission line increased, the mean property values increased, up to 1,640 feet. The decrease in property values with proximity to the transmission line was not consistent throughout the study area. The authors concluded that this was because there were some municipalities where properties adjacent to transmission lines were of better quality and larger size than comparable properties farther away. Properties adjacent to the transmission line also demonstrated equally good socio-economic characteristics when compared to the average for their census tract. The authors stated that their modeling could have been improved with the use of distance from the power lines as a continuous and not discrete variable, and by considering voltage of the power lines, height of the towers, lot size, and specifics on easements as independent variables.

Wolverton and Bottemiller (2003) augmented data used in a previous study (Cowger, Bottemiller, and Cahill 1996), and submitted the new data set to an analysis of covariance so that they could control for differences between subject properties adjacent to a transmission line ROW and comparable properties in the same geographic location but not adjacent to a ROW. They tested for an effect on sales price of adjacent properties, and for a difference in appreciation. The new data set consisted of 712 observations (including the original 592 properties) of residential sales that occurred from 1989 to 1992, including 300 sales of properties adjacent to a transmission line. The authors estimated four different models, two using the natural log of price as the dependent variable, and two using the nominal price. All of the modeling approaches supported the finding of no significant evidence of price effects for properties adjacent to transmission lines. In addition, they did not find evidence that adjacent properties appreciated at a different rate than non-adjacent properties.

Des Rosiers (2002) studied sales records of 507 single-family houses in the Greater Montreal area from 1991 to 1996, using a micro-spatial approach (i.e., an examination of detailed lot-specific characteristics) to investigate the effects of proximity to a transmission line on property values. The study area has a 315kV-transmission line mounted on improved visual appearance conical steel pylons running through its center. The ROW corridor is 200 feet wide and the line is 50 feet from the eastern boundary and 150 feet from the western boundary. This setback asymmetry produced some interesting results. Distance to the line and to pylons, and view of the line and pylons were factors included in a multiple regression analysis. Figure 3-1 provides a summary of results.



* Percentage sales-price changes reflect averages of all significant coefficients from various functional forms and are presented as general indicators. They reflect gross location effects.

Figure 3-1
Effects* of Transmission Line and Pylon Proximity–Des Rosiers Study

Properties adjacent to the transmission line showed a mean increase in value of 0.2 percent. This result is misleading, however, because it is the nature of the arithmetic mean that the increases in property value roughly offset the decreases. As the figure illustrates, properties adjacent to the transmission line did not necessarily have an increase in value. Average value changes for adjacent property groups, characterized both by their position relative to the pylon, and their setback distance (i.e., whether they are located on the 50-foot or 150-foot setback side) ranged from a decrease of 14 percent to an increase of 16 percent. Even property groups with the same position relative to the pylon but with different setback distances showed remarkable variation in property-value effects. Properties located at mid-span showed similar average value decreases regardless of setback distance. The most negatively affected properties were those deemed "severely visually encumbered" (i.e., adjacent properties with a direct view on a pylon). Less-expensive properties thus encumbered showed value reductions of 10 to15 percent while more-expensive properties showed reductions of 15 to 20 percent.

Non-adjacent properties with a view of structures generally experienced higher property values, which the author suggested may be due to improved visual clearance. Houses with limited or moderate rear or side view of the corridor received an average 3 to 4 percent premium on market price. The author pointed out that negative visual impacts, when applicable, appeared to diminish rapidly with distance and were no longer significant at 500 feet.

Considering this detailed study, the limitation of using summary statistics to describe the relationship between transmission lines and property values becomes clear. Reporting an average change in property values obfuscates the actual effects on individual properties. On the other hand, a drawback to analyzing property values at this level of detail is that sample sizes become very small (e.g., the overall sample of 507 sales in this study included only 34 sales of properties adjacent to the transmission line, which were then split into the various categories of setback and distance from a pylon).

Summary of Quantitative Sales-Price Studies

Table C-2 in Appendix C lists summary information on recent quantitative sales-price studies. The two primary factors that have been investigated with respect to property values are proximity to a transmission line, and view of a structure such as a tower, pole or pylon (i.e., visual encumbrance).[5] To summarize the findings from the 11 sales-price studies presented in this report, four found that proximity to a transmission line had a negative effect on property values, five found that it had no effect, and two that looked in more detail at proximity and view relative to transmission structures found highly variable effects, both positive and negative. How are these findings to be reconciled? A number of issues are relevant, as listed below.

- Results often report average price change over a number of properties. Studies reporting summary statistics have found an average change in property values ranging from a slight increase to a decrease of up to 6.3 percent attributed to proximity to a transmission line. Averaging changes in sales prices over properties produces results in which positive and negative effects tend to cancel each other out. Even when sales prices are broken down by category (e.g., adjacent properties, properties within 100 feet), unless all of the properties in a category experience identical effects, this practice does not provide meaningful information;
- Few studies have investigated detailed local effects on individual properties. Studies that looked in greater detail at individual properties found much wider variation in property values, both positive and negative. This level of detail is needed to understand the complicated relationship between transmission lines and property values. In fact, a review of the studies presented in this report suggests that much of the apparent variation in results stems partly from varying levels of specificity in measurement. The difficulty with this approach is gathering enough data to insure statistical power;
- In calculating the overall impact of a transmission line on property values, it is acceptable to take into account both negative and positive effects and arrive at an average. As a planning tool in communicating the general effect of a line, the average change in property values may be useful; and
- On the other hand, in calculating compensation for negotiation with property owners, the data must portray two different groups of properties, those affected positively, and those affected negatively. For properties expected to have a negative effect, the data can be used to establish fair compensation. For properties expected to have a positive effect, the data can be

[5] Three studies (Des Rosiers 2002; Hamilton and Carruthers 1993; Kinnard, Geckler, and DeLottie 1997) looked for changes in property values that could be attributed to publicity from the Swedish reports linking EMF from power lines with health issues but failed to find any effects.

used as a foundation for negotiation of lower compensation, if any. This approach, in the end, is an argument for variable compensation. Even though proximity to a transmission line results in a gain in value for some properties and a loss for others, overall, the gains are essentially meaningless in the final accounting, because they will never be recouped by an energy company.

A number of factors limit generalization of results. In addition to local effects of proximity, view, property characteristics, and land use, a number of other variables related to transmission infrastructure limit generalization of findings from recent studies:

- Regional factors, such as variation across regions of the United States and Canada;
- Structural factors, such as pole design, line voltage, landscaping, topography; and
- Temporal factors, such as issue evolution, age of lines, currency of data.

4
CONCLUSIONS

Quoting from William N. Kinnard Jr. (1990), " . . . no quantitative generalizations about findings from the studies can be made with any degree of reliability." Still today, differences in location and time of data collection, as well as research design, make direct comparisons of results from all of the studies reviewed very difficult. That said, the research projects covered in this report do suggest a number of conclusions that are not substantially different from what we already knew, as listed below.

- There is evidence that transmission lines have the potential to decrease nearby property values, but this decrease is usually small (6.3% or lower);
- Lots adjacent to the ROW often benefit; lots next to adjacent lots often have value reduction;
- Higher-end properties are more likely to experience a reduction in selling price than lower-end properties;
- The degree of opposition to an upgrade project may affect the size and duration of the sales-price effects;
- Setback distance, ROW landscaping, shielding of visual and aural effects, and integration of the ROW into the neighborhood can significantly reduce or eliminate the impact of transmission structures on sales prices;
- Although appreciation of property does not appear to be affected, proximity to a transmission line can sometimes result in increased selling times for adjacent properties;
- Sales-price effects are more complex than they have been portrayed in many studies. Even grouping adjacent properties may obscure results;
- Effects of a transmission line on sales prices of properties diminish over time and all but disappear in five years;
- Opinion surveys of property values and transmission lines may not necessarily overstate negative attitudes but they certainly understate (or ignore) positive attitudes; and
- The release of findings from the Swedish study on EMF and health effects had no measurable influence on sales prices.

This report presents the advantages and disadvantages of the different methodological approaches employed in recent research, the necessity of investigating a variety of cultural and geographic settings, the importance of using large, accurate, and reliable data sets, the value of conducting sophisticated statistical analysis, and the significance of asking the right questions.

5
RESEARCH NEEDS

In setting out an agenda for future research, five areas of need are paramount:[6]

- Address flaws in current methodologies to promote consistent and comparable studies.
- Address the range and limits of variables that have an impact on the value of specific types of properties.
- Employ methods to incorporate variation in personal and social values, as well as attitudes.
- Expand research to a variety of property types.
- Set up longitudinal studies to track the timing of effects and changes in public information and transmission infrastructure technology.

A number of researchers have also identified areas of methodological concern:[7]

- Paired-sales studies should be augmented with field surveys to insure complete information on properties under study.
- A consistent methodology using well-defined property characteristics and line characteristics should be employed in a variety of geographic and land-use settings.
- External effects on data over time must be considered, such as inflation and technological advances.
- When heteroscedasticity of the data exists, it should be accounted for and corrected.
- Limitations of cross-sectional models should be recognized and supplemented with several separate models or one incorporating time series.

Some progress in our understanding of the effects of transmission lines on property values has been made over the past 12 years; however, we still do not have a clear picture of the relationship. One problem has to do with the sheer number of property variables and transmission infrastructure variables that need to measured and investigated, both singly and in combination. No one study can address the complex nature of the transmission line/property value relationship. Quantitative research employing a consistent methodology is needed to add to our knowledge of the impact of particular variables and their interactions. The key is to carry out studies with enough detail to be meaningful and enough breadth to be generalizeable.

[6] Individual topics are discussed by a number of investigators (e.g., Kroll and Priestley 1992; Montgomery 1994).

[7] For example, see Kroll and Priestley 1992; Hamilton and Carruthers 1993; Montgomery 1994.

In addition, there is a continued need for qualitative studies on perceptions of the effect of transmission lines on property values. Studies on perception provide a context for quantitative research and can identify variables to select for further study. By combining qualitative and quantitative studies, overall perceptions can be identified in relationship to demonstrated impacts. Development of a research design that would incorporate measurement of attitudes and perceptions into econometric studies of property values has been advocated by a number of researchers as a way to support our understanding of the factors that affect property values. A set of these studies, in combination, could provide energy-company professionals charged with routing a transmission line with substantive information that could be useful for public information sessions and in negotiations with individual property owners.

A
SURVEY AND OPINION-BASED STUDIES

Table A-1
Summary of Attitudinal Studies from Kroll and Priestley (1992)

Author/ Date	Type of Study	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Key Property Value Related Findings
Mitchell et al. 1976	perception study	230kV, and control area one mile away with no line	rural area in southern Ontario	farm land, and rural non-farm	questionnaires administered through face-to-face interviews	32 respondents	33% of respondents near line believed line had negative effect on property; 94% in the control area felt that the line had reduced nearby property values
Boyer et al. 1978	perception study	230kV, 500kV, and control areas one mile away with no lines	rural area in southern Ontario	farm land, and rural non-farm	questionnaires administered by drop-off for mail-back and pick-up	108 respondents	44% near lines said lines were a purchase consideration; 74% near lines thought lines affected property values; 12% near lines considered selling because of power lines; 78% in control are said presence of lines would be a property purchase consideration; 79% in control area thought lines affected property values in vicinity; opposition to lines peaked in planning/construction phase, diminishing in time; most lasting impact was perception of negative property value effect

Author/ Date	Type of Study	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Key Property Value Related Findings
Real Estate Counseling Group of Connecticut May 1984 (a.k.a. Kinnard et al. 1984)	perception study: supplement to hedonic model	345kV line	New York metropolitan region's exurban area	single family residential	questionnaires mailed to town assessors and realtors; in-person and mail questionnaires for property owners within line's vicinity	4 assessors; 21 real estate brokers and appraisers; 47 property owners; 9 long term owners within 300' of line; 58 recent home buyers within 1600' of line	assessors: 2 said no effect, 2 said lower value due to line's proximity; real estate Professionals: 90% thought lines often or always reduced sales prices; 86% thought properties close to line sold more slowly, less than half said financing is harder to obtain for property near line; residents included in hedonic study: 60% knew of lines, 7% paid less due to lines, 88% would by again, 54% said no effect on value; post-project purchasers: 52% knew of line, 14% paid less due to lines, 56% would by again, 7% would require reduced price, 26% would require reduced price and good financing if doing this again
Market Trends June, 1988	opinion survey on line and substation appearance policies	various	metropolitan Phoenix, AZ:	urban and suburban households	surveyed households in proximity to existing lines & substations, and random households with no proximity requirement	200 households near lines and substation; 900 surveyed at random	53% of respondents thought proximity to lines and substations reduced property values; little difference in opinion between those near lines & substations and the general population.
Rhodeside and Harwell June, 1988	perception study	various	Virginia suburbs and Washington, D.C.	residential neighborhoods	questionnaire to residents adjacent to existing transmission lines	205 residents; 10 different neighborhoods	57% said no effect on property value, 27% said negative effect, 16% said positive effect due to open space, 74% would buy again; highly visible line had more likely negative effect, wooded right-of-way had more positive effect; owners in are before line built more likely to have negative impression of line

Author/ Date	Type of Study	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Key Property Value Related Findings
Economics Consultants Northwest June, 1990	perception study	500kV	western Montana	suburban and rural residences	face to face and telephone interviews	400 residents	50% of respondents within one mile of line felt there was a negative effect on property value; only 5% living one to three miles away said the same
Beauregard Conseil, Enr. July, 1990	post-construction perception study	450kV	along the St. Lawrence River, in Quebec	rural and second home residences	focus groups, questionnaire surveys	20 in focus group within 2 km of river crossing. 202 surveyed with view of river crossing.	12% of respondents concerned with property value impact, 49% were concerned with the line's effect on appearance of the landscape
Priestley and Evans December, 1990	perception study of recently rebuilt transmission line	115kV and 230kV	northern California	single family residential	questionnaire surveys	266 residents within 900' of rebuilt power line	65% thought line had a moderate to large negative effect on property value; 30% said no effect, 5% said positive effect, 8% had strong reservations about buying near line, 39% had mild reservation, 52% weren't influenced, 1% more interested; higher impact seen by those in area before rebuild; rank of concerns: 1) health/safety, 2) property value, 3) aesthetic

Table A-2
Summary of Recent Survey and Opinion-Based Studies

Author/ Date	Type of Study	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Key Property Value Related Findings
Delaney and Timmons 1992	perception study of real estate appraisers to find perceived effect on market value	not applicable	United States, multiple areas	residential	mail survey	219 appraisers responded from throughout the US	84.0% felt market value was lower for properties proximate to transmission lines; range of value decline for properties bordering or within sight of transmission lines was 0-50% (averages for regions ranged from 7.77 to 15.5% with an overall average of 10.3% standard error of 0.49); average decline varied by region; less experienced appraisers suggested greater effects; visual unsightliness was stated as the leading reason for the price effects
Gallimore and Jayne 1997	perception study of property occupiers and valuers in the UK	132kV	west Midlands, UK, 1997	residential	mail survey sent to occupiers and valuers, rank risks of living near HVOTLs with other risks	45 responses from the public and 35 responses from valuers	valuers perceive the risk of living near power lines to be greater than the public does; authors point out that there is a danger that valuers may amplify public fears in formulating their advice
Priestley and Evans 1996	perception study of residents living near a transmission line	115kV with 60' lattice steel towers upgraded prior to survey to add a 230kV line with 120-160' tubular steel towers	California	residential dwellings within 900' of upgraded line	mail survey, psychometric rating scales, multiple regression to identify predictor variables, discriminant analysis	266 questionnaires	over 75% had negative or very negative feelings about the transmission line and 75% rated the line's appearance as somewhat or very unattractive; 87% felt line had negative effect; 47% felt tubular towers helped, 21% thought they made it worse; similar feelings were expressed about use of green paint; improved landscaping at highly visible intersections with neighborhoods was favorably viewed by 66%; respondents overestimated the visibility of structures from their residences especially those who opposed the line prior to construction

Author/ Date	Type of Study	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Key Property Value Related Findings
Sims and Dent 2003	perception study using visual simulation techniques ant attitude surveys, residents and chartered surveyors	various structures	west Midlands, UK	residential	survey, psychometric testing, listed power lines among list of possible contaminants	109 responses from residents, almost 400 responses from surveyors, 45 responses to follow-up questionnaire from surveyors	HVOTLs were considered a contaminant by 88% of respondents with 56% saying it was due to health risks; visual simulation exercise with surveyors and estate agents asked to re-value a sample residence with addition of structures, there were differences in surveyors and agents perceived impacts on residences; in separate more in-depth study of HVOTLs only, most surveyors and agents reduced value by 5-10%, professionals more experienced in working with HVOTL-proximate properties produced greater reductions
Right of Way Associates 2001	interviews of owners, leasing agents and property managers about adverse effects	rating not available, single poles and H-frames	Kansas City metropolitan area (KS and MO)	commercial	survey, summary statistics	30 properties	found no quantifiable impact from transmission lines on rent levels, marketing time, sales prices for properties or tenant's desire to rent space; all encumbered land was used as either parking or green space

B
APPRAISER STUDIES

Table B-1
Summary of Appraiser Studies (adapted from Kroll and Priestley 1992)

Author/ Date	Client	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Conclusions
Ball 1989	utility company	69kV or 230kV line (some with 12kV line, also) 120' easement	Arizona	developed residential; undeveloped residential commercial, industrial; agricultural	comparison of average sales values; paired sales; interview with rental agent (multifamily only)	8 case studies; between 4 and 200 sales, depending on case	mixed; no impact for some residential, < 5% loss in value for other developed residential; 12+% impact on commercial & industrial from easements; overall 2% effect on farmland, 44% loss of value for easement area
Ball 1979	independent	69kV line 230kV line 500kV line	Arizona (Phoenix and Tempe)	residential	survey of homeowners and sales agents	5 subdivisions Small number of homeowners and agents	developers gave no discounts for proximity to a power line, even when 3 lines involved
Ball 1983	independent	69kV 138kV 230kV	Arizona (Phoenix and Tucson)	mobile home	survey of mobile home park managers	6 mobile home parks	managers received no complaints about lines and did not lower prices for sites adjacent to line
Blanton 1980	utility company	69kV 138kV 345kV	Texas	single family homes	mean difference among matched sales (dollars per square foot); homeowner interviews	3 subdivisions, 39 parcels on the ROW, 351 in subdivision, not on ROW	no set pattern--(values ranged from $8 less per square foot for ROW homes to $11 more); no stated concern among homeowners
Thompson Associates 1985	Bonneville Power Administration	230kV (proposed 500kV line)	western Montana	suburban and rural residential, improved and unimproved	comparison of sales prices among similar properties	2 areas (suburban, rural); 8 homes or sites, total	no adjustment to market price for properties encumbered by or in view of line

Author/ Date	Client	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Conclusions
Oregon 1983	utility company	500kV 175' ROW	Oregon/ Idaho boarder	agricultural (grazing land)	comparison of sales along ROW with sales from previous study; interviews with buyers and sellers	8 sales	value affected only by amount of land removed by tower, roads; owners perceive effects if potential exists for residential or if lines disrupt irrigation
Jensen and Weber 1982	utility company	230kV 400kV	west-central Minnesota	farm land	comparison of sales prices of encumbered and unencumbered property	25 encumbered, 57 unencumbered sales	broad range from no effect to 20% reduction, depending on amount of disruption to farm operations
New Jersey 1989	utility company	proposed 230kV (in existing railroad ROW)	New Jersey	residential, commercial, industrial, resid-agri., case studies: residential lots and homes	visual inspection of proposed route, survey of home values on similar lines	7 case studies 48 encumbered, 43 unencumbered properties	because of existing ROW, new line would not impact values; case studies showed no effects of ROW in most cases (up to a 10% effect in one case, but with few observations)
Van Court and Company 1988	Public Services Company of Colorado	upgrade of 115kV to 230kV within existing easement	Colorado	residential and open space	market-data comparison	40+ sales	average price of properties with existing line about 3% below those away from line, but variance high and prices overlap; no further price effect from upgrade
Rasmussen 1976	utility company	not stated	North Dakota	agricultural land	sales data and interviews	100 verified sales	transmission line not significant in prices, respondents rarely mentioned it

Author/ Date	Client	Line Features	Geographic Area	Property Type	Methodology	Number of Cases and Observations	Conclusions
Jensen and Weber 1979	utility company	450kV, 875' ROW (Note: Fee purchase rather than easement; Company allows free use of land)	Manitoba Province (Canada)	agricultural land	interviews of property owners compared sales	6 owners 6 sales	individuals mentioned inconvenience but no production effects or drop in property values
Jensen Management Company 1980	utility company	118kV 230kV 345kV 500kV	west-central Minnesota	residential, commercial/ industrial, mobile homes park, office building	interviews	53 interviews	10-25% felt the property value was lowered by the line, with residential more concerned than nonresidential
Weber and Jensen 1978	utility company	230kV, 125' ROW, built in 1950s	west-central Minnesota	agricultural	interviews and sales analysis of encumbered and comparable properties	4 counties; 10 encumbered, 20 unencumbered parcels	owners cited inconvenience but had not paid less, felt it was a “seller’s market”
Earley and Earley 1988	utility company	proposed 230kV line; comparison with views of 44kV, 100kV, and 230kV; views only no ROW cross	North Carolina	residential lots, single fam homes, condominiums	paired-sales	5 property types, total of 110 sales	no discernable effect on market value

C
QUANTITATIVE SALES-PRICE STUDIES

Table C-1
Summary of Statistical Analysis Studies (adapted from Kroll and Priestley 1992)

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance*	Conclusions
Blinder 1979	State of Maryland	230kV, 80ft ROW, lots abutting ROW, tower behind backyard	Maryland	residential subdivisions, 1972-75, 1970-72	t-test of means; multiple regression	2 subdivisions 350+ observations	R-squared 0.57, 0.82, Regression results: (for lots only) abut transmission line: significant tower: significant	t-test of means showed no difference in home price; significant (negative) difference in lot price for lots in one subdivision
Boyer et al. 1978	Royal Commission on Electric Power Planning	230kV; 500kV/ in or out of zone with line; before or after 500kV construction	Ontario	agricultural; 1967-77	chi-squared tests by size category	2 study areas, 1,000+ cases	# of sales: 500kV – significant at >99% confidence; 230kV – significant only at 80% confidence price: Chi-squared results not described	fewer sales occurred near the 500kV line; sales prices were 16-29% lower in zones with transmission lines
Brown 1976	not stated	72kV and higher; # of lines per lot	Saskatchewan Province	agricultural, 1965-70	multiple regression	2 districts, 411 quarter section sales, 377 half section sales	R-squared from 0.55 to 0.71; number of lines not significant	transmission lines affect farm productivity in the immediate vicinity, but the effect does not appear to be strong enough to lower property values

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance*	Conclusions
Carriere, Chung and Lam 1976	Hydro-Quebec	120kV, 71' high; 735kV; compared sales in transmission line and control zones	Quebec	urban – multi-family housing urban fringe – residential-recreational ("riveraine"), agricultural and single family homes, 1960-76	multiple regression	urban – 190 units, 1965-76; urban fringe – 91 riveraine, 1960-76; agricultural – 113, 1960-76; single-family and vacant lots – 101, 1971-76	urban – many models, results range from R-squareds of 0.07 to .92; TL zone sometimes significant, sometimes not; higher significance for resales	in some cases transmission lines appear to affect property values; in other cases no impact is apparent, although this may in part occur from data limitations (only tested urban area statistically)
Colwell 1990	independent (academic)	138kV, 50' ROW; distance from line; tower on property; easement on property; effect over time	Illinois	single family homes, 1968-78	multiple regression, exponential model	2 neighborhoods, 200 sales	R-Squared 0.77; several models tested; distance from the line always significant at 95% or higher; tower not significant or at 90% only; timing of sale significant at 90 or 95%; easement significant at 95%	the distance from the line affects the price of the home, with the major changes seen in the first 50' from the line; distance affects property value apart from any impacts of the easement; effects diminish over time
Colwell and Foley 1979	independent (academic)	138kV, 50' ROW; distance from line; tower on property	Illinois	single family homes, 1968-78	multiple regression, exponential model	2 neighborhoods, 200 sales	R-squared 0.75; distance from line significant; tower behind lot not significant	the distance from the line affects the price of the home with the major changes seen in the first 50' from line; no distance effect beyond 200'

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance*	Conclusions
Kinnard and Mitchell 1988	New York Power Authority	345kV, distance zones and before/ after specific route selected	New York State	vacant land, residential categories, abandoned ag land, waterfront, commercial, 1983-87	multiple regression (stepwise regression)	397 sales	R-squared 0.69, distance zones not significant; significant positive effect for sales after route announcement	no evidence that transmission line affects the value of vacant land in the study area
Kinnard et al. 1988	Utility Company	345kV, 10 years after construction, distance zones	Maine	single family homes and vacant land, 1978-88	multiple regression (stepwise regression)	6 towns, 305 homes, 247 vacant parcels	R-squared 0.57, no zones significant at 90% or above, although those closest to line have negative signs	no significant effect on property values
Kinnard et al. 1984	New York Power Authority	345kV, distance zones	New York State	single family homes, 1972-84	matched-sales, interviews, ANOVA, simple and multiple regression	up to 329 sales	R-squared 0.49, no significant differences among equations by zone, slope of simple regression analysis showed prices rising faster in areas close to line	no significant effect on property values

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance*	Conclusions
Kinnard, Mitchell and Webb 1989	New York Power Authority	345kV, distance zones and before/ after specific route selections	New York State	vacant land, residential categories, abandoned ag land, waterfront, commercial	multiple regression (stepwise regression), MANOVA	371 sales	R-squared values up to 0.69, zone variables not significant, after period significant and positive	no negative effect of power line on property values
Mitchell et al. 1976	Royal Commission on Electric Power Planning	not available	Ontario	agricultural and rural estates, 1966-71	chi-squared tests of difference of means	81 sales	chi-squared ranging from 0.245 to 1.491, indicating significance only 10-70% of the time	property near the power line was neither likely to appeal to a different set of buyers, nor were prices lower near the power line
Pacific Consulting Services 1991	Southern California Edison	115kV, 230kV, distance from line, # of towers seen, crossed by ROW, effects of upgrade	California	single family homes, 1976-89	multiple regression	7 neighborhoods, 1800+ sales	R-squared of 0.84, upgrade has significant negative effect, upgrade effect lessens over time, sign and significance of distance vary by neighborhood, easement has significant negative effect	the effect of upgrading the line from 60 to 160' high is negative, affecting property values by 5% or less; some evidence that effect reduced with time; ROWs developed for recreational use may have positive effects

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance*	Conclusions
Thompson 1982	masters thesis, University of Alberta	64kV (1952), 240kV (1969, 1978-80)	Alberta Province	agricultural land, 1976-81	matched pairs, comparable sales comparisons, multiple regression	74 recorded sales (26 encumbered), 69 questionnaires	R-squared of 0.52 to0.86, significant effects found when 2 lines crossed the property (at 99% confidence level)	presence of more than one line reduces property values, especially for land with irrigation potential
Université du Québec à Montréal 1982	Hydro-Quebec	735kV (built 1975), 120-161kV (built 1973), distance/ visibility scale easement	Quebec Province	second homes (vacant land and developed), 1965-81	multiple regression	2 regions, 946 sales	R-squared from 0.47 to 0.55, distance/visibility, scale significantly negative for all but developed sites, easement significant and positive for all but developed sites	transmission lines affect the value of land for second homes with effects up to 34%; smaller parcels are affected more severely than larger parcels
Woods Gordon 1981	Ontario Hydro	230kV, 500kV, distance, towers, ROW crossing	Ontario	agricultural land, 1969-79	case studies and multiple regression	6 line segments, 1000+ observations	R-squared not reported, some power line variables significant and negative at the 95% level, but only in 2 of the 6 cases	evidence exists of widely varying impacts, from negative effects in areas with residential potential to positive effects in some agricultural areas

* Significance level: Statistical analysis tests whether the estimated parameter is significantly different from zero. A parameter is normally considered significant when the analysis shows that the results would be different from zero in 95 percent of cases or more (a 95% confidence interval).

Table C-2
Summary of Recent Quantitative Sales-price Studies

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Bolton 1993	undisclosed	undisclosed	Houston, Texas	residential, single family detached, data dates unknown	paired-assessed values	4 subdivisions, 200 assessments	not available	assessed values showed T-line related property value differences of 21% (reduction) on average
Bottemiller, Cahill, and Cowger 2000	Bonneville Power Administration	16 lines ranging from 115-500kV, various pylon designs and ROW features, also studied selling time	Portland, OR; Vancouver, BC; Seattle, WA	residential single family dwellings, 1994-95	pair-wise matches and comparison of means, multiple regression	260 matched pairs sales	R-squared not given, 95% confidence	no significant relationship between transmission line proximity and selling price, properties near lines had 1-1.5 mo. longer selling times
Cowger, Bottemiller, and Cahill 1996	Bonneville Power Administration	16 lines ranging from 115-500kV, various pylon designs and ROW features	Portland, OR; Vancouver, BC; Seattle, WA	residential single family dwellings, 1989-92	pair-wise matches and comparison of means, multiple regression (stepwise regression)	296 matched pairs sales	R-squared 0.04, 95% confidence	no significant relationship between transmission line proximity and selling price

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Des Rosiers 2002	independent (academic)	315kV line on improved visual appearance pylons, 200' ROW, line 50' from one side, 150 from other distance from line, tower proximity, view of structures, effect of Swedish epidemiological studies	Greater Montreal Area, Quebec	residential single family houses, 1991-96	standard and stepwise regression, (linear and log-linear forms), micro-spatial method uses property/line positioning for analysis	3 neighborhoods, 507 sales	R-squared .951 (linear) and .968 (log-linear) for the global sample, ranged from .857 to .973 for the other models	price effects for adjacent properties averaged +0.2% and ranged from –14% to +15.7% depending on setback distance and tower position relative to the property; direct view on a pylon or the sag point of lines had effects on prices ranging from 0 to –14% of value; non-adjacent properties with view of the line had price benefits possibly due to enlarged visual field, found no apparent price effects from Swedish studies

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Haider and Haroun (unpublished)	Masters thesis funded by NSERC Collaborative Project and Individual Operating Grants	power line characteristics not given, distance from line, housing quality and line proximity, differences in perceptions between neighborhoods, socio-demographic characteristics of houses	Greater Toronto Area	residential single family dwellings, 1987-95	spatial autoregression (SAR) and ordinary least squares models, T-test of means	27,400 sales records, 27 communities	R-squared 0.81% (SAR)	found 4.0 to 6.2 percent decrease in property values for those located within 0.6 miles of a transmission line; as distance from line increases mean prices for properties increases up to a distance of 1,640'; some communities reported higher mean prices for properties within 328' transmission lines than for those at greater than 328' distance; found no evidence of lower socioeconomic status for census tracts with power lines

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Hamilton and Carruthers 1993	Undisclosed	various line and tower types, effects over distance and over time, changes with news story alleging possible health effects	metropolitan Vancouver	residential, 1985-1991	multiple regression, beyond 270m are controls	5 neighborhoods and 15,663 sales records	R-squared 0.84	price effects of transmission lines fall in the 1.5 to 4% range and are limited to properties within 394' of the line; no statistically significant difference in prices for adjacent properties versus those close to the line; properties partially within the ROW have benefit; no shift in prices seen after news story

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Hamilton and Schwann 1995	Real Estate Foundation British Columbia and Lusk Center for Real Estate Development	2 areas with 460' corridor with 2 500kV and 1 230kV lines on steel towers, 1 area with 2 transmission lines on steel towers and one area with a 60kV line on wood poles,	metropolitan Vancouver area	residential single family detached dwellings, 1985-91	multiple regression	4 neighborhoods, 12,907 sales	because distance zones had different functional forms, used Box Cox transformation of dependent variables to correct for heterosce-dasticity, translog model, separate regressions for each zone	moving a property from adjacent to mid-range increases value by 5.8% (t stat=5.32); removing tower view for adjacent property increases value by 5.7% (t stat=1.91); moving property from mid-range (328') to 656' increases value 2.8% (t stat=8.88); removing both tower and ROW from adjacent properties increases property values 6.3% (t stat =2.75)

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Ignelzi and Priestley 1991	Southern California Edison	3 neighborhoods have 115kV upgraded to 115kV/230kV combined, two have 115kV, and one has 230kV line variation with distance, view and over time, lines built prior to neighborhood, line upgrades	California	residential single family detached, 1976-89	multiple regression	8 neighborhoods, 6 with trans lines and 2 without	average impacts model r-square =.84, 95% confidence level, yearly impacts model r-square =.84, 95% confidence level	found less than one percent reduction in average sales prices; lower sales prices for properties when line passed through an adjacent property; some neighborhoods had higher prices for properties next to line; upgrades in existing neighborhoods had higher impacts –4.2 to –8.9%, but gone in 5 years

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Kinnard Geckler and DeLottie 1997	Paper presented at 1997 Annual Conference American Real Estate Society	90' concrete poles with 138kV lines (Sun City), and 90' steel poles with138kV lines and 4 substations (MO counties), visibility of structures (MO only), Swedish studies effect	Sun City (Las Vegas) NV, St. Louis and St. Charles Counties, MO	single family, duplex, triplex and quadriplex residences (NV), detached single family residences (MO), 1989-96 (NV) and 1990-96 (MO)	multiple regression, modified Log-Log model	5,952 sales and 6 distance zones (NV), 1,377 sales records, 5 study areas and 5 distance zones (MO)	R-squared 0.92 (for each of 2 models), 95% confidence level	no consistent relationship between proximity to or visibility of structures and declines in property values; no evidence of consistent negative market-wide effect on prices for properties closest to lines; no evidence of negative impact from Swedish study; structure visibility (in MO) produced 10-11 day average increase in days on market

Author/ Date	Client	Line Features/ Factors Tested	Geographic Area	Property Type/ Time Period	Methodology	# of Cases and Observations	Statistical Results, R-Squared, Significance	Conclusions
Mitchell and Kinnard 1996	New York Power Authority	345kV, effect of construction and route announcement	Orange County NY	undeveloped rural residential land, 1983-87	multiple linear regression and time trend analyses	376 sales records	linear model had R-squared 0.70, semi-log model (used ln of size) had R-squared of 0.62	no measurable effect on property values associated with construction of the transmission line
Wolverton and Bottemiller 2003	Bonneville Power Administration	16 lines ranging from 115-500kV, various pylon designs and ROW features, also studied selling time, variation in price appreciation	Portland, OR; Vancouver, BC; Seattle, WA	residential single family dwellings, 1989-92	ANCOVA test for abutting line effect on sales price, 4 models – 2 used in price as dependent variable, 2 used nominal price	The original (1996) study had 296 matched pairs sales (592 observations), this added subject properties and comparable sales to increasing observations to 712	adjusted R-squared range 0.85 to 0.86, for price effects due to abutting lines t statistics were 0.06 to 0.90 (threshold level for significance =1.65 at 90% confidence level and 1.96 at 95%)	no evidence of significant effects on price for properties adjacent to a transmission line; evidence that prices of these properties appreciated differently than did properties not adjacent to a t-line

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