part 3

Lennhoff

WITNESS REBUTTAL TESTIMONY SUMMARY

Witness: David C. Lennhoff

Title: Senior Director of the Altus Group U.S., Inc.

Summary:

Altus Group U.S., Inc. Witness David C. Lennhoff testifying on behalf of the Company addresses the impact of a proposed power line easement and presence of a high voltage transmission line ("HVTL") on adjacent and nonadjacent properties. His analysis is limited to those properties not actually encumbered by the transmission line right-of-way easement.

Mr. Lennhoff explains there is no consensus in literature that property abutting a right-of-way suffers a value loss. He explains many studies indicate that an HVTL has no significant effect on residential property values. When negative impacts are found, studies report an average discount of between 1% and 10% of property value. Importantly, however, these impacts diminish as distance from the line increases and disappear at a distance of 200 feet from the HVTL. Value diminution attributable to HVTL proximity is also temporary and usually decreases over time, disappearing entirely in 4 to 10 years. Mr. Lennhoff also disputes claims that proximity to an HVTL will make a property more difficult to sell or otherwise impact its time on the market.

Mr. Lennhoff further notes as a general rule, that the effects on commercial properties are much less evident than any on residential property. There is simply no evidence that commercial properties adjacent to but not actually encumbered by an HVTL see any loss in marketability or overall market value. The same would, of course, be true for those properties not immediately adjacent to, but with a view of, the HVTL. .

REBUTTAL TESTIMONY
OF
DAVID C. LENNHOFF
ON BEHALF OF
VIRGINIA ELECTRIC AND POWER COMPANY
BEFORE THE
STATE CORPORATION COMMISSION OF VIRGINIA
CASE NO. PUE-2015-00107

Q. Please state your name, position, and business address.

A. My name is David C. Lennhoff and I am Senior Director of the Altus Group U.S., Inc. My business address is 7900 Westpark Drive, Suite T600, Tysons, Virginia 22102.

Q. What is your educational and professional background?

A. I earned my Bachelor of Arts from the University of Kentucky, Lexington, and have been a Certified General Real Estate Appraiser in Washington, D.C., the Commonwealth of Virginia, the Commonwealth of Pennsylvania, and the states of Maryland, New Jersey, Minnesota, Texas, Iowa, Michigan, Indiana, Florida, Georgia, and Arizona. I am a member of the Appraisal Institute, the Counselors of Real Estate, the Real Estate Counseling Group of America, and the Royal Institution of Chartered Surveyors.

My position involves leading the Altus Group U.S. appraisal practice. My staff and I at Altus Group provide client services in absorption studies – for both leasing and sales analysis – and conduct appraisals for acquisitions and third-party reviews. My expertise spans demographic and marketability analysis, real estate valuation, and risk analysis in virtually all U.S. and several Canadian real estate markets.

A more detailed statement of my background and qualifications is attached as Appendix A.

Q. Have you previously submitted testimony before the State Corporation Commission of Virginia ("Commission")?

A. Yes. I provided testimony on behalf of Virginia Electric and Power Company ("Dominion Virginia Power" or the "Company") in Case No. PUE-2007-00031, *Joint Application of Virginia Electric and Power Company d/b/a Dominion Virginia Power and Trans-Allegheny Interstate Line Co., For certificates of public convenience and necessity to construct facilities: 500 kV Transmission Line from Trànsmission Line #580 to Loudoun Substation.*

Q. What is the purpose of your rebuttal testimony?

A. I have been retained by Dominion Virginia Power to review the testimony of respondents and public witnesses regarding the impact of a proposed power line easement and presence of a high voltage transmission line ("HVTL") on adjacent and nonadjacent properties. My analysis is limited to those properties not actually encumbered by the transmission line right-of-way easement; I have not evaluated right-of-way acquisition costs for the real estate nor damages, if any, to encumbered residual properties.

Q. Are you sponsoring any exhibits as part of your rebuttal testimony?

A. Yes. Company Exhibit No. __, DCL, consisting of Rebuttal Schedules 1-4, was prepared under my direction and supervision, and is accurate and complete to the best of my knowledge and belief.

Q. Are you familiar with Dominion Virginia Power's application ("Application") in this proceeding generally and with Prince William County where the proposed project would be located?

A. Yes, I have reviewed the Company's Application at a high level, including the various routes under consideration. With respect to Prince William County, I have been appraising there since 1975. My valuation subjects include land, shopping centers, houses, apartments, and hotels.

Q. A number of public witnesses expressed concern regarding the potential effect that a HVTL in their neighborhood or community would have on their homes' value. James R. Napoli on behalf of Somerset Crossing Home Owners Association, Inc. ("Somerset") similarly claims that construction of certain overhead alternative routes would negatively impact the viewsheds within Somerset, as well as other neighboring communities, resulting in "a reduction in home values due to the loss of use of open space, reduction in viewsheds, and proximity to potentially-dangerous, high voltage lines located within the broader Somerset Crossing area." (Amended Napoli at 16.) What is your response?

A. There is no consensus in literature that property abutting a right-of-way suffers a value loss. (*See, e.g.*, Jennifer M. Pitts and Thomas O. Jackson, "Power Lines and Property Values Revisited," *The Appraisal Journal* (Fall 2007), at 323, a copy of which is attached as my Rebuttal Schedule 1.)

In their extensive study on the topic, Ms. Pitts and Dr. Jackson summarize research findings from past studies related to power lines and property values. They explain that many studies indicate that an HVTL has no significant effect on residential property values. When negative impacts are found, studies report an average discount of between 1% and 10% of property value. Importantly, however, these impacts diminish as distance from the line increases and disappear at a distance of 200 feet from the HVTL. Further, when HVTL structures are at least partially screened from view by trees, landscaping, or topography, any negative effects are reduced considerably. Value diminution attributable to HVTL proximity is also temporary and usually decreases over time, disappearing entirely in 4 to 10 years.

Q. Public Witness Catherine Calvin referenced a study by the "Askin Consulting Group" conducted in 2008, which estimated a loss of 38% for homes that are in the proximity of power lines. (Public Witness Hearing, Feb. 24, 2016, Tr. at 79.) Are you familiar with that study?

A. I believe that Ms. Calvin was referring to the "Askon Report on Undergrounding," which I have reviewed and analyzed. While this report refers to the results of two studies – one in Britain and the other in Canada – the report does not provide sufficient detail to confirm the reliability of its conclusions. (*See* Rebuttal Schedule 2.) On the other hand, all of the U.S. studies that I reviewed show little to no significant impact on home values due to HVTLs. (*See, e.g.*, James A. Chalmers and Frank A. Voorvaart, "High-Voltage Transmission Lines: Proximity, Visibility, and Encumbrance Effects," *The Appraisal Journal* (Summer 2009), at 227-245, attached as Rebuttal Schedule 3; *see also* Pitts and Jackson, at 323-325, attached as Rebuttal Schedule 1.)

Q. Public Witness Tad Wilson referenced an econometric study from the Appraisal Journal in 2013 that cited 12% as the expected loss in home value of a substantially high value home. (Public Witness Hearing, Mar. 14, 2016, Tr. at 394.) Are you familiar with the study Mr. Wilson is citing?

A. Yes, I am. The article containing the study that Mr. Wilson cites actually references numerous other studies, most of which concluded there was no observable significant price effect from proximity to, or visibility of, HVTLs. In fact, the authors of the article conducted a study of the impact of HVTLs on properties in the Portland, Oregon and Seattle, Washington markets. The Portland study indicated less than a 2% difference due to HVTLs, while the Seattle study indicated a 2.4% difference. The article also makes an important observation, namely: "that all markets do not react in the same way to HVTL proximity." (*See* Rebuttal Schedule 4, at 61.)

Q. Have you also reviewed the testimony filed by Neil Joshipura and Wayne D. McCoy on behalf of Commission Staff regarding the potential for a negative economic impact on property owners due to the existence of overhead HVTL in proximity to their properties? (Joshipura at 21; McCoy at 13.)

A. Yes. Again, the studies I researched indicate there is no empirical research evidence to support such statements.

Q. Staff Witness McCoy summarized public witnesses' understanding that a 12-30% decrease in property values is common with houses in close proximity of overhead transmission lines. (McCoy at 17.) How would you respond?

A. Again, there is no empirical research evidence to support such an understanding. The reports I cited all conclude that while adverse perceptions and general dislike for overhead transmission lines do exist, sales data reveals little to no diminution in home prices. Preferences by market participants generally do not translate into noticeable price effects as revealed in market data.

Q. In addition to the potential loss in value, some public witnesses have stated they fear their homes will take longer to sell due to proximity to the HVTL. Do you have a response?

A. Yes. The Pitts and Jackson article I referenced earlier (attached as Rebuttal Schedule 1) addresses this issue. Based on in-depth interviews with realtors and appraisers on market conditions, approximately half of those interviewed for the Pitts and Jackson article said they had not observed that the presence of power lines negatively impacted the number of days that homes remained on the market. The remaining realtors and appraisers had observed that homes either adjacent to or with a view of the lines could expect to remain 0 to 60 additional days on the market. None of the realtors or appraisers interviewed reported observing any negative impacts on residential properties in close proximity to the lines, but without a direct view.

Another more recent study by Dr. James A. Chalmers and Dr. Frank A. Voorvaart agrees with that assessment. In their article, attached as Rebuttal Schedule 3, the authors report the findings of sixteen studies on the topic, which they say "form the core of the professional literature." (*Id.* at 229.) These studies report that when effects from HVTLs on property values have been found, they tend to be small; almost always less than 10% and usually in the range of 3-6%. These effects decay rapidly as distance to the lines increases and usually disappear at about 200-300 feet. They also report these effects tend to dissipate over time. The cause of most property value loss is attributable to encumbrance (*i.e.*, line easement on the property) rather than proximity, and the encumbrance effect is mistakenly interpreted as proximity effects. Furthermore, the studies show transmission line effects do not seem to be more pronounced on higher-valued properties. There was support that the effects are greater in a down market.

Overall, the realtors and appraisers cited in these studies indicated that price and marketability effects of HVTL depend on the market conditions at the time of sale.

Q. **And are you familiar with the current real estate market conditions in Prince William County?**

A. Yes, I am. Like many areas in Virginia, Prince William County's housing market is up. Year-over-year, they have seen increases in number of houses sold and median sales price, and a decrease in the number of days on the market.

Q. **Mr. Lennhoff, are you also familiar with impacts to commercial properties located in proximity to power lines?**

A. Yes. My experience leads me to conclude, as a general rule, that the effects on commercial properties are much less evident than any on residential property.

Q. **FST Properties, L.L.C. ("FST") Witness Don Mayer states that he believes no retail user would be interested in FST's property with overhead lines in place because buildings would be set back over 100 feet from the Route 55 frontage and retail users would be traveling under power lines to enter the businesses. (Mayer at 2-3.) Do you agree?**

A. I have not specifically studied the property site referenced by Mr. Mayer; however, based on my experience, my expectation is that there would be no negative effect on the value of retail property from users traveling under power lines to enter the businesses.

Q. Somerset Witness Napoli asserts that "Dominion is not competent to determine the effect the existence of a transmission line could have on any potential economic development or to opine as to what 'could' negatively impact economic development." (Amended Napoli at 5.) What is your response?

A. I disagree with Mr. Napoli's assessment. Studies are widely available that would enable the Company, as well as anyone else, to understand the likely impact of a transmission line on potential economic development. There is also no reason I can think of that would prohibit the Company from making its own independent determination.

Q. Finally, Russell Gestl, on behalf of Heritage Hunt, LLC, *et al.* ("Heritage") Respondents, criticizes the Company's estimates for real estate costs because, according to him, they do not account for impaired marketability for immediately adjacent buildings and sites, nor do they capture any lost property value for the properties that are not immediately adjacent but are impacted visually by an HVTL. (Gestl at 4.) What is your response?

A. I believe that it is entirely reasonable not to account for the items referenced by Mr. Gestl. Specifically, there is simply no evidence that commercial properties adjacent to but not actually encumbered by an HVTL see any loss in marketability or overall market value. The same would, of course, be true for those properties not immediately adjacent to, but with a view of, the HVTL. As Dr. Chalmers and Dr. Voorvaart noted in their extensive study on this issue, "The only variable that appears to have any systematic effect is the encumbrance variable (when line is actually on the property); however, its magnitude is generally small." (*See* Rebuttal Schedule 3, at 237.)

Q. Please summarize your testimony.

A. Academic literature and market interviews demonstrate that the impact of an HVTL on property values can vary by market and are sometimes difficult to measure. However, based on the vast majority of studies on this issue, I believe that the impact of HVTLs on property values will be minimal. Where effects from HVTLs on property values have been found, they typically tend to be quite small, and the effects fall off rapidly as the distance to the lines increases. Further, the effect on property values is attributable to encumbrance of the line on property rather than line proximity. Moreover, the impact of HVTLs on property values tends to dissipate over time.

Q. Does this conclude your rebuttal testimony?

A. Yes, it does.

APPENDIX A 180923495

David Lennhoff, MAI, SRA, CRE, FRICS
Director
Appraisal Services
Altus Group State & Local Tax and Advisory

David Lennhoff's expertise has been summoned nationally and internationally for real estate appraisal analysis as well as for expert witness testimony. Examples include: his testimony on the workings of real estate assessments and appraisals on behalf of the owners of the Alaskan Pipeline; with Toronto Pearson International Airport; and to further the understanding of the House of Representatives' Ways and Means Committee.

David leads Altus Group Appraisal Services as part of the company's State & Local Tax and Advisory practice. Often called upon as an expert witness, David brings his years of experience and knowledge of real estate appraisal to bear in litigation cases nationwide. As a highly experienced appraisal analyst, he and his staff at Altus Group provides client services in absorption studies – for both leasing and sales analysis – and conducts appraisals for acquisitions and third-party reviews. David's expertise spans demographic and marketability analysis, real estate tax valuation, and risk analysis in virtually all U.S. and several Canadian real estate markets.

Among the industries and businesses for which David has provided appraisals and court testimony are residential and commercial real estate development, hospitals, retail businesses, hospitality, office buildings, manufacturing plants, and datacenters. Government clients have included The Federal National Mortgage Association, the IRS, the U.S. Department of Justice (DOJ), the Federal Deposit Insurance Corporation, the U.S. Army Corps of Engineers, National Park Service, and the U.S. General Services Administration (GSA). Government agencies have retained David to provide lease rate studies and appraisals for federally owned buildings, and for him to testify in various courts on several of these assignments.

David regularly teaches advanced courses offered by the Appraisal Institute, and travels throughout the world as an educator of appraisal valuation methodologies. He is on the editorial board for *Appraisal Journal*, which he had served as editor, and for which he has written extensively. A recent article of his was cited by a tax judge, who instructed counsel to incorporate the article into their briefs to the court.

David earned his B.A. the University of Kentucky, Lexington. He has been a Certified General Real Estate Appraiser in Washington, D.C., the Commonwealth of Virginia, the State of Maryland, the Commonwealth of Pennsylvania, and the states of New Jersey, Indiana, Florida, Georgia, and Arizona. David is a member of the Counselors of Real Estate (CRE), the International Association of Assessing Officers (IAAO), the Real Estate Counseling Group of America (RECGA), and the Royal Institution of Chartered Surveyors (UK).

Company Exhibit No. ______
Witness: DCL
Rebuttal Schedule 1
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Power Lines and Property Values Revisited

by Jennifer M. Pitts and Thomas O. Jackson, PhD, MAI

This edition of "Environment and the Appraiser" revisits an issue that has been extensively studied but has recently received little attention. While issues concerning the health effects of electromagnetic fields are beyond the scope of this column, the effects of power lines and perceptions of health risks that can influence residential property values in some situations are summarized here.

There are a number of intervening factors that make generalizations about such influences difficult. Below is a summary of research findings from past studies as well as some recent research, consisting of market interviews focused on residential developments in the central California area. As will be discussed, impacts are varied as are market perceptions. The referenced literature is available from the Appraisal Institute's Y. T. and Louise Lee Lum Library.

Research

Over the years, the impact of high-voltage transmission lines (HVTL) on the value of residential property has been studied extensively. These impacts are not easily measurable. Research shows that the effects of HVTL on residential properties are varied and are determined by five interplaying factors: proximity to towers and lines; the view of towers and lines; the type and size of HVTL structures; the appearance of easement landscaping; and surrounding topography. Many studies indicate that the HVTL have no significant effect on residential property values.[1] More recently, however, an increasing number of studies do show a small diminution in value attributable to the close proximity of these lines.

When negative impacts are evident, studies report an average discount of between 1% and 10% of property value.[2] This diminution in value is attributable to the visual unattractiveness of the lines, potential health hazards, disturbing sounds, and safety concerns.[3] These impacts diminish as distance from the line increases and disappear at a distance of 200 feet from the lines. Where views of the lines and towers are completely unobstructed, negative impacts can extend up to a quarter of a mile. If the HVTL structures are at least partially screened from view by trees, landscaping, or topography, any negative effects are reduced considerably. Value diminution attributable to tower line proximity is temporary and usually decreases over time, disappearing entirely in 4 to 10 years.[4]

Research also has found that the negative impacts on lots adjacent to or with a direct view of a tower or pylon may be slightly greater than impacts on lots further from the tower. This is most likely

1. J. R. Cowger, Steven C. Bottemiller, and James M. Cahill, "Transmission Line Impact on Residential Property Values, A Study of Three Pacific Northwest Metropolitan Areas," *Right of Way* (Sept/Oct 1996): 13–17; William N. Kinnard, "Tower Lines and Residential Property Values," *The Appraisal Journal* (April 1967): 269–284; Hsiang-te Kung and Charles F. Seagle, "Impact of Power Transmission Lines on Property Values: A Case Study," *The Appraisal Journal* (July 1992): 413–418; and Marvin L. Wolverton and Steven C. Bottemiller, "Further Analysis of Transmission Line Impact on Residential Property Values," *The Appraisal Journal* (July 2003): 244–252.
2. Peter F. Colwell and Kenneth W. Foley, "Electric Transmission Lines and the Selling Price of Residential Property," *The Appraisal Journal* (October 1979): 490–499; Charles J. Delaney and Douglas Timmons, "High Voltage Power Lines: Do They Affect Residential Property Value?" *Journal of Real Estate Research* 7, no. 3 (1992): 315–329; William N. Kinnard and Sue Ann Dickey, "A Primer on Proximity Impact Research: Residential Property Values Near High-Voltage Transmission Lines," *Real Estate Issues* (April 1995): 23–29; and William N. Kinnard and Sue Ann Dickey, *High Voltage Transmission Lines and Residential Property Values: New Findings About Unobstructed Views and Tower Construction* (Real Estate Counseling Group of Connecticut, Inc., 2000).
3. Delaney and Timmons.
4. Kinnard and Dickey, "A Primer on Proximity Impact Research."

because the visual obstruction from a tower is more substantial than that from the lines themselves. The value diminution on lots adjacent to or with direct views on a tower may not decrease with time.[5]

A slower absorption rate and extended marketing period for residential properties adjacent to a tower line right-of-way are observed in some studies. However, when the nearby lots are attractively developed, the lots abutting a right-of-way will sell more quickly.[6] It has also been found that higher-end custom homes are generally more sensitive to the negative impacts of HVTL than lower-end homes.[7]

While most research indicates that HVTL have no significant impact or a slight negative impact on residential properties, some studies have shown that lots adjacent to or with views of an HVTL right-of-way actually sell for a premium over more distant lots. This premium is most likely due to improved visual clearance, increased privacy, and larger lot sizes.[8]

Recent Market Interviews

While academic and professional literature provide a broad background of findings on the price effects of HVTL, brokers and appraisers can provide additional perspective into current market conditions. In early 2007, interviews were conducted of local realtors and appraisers in several central California communities: Discovery Bay near Brentwood, Summer Lake near Oakley, and Sierra View in Roseville. HVTL right-of-ways run through or near these residential developments. Each realtor or appraiser was asked a series of questions about their background, market knowledge, and opinions on the effects of these high-voltage power lines.[9]

Approximately half of the realtors and appraisers interviewed said they had not observed negative impacts on either residential sale prices or days on market due to the presence of the power lines. According to these realtors and appraisers, major factors affecting sale price and marketability of residential properties include: location, the general economy, interest rates, inventory, and neighborhood amenities. A local appraiser in Discovery Bay commented that the presence of power lines "has not deterred residential development in Discovery Bay and surrounding areas." A realtor in Oakley agreed, stating that "buyers are building and selling homes near power lines in many areas of California, and the power lines don't seem to deter buyers."

The remaining realtors and appraisers interviewed had observed negative impacts on homes directly adjacent to a power line right-of-way. They said that on average, the indicated price discounts ranged between 2% and 7% for adjacent homes. For homes not directly adjacent but with a view of the power lines, average price impacts were estimated between 0% and 5%, depending on the view and proximity to the lines. On average, homes adjacent to or with a view of the lines could anticipate an increase of 0 to 60 days on the market. None of the realtors or appraisers interviewed had observed any negative impacts on residential properties in close proximity to the lines, but without a direct view.

Many realtors and appraisers indicated that price and marketability effects of HVTL depend on the market conditions at the time of sale. The presence of power lines can be viewed as a negative externality. *Externalities*, as defined in the Appraisal Institute's *The Appraisal of Real Estate*, 12th edition, are "the use or physical attributes of properties located near the subject property, or the economic conditions that affect the market in which the subject property competes."[10]

According to a broker active in Discovery Bay, "the negative effects from the power line (and from other negative externalities) are evident in a slow market. When demand is strong, these effects diminish. The price effects depend on property characteristics and market conditions." Another realtor in Roseville agreed, stating, "In a slow market, homes adjacent to a power line are harder to sell. These homes are great investment opportunities in a slow market, because any price effects diminish and may disappear when the market picks up."

5. Peter F. Colwell, "Power Lines and Land Value," *Journal of Real Estate Research* 5, no. 1 (1990): 117–127.
6. Louie Reese, "The Puzzle of the Power Line," *The Appraisal Journal* (October 1967): 555–560.
7. Francois Des Rosiers, "Power Lines, Visual Encumbrance and Home Values: A Microspatial Approach to Impact Measurement," *Journal of Real Estate Research* vol. 23, no. 3 (2002).
8. Delaney and Timmons; and Des Rosiers.
9. Interviews conducted by Real Property Analytics, Inc., January 2007. For methodology, see Thomas O. Jackson, "Surveys, Market Interviews, and Environmental Stigma," *The Appraisal Journal* (Fall 2004): 300–310.
10. Appraisal Institute, *The Appraisal of Real Estate*, 12th ed. (Chicago: Appraisal Institute, 2001), 42.

The impact of the power lines on residential property values may also be influenced by a buyer's personal preference. Several realtors and appraisers indicated that there might not be a market consensus on the impacts of power lines because some buyers may consider these power lines a nuisance and an eyesore, while other buyers do not. A broker in Discovery Bay stated, "personal preference may cause some buyers to locate further from the power lines, but the lines have caused no observable negative impacts for the market in general." Another Discovery Bay realtor stated, "external factors such as power lines have less of an effect on lower-end homes than on luxury properties."

Conclusion

Both the market interviews and academic literature show that the impacts of power lines on residential properties are varied and difficult to measure. The impacts from the power lines, as well as other negative externalities, depend on many factors, including market condition, location, and personal preference.

Jennifer M. Pitts researches environmental issues and their effects on real estate markets for Real Property Analytics, Inc. She received her master's degree in land economics and real estate from Texas A&M University. Pitts also has a bachelor's degree, *summa cum laude*, in finance from the Mays Business School at Texas A&M. **Contact: T 254-760-0847; E-mail: jennifer@real-analytics.com**

Thomas O. Jackson, PhD, MAI, CRE, is a clinical associate professor in the Department of Finance of the Mays Business School at Texas A&M University, where he teaches real property valuation in the Land Economics and Real Estate Program. In addition, he is the president of Real Property Analytics, Inc., based in College Station, Texas, where he specializes in analyzing the effects of environmental contamination on real property. **Contact: T 979-690-1755; E-mail: tomjackson@real-analytics.com; Web site: www.real-analytics.com**

THE ASKON REPORT ON UNDERGROUNDING

Summary and Recommendations

October 2008

MAIN AUTHOR

The main author of the ASKON report is world renowned in his chosen field of research. Up to 2003, Professor Friedhelm Noack was Director of the Institute of Electrical Power and High Voltage Engineering at the University of Technology, Ilmenau, Germany.

He is the author of two celebrated books: 'Stresses of circuit breakers in high voltage networks', 1980 and 'Introduction to electrical power engineering', 2003. Professor Noack has written more than sixty scientific papers in national and international journals and presented over sixty papers for international conferences. He is the author of more than eighty research reports on fundamental and industrial research projects as well as over sixty expert reports.

As a figure of international stature, Professor Noack has been a member of CIGRE – the International Council on Large Electrical Systems and is involved in working groups of IEC – the International Electrotechnical Commission and CENELEC – the European Committee for Electrotechnical Standardisation.

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ASKON CONSULTING GROUP

NORTH EAST
***PYLON* PRESSURE**

Underground makes sense

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NORTH EAST
PYLON PRESSURE

INTRODUCTION

EirGrid, in collaboration with Northern Ireland Electricity, is proposing to build a North-South electricity interconnector through counties Meath, Cavan, Monaghan, Armagh and Tyrone using 400 kV extra high voltage Overhead Transmission Lines, at an estimated cost of €280 Million. Three route corridor options have been chosen. All three route options are based on Overhead Transmission Lines only. Despite the scale and significance of the North-South interconnector project, EirGrid have not performed a detailed analysis of the feasibility and cost of an Underground Cable alternative system.

North East Pylon Pressure (NEPP) is the overall representative group for the people of the North East who advocate that high power electric cables should go underground. The group was formed in November 2007,in response to the EirGrid announcement of its plans for a North-South interconnector from Meath to Tyrone. The strong consensus is that the interconnector should be established using Underground Cables instead of Overhead Transmission Lines.

In April 2008 NEPP commissioned ASKON to carry out a study, with the following objectives:

1. Determine the feasibility of using a 400kV Underground Cable transmission line for the North-South interconnector project, that could be integrated into the existing grid network managed by EirGrid.

2. Assess the feasibility of such an underground cable option to meet the EirGrid benchmark criteria of affordability, reliability, safety, efficiency and security.

3. Explore possible route options and methodologies for minimising road traffic disruptions.

In the course of their study ASKON carried out aerial and land analysis of the project area, in order to achieve a detailed, accurate and realistic set of conclusions. The report was issued in October 2008. *('Study on the Comparative Merits of Overhead Lines and Underground Cables as 400 kV Transmission Lines for the North-South Interconnector Project').*

NORTH EAST
PYLON PRESSURE

Underground makes sense

4. MAIN FINDINGS

1. The Askon report is **the first project specific analysis** of determining the feasibility of undergrounding the North-South interconnector. Askon examined the feasibility of undergrounding using EirGrid's benchmark criteria of affordability, reliability, safety, efficiency and security.

2. **A design consisting of two groups of Underground Cables running in parallel is recommended** for the transmission system, as an alternative to the planned Overhead Lines single system. The design consists of using two groups of aluminium cables entrenched in parallel to each other. The two trenches are 1.4 metres in width and in depth and situated 5 metres apart.

3. The Underground Cable solution **is better suited to integrating with the existing grid network** than the proposed Overhead Line system, as defined by a well established International Standard for evaluating operational security and power disturbances ("N-1 criterion"). Undergrounding enhances national grid security and reliability, compared with Overhead Lines, and gives improved performance in the grid.

4. The Underground Cable solution is significantly **more reliable** than its equivalent Overhead Line option, whether in conditions of either planned or forced outages. Failures in Underground Cables are significantly lower than in Overhead Lines. **The probability of both parallel cables being unavailable is once in every 100,000 years.** The second parallel cable system can immediately be brought into operation should any issues arise with the first cable system. This is not feasible with a single Overhead Line.

5. The Underground Cable system is significantly **more efficient** than the equivalent proposed Overhead Line system. Transmission losses over the lifetime of the Underground Cable system are significantly lower than for a single Overhead Line system. This translates to a significantly better carbon footprint profile than the Overhead Line system. It is also a major component in cost comparisons between the two systems.

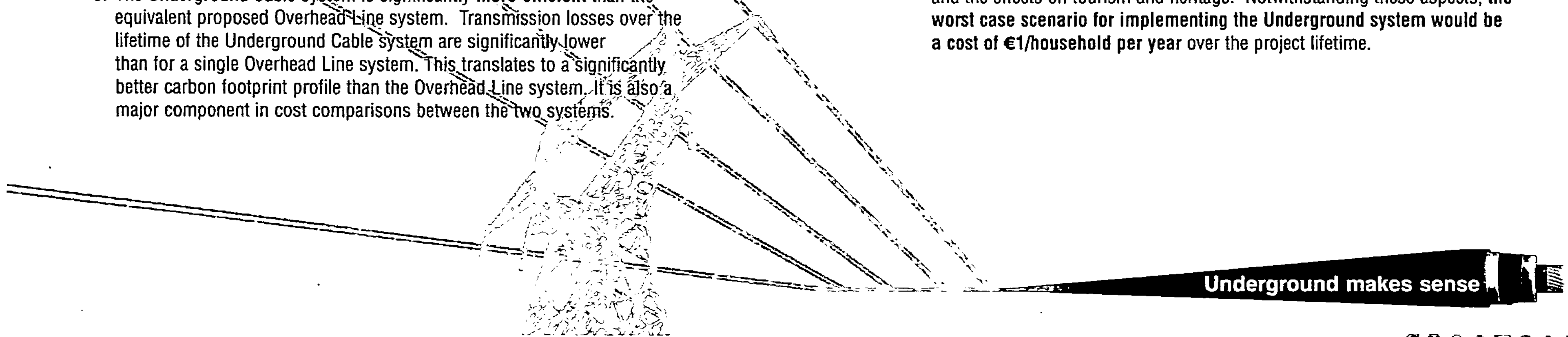
6. The Underground Cable system is significantly **safer** than its equivalent Overhead Line system. No electric fields are emitted from the Underground Cables. Importantly, the magnetic field is also greatly reduced. Underground Cable routes can, if necessary, be placed within 11-17 metres from dwellings versus 95 metres for Overhead Lines, in order to comply with recommended magnetic field exposure levels.

7. The Underground Cable system provides **obvious environmental benefits** versus Overhead Lines, in terms of land use, visual impact, land and property valuation and tourism and heritage responsibilities.

8. Crucially, the identified Underground Cable system **can be established at an affordable cost** when compared with an Overhead Line option. There is a higher initial investment cost, but this difference is cancelled out by the much higher losses of electricity in Overhead Lines over a 40 year life cycle. Over the entire distance of the project, for the Overhead Lines system the cost of electricity lost is nine times (= €875 million) the basic investment cost. By comparison, the value of electricity lost in an Underground Cables system is distinctly lower (€336 million).

9. The combined investment and transmission losses costs over the 40 year period are estimated at **€968 Million for Overhead Lines compared to €805 Million for the recommended Underground Cables System.**

10. None of the cost estimates above take account of the costs of lengthy planning delays for Overhead Line approvals, the land and property devaluation impacts and the effects on tourism and heritage. Notwithstanding these aspects, **the worst case scenario for implementing the Underground system would be a cost of €1/household per year** over the project lifetime.



Company Exhibit No. ____
Witness: DCL
Rebuttal Schedule 2
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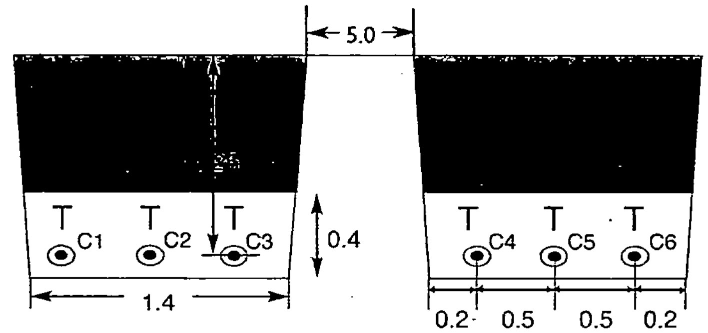
SYSTEM DESIGN

A design consisting of two groups of Underground Cables running in parallel is recommended for the transmission system, as an alternative to the planned Overhead Lines single system. The design consists of using 2 groups of aluminium cables entrenched in parallel to each other. The 2 trenches are 1.4 metres in width and in depth and situated 5 metres apart.

The 2 groups of cables are placed in trenches that are 1.4 metres in width and in depth and situated 5 metres apart.



Two separate cable trenches: each cable system in flat arrangement

Modern Underground Cables with cross-linked polyethylene insulation (XLPE) are an alternative to the historically well proven technology of Overhead Lines. These Underground Cables are easy to install, easy to maintain and easy to repair. **Several Underground projects with lengths up to 210 km are under consideration in Europe at present.**

GRID SECURITY

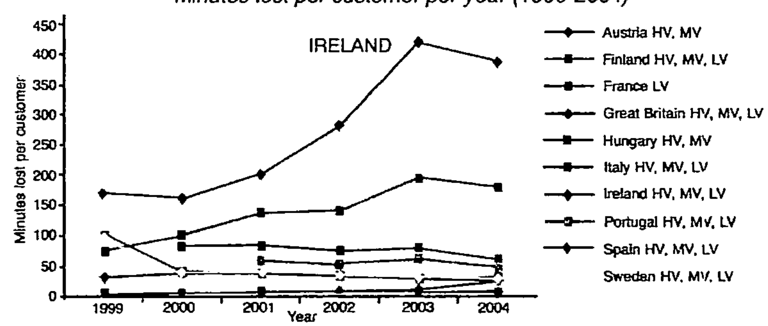
This Underground Cables system solution is better suited to integrating with the existing grid network than the proposed Overhead Lines system, as defined by a well established International Standard for evaluating smooth operation and security of interconnected power systems ("N-1 Criterion"). The "N-1 Criterion" is of major importance to prevent disturbances. The "N-1" Criterion is not fulfilled within the proposed expanded Irish 400 kV grid itself, when single system Overhead Lines are planned to be used in this project. Undergrounding enhances national grid security and reliability, compared with Overhead Lines, and gives improved performance in the grid.

RELIABILITY

The Underground Cable solution is significantly more reliable than its equivalent Overhead Line option, whether in conditions of either planned or forced outages. Failures in Underground Cables are significantly lower than in Overhead Lines, which are permanently affected by the climate and environmental conditions (sun, wind, rain, fog, snow, ice, pollution, and lightning strikes) and thus the components age.

When a failure occurs in Overhead Lines, the transmissible power of the system is zero. Statistical data and statistical reliability analysis, however, shows that the probability of an Underground Cable failure is very low. The longer time it may take to repair an Underground Cable is eliminated by having two cables in parallel, as is the current practice around the world. The probability of both parallel cables being unavailable is once in every 100,000 years. The decisive advantage of the two parallel Underground Cable systems is the redundancy of one cable system, which has, together with the overloading performance of the cables, remarkably favourable advantages over the Overhead Lines system regarding availability and security.

Unavailability in European grids caused by planned interruptions.
Minutes lost per customer per year (1999-2004)



Third Benchmark Report on Quality of Electricity Supply, CEER, 2005

Currently, the Irish grid, in comparison to the other European grids, has a remarkably high factor of unavailability, which is caused by planned interruptions. Undergrounding would reduce this level of interruptions.

Underground makes sense

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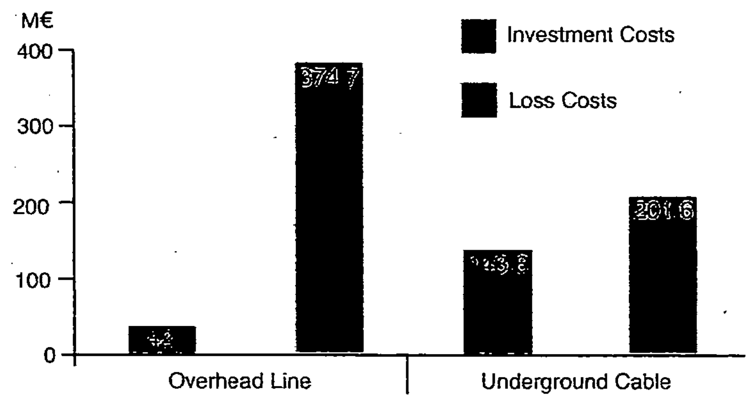
EFFICIENCY

The Underground Cable system is significantly more efficient than the equivalent proposed Overhead Line system. Transmission losses over the lifetime of the Underground Cable system are significantly lower than for a single Overhead Line system. This translates to a significantly better carbon footprint profile than the Overhead Line system, through reduced greenhouse gas emissions.

Transmission losses represent a loss in value and an increase in fuel burn and environmental impact. In Europe, transmission line losses alone represent the waste of around 20 million tonnes of coal, 3.1 million tonnes of gas and 1.7 million tonnes of oil. The annual loss in value is around €12 billion. The annual increase in greenhouse gas emissions is around 60 million tonnes of CO_2 per year. In some countries, older transformer infrastructure and lines can yield losses as high as 21%. Ireland's grid losses are above the European average.

Transmission losses are, therefore, a major component in analysing life-cycle cost comparisons between Underground and Overhead alternatives. Underground Cables in the grid have lower voltage drops, higher voltage stability for the consumers and improved transmission stability compared with Overhead Lines. Importantly, the Underground Cables do not have any unfavourable influence on the load flow in the Irish Grid.

Loss costs of transmission systems over 40 years in comparison to the investment costs, for the 60 km Woodland-Kingscourt route.



ENVIRONMENTAL IMPACT

The Underground Cables system provides obvious environmental benefits versus Overhead Lines, in terms of land use, visual impact, land and property valuation, tourism and heritage responsibilities.

Preparing for trenching

Regeneration after trenching

Studies have been carried out over the last fifty years to assess the impact of overhead power lines on the value of residential property and land in close proximity to pylon towers.

A study carried out in Britain in 2007 showed the value of detached properties at a distance of less than 100m from overhead transmission lines was 38 percent lower than comparable properties. The effect of devaluation has been seen up to two-and-a-half kilometres from such lines.

In relation to non-residential holdings a rigorous and comprehensive study in Canada over 20 years ago found that the per acre values from more than 1,000 agricultural property sales were 16-29 percent lower for properties with easements for transmission lines than for similar properties without easements.

NEPP have commissioned a study to quantify in particular the potential land and property devaluation effects in the North-East, based on proximity of existing dwellings and land-holdings to the proposed route corridors.

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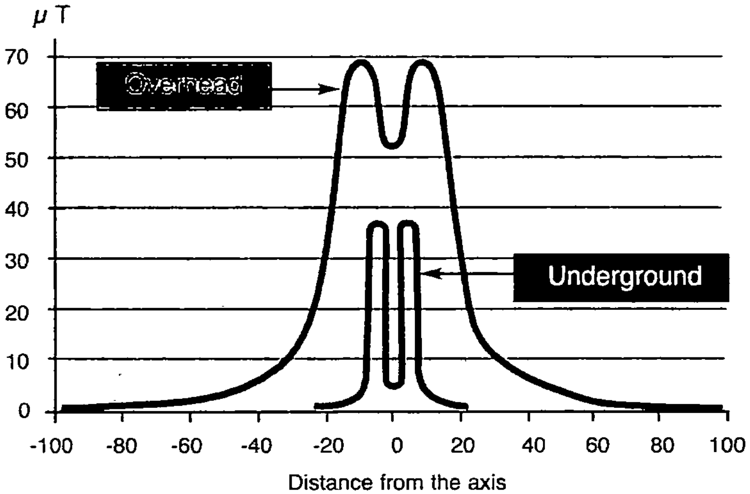
SAFETY

For some decades many human and epidemiological studies have been undertaken to investigate the influence of electric and magnetic fields on human and animal health. The International Commission on Non-Ionising Radiation Protection (ICNIRP) in 1998 issued guidelines for exposure to time varying electromagnetic fields (EMF). These guidelines were adopted by the European Union in 1999. A limit level of 100 µT (micro Tesla, the international scientific unit of EMF measurement) was set for permanent exposure of humans at this time. However more recent findings suggest that childhood leukaemia may be caused by permanent exposure to low magnetic fields. As a result of these studies, some countries and regions in Europe and America have reduced the magnetic field exposure limits (e.g. Italy 3 µT, Switzerland 1 µT, Netherlands 0.4 µT, Tuscany 0.2 µT). For new installations the precautionary level for permanent exposure as adopted in Switzerland of 1 µT should be applied as best practice.

The Underground Cables system is significantly safer than its equivalent Overhead Line system. No electric fields are emitted from the Underground Cables. Importantly, the magnetic field is also greatly reduced. Underground Cable routes can, if necessary, be placed within 11-17 metres from dwellings versus 95 metres for Overhead Lines, in order to comply with exposures below the 1 µ Tesla level. The EMF field from an overhead electricity line cannot be shielded and humans need to be more than 90 metres from the line to meet the precautionary safe reading of 1 µ T. In contrast, even during peak loads, the EMF density above underground cables reduces to 1 µ Tesla after only 11 metres distance. Short term exposure by walking or working above cables is harmless.

Comparison of EMF Levels for Overhead Lines versus Underground Cables



Magnetic field Single Overhead Lines System compared to two parallel Underground Cable systems in flat arrangement at full loads in lateral distance (in metres) from axis.

There are some uncertainties about the magnitude of the loads of the planned transmission systems. Taking into account that existing Overhead Lines can be up-rated or replaced by multi-system lines, as usually happens in other countries, this corridor should have a width of at least 100 metres on both sides of the axis.

AFFORDABILITY

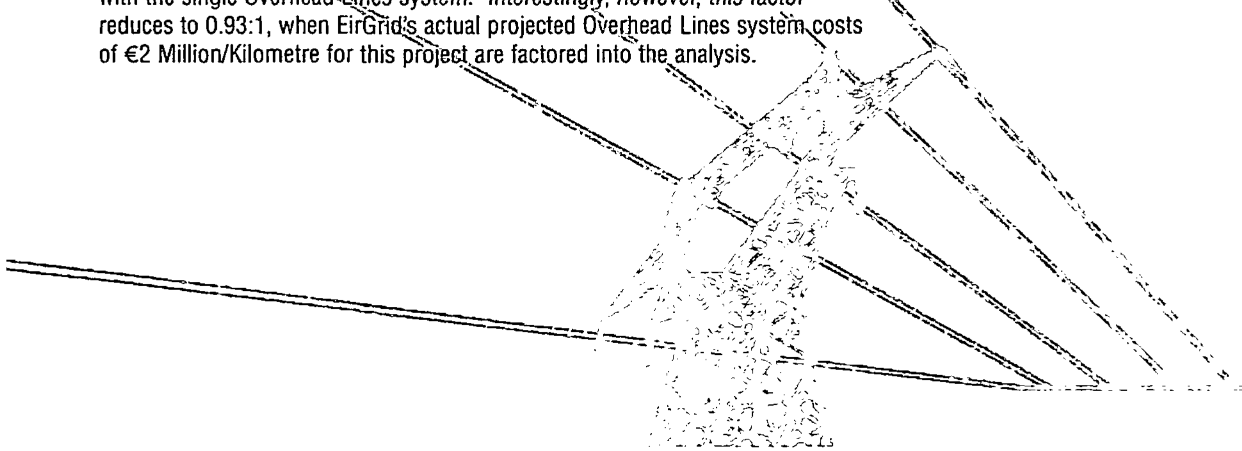
Two components are important in determining overall costs for the 40 year lifetime of this project, namely capital costs in establishing the system, and losses in electricity during the 40 year lifetime of the system.

For the North-South interconnector project, the capital costs for an Overhead Lines system are smaller than for a parallel Underground Cables system. Power transmission losses, however, in Overhead Lines are distinctly higher than for Underground Cables. Therefore, the financial losses incurred through wasted electricity are much higher. Over the entire distance of the project, for the Overhead Lines system the cost of electricity lost is nine times (= €875 million) the basic capital investment cost. By comparison, the value of electricity lost in an Underground Cables system is distinctly lower (€336 million).

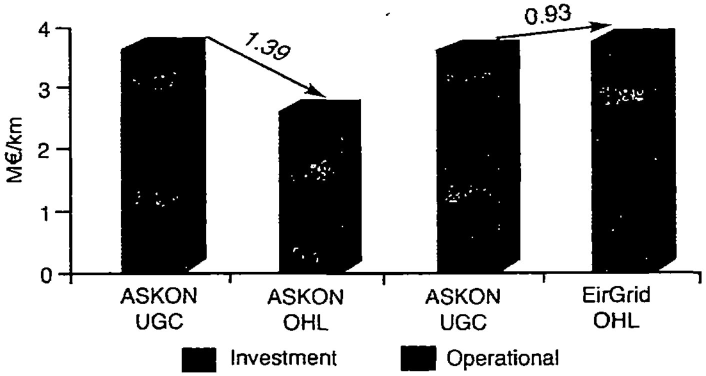
The efficiency of Underground Cables is equivalent to eliminating a power station with a capacity of 6 to 11 Mega Watts, which represents a considerable saving on the carbon footprint of Undergrounding.

The combined investment and transmission losses costs over the 40 year period are estimated at €968 Million for Overhead Lines compared to €805 Million for the recommended Underground Cables System.

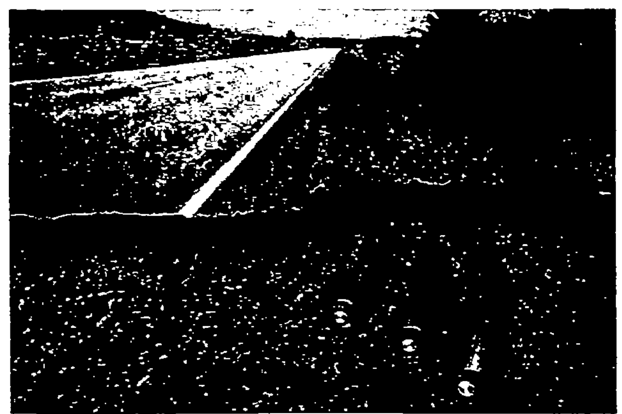
For an assessment of the financial aspects of this project standard appraisal methods involving "Net Present Value method" (NPV) and Weighted Average Cost of Capital (WACC) were used. The capitalised costs, which are the sum of the capital cost and the net present value of the operational costs, were determined for a 40 year lifespan. The life-cycle costs of the Underground Cable options were found to be higher than those of the Overhead Lines, with a lifetime cost factor of 1.39:1 for the recommended Underground Cables system compared with the single Overhead Lines system. Interestingly, however, this factor reduces to 0.93:1, when EirGrid's actual projected Overhead Lines system costs of €2 Million/Kilometre for this project are factored into the analysis.



Capitalised Cost Comparisons for Underground Cables (UGC) versus Overhead Lines (OHL) over a 40 year life-cycle.



None of the cost estimates above take account of the costs of lengthy planning delays for overhead line approvals, the land and property devaluation impacts and the effects on tourism and heritage. **Notwithstanding these aspects, the worst case scenario for implementing the Underground Cables system would be a cost of €1 Euro per household per year over the project lifetime.**



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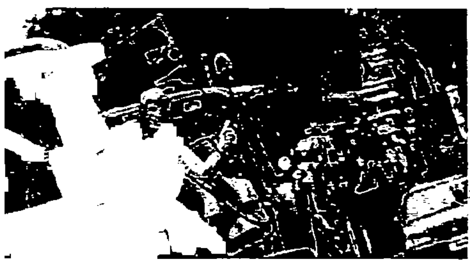
NEPP RECOMMENDATIONS

1. *EirGrid need to review their strategy in relation to the feasibility and affordability of undergrounding the North-South interconnector.*
2. *The Minister for Communications, Energy and Natural Resources must revise the Statutory Instrument establishing EirGrid to direct the company to put this project and all future extra high voltage power lines underground.*
3. *NEPP requests the Joint Oireachtas Committee on Communications, Energy and Natural Resources to institute public hearings based on this report.*
4. *NEPP requests the Department of Environment, Heritage and Local Government to implement the key recommended actions from the March 2007 report by the Expert Group on health effects of Electromagnetic Fields.*
5. *A coordinated approach to examining practical options for an Underground Cable route corridor needs to be adopted, involving the relevant State bodies, including the Departments of Communications, Energy and Natural Resources; Transport; and Environment, Heritage and Local Government, with inputs from all relevant stakeholders in the North East region.*



ASKON CONSULTING GROUP

ASKON Consulting Group GmbH is a leading international technology consultancy, specialising in energy, automotive sector and aerospace. ASKON employs more than 350 people. ASKON operates from offices in Hamburg, Munich, Dusseldorf, Bremen, Leipzig, Gummersbach and Lippstadt. **www.askon.de**

ASKON has been part of the ALTRAN Group since 1996. ALTRAN is the European market leader in innovation consulting. In 2007, the Group's turnover reached €1.6 billion with over 17,500 employees in twenty countries. Group headquarters is in Frankfurt, Germany. In its energy division, ALTRAN focuses on support for major utilities, especially on power transmission and distribution, and on renewable energies such as wind power and solar energy. **www.altran.com**

Unlike the Government's Ecofys report – which was a desktop, theoretical exercise – the ASKON Consulting experts made an extended site visit to Ireland and their report is specific to viable routes and to the conditions in the North East of Ireland. They visited the historic Bective Abbey which is threatened by giant pylons nearby.

(L to R) Dr Hans Pleuger, Intelligent Energy, Gisbert Weber BE, Consultant, ASKON, Dr Udo Hass, Managing Consultant, ASKON, and Professor Friedhelm Noack, Faculty of Electrical Engineering, University of Technology, Ilmenau, Germany. The ASKON study is the first and only project-specific analysis of the comparative merits of underground cables and overhead lines for the proposed North / South interconnector.

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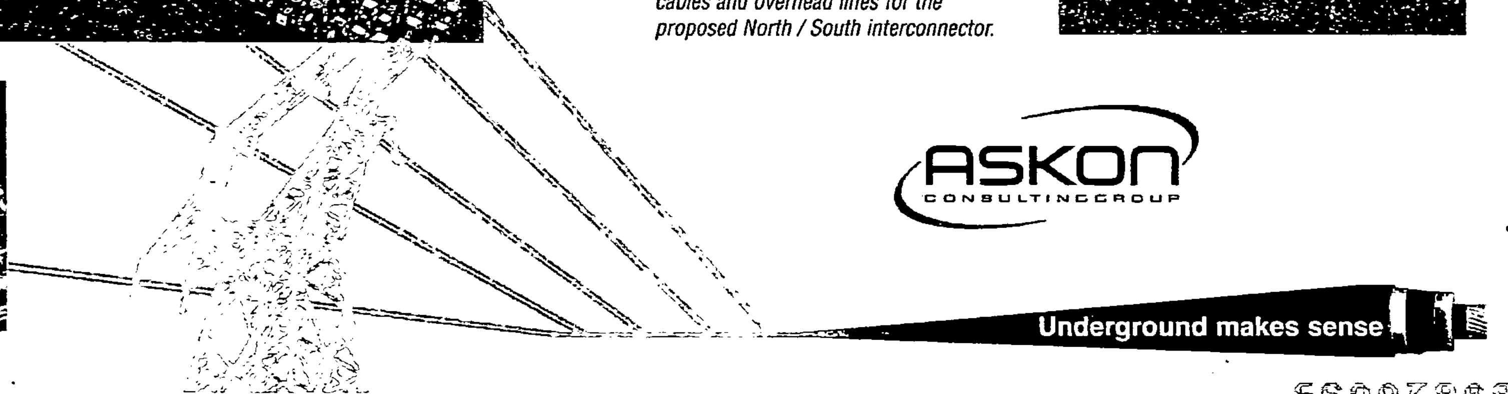

FEATURES

High-Voltage Transmission Lines: Proximity, Visibility, and Encumbrance Effects

by James A. Chalmers, PhD, and Frank A. Voorvaart, PhD

ABSTRACT

In this study, over 1,200 home sales in 1998–2007 are aggregated into four study areas with a 345-kV transmission line. Field data are collected on the sale properties relative to proximity to and visibility of transmission line towers, and the extent of encumbrance by a transmission line easement. A multiple regression model is used to test whether the sale prices are affected by line proximity, tower visibility, or property encumbrance. In both continuous distance and distance zone models, the proximity and visibility variables typically fail to be statistically significant. The only variable that appears to have any systematic effect is the encumbrance variable; however, its magnitude is generally small.

There will be a significant expansion of the 345-kV transmission grid in New England over the next decade; this has raised issues on the potential effects of transmission lines on the value of nearby properties.[1] As will be reviewed briefly, the professional literature on the impact of high-voltage transmission lines (HVTLs) on residential real estate values is extensive. While the literature creates a relevant foundation for addressing the potential effects of new 345-kV transmission lines on property values, the current research is designed to investigate three outstanding issues.

First, most of the literature is somewhat dated. Of the most important studies (those that examined large numbers of sales using statistical procedures), only one study analyzes data from a period subsequent to 2000.[2] Since attitudes, behaviors, and their reflection in the market can change over time, it is important to have contemporary evidence on the question of possible property value effects.

Second, the construction that motivates this study is specific to 345-kV lines (which are mostly on 130-foot steel poles), while the historical research has no such focus and only occasionally has dealt with this corridor configuration.

Third, a careful analysis has to look at the interaction of three interrelated variables–proximity, visibility, and the extent to which an adjoining property is actually encumbered by the transmission line right-of-way easement. Since proximity and encumbrance are highly correlated, the effects of one could be

1. This research was carried out under contract to Northeast Utilities over the period April 2008–October 2008. High-voltage transmission lines carry currents of 138 kilovolts (kV) up to 765 kV; see Energy Information Administration, "The U.S. Electric Power Industry Infrastructure: Functions and Components," in *The Changing Structure of the Electric Power Industry 2000: An Update* (Washington, DC: U.S. Department of Energy, 2000), available at http://www.eia.doe.gov/cneaf/electricity/chg_stru_update/chapter3.html.
2. These studies will be referenced and summarized in the next section.

attributed to the other if both are not adequately accounted for. Similarly, the effects of visibility and proximity must be considered in tandem if the effect of each is to be properly measured.

In the course of this research, three additional questions were investigated: (1) are higher-valued properties more vulnerable to HVTL effects than lower-valued properties? (2) are properties in general more vulnerable to HVTL effects in a down housing market? and (3) since much of the proposed expansion of the grid will take place in existing utility corridors, how can the incremental effect of these expansions be measured?

Summary of the Literature

Methodology

Reliable evidence of the effect of HVTLs on the value of adjacent or nearby residential property must rely on actual, arm's-length sales of property that lie in close proximity to an existing line. These sales are then compared to other selected transactions involving properties located outside of the potential area of influence.[3] The three most common approaches for performing this comparison are paired data analysis, retrospective appraisal, and multiple regression analysis.

Paired Data Analysis. The paired data approach attempts to match the characteristics of a subject property sold within a claimed area of impact (the subject area) with individual sales of similar properties sold outside the claimed area of impact (the control area). The issues here center on the availability of sales and the ability to identify sales that can be considered a match to the subject property.[4]

Retrospective Appraisal Based on Control Properties. The retrospective appraisal approach recognizes that a perfect match is unlikely and relies on standard residential appraisal sales comparison methodology. A subject property is selected that has been sold, and it is then appraised retrospectively, i.e., at the date of its historical sale. The appraised value based on control area comparables can then be compared to the actual sale price to see if the HVTL had any effect on the sale price of the subject property. This is obviously an improvement over the paired data analysis, but still suffers from the fact that, as discussed later, the effects under investigation are likely to be small, and may well be within the error range of standard appraisal methodology.

Multiple Regression Analysis of Large Numbers of Subject and Control Area Sales. The third approach, multiple regression analysis, uses statistical tools to try to isolate the effects of the HVTL from all of the other determinants of value. This is only possible with a relatively large number of subject area and control area sales. If the sales, property, and neighborhood data exist to carry out this approach, it is ideally suited to identifying the independent effect of the transmission line, holding the other value-determining factors constant.[5] In addition, it is the least subjective of the three potential approaches and is the only approach to give explicit measures of reliability, which helps the user determine what weight to give the results.

Conclusions from the Literature

While the literature on the effect of HVTLs on property values is extensive, it is of uneven quality, ranging from anecdotal reports to large, rigorously conducted statistical studies. Several hundred articles were reviewed as part of the current study, and thirty-eight had direct relevance to either the methodological or empirical questions at issue here. These are referenced in footnotes or in the Additional Reading section at the end of this article.

Over the past twenty-five years, the literature has increasingly recognized multiple regression analysis as the most reliable technique to investigate whether HVTLs impact property values and, if so, to quantify the effect. As mentioned, multiple regression has the significant advantage of not relying on the subjective judgment of the appraiser. Rather, it represents an objective reflection of the data together with measures of reliability that attach to the results. A large number of studies have been undertaken since the 1980s using large databases and statistical

3. Analysis of trends, days on market, or turnover rates can be suggestive of the existence of effects, but are not useful in quantifying the magnitude of the effect. Surveys of market participants can also be instructive as to how these effects are perceived, but are no substitute for analysis of how these effects actually manifest themselves in the market.

4. The problem with this approach is evident by a review of residential appraisals; despite best efforts to find comparables, it is very rare to see a comparison sale to which no adjustments are made.

5. For a general discussion of the methodological issues associated with multiple regression, see Thomas O. Jackson, "Evaluating Environmental Stigma with Multiple Regression Analysis," *The Appraisal Journal* (Fall 2005): 363–369.

tools to investigate the effect of transmission lines on property values. Sixteen of these studies form the core of the professional literature and are widely quoted and cross-referenced one to the other.[6] The results of these studies can be generally summarized as follows:

- Over time, there is a consistent pattern with about half of the studies finding negative property value effects and half finding none.
- When effects have been found, they tend to be small; almost always less than 10% and usually in the range of 3%–6%.
- Where effects are found, they decay rapidly as distance to the lines increases and usually disappear at about 200 feet to 300 feet (61 meters to 91 meters).
- Two studies investigating the behavior of the effect over time find that, where there are effects, they tended to dissipate over time.
- There does not appear to have been any change in the reaction of markets to high-voltage transmission line proximity after the results of two widely publicized Swedish health-effects studies were preliminarily released in 1992.[7]

These general conclusions have characterized the appraisal and economic literature throughout the last twenty-five years, and there do not appear to be any new or different trends in the research. It is during this period that most of the medical studies on electromagnetic field (EMF) exposure were published, including the oft-referenced Swedish studies. One of the questions, therefore, is the apparent inconsistency between these statistical results and the intensity of opposition that new transmission line corridors generate. How can it be that if people are so intensely adverse to HVTLs, we do not see more of a market effect? This inconsistency is seen clearly when residents along existing HVTLs are interviewed.

The basic thrust of survey questioning is whether home purchasers were aware of the transmission lines prior to their purchases and, if so, whether their purchase decisions or the prices they paid were affected by the lines.[8] Like the statistical analyses of sales, the results of these survey studies are quite consistent with one another. Their findings can be summarized as follows:

- A high proportion of the residents were aware of the lines at the time of purchase.

6. The sixteen referenced articles are the following: Judith Callanan and R.V. Hargreaves, "The Effect of Transmission Lines on Property Values: A Statistical Analysis," *New Zealand Valuers Journal* (June 1995): 35–38; Peter F. Colwell, "Power Lines and Land Values," *Journal of Real Estate Research* 5, no. 1 (Spring 1990): 117–127; Peter F. Colwell and Kenneth W. Foley, "Electric Transmission Lines and the Selling Price of Residential Property," *The Appraisal Journal* (October 1979): 490–499; J. R. Cowger, Steven C. Bottemiller, and James M. Cahill, "Transmission Line Impact on Residential Property Values: A Study of Three Pacific Northwest Metropolitan Areas," *Right of Way* (September/October 1996): 13–17; François Des Rosiers, "Power Lines, Visual Encumbrance and House Values: A Microspatial Approach to Impact Measurement," *Journal of Real Estate Research* 23, no. 3 (2002): 275–301; Murtaza Haider, "Influence of Power Lines on Freehold Property Values in the Greater Toronto Area" (Series in Spatial Econometrics, University of Toronto, January 2000); S. W. Hamilton and Cameron Carruthers, "The Effects of Transmission Lines on Property Values in Residential Areas" (University of British Columbia, Vancouver, April 1993); Stanley W. Hamilton and Gregory M. Schwann, "Do High Voltage Electric Transmission Lines Affect Property Value?" *Land Economics* 71, no. 4 (November 1995): 436–444; Patrice C. Ignelzi and Thomas Priestley, *A Statistical Analysis of Transmission Line Impacts on Residential Property Values in Six Neighborhoods* (Southern California Edison Environmental Affairs Division, 1991); William N. Kinnard, Jr., Mary Beth Geckler, and Jake W. DeLottie, *Post-1992 Evidence of EMF Impacts on Nearby Residential Property Values (Nevada)* (Storrs, CT: Real Estate Counseling Group of Connecticut, Inc., April 1997); William N. Kinnard, Jr., Mary Beth Geckler, and Jake W. DeLottie, *Post-1992 Evidence of EMF Impacts on Nearby Residential Property Values (Missouri)* (Storrs, CT: Real Estate Counseling Group of Connecticut, Inc., April 1997); William N. Kinnard, Jr., Phillip S. Mitchell, and James R. Webb, "The Impact of High-Voltage Overhead Transmission Lines on the Value of Real Property" (paper presented at Fifth Annual American Real Estate Society Conference, Arlington, VA, April 1989); William N. Kinnard, Jr., Mary Beth Geckler, and Phillip S. Mitchell, *Effects of Proximity to High-Voltage Electric Transmission Lines on Sales Prices and Market Values of Vacant Land and Single-Family Residential Property: January 1978–June 1988* (Storrs, CT: Real Estate Counseling Group of Connecticut, Inc., 1988); William N. Kinnard, Jr., Mary Beth Geckler, and Phillip S. Mitchell, *An Analysis of the Impact of High Voltage Electric Transmission Lines on Residential Property Values in Orange County, New York* (Storrs, CT: Real Estate Counseling Group of Connecticut, Inc., 1984); Phillip S. Mitchell and William N. Kinnard, Jr., "Statistical Analysis of High-Voltage Overhead Transmission Line Construction on the Value of Vacant Land," *Valuation* (June 1996): 23–29; and Marvin L. Wolverton and Steven C. Bottemiller, "Further Analysis of Transmission Line Impact on Residential Property Values," *The Appraisal Journal* (July 2003): 244–252.

7. The two studies are Maria Feychting and Anders Ahlbom, "Magnetic Fields and Cancer in Children Residing Near Swedish High-Voltage Power Lines," *American Journal of Epidemiology* 138, no. 9 (1993): 467–481; and Birgitta Floderus et al., "Occupational Exposure to Electromagnetic Fields in Relation to Leukemia and Brain Tumors: A Case-Control Study in Sweden," *Cancer Causes Control* 4 (1993): 465–476. The results of these two studies were released preliminarily in 1992 by Susan Kolare, "Power Lines Increase Cancer Risk for Children," *Forskning & Praktik* (Solna, Sweden: National Institute of Occupational Health) (July 1992): 387–388; and Lars Gronkvist, "Cancers Related to Strong Electromagnetic Fields," *Forskning & Praktik* (Solna, Sweden: National Institute of Occupational Health) (July 1992): 383–385.

8. Five studies are prominent in the literature: William N. Kinnard, Jr., "Tower Lines and Residential Property Values," *The Appraisal Journal* (April 1967): 269–284; Thomas Priestley and Gary Evans, *Perceptions of a Transmission Line in a Residential Neighborhood: Results of a Case Study in Vallejo, California*, Southern California Edison Environmental Affairs Division, December 1990; Hsiang-te Kung and Charles F. Seagle, "Impact of Power Transmission Lines on Property Values: A Case Study," *The Appraisal Journal* (July 1992): 413–418; Sandy G. Bond, "The Impact of Transmission Lines on Property Values" (paper presented at Twelfth Annual American Real Estate Society Conference, South Lake Tahoe, CA, March 1996); and Cheryl Mitteness and Steve Mooney, "Power Line Perceptions: Their Impact on Value and Market Time" (College of Business, St. Cloud State University, 1998).

- Between one-half and three-fourths of the respondents have negative feelings about the lines.
- The negative feelings center on fear of health effects, aesthetics, and property-value effects.
- Of those who have negative feelings about the lines, the vast majority (67%–80%) report that the purchase decision and the price they offered to pay were not affected by the lines.

In summary, the relatively small effects on property value attributed to HVTL proximity in the literature does not mean that the direction of the effect of transmission lines on property values is not negative. The general interpretation is that, even though transmission line issues have been a prominent concern in most of the communities studied, and even though the direction of effect on real estate value is generally negative, the presence of transmission lines is apparently not given sufficient weight by buyers and sellers of real estate to have had any consistent, material effect on property values.

Connecticut and Massachusetts 2008 Case Study

Study Area Selection

Given the anticipated expansion of the 345-kV transmission grid in New England over the next decade, this study focused on Connecticut and Massachusetts. The objective was to find both rural residential and suburban residential developments along existing 345-kV corridors where the effects of the lines could be studied. The study called for at least 10 years of sales data (1998–2007). The criteria for study area selection were (1) the existing transmission corridor had to contain a 345-kV line, preferably on 130-foot steel poles; (2) the line had to have been built by 1997; and (3) the development patterns along the corridor had to produce a sufficient number of sales to make statistical analysis feasible.

Based upon a combination of field inspection, review of aerial photography, and review of maps of the existing electric transmission grid, nine areas were selected for the study.[9] Table 1 describes the location, configuration of transmission lines, and number of records for each area for the 10-year

Database Development

Once the study areas had been selected, local appraisers were retained to assist in the data collection process.[10] A download from the Warren Group identified all sales within a set of street addresses that had been developed to describe an area that approximated 2,000 feet on either side of the transmission line corridor. Using this information, appraisers collected the assessors' record and the multiple listing service (MLS) "sold record" for each of the transactions in the data set. A sales database containing the information shown in Table 2 was then populated for each sale transaction.

Next, the sales database record for each property was returned to the appraisers together with a hard copy of the assessors' record and the MLS sheet. The appraisers were then asked to visit each property and record its location coordinates with a GPS device at the street curb opposite the front door. When obtaining the location information, they were also asked to verify the data entry to the sales database and to opine as to whether, in their judgment, the sale appeared to be an arm's-length transaction.

Next, the appraisers recorded the extent to which the transmission line structures were visible from the property.[11] For each property, the appraisers were given an aerial photograph that showed and labeled all structures in the vicinity of the property. Since the field observations were taken in July and August, it was important for the appraisers to know where structures might potentially be seen. Standing at the street curb, they made three observations and took photos of each; one from the right edge of the property, one from the left edge of the property, and one from the point on the street curb opposite the front door. These views were then coded for up to three of the most visible structures (or structure combinations) from each of the three locations.[12] Visibility was rated as follows:

- Highly Visible–At least one arm holding a conductor is fully visible and not obscured by trees or foliage.

9. When this research began, the number of sales that occurred in each area over the 10-year period was unknown. It was anticipated that some of the areas could be aggregated in the final analysis.

10. Race Appraisal Services, LLC, was retained for the four Massachusetts study areas, Oles & Jerram, Inc., for the three western Connecticut areas, and Archambault & Murray Appraisal Group for the two north-central Connecticut areas.

11. *Structures would include steel poles, steel lattice towers, and wood H-frame towers.*

12. In instances where a 345-kV structure was collocated with a 115-kV line or another 345-kV line, visibility ratings to both structures were recorded.

Table 1 Study Area Locations and Transmission Line Configurations

Area	Location	Transmission Line Configuration	Total Records Considered
Study Area 1			
Subarea 1.1 (South-Central MA)	Located in Ludlow, Hampton County, MA, approx. 5 miles east of I-291 and bordered by I-90 to the north.	345-kV line supported by steel poles and 115-kV line supported by H-frame structures.	71
Subarea 1.2 (South-Central MA)	Located on the CT and MA border in East Longmeadow, Hampton County, MA, approx. 7 miles east of I-91.	345-kV line supported by steel poles and 115-kV line supported by H-frame structures.	35
Subarea 1.3 (North-Central CT)	Located in Bloomfield, Hartford County, CT, approx. 3.5 miles west of I-95 and east of CT 189.	345-kV line supported by steel poles and 115-kV line supported by H-frame structures.	80
Subarea 1.4 (North-Central CT)	Located in Windsor and Bloomfield, Hartford County, CT, immediately west of I-91 and north of CT 218.	345-kV line supported by steel poles and 115-kV line supported by H-frame structures.	445
Study Area 2			
Subarea 2.1 (West CT)	Located in New Milford, Litchfield County, CT, approx. 13 miles north of I-84 along Route 202.	345-kV line supported by H-frame structures and 115-kV line supported by H-frame structures.	77
Subarea 2.2 (West CT)	Located in New Milford, Litchfield County, CT, approx. 10 miles north of I-84 along Route 202.	345-kV line supported by steel poles.	85
Subarea 2.3 (West CT)	Located in Brookfield, Litchfield County, MA, approx. 5 miles north of I-84 along Route 202.	345-kV line supported by steel poles.	237
Study Area 3 (East MA)	Located in Stoughton, Norfolk County approx. 4 miles south of I-93 and east of State Hwy 138.	Two 345-kV lines supported by steel lattice towers.	206
Study Area 4 (East MA)	Located in Randolph, Norfolk County approx. 4 miles south of I-93 and east of State Hwy 24.	Two 345-kV lines supported by steel lattice towers.	418
All Areas			**1,654**

- Somewhat Visible–Some portion of the structure is visible independent of trees or foliage, but not a full arm holding a conductor.
- Barely Visible–The entire structure is mostly obscured by trees or foliage, but can be recognized, especially in winter.

Given that the appraisers knew where to look, the ratings reflect the distinction between Barely Visible and not visible as they would be recorded in the winter. That is not an issue with the first two categories as the structure elements are visible independent of trees or foliage. A larger issue is that visibility is being measured as of the summer of 2008 and not as of the date of the sale transaction. Thus, visibility of the structures is being underestimated, especially for sales early in the study period.[13] Another issue is the visibility of the conductors them-

13. Perhaps a forestry PhD candidate could develop a height and density foliage model that could be used to make visibility adjustments over time.

Table 2 Sale and Property Characteristic Data

Variable	Description
Sale Price	Transaction sale price
Liveable Area	Liveable area in square feet
Lot Size	Lot size in acres
A/C	Value of 1 if property has central A/C; zero otherwise
Age (at the time of sale)	Age of property at time of transaction (sale year minus year built)
Total Bathrooms	Sum of full, half, and three-fourths baths (full = 1; half = 0.5; three-fourths = 0.75)
Basement Area	Basement area in square feet
Deck-Small	Value of 1 if the property's deck size is less than or equal to the median deck size of the area; zero otherwise
Deck-Large	Value of 1 if the property's deck size is greater than the median deck size of the area; zero otherwise
Garage-Small	Value of 1 if the property's garage size is less than or equal to the median garage size of the area; zero otherwise
Garage-Large	Value of 1 if the property's garage size is greater than the median garage size of the area; zero otherwise
Patio-Small	Value of 1 if the property's patio size is less than or equal to the median patio size of the area; zero otherwise
Patio-Large	Value of 1 if the property's patio size is greater than the median patio size of the area; zero otherwise
Porch-Small	Value of 1 if the property's porch size is less than or equal to the median porch size of the area; zero otherwise
Porch-Large	Value of 1 if the property's porch size is greater than the median porch size of the area; zero otherwise
Sale Year 1999	Value of 1 if transaction occurred in 1999; zero otherwise
Sale Year 2000	Value of 1 if transaction occurred in 2000; zero otherwise
Sale Year 2001	Value of 1 if transaction occurred in 2001; zero otherwise
Sale Year 2002	Value of 1 if transaction occurred in 2002; zero otherwise
Sale Year 2003	Value of 1 if transaction occurred in 2003; zero otherwise
Sale Year 2004	Value of 1 if transaction occurred in 2004; zero otherwise
Sale Year 2005	Value of 1 if transaction occurred in 2005; zero otherwise
Sale Year 2006	Value of 1 if transaction occurred in 2006; zero otherwise
Sale Year 2007	Value of 1 if transaction occurred in 2007; zero otherwise
Subarea 1.1	Value of 1 if property is located in Subarea 1.1; zero otherwise
Subarea 1.2	Value of 1 if property is located in Subarea 1.2; zero otherwise
Subarea 1.3	Value of 1 if property is located in Subarea 1.3; zero otherwise
Subarea 2.1	Value of 1 if property is located in Subarea 2.1; zero otherwise
Subarea 2.2	Value of 1 if property is located in Subarea 2.2; zero otherwise

selves. It was observed that conductors were seldom noticeable without a structure or structures being visible and that structure visibility was the defining characteristic of the visibility of the conductor/structure combination.

The final field task carried out by the appraisers was to review assessor maps for all properties adjacent to the transmission line corridor to determine if each property was encumbered with an easement associated with the HVTL. If so, the size of the encumbrance was estimated from assessor maps.

Once the field data had been collected, the final step was to construct the proximity and visibility variables to be used in the analysis. Since the location coordinates of all the structures were known, the distance could be calculated from the street curb opposite the front door of each property to any structure coded as visible by the appraisers. The perpendicular distance was also calculated, from the street curb opposite the front door to the centerline of the transmission line corridor. Using all the collected information, six variables were constructed designed to test for proximity, visibility, and encumbrance effects: Continuous Distance; Zone 0–75 Meters; Zone 75+–150 Meters; Number of Structures Visible; Weighted Number of Structures Visible; and Encumbrance. Table 3 describes these six variables.

Aggregation of the Data

Based on the data on geographic proximity, sale prices, and sale prices per square foot, the nine initial areas were aggregated to four large study areas. Study Area 1 (A1) is an aggregated area consisting of the two South-Central Massachusetts areas (Subareas 1.1 and 1.2) and the two North-Central Connecticut areas (Subareas 1.3 and 1.4). Study Area 2 (A2) is an aggregated area consisting of the three West Connecticut areas (Subareas 2.1, 2.2, and 2.3). The two East Massachusetts areas continue to be treated independently as Study Area 3 (A3) and Study Area 4 (A4), respectively, due to the significant difference in their sale price per square foot and the practical consideration that both have large enough numbers of sales to support independent analysis.

The total number of sale transactions considered for each of the four areas is shown in Table 4. Of the initial 1,654 records, 308 records were discarded because they did not meet the arm's-length criterion in the opinion of the appraisers (or the sale transactions could not be confirmed). The two most common reasons given were (1) an institution was identified as one of the parties to the sale, or (2) only a single party was indentified in the transaction. There were also sales in which the buying and selling parties had the same last names or cases where the reported consideration was zero. For 38 transactions, the appraisers were not able to complete all required data fields for the analysis, the transaction appeared to be a duplicate transaction, or the transaction was otherwise sufficiently unrepresentative of the general study area as to be discarded.[14]

Finally, a relatively small number (22) of additional sales were eliminated to improve the fit of the regression model. A base model was estimated for each area and observations with residuals of more than ± 2.5 standard deviations were excluded from subsequent regression runs. Overall, this filter improved the fit of the regression models by several percentage points, but only eliminated 1.7% of the usable transactions. The residual filter did not impact the sign of the estimated coefficients, but generally improved the significance of the studied variables, i.e., if an estimated coefficient was negative and borderline significant before applying the residual filter, it

Table 3 HVTL Variables

Variable	Description
Continuous Distance	Shortest distance from the street curb opposite the front door of the property to the centerline of the transmission line
Zone 0–75 Meters	Value of 1 if the property is less than or equal to 75 meters away from the centerline of the transmission line; zero otherwise
Zone 75+–150 Meters	Value of 1 if the property is greater than 75 or less than or equal to 150 meters away from the centerline of the transmission line; zero otherwise
Number of Structures Visible	Number of unique structures visible from the property
Weighted Number of Structures Visible	Sum of the numeric value of the rating assigned to each tower visible from the property; Highly Visible = 4, Somewhat Visible = 2, Barely Visible = 1
Encumbrance	Square feet encumbered by the easement

Table 4 Number of Records Considered

	Study Area				
	A1	**A2**	**A3**	**A4**	**Total**
Total Records Considered	631	399	206	418	1,654
Less Non-Arm's-Length Transactions	142	37	48	81	308
Less Incomplete, Duplicate, or Otherwise Not Usable Transactions	8	12	1	17	38
Less Outliers Filtered by Residual Filter	6	6	4	6	22
Transactions Used in Regression Models	**475**	**344**	**153**	**314**	**1,286**

14. Nine transactions were excluded that were not representative of the general study areas. For example, we excluded a transaction with a sale price of $800,000 in a neighborhood with average home values of $192,611, a property (which sold twice during our study time period) that contained a 130 acre lake, and a property that appeared to be a lot sale only.

stayed negative, but typically became more significant after applying the residual filter. Appendix 2 contains descriptive statistics of the four Study Areas.

The Base Model

Before working with the transmission line-related variables, a base model was estimated for each of the four study areas; the results are shown in Table 5. Various functional formats were explored during the model specification stage. Based upon guidance provided in the published literature and an evaluation of alternative specifications, the natural log of the sale price was used as the dependent variable. Three of the independent variables (*Liveable Area*, *Lot Size*, and *Basement Area*) were also entered as natural logs to allow for a nonlinear response of the sale price to increases in size.

Data for the total number of bedrooms was available, but it was not included in the model because it did not add statistical explanatory power after liveable area and number of bathrooms were accounted for. Data on square feet of finished basement was available for most sales, but it also did not add any explanatory power once total basement size was in the model, so it was dropped as well.[15] For deck, garage, and porch square footage, the dummy variables of small and large were used, depending on whether the feature was above or below the median size.[16] A regional home price deflator was not used to adjust sale prices, since there were plenty of observations and the annual dummy variable for year of sale (1998 is the excluded year) seemed more reliable. Finally, dummy variables were included for the subareas that were aggregated to form Study Area 1 (A1) and Study Area 2 (A2).[17]

Overall, the base models have very good explanatory power; the independent variables are generally statistically significant with the anticipated sign and are of reasonable magnitudes.[18] Table 6 provides a sample interpretation of the regression coefficients for A2.[19]

Testing for the Effects of Proximity, Visibility, and Encumbrance

Table 7 shows the frequency distribution and the summary statistics of the key transmission line-related variables in the sales database. As expected, encumbered properties are slightly larger than the unencumbered properties.

Out of the 1,286 sales, over 100 properties are within 75 meters of an existing 345-kV transmission line, 78 properties are encumbered with an easement associated with the transmission line, and 527 are of properties from which one or more transmission line structures can be seen.

Tables 8 and 9 summarize the results when the transmission line variables are added to the base model for each of the four study areas. There are two basic approaches to testing for proximity effects: (1) distance as a categorical variable representing distance zones, and (2) distance measured as a continuous variable. Both approaches are investigated, with distance zones shown in Table 8 and continuous distance shown in Table 9. The tables are structured so that distance is examined first by itself (Model 1), the encumbrance variable is then added (Model 2), and then two visibility variables are considered–the number of structures visible (Model 3) and the number of structures visible weighted by the degree of visibility (Model 4).[20]

Proximity. Tables 8 and 9 are striking in that there is no systematic effect of proximity to the transmission

15. Care must be exercised here not to misinterpret the effect of the variables in the base model. Because many of the variables are highly correlated (e.g., liveable area, number of bathrooms, number of bedrooms), the regression may not be able to sort out the independent effect of each. The coefficients on the included variables must, therefore, be interpreted as the joint effect of the included variables and any excluded, highly correlated variable(s).

16. Since for a significant number of transactions, the properties did not have a garage, deck, and/or porch, these variables exhibit a skewed distribution with most of the transactions centered around the '0' value (i.e., these variables do not follow a normal distribution). Therefore, to address the non-normal distribution of the variables these variables were entered as categorical variables (dummy variables). For a categorical variable, one category must be left out of the regression, and the coefficients on the included categories measure the effect on sale price relative to the excluded category. For the garage, deck, and porch dummy variables, the excluded groups are properties that do not have a garage, deck, and/or porch.

17. The excluded subarea for Study Area 1 was Subarea 1.4; for Study Area 2, it was Subarea 2.3.

18. Given that the dependent variable is in natural logs, the interpretation of the coefficients on the independent variables is as follows: (1) the coefficient of an untransformed continuous variable (e.g., number of bathrooms) approximates the percentage change in sale price due to a one-unit change in the underlying variable; (2) the coefficient of a dummy variable approximates the percentage change in the sale price if the value of the dummy variable is 1; and (3) the coefficient of a log transformed continuous variable approximates the percentage change in sale price given a 1% change in the log transformed variable.

19. Property characteristics were assumed that approximate the median values for Study Area 2.

20. Without additional research, the weights attached to the three categories of visibility are necessarily subjective. The results shown in the tables are based on a 4:2:1 scheme, i.e., highly visible carries twice the weight of somewhat visible, which has twice the weight of barely visible. Other schemes were tried, but the results were largely unaffected.

Table 5 Base Model Estimation Results

	Study Area			
Variable	**A1**	**A2**	**A3**	**A4**
Constant	9.3295**	9.0552**	9.7858**	9.5877**
	(51.3163)	(41.2176)	(33.2529)	(53.7392)
ln*Liveable Area* (in sq. ft.)	0.3018**	0.3700**	0.3149**	0.3032**
	(11.9133)	(11.9432)	(7.6257)	(11.8995)
ln*Lot Size* (in acres)	0.0569**	0.0174	0.0523**	0.0389**
	(4.1087)	(0.9404)	(2.2025)	(2.0536)
A/C (yes/no)	–0.0012	0.0505**	0.0433*	0.0211
	(–0.0773)	(2.7320)	(1.7767)	(1.6144)
Age	–0.0039**	–0.0009**	–0.0049**	–0.0017**
	(–9.2045)	(–3.0085)	(–5.1140)	(–6.0633)
Total Bathrooms	0.0681**	0.0397**	0.0180	0.0762**
	(5.9799)	(2.5000)	(0.9160)	(6.5439)
ln*Basement Area* (in sq. ft.)	0.0139**	0.0313**	0.0126**	0.0159**
	(5.2651)	(4.8848)	(4.0452)	(5.1089)
Deck-Small	0.0160	0.0150	–0.0101	0.0145
	(1.1576)	(0.7761)	(–0.4087)	(1.0105)
Deck-Large	0.0127	0.0248	0.0561**	0.0454**
	(1.0065)	(1.2731)	(2.1352)	(3.0625)
Garage-Small	0.0738**	0.1211**	0.0224	0.0528**
	(4.9800)	(4.1899)	(1.0559)	(3.8013)
Garage-Large	0.1154**	0.1445**	0.0832**	0.0460**
	(7.2675)	(4.7379)	(3.3965)	(2.8108)
Porch-Small	0.0332**	0.0389**	0.0120	0.0163
	(2.6389)	(1.9962)	(0.6302)	(1.1652)
Porch-Large	0.0429**	0.0186	0.0222	0.0236
	(3.2400)	(0.9402)	(1.0357)	(1.5621)
Sale Year 1999	0.0647**	0.0884**	0.0898**	0.1312**
	(2.7723)	(2.2858)	(2.9167)	(5.4847)
Sale Year 2000	0.1355**	0.2296**	0.3423**	0.2746**
	(5.5220)	(5.5944)	(9.3656)	(9.3996)
Sale Year 2001	0.2293**	0.3085**	0.5027**	0.4011**
	(8.8978)	(7.8390)	(14.0765)	(14.7889)
Sale Year 2002	0.2924**	0.4285**	0.5883**	0.5603**
	(12.7420)	(11.4544)	(18.0932)	(23.1608)
Sale Year 2003	0.3676**	0.4953**	0.7308**	0.6712**
	(15.7658)	(14.1213)	(22.1995)	(27.7454)
Sale Year 2004	0.5122**	0.6253**	0.7797**	0.7600**
	(21.5832)	(18.4644)	(22.7246)	(32.8114)
Sale Year 2005	0.6244**	0.7255**	0.8802**	0.8589**
	(28.3895)	(20.6101)	(26.6213)	(34.9250)
Sale Year 2006	0.7059**	0.7261**	0.8612**	0.7999**
	(30.4294)	(20.1332)	(26.1725)	(31.2761)
Sale Year 2007	0.6968**	0.7147**	0.7850**	0.7522**
	(29.1600)	(18.0000)	(22.4262)	(26.6658)
Subarea 1.1	0.0910**			
	(4.4589)			
Subarea 1.2	0.2110**			
	(9.3416)			
Subarea 1.3	–0.0062			
	(–0.3908)			
Subarea 2.1		–0.1789**		
		(–8.8005)		
Subarea 2.2		–0.1773**		
		(–6.8976)		
Adjusted *R*-Squared	88.25%	87.85%	93.52%	92.16%
Mean Sale Price	$172,786	$298,740	$227,927	$258,249
Included Observations	475	344	153	314

t-Statistics provided in parentheses.

* Indicates variable is significant at the 90% level.

** Indicates variable is significant at the 95% level.

Table 6 Sample Calculation of Estimated Sale Price for Study Area 2 (A2)

Variable	Assumed Value	Natural Log Transformed Values	Estimated Coefficient	Estimated Effect
Constant	1		9.05516	9.05516
ln*Liveable Area* (in sq. ft.)	2,000	7.6009	0.37005	2.81269
ln*Lot Size* (in acres)	0.75	-0.2877	0.01742	-0.00501
A/C (yes/no)	1		0.05048	0.05048
Age	35		-0.00092	-0.03234
Total Bathrooms	2.5		0.03969	0.09922
ln*Basement Area* (in sq. ft.)	1,000	6.9078	0.03126	0.21595
Deck-Small	1		0.01504	0.01504
Deck-Large	0		0.02480	0
Garage-Small	1		0.12108	0.12108
Garage-Large	0		0.14448	0
Porch-Small	1		0.03894	0.03894
Porch-Large	0		0.01855	0
Study Area 2.1	0		-0.17888	0
Study Area 2.2	0		-0.17732	0
Sale Year 1999	0		0.08843	0
Sale Year 2000	0		0.22960	0
Sale Year 2001	1		0.30849	0.30849
Sale Year 2002	0		0.42848	0
Sale Year 2003	0		0.49534	0
Sale Year 2004	0		0.62529	0
Sale Year 2005	0		0.72548	0
Sale Year 2006	0		0.72609	0
Sale Year 2007	0		0.71470	0
Estimated Natural Log Transformed Value (Sum of Effects)				12.67969
Estimated Value				$321,159

Table 7 Summary of Transmission Line Variables

	Study Area			
	A1	A2	A3	A4
Distance Zones				
Zone 0–75 Meters				
Number of Properties	43	7	20	41
Median Distance	62	62	53	50
Zone 75⁺–150 Meters				
Number of Properties	63	65	20	55
Median Distance	97	118	103	104
Greater than 150 Meters				
Number of Properties	369	272	113	218
Median Distance	343	371	294	304
Continuous Distance				
Number of Properties	475	344	153	314
Median Distance	275	286	237	228
Encumbrance				
Number of Properties Encumbered	29	32	7	10
Median Sq. Ft. Encumbered	8,527	11,825	7,601	5,707
Median Lot Size of Encumbered Properties	0.50	0.99	0.35	0.33
Median Lot Size of Unencumbered Properties	0.40	0.93	0.21	0.28
Number of Properties with Transmission Structure(s) Visible				
1 Structure Visible	87	69	10	51
2 Structures Visible	71	24	30	61
3 Structures Visible	23	8	13	29
4 Structures Visible	6	0	14	15
More than 4 Structures Visible	2	0	13	1

Table 8 Zone Distance Model

	Study Area			
	A1	A2	A3	A4
Model 1: Distance Zone Model				
Zone 0–75 Meters	-0.0226	-0.0874	0.0131	-0.0055
	(-1.2734)	(-1.6429)	(0.5278)	(-0.3159)
Zone 75⁺–150 Meters	0.0041	-0.0388*	0.0069	0.0237
	(0.2768)	(-1.9251)	(0.2443)	(1.5212)
Model 2: Distance Zone Model & Encumbrance				
Zone 0–75 Meters	-0.0179	-0.0539	0.0306	0.0050
	(-0.8636)	(-1.0068)	(1.0550)	(0.2711)
Zone 75⁺–150 Meters	0.0056	0.0012	0.0064	0.0257
	(0.3666)	(0.0492)	(0.2280)	(1.6495)
Encumbrance	-0.0012	-0.0113**	-0.0061	-0.0073*
	(-0.4387)	(-3.1867)	(-1.1684)	(-1.7323)
Model 3: Distance Zone Model & Encumbrance & Number of Structures Visible				
Zone 0–75 Meters	-0.0283	-0.0697	0.0151	-0.0019
	(-1.1314)	(-1.2515)	(0.4562)	(-0.0832)
Zone 75⁺–150 Meters	-0.0034	-0.0122	-0.0033	0.0206
	(-0.1776)	(-0.4561)	(-0.1120)	(1.1312)
Encumbrance	-0.0014	-0.0113**	-0.0073	-0.0078*
	(-0.5065)	(-3.1996)	(-1.3663)	(-1.8018)
Number of Structures Visible	0.0055	0.0139	0.0069	0.0038
	(0.7434)	(1.0312)	(0.9784)	(0.5519)
Model 4: Distance Zone Model & Encumbrance & Weighted Number of Structures Visible				
Zone 0–75 Meters	-0.0170	-0.0681	0.0218	0.0011
	(-0.6796)	(-1.2174)	(0.6204)	(0.0479)
Zone 75⁺–150 Meters	0.0062	-0.0117	0.0023	0.0231
	(0.3355)	(-0.4224)	(0.0792)	(1.3250)
Encumbrance	-0.0012	-0.0114**	-0.0068	-0.0076*
	(-0.4281)	(-3.2124)	(-1.2424)	(-1.7606)
Weighted Number of Structures Visible	-0.0001	0.0034	0.0009	0.0006
	(-0.0621)	(0.8760)	(0.4443)	(0.3291)

t-Statistics provided in parentheses; p-values available from authors upon request.
* Indicates variable is significant at the 90% level.
** Indicates variable is significant at the 95% level.

line corridor on sale price. The only exception is A2 in the continuous distance specification. In Models 1, 3, and 4, the distance variable is negative for A2 and statistically significant at either the 95% or 90% level. However, further analysis reveals that the distance variable of Model 1 becomes insignificant once encumbrance is accounted for (in Table 9, see Model 2 for A2). Further, even though both Models 3 and 4 show a significant distance effect, Model 3 also shows an unexpected positive effect of structure visibility. A possible interpretation is that although encumbrance clearly has a negative effect, the combination of greater distance and more structures visible may imply long views and the positive value of the long views may outweigh any negative effects of the HVTLs. The only other remaining distance variable with a statistically significant value–Zone 75⁺–150 Meters in Model 1 for A2 (Table 8) –also becomes insignificant once encumbrance is added to the model (Zone 75⁺–150 Meters in Model 2 for A2).

Encumbrance. The only variable that appears to have any kind of systematic effect is the encumbrance variable, which for A2 and A4 is of the expected sign in both the Zone Distance and Continuous Distance models and is statistically significant at either the 90% or 95% level. However its magnitude is generally small. For example, for A2 the reported coefficient on

Table 9 Continuous Distance Model

	Study Area			
	A1	A2	A3	A4
Model 1: Distance Zone Model				
Continuous Distance	0.0008	0.0351**	-0.0116	-0.0034
	(0.1030)	(2.7181)	(-0.9393)	(-0.4711)
Model 2: Distance Zone Model & Encumbrance				
Continuous Distance	-0.0031	0.0157	-0.0214	-0.0091
	(-0.3772)	(1.0921)	(-1.5094)	(-1.1699)
Encumbrance	-0.0027	-0.0099**	-0.0071	-0.0087**
	(-1.0350)	(-2.9613)	(-1.3956)	(-2.0392)
Model 3: Distance Zone Model & Encumbrance & Number of Structures Visible				
Continuous Distance	-0.0016	0.0327*	-0.0153	-0.0057
	(-0.1378)	(1.8681)	(-0.8046)	(-0.5704)
Encumbrance	-0.0028	-0.0101**	-0.0075	-0.0090**
	(-1.0475)	(-3.0395)	(-1.4443)	(-2.0834)
Number of Structures Visible	0.0014	0.0240*	0.0038	0.0036
	(0.1875)	(1.6896)	(0.4749)	(0.5332)
Model 4: Distance Zone Model & Encumbrance & Weighted Number of Structures Visible				
Continuous Distance	-0.0085	0.0293*	-0.0220	-0.0078
	(-0.7440)	(1.7083)	(-1.1501)	(-0.7928)
Encumbrance	-0.0025	-0.0104**	-0.0070	-0.0088**
	(-0.9308)	(-3.1019)	(-1.3383)	(-2.0471)
Weighted Number of Structures Visible	-0.0014	0.0057	-0.0001	0.0004
	(-0.6849)	(1.4415)	(-0.0500)	(0.2160)

t-Statistics provided in parentheses; *p*-values available from authors upon request.
* Indicates variable is significant at the 90% level.
** Indicates variable is significant at the 95% level.

the encumbrance variable in Continuous Distance Model 2 (Table 9) implies an effect of approximately $3,000 for a property with 12,000 square feet encumbered and a sale price of $300,000.[21]

Visibility. With respect to the impact of visibility of the transmission tower, the results did not indicate any systematic impact with respect to sign or magnitude.[22] As previously discussed, the only time when the visibility variable was statistically significant, the sign of the coefficient was positive.

Other Hypotheses Tested

Two other hypotheses were offered that can be examined with the data collected in this study. First, it was suggested that property values would be particularly vulnerable to HVTL effects in a down market. Second, it was suggested that higher-valued properties would be more vulnerable to HVTL effects than lower-valued properties.

Effect in Market Downturn. Looking back at the coefficients on the sale year variables for 2006 and 2007 in Table 5, the market downturn appears to have affected the four study areas quite differently. Study Area 1 still experienced a significant increase in real estate values in 2006 and experienced a slight drop in 2007. Study Area 2 properties leveled off in 2005 with only a nominal change between 2005 and 2006 and a small drop in 2007. However, the two areas south of Boston, Study Areas 3 and 4, clearly peaked in 2005 with significant drops in values between 2005 and 2007.

Therefore, the study investigated whether there was any evidence that property values were more sensitive to HVTL effects in 2006 and 2007 for Study

21. The coefficient of –0.0099 can be interpreted as the percentage change (i.e., approximately –0.01%) of a 1% change in encumbrance. Therefore, assuming a sale price of $300,000 and an encumbrance of 12,000 square feet, a 1-square-foot change in encumbrance would correspond to a –$0.25 change in sale price (0.25 = $30.00/120).

22. Theory would suggest that the distance and visibility variables should be entered multiplicatively implying the effect of each depends on the value of the other. This was tried but had no effect on the results.

Areas (A3) and Study Area 4 (A4), i.e., the areas which experienced significant market softening. The hypothesis was that the effect of the encumbrance, proximity, and visibility variables would be more pronounced in these two years of falling market values. This was tested by adding interaction terms for sale years 2006 and 2007 with each of the transmission line variables shown in Table 9.[23]

The encumbrance variable and the encumbrance interaction term were both negative for A3, but not statistically significant. Since there were only two encumbered properties that sold in 2006 and 2007 in A3, no reliability can be attached to these results; the same situation existed for A4. The encumbrance variable stayed significant at the 95% level (similar in magnitude as in Table 9). However, the interaction term testing for the down-market effect was insignificant and since there was only one encumbered property transacted in the 2006–2007 period, no reliability can be attached to this result either. The remaining coefficients on the transmission line variables and the interaction variables were not significant at any conventional level of significance. Thus, there is no evidence here to support the hypothesis of greater vulnerability of values to HVTL effects in a down market, but it has to be recognized that the number of observations on the key transmission line variables is small for just two sale years and more observations over a longer period would yield a more definitive result.

Effects on Higher-Valued Properties. The second hypothesis often suggested is that higher-valued properties would be more vulnerable to transmission line effects than lower-valued properties. To investigate this, all of the models shown in Tables 8 and 9 were reestimated based on observations that fell above the median sale price in their sales year. The results showed the same pattern of lack of statistical significance for the HVTL variables as in Tables 8 and 9; this supports the conclusion that the higher-valued properties show no greater sensitivity to HVTL variables than lower-valued properties.

Finally, since almost all of the anticipated 345-kV line construction that motivated this study will take place in existing transmission corridors, a couple of questions remain. First, is it possible to say anything about the incremental effect of a corridor upgrade? Second, and perhaps related, is it possible that there would be short-term proximity and visibility effects but that these would dissipate over time?[24] The first question does not seem relevant here. Since all of the sales studied here are in the vicinity of the corridor configuration that will exist after the upgrade, and since there are no proximity or visibility effects, it is hard to see how there could be upgrade effects.

This study, however, does not eliminate the possibility that the upgrade might induce short-term effects that would dissipate over time. The data represent situations where the existing HVTL corridor has been in place for some time, so, it can be said with some confidence that there are no permanent property value effects of the corridor due to proximity or visibility. However, this does not rule out a temporary effect. Therefore, a useful complement to this study might look at the history of a corridor over a period that includes a pre-upgrade period, an announcement and construction period, and then a post-upgrade period.

Conclusions

The research reported here investigates the effect of existing 345-kV transmission lines in Connecticut and Massachusetts on the value of properties sold over the period 1998–2007. Extra care has been taken in the research to account for encumbrance, proximity, and visibility effects. There are obvious relationships among the three variables, and if each is not considered, the effects of one could be mistakenly attributed to another. In particular, encumbrance effects could be mistakenly interpreted as proximity effects if both are not considered.

In the four study areas examined here, there is no evidence of systematic effects of either proximity or visibility of 345-kV transmission lines on residential real estate values. Encumbrance of the transmission line easement on adjoining properties does appear to have a consistent negative effect on value, although the statistical significance with which it is measured varies. The hypothesis that property values are more vulnerable to transmission line effects in a down market also is considered; although no evidence

23. The down-market hypothesis could not be tested with the zone distance models as there were not a sufficient number of transactions in each of the two distance zones; therefore, the hypothesis was only tested on the continuous distance model.

24. Colwell (1990) in a study in Illinois based on data from the 1970s finds small proximity effects, but also finds that the effects dissipated over the 10 or so years of sales that he studied. The transmission line in question, however, had been in place for several years prior to the study period. Most on point is the study by Ignelzi (1991), which finds small proximity effects following an upgrade, but that the effects disappeared after 4–5 years.

supports that proposition that there are greater effects in a down market, the number of observations in the relevant period is small. Finally, the hypothesis that higher-valued properties are more vulnerable to transmission line effects is considered; again, the data provides no support for that hypothesis.

The professional literature cited, combined with the results reported here, support the position that a presumption of material negative effects of HVTLs on property values is not warranted. An opinion supporting HVTLs effects would have to be based on market data particular to the situation in question and could not be presumed or based on casual, anecdotal observation. It is fair to presume that the direction of the effect would in most circumstances be negative, but the existence of a measureable effect and the magnitude of such an effect can only be determined by empirical analysis of actual market transactions.

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Additional Reading

Acks, Kenneth. "Valuation of Environmental Damages to Real Estate." http://www.damagevaluation.com/text/html/valredi4.html (January 1995).

Barth, James R., and James T. Bennett. "The Effects of Electric Utility Power Plant Location on Area Property Values." *Land Economics* (February 1974).

Delaney, Charles J., and Douglas Timmons. "High Voltage Power Lines: Do They Affect Residential Property Value?" *Journal of Real Estate Research* 7, no. 3 (June 1992): 315–329.

Delaney, Charles J., and Douglas Timmons. "Valuation Implications for Residential Property Proximate to High Voltage Power Lines: A New Environmental Concern?" Unpublished paper, Department of Real Estate, Baylor University, January 1991.

Dempsey, William E. "The DUPA Technique for Electric Transmission-Line Easement Acquisitions." *The Appraisal Journal* (July 1981): 382–390.

Furby, Lita, Robin Gregory, Paul Slovic, and Baruch Fischoff. "Electric Power Transmission Lines, Property Values, and Compensation." *Journal of Environmental Management* 27 (January 1988): 69–83.

Green, Gordon G. "Easement-to-Fee-Simple Value Ratios for Electric Transmission Line Easements: A Common Approach." *The Appraisal Journal* (July 1992): 399–412.

Gregory, Robin, and Detlof von Winterfeldt. *Proposal for Property Values Feasibility Studies.* Irvine, CA: Decision Insights, Inc., 1999.

Kinnard, William N., Jr. *Patterns of Property Value Impacts from Proximity to High-Voltage Transmission Lines: Analytical Update.* Storr, CT: Real Estate Counseling Group of Connecticut, Inc., 1992.

Kinnard, William N., Jr. "The Impact of High Voltage Transmission Lines on Real Estate Values." *Journal of Property Tax Management* 1, no. 4 (1990): 324–346.

Kinnard, William N., Jr. *Tools and Techniques for Measuring the Effects of Proximity to Radioactive Contamination on Single-Family Residential Sales Prices.* Storr, CT: Real Estate Counseling Group of Connecticut, Inc.

Kinnard, William N., Jr., and Sue Ann Dickey. "A Primer on Impact Research: Residential Property Values Near High-Voltage Transmission Lines." *Real Estate Issues* (April 1995): 23–29.

Kroll, Cynthia A. "Property Valuation: A Primer on Proximity Impact Research." Paper presented at Conference on Electric and Magnetic Fields, February 1994.

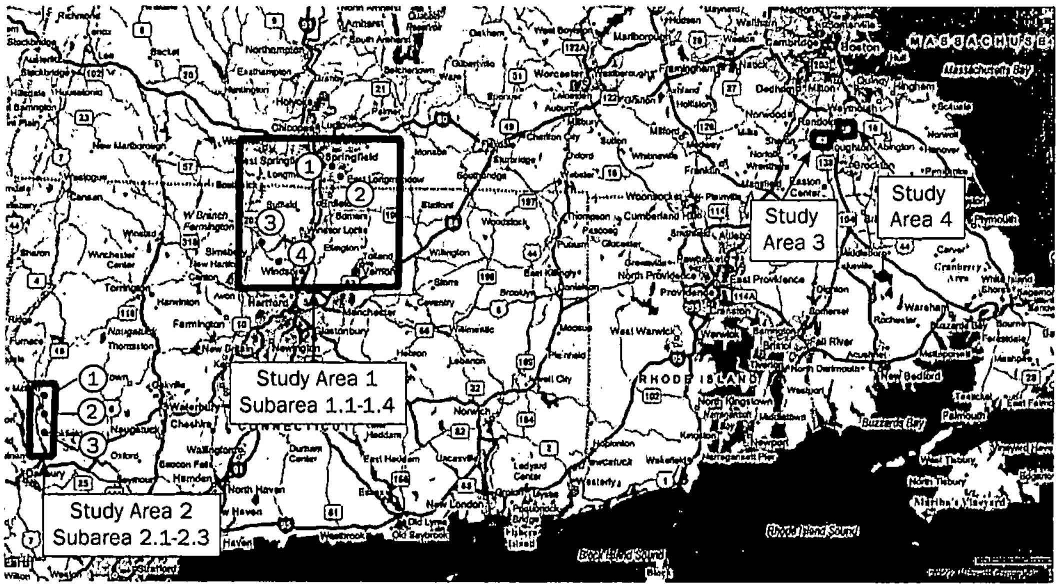
Pitts, Jennifer, and Thomas O. Jackson. "Power Lines and Property Values Revisited." *The Appraisal Journal* (Fall 2007): 323–325.

Priestley, Thomas, and Patrice C. Ignelzi. *A Methodology for Assessing Transmission Line Impacts in Residential Communities.* Washington, DC: Edison Electric Institute, June 1989.

Wilson, Albert R. "Proximity Stigma: Testing the Hypothesis." *The Appraisal Journal* (Summer 2004): 253–262.

Appendix 1

Study Area and Subarea Locations



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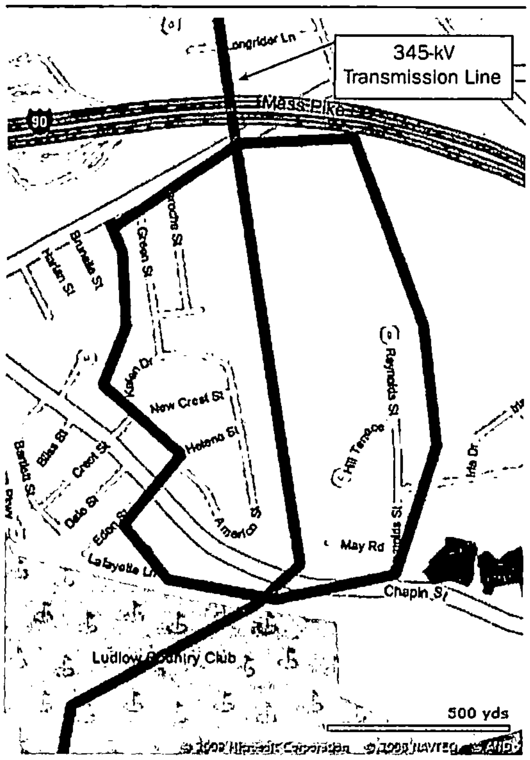

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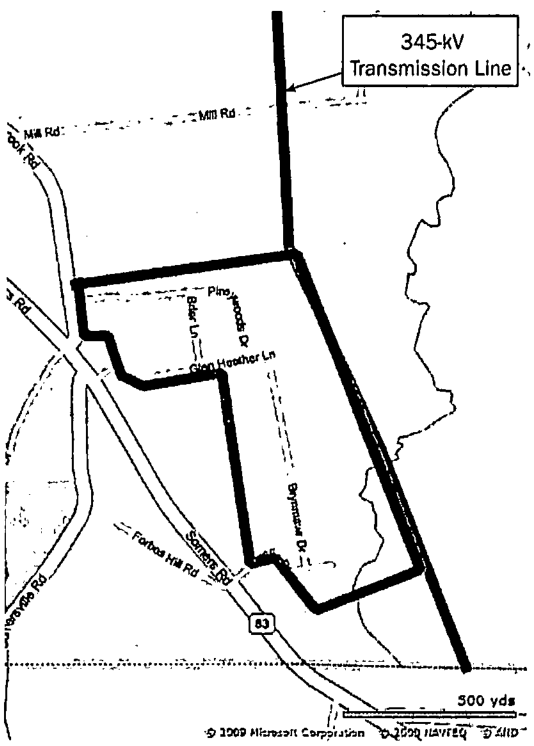

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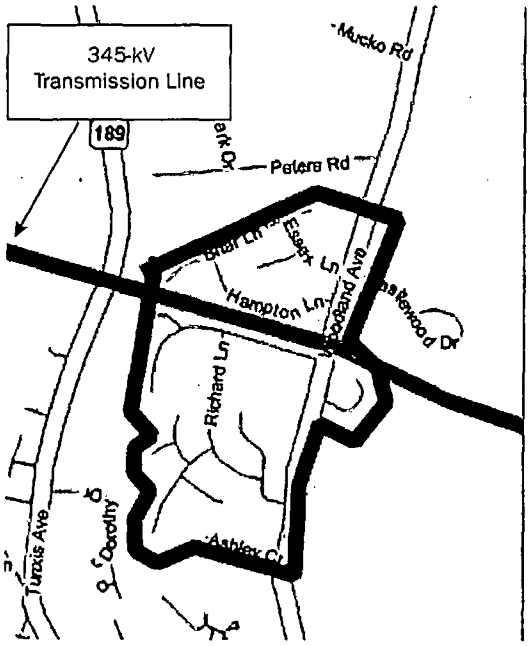

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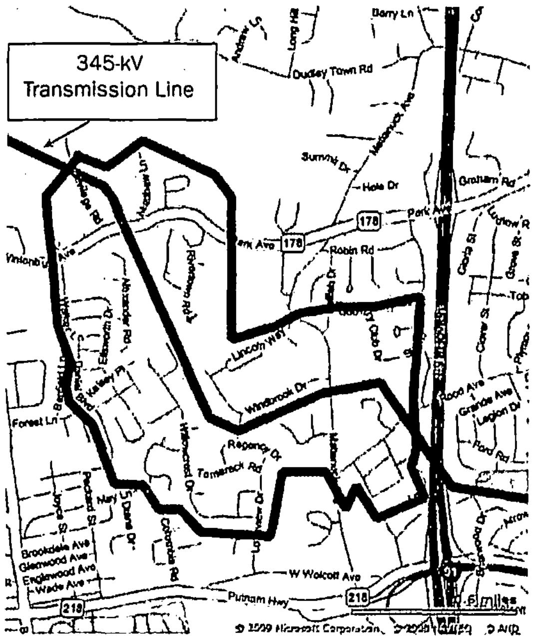

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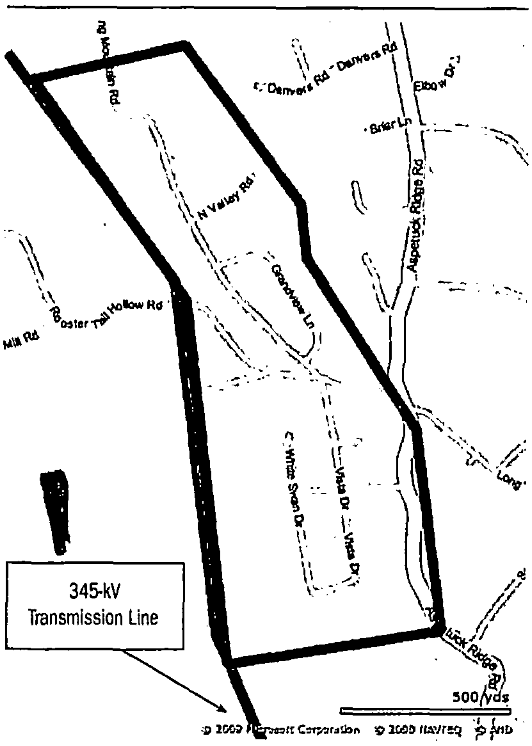

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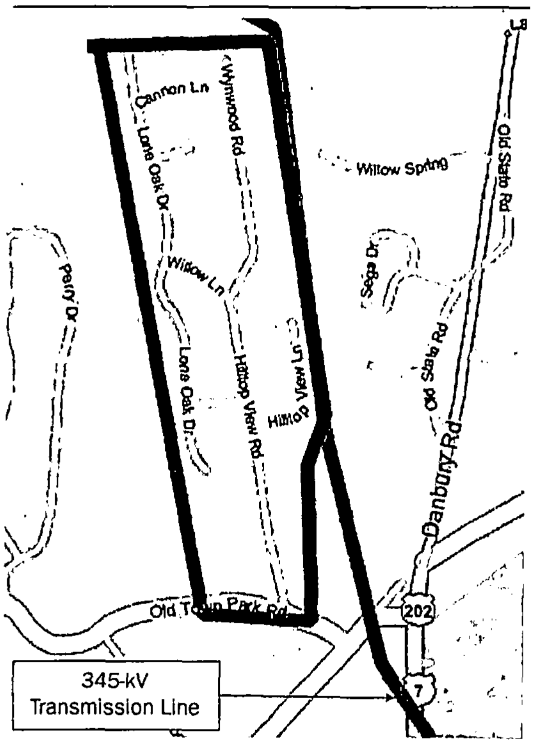

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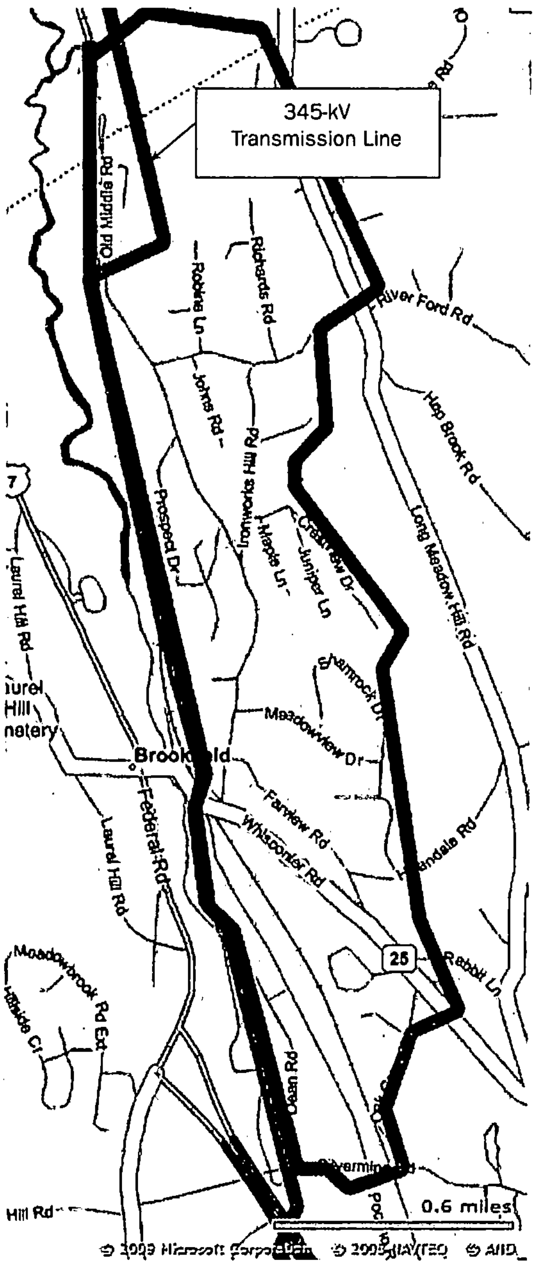

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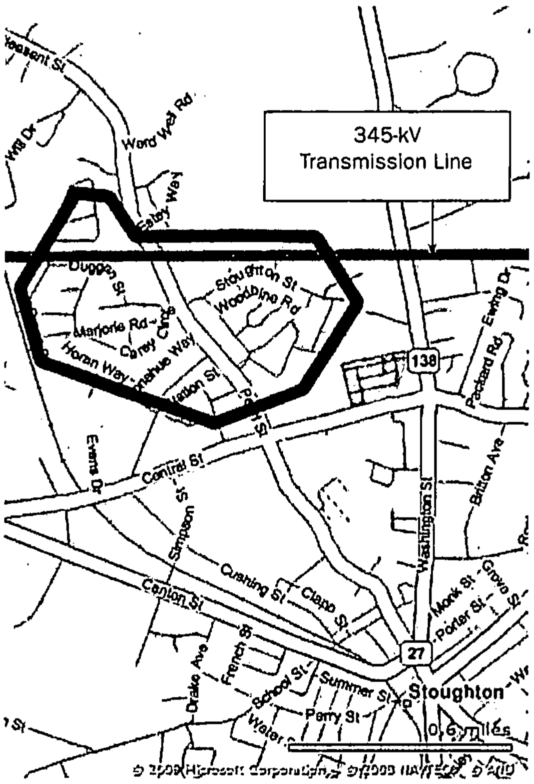

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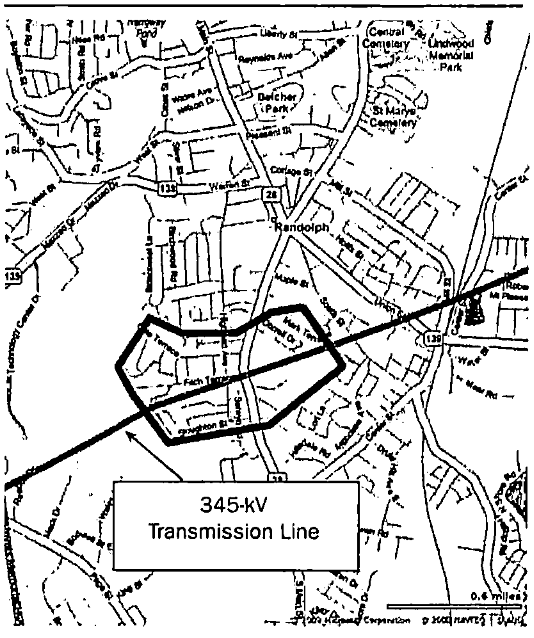


Appendix 2

Descriptive Statistics by Study Area

Property Characteristic	A1	A2	A3	A4
	Study Area			
Liveable Area (in sq. ft.)				
Mean	1,386.54	1,696.32	1,205.18	1,448.93
Median	1,288.00	1,500.00	1,144.00	1,346.00
Standard Deviation	363.98	678.62	307.85	478.05
Lot Size (in acres)				
Mean	0.4787	1.0542	0.2684	0.2936
Median	0.4140	0.9300	0.2180	0.2778
Standard Deviation	0.3978	0.9518	0.1476	0.1113
A/C				
Percent of Properties with A/C	25.05%	24.42%	23.53%	35.35%
Age				
Mean	34.20	37.24	50.07	46.78
Median	31.00	34.00	52.00	45.00
Standard Deviation	15.29	3.36	12.23	25.39
Total Bathrooms				
Mean	1.83	1.99	1.36	1.61
Median	2.00	2.00	1.00	1.50
Standard Deviation	0.56	0.76	0.55	0.71
Basement (in sq. ft.)				
Mean	793.85	975.87	384.40	867.82
Median	802.00	943.00	0.00	864.00
Standard Deviation	378.18	403.66	466.59	394.58
Deck (in sq. ft.)				
Number of Properties with Deck	295.00	240.00	43.00	178.00
Mean	204.53	312.21	219.33	168.74
Median	168.00	264.00	210.00	144.00
Standard Deviation	123.23	206.93	118.45	116.41
Garage (in sq. ft.)				
Number of Properties with Garage	393.00	316.00	53.00	170.00
Mean	452.67	470.23	335.72	440.16
Median	484.00	506.00	275.00	511.50
Standard Deviation	136.07	174.18	121.24	136.03
Porch (in sq. ft.)				
Number of Properties with Porch	225.00	152.00	87.00	176.00
Mean	138.12	166.41	128.86	128.98
Median	102.00	134.00	144.00	120.00
Standard Deviation	120.68	152.40	78.16	91.49

FEATURES

The Price Effects of HVTLs on Abutting Homes

by Steven C. Bottemiller, MAI, and Marvin L. Wolverton, PhD, MAI

ABSTRACT

This article reports findings of an empirical study of Portland, OR, and Seattle, WA, housing markets. It examines the price effect of abutting high-voltage transmission line (HVTL) rights of way. The results are based on an examination of a rich sample of single-family home sales occurring in 2005, 2006, and half of 2007. It adds to an understanding of residential HVTL proximity price effects in a number of ways: it revisits the Portland and Seattle housing markets during a different market period; it relies on data from a seller's market in the housing market cycle; it relies on richer and larger data sets than prior research in these markets; it confirms many findings of a previous study concerning how abutting homes are affected by HVTLs; and it provides a new perspective on the Seattle market by investigating the HVTL price effect on higher-priced homes. It also buttresses the idea that all markets do not react in the same way to HVTL proximity.

The Bonneville Power Administration (BPA) was created in 1937 to market electricity generated at the then new Bonneville Dam on the Columbia River. In fulfillment of its mission, BPA now operates a system of 15,000 circuit miles[1] of high-voltage transmission lines (HVTLs). BPA's 300,000-square-mile service area includes the states of Washington, Oregon, and Idaho as well as parts of extreme northeastern California, western Montana, northern Nevada, extreme northwestern Utah, and far western Wyoming. BPA is a federal agency within the US Department of Energy and operates as a nonprofit entity, selling wholesale power to the region's utility companies at cost. It provides about one-third of the electricity used in the Pacific Northwest region.

Although a high percentage of its HVTLs cross open and agricultural land in these western states, they also run throughout the urbanized western regions of Oregon and Washington in and around dense housing markets in Portland and Seattle. Also, BPA is adding HVTLs to its grid to keep up with population growth in the Pacific Northwest, especially in the urban centers of Portland and Seattle. Its HVTLs primarily range in voltage from 69 kV to 1,000 kV,[2] although the most frequently occurring line voltages are 115 kV (23.4% of the HVTLs), 230 kV (35.0% of the HVTLs), and 500 kV (31.1% of the HVTLs). The HVTLs abutting the study properties range from 115 kV to 500 kV.

BPA rights of way consist of HVTL easements maintained to prevent line damage from trees, other forms of vegetation, and structural improvement interference. Benefits of right of way management include reducing the possibility of adverse electrical impacts on the environment. BPA rights of way also provide amenities to the cities they cross. BPA permits the construction of parks and trails in some locations on its fee title property. Alternatively, many of its easements are jointly used by abutting property owners, who own the underlying fee title, for gardening or other agrarian purposes subject to BPA's need for maintenance access.

1. A *circuit mile*, as the name implies, is the distance covered by a circuit. A transmission right of way often accommodates more than one circuit. For example, a right of way containing three circuits would include three circuit miles for each right-of-way mile.
2. A *kV* is a kilovolt (1,000 volts).

This study was undertaken to gain further understanding regarding the effect of BPA's HVTL rights of way on abutting single-family home prices. The sample data was sufficient to derive precise market price equations via multiple linear regression analysis for both Portland and Seattle. In addition, due to where the rights of way are located in the Seattle area, there are enough higher-priced home sales in the Seattle sample to facilitate a study of HVTL proximity effects on homes averaging $1 million in price, in comparison to HVTL effects on more typically priced homes. Lastly, the study looks at price movement in response to changing market conditions over the 2½ year study period to determine whether or not HVTL abutting homes appreciated in value at a rate different from non-HVTL abutting homes.

Given the moderate marine climate in Portland and Seattle, it is not unusual for power line visibility from abutting homes to be fully or partly obscured by trees. This differs from many areas of the country where trees grow smaller, less vigorously, or not at all. As a result, the findings of this study relate best to the portion of the service area located west of the Cascade Mountains where the marine climate prevails and large trees are abundant. There are nevertheless differences between the Portland sample and the Seattle sample. In particular, lot sizes are typically much smaller in the Portland sample (roughly 6,500 square feet, compared to roughly 1 acre on average in Seattle). Therefore, Portland homes cover a much greater proportion of the typical lot, leaving less room for HVTL view-blocking trees. For this reason alone, the Portland results are not applicable to Seattle and the Seattle results are not applicable to Portland.

The study is organized as follows. A literature review places the study into the context of prior research and information regarding HVTL rights of way. The data is presented next, including descriptive statistics tables comparing the treatment sample (abutting properties) to the control sample (non-abutting properties) for each market. These tables illustrate the extent to which the affected and unaffected property sales are as similar as possible in all other respects. The data presentation is followed by data analyses, including a full-sample Portland home price model, a full-sample Seattle home price model, Seattle high-priced and typically priced subsample price models, and a discussion of price appreciation rates by abutting and non-abutting homes in each market. A summary statement of findings and conclusions is included as the last section of the article.

Literature Review

The literature review presented here, in chronological order by topical classification, sets the context for the current HVTL property price effect study. Prior articles and studies are sorted into three topics for the purposes of discussion and relevance to the present study—informational articles, surveys and case studies, and statistical methods (mostly linear regression) applied to sample data. Inquisitive readers might want to also read Pitts and Jackson[3] for an entrée into a more comprehensive literature review.

Informational Articles

Rikon[4] focuses on the 1993 New York Court of Appeals ruling in *Criscuola v. Power Authority of the State of New York* concerning the reasonableness of the basis of a price response to fear of electromagnetic field (EMF) health effects. Rikon notes that the court ruled if there is market evidence of a price effect in the after condition, then the price effect is compensable. Bryant and Epley[5] cast a wider net in their summary of legal precedent regarding compensation from the real or perceived effects of exposure to EMFs, which culminates in the *Criscuola* case. According to these authors, legal precedent relieves appraisers of the need to assess whether market behavior is rational or not (if this need ever actually existed), and frees them to base their conclusions solely on market data.

Tikalsky and Willyard[6] chime in on the health issue, stating "extensive research has yet to establish a link between health risks and EMF." In addition, they provide a historical study of HVTL structure design over three decades and how design relates to "public perception of transmission lines." In 2008,

3. Jennifer M. Pitts and Thomas O. Jackson, "Power Lines and Property Values Revisited," *The Appraisal Journal* (Fall 2007): 323–325.
4. Michael Rikon, "Electromagnetic Radiation Field Property Devaluation," *The Appraisal Journal* (January 1996): 87–90.
5. James A. Bryant and Donald R. Epley, "Cancerphobia: Electromagnetic Fields and Their Impact in Residential Loan Values," *Journal of Real Estate Research* 15, no. 1/2 (1998): 115–129.
6. Susan M. Tikalsky and Cassandra J. Willyard, "Aesthetics and Public Perception of Transmission Structures," *Right of Way* (March/April 2007): 34–38.

Holisko[7] adds a list of factors that affect the impact of power lines and design elements to consider as ways to mitigate the impact. He notes that diverse impacts stem from differences in development density, right of way width (power line distance), right of way amenities, and topography. Tree cover is important as well, although not included in Holisko's list.

These legal perspectives, as well as personal experience with high-voltage transmission lines, led to the study's focus on the "what" rather than the "why" of HVTL home price effects. In addition, differences in development density and related tree cover (among other factors) between the Portland and Seattle Study Areas, suggested that there would not be similar results for these markets.

Surveys and Case Studies

In 1967, Kinnard reported on a survey of owners of residential properties located in subdivisions either abutting power line right of way easements or encumbered by them.[8] His findings were based on 361 responses from residents of 15 subdivisions located in Hartford, Connecticut. He also surveyed appraisers, builders, real estate sales professionals, and lenders. Kinnard's main findings were (1) the value of most residential properties is unaffected by overhead electric transmission lines, (2) overhead electric lines do affect land development by reducing density due to larger lots being typical of abutting and encumbered properties, and (3) real estate sales professionals and appraisers expressed more negativity toward power line proximity than actual market participants. Reese[9] put a public voice to appraiser negativity toward power lines in his response to the Kinnard article while also posing two important questions: (1) are survey responses valid, and (2) are survey methods powerful enough to measure and control for all of the factors affecting market value?

In 1992, Kung and Seagle[10] analyzed 47 responses to a survey of homeowners living near power lines. They also analyzed a small sample of four home sales near the same power lines and seven home sales located in the same neighborhood but not near the power lines. They did not control for differences in elements of comparison prior to computing and comparing price per square foot differences—a troubling issue foreseen by Reese in 1967 extending here to Kung and Seagle's small sample empirical analysis. In addition, their survey questionnaire included strong language linking power line proximity to cancer, resulting in a predictable response.

Delaney and Timmons[11] surveyed a random sample of residential appraisers holding the Appraisal Institute's RM designation, obtaining 219 usable responses. In summary, appraiser opinions reported by them were (1) proximity to power lines reduces home value by about 10% and (2) reasons for the value diminution are unattractiveness, health concerns, and sound. Surveyed appraisers also noted that developers attempt to mitigate power line effects on sales activity through price reductions, larger lot sizes near the lines, and creation of buffer zones. Delaney and Timmons make a tacit assumption that the opinions of the responding appraisers on the effects of HVTLs are an accurate reflection of market response, which may or may not be true (see Kinnard). However, use of random sampling methods does support the validity of their results in so far as they represented the opinions of RM designated appraisers at that time.

Chapman[12] provides a different perspective on the effects of HVTLs by examining industrial properties. He reports on more than 100 interviews of property owners, brokers, and property managers. Based on his interviews, Chapman finds no basis for consequential damages to industrial properties based on proximity to HVTLs. He also provides an informative discussion of property rights issues and remainder parcel configuration issues that can arise when appraising industrial properties in an eminent domain setting. He speaks to the issue of the difficulty of doing matched pairs (and by implication the benefit of multiple linear regression analysis) when there are numerous property characteristics to control.

7. Gary Holisko, "Developing Near Transmission Lines?" *Right of Way* (July/August 2008): 32–36.
8. William N. Kinnard, Jr., "Tower Lines and Residential Property Values," *The Appraisal Journal* (April 1967): 269–284.
9. Louie Reese, "The Puzzle of the Power Line," *The Appraisal Journal* (October 1967): 555–560.
10. Hsiang-te Kung and Charles F. Seagle "Impact of Power Transmission Lines on Property Values: A Case Study," *The Appraisal Journal* (July 1992): 413–418.
11. Charles J. Delaney and Douglas Timmons, "High Voltage Power Lines: Do They Affect Residential Property Value?" *Journal of Real Estate Research* 7, no. 3 (Summer 1992): 315–329.
12. Dean Chapman, "Transmission Lines and Industrial Property Value," *Right of Way* (November/December 2005): 20–27.

Most recently, Chalmers[13] employs case study methods to investigate HVTL effects on generally large land parcels located across west-central Montana. Properties studied were classified as agricultural production land, agricultural land with a recreation influence, agricultural land with high recreation and natural feature amenities, rural residential subdivisions with either less than or greater than five-acre lots, large rural residential acreages, and rural residential tracts (cabin sites). The author concludes that properties oriented toward residential use are more vulnerable to a (negative) HVTL price effect, larger properties are less vulnerable, and when a market provides more purchase alternatives (substitute properties) HVTL-impacted properties are more apt to experience a price effect. Price effect evidence presented by Chalmers is primarily anecdotal, a consequence of a paucity of data and information due to the rural nature of the power lines' locations and difficulties inherent in obtaining information in a non-disclosure state.

Credible and reliable results are much more difficult to obtain using survey and case study methods. As these studies reveal, (1) survey methods exhibit inherent difficulty controlling for all of the factors affecting market value, (2) the opinions of market participant proxies (brokers, lenders, and appraisers) may not accurately represent the opinions of buyers and sellers, and (3) case study evidence is mostly anecdotal in nature.[14] For these reasons, revealed-preference analyses (e.g., regression modeling of actual market prices) are much more popular for addressing these questions today than stated-preference methods (e.g., questionnaires, contingent valuation methods, and case studies). Revealed-preference (price) analyses are used here. The database is relatively large and regression modeling allows control for many property characteristics and takes advantage of the method's statistical power.[15]

Statistical Modeling

Colwell and Foley[16] and Colwell[17] analyzed 200 home sales located in Decatur, Illinois. The Colwell and Foley study found that proximity to an HVTL reduced sale price and that lots encumbered by a power line easement tended to be larger than unencumbered lots. Colwell's later study looked at the same data as the earlier study, finding that the HVTL price effect diminished over time. This finding is rationalized by observed tree growth (screening), changing attitudes, and reduced uncertainty regarding the effects of an HVTL. Both analyses relied on multiple regression equations relating the natural log of sale price to elements of comparison, capturing the effects of home and site characteristics, changing market conditions, varying neighborhoods, and proximity to an HVTL.

Hamilton and Schwann[18] analyzed 12,907 transactions from four neighborhoods in Vancouver, Canada, occurring over the 1985—1991 period. The study found a 6.3% diminution in value for homes in close proximity to power lines and towers. An important aspect of this study is the rich (large and detailed) sample, which enabled the authors to investigate the effects of numerous elements of comparison and to examine many functional forms for the regression equation. Price equations were found to be heteroskedastic, and estimation methods were used to account for this and derive credible estimates of statistical significance. The article is silent, however, concerning whether the power lines are on easements or fee title land, the prevailing topography, prevalence or lack of tree screening, and the like.

Cowger, Bottemiller, and Cahill[19] used matched pairs to test for significant HVTL proximity effects. They examined 296 matched pairs consisting of a home sale abutting an HVTL right of way paired with a sale of a highly similar, nearby home unaffected by an HVTL. They used t-tests to examine differences between pairs in mean price per square foot, finding that HVTL proximity had no impact on home price.

13. James A. Chalmers, "High-Voltage Transmission Lines and Rural, Western Real Estate Values," *The Appraisal Journal* (Winter 2012): 30–45.
14. Note also that Bryant and Epley, cited earlier, question the viability of survey-based, stated-preference measures due to difficulties in an survey respondent estimating "his/her reaction without the pressure of the transaction, negotiation and financial commitment."
15. Statistical power can be thought of as the ability to isolate and assess the significance of small price movements.
16. Peter F. Colwell and Kenneth W. Foley, "Electric Transmission Lines and the Selling Price of Residential Property," *The Appraisal Journal* (October 1979): 490–499.
17. Peter F. Colwell, "Power Lines and Land Value," *Journal of Real Estate Research* 5, no. 1 (Spring 1990): 117–127.
18. Stanley W. Hamilton and Gregory M. Schwann, "Do High Voltage Electric Transmission Lines Affect Property Value?" *Land Economics* 71, no. 4 (November 1995): 436–444.
19. J. R. Cowger, Steven C. Bottemiller, and James M. Cahill, "Transmission Line Impact on Residential Property Values," *Right of Way* (September/October 1996): 13–17.

The study did not analyze or control for the impact of lot size differences between affected and unaffected properties, nor did it control for minor differences in other elements of comparison. These potential weaknesses were addressed in a follow-up study by Wolverton and Bottemiller,[20] where multiple regression modeling was used to control for element of comparison disparities. The follow-up study confirmed the "no-effect" conclusion of the earlier matched pairs analysis.

Des Rosiers[21] used a microspatial approach involving 50 multiple linear regression models, which found disparate power line effects, ranging from negative 23% to positive 22%. However, the primary result was a 9.6% reduction in value for a home adjacent to a power line and facing a pylon. The regression models used included both nominal price and natural log of price as dependent variables. The data consisted of 257 sales transactions located in three neighborhoods of Brossard, Quebec, differentiated by mean price—CN$225,924, CN$160,209, and CN$115,260. The HVTL pylons were described as being of "enhanced visual appearance" conical steel; however, the pylons and power lines were highly visible and mostly unscreened by vegetation.

Chalmers and Voorvaart[22] analyzed 1,286 single-family residential transactions located in four study areas in the northeastern United States. They regressed the natural log of sale price on housing characteristics, year of sale, and neighborhood subareas. Their study found no significant price effect from proximity to, or visibility of, HVTLs. They did investigate whether or not higher-valued properties were affected, operationalizing "higher valued" as prices in excess of the median price.

Jackson[23] examined rural agricultural and recreational land located in Wisconsin. He used regression modeling to compare online (HVTL power line proximate) sales to offline sales (more than one-quarter mile from an HVTL power line). Although the models indicated online sale prices 1.1% to 2.4% lower than offline sale prices, the differences were not statistically significant—meaning one cannot reject the null hypothesis of no power line price effect. The article also provides guidance for identifying variations in types of power line intersections—such as edge position, clipping, middle position, and diagonal position—that could be useful for appraisal report-writing purposes.

The data set in the study reported on in this article is a rich one, allowing examination of and control for numerous price effects stemming from market conditions, seasonality, topography, lot size, lot configuration, landscaping, building characteristics, and location (school districts, high schools, neighborhoods, counties, state, and zip code). Multiple linear regression analysis is used, with the natural log of price as the dependent variable. This functional form is the most prevalent in the literature, and it provided the most predictive precision.

The results were examined for heteroskedasticity (non-constant regression error variance) and none were found, unlike the data examined by Hamilton and Schwann. In addition, higher-valued homes in Seattle were investigated (similar to what was done by Chalmers and Voorvaart), operationalizing "higher valued" as the upper price quartile. This resulted in a more price-differentiated higher-priced subsample than the greater-than-median-priced subsample selected by Chalmers and Voorvaart. Finally, the study investigated price change over time for HVTL-affected properties versus unaffected properties, confirming the earlier results reported by Wolverton and Bottemiller.

Data

Sample data covered a 2½ year period spanning 2005, 2006, and the first half of 2007. Some non-abutting sales were included from outside of this time frame when they were deemed to have been most comparable to a nearby HVTL-abutting sale. In these few, exceptional instances the out-of-range sales were either from late 2004 and comparable to a nearby early 2005 sale or from early in the third quarter of 2007 and comparable to a nearby second quarter 2007 sale.

20. Marvin L. Wolverton and Steven C. Bottemiller, "Further Analysis of Transmission Line Impact on Residential Property Values," *The Appraisal Journal* (July 2003): 244–252.

21. Francois Des Rosiers, "Power Lines, Visual Encumbrance and House Values: A Microspatial Approach to Impact Measurement," *Journal of Real Estate Research* 23, no. 3 (2002): 275–301.

22. James A. Chalmers and Frank A. Voorvaart, "High-Voltage Transmission Lines: Proximity, Visibility, and Encumbrance Effects," *The Appraisal Journal* (Summer 2009): 227–245.

23. Thomas O. Jackson, "Electric Transmission Lines: Is There an Impact on Rural Land Values?" *Right of Way* (November/December 2010): 32–35.

The data collection protocol involved identifying a sufficient number of HVTL-abutting sales in each study area (Portland and Seattle) then searching for at least two, and preferably three, non-abutting sales from the same neighborhood and time frame as similar in square footage, lot size, and other elements of comparison as possible. This resulted in a "treatment" sample of HVTL-abutting homes and a "control" sample of non-HVTL-abutting homes. Tables 1 and 2 illustrate that the data collection effort was successful in its attempt to acquire highly similar treatment and control samples. In the analytical phase of the study, any remaining variation in elements of comparison between sample and within each sample was controlled for by use of a multiple regression model using an "Abutting HVTL" dummy variable to distinguish the HVTL price effect, all else being equal.

Sales were eliminated from consideration if the recorded title transfer relied on a deed that indicated something other than a market transaction. Also, each property ultimately included in the data set had been sold through the multiple listing service, a good indication that the transaction occurred in the open market. In conclusion, there is high confidence that the data satisfies the goal of the treatment and control subsets being as identical as possible, except for the treatment sales abutting a HVTL right of way.

Portland Study Area Sample

The Portland Study Area sample included 538 home sales: 152 treatment sales (HVTL abutting) and 386 control sales (non-HVTL abutting) located in three Portland metro-area counties—Washington County and Clackamas County in Oregon and Clark County in Washington. As shown in Table 1, central tendencies and dispersions for numerical variables were highly similar across control (non-abutting) and treatment (abutting) data subsets. The same holds true for categorical (dummy) variable proportions.

Data were assembled from numerous sources. Two secondary data sources were county tax assessment records and each area's multiple listing service (MLS). Primary data sources were property inspection (noting the appearance of each home viewed from the fronting street), aerial photographs, and recorded documents. In addition, assessor quality and condition ratings were cross-referenced with MLS descriptions and photographs included in the MLS database. Lot shape was confirmed by recorded plat, aerial photography, and field inspection. Lot topography and landscape quality were field assessed. Landscape quality assessments were verified as being consistent with the date of sale by examining exterior MLS photos to determine if the landscape had been altered after the sale date.

Other variables not listed in Table 1 include the sale's municipal address, each sale's school district and serving high school, market area's name (neighborhood), and zip code. The sample data also included cell phone tower visibility, the type of exterior and roof finish, existence of nearby parks, and membership in a homeowner's association. Distribution across treatment and control properties was similar for these additional variables as well. Nearly all of the additional variables (except for a few select location identifiers) proved to be statistically insignificant and were not included in the final models reported here.

Seattle Study Area Sample

The Seattle Study Area sample included 568 suburban home sales: 153 treatment sales and 415 control sales—all located in King County, WA (none were within the Seattle city limits).[24] As shown in Table 2, central tendencies and dispersions for numerical variables were highly similar across control (non-abutting) and treatment (abutting) data subsets. The same holds true for categorical (dummy) variable proportions.

As in Portland, data collection relied on secondary sources (county tax assessment records and MLS) and primary data collection (property inspection from the fronting street, aerial photographs, and recorded documents). Assessor quality and condition ratings were relied on and cross-referenced with MLS descriptions and photographs included in the MLS database. Lot shape was confirmed by recorded plat, aerial photography, and field inspection. Lot topography and landscape quality were field assessed, and the landscape was cross verified by exterior MLS photos to determine if it had been altered after the sale date.

Also similar to Portland, other variables not listed in Table 2 include the sale's municipal address, each sale's school district and serving high school, market

24. Bonneville Power has no transmission line rights of way within Seattle's city limits. Seattle is totally within King County, as are the suburbs studied here. These suburbs are considered to be part of the Seattle Metropolitan Area, and are included in the Seattle MSA, although they are outside of the Seattle city limits.

Table 1 Descriptive Statistics for Portland Area Sample Data, Control and Treatment Groups

Variable	Control Mean	Control Std. Deviation	Treatment Mean	Treatment Std. Deviation
Price	$294,048	$74,812	$291,122	$72,210
State of Oregon	0.648	**	0.665	**
State of Washington	0.352	**	0.335	**
Clark County, WA	0.352	**	0.336	**
Clackamas County, OR	0.042	**	0.040	**
Washington County, OR	0.606	**	0.625	**
2004 Sale	0.008	**	0.000	**
2005 Sale	0.301	**	0.270	**
2006 Sale	0.505	**	0.474	**
2007 Sale	0.187	**	0.257	**
Living Area (sf)	1,775	514	1,748	498
Lot Size (ac)	6,455	1,904	6,700	2,772
Bedrooms	3.380	0.580	3.360	0.560
Bathrooms	2.310	0.390	2.310	0.420
Age at Sale (yrs)	15.320	10.750	13.840	9.330
Garage (cars)	2.030	0.350	1.990	0.270
Fireplaces	0.852	0.496	0.783	0.473
Pool	0.005	**	0.013	**
Hot Tub	0.044	**	0.079	**
Deck	0.386	**	0.434	**
Patio	0.609	**	0.572	**
Outbuilding/Shed	0.158	**	0.204	**
Central Air Cond.	0.560	**	0.599	**
Fair Quality	0.005	**	0.013	**
Below Avg. Quality	0.067	**	0.086	**
Avg. Quality	0.738	**	0.737	**
Above Avg. Quality	0.109	**	0.059	**
Good Quality	0.080	**	0.105	**
Fair Condition	0.008	**	0.013	**
Below Avg. Condition	0.021	**	0.000	**
Avg. Condition	0.785	**	0.790	**
Above Avg. Condition	0.036	**	0.033	**
Good Condition	0.150	**	0.165	**
Poor Landscape	0.016	**	0.000	**
Fair Landscape	0.109	**	0.158	**
Avg. Landscape	0.733	**	0.691	**
Good Landscape	0.143	**	0.153	**
Level Site	0.749	**	0.645	**
Gentle Slope	0.184	**	0.283	**
Moderate Slope	0.062	**	0.072	**
Steep Slope	0.003	**	0.000	**
Rectangular Lot	0.676	**	0.763	**
Cul-de-Sac Lot	0.135	**	0.105	**
Corner Lot	0.145	**	0.053	**
Irregular Lot	0.044	**	0.072	**
Flag Lot	0.000	**	0.007	**
Quarter 1 Sale	0.218	**	0.178	**
Quarter 2 Sale	0.345	**	0.401	**
Quarter 3 Sale	0.251	**	0.263	**
Quarter 4 Sale	0.187	**	0.158	**

* Totals for any particular construct may not add to 100% due to rounding.
** Sample standard deviations are not included for 0,1 dummy variables.

Table 2 Descriptive Statistics for Seattle Area Sample Data, Control and Treatment Groups

Variable	Control Mean	Control Std. Deviation	Treatment Mean	Treatment Std. Deviation
Price	$483,435	$333,165	$502,261	$418,691
2005 Sale	0.506	**	0.497	**
2006 Sale	0.386	**	0.366	**
2007 Sale	0.108	**	0.137	**
Living Area (sf)	2,249	909	2,305	965
Lot Size (ac)	1.030	1.49	1.550	2.37
Bedrooms	3.580	0.68	3.620	0.77
Bathrooms	2.390	0.66	2.410	0.69
Age at Sale (yrs)	21.160	13.47	19.370	13.44
Garage (cars)	2.430	1.11	2.410	1.06
Fireplaces	1.330	0.74	1.350	0.73
Pool	0.019	**	0.000	**
Hot Tub	0.147	**	0.118	**
Deck	0.639	**	0.634	**
Patio	0.605	**	0.556	**
Outbuilding/Shed	0.080	**	0.053	**
Greenhouse	0.017	**	0.046	**
Sports Court	0.017	**	0.020	**
Apt./MLS[a]	0.051	**	0.026	**
Below Avg. Quality	0.075	**	0.105	**
Avg. Quality	0.518	**	0.500	**
Above Avg. Quality	0.241	**	0.222	**
Good Quality	0.123	**	0.105	**
Very Good Quality	0.034	**	0.052	**
Below Avg. Condition	0.051	**	0.085	**
Avg. Condition	0.692	**	0.654	**
Above Avg. Condition	0.222	**	0.190	**
Very Good Condition	0.034	**	0.072	**
Fair Landscape	0.082	**	0.118	**
Avg. Landscape	0.706	**	0.712	**
Good Landscape	0.190	**	0.131	**
Exc. Landscape	0.022	**	0.039	**
Level Site	0.451	**	0.490	**
Gentle Slope	0.378	**	0.353	**
Moderate Slope	0.194	**	0.150	**
Steep Slope	0.022	**	0.007	**
Rectangular Lot	0.554	**	0.510	**
Cul-de-Sac Lot	0.142	**	0.163	**
Corner Lot	0.135	**	0.052	**
Irregular Lot	0.142	**	0.242	**
Flag Lot	0.027	**	0.033	**
Quarter 1 Sale	0.207	**	0.170	**
Quarter 2 Sale	0.316	**	0.333	**
Quarter 3 Sale	0.272	**	0.268	**
Quarter 4 Sale	0.205	**	0.229	**

a Mother-in-law suite.
* Totals for any particular construct may not add to 100% due to rounding.
** Sample standard deviations are not included for 0,1 dummy variables.

area's name (neighborhood), and zip code. The sample data also included cell phone tower visibility, the type of exterior and roof finish, existence of nearby parks, membership in a homeowner's association, and gated entries. With one exception, distribution across treatment and control properties was similar for all variables. The exception is lot area, which averaged 1.03 acres for non-HVTL abutting properties and 1.5 acres for HVTL-abutting properties.[25] Use of multiple regression modeling in the analytical phase controlled for any differences between treatment and control groups to isolate and measure the HVTL proximity effect on price. Similar to the Portland data, most of the additional variables (except for a few select location identifiers) proved to be statistically insignificant.

Analysis

Portland Study Area Analysis

As illustrated in Table 3, the price effect of abutting a HVTL transmission line was found to be negative and statistically significant in the Portland Study Area. The magnitude of the effect was $(e^{-0.016615} - 1) \times 100\% =$ –1.65% for the average priced treatment group (abutting) home in the study area. Given the Portland Study Area treatment group's $291,122 average sale price, the Portland treatment group's typical home would have sold for $4,884 more if not abutting an HVTL.[26]

The adjusted R^2 for Portland Study Area multiple regression analysis is 92.9%. The analysis indicates significantly lower 2004 prices and significantly higher prices in 2006 and 2007 in comparison to 2005. Double-digit percentage increases in price over the study period are consistent with the seller's market the Portland area experienced during this time. In addition, the market exhibits the sort of cyclicality expected in a northern climate, with significantly higher market prices during non-winter quarters.

As expected, the improved living area of the home is the most significant element of comparison for the price model. Bedroom and bathroom variables are opposite in sign, which is not unusual for these sorts of models given the high correlations among bedroom counts, bathroom counts, and a home's improved living area. Property condition and landscaping quality both affect sale price, as do lot size and property age. The significance of the age squared element of comparison indicates a nonlinear improvement depreciation rate. It appears that swimming pools may not be advantageous from a market price perspective in this market, whereas hot tubs do show a positive price effect.

The Portland Study Area real estate market is made up of numerous submarkets, and several of them are associated with significantly different home prices. The Rock Creek, Northwest Portland, Southwest Beaverton, Scholls Ferry, and Mt. Vista submarkets all indicate significantly higher-than-average prices. In Forest Grove and Covington-Orchards, prices tend to be significantly lower than average. In addition, after controlling for submarket identification, a Beaverton School District location provides an additional price increment. At a more macro-location level, prices tend to be higher in Clackamas County, OR, and lower in Clark County, WA (Vancouver), in comparison to the base location (Washington County, OR).

Seattle Study Area Analysis

As shown in Table 4, the price effect of abutting an HVTL was also negative and statistically significant for the Seattle Study Area sample. The magnitude of the effect was $(e^{-0.02459} - 1) = -2.429\%$ for the average-priced treatment group (abutting) home in the study area. Given the Seattle Study Area treatment group's $502,261 average sale price, the Seattle treatment group's typical abutting home would have sold for $12,504 more if not abutting an HVTL.[27]

The adjusted R^2 for Seattle Study Area multiple regression analysis is 93.5%. The analysis indicates significantly higher prices in 2006 and 2007 in comparison to 2005. As in Portland, double-digit percentage increases in price over the study period are consistent with the seller's market the Seattle area experienced during this time. In addition, the Seattle market also exhibited the sort of cyclicality expected in a northern climate, with significantly higher market prices during non-winter quarters.

Again, improved living area of the home is the most significant element of comparison for the price model. As in the Portland model, bedroom

25. Larger HVTL-abutting lots are not unusual, given the data descriptions included in many of the articles cited in the literature review.

26. $\frac{291{,}122}{(1 - 0.0165)} - 291{,}122 = 4{,}884$

27. $\frac{502{,}261}{(1 - 0.02429)} - 502{,}261 = 12{,}504$

Table 3 Multiple Regression Analysis of the Natural Log of Sale Price, Portland Study Area

Predictor	Coefficient	*t*-Statistic	*P*-Value
Constant	11.73260000	320.64	0.000
Abuts HVTL	−0.01661500	−2.61	0.009
2004 Sale	−0.16722000	−4.13	0.000
2006 Sale	0.12987800	19.06	0.000
2007 Sale	0.17290100	19.24	0.000
Quarter 2	0.03179700	3.94	0.000
Quarter 3	0.05439400	6.04	0.000
Quarter 4	0.06355800	6.40	0.000
Age	−0.00444460	−5.85	0.000
Age Squared	0.00003131	2.96	0.003
Lot Size (ac)	0.42296000	5.01	0.000
Fair Landscape	−0.02980600	−3.26	0.001
Good Landscape	0.04986000	5.64	0.000
Above Avg. Condition	0.04020000	2.58	0.010
Good Condition	0.03544300	3.98	0.000
Living Area (sf)	0.00028992	25.02	0.000
Bedrooms	−0.01217100	−1.59	0.113
Baths	0.03968000	3.44	0.001
Garage (cars)	0.04602000	4.51	0.000
Central AC	0.01409400	2.21	0.027
Pool	−0.05634000	−1.64	0.102
Hot Tub	0.02659000	2.14	0.033
Rock Creek Market	0.03855000	2.64	0.009
NW Portland Market	0.06520000	4.88	0.000
Forest Grove Market	−0.07477000	−4.05	0.000
SW Beaverton Market	0.08464000	4.41	0.000
Scholls Ferry Market	0.03421000	1.84	0.066
Covington–Orchards Market	−0.07356000	−1.95	0.052
Mt. Vista Market	0.12579000	3.22	0.001
Beaverton School Dist.	0.07845900	8.02	0.000
Clackamas County	0.11841000	7.02	0.000
Clark County	−0.10052000	−9.82	0.000

S = 0.0640650 R^2 = 93.3% R^2(adj) = 92.9%

and bathroom variables are opposite in sign as a consequence of the high correlations among bedroom counts, bathroom counts, and improved living area. Property quality, property condition, and landscaping quality affect sale price here, as does lot size. Unlike Portland, a visible cell phone antenna ($n=55$) was a significant negative influence on price in the Seattle market.

The Seattle Study Area sample covers a much wider price range than the Portland data. Therefore, some of the significant elements of comparison may actually be more applicable either to higher-priced homes or to more typically priced homes, entering the regression equation via significance in a given price segment but not in the other (this phenomenon is studied in more detail later in the article).

Table 4 Multiple Regression Analysis of the Natural Log of Sale Price, Seattle Study Area

Predictor*	Coefficient	t–Statistic	P–Value
Constant	12.03530000	348.58	0.000
Abuts HVTL	−0.02459000	−2.07	0.039
2006 Sale	0.16855000	15.48	0.000
2007 Sale	0.21629000	11.95	0.000
Quarter 2	0.03103000	2.10	0.036
Quarter 3	0.06668000	4.18	0.000
Quarter 4	0.07266000	4.38	0.000
Living Area (sf)	0.00025187	21.93	0.000
Garage (cars)	0.02904600	5.47	0.000
Lot (ac)	0.05042200	12.96	0.000
Moderate Slope	−0.02618000	−1.79	0.074
Creek River or Lake View	0.10392000	3.10	0.002
Rural Land View	−0.09454000	−1.94	0.052
Fair Landscape	−0.02911000	−1.62	0.106
Good Landscape	0.04146000	2.77	0.006
Exc. Landscape	0.29246000	7.99	0.000
Bedrooms	−0.02395300	−2.66	0.008
Bathrooms	0.03472000	2.75	0.006
Pool	0.06714000	1.52	0.130
Barn	0.13152000	6.05	0.000
Above Avg. Quality	0.05190000	3.85	0.000
Good Quality	0.08680000	4.32	0.000
Above Avg. Condition	0.03614000	2.61	0.009
Cement Fiber Board and Masonry	0.03089000	1.94	0.053
Torch Down Roof	−0.09631000	−1.94	0.053
Cell Phone Ant. Visible	−0.06327000	−3.46	0.001
Federal Way	−0.08459000	−3.22	0.001
Maple Valley	−0.03311000	−1.74	0.082
Issaquah	0.14206000	4.92	0.000
Sammamish	0.16244000	4.52	0.000
Lake Washington SD	0.24369000	15.63	0.000
Snoqualmie Valley SD	0.15103000	3.54	0.000
Auburn SD	−0.05125000	−2.88	0.004
Issaquah HS	0.13107000	2.51	0.012
Skyline HS	0.11901000	3.52	0.000
Cedar Crest HS	0.26239000	4.83	0.000
Woodinville HS	0.34840000	2.92	0.004
Inglewood HS	−0.28170000	−2.26	0.024
ZIP98045	−0.07825000	−1.44	0.149
ZIP98010	0.17823000	2.54	0.011
ZIP98059	0.06275000	1.34	0.181
ZIP98023	0.04924000	1.59	0.112

S = 0.115197 R^2 = 94.0% R^2(adj) = 93.5%

*Unlike the Portland Study Area model, there is no age variable in this model because age was highly correlated with the quality and condition variables. The age variable was insignificant in the presence of the data's quality and condition variables, and the standard error of the regression was lower without the age variable in the model (i.e., the model provides more precise price estimates without an age variable).

Examples of these sorts of variables include some of the geographic location identifiers, torch down roofing,[28] swimming pools, and a cement fiber board and masonry exterior finish.

Unlike Portland's multistate and multicounty data, all of the Seattle transactions were in the same state (WA) and the same county (King). Although named submarkets exist in the Seattle Market, city name, school district, and high school influences provide more precise price models, accompanied by zip code micro-location information. However, the significant location identifiers proved to vary between higher-priced homes and more typically priced homes.

Seattle Study Area—Higher-Priced Home Market

For the Seattle Study Area, the higher-priced home market was operationalized by isolating and analyzing the upper price quartile of the data (25% of the sample with a mean treatment group sale price of $1,035,105). As shown in Table 5, for higher-priced homes the effect of abutting an HVTL right of way was a much greater percentage of price and the effect was more significant than for the data as a whole, $(e^{-0.11906} - 1) \times 100\% = -11.225\%$. Given the Seattle Study Area higher-priced home subset's $1,035,105 average treatment group sale price, the Seattle Study Area's typical abutting, higher-priced home would have sold for $130,882 more if not abutting an HVTL.[29]

Table 5 Multiple Regression Analysis of the Natural Log of Sale Price, Seattle Study Area, Higher-Priced Homes

Predictor	Coefficient	*t*–Statistic	*P*–Value
Constant	12.48510000	126.59	0.000
Abuts HVTL	–0.11906000	–3.34	0.001
2006 Sale	0.17862000	5.39	0.000
2007 Sale	0.23082000	4.85	0.000
Living Area (sf)	0.00020814	8.23	0.000
Garage (cars)	0.04791000	4.01	0.000
Lot (ac)	0.03763200	5.43	0.000
Rural Land View	–0.33530000	–2.68	0.009
Good Landscape	0.09738000	3.04	0.003
Exc. Landscape	0.25137000	5.28	0.000
Bedrooms	–0.05165000	–2.47	0.016
Bathrooms	0.03153000	1.12	0.266
Fireplace	0.03115000	1.50	0.137
Pool	–0.11282000	–1.81	0.074
Barn	0.14622000	2.74	0.007
Above Avg. Quality	–0.07293000	–2.00	0.049
Cell Phone Ant. Visible	–0.09878000	–1.05	0.296
Issaquah	0.16150000	2.73	0.008
Sammamish	0.32308000	5.71	0.000
Lake Washington SD	0.14799000	4.49	0.000
Cedar Crest HS	0.18930000	2.54	0.013
Inglewood HS	–0.39710000	–2.45	0.016
ZIP98010	0.19440000	1.34	0.185

$S = 0.139418$ $R^2 = 89.8\%$ $R^2(\text{adj}) = 87.1\%$

28. A colloquial expression identifying a multi-ply, flat, rubberized asphalt roof.

29. $\frac{1{,}035{,}105}{(1 - 0.11225)} - 1{,}035{,}105 = 130{,}882$

The magnitude of this effect also suggests that the significant -2.429% HVTL price effect for the full Seattle data set was impacted by inclusion of higher-priced homes in the full sample.

Many of the quality, condition, and location elements of comparison are not evident in this more-parsimonious, higher-priced home model—often as a consequence of there being no sales exhibiting the missing characteristics (e.g., no homes with fair landscaping and no homes located in Federal Way). Cell phone antenna visibility loses significance (presumable due to relatively larger average lot size), and city address, school district, and high schools are reduced to a few relevant locations.

The adjusted R^2 is 87.1% for the Seattle Study Area higher-priced home multiple regression analysis. The analysis indicates significantly higher prices in 2006 and 2007 in comparison to 2005, similar to the larger Seattle data set. Unlike the Portland data and the larger Seattle data set, seasonal cyclicality was not a significant factor for the higher-priced home market.

Seattle Study Area—More Typically Priced Home Market

For the purposes of this analysis, the Seattle Study Area's more typically priced home sample consists of the lower three price quartiles of the data (75% of the sample with a mean treatment group sale price of $366,866). As shown in Table 6, the effect of abutting an HVTL right of way was a much smaller percentage of price and statistically insignificant for typically priced Seattle Study Area homes, $(e^{-0.006415} - 1) \times 100\% = -0.6415\%$. If statistically significant, this percentage would amount to -$2,369 for homes in the subsample's average-priced treatment group.[30] However, due to the small t-statistic of -0.65, there is no strong statistical evidence to support the existence of an HVTL effect for more typically priced homes in the Seattle Study Area. The small magnitude and lack of significance of this effect suggests that the apparently significant -2.429% HVTL price effect for the full Seattle data set was almost entirely the result of including higher-priced homes in the full Seattle Study Area sample.

The adjusted R^2 is 87.3% for Seattle Study Area's more typically priced homes multiple regression analysis. The analysis also indicates significantly higher prices in 2006 and 2007 in comparison to 2005, similar to the larger Seattle data set. Like the Portland data, seasonal cyclicality was a significant factor for the Seattle more typically priced home market, and in contrast with Portland, cell phone tower visibility did have a significant negative impact on home price.

Analysis of Price Sensitivity to Various HVTL Voltages

The Portland sales data and the Seattle sales data include treatment (HVTL-abutting) effects from a variety of power line voltages. Four levels of line voltage are present in the Portland data—115 kV, 230 kV, 345 kV, and 500 kV. Whereas, three levels are present in the Seattle data—230 kV, 345 kV, and 500 kV. HVTL voltage distributions among the treatment sales are summarized in Table 7.

Two additional regression models were developed, replacing the "Abuts HVTL" variable in the models shown in Tables 3 and 4 with interaction variables representing the maximum line voltage present at each abutting (treatment) sale. All other variables were left unchanged. The result is an indication of the HVTL proximity effect broken down by line-voltage category. Line voltage is a variable of interest because voltage affects the tower type and configuration, width of right of way, and amount of line noise.[31]

Since the kV interaction variables fully capture the "Abut HVTL" effect in both regression models, R^2 and adjusted R^2 remained the same as reported in Tables 3 and 4, and the full list of variable coefficients and significance levels are unchanged. Results of the kV category effects are included in Table 8.

As shown in Table 8, the data do not support the idea that price effects are greater or more significant when a home abuts a higher-voltage HVTL. Although the Portland results in Table 8 suggest a lesser price effect from higher-voltage lines, there are too few higher-voltage abutting sales in the Portland data to support the credibility of this counter-intuitive indication.

The Seattle results in Table 8 also suggest a counter-intuitive result—a greater and more significant price effect associated with the Seattle

30. $\frac{366,866}{(1 - 0.006415)} - 366,866 = 2,369$

31. Higher voltages are associated with larger towers, wider rights of way, and greater line noise.

Table 6 Multiple Regression Analysis of the Natural Log of Sale Price, Seattle Study Area, More Typically Priced Homes

Predictor	Coefficient	*t*–Statistic	*P*–Value
Constant	12.07930000	87.44	0.000
Abuts HVTL	–0.00641500	–0.65	0.517
2006 Sale	0.16601800	18.13	0.000
2007 Sale	0.21829000	14.64	0.000
Quarter 2	0.02720000	2.26	0.024
Quarter 3	0.07700000	5.96	0.000
Quarter 4	0.07728000	5.84	0.000
Living Area (sf)	0.00021149	17.10	0.000
Garage (car)	0.02019100	4.17	0.000
Lot (ac)	0.05990600	12.63	0.000
Fair Landscape	–0.03319000	–2.42	0.016
Bedrooms	–0.00993700	–1.20	0.231
Bathrooms	0.02874000	2.42	0.016
Pool	0.39380000	4.33	0.000
Barn	0.11218000	5.63	0.000
Above Avg. Quality	0.07294000	6.24	0.000
Good Quality	0.11901000	5.88	0.000
Above Avg. Condition	0.03663000	2.97	0.003
Cement Fiber Board and Masonry	0.02538000	1.76	0.079
Torch Down Roof	–0.09667000	–2.36	0.019
Cell Phone Ant. Visible	–0.0564300	–3.93	0.000
Federal Way	–0.08896000	–4.43	0.000
Maple Valley	–0.06119000	–3.94	0.000
Issaquah	0.07793000	3.63	0.000
Lake Washington SD	0.25318000	18.17	0.000
Auburn SD	–0.05947000	–4.17	0.000
Issaquah HS	0.21774000	4.82	0.000
Skyline HS	0.20463000	9.28	0.000
ZIP98010	0.16664000	2.65	0.008
ZIP98023	0.05955000	2.52	0.012

S = 0.0872944 R^2 = 88.1% R^2 (adj) = 87.3%

Table 7 Treatment Sales, HVTL Frequency Distributions by Line kV

Portland Data		Seattle Data	
HVTL kV	**Frequency**	**HVTL kV**	**Frequency**
115 kV	41	115 kV	0
230 kV	89	230 kV	80
345 kV	12	345 kV	3
500 kV	10	500 kV	70

Table 8 HVTL Proximity Price Effect by Line Voltage Category

Line Voltage	Coefficient	*t*-Statistic	*P*-Value
Portland Data			
115 kV	–0.01285	–1.14	0.253
230 kV	–0.02099	–2.66	0.008
345 kV	–0.00628	–0.31	0.759
500 kV	–0.00293	–0.13	0.897
Seattle Data			
Line Voltage	**Coefficient**	***t*-Statistic**	***P*-Value**
230 kV	–0.03535	–2.29	0.023
345 kV	+0.03275	0.42	0.677
500 kV	–0.01457	–0.88	0.381

Dependent variable is natural log of price.

data's lowest line voltage. This result is misleading, because 87% of the higher-priced, most-affected home sales reported in the Seattle data (analyzed in Table 5) are abutting 230 kV lines. Therefore, the 230 kV variable in the Seattle regression model reported in Table 8 serves as a proxy for the much greater, higher-priced home HVTL effect in Seattle.

Market Conditions Adjustment and HVTL Proximity

Rates of price change for 2005 to 2006 and 2005 to 2007 were isolated for HVTL-abutting and non-HVTL abutting properties in both Portland and Seattle. These were isolated and estimated by running multiple regression models identical to those shown previously for "abutting" and "non-abutting" subsets of each study area's data. Table 9 includes coefficients on 2006 and 2007 market conditions adjustment coefficients for each study area, using a 2005 base year (the data did not include enough 2004 sales to allow meaningful 2004 comparisons).

As Table 9 shows, there was very little difference in percentage change in price from 2005 to 2006 and from 2005 to 2007 for HVTL-abutting and non-HVTL-abutting homes in either the Seattle or Portland Study Areas. Rates of price change during the 2005–2007 study period were not materially affected by HVTL proximity, having been slightly greater in Portland for HVTL-abutting properties and slightly less in Seattle for HVTL-abutting properties in 2006, but greater in 2007. Therefore, HVTL proximity price effects appear to have been limited to the sale price as of the date of the transaction, with no material effect on rates of price change. Figure 1 provides a graphic representation of these market condition adjustment percentages.

Findings and Conclusions

Results from the Portland Study Area represent a refinement to the earlier work by Wolverton and Bottemiller[32] by provision of a more precise model, principally due to the current study's data set allowing for better statistical control of the pricing influence of the city's market areas (neighborhoods) and school districts. The resulting improved precision, in terms of smaller regression error, uncovers the significance of the HVTL price effect, which was not evident in the prior study. In addition, this study confirms the earlier Portland area finding of no appreciable difference in the price response to changing market conditions for HVTL-abutting and non-abutting homes.

The Seattle study is unique in regard to its breadth of home price coverage (25% of the data having a mean price of approximately $1 million). Like the Portland portion of this study, the Seattle area data benefits from inclusion of a wealth of location data, including municipalities, school districts, market areas (neighborhoods), high schools, and zip codes. At first blush, the Seattle findings appear to be consistent with the Portland analysis—a small, significant, negative HVTL price effect. However, when the higher-priced homes and more typically priced homes are analyzed separately the price effects are found to be quite different. The

32. Wolverton and Bottemiller, "Further Analysis of Transmission Line Impact on Residential Property Values."

Table 9 Market Conditions Coefficients for HVTL Abutting and Non-Abutting Homes

	Coefficient	t–Statistic	P–Value
Seattle Study, HVTL Abutting			
2006 Sale	0.14140	7.31	0.000
2007 Sale	0.21984	7.27	0.000
Seattle Study, Non-HVTL Abutting			
2006 Sale	0.16813	12.99	0.000
2007 Sale	0.20509	9.36	0.000
Portland Study, HVTL Abutting			
2006 Sale	0.13520	9.98	0.000
2007 Sale	0.17971	10.15	0.000
Portland Study, Non-HVTL Abutting			
2006 Sale	0.128525	16.25	0.000
2007 Sale	0.171420	16.33	0.000
2007 Sale	0.171420	16.33	0.000

Dependent variable is natural log of sale price, convert to percentages using $[e^{coef} - 1] \times 100\%$

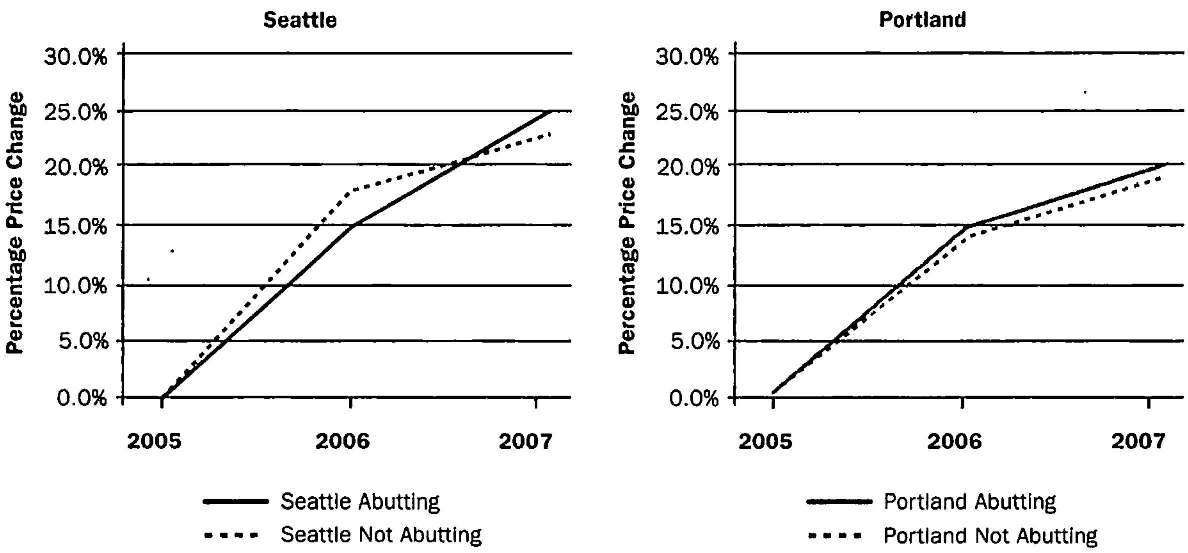
data for more typically priced homes reveal a very small negative and statistically insignificant HVTL price effect. One cannot conclude that the HVTL price effect differs from zero for this subset of the data. Conversely, the negative HVTL price effect for the higher-priced Seattle Study Area homes is substantial and highly significant. Finally, as in Portland, there is no evidence that HVTL proximity affected the rate of change in home prices in the Seattle area during the study period.[33]

These outcomes, like all studies of this sort, are derived from sample data intended to be representative of their markets. Such samples are not generalizable to other markets due to differences in climate, government, terrain, vegetation, and local attitudes toward HVTL proximity and views. Furthermore, as the relatively high market price appreciation rates herein indicate, these markets could be described as occurring during an up-sloping segment of the real estate price cycle. One should not necessarily expect similar buyer and seller pricing behavior during other segments of the market cycle—such as balanced markets with very little price movement over time or under-demanded markets evidenced by falling prices.

Additionally, there are material differences between the Portland market and the Seattle market. Portland is a multicounty, multistate housing market; Seattle is not. The choice of state of residence in the Portland area determines income tax rates and sales tax rates. No such dynamic occurs in Seattle. Also, Portland's Washington County is highly urban whereas Clackamas County (OR) and Clark County (WA) are less so. In contrast, Seattle's King County includes urban, suburban, and exurban lands. The Seattle sale data locations are almost exclusively suburban, and some of the higher-priced homes are at the suburban fringe where land uses rapidly transition into an exurban environment. Therefore, the Portland findings are not directly applicable to Seattle, and the Seattle findings are not directly applicable to Portland. The most stark, and revealing difference between the data from these two markets is the much larger percentage-of-price effect exhibited for higher-priced homes in Seattle. It seems more likely that this effect is more attributable to home price than it is to city location (Seattle versus Portland). Unfortunately, there is no available Portland data for testing this supposition.

33. For completeness, standard errors were examined for evidence of heteroskedasticity and none was apparent. To further ensure that the results were credible, each regression model was also estimated using White's heteroskedasticity consistent covariances and the findings were unchanged from those reported here.

Figure 1 Market Conditions Adjustment Percentages



The study's regression equations also reflect what appraisers generally find to be axiomatic. Location matters in these two housing markets. Unlike investment income, housing is not fungible. Families care about the state, county, city, school district, high school service area, and neighborhood they live in. In addition, all else being equal, improved living area is usually the most important factor in home price. Furthermore, living area, bedroom counts, and bathroom counts are highly correlated. The appraisal "Principal of Balance" is confirmed by these correlations, and when room counts depart from market norms for a given floor area, SF-BR-BA balance is disturbed. Also, the analyses found here highlight the importance of market condition adjustments. When prices are varying by 20% to 25% over a brief 2½ year period, market condition adjustments quickly add up to meaningful amounts of money. Lastly, markets often exhibit a significant amount of seasonal cyclicality. Therefore, a winter season sale may not be comparable to a summer season sale absent a seasonality adjustment, regardless of longer term market condition effects.

Considerable research has been conducted regarding the price effects of HVTL proximity. This study adds to an understanding of this complex phenomenon in a number of ways: it takes a second look at Portland and Seattle during a different market period; it focuses on a seller's market segment of the market cycle; it offers a first-ever empirical HVTL study of the Seattle upper-priced housing market; and it confirms findings of a previous study regarding how abutting and non-abutting homes react to changing market conditions. The study also confirms that all markets do not react in the same way to HVTL proximity. Portland appears to differ from Seattle, and higher-priced homes in Seattle differ from more typically priced Seattle homes. Given this finding, it would be beneficial if a future study were to compare higher-priced custom homes with typically priced homes in other locations to determine if this result can be confirmed elsewhere.

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Web Connections

Internet resources suggested by the Y. T. and Louise Lee Lum Library

Electric Power Research Institute
http://my.epri.com

Environmental Impacts of Transmission Lines, Public Service Commission of Wisconsin
http://psc.wi.gov/thelibrary/publications/electric/electric10.pdf

Federal Energy Regulatory Commission—Transmission Line Siting
http://www.ferc.gov/industries/electric/indus-act/siting.asp

US Department of Energy
http://www.energy.gov

US Energy Information Administration
http://www.eia.gov/