Wallingford-Ingo, Gail

From: McWharter, Pamela <Pamela.McWharter@hdrinc.com>
Sent: Friday, December 20, 2019 4:58 PM
To: Wallingford-Ingo, Gail
Cc: Salazar, Louella; seth.boutilier@blackhillscorp.com; Mansholt, Tyler; Vigil, John (John.Vigil@blackhillscorp.com)
Subject: RE: BOCC ACTION LETTER - 1041 2019-003
Attachments: BHE Response to Information Requests Dec 20_2019 pdf file.pdf

Hello Gail,

Please find attached, Black Hills Energy's *Response to Information Requests* submitted in response to the December 12, 2019 Board of County Commissioners' Action Letter.

Regards,

Pam McWharter
Sr. Environmental Project Manager

HDR
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From: Salazar, Louella [mailto:Salazar@pueblocounty.us]
Sent: Friday, December 13, 2019 11:37 AM
To: seth.boutilier@blackhillscorp.com; McWharter, Pamela <Pamela.McWharter@hdrinc.com>; Day, Marci <daym@pueblocounty.us>; Benbow, Dave <Benbow@pueblocounty.us>; Jimenez-Garcia, Dominga <jimenezdo@pueblocounty.us>; jdeherrera@pwmd-co.us; swinters@pwmd-co.us; mmoorhead@tnc.org; hgifford@pwmd-co.us; nvetter@pwmd-co.us
Subject: BOCC ACTION LETTER - 1041 2019-003

Hello! Please find attached the action letter from the December 12, 2019 Board of County Commissioners' meeting regarding the following land use case:

- 1041 Permit No. 2019-003, Black Hills Energy

Please make sure to retain a copy for your files. If you should have any questions, please contact **Gail Wallingford-Ingo** at gailwi@pueblocounty.us directly. Have a great weekend!

PUEBLO COUNTY

Louella R. Salazar
Administrative Support Manager
Department of Planning and Development
Pueblo Area Council of Governments
229 West 12th Street

December 20, 2019

Gail Wallingford-Ingo
Interim Director
Pueblo County Department of Planning and Development
229 West 12th Street
Pueblo, CO 81003-2810
Phone: 719.583.6100
Fax: 719.583.6376
Email: gailwi@pueblocounty.us

Re: Information Requests for 1041 Permit No. 2019-003: Black Hills Energy's Reliability Upgrade for Southern Colorado Project, Pueblo County, Colorado

Dear Ms. Wallingford-Ingo,

Black Hills Colorado Electric, LLC d/b/a Black Hills Energy (BHE) is submitting this *Response to Information Requests* issued December 12, 2019, regarding the Reliability Upgrade for Southern Colorado Project (Project) brought before the Commissioners on November 26, 2019.

Should you have any questions or comments, please do not hesitate to contact Seth Boutilier at 719-546-6449 (Seth.Boutilier@blackhillscorp.com) or Pam McWharter at 303-764-1570 (Pamela.McWharter@hdrinc.com).

Sincerely,

Black Hills Energy
Seth Boutilier
Project Manager

Enclosure

Enclosure

Black Hills Energy's Response to Pueblo County 1041 Information Request
December 20, 2019
Docket No. 1041-2019-03

INTRODUCTION

On December 12, 2019, Ms. Gail L. Wallingford-Ingo issued a letter requesting on behalf of the Pueblo Board of County Commissioners (Commissioners) a request for more information on a list of issues from Black Hills Energy, Pueblo West, and members of the public opposed to the 1041 Permit for the Reliability Upgrade for Southern Colorado Project (Project). Black Hills Energy (BHE) appreciates the opportunity to provide the requested information to the Commissioners. Below, BHE responds to the request for more information in the order requested by the Commissioners.

RESPONSE TO REQUEST FOR MORE INFORMATION

1. Floodplain.

Commissioners' Request: Black Hills is to provide information on the maximum variation from the indicated center line alignment that may be possible due to engineering requirements and what will be the minimum possible distance from the alignment to the property line of all adjacent properties. Black Hills is to provide information on the effect of steel monopoles within a 100-year floodplain in the event of a 100-year flood and possible mitigation and reclamation measures that may be taken to prevent and remedy such effects.

Response:

Per the first two questions, Black Hills Energy has done preliminary engineering for the segment of line in Pueblo West, and it has the ability to engineer the new transmission line along the route included in the 1041 application while still meeting the advisement from Pueblo County Staff to keep pole structures out of flooding sources and other recommendations in their Staff Review.[1] If requested by Pueblo County, BHE can engineer the transmission line along any alignment within the full easement of Wildhorse Creek while considering the constraints of avoiding the flooding source waters and with

[1] See Attachment No. 1. Pueblo County Planning and Development Staff Recommendations to Docket 1041 2019-003

coordination with the Pueblo West Metropolitan District. Variations from the proposed centerline are limited by the property lines of Wildhorse Creek. While Black Hills Energy prefers to stay near the center of the Wildhorse Creek easement, if requested, it will be possible for the line to be built within 20 feet of the easement edge assuming that the easement is abutting and paralleling the property line.

For the last question, Black Hills Energy will avoid placing transmission structures within any floodplain to the extent practicable. Currently, Black Hills Energy's wood-based distribution structures are located in the floodplain of the Wildhorse Creek easement. As a mitigation measure to avoid any incremental flooding related issues, the Reliability Upgrade for Southern Colorado Project will replace the wood distribution structures in the floodplain with new steel structures that will accommodate both a transmission and a distribution line on the same centerline. The Project's steel structures are designed to withstand flooding, and they will not constrict flood flows. Steel poles are stronger and embedded in concrete and generally have a longer service-life than wood poles in arid climates. The Project's structures are round in shape, and they are self-supported without any down guys or anchors that could otherwise pose a potential threat in a floodplain. Construction activities and the presence of the Project's structures will not alter the floodplain characteristics or create the potential for greater loss of property or life during any flooding event.

As another mitigation measure, a project-specific Stormwater Management Plan (SWMP) will be prepared to reduce and prevent pollutants in storm water runoff from entering waterbodies. The SWMP, through the use of best management practices, will establish erosion and sedimentation controls, hazardous material management, and any necessary reclamation or monitoring events. A SWMP will be prepared and a Stormwater Construction Permit will be obtained prior to construction. BHE will also fully comply with Pueblo County Planning and Zoning staff recommendations.

2. Fremont County.

Commissioners' Request: Black Hills is to provide information on the current status of the project in Fremont County and clarify statements made by the applicant in the Pueblo County 1041 permit application as to the status of the project in Fremont County.

Response:

In BHE's 1041 application, Section 9.2 explained that BHE has initiated the Special Review Use Permit in Fremont County (SRUP), and in Table 9 BHE noted the pre-application meeting and outreach to landowners. A formal submission of a SRUP application from BHE is pending finalization based on the alignment in a few areas in Fremont County. Under the SRUP process, it is critical to have a finalized alignment before submitting an application because new, directly affected land owners cannot be introduced once the SRUP review and public hearings commence. Below is a summary of the efforts conducted to date.

Black Hills Energy first held a pre-application meeting with the Fremont County Planning and Zoning staff on October 11, 2017. In this meeting, BHE described the project purpose, need, and proposed a preliminary route alignment. Fremont County staff described the procedures for obtaining a SRUP for the Project. On December 12, 2017, BHE staff and BHE right-of-way agents met with Fremont County officials including the Planning and Zoning staff, the County Manager, County Attorney, and County Commissioners. BHE provided an overview map of the preliminary project alignment, as well as Project information documents with each of the County officials and staff members. Since these early meetings, BHE conducted phone communications with the Planning and Zoning staff member Matt Koch before he left the position.

Public outreach in support of the SRUP in Fremont County started in 2017 and has continued into 2019. In addition to one-on-one meetings with every landowner near the proposed alignment, plus attendance at a neighborhood meeting in Penrose, BHE hosted two community meetings in Fremont County: one in Penrose and one in Florence. These community meetings permitted the sharing of Project information and facilitated conversations with landowners to obtain their feedback and to answer questions. BHE also hosted a telephone town hall for those unable to attend the in-person meetings.

3. Undergrounding Report.

Commissioners' Request: Black Hills is to provide a copy of any reports or documents prepared or to prepare reports or documents that examine the feasibility and cost of undergrounding transmission lines in the portion of the alignment that borders residential properties.

Response:

Black Hills Energy provides the requested information report as Attachment 2 to this Response.[2] As shown in Attachment 2, BHE has conducted an analysis of the logistics and cost of undergrounding the Project line. The analysis concluded that it would be over nine and one-half (9 1/2) times more expensive for a section of the transmission line to be located underground. In other words, a mile of 115 kV line as proposed by BHE will cost approximately $350,000 for steel monopoles. However, a mile of 115 kV line placed underground would cost approximately $3,387,000.

Black Hills Energy raises a concern for the Commissioners consideration pertaining to the cost impacts associated with undergrounding the transmission line. The Colorado Public Utilities Commission (PUC) has approved the construction of the Project, and that approval did not include any proposal to underground the transmission line. In the event that the Pueblo Board of County Commissioners direct the undergrounding of the Project, BHE has a concern of the rate impacts to its customers of that condition, as well as how the PUC would consider the implications of that rate impact. BHE's rates for its electric services are governed by the PUC. Accordingly, the PUC would ultimately determine how the incremental costs of undergrounding the Project would be addressed. The customer base that would bear the significant added expense for undergrounding could be as narrow as the customers on whose property the line is placed underground or as broad as all of Black Hills' customers in Southern Colorado.

Attachment 2 also includes the *Black Hills Energy 115 kV Underground Transmission Technical Requirements* that analyzed the logistics and costs associated with undergrounding the transmission line.

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[2] Attachment 2 was prepared for BHE's 2018 1041 Application. Because the terrain and engineering for BHE's instant 1041 Application does not materially differ from that proposed in its 2018 Application, the analysis and conclusions of the report are likewise applicable to BHE's 2019 Application.

4. Existing Substation Expansion.

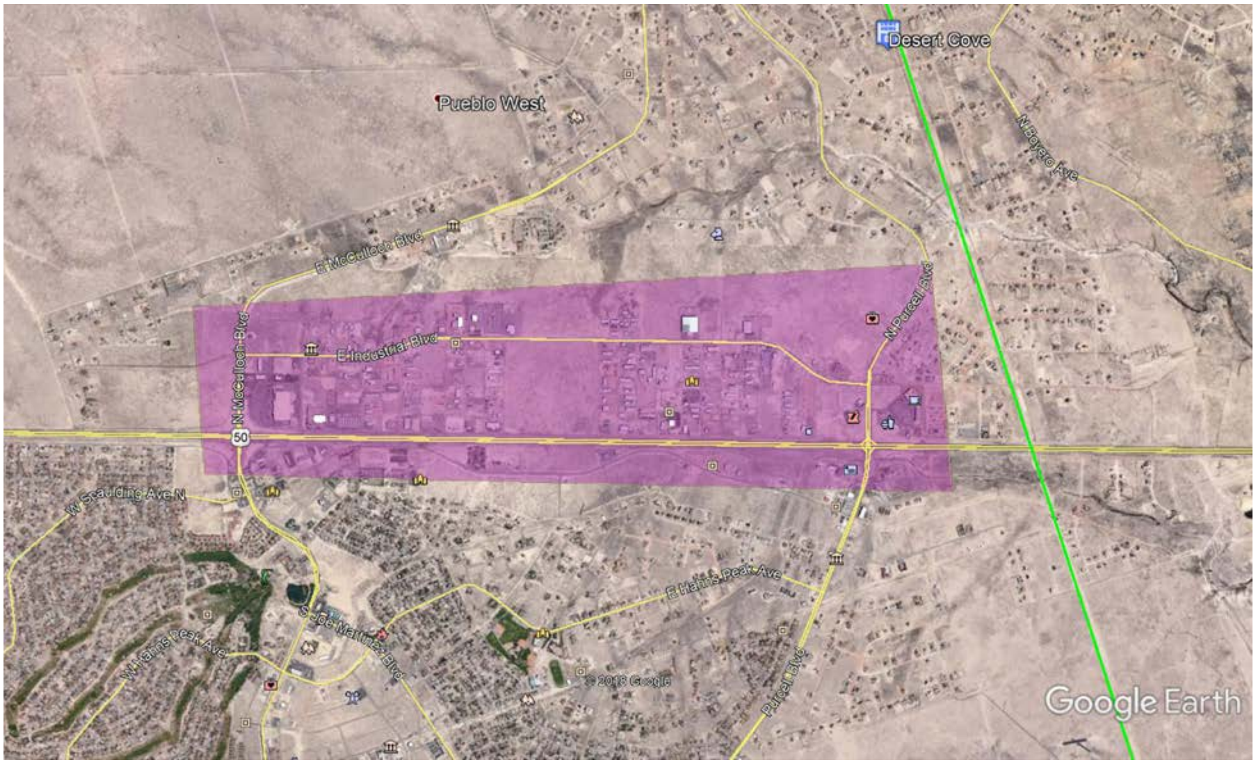
Commissioners' Request: Black Hills is to provide additional information, reports or documents that support the position that the existing substation could not support additional infrastructure required to complete the project and that a new substation is necessary.

Response:

The heavy load growth area in Pueblo West is depicted in Figure 1 below. Pueblo West is currently fed by BHE's Desert Cove Substation. Transformer number one at the Desert Cove Substation has reached its maximum operating capacity and transformer number two is at nearly 75% of its operating capacity. If one transformer is lost at the Desert Cove Substation, BHE would have to install a mobile transformer to act as a temporary and non-permanent solution to continue serving its customers. The use of a mobile transformer at any given moment could take several hours to install. It is critical that additional resources be added to the distribution system to continue reliable service and to support growth in Pueblo West.

Adding the proposed new substation close to the growth areas in Pueblo West is important because power loss through heat on the distribution lines reduce the efficiency of the system, causing customers to incur added cost to receive their power. Desert Cove Substation is three miles from the center of the heavy load growth in Pueblo West, making it an inefficient location to add additional resources. In addition to increased efficiency, installing a new substation in the area of heavy growth in Pueblo West will stabilize voltage, and reduce the risk of power loss in the industrial area by limiting exposure to the distribution system. Further, the new substation location in the area of heavy growth in Pueblo West will improve the overall reliability of the entire distribution system in Pueblo West by connecting back into the Desert Cove Substation. These are clear benefits to the customer that are crucial to meeting North American Electric Reliability Corporation (NERC) reliability standards. Expanding the Desert Cove Substation would not provide these benefits. Accordingly, BHE's decision to construct a new substation rather than upgrade the Desert Cove Substation is based on prudent reliability planning, rather than on the ability to upgrade the Desert Cove Substation.

FIGURE 1: Aerial View of Heavy Load Increase Area in Pueblo West



5. Alternative Route Feasibility.

Commissioners' Request: Feasibility of the use of alternatives routes (i.e., Highway 50 corridor and along the north section of the Walker Ranches adjacent to the Fort Carson Military Reservation).

Response:

Many routes were explored and considered for the Pueblo County segment of the Reliability Upgrade for Southern Colorado Project. Our application explains these alternatives in Section 8.4. Of the many routes considered in Pueblo County, only the proposed route stays entirely in existing utility easements in Pueblo West. This route would use the existing easements and require the least amount of new disturbance in the community. BHE will upgrade existing infrastructure where possible and install additional infrastructure where needed. Within the boundaries of Pueblo West, this route requires only approximately 20 of the 80 total estimated poles (25%) needed for the Project to be placed in a location that does not already have a pole (accomplished by upgrading the existing distribution infrastructure). Once the proposed transmission line route leaves Pueblo West, it will cross the Walker Ranches along a route that the land owner has helped identify. Below are the routes that the Commissioners asked for more information.

5a. Alternative Routes: Explain why you are not following HWY 50.

Routing the transmission line along Highway 50 was an often-suggested alternative by residents. BHE fully considered this alternative. The following factors are cited for BHE's decision not to propose this route:

- Following Highway 50 through Pueblo West would impact more residents and businesses, including nearly 40 unencumbered parcels, easements on Walker Ranch and two additional privately-owned parcels west of Pueblo West. The Walker Ranch is home to a black-footed ferret restoration area centered around prairie dog colonies on the southern border of Walker Ranch and near highway 50. The black-footed ferret is an endangered species, and Walker Ranch is home to the release of these ferrets through a U.S. Fish and Wildlife Service Safe Harbor Agreement.

- Due to physical constraints along the Highway 50 route, the transmission line would have to be built within 50 feet of at least two buildings and may require the removal of some aerial signs. Per the 1041 checklist criteria, BHE is attempting to minimize the impact on the environmental and social surroundings and due to these impacts, the Highway 50 route does not match those requirements.

- It is not favorable to use Colorado Department of Transportation (CDOT) right-of-way to build high voltage power lines due to the level of activity associated with CDOT maintenance. Utilities built within the CDOT rights-of-way are subject to being relocated at the request of CDOT. Relocation of the high voltage transmission line would increase the environmental, financial, and residential impacts of this Project. The cost of relocating the utilities is ultimately paid by the customer. In the case of relocating transmission lines, this cost is significant, and BHE has serious concerns about the rate impacts to its customers associated with any such potential relocation that would be outside of BHE's control.

- BHE has also learned through other recent projects that overhead utilities constructed along highways can also be contentious. BHE received this feedback earlier this year when we upgraded our existing distribution line along Highway 78.

5b. Alternative Routes: Explain why BHE is not following the WAPA line on Walker's property.

This route was another option offered by residents. BHE analyzed the possibility of this route by following the Ft. Carson border on Walker Ranch. BHE found that routing the line on Walker Ranches would require crossing multiple Nature Conservation Easements. Our 1041 application, in Appendix D, includes a letter from the Nature Conservancy expressing concern about the environment and protected species present on this land, including globally rare protected plant species. Additionally, the landowner is not in favor of this route.

5c. Alternative Routes: Explain why BHE is not going north to Fountain Valley Pump Station.

This option would require crossing more than three miles of conservation easements and property owned by the Walker Ranches. The Nature Conservancy has expressed concerns with this option (reference Appendix D of our 1041 application). To avoid those conservation easements, the Reliability Upgrade would have to be built along the southern border of the conservation easement and Walker Ranches property line, resulting in visual impacts on more than 50 properties that are north of Wildhorse Creek and that border a conservation easement.

6. Property Value.

Commissioners' Request: Provide documentation, reports or other evidence that property values are or are not affected by the placement of transmission lines near adjacent residential properties.

Response:

As discussed below, there is no conclusive evidence that the property values are affected by the placement of transmission lines near adjacent residential property. In addition, BHE has taken mitigation efforts to ensure no adverse impacts to property values. BHE has chosen a route that will locate in existing utility easements, where the Project is intended to be located. Residents had clear notice of the location of utility infrastructure when they purchased their property. Moreover, BHE is upgrading to the extent possible distribution infrastructure that already exists in the utility easement, significantly minimizing new impacts. BHE is also using steel monopoles to further lessen visual impacts. These efforts ensure the route proposed is the most optimal route to meet the community's need.

Focusing on property value related documentation, throughout the land rights process, and in an effort to provide the most balanced and fair terms for landowner compensation, BHE has engaged the support services of licensed Colorado appraisers. In addition to securing project specific sales and market data reports prepared by these appraisers, a summary of market data studies was prepared. Specifically, Attachment 3-1 includes the *Summary of Studies on Property Values Conducted Over the Past 50 Years by Earley & Associates* (December 2019). This attachment includes a summary of market data studies prepared to determine if there was a diminution of property value due to proximity to a high voltage transmission line (HVTL). Determination of diminution in value is governed by the Uniform Standards of Professional Appraisal Practice (USPAP). The studies included in the analysis consist of 56 HVTL areas in Colorado, 2 HVTL studies in North Carolina, 2 electrical substation studies (consisting of 9 different substation site locations), 2 underground natural gas pipeline study areas, and 2 natural gas compressor station site facility areas. In Colorado, 8,228 sales in 16 counties were analyzed. After reviewing these studies, Earley & Associates' licensed appraiser Michael H. Earley, Member of Appraisal Institute, SRA concluded that there is no significantly measurable market impact in the sale price of properties with power lines as compared to similar properties without power lines.

Attachment 3-2 includes three additional reference studies on the lack of impact on property values associated with transmission lines. These additional reference studies provide that there is no definite evidence that that property values are diminished due to the construction and location of a proximate transmission line. For example, as stated in the 2010 *Effects of Electric Transmission Lines on Property Values*, 'most studies found no effect and in some cases a premium was observed. This was attributed to the additional open area usually behind the residence created by the transmission line easement'. In the 2011 *Effect of High Voltage Transmission Lines on Real Estate Values* the synopsis is that HVTLs have a modest or no measurable impact on property values, The *2017 Effect of High-Voltage Overhead Transmission Lines on Property Values: A Review of the Literature Since 2010* states that 'Survey-based research finds adverse perceptions and general dislike for HVOTLs, but sales data reveals little to no diminution in prices'.

BHE acknowledges that, despite the reliability and increased capacity the Project will bring to Pueblo County residents, many necessary infrastructure projects (including utilities, cell towers, water storage tanks, and transit projects) may be an inconvenience to some. BHE has worked diligently to mitigate concerns by staying in designated utility corridors, upgrading existing poles, and using monopoles to reduce the physical footprint of the Reliability Upgrade.

<u>CONCLUSION</u>

Black Hills Energy appreciates this opportunity to provide the Pueblo Board of County Commissions additional information requested on the 1041 Permit application for the Reliability Upgrade for Southern Colorado Project. Black Hills Energy's 1041 Permit application meets the approval criteria and guidelines in Section 17.168 of the Pueblo County Code. Black Hills Energy appreciates that Staff of Pueblo County has concurred that the 1041 Permit application meets the County's guidelines. Black Hills Energy agrees to abide by Staff's conditions of approval for issuance of the 1041 Permit. Black Hills Energy looks forward to continuing its efforts to provide safe and reliable energy to the communities it serves.

Attachment 1

Pueblo County Planning and Development Staff Recommendations

STAFF RECOMMENDATION

Staff acknowledges the Pueblo West Metropolitan District Board of Directors has expressed a concern over the Project as it relates to the construction near the Pueblo West Industrial Park and currently opposes approval of the application until Black Hills Energy's intent regarding the West Station utility corridor is further defined; however, the submittal does meet the provisions as outlined in Chapter 17.168 *Site Selection and Construction of Major Facilities of Public Utilities* (*1041 Permit*), Section 040, Guidelines of the Pueblo County Code. The applicant will need to secure the easement in the area identified on Parcel E of Subdivision Exemption No. 86-4 prior to developing the Project since it is included in the materials submitted by the applicant for 1041 Permit No. 2019-003.

Therefore, staff recommends approval of 1041 Permit No. 2018-002 (Cañon West Reliability Project) within Pueblo County, contingent on the following conditions of approval:

1. This permit shall not constitute an exemption from zoning, health, building permits, or other applicable regulations. Issuance of this permit is subject to approval by any regulatory agency where required by regulation or statute.

2. The Cañon West Reliability Project construction and activity shall be according to the plans and information in the materials submitted by the applicant for 1041 Permit No. 2019-003, attached hereto as Exhibit 1. The applicant's description of Construction Activities, Operations and Maintenance Activities for the Project within the application materials, including but not limited to Permit area, safety, dust and erosion control, re-vegetation and reclamation, measures to protect wildlife, environmental and other impacts, and other required permits, shall be strictly adhered to. Noncompliance may result in the Department of Planning and Development scheduling a Show Cause Hearing before the Permit Authority to review the Permit approval.

3. The Permit shall be approved for the areas within the applicant's submitted legal descriptions and maps, noting minor changes could be taken under consideration through the submission of an amendment with substantial changes requiring the submission of a new 1041 permit for review and consideration. The Department of Planning and Development shall review and approve site plans, drawn to scale, depicting specific locations of all components, equipment, facilities and structures, prior to the applicant receiving approval for a building permit to begin construction.

4. The applicant shall provide to the Department of Planning and Development copies of all subsequent permit approvals by other regulatory agencies within sixty (60) days of said permit approvals being received by applicant.

5. On or before November 26, 2020, the applicant shall submit a report to the Department of Planning and Development, detailing the overall status and viability of the Project. The report shall address compliance with each of the approved Conditions of Approval for 1041 Permit No. 2019-003. The Department of Planning and Development may request subsequent, similar reports regarding the Project status.

OTHER AGENCY CONDITIONS:

1. The applicant is required to apply for an access permit from every County Road and an excavation permit for the crossing of County right-of-ways with the Pueblo County Department of Engineering and Public Works and comply with the conditions of those permits.

2. The applicant shall comply with the requirements of the Pueblo West Metropolitan District's Public Works Department relative to the submission of a Stormwater Management Plan (SWMP) and Right-of-Way Use Permit and any conditions of those permits.

3. The applicant shall address the requests from the Nature Conservancy District relative to providing more acknowledgement of the presence of the easement(s) and their purpose to protect populations of rare plants, the mapping, monitoring and controlling of invasive species (weeds) and consultation for future seed mixtures during reclamation.

Attachment 2

Black Hills Energy 115 kV Underground Transmission Technical Requirements

115 kV Underground Transmission Technical Requirements – Supplement to Cost Estimate

Technical Analysis and Estimates

Location

November 7, 2018

Prepared by

HDR Engineering

Vincent Curci
Ted Nishioka

Contents

Tables

Figures

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1 INTRODUCTION

HDR Engineering has been requested by Black Hills Energy (BHE) to provide engineering to develop a unit cost estimate and some detail drawings for undergrounding portions of a 115 kV overhead line (OHL).

This report provides additional information to supplement the estimate and to provide further information and considerations for the 115 kV underground cable (UGC) portion.

1.1 Assumptions

The estimate and detail drawings are based on the following assumptions

- The cable system type will be extruded with cross-linked polyethylene insulation.
- Cost estimate will be provided for a 115 kV underground circuit for a single circuit configuration in single trench based on a current of 1200 A.
- Cost estimates will include costs of material and installation by major component.

2 ADVANTAGES AND DISADVANTAGES OF UNDERGROUND LINES

2.1 Advantages

Below are the advantages of 115 kV underground lines as compared to overhead lines. These factors tend to favor underground lines, but it is important to note that evaluations and comparisons must be done for the specific requirements of individual projects with similar alternatives.

2.1.1 Reliability

Reliability statistics tends to favor the use of underground cables in comparison to overhead lines.

Overhead lines have a higher failure rate than underground lines.

As a result of this information, it is assumed cables would be subjected to less transient surge phenomena and spikes as compared to overhead lines.

In addition, most of the major blackouts in North America have been caused by overhead line electrical failures.

References [1], [2] and [3] provide information on the reliability of underground lines.

2.1.2 Security of the Power System

The security of the power system would tend to favor 115 kV cables over lines based on the following:

- Cables are not affected by atmospheric conditions such as ice, snow, rain, wind, and fog, unlike overhead lines.
- They are also not affected by events such as smoke caused by fires and dust storms.
- Cables are also not affected by hurricanes, tornadoes and ice storms
- The 115 kV cables would not be affected by human activities such as sabotage, vandalism, terrorism and theft. (Comment: I am assuming you have secured manhole lids and substation walls for our system).

2.2 Disadvantages of 115 kV Underground Lines

2.2.1 Costs

Generally, costs tend to be less for OHL.

Costs are higher for underground cables but they cannot be quantified unless evaluating specific projects with underground alternatives.

Capital and life cycle costs tend to be less for OHL. Initial capital and life cycle costs have been investigated and or reported by various entities as indicated in References [5], [6], [7] [8] [9]. Capital cost ratios reported for UGL range from 4 to 14 times higher than OHL.

2.2.2 Outage Times for System Restoration

Outage times tend to be less for OHL. Outage times will be longer for 115 kV underground lines for fault locating and repair and they will be in the 7-10 days range assuming that fault finding equipment, all parts, equipment, personnel and special tools are available and mobilized from the start of the outage.

2.2.3 Ampacity and Thermal Limitations

OHL has higher rating that UGL for the same conductor size. Cables dissipate heat via conductions through the surrounding earth to atmosphere. This heat transfer is a function of the thermal characteristics of the native soil. Special backfills are required to improve thermal limitation by replacing native soil with low thermal resistivity backfills. Overhead lines transfer heat via convection and radiation and are only limited by the conductor sag, as result they can typically transfer twice as much load for the same conductor cross-sectional area and material.

2.2.4 Cable System Life Expectancy

The expected service life for a 115 kV XLPE insulated cable system installation is 40 years minimum. In comparison, the life of a 115 kV line with steel structures would have an expected life of over 80 years.

3 SURVEYS

3.1 Alignment and Underground Utilities

Route surveys will be required in order to establish the final feasibility of the underground installation route. The surveys will be needed for the following:

- Establish constructability
- Spot vault locations
- Identify above ground and underground structures paralleling or crossing the route so that they can be plotted on construction or survey drawings.

3.2 Geotechnical

Geotechnical studies and field borings should be done to establish constructability and structural suitability, especially for transition structures or if trenchless methods of horizontal directional drilling or jack and bore are needed to cross bodies of water, railroad easements and large interfering substructures.

3.3 Geothermal

A thermal resistivity survey consisting of in-situ testing and laboratory analysis of soil samples along the proposed route should be conducted. The data is then used to select appropriate thermal resistivity parameter values t for use in ampacity calculation.

Ambient earth measurements should be taken in conjunction with in-situ testing.

4 CROSS-LINKED POLYETHYLENE CABLE SYSTEMS

4.1 Available High Voltage (HV) Cable Systems

Currently, there are four distinct underground transmission cable systems with worldwide acceptance and usage:

- Extruded Dielectric Cable Systems
  - Cross-Linked Polyethylene (XLPE) Insulated cable
  - EPR insulated cable.
- Self-Contained Fluid-Filled Cables (SCFF)
- High-Pressure Fluid-Filled (HPFF) Pipe-Type Cables

- Gas Insulated Lines (GIL)

The report focuses on XLPE cables in accordance with the Scope of Work.

XLPE cables have many advantages over SCFF or HPFF.

4.2 Preferred XLPE Cable Construction

The preferred cable would be an XLPE insulated cable with construction shown in Figure 4-1 and Figure 4-2. The single circuit would have a 2500 kcmil copper conductor cable while the double circuit would have a 3500 kcmil copper conductor cable.

Figure 4-1 XLPE Cable Cross Section

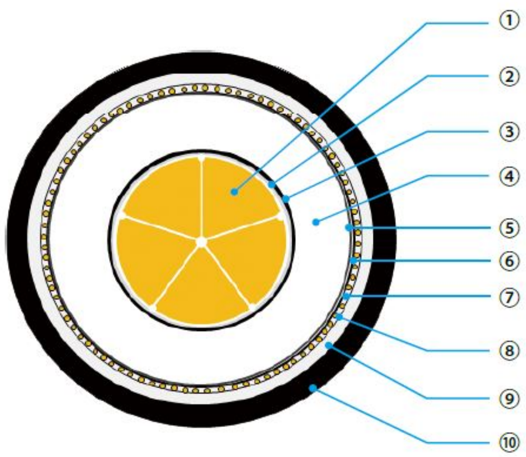
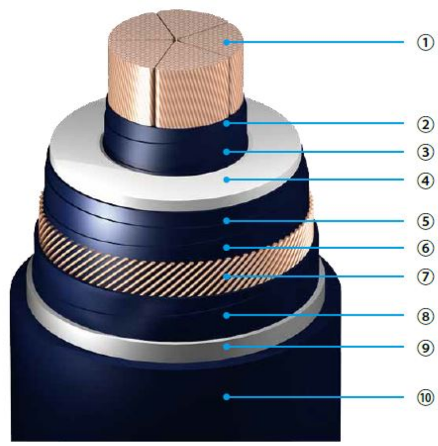


Figure 4-2 XLPE Cable Construction

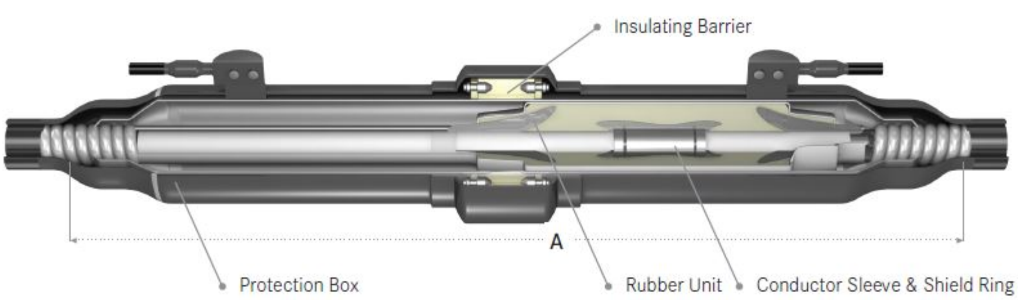


115 kV rated XLPE cables are available from manufactures in Europe, Korea, Japan, China and US. Delivery time requirements are normally 4 to 6 months after receipt of order by the cable manufacturers.

5 XLPE CABLE SPLICES

The preferred splice would be the one-piece premolded (OPJ) slip-on, Figure 5-1.

Figure 5-1 One Piece Premolded Slip-On Splice



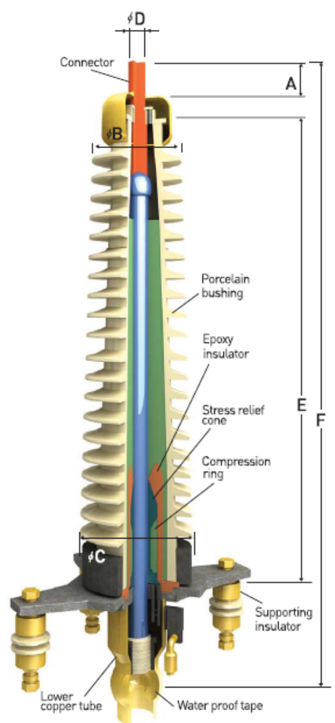
Splices are available for the most part from the selected cable manufacturers.

Delivery time is normally 4 to 6 months after receipt of order by the manufacturer.

6 CABLE TERMINATIONS

The preferred termination is the premolded oil-filled, Figure 6-1. The external bushing or housing is available in porcelain or as a polymer composite that consists of a fiberglass tube bonded to EPDM rubber.

Figure 6-1 Premolded Termination Oil-Filled



There are other designs such as the dry-type and the cold shrink which could be utilized.

Terminations are available for the most part from the selected cable manufacturers.

Delivery time is normally 4 to 6 months after receipt of order by the manufacturer.

7 CONSTRUCTION TECHNOLOGIES

High voltage cables have been installed using the following construction technologies:

- Duct and Vault Systems
- Direct Buried System
- Tunnels
- Horizontal directional drilling (HDD) for crossing obstacles such as rivers

- Jack and Bore for crossing highways, large substructures and railroad right of ways (ROW)

This report focuses on duct and vault system.

7.1 Direct Buried Systems

Direct buried systems, although not common in North America, have been used with success in Europe, the Middle East, and other parts of the world. They have a lower installation cost than the duct and vault systems and are more flexible since trenches can be opened to match the cable reel lengths.

They also produce high ampacity for the same cable size since they are thermally more efficient in eliminating the thermal resistance of the conduit and the thermal resistance of the air space within the conduit. In addition, cables can be spaced closer together minimizing trench size requirements.

The main disadvantage is that the entire system has to be abandoned when the cables have reached their useful service life.

Figure 7-1 and Figure 7-2 show installations of direct buried system.

Figure 7-1 Direct Buried Installation – Rural

Figure 7-2 Direct Buried Installation- Urban

7.2 Duct Bank and Vault System

In North America the preferred installation method, especially in urban areas, is the duct and vault system installed by open cut trenching.

Duct and vault systems have several advantages including easier coordination with cable system installation, high protection for the cables due to concrete encasements of conduits, and in the event of a fault, cables can be removed from conduits without need for excavations.

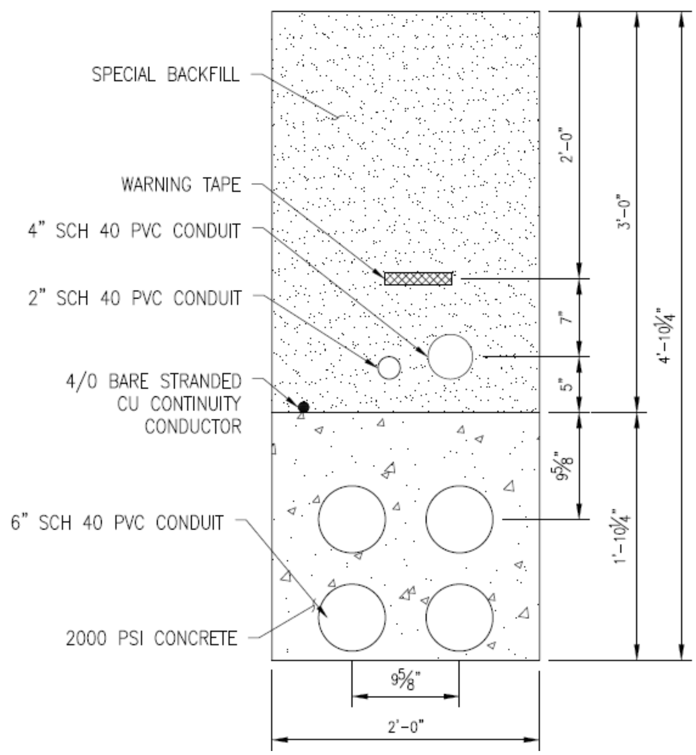
The preferred installation method for the 1-mile UGL is the conduit and vault system.

The trench configuration for the single circuit is shown in Figure 7-3 and would be approximately 2 feet wide by 5 feet deep and contain 4-6" PVC schedule 40 conduits.

The conduits would be encased in concrete. The trench backfill above the concrete encasement would be a low thermal resistivity fluidized thermal backfill consisting of cement, thermal sand and water.

The trench depth would vary as needed to cross over or under interfering substructures such as existing utilities.

Figure 7-3 Single Circuit Square Configuration



8 VAULTS

8.1 Available Vault Designs and Types

Vaults normally are installed for splicing of the cables. There are different vault designs but the precast tub type would be preferred. The vault design and construction is shown in Figure 8-1 and consists of two prefabricated tub sections, bottom and top, that are delivered to the installation site by truck and installed with a crane. For the double circuit the width of the vault would be larger.

Figure 8-1 Tub Type Vault for Single or Double Circuit Configuration

9 EQUIPMENT ARRANGEMENT IN VAULTS

The cable and splices would be arranged in the vault in straight-through configuration as shown in plan view in Figure 9-1. The cable and splices would be mounted vertically on steel supporting hardware and solidly fastened in place with clamps as shown in the elevation view of Figure 9-2. Figure 9-3 shows an actual installation with the cable and joints arranged in straight through configuration in the vault.

Figure 9-1 Rigid Straight-Through Single Circuit Arrangement in Vault – Plan View

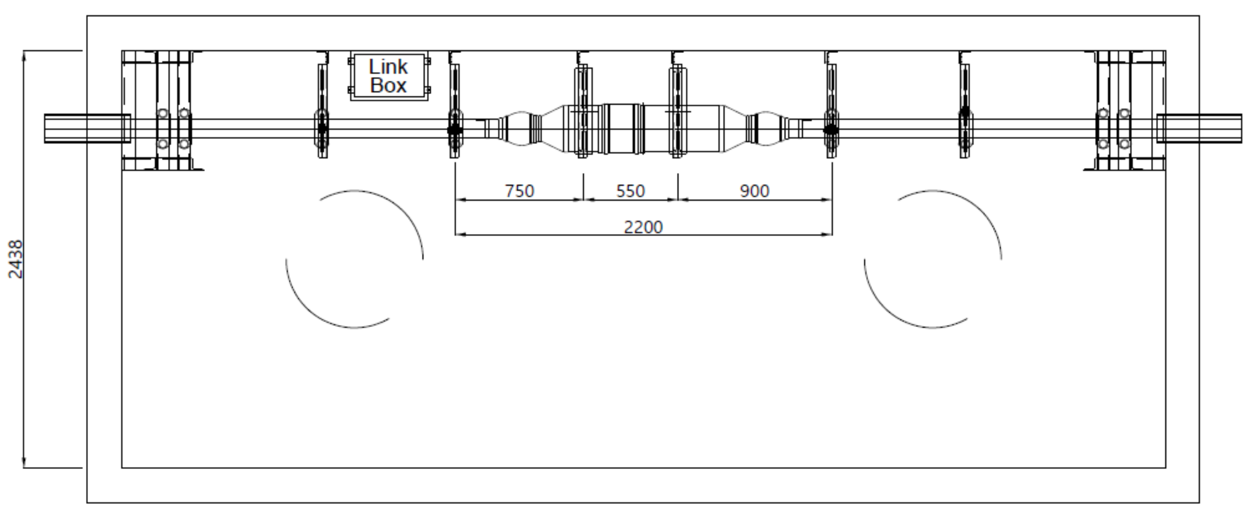


Figure 9-2 Arrangement of 115 Cables and Joints – Elevation View

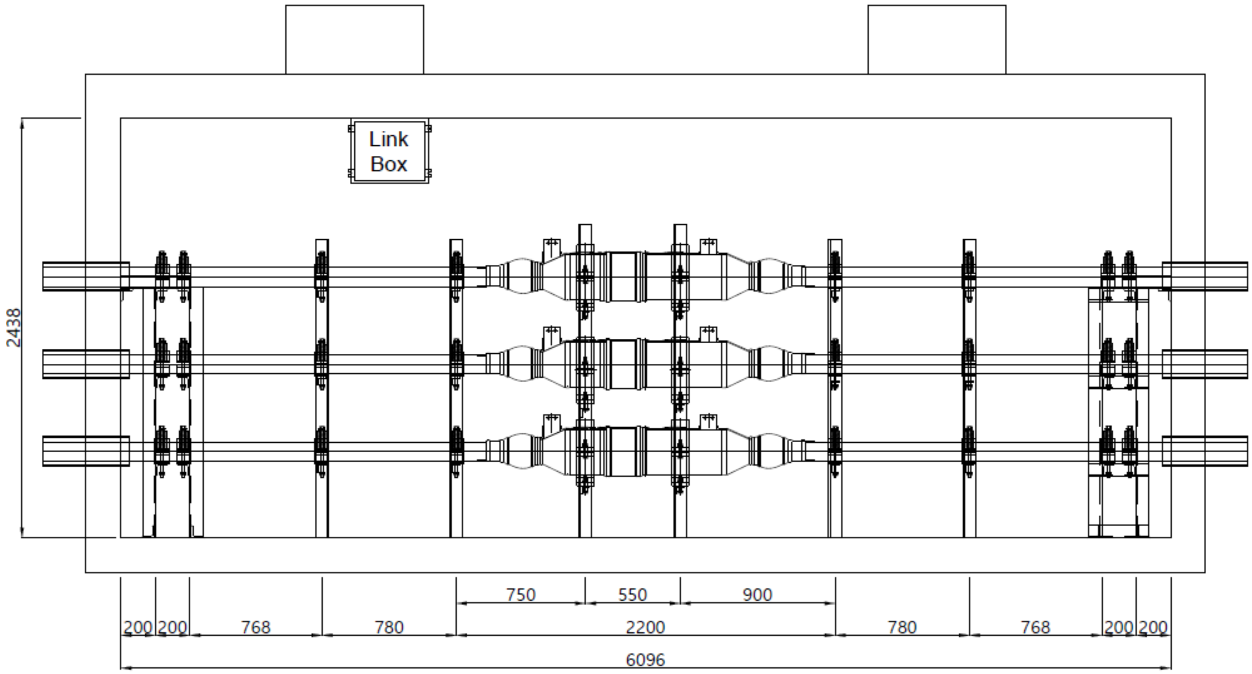
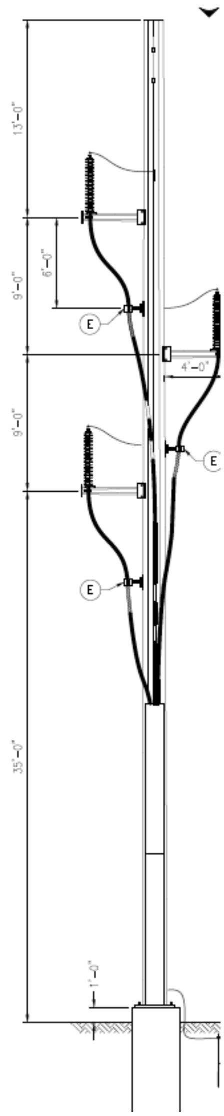


Figure 9-3 Actual Installation of Cables and Joints in Straight through Arrangement

10 TRANSITIONS FROM OHL TO UGL

The cables would transition from overhead to underground by installing cable terminations on steel poles. A typical transition pole is shown in Figure 10-1.

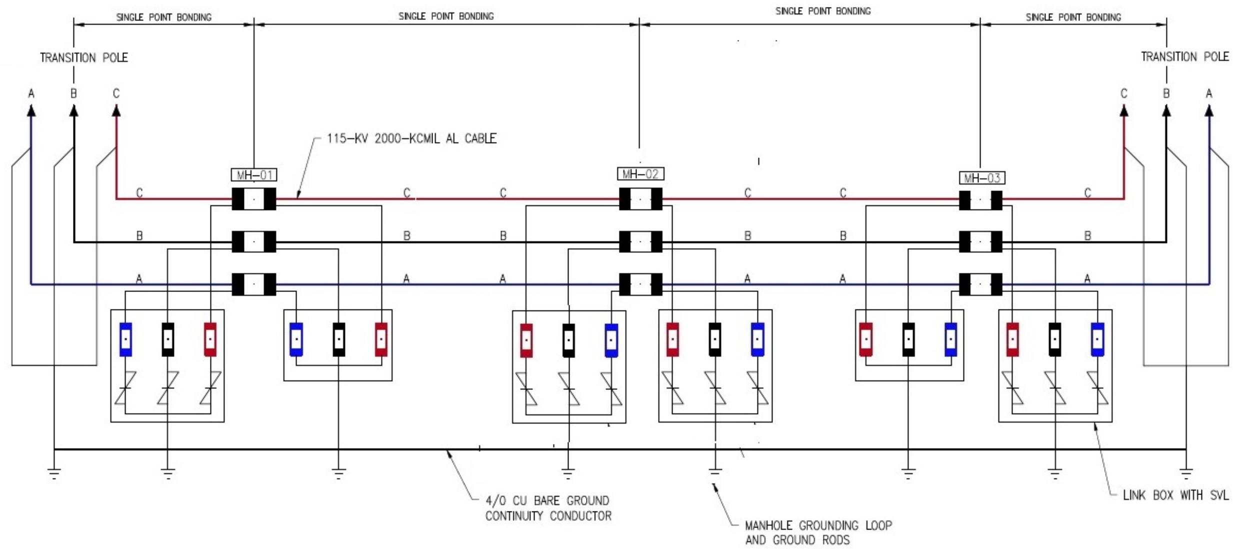
Figure 10-1 Typical Single Circuit Transition Pole Equipment Arrangement



11 BONDING AND GROUNDING

The cables would have single point grounding as shown in Figure 11-1. Link boxes with sheath voltage limiters (arresters) and grounding boxes would be installed as shown in the figure to achieve the single point bond. A 4/0 copper AWG ground continuity conductor would be installed along the length of the underground portion from transition pole to transition pole for grounding purposes and for transport of fault currents.

Figure 11-1 Single Point Bonding Arrangement of 115 kV Cables



12 CONSTRUCTION – NON URBAN AREAS

The construction process shown is as follows:

- Clearing of the alignment and removing any vegetation or removing top soil in farmland areas
- Trench excavation.
- Installation of the conduits in the trench using plastic spacers to achieve the design configuration
- Pouring of 1,500 to 3,000 psi compressive strength concrete over the conduit assembly
- Placing a warning tape in the trench as an option
- Backfilling the trench portion above the concrete with the following:
  - Clean excavated material,
  - Fluidized thermal backfill (FTB) consisting of a weak mix of thermal sand, cement, and water;
  - Slurry mix of low compressive strength in the range of 100 to 200 psi.
- Replacement, if required, of top soil

12.1 Conduit Installation

For installation in non-public alignments across farmlands or through forested areas, temporary and permanent easements of 20 to 50 feet would be needed depending on the number of circuits. In addition, this would require construction of a haul road in the alignment for construction vehicles to bring materials and for installation of the underground cable system. Minimum requirements for a haul road and ROW are shown in Figure 12-1.

Figure 12-1 Haul Road and ROW Requirements for Construction

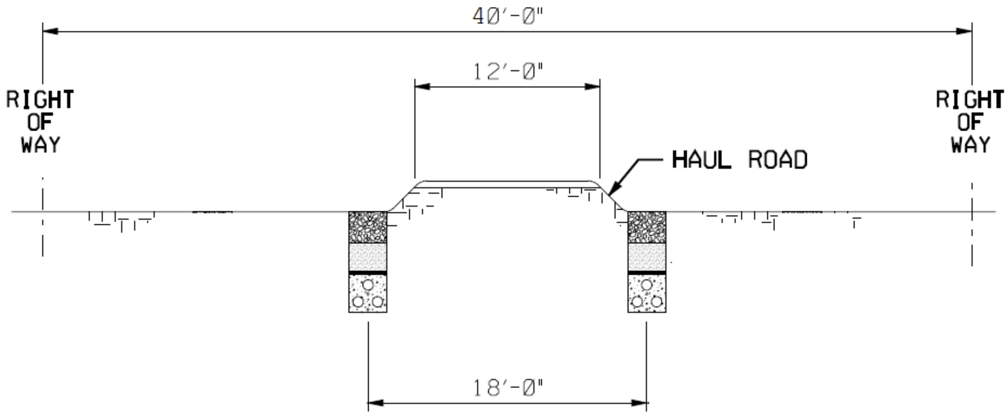


Figure 12-2 and Figure 12-3 show installation of a duct bank in a non-urban area.

Figure 12-2 Conduit Placement	**Figure 12-3 Conduit Backfilling**
	

13 CABLE SYSTEM INSTALLATION

13.1 Cable Pulling

Following the installation of the conduit system, the cables will need to be installed in the conduits. This will require a reel carrier, Figure 13-1, to transport the cable reel to the project site, a cable feeding set up, Figure 13-2, at the feeding vault, and a winch truck at the pull out vault.

Figure 13-1 Reel Carrier and Tractor

Figure 13-2 Cable Installation

13.2 Splicing

Splicing of high voltage cables requires trained and specialized personnel to assure correct installation for reliability and longevity of operation. It is recommended that the splice installation be done by splicers provided by the cable manufacturer. Figure 13-3 and Figure 13-4 show some of the steps required in the installation of high voltage splices.

Figure 13-3 Preparation of Cable Ends

Figure 13-4 Preparing the Cable End

13.3 Terminating

As for the case of the splices, installation of high voltage cable termination requires trained and specialized personnel. It is also recommended that the terminating of the cable be conducted by splicers provided by the cable supplier. Figure 13-5 shows the assembly of terminations on transition poles by use of a bucket truck or scaffolding.

Figure 13-5 Cable Termination Installation on Transition Pole

14 AMPACITY ANALYSIS

The required ampacity are as follows:

- Summer: 1110 A
- Winter: 1376 A

HDR conducted ampacity calculations for single and double circuit configurations and different cable conductor sizes different using CYME International "CYMCAP" ampacity analysis software to arrive at the optimal conductor size.

Figure 14-1 and Figure 14-2 show the cable configurations and ampacity for the winter and summer rating, respectively. The duct bank would have 3-2500 kcmil copper conductor cables.

The ampacity are based on earth thermal resistivity of 120 C-Cm/W, 75% load factor, 16°C winter and 30°C summer ambient earth temperatures at the depth of the cables. Minimum depth of cover to the top of the duct bank is 3 feet.

The cable conductor size will need to be recalculated if conditions are different than as indicated above.

Figure 14-1 Ampacity – 1454 A (Winter)

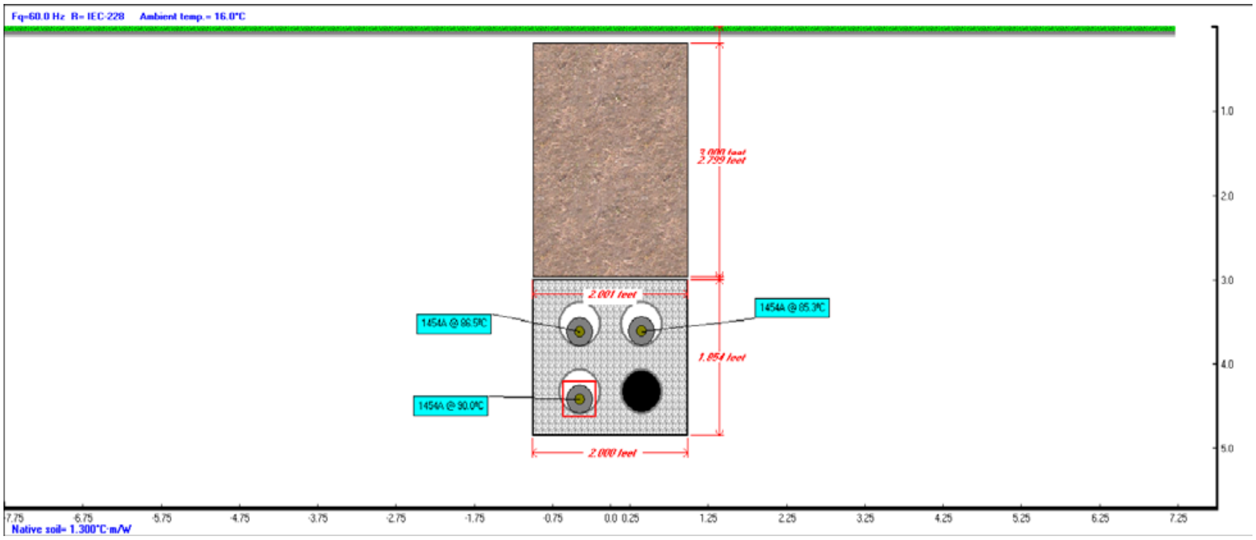
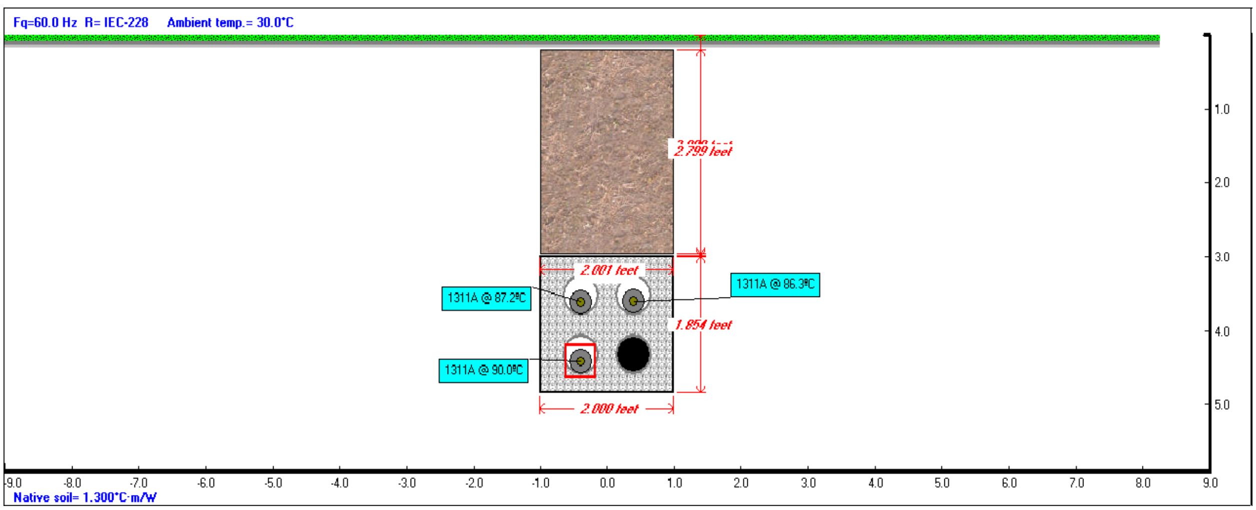


Figure 14-2 Ampacity – 1305 A (Summer)



15 ESTIMATED COSTS FOR 115 kV SYSTEMS

Table 15-1 provides estimated costs for the cable system, conduit system, engineering and contingency for areas where soil geology does not include trenching or excavating through rock. Cost for vegetation clearing, acquisition of land, access roads, and re-vegetating are also not included in the estimate.

Table 15-1 Estimated Costs for One Mile

Description	Material	Labor	Total
Subtotal - Cable System	$ 1,338,000	$ 578,000	$ 1,916,000
Subtotal - Communication System	$ 42,000	$ 92,000	$ 134,000
Subtotal - Duct Bank and Earth Work	$ -	$ -	$ -
Subtotal - Commissioning Testing	$ 377,000	$ 356,000	$ 733,000
Subtotal – Engineering and Construction Management	$ -	$ 21,000	$ 21,000
Subtotal - Contingency	$ -	$ 306,000	$ 306,000
Totals	***$ 1,931,000***	***$1,456,000***	***$ 3,387,000***

15.1 Basis of Preliminary Estimated Costs for All Scenarios

Assumptions - General

- Estimate is ±20 percent since it was developed without detailed information such as detailed plan drawings or survey notes.
- Costs are in 2018 dollars and no escalation is included.
- Costs do not include any sales tax.
- Costs do not include environmental studies or work.
- Costs do not include costs for local, state, and federal permits which may be required.
- Costs do not include any acquisition of land if crossing private easements.
- Costs do not include any vegetation clearing needed for construction.
- Costs do not include access road construction.
- Costs do not include any allowance for funds used during construction (AFUDC).
- A 10% contingency has been added to material and labor costs.
- The estimate is based on the conduit and vault construction method installed in a rural environment with relatively flat terrain.
- Costs of spare material including additional cable, 1 splice and 1 termination are included in the estimate.
- The cable system type used for estimate is cross-linked polyethylene insulated cable.

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115 KV Underground Line Drawings

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BLACK HILLS ENERGY

115 KV UNDERGROUND TRANSMISSION LINE

DRAWING LIST

DRAWING #	DRAWING DESCRIPTION
DLU-01	DRAWING LIST, SHEET 1
	MANUFACTURER DRAWINGS
MD-01	MANUFACTURER DRAWING, SHEET 1
MD-03	MANUFACTURER DRAWINGS, SHEET 3
	MANHOLE DRAWINGS
MEA-01	MANHOLE EQUIPMENT ARRANGEMENT
MH-01	TRANSMISSION MANHOLE DETAIL
	STRUCTURE DETAILS
SD-01-01	STRUCTURE DETAILS, POTHEAD SUPPORT RACK
SD-01	TRANSITION POLE

Black Hills Corporation

HDR

ISSUE	DATE	DESCRIPTION
-	-	ISSUED FOR

PROJECT MANAGER	J. ELLSWORTH
PROJECT ENGINEER	V. CURCI
DESIGNER	J. JUSTICE
CAD TECHNICIAN	D. HEPPNER
PROJECT NUMBER	10095843

BLACK HILLS ENERGY

115KV TRANSMISSION LINE

DRAWING LIST
UNDERGROUND TRANSMISSION DESIGN

0 1" 2"

FILENAME DLU-01.dwg

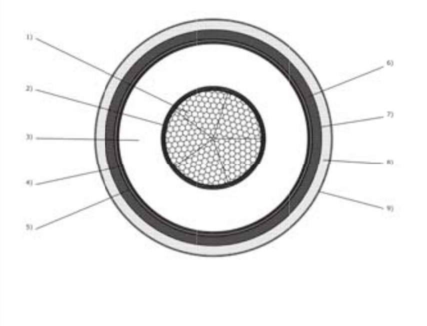
SCALE N.T.S.

SHEET DLU-01

CROSS SECTION OF 138kV CU 1Cx2500 KCMIL XLPE INSULATED CABLE

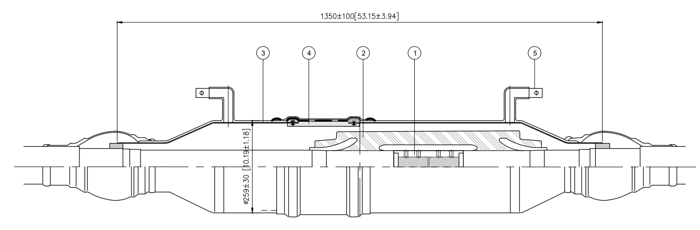
5 SEGMENTAL COMPACTED COPPER CONDUCTOR, XLPE INSULATION
LEAD SHEATH, MDPE INNER JACKET AND SEMI-CON PE OUTER JACKET

RATED VOLTAGE : 80/138/200KV	CONDUCTOR SIZE : 2500 KCMIL	BASIC STANDARD : AEIC CS9



ITEM	DESCRIPTION	MATERIAL	THICKNESS (MIL)	OUTER DIAMETER
1)	CONDUCTOR	5 SEGMENTAL COMPACTED ANNEALED COPPER WIRES	5 X 61 Str	1.72
2)	CONDUCTOR SHIELD	SEMI-CONDUCTING TAPE & SEMI-CONDUCTIVE COMPOUND	20 59	1.87
3)	INSULATION	CROSS-LINKED POLYETHYLENE (XLPE)	760	3.39
4)	INSULATION SHIELD	SEMI-CONDUCTIVE COMPOUND	41.2	3.48
5)	WATERBLOCKING LAYER	SEMI-CONDUCTIVE SWELLING TAPES	20 each	3.56
6)	METALLIC SHEATH	LEAD SHEATH	160	3.88
7)	ANTI-CORROSION LAYER	BITUMINOUS COMPOUND	4	-
8)	INNER JACKET	MDPE	180	4.24
9)	OUTER JACKET	SEMI-CON PE	20	4.28
COMPLETED CABLE		- WEIGHT : APPROX. 21.9 lb/ft - PHASE TO GROUND FAULT CURRENT CARRYING CAPACITY : 33 kA for 18 CYCLE - MAXIMUM D.C RESISTANCE OF CONDUCTOR AT 20°C : 4.35*E-06 Ohm/ft		

DWG. 138C2500MXNLE-C100608	REV.0	SCALE : N.S DMS IN INCH	SHEET: A4 PAGE: 1 OF 1	TAIHAN ELECTRIC WIRE CO.,LTD



NOTE.

1. All dimensions are in mm[inch].

No.	NAME OF PARTS	MATERIAL
1	CONDUCTOR SLEEVE	ALUMINUM & SHEAR BOLT
2	PMJ UNIT	SYNTHETIC RUBBER
3	OUTER CASE	COPPER / ALUMINUM
4	INSULATOR	PE
5	EARTHTING TERMINAL	COPPER

NOTE:

1. CABLE DRAWING SHOWN IS TYPICAL AND OTHER CONSTRUCTIONS WILL BE CONSIDERED.
2. JOINT DRAWING SHOWN IS TYPICAL ONLY AND OTHER CONSTRUCTIONS WILL BE CONSIDERED.
3. REFER ALSO TO CABLE SYSTEM MATERIAL SPECIFICATIONS.

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PROJECT MANAGER	J. ELLSWORTH
PROJECT ENGINEER	V. CURCI
DESIGNER	J. JUSTICE
CAD TECHNICIAN	D. HEPPNER
PROJECT NUMBER	10095843

BLACK HILLS ENERGY

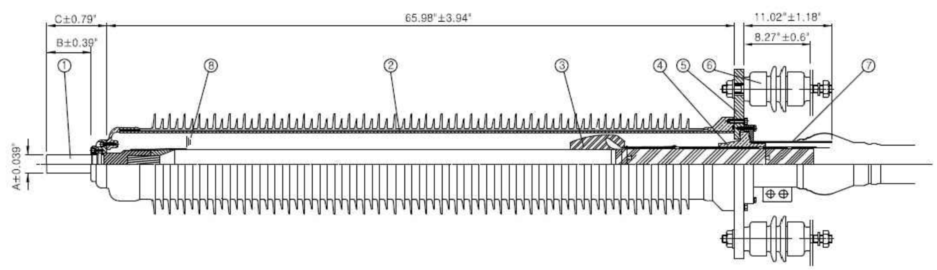
115KV TRANSMISSION LINE

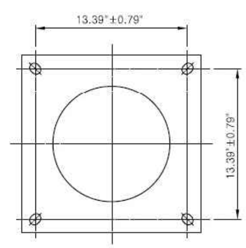
MANUFACTURER DRAWINGS

0 1" 2"

FILENAME MD-01.dwg
SCALE AS SHOWN

SHEET **MD-01**





UPPER VIEW OF No. 5

Conductor size(mm²)	Dimension		
	A	B	C
200 ~ 1000	1.77"	4.65"	6.61"
1200 ~ 2500	2.36"	5.63"	7.60"

No	Name of parts	Material
1	Conductor sleeve	Copper
2	Composite bushing	Silicone & Aluminum alloy
3	Stress cone	Silicone rubber
4	Sealing unit	Silicone rubber
5	Fitting metal	Aluminum
6	Porcelain supporter	Porcelain
7	Lower metal case	Aluminum
8	Compound	Polybutene

NOTE
1. All Dimensions are in inch.

PHYSICAL CHARACTERISTICS
Creepage Distance : Min. 201.6 inch

MANUFACTURER
VARIOUS

NOTE: MANUFACTURER TO BE DETERMINED

OUTDOOR TERMINATION
FOR 115kV ~ 161kV XLPE CABLE

NOTES:

1. TERMINATION DRAWING IS TYPICAL AND OTHER CONSTRUCTIONS WILL BE CONSIDERED.

ISSUE	DATE	DESCRIPTION
-	-	ISSUED FOR

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PROJECT ENGINEER	V. CURCI
DESIGNER	J. JUSTICE
CAD TECHNICIAN	D. HEPPNER
PROJECT NUMBER	10095843

BLACK HILLS ENERGY

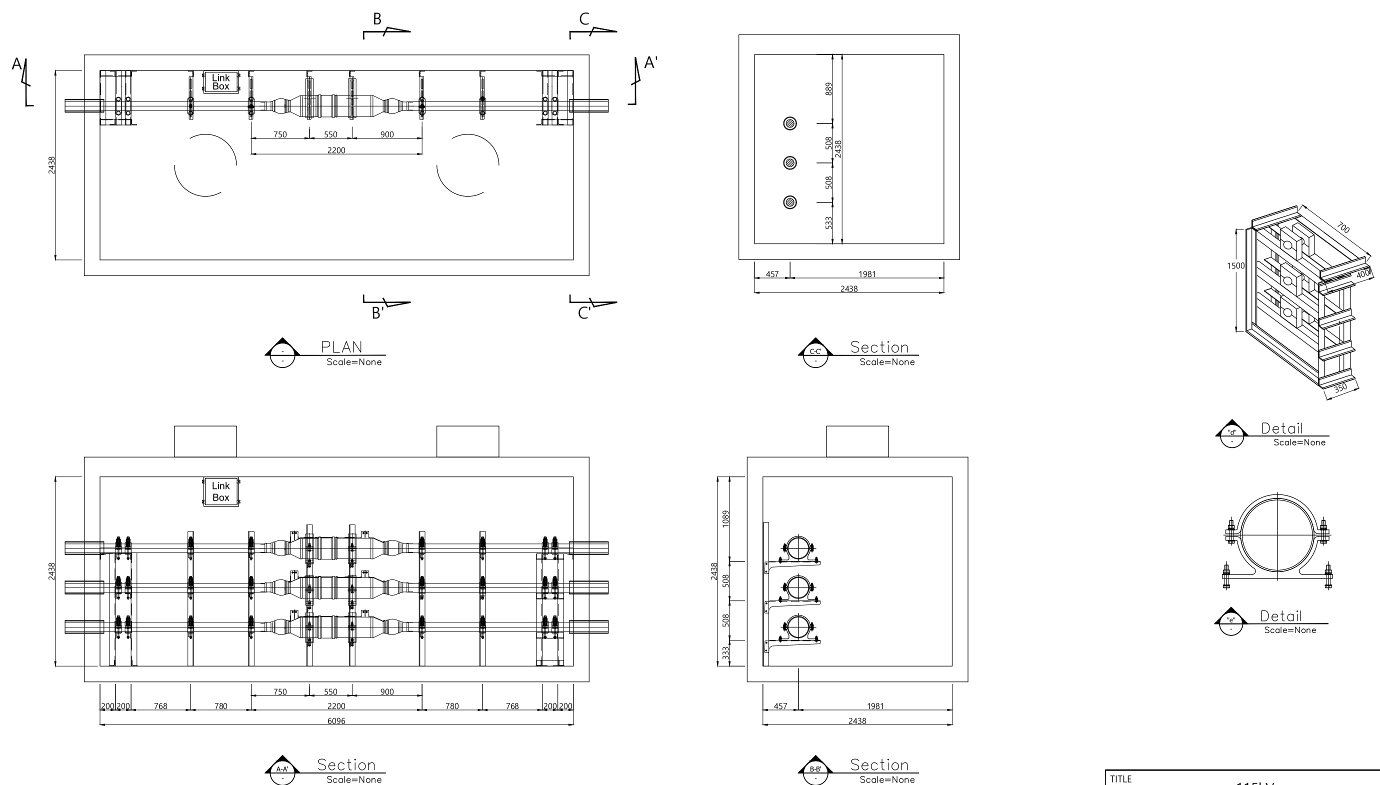
115KV TRANSMISSION LINE

MANUFACTURER DRAWINGS

0 1" 2"

FILENAME MD-03.dwg
SCALE AS SHOWN

SHEET **MD-03**



NOTES:

1. JOINTS AND CABLES RACKING IS TYPICAL AND OTHER CONFIGURATIONS WILL BE CONSIDERED DEPENDING ON MANUFACTURER.

TITLE
115kV
Typical M/H Deisgn

Black Hills Corporation

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PROJECT ENGINEER	V. CURCI
DESIGNER	J. JUSTICE
CAD TECHNICIAN	D. HEPPNER
PROJECT NUMBER	10095843

BLACK HILLS ENERGY

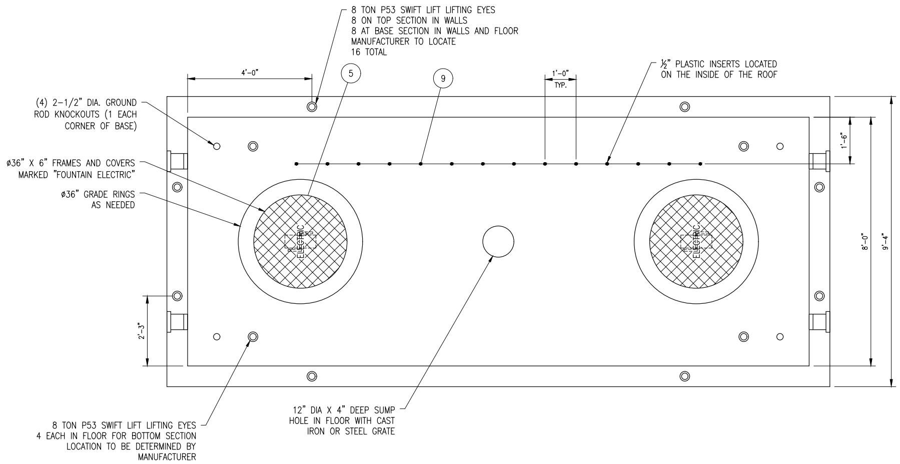
115KV TRANSMISSION LINE

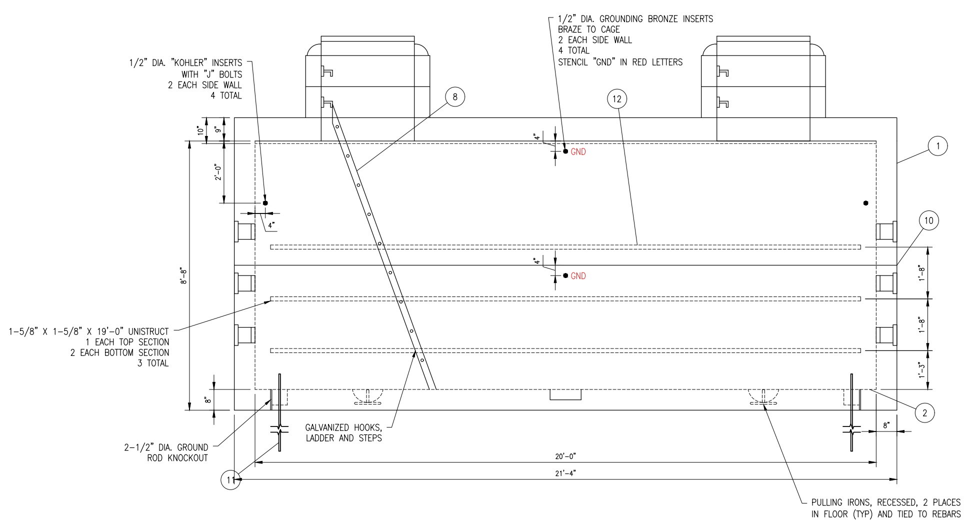
MANHOLE EQUIPMENT ARRANGEMENT

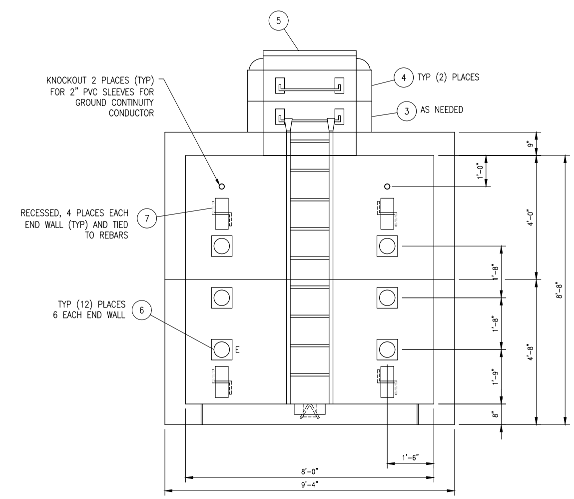
0 1" 2"

FILENAME MEA-01.dwg
SCALE AS SHOWN

SHEET **MEA-01**







ITEM	QTY	DESCRIPTION
1	1	EA. TOP PORTION
2	1	EA. BOTTOM PORTION
3	2	EA. GRADE RINGS, 12" X 36"
4	2	EA. GRADE RINGS, 6" X 36"
5	2	EA. COVER ASSEMBLY, DEETER 1191-A FRAME AND COVER
6	12	EA. TERMINATOR, DUCT, 6"
7	8	EA. PULLING IRON
8	2	LOT, RING MOUNTED LADDER AND HANGING HARDWARE
9	9	EA. PLASTIC INSERT, ½"
10	60	FT. CONSEAL CS-101 BUTYL RUBBER ROPE
11	4	EA. GROUND ROD, ⅝" DIA. X 8' LONG, 304 STAINLESS STEEL CLAD
12	60	FT., UNISTRUT CHANNEL, P3200, 1-5/8" X 1-5/8", GALVANIZED STEEL

GENERAL NOTES

1. VAULT SHALL BE REINFORCED CONCRETE
2. ALL ½" INSERTS SHALL BE MADE FROM PLASTIC AND SHALL WITHSTAND A MINIMUM PULL-OUT LOAD OF 150LBS/INSERT, AND A MINIMUM SHEAR LOAD OF 300LBS/INSERT.
3. ALL PULL IRONS ON END WALLS AND FLOORS SHALL BE DESIGNED AND SO PLACED AS TO WITHSTAND A WORKING LOAD OF 20,000 LBS.
4. ALL PULL IRONS ON SIDEWALLS SHALL BE DESIGNED AND SO PLACED AS TO WITHSTAND A WORKING LOAD OF 10,000 LBS.
5. LADDER AND HANGING HARDWARE TO BE INSTALLED WITH VAULT. USE PREINSTALLED INSERTS FOR LADDER AND UNISTRUT UNSTALLATION.
6. STRUT AND BOLT INSTALLATION SHALL WITHSTAND A MINIMUM SHEAR LOAD OF 300 LBS/LF AND A PULL-OUT LOAD OF 150 LBS PER BOLT. MAXIMUM SPACING REQUIRED IS 16" O.C. AND 3" FROM EACH END OF STRUT.
7. ALL 2-1/2" FLOOR KNOCKOUTS SHALL HAVE CAST-IN WATER TIGHT DOUBLE MEMBRANE PLASTIC PLUGS.
8. DO NOT REMOVE ANY FLOOR KNOCKOUT.
9. VAULT SHALL BE REJECTED IF ANY PORTION OF KEYWAY, 12" OR LONGER IS MISSING OR DAMAGED.
10. THE LADDER LENGTH SHALL BE DESIGNED TO ACCOMMODATE FOR THE HEIGHT OF NECK RINGS AS REQUIRED IN THE FIELD.
11. VAULT SHALL BE SET ON 12" THICK CONCRETE PAD TO PREVENT SETTLEMENT.

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-	-	ISSUED FOR

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PROJECT NUMBER	10095843

BLACK HILLS ENERGY

115KV TRANSMISSION LINE

TRANSMISSION MANHOLE DETAIL

0 1" 2"

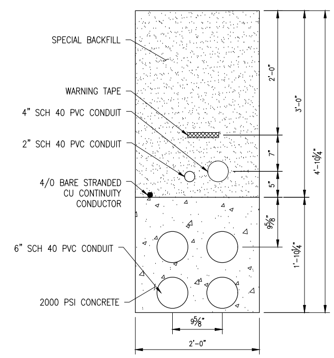
FILENAME MH-01.dwg
SCALE AS SHOWN
SHEET **MH-01**

LEGEND

A–PHASE CABLE DUCT
B–PHASE CABLE DUCT
C–PHASE CABLE DUCT
A'–PHASE SPARE DUCT
B'–PHASE SPARE DUCT
C'–PHASE SPARE DUCT

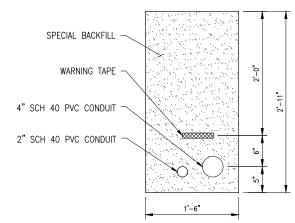
NOTES:

1. CONCRETE SHALL BE DYED RED
2. BACKFILL SHALL BE DYED RED
3. CONDUITS LABELED A', B', C' ARE SPARE DUCTS



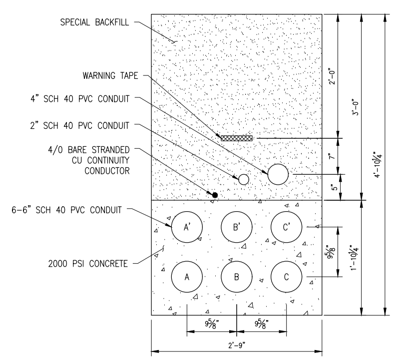
SINGLE CIRCUIT
SCALE: 1"=1'-0"

STANDARD CROSS SECTION



SECTION I–I
SCALE: 1"=1'-0"

FIBER OPTIC SECTION



DOUBLE CIRCUIT
SCALE: 1"=1'-0"

TRANSITION SECTION PRIOR TO D–D SECTION

ISSUE	DATE	DESCRIPTION
-	-	ISSUED FOR

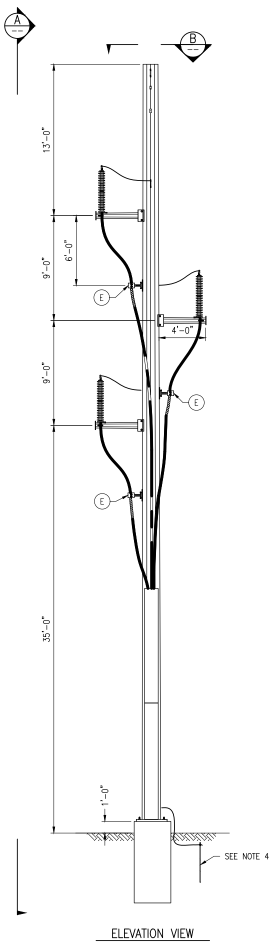
PROJECT MANAGER	J. ELLSWORTH
PROJECT ENGINEER	V. CURCI
DESIGNER	J. JUSTICE
CAD TECHNICIAN	D. HEPPNER
PROJECT NUMBER	10095843

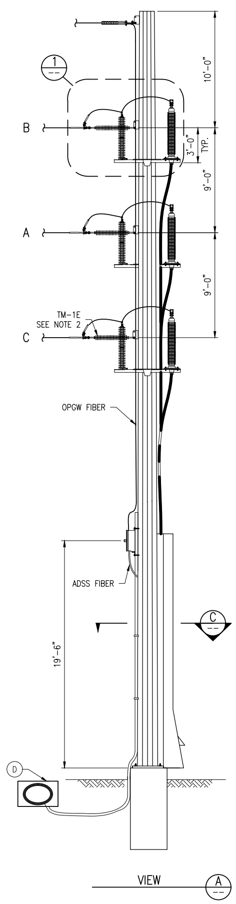
BLACK HILLS ENERGY

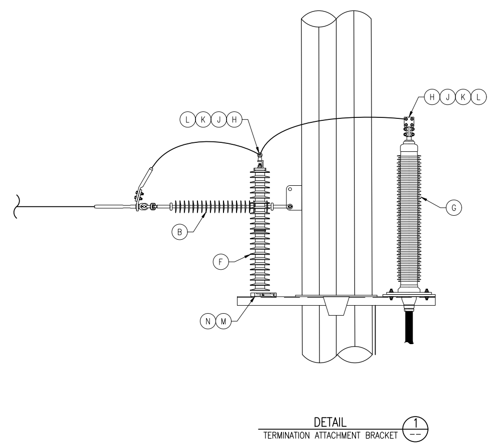
115KV TRANSMISSION LINE

DUCT BANK DETAILS

FILENAME: PP-03.dwg
SCALE: AS SHOWN
SHEET: PP-03





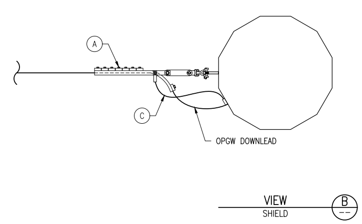


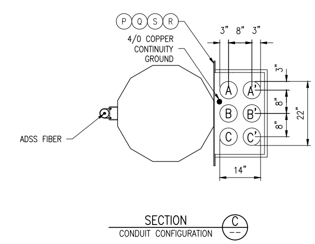
TSS-5A-OH LIST OF MATERIALS				
DWG. REF.	REQ.	DESCRIPTION	ITEM	CLIENT NO.
A	1	OPGW ASSEMBLY, DEADEND	TM-4EE	
B	3	INSULATOR ASSEMBLY, DEADEND	TM-1E	
C	1	OPGW GROUNDING ASSEMBLY	TM-9TF	
D	1	OPGW TERMINATION	TL-OT-1S & HO-1 & FD-02-1S	
E	3	CONDUIT RISER GRIP, SINGLE WEAVE, CLOSED MESH	M803	
F	3	ARRESTER, POLYMER, STATION CLASS, 90KV, 70 MCOV, NEMA 4-BOLT PAD	R404	
G	3	CONDUCTOR TERMINATION, 115KV, 2000KCMIL	M804	
H	6	TERMINAL, BOLTED ALUMINUM, CABLE TO FLAT, 715 TO 1113 ACSR	M408	
J	24	BOLT, HEX, 1/2" X 2" ALUMINUM	B750	
K	48	WASHER, FLAT, ALUMINUM, 1/2" BOLT	W412	
L	24	NUT HEX, 1/2", ALUMINUM	N505	
M	12	BOLT, MACHINE, 1/2" X 2 1/2"	B251	
N	24	WASHER, ROUND, 2" X 1/4", 9/16" HOLE	W404	
P	40	BOLT, MACHINE, 5/8" X 3"	B2503	
Q	40	NUT, SQUARE, 5/8"	N105	
R	80	WASHER, SQUARE, 2" X 1/4", 11/16" HOLE	W304	
S	40	NUT, LOCK, MF TYPE, 5/8"	N405	

NOTES:

1. SEE DWG. AD-02 FOR OVERHEAD GROUND WIRE DETAILS. REFERENCE THE PLAN & PROFILE DRAWINGS AND THE STAKING SHEETS FOR REQUIRED DEADEND ASSEMBLY AT EACH STRUCTURE.
2. SEE DWG. AD-01 FOR THE TM-1E TRANSMISSION DEADEND DETAILS. REFERENCE THE PLAN & PROFILE DRAWINGS AND THE STAKING SHEETS FOR REQUIRED DEADEND ASSEMBLIES AT EACH STRUCTURE.
3. PHASES CALLED OUT WITH " ' " IE. A' ARE FOR FUTURE CONDUITS.
4. SEE DWG. AD-02, DETAIL TM-9ST-OH FOR 4/0 GROUNDING ASSEMBLY.
5. SEE DWG. AD-02, DETAIL TM-9ST FOR POLE GROUNDING.

STR #	HEIGHT
1	70'-0"
34	80'-0"





Black Hills Corporation

HDR

-	-	ISSUED FOR
ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	J. ELLSWORTH
PROJECT ENGINEER	V. CURCI
DESIGNER	J. JUSTICE
CAD TECHNICIAN	D. HEPPNER
PROJECT NUMBER	10095843

BLACK HILLS ENERGY

115KV TRANSMISSION LINE

STRUCTURE DETAILS
TSS-5A-OH

FILENAME SD-01.DWG
SCALE NONE

SHEET SD-01

115 KV Underground Cost Estimate for Single Circuit

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BLACK HILLS ENERGY - 115 KV UNDERGROUND COST ESTIMATE FOR SINGLE CIRCUIT

INPUT DATA		
Enter Line Length in Miles	3.00	Miles
Calculted Line Length in Feet	15840	Feet

Black Hills Energy - One 115-kV Underground Transmission Circuit in Single Trench
Cable: 2500 kcmil Cu XLPE Insulated — 1 Number of Circuits
3 Cables - 1 Cables/Phase — 1 Number of Duct Banks
Current Capacity: 1376 Amps — 1 Number of Comm Ducts
Length Circuit 1: Variable Feet — 1 Number of ECC Conduits
Length Circuit 2: - Feet
Trench Length: 5280 Feet

Prepared by: V.Curci
Date: Nov 1 2018
Checked by: Ted Nishioka
Date:

Description	Quantity	Material Price	Total Material Price	Labor & Equipment Price	Total Labor Price	Total Price
Cable and Accessories Section:						
Cable, 2,500 Kcmil CU, XLPE, per foot	50,900	$ 50	$ 2,545,000	$ 10	$ 509,000	$ 3,054,000
Terminators, each	6	$ 10,000	$ 60,000	$ 15,000	$ 90,000	$ 150,000
Splices, each	27	$ 8,000	$ 216,000	$ 15,000	$ 405,000	$ 621,000
Terminal Poles	2	$ 52,000	$ 104,000	$ 26,000	$ 52,000	$ 156,000
Support rack, for potheads, Ea	0	$ 10,000	$ -	$ 10,000	$ -	$ -
Hardware kit, cable and joint supports, each	27	$ 4,000	$ 108,000	$ 5,000	$ 135,000	$ 243,000
Grounding system for vaults (splice pit) , each	27	$ 4,000	$ 108,000	$ 5,000	$ 135,000	$ 243,000
Grounding system for structures, (link boxes) each	2	$ 4,000	$ 8,000	$ 5,000	$ 10,000	$ 18,000
Cable clamps, each	810	$ 150	$ 121,500	$ 10	$ 8,100	$ 129,600
Continuity conductor, per foot	17,200	$ 2	$ 34,400	$ 3	$ 51,600	$ 86,000
Cable, Spare, 2,500 Kcmil CU, XLPE, per foot	5,400	$ 50	$ 270,000	$ -	$ -	$ 270,000
Terminators, Spare, each	1	$ 10,000	$ 10,000	$ -	$ -	$ 10,000
Splices, Spare, each	1	$ 8,000	$ 8,000	$ -	$ -	$ 8,000
Bonding cables, per foot	5,800	$ 5	$ 29,000	$ 5	$ 29,000	$ 58,000
Subtotal - Cable System			**$ 3,621,900**		**$ 1,424,700**	**$ 5,046,600**
Communication System:						
Fiber-optic cable, per foot	17,200	$ 3	$ 43,000	$ 5	$ 86,000	$ 129,000
Fiber-optic cable splices, each	27	$ 1,000	$ 27,000	$ 5,000	$ 135,000	$ 162,000
Handholes, each	27	$ 2,000	$ 54,000	$ 2,000	$ 54,000	$ 108,000
Subtotal - Communication System			**$ 124,000**		**$ 275,000**	**$ 399,000**
Temperature Monitoring System:						
Fiber-optic cable, per foot	0	$ 4	$ -	$ 4	$ -	$ -
Fiber-optic cable splices (incl. Enclosures), each	0	$ 4,000	$ -	$ 3,000	$ -	$ -
Terminal equipment, each	0	$ 4,000	$ -	$ 3,000	$ -	$ -
Subtotal - Temperature Monitoring System			**$ -**		**$ -**	**$ -**
Duct Bank and Earthwork:						
Conduit, per foot, 6" PVC	50,900	$ 2.5	$ 127,250	$ -	$ -	$ 127,250

Earth Continuity conduit (ECC) , per foot, 2" PVC	17,200	$ 1.0	$ 17,200	$ -	$ -	$ 17,200
Communication conduit, 2" PVC	17,200	$ 1	$ 17,200	$ -	$ -	$ 17,200
TM conduit, per foot	0	$ 3	$ -	$ -	$ -	$ -
Conduit spacers, each	3,500	$ 5	$ 17,500	$ 3	$ 10,500	$ 28,000
Excavation and Duct Bank Installation, per foot	15,840	$ -	$ -	$ 50	$ 792,000	$ 792,000
Duct encasement concrete, per cubic yard	1,800	$ 120	$ 216,000	$ 10	$ 18,000	$ 234,000
Fluidized Thermal Backfill, including hauling, per cubic yard	3,600	$ 120	$ 432,000	$ 10	$ 36,000	$ 468,000
Soil backfill, including hauling, per cubic yard	0	$ 50	$ -	$ -	$ -	$ -
Manholes, each	9	$ 30,000	$ 270,000	$ 20,000	$ 180,000	$ 450,000
1" steel plating, per foot	0	$ 25	$ -	$ 25	$ -	$ -
Sheeting and shoring, per foot	0	$ 25	$ -	$ 30	$ -	$ -
JACK AND BORE						
Jack and bore, per foot	0	$ 750	$ -	$ 550	$ -	$ -
Casing, per foot	0					
Bore spacer, each	0	$ 275	$ -	$ 50	$ -	$ -
Bore grouting, per cubic yard	0	$ 200	$ -	$ 150	$ -	$ -
HORIZONTAL DIRECTIONAL DRILLING						
HDD, 24" Bore, per foot	0	$ -	$ -	$ 500	$ -	$ -
Casing, steel, 18"	0	$ 30	$ -	$ -	$ -	$ -
Bore spacer, each	0	$ 275	$ -	$ -	$ -	$ -
Bore grouting, per cubic yard	0	$ 150	$ -	$ 10	$ -	$ -
RESTORATION						
Pavement repair, per square foot	0	$ 20	$ -	$ 20	$ -	$ -
Curb repair, per square foot	0	$ 25	$ -	$ 5	$ -	$ -
Sidewalk repair, per square foot	0	$ 25	$ -	$ 15	$ -	$ -
Landscape restoration, per square foot	0	$ 3	$ -	$ 3	$ -	$ -
Loam and seed, per square foot	0	$ 0	$ -	$ 0	$ -	$ -
TRAFFIC CONTROL						
Traffic control	0.0%	$ -	$ -	$ -	$ -	$ -
MOB AND DEMOB						
Mobilization, each (@ 2.0% of field work)	1.5%	$ -	$ 16,457		$ 15,548	$ 32,005
Demobilization, each (@ 2.0% of field work)	1.5%	$ -	$ 16,457		$ 15,548	$ 32,005
Subtotal - Duct Bank and Earth Work			**$ 1,130,065**		**$ 1,067,595**	**$ 2,197,660**
Subtotal			***$ 4,875,965***		***$ 2,767,295***	***$ 7,643,260***
Commissioning Testing						
Conductor Resistance Tests, Ea	0	$ -	$ -	$ 500	$ -	$ -
Insulation Resistance and Capacitance, Ea	0	$ -	$ -	$ 500	$ -	$ -
Jacket integrity test, Ea	12	$ -	$ -	$ 500	$ 6,000	$ 6,000
High Voltage Time Test, Ea	0	$ -	$ -	$ -	$ -	$ -
PD Testing, Lot	1	$ -	$ -	$ 15,000	$ 15,000	$ 15,000
24-Hours Soak Test, Ea	1	$ -	$ -	$ -	$ -	$ -
Subtotal - Commissioning Testing			**$ -**		**$ 21,000**	**$ 21,000**
Engineering Tasks						
Internal Engineering, lot	0.0%		$ -		$ -	$ -
Survey	1.0%		$ -		$ 76,433	$ 76,433
Geotechnical	1.0%		$ -		$ 76,433	$ 76,433
Gehthermal	1.0%		$ -		$ 76,433	$ 76,433
Engineering	4.0%		$ -		$ 305,730	$ 305,730
Project Management and Coordination and Accounting	1.0%		$ -		$ 76,433	$ 76,433
Construction Management	3.0%		$ -		$ 229,298	$ 229,298

Subtotal - Engineering, Project & Construction Management			**$ -**		**$ 840,759**	**$ 840,759**
Unallocated Costs:						
Hard Dollar Overheads: Escalation						
Hard Dollar Overheads: AFUDC						
Subtotal - Unallocated Costs			**$ -**		**$ -**	**$ -**
Contingency						
Contingency	10%		$ 487,596		$ 276,729.50	$ 764,326
			$ -			$ -
Subtotal - Contingency			**$ 487,596**		**$ 276,730**	**$ 764,326**
TOTAL	**$**		***$ 5,363,561***	***$***	***$ 3,905,783***	***$ 9,269,344***

Description	Quantity	Unit Cost per Foot (Material Price)	Cost Based Material	Unit Cost per Foot (Labor & Equipment)	Cost Based on Labor and Equipment	Total Price / Foot
Cost Breakdown and Per Foot						
Subtotal - Cable System	15,840	$ 229	$ 3,621,900	$ 90	$ 1,424,700	$ 319
Subtotal - Communication System	15,840	$ 8	$ 124,000	$ 17	$ 275,000	$ 25
Subtotal - Temperature Monitoring System	15,840	$ -	$ -	$ -	$ -	$ -
Subtotal - Duct Bank and Earth Work	15,840	$ 71	$ 1,130,065	$ 67	$ 1,067,595	$ 139
Subtotal - Commissioning Testing	15,840	$ -	$ -	$ 1	$ 21,000	
Subtotal - Engineering	15,840	$ -	$ -	$ 53	$ 840,759	$ 53
Subtotal - Unallocated Costs	15,840	$ -	$ -	$ -	$ -	$ -
Subtotal - Contingency	15,840	$ 31	$ 487,596	$ 17	$ 276,730	$ 48
Totals	**15,840**	**$ 339**	**$ 5,363,561**	**$ 247**	**$ 3,905,783**	**$ 585**

EQUIVQALENT COST PER FOOT		**$ 339**	**$ -**	**$ 247**	**$ -**	**$ 585**

Description	Quantity	Percent of Total Cost (Material Price)	Cost Based Material	Percent of Total Cost (Labor & Equipment)	Cost Based on Labor and Equipment	Percent of Total Cost (Material and Labor)
Cost Breakdown and Percent Cost						
Subtotal - Cable System	15,840	39.1	$ 3,621,900	15.4	$ 1,424,700	54.4
Subtotal - Communication System	15,840	1.3	$ 124,000	3.0	$ 275,000	4.3
Subtotal - Temperature Monitoring System	15,840	-	$ -	-	$ -	-
Subtotal - Duct Bank and Earth Work	15,840	12.2	$ 1,130,065	11.5	$ 1,067,595	23.7
Subtotal - Commissioning Testing	15,840	-	$ -	0.2	$ 21,000	0.2
Subtotal - Engineering	15,840	-	$ -	9.1	$ 840,759	9.1
Subtotal - Unallocated Costs	15,840	-	$ -	-	$ -	-
Subtotal - Contingency	15,840	5.3	$ 487,596	3.0	$ 276,730	8.2
Totals	**15,840**	**57.9**	**$ 5,363,561**	**42.1**	**$ 3,905,783**	**100.0**

BLACK HILLS ENERGY - 115 KV UNDERGROUND COST ESTIMATE FOR SINGLE CIRCUIT

COST SUMMARY TABLES

Description	Material	Labor	Total
Subtotal - Cable System	$ 3,622,000	$ 1,424,700	$ 5,046,700
Subtotal - Communication System	$ 124,000	$ 275,000	$ 399,000
Subtotal - Temperature Monitoring System	$ -	$ -	$ -
Subtotal - Duct Bank and Earth Work	$ 1,130,065	$ 1,067,595	$ 2,197,660
Subtotal - Commissioning Testing	$ -	$ 21,000	$ 21,000
Subtotal - Engineering, Project & Construction Management	$ -	$ 840,759	$ 840,759
Subtotal - Contingency	$ 487,596	$ 276,730	$ 764,326
Totals	***$ 5,363,561***	***$ 3,905,783***	***$ 9,269,344***

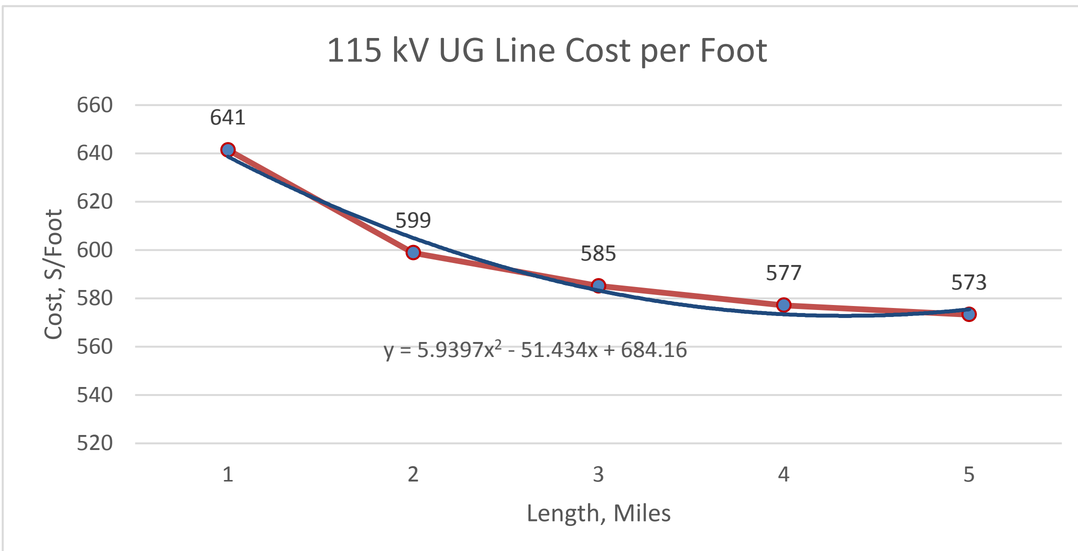
Description	Material	Labor	Total
Subtotal - Cable System	$ 3,622,000	$ 1,425,000	$ 5,047,000
Subtotal - Communication System	$ 124,000	$ 275,000	$ 399,000
Subtotal - Temperature Monitoring System	$ -	$ -	$ -
Subtotal - Duct Bank and Earth Work	$ 1,130,000	$ 1,068,000	$ 2,198,000
Subtotal - Commissioning Testing	$ -	$ 21,000	$ 21,000
Subtotal - Engineering, Project & Construction Management	$ -	$ 841,000	$ 841,000
Subtotal - Contingency	$ 488,000	$ 277,000	$ 764,000
Totals	***$ 5,364,000***	***$ 3,906,000***	***$ 9,269,000***

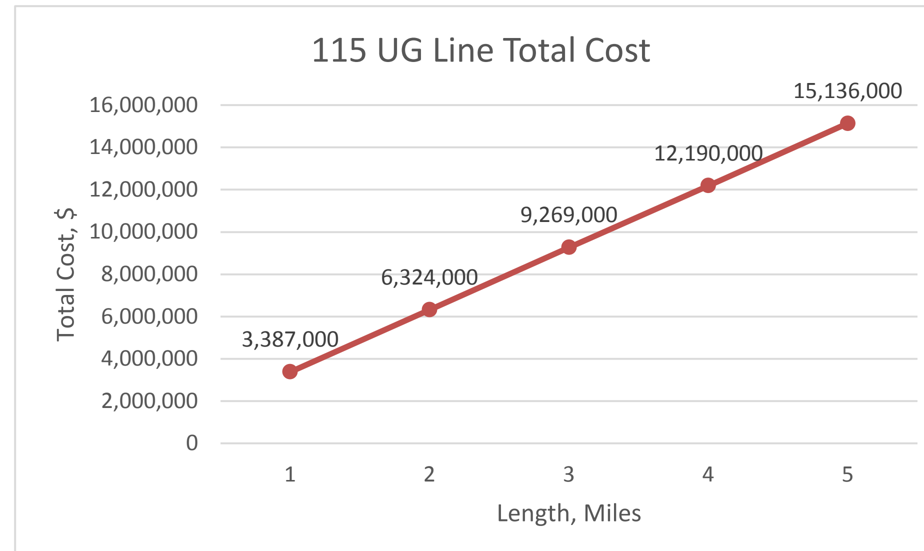
SUMMARY	Cost
Material	$ 4,876,000
Labor	$ 2,768,000
Testing	$ 21,000
Engineering, Project & Construction Management	$ 841,000
Contingency	$ 764,000
TOTAL	*$ 9,270,000*

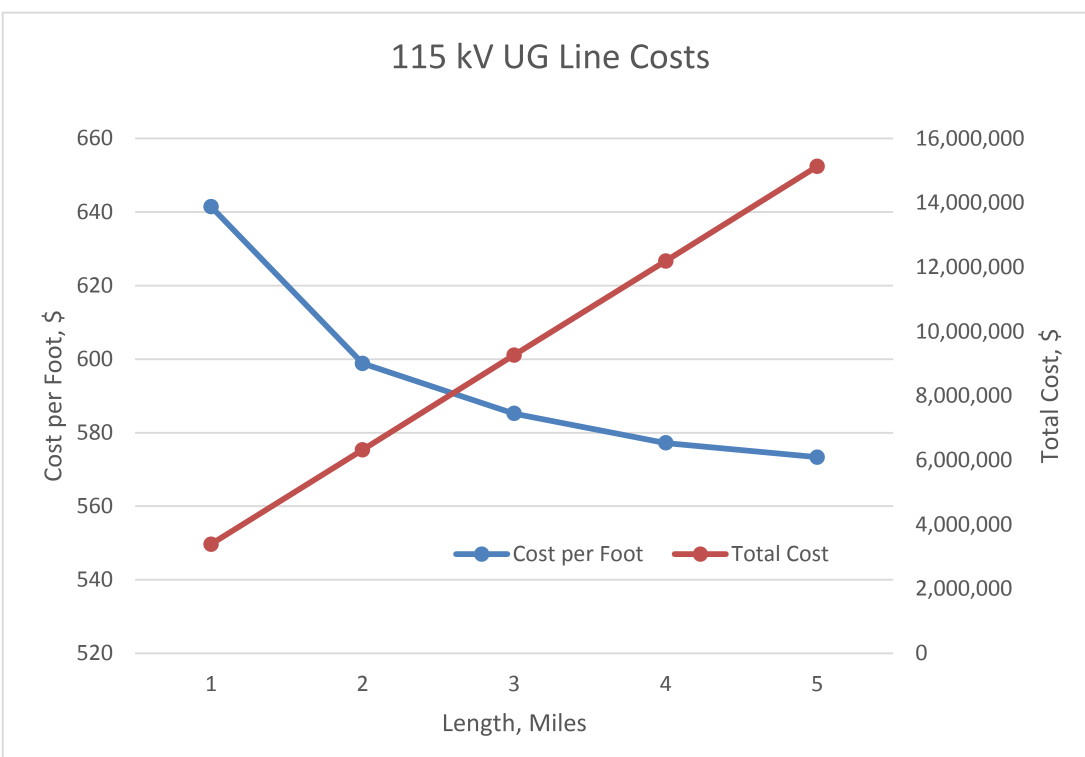
NERGY - 115 KV UNDERGROUND COST ESTIMATE FOR SINGLE CIRCUIT

' OF UNDERGROUND LINE PER FOOT

1	2	3	4	5
641	599	585	577	573
3,387,000	6,324,000	9,269,000	12,190,000	15,136,000







Attachment 3-1

Summary of Studies on Property Values Conducted Over the Past 50 Years by Earley & Associates (December 2019)

MARKET DATA STUDIES

HVTL POWER LINES
UNDERGROUND NATURAL GAS FACILITES
NATURAL GAS COMPRESSOR STATIONS
ELECTRICAL SUBSTATIONS

SUMMARY OF STUDIES ON PROPERTY VALUES CONDUCTED
OVER THE PAST 50 YEARS BY EARLEY & ASSOCIATES

Prepared by
Michael H. Earley, MAI, SRA
Certified General Appraiser – State of Colorado
27911 Alabraska Lane
Evergreen, CO 80439
(303)917-2558 cell/office

EARLEY and ASSOCIATES *Michael H. Earley, MAI, SRA*
Real Estate Appraisals and Consulting
Earley Executive Plaza, Suite B
27911 Alabraska Lane
Evergreen, Colorado 80439

December 14, 2019

Black Hills Energy
c/o Cristin Cochran, Contract Agent
C^2 Consulting
799 Dahlia Street, Unit #7A
Denver, Colorado 80220-5199

RE: Summary of market data studies conducted by Earley and Associates.

Dear Ms. Cochran:

In accordance with your request, I have included, as an attachment with this letter, a tabulation of all the market data studies that have been prepared specifically by Earley & Associates, Michael H. Earley, MAI, SRA, over the past 50 years in numerous areas of Colorado and portions of North Carolina. This table includes a complete history of the studies that have been conducted over the years, including market data studies on HVTLs, high voltage transmission lines, that ranged in size from 115kv to 500kv, underground natural gas pipelines, above ground natural gas compressor stations and electrical substations.

The studies included in the table consist of 56 HVTL, high voltage transmission line, areas in Colorado, 2 HVTL studies in North Carolina, 2 electrical substation studies, consisting of 9 different substation site locations, 2 underground natural gas pipeline study areas and 2 natural gas compressor station site facility areas. The market data studies on the natural gas pipelines, natural gas compressor stations and electrical substations are specifically identified in the "General" column of the table and are underlined, with all of the remaining studies consisting of market data analysis on HVTLs, high voltage transmission lines, only.

As noted in the subtotals toward the bottom end of the table pages, approximately 8,228 sales were analyzed in the Colorado studies on various power lines over 20 different county locations. Over the numerous years of studying the impact of electrical power lines on property values, various methods of analysis has been considered in estimating the differences between a property with a power line or having a view of a power line in contrast to similar properties in the same area that did not have easements for power lines, were not in close proximity to power lines and/or did not have views of the power line. The various methods included primarily paired sales analysis, simple descriptive statistical measurements (mean, median, minimum, maximum), appreciation rate paired sales and multiple regression analysis.

In arriving at the final conclusions for all of the studies, primary reliance was placed on the results indicated by the paired sales analysis, the simple descriptive statistical measurements and the appreciation rate paired sales methods. Although regression analysis was considered and the output in some instances, where there was a sufficient quantity of sales, results in equations that appeared to predict reasonable overall sale prices that were consistent with market data. However, in contrast, attempting to use the regression coefficient estimated for the power line variable as an indication of the effect on property value was not consistent with actual market data such as the paired sales and was disregard from any consideration in the final conclusions.

In a paired sales analysis, the perfect comparison would be two properties that sold at the same time and are in a similar relative location, with the only primary difference being the presence of a HVTL, high voltage transmission line, on one sale and the other sale with no line or impacted view. Unfortunately, the typical real estate market does not function in this form and the paired sales can have multiple variations that the appraiser may have to consider. In the studies that have been completed over the past years by Michael H. Earley, MAI, SRA, the paired sales application has been performed by pairing sales with and without power lines that are as similar as possible, with maybe one or two other minor variations that would require minimal adjustments. In some instances, the pairs were similar enough that no market adjustments were necessary for comparison purposes and the results of the comparison between the pairs were considered to be a good market test in determining if a property is adversely impacted by a power line.

The paired sales analysis described above can provide a visual observation of the prices paid for similar properties, with and without power lines, and an observation of the units of comparison, such as the overall price per square foot of improvement area that can be a basis for a conclusion regarding power lines and property values. In addition, the paired sales were processed graphically, using line and/or bar charts for further visual observation of the sale prices and/or unit of comparison between properties with and without power lines.

Simple descriptive statistical measurements were applied to the sales to determine trends in reference to the mean and/or median of the sale prices and the units of comparison, price per square foot of improvements for improved residential property, price per square foot of small vacant home sites and price per acre for larger properties that are typically sold on these bases, for properties with and without power lines. The mean and median measurements of the sale prices and/or units of comparison for properties with power lines are compared to the mean and median measurements for similar properties without power lines to determine if there is a market impact on value.

Another method of comparison applied in analyzing sales with and without power lines is calculating the appreciation rates of properties that have sold and resold, with no major changes in the properties between the sale and resale, and comparing these rates of change with similar properties in the area that have sold and resold. As an example, a property with a power line sells in 2015 and the same property resells in 2019, with no significant changes to the land and/or improvements, with a calculation of the rate of change between these two sale dates. Another relatively similar property, that does not have a power line, sells and resells in the same time periods, with no major changes in the land and/or improvements and the rate of change is determined for this sale and resale. The rate of change between the property with the power line and the rate of change for the property that did not have a power line can be compared to determine if the properties increased at a similar rate over time or if the property with the power line reflected a rate of change that is significantly different than the property without a power line. Regardless of whether the property with the power line sold at a price below, equal to or above a similar property without a power line over the time frame in the example, the rates of change are compared to determine if there is a market impact in the rate of change, based on the respective investment chosen by the buyers and/or sellers.

All three methods considered above in the analysis of the market data reflected measurements that were positive, negative or equal in the individual pairings and appreciation rate pairings. This is considered to be a result of the real estate market that is not perfect and is not subject to exact numerical or scientific measurement, due to the desires, emotions and other factors that are typical considerations on the part of buyers and sellers, which is why not all of the comparison are strictly positive, negative or equal. Taking this into consideration, the final step in the analysis of the comparisons and/or measurements by the paired sales and appreciation rates is observing the overall cumulative results of these measurements to determine if an impact exists in the market.

In summary, the respective studies that have been completed on HVTL, high voltage transmission lines, over the past 50 years by Earley & Associates, have generally indicated that there is no significantly measurable market impact in the sale price of properties with power lines as compared to similar properties without power lines.

Respectfully submitted,

Michael H. Earley, MAI, SRA
Designated Member of the Appraisal Institute
#CGO1313447, Certified General Appraiser
State of Colorado

MICHAEL H. EARLEY, MAI, SRA

ELECTRICAL TRANSMISSION LINE STUDIES/NATURAL GAS STUDIES/ELEC SUBSTATION STUDIES
Report Index Summary

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
1	Rural residential home sites, 40 ac+	30 miles E of Colo Springs, N of Ellicott	1972-1973 (6 sales)	39-360 ac	n/a	El Paso/ CO
2	Platted sites, potential comm. dev, interchange sites	Interstate 25 and Baseline Road	1967-1971 (7 sales)	5.00-5.11 ac	n/a	Adams Weld/ CO
3	Investment sites, potential res dev	100th Ave and Eldridge	1968 (2 sales)	40-80 ac	n/a	Jefferson/ CO
4	Ranch lands, w/rec dev potential	Midway between Gunnison/Crested Butte	1970-1972 (4 sales)	1,243.54-3,160 ac	n/a	Gunnison/ CO
5	Ranch lands, w/res & rec potential	Yampa River Valley, between Phippsburg and Toponas	1970-1975 (28 sales)	80-5,170 ac	n/a	Routt/ CO
6	Rural/res home sites, 35-40 ac	W/fringe Longmont area	1982-1985 (3 sales)	35-44.83 ac	n/a	Boulder/ CO
7	Mixed res (sfr, mf), dev lands	NW quad, Longmont area	1982-1983 (4 sales)	11.59-83.03 ac	n/a	Boulder/ CO
8	Farmland w/potential toward MU dev	NE edge Longmont area	1983-1985 (3 sales)	47.98-158.65 ac	n/a	Boulder/ CO
9	Farmland, w/potential toward MU dev	NE edge Longmont area	1984 (3 sales)	78.80-135.10 ac	n/a	Boulder/ CO
10	MU dev land & impr res	Buckley Rd/Orchard Rd, Hills at Piney Creek Sub	1983-1984 (7 sales)	42-217 lots	n/a	Arapahoe/ CO
11	Impr Apt complex properties	N area of Longmont	1983-1984 (4 sales)	n/a	4 units each Apartment	Boulder/ CO
12	SFR impr properties	Woodland Valley Sub	1968-1973 (155 sales)	small lot subdivision (0.15-0.33ac)	1,029-2,347 sq. ft.	Jefferson/ CO

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
13	Ranchlands w/potential for rec dev	Granby/ Kremmling area	1984-1986 (4 sales)	955-1,898 ac	n/a	Grand/ CO
14	Ranchlands w/potential for res/rec dev	Kremmling area	1984-1985 (3 sales)	1,826-2,734 ac	n/a	Grand/ CO
15	Lake Toxaway/Glen Cannon, res/golf course subdivisions (over 300 sales in the original research)	Brevard area of western North Carolina, condos, impr SFR, home sites	Condos 1983-1987 SFR 1984-1987 SFR2 1984-1987 Home sites 1984-1987 Home sites2 1984-1987 (110 sales)	 0.61-4.59 ac 0.69-4.59 ac	1,152-1,728 sq. ft. 1,600-2,969 sq. ft. 1,920-2,478 sq. ft. n/a n/a	Transylvania/ North Carolina
16	Rural res/rec properties	Divide area of Teller County	1986-1992 (6 sales) 1987-1992 (3 sales) 1990-1992 (6 sales) 1992 (6 sales)	8.15-10.22 ac 62.77-76.25 ac 5.08-6.74 ac 0.57-1.08 ac	n/a n/a n/a n/a	Teller/ CO
17	Rural res/rec properties	S of Buena Vista Highland Estates Mesa Antero North Cottonwood West Range Sub Pinon Acres	1990-1992 (11 sales) 1991-1992 (4 sales) 1990-1992 (46 sales) 1990-1992 (9 sales) 1990-1992 (11 sales) 1990-1992 (7 sales)	12.58-200 ac 35.11-106.15 ac 2.38-45.38 ac 1.66-4.73 ac 4.36-4.79 ac 2.13-4.79 ac	n/a n/a n/a n/a n/a n/a	Chaffee/ CO
18	Suburban res/rec home sites	Grand West Estates	1991-1993 (14 sales)	5.00-12.97 ac	n/a	Lake/ CO
19	Rural ranch land properties	Yampa Valley area	1990-1992 (2 sales)	974-1,287.50 ac	n/a	Routt/ CO

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
20	Rural res/rec properties	Between Gunnison & Crested Butte Ohio Meadows	1987-1992 (9 sales) 1990-1992 (15 sales)	35-4,145.41 ac 2.28-9.17 ac	n/a n/a	Gunnison/ CO
21	Suburban impr res properties (over 200 sales)	N. Table Mtn, Trails, Creekside, Canyon Point, The Orchard	1991-1995 (199 sales)	Small lot subdivisions (+/-0.25 ac)	1,236-3,285 sq. ft.	Jefferson/ CO
22	Suburban impr res properties (over 600 sales)	Meadow Hills, Smoky Hills	1990-1995 (660 sales)	Small lot subdivisions (+/-0.25 ac)	964-3,765 sq. ft.	Arapahoe/ CO
23	UPDATED -Lake Toxaway/Glen Cannon, res/golf course subdivisions (over 700 sales, plus prior sales in original study)	Brevard area of western North Carolina, condos, impr SFR, home sites	Condos 1987-1995 SFR 1987-1995 SFR2 1987-1995 Home sites 1987-1995 Home sites2 1987-1995 (935 sales total)	 0.61-4.59 ac 0.69-4.59 ac	1,152-1,728 sq. ft. 1,600-2,969 sq. ft. 1,920-2,478 sq. ft. n/a n/a	Transylvania/ North Carolina
24	Rural res home sites and impr lots	Cantebury West and East	1990-2002 (98 sales) 1990-2003 (127 sales)	4.83-5.71 ac n/a	n/a 1,050-3,907 sq. ft.	El Paso/ CO
25	Suburban res impr lots	Greenfield #2 Subdivision	1995-2002 (62 sales)	0.25-0.33 ac	2,586-3,563 sq. ft.	Arapahoe/ CO
26	Suburban res impr lots	Hills at Piney Creek	1985-2002 (55 sales)	0.15-0.25 ac	2,174-3,292 sq. ft.	Arapahoe/ CO
27	Suburban res vac/impr lots	Lazy Hills/Cherry Creek East	1993-2001 (8 sales)	2.50-5.00 ac	3,297-5,794 sq. ft.	Arapahoe/ CO
28	Suburban res impr lots	Founders Village	1986-2002 (12 sales)	0.15-0.33 ac	1,269-2,497 sq. ft.	Douglas/ CO
29	Suburban res impr lots	Sierra Vista Subdivision	1991-2001 (25 sales)	n/a	2,002-4,496 sq. ft.	Douglas/ CO
30	Rural res home sites	Spring Park Meadows	1997-2002 (15 sales)	35.07-52.08 ac	n/a	Eagle/ CO
31	Rural res home sites	Grass Mesa Subdivision	1995-1998 (10 sales)	35.16-48.33 ac	n/a	Garfield/ CO
32	Suburban res home sites	Evans Ranch Subdivison	1994-1996 (30 sales)	35.07-37.29 ac	n/a	Douglas/ C0

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
33	Suburban res home sites	Sterling Tree Farm Sub	1995-2000 (40 sales)	5.00-18.80 ac	n/a	Douglas/ CO
34	Suburban res impr lots	Hutchinson Hills 1 & 2	1992-2001 (89 sales)	n/a	1,187-2,719 sq. ft.	Denver/ CO
35	Rural res home sites	Sopris Mesa Subdivision Silverado Town Homes	1999-2001 (25 sales) 1997-2001 (20 sales)	+/- 0.50-1.00 ac n/a	n/a 1,244-1,618 sq. ft.	Eagle/ CO
36	Apartments	37 total complexes 19 apts complexes w/line 18 apts complexes w/o line	1992-2000 sales time frame (6 sales w/line, 6 sales w/o line) remainder analyzed by rent, PGRMs	n/a	68-564 units per complex 1,2 &3 bdrms 763-937 sq. ft.	Douglas, Jefferson, Arapahoe, Adams/ CO
37	Suburban res vac/impr home sites	Line upgrade w/underbuild added	1992-2004 (1,109 sales)	0.14-207.32 ac	432-4,578 sq. ft.	Ashe Co, Watauga Co/ North Carolina
38	Rural res home sites, proximity to natural gas plant facilities	Metes and bounds parcels	1999-2001 (10 sales)	60.89-80.29 ac	n/a	Weld/ CO
39	Suburban res vac/impr home sites, proximity to natural gas pipeline	Basalt to Brush Creek Rd, along Hwy 82	1986-2003 (25 sales) appr. rate analysis	1.50-45.00 ac	948-5,066 sq. ft.	Pitkin/ CO
40	Suburban res impr home sites, proximity to electrical substations	City of Glenwood Basalt, The Wilds Ralston sub Bancroft sub	1995-1997 (5 sales) 1997-1998 (14 sales) 1995-1998 (11 sales) 1995-1998 (30 sales)	n/a n/a n/a n/a	1,336-2,430 sq. ft. 1,401-2,567 sq. ft. 1,044-1,680 sq. ft. 812-2,066 sq. ft.	Garfield/CO Pitkin/CO Jefferson/ CO Jefferson/ CO

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
41	Rural res home sites	Brick Center Estates, S of Bennett	2005-2006 (11 sales)	35-38.55 ac	n/a	Arapahoe/ CO
42	Suburban res impr home sites	Saddleback Ridge Estates	2004 (2 sales)	2.00-2.47 ac	1,856-1,992 sq. ft.	Clear Creek/ CO
43	Suburban res impr home sites	Castle Pines area	1990-2003 (552 sales)	0.23-7.29 ac	1,799-4,582 sq. ft.	Douglas/ CO
44	Suburban res impr home sites, proximity to a natural gas pipeline	Brush Creek, Aspen	1981-1999 (61 sales)	1.15-45 ac	948-6,225 sq. ft.	Pitkin/CO
45	Vacant res home sites, proximity to natural gas compressor facility	Gilcrest, Ft. Lupton, Evans	1999-2001 (10 sales)	60.00-80.00 ac	n/a	Weld/ CO
46	Suburban res impr home sites	Rowley Downs, Parker	2011-2014 2000-2011 (42 sales) Appr rate pairs	0.21-0.34 ac	1,395-3,546 sq. ft.	Douglas/ CO
47	Suburban res impr home sites	Rowley Downs, Parker (1st update)	2014-2019 (82 sales)	0.21-0.31 ac	1,743-3,706 sq. ft.	Douglas/ CO
48	Suburban res impr home sites	Surrey Ridge, Parker	2011-2014 2000-2011 (17 sales) Appr rate pairs	1.32-5.23 ac	1,440-3,685 sq. ft.	Douglas/ CO
49	Suburban res impr home sites	Tallyns Reach, Parker	2012-2014 2001-2011 (380 sales) Appr rate pairs	0.12-1.33 ac	1,347-4,553 sq. ft.	Arapahoe/ CO

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
50	Suburban res impr home sites	Tallyns Reach, Parker (1st upadate	2014-2019 (459 sales)	0.11-1.33 ac	1,347-5,364 sq. ft.	Arapahoe/ CO
51	Suburban res impr home sites	Creekside at Eagles Bend, Parker	2011-2014 2002-2012 (36 sales) Appr rate pairs	0.23-0.32 ac	2,294-4,559 sq. ft.	Arapahoe/ CO
52	Suburban res impr home sites	Creekside at Eagles Bend, Parker (1st update)	2014-2019 (36 sales)	0.23-0.54 ac	2,297-4,687 sq. ft.	Arapahoe/ CO
53	Suburban res impr home sites	Villages at Parker, Parker	2012-2014 2000-2011 (561 sales) Appr rate pairs	0.09-0.51 ac	1,000-4,432 sq. ft.	Douglas/ CO
54	Suburban res impr home sites	Villages at Parker, Parker (1st update)	2014-2019 (556 sales)	0.10-1.55 ac	1,236-4,450 sq. ft.	Douglas/ CO
55	Suburban res impr home sites	Sorrel Ranch, Aurora	2011-2014 (94 sales)	0.12-0.23 ac	1,514-2,812 sq. ft.	Arapahoe/ CO
56	Suburban res impr home sites	Sorrel Ranch, Aurora (1st update)	2011-2016 (155 sales)	0.12-0.23 ac	1,514-3,017 sq. ft.	Arapahoe/ CO
57	Suburban res impr home sites	Sorrel Ranch, Aurora (2nd update)	2015-2019 (158 sales)	0.11-0.27 ac	1,512-3,431 sq. ft.	Arapahoe/ CO
58	Suburban res impr home sites	Maher Ranch, Castle Rock	2011-2014 (178 sales)	0.16-1.04 ac	2,174-7,189 sq. ft.	Douglas/ CO

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
59	Suburban res impr home sites	Tollgate Crossing, Aurora	2012-2014 2004-2012 (116 sales) Appr rate pairs	0.12-0.38 ac	1,260-3,267 sq. ft.	Arapahoe/ CO
60	Suburban res impr home sites	Tollgate Crossing, Aurora (1st update)	2014-2019 (473 sales)	0.12-0.36 ac	1,153-4,179 sq. ft.	Arapahoe/ CO
61	Suburban res impr home sites	Castle Pines, Castle Rock	2012-2014 2008-2012 (892 sales) Appr rate pairs	0.14-0.44 ac	1,624-6,163 sq. ft.	Douglas/ CO
62	Suburban res impr home sites	Green Valley, Castle Rock	2012-2014 2008-2010 (75 sales) Appr rate pairs	0.24-2.03 ac	2,709-7,475 sq. ft.	Douglas/ CO
63	Suburban res impr home sites, proximity to <u>electrical substations</u>	Smoky Hill sub, Aurora Soda Lakes sub, Lakewood Meadow Hills sub, Aurora Buckley sub, Aurora	2016-2019 (60 sales) 2016-2017 (23 sales) 2015-2017 (19 sales) 2016-2019 (26 sales)	0.10-0.26 ac 0.15-0.27 ac 0.09-0.31 ac 0.01-0.27 ac	1,914-4,132 sq. ft. 846-1,775 sq. ft. 1,576-1740 sq. ft. 1,469-2650 sq. ft.	Arapahoe/ CO Jefferson/ CO Arapahoe/ CO Arapahoe/ CO
63	Suburban res impr home sites	Founders Village, Castle Rock	2012-2014 2008-2013 (375 sales) Appr rate Pairs	0.09-0.53 ac	728-4,345 sq. ft.	Douglas/ CO
	Sub Totals	**HVTLs, CO**	56 studies 8,228 sales	0.09-5,170 ac	Vacant & Impr 728-7,475 sq. ft.	

		HVTLs, NC	2 studies 1,045 sales	0.14-207.32 ac	Vacant & Impr 432-4,578 sq. ft.	
		Natural gas pipelines, CO	2 studies 86 sales	1.15-45 ac	Impr 948-6,225 sq. ft.	
		Natural gas compressors, CO	2 studies 20 sales	60.00-80.29 ac	Vacant only	
		Electrical substation sites, CO	1 study, 5 locations, 2nd study, 4 locations 188 sales	0.01-0.31 ac	Vacant & Impr 846-4,132 sq. ft.	

ID	General	Location	Sale date range	Land size range	Impr size range	County/ State
	Totals		Over 9,567 sales studied	Range 0.01-5,170 ac	Range 728-7,475 sq. ft.	21 counties 2 states

QUALIFICATIONS OF MICHAEL H. EARLEY, MAI, SRA

Profession - Independent Fee Appraiser and Valuation Consultant

Education - Evergreen High School Graduate (1970)
University of Denver Graduate (1976, B.A. Mathematics)
Specialized Field of Study: DU, Real Estate (330hrs instruction) and computer applications
Appraisal Institute: 700 + hours of instruction and 20+hrs/yr Continuing Education from 1991 forward (560 hrs +)
Certification of Completion-Valuation of Conservation Easements

Publications - "The Effects of Overhead Transmission Lines on Property Values", pub. July, 1992, prepared by Dr. Cynthia A. Kroll, University of California at Berkeley Thomas Priestley, Ph.D. Transmission Line Study on property values, North Carolina (1988), for Duke Power Company

"Environmental Assessment for the Divide Transmission Loop Project", US Forest Service, Dept. of Agriculture, pub. May, 1994. Transmission Line Studies (1993), 7 counties, over 450 sales, State of Colorado, for Public Service

Professional Designations -
Appraisal Institute #7296 (MAI) 1985, Appraisal Institute, (SRA) 1980
Certified General Appraiser State of Colorado #CG01313447 (1991)
Jefferson County Board of Realtors, member #01656 (1980)
International Right-of-Way Association, member (1985)

Experience - Three years construction; six (6) years, part time, Independent Fee Appraiser
Forty-three (43) years, full time, Independent Fee Appraiser
Teaching- seminar on Transmission lines versus property values

Qualified as Expert Witness -

Jefferson County District Court, CO	Elbert County, CO
Gilpin County District Court, CO	Arapahoe County, CO
El Paso County District Court, CO	Cherokee County, NC
Weld County District Court, CO	Teller County, CO
La Plata County District Court, CO	Boulder County, CO
City and County of Denver District Court, CO	Douglas County, CO
Longmont Municipal Court Boulder County, CO	Clear Creek County, CO
Adams County District Court, CO	Pitkin County, CO
State of Colorado Board of Assessment Appeals	Transylvania County, NC
Watagua/Ashe Counties, NC	Federal District Court, Denver, CO
Converse County, WY	

States Appraised in - Colorado, Wyoming, Nebraska, New Mexico, Kansas, North Carolina, Nevada, Michigan, Oklahoma

Attachment 3-2 Property Value Studies

1. **The Effect of High-Voltage Overhead Transmission Lines on Property Values: A Review of the Literature Since 2010 (2017)**
2. **The Effect of High Voltage Transmission Lines on Real Estate Values (2011)**
3. **The Effects of Electric Transmission Lines on Property Values: A Literature Review (2010)**

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

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

Abstract

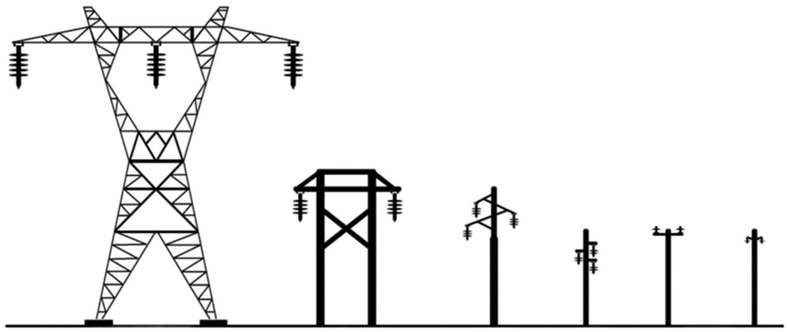
Renewable energy initiatives require modernization to the power grid. Renewable energy must be transported long distances by high-voltage overhead transmission lines (HVOTLs) from generation point to population centers. This article discusses the literature since 2010 regarding the impact of HVOTLs on property values. Previous reviews have divided the literature into three categories: statistical price models, survey-based research, and other appraisal methods, such as paired sales and resale analyses. The article examines the developments within these three established empirical approaches and extends the literature review beyond the United States to studies in Europe and New Zealand.

Introduction

Recent changes in energy policy and infrastructure have continued to encourage research on the impact of high-voltage overhead transmission lines (HVOTLs) on property values.[1] The current transmission grid has its origins in the early- to mid-twentieth century during the modernization and electrification of the United States energy system. Investment declined for three decades between the 1960s and the 1990s. However, it has risen steadily since then. The original transmission infrastructure has been nearing the end of its intended useful life, and the recent shift towards renewables and more diverse energy generation has placed increasing demands on the aging system. Twenty-nine states have adopted Renewable Portfolio Standards that require them to generate a certain percentage or amount of their energy from renewable sources. But political demands for a more diverse energy production portfolio have been met with the sobering reality that a nation powered by renewable energy requires an expanded and updated transmission grid. Because of their dependence on regional climate and geography, renewable energy resources, such as hydroelectric, solar, and wind power, are often located far from final demand in dense population centers, often requiring high-capacity, efficient transmission across hundreds of miles. For example, California has adopted a Renewable Portfolio Standard requiring 33% of its energy to be generated from renewable sources by 2020, and 50% by 2030. The 173-mile Tehachapi Renewable Transmission Project,

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

Exhibit 1 Electric Power Transmission Line Types



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

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

The research into the effects of HVOTLs on property values is a mature area of research and has been extensively reviewed, notably by Jackson and Pitts in 2010.[2] Jackson and Pitts find that the actual negative effects reported in the literature are either small or negligible. Survey-based research between the late 1960s and 2010 finds persistent adverse perceptions of HVOTLs, primarily because of perceived health risks and aesthetic concerns. However, negative perceptions held by market participants did not necessarily translate into observable price differences. Though mixed, most of the statistical research before 2010 concludes that properties near HVOTLs generally do not show a significant negative impact on value and that any observed impacts diminish with distance from the lines. These studies even find a premium for houses located near the lines, presumably because of increased views, increased privacy, and the recreational value of the transmission corridors. Jackson and Pitts, in summarizing the literature, report that any negative price effects ranged from approximately 2% to 9%, but generally there were no effects and any effects decreased with distance.

Statistical Price Studies

Researchers since 2010 have continued to produce hedonic regression studies of the impact of transmission lines on property values (Exhibit 2). Hedonic regression is a statistical method for decomposing the price of real property, or some other good, into the prices of its component characteristics such as lot size, square footage, and age—even though these characteristics may not be unbundled in the marketplace. The assumption is that the prices of goods in the market are affected by their characteristics. To estimate the value of real property using a hedonic

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

regression analysis, a researcher will identify the characteristics or independent variables that contribute to market value such as view, lot size and shape, topography, location, utility, and entitlements. By including proximity or view of an HVOTL as a variable in the regression, the researcher in theory can estimate the negative or positive contribution to price that the HVOTL has on the value of the property.[3]

In a 2011 article, May, Corbin, and Hollins[4] use a hedonic multiple regression model to study the price data for 1,251 homes sold between 2000 and 2009 over a 1.15-square-kilometer area of South London, United Kingdom. This study focuses on the effects of certain determinants—including house characteristics, psychological and health conditions, aesthetic factors, and services—on residential property values. One of the factors considered is proximity to an HVOTL. The authors consider the distance to the nearest pylon as well as the distance to the centerline of the HVOTL. In the United Kingdom, transmission lines can be built on residential property and lines may pass directly over homes, so the authors also consider whether the plot or home is oversailed by a transmission line and whether a pylon is on the property. The authors claim this study is the first of its kind in that it analyzes the dynamic relationships—or "cross elasticities"—between these price determinants. For example, the authors measure the relationship between distance to a park and distance to an HVOTL and find that proximity to a park only had a positive effect for houses located away from HVOTLs.

This model shows that house values increase by 0.03% when distance from the centerline of the HVOTL increases by 1%. This claim, however, must be interpreted with caution. While most statistical studies of transmission line effects have used distance bands to measure changes in price impacts over various distances, the authors in this study entered these multiple distance variables into the regression as continuous variables. Expressing distance as a continuous variable, however, constrains the regression and imposes the assumption that the distance effect decays everywhere at the same rate.[5]

While most of the literature focuses on the effects of transmission lines on residential properties, especially single-family homes, Jackson, Pitts, and Norwood[6] study the effects on both commercial and industrial properties. They use the formal methods that have already been applied for decades to residential properties. The study analyzes the effects of HVOTLs on the sale prices of commercial and industrial properties between 2005 and 2010 in Madison, Wisconsin, and other "generally urbanized areas" of Wisconsin using a combination of five regression models, a paired sales analysis, and interviews. The sample size was 187 commercial and industrial properties, with a control group of 145 unencumbered properties, and a treatment group of 42 properties either encumbered by or in proximity

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

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

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

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

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

In a study published in 2013, Bottemiller and Wolverton[7] analyze sales data for the period between 2005 and mid-2007 in the areas surrounding Portland, Oregon, and Seattle, Washington. The transmission lines considered in this study range from 115 kV to 500 kV. The Portland sample includes 538 home sales, with 152 HVOTL-abutting sales and 386 non-abutting control sales. The Seattle study includes 568 home sales, with 153 abutting sales and 415 control sales. The authors use a multiple regression analysis and find small but statistically significant price effects. Portland homes abutting HVOTLs show a negative impact of 1.67% and Seattle homes show a negative impact of 2.43%. This study is a refinement of a two earlier studies by the same authors that found no significant price effects. A richer data set in this project allowed the authors to control for neighborhood and school district.

The authors note that 25% of the Seattle homes have a mean price of about $1 million. When the authors separately analyze the higher-end Seattle homes, they find a significant negative impact of 11.23%, which would translate to a $130,882 decrease in price for a typical home in the group. The price effect for a typical home in Seattle, on the other hand, is a mere 0.65% negative impact, which is not statistically significant. This suggests that nearly all of the 2.49% negative impact in the Seattle area is due to the high-end homes in the study. Bottemiller and Wolverton are conservative in their language and quick to acknowledge the limitations of this kind of study. They point out that the huge trees in the Northwest largely cover HVOTLs, so this study is not applicable outside the Northwest. The smaller lot sizes in Portland suggest that there is less room for trees and so the HVOTLs are more visible. This could explain the higher negative impact for a typical home in Portland (1.67%) when compared to a typical home in Seattle (0.65%). The authors warn against generalizing these results beyond the respective geographical areas.

In a refinement of a 2005 study, Sims and Dent[8] conduct a regression analysis of mid-priced homes sold in Blackwood, Scotland, between 1994 and 2010. The authors consider the sales of 620 properties, of which 483 have some view of the supporting pylons of a 275 kV transmission line running through the center of the neighborhood. Along with slight changes to the original 2005 data set, Sims and Dent add several variables. This study is the most ambitious of the five statistical HVOTL studies included in this review in its attempts to detect the subtleties of different view effects. Using property characteristics determined using plot maps and physical observation, the authors consider, among many other possibilities, homes with one-fourth of a pylon visible from the front, homes with half a pylon visible from the front, homes with side views of an HVOTL, and homes with two pylons visible from the rear. They considered distance effects using 50 meter-wide distance bands.

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

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

The authors find that a view of a pylon from the rear of the home has a significant price impact, which decreased with distance. The greatest negative impact resulted from a three-fourths view of a pylon from the rear of the home. The value of a property within 100 meters of a pylon shows a 21% discount compared to a similar house 400 meters away. All of these negative price effects diminish with distance. A side view of the HVOTL line, on the other hand, significantly increases value, presumably because of increased privacy. Sims and Dent argue that these findings suggest that implementing rights of way in the United Kingdom, as they exist in the United States, could mitigate effects from HVOTLs. The authors echo Bottemiller and Wolverton in noting that the results from this kind of research are difficult to generalize.

The literature generally estimates the impacts of existing HVOTLs on property, not their removal. A 2014 study by Callanan,[9] however, uses a hedonic pricing model and a repeat sales analysis to attempt to measure the length of time that any market resistance remains after transmission lines are removed (the repeat sales analysis method is discussed later in this article). Callanan studies the low-income Newlands suburb of Wellington, New Zealand, in which two 110 kV lines were removed in the mid-1990s. A before-removal study included 330 homes sold between 1989 and 1995 and an after-removal study included 3,345 homes sold between 1995 and 2010. The author considers the distance from each line and the distance from each pylon as well as various other property characteristics. Distance variables in this study are entered into the regression as continuous variables. Callanan explicitly criticizes the distance bands method, noting that price effects are often subtle and can be lost within the distance bands.

Before removal, the analysis showed a negative impact of 27% for properties within 20 meters of the pylons; this impact decreases to 5% at 50 meters and is negligible at 100 meters. The lines themselves, rather than the pylons, did not have a significant negative impact. The model shows less than a 1% effect for homes directly under the line. After removal, the neighborhood as a whole, not just individual properties, improved in value, with a significant increase in sale prices in the three- to four-year period after removal. However, post-removal results were impeded by significant demographic changes in the study area and wide price swings in the New Zealand real estate market at the time. Therefore, the 27% figure must be interpreted with care. It is most likely an artifact of the close siting of towers allowed in New Zealand. For example, there was a home used in the study with a pylon directly on the lot.

In a 2016 article in *The Appraisal Journal*, researchers Tatos, Glick, and Lunt[10] present a comprehensive new statistical study of the effects of transmission lines on residential property values. Citing the limited sample sizes of previous studies, this research compiles an unusually large and rich sample, using single-family residential sales in Salt Lake County, Utah, between 2001 and 2014. The study encompasses over 125,000 transactions and 250 home characteristics. The data in this study also includes location information for different line voltages, which allows the authors to separately study the effects of different voltages on nearby residential property values.

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

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

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

Exhibit 2 Statistical Price Studies

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

CONTINUED >

Exhibit 2 Statistical Price Studies (*continued*)

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

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

Other Research Methods

Few scholars have turned to case-by-case sales comparisons as a more reliable alternative to these hedonic pricing methods. Typically, researchers either improve upon the existing hedonic models or move away from transactional data altogether and rely on survey-based contingent valuation.

Three survey-based studies are reviewed here, as outlined in Exhibit 3. When survey-based research methods are used, they are generally combined with a hedonic regression model (see Jackson, Pitts, and Norwood, and Callanan above). However, hedonic regressions require a large amount of data, so they are most suited for densely populated urban areas.

Citing this criticism of the hedonic approach, Chalmers[11] in a 2012 article reports a case study analysis of rural properties located along transmission lines in Montana. This study uses the traditional appraisal methods of interviews, sales comparison, and paired sales analysis. The study includes 49 individual transactions, along with 7 residential subdivisions in Sanders County. The properties are spread over 640 miles of rural Montana and represent a wide range of characteristics and uses—including agricultural, residential, recreational, and mixed uses. Chalmers identifies three general characteristics that make properties vulnerable to price effects: use, size, and uniqueness. The analysis finds that the more a property is used for residential purposes, the more vulnerable it is to a price effect. Strictly recreational properties are less vulnerable, and agricultural properties show no effects. In terms of size, larger properties are less vulnerable than smaller properties. Also, the study finds that the more unique a property is—or the less likely a buyer was to find a substitute—the less vulnerable it is to negative effects from transmission lines since for a unique property HVOTLs are but one of many differentiating factors.

In their 2012 article, Jackson, Pitts, and Norwood[12] supplement a multiple regression analysis of commercial and industrial properties in Wisconsin with a paired sales analysis. The paired sales study compares abutting and non-abutting properties sold between 2000 and 2010 in Dane and Milwaukee counties. The methodology includes three separate paired sales analyses, one for each property type—apartments, office buildings, and office land. The study considers three comparable apartments, four comparable office buildings, and five comparable office land sales. The paired sales analysis confirms the conclusion of the regression analysis, finding no evidence of any negative impact from the HVOTLs. This is consistent with the interviews of the market participants in each transaction.

The 2014 Callanan study[13] includes a repeat sales analysis to supplement the multiple regression analysis of homes in a suburb of Wellington, New Zealand, before and after the removal of two 110 kV transmission lines. The repeat sales analysis considers six case study sales within 50

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

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

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

Exhibit 3 Other Appraisal Methods

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

meters of pylons, along with six comparable control sales. Like the sample used for the regression analysis, these homes are lower-priced single-family residential homes sold between 1993 and 2009. The repeat sales analysis contradicts the results obtained with the regression model. The regression model shows that prices around HVOTLs increase more slowly than prices for comparable properties away from HVOTLs. In the repeat sales analysis, the case study properties increase in price at a higher rate when compared to the control area properties. Callanan notes that one property with a considerably higher resale price underwent renovations during the study period, and therefore it may have skewed the results obtained from this analysis.

Survey Research

Survey-based research into the potential price impacts of transmission lines consists primarily of contingent valuation (CV) experiments (Exhibit 4). The survey-based methods are used as alternatives to statistical price analyses to estimate the value of environmental amenities and potential detrimental conditions. A CV survey, considered a Type III survey within appraisal literature, is an interview "in which survey participants are not qualified as active market participants but are asked to pretend that they are participating in the market and that they are going to purchase a property with certain attributes."[14] Respondents are asked to choose

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

alternative scenarios, designed to elicit their preferences for environmental amenities and other nonmarket goods. CV surveys often estimate a monetary value for respondents' willingness to pay (WTP) for the preservation or removal of a certain environmental amenity or disamenity. This has not been a particularly active area of power line research since 2010, but it is of interest because of the frequent—and controversial—use of CV research in environmental litigation.

Giaccaria, Frontuto, and Dalmazzone[15] estimate the willingness to pay for the removal of HVOTLs of households located along transmission line corridors in Piedmont, Italy. The novelty of this CV study is its use of GIS data in the sampling of survey subjects. The authors overlay 1,200-meter corridors along HVOTLs to guide in the selection of households. An online questionnaire was then administered in 2012. There are a total of 1,194 households in the final sample. The authors distinguish three different levels of perceived damage—ordinary, intermediate, and heavy damage. Households reporting ordinary impacts, such as landscape degradation and visual impacts, indicate a willingness to pay €189 ($241)[16] to remove the lines near their property. The average household income in the sample is €22,800 ($29,045) per year. Those reporting an intermediate impact—defined as visual degradation, perceived health risks, environmental effects, and ecological risk—indicate a willingness to pay €576 ($734) for removal. Finally, respondents with perceived property value effects in "extreme proximity" indicate a willingness to pay €3,753 ($4,781) for removal.

Callanan[17] conducts a CV study supplemented by an attitudinal survey and a sale price analysis to determine the willingness to pay for transmission line removal. The CV survey consists of mailed questionnaires and face-to-face interviews in Auckland, New Zealand. The final sample is 887 households in proximity to HVOTLs. In the attitudinal study, 70% of respondents state that HVOTLs have an effect on property values and 60% state they believe that the removal would increase property value by 10%. The CV survey results show that depending on the method of payment, 67% to 80.5% of respondents oppose any contribution to the removal. However, Callanan did not collect sufficient responses to reach a monetary estimate.

Tempesta, Vecchiato, and Girardi[18] conduct a discrete choice experiment, or "conjoint valuation," to estimate the benefits of undergrounding HVOTLs in rural areas of Italy. This study encompasses an online questionnaire survey conducted in 2012. There are 3,846 final observations chosen as representative of the Italian population. The survey results indicate that 88% of respondents value the landscape as an economic resource in Italy, and 55% think HVOTLs spoil the landscape. However, only 39.2% state they would be willing to pay for the burial of the power lines. The authors conclude that undergrounding lines is justified only in areas of environmental interest because of the high costs of undergrounding transmission lines. However, because undergrounding costs are decreasing, the authors expect these results to change.

Whereas much of the literature has attempted to observe subtle price effects using increasingly sophisticated hedonic models and data sets, Seiler[19] criticizes hedonic modeling as inherently limited when it comes to measuring the impact of power lines because "no study is able to control for everything." Seiler conducted a survey of

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

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

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

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

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

Exhibit 4 Survey Research

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

eminent domain attorneys from across the United States during a live experiment at an American Law Institute–American Bar Association conference. He isolates three factors: easement rights, noise pollution (the "humming" of HVOTLs), and proximity (near/far). The study consists of a questionnaire accompanied by pictures—one showing a house with a power line immediately behind it, another showing the power line farther away. Easement rights are found to have no significant effect. Noise pollution led to a 2% diminution, while siting HVOTLs immediately behind a house led to a 2.5% diminution.

Public Perception Research

In recent years, governments have pushed to upgrade the power grid to accommodate decentralized low-carbon generation. There has been much activity and attention given to the public acceptance of new and existing transmission line projects. These are not studies of price impacts, per se. Rather, they are attitudinal studies of public perception and the social acceptance of power lines. Though they do not attempt to estimate price effects, the studies may inform, for instance, the choice of variables in statistical studies or the sample selections and questionnaire designs used in CV studies. These studies (Exhibit 5) find that local opposition is greater than general opposition, that the dislike of the pylons and lines is influenced by the belief that local communities have no say in the HVOTL planning process, and that respondents favor undergrounding. At the very least, these studies may provide insight into any price effects observed in more rigorous large-scale statistical studies.

Devine-Wright, Devine-Wright, and Sherry-Brennan[20] assert that there exists a gap in the literature because there are few studies examining public beliefs about the power grid. In their study of 1,041 UK adults, they find that electricity supply networks are understood largely in terms of physical technologies rather than organizations—the visible and tangible cables and wires, rather than the concept of an energy-supply network. For new transmission line planning, respondents assume the government makes decisions, while locals have little influence. The surveys shows strong public support for putting new lines underground regardless of cost.

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

Batel, Devine-Wright, and Tangeland,[22] and Cohen, Reichl, and Schmidthaler[23] critique the very concept of "acceptance" as limiting the research so far.

Batel, Devine-Wright, and Tangeland propose doing away with the "acceptance" versus "opposition" framework. They suggest that the idea of local opposition perpetuates a top-down, passive, condescending narrative about people's relationships to new energy infrastructures and ignores other possible responses, such as support, uncertainty, resistance, and apathy.

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

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

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

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

Exhibit 5 Public Perception Research

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

Cohen, Reichl, and Schmidthaler try to develop a new definition of "social acceptance" to inform future quantitative research. Their work discusses the social acceptance of wind farms, transmission lines, and pump hydro-storage facilities. The authors offer suggestions on how to improve acceptance rather than simply trying to identify the origins of opposition. In addition to improving local participation in the planning process, the authors recommend locating pylons near existing pylons and using T-pylon designs for rural landscapes.

Devine-Wright and Batel[24] in their research observe the public preference for the T-pylon design. In a study of 1,519 UK adults, Devine-Wright and Batel find that the T-pylon design is by far the most preferred and perceived to fit the rural landscape, while undergrounding, not taking into account cost, is preferred to all overhead designs.

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

Conclusion

Changes in energy policy and infrastructure continue to encourage research into the effects of HVOTLs on property values. Meanwhile, more sophisticated research methods continue to inform the literature. For example, new GIS and spatial econometric techniques allow researchers to attempt to measure, on a large scale, such subtle and hard-to-define factors as impaired viewsheds. There has been increased interest in the sociological research as it relates to local opposition of HVOTLs and other perceived energy infrastructure disamenities. As efforts to curb carbon emissions and decentralize the power grid continue, research will continue into the effects, if any, of these possible disamenities on property values. Nevertheless, the most recent conclusions remain the consistent with the literature before 2010. Survey-based research finds adverse perceptions and general dislike for HVOTLs, but sales data reveals little to no diminution in prices. Stated preferences by market participants in this case generally do not translate into noticeable price effects as revealed in market data. All studies are difficult to generalize due to geographical, methodological, and other constraints. This is especially true of survey-based and statistical studies, which have faced intense scrutiny in the courts. Ultimately, the reliability, applicability, and integrity of every study must be judged based on the merits of its design and the quality of the data.

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Additional Resources

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

Appraisal Institute

Lum Library, External Resources [Login required]

Information Files—Real estate damages/proximity impact

Electric Power Research Institute—Research

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

Federal Energy Regulatory Commission—Electric Smart Grid

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

National Association of Regulatory Commissioners—Research Lab

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

US Department of Energy—Electric Power

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

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THE EFFECT OF HIGH VOLTAGE TRANSMISSION LINES ON REAL ESTATE VALUES: A REVIEW OF THE APPRAISAL LITERATURE
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This report was prepared by Russell Thibeault of Applied Economic Research at the request of Dana Bisbee Esq. of the Devine, Millimet law firm with compensation from Northeast Utilities.

By way of disclosure, Russell Thibeault, President of Applied Economic Research, has previously performed valuation studies of right of way values for the Public Service Company of New Hampshire. The Public Service Company of New Hampshire is owned by Northeast Utilities, which is overseeing an effort to expand its network of New England transmission capacity through New Hampshire in conjunction with Hydro Quebec.

The purpose of this literature search is to provide a synopsis of the appraisal literature addressing the issue of the impact of High Voltage Transmission Lines (HVTLs) on real estate values. The primary focus is on research appearing in professional appraisal journals since the year 2000, including the *Appraisal Journal*, published quarterly by the Appraisal Institute and *Right-of-Way* published quarterly by the International Right-of-Way Association. These two publications are well regarded in their respective fields. Relevant articles appearing in *The Journal of Real Estate Research* and the *Assessment Journal* were also examined. Recent studies were selected because they are likely to be more reflective of recent attitudes of buyers and sellers. Several older but particularly relevant studies are, however, also examined. Study sponsorship, when cited by the author or peers, is noted. While there is no transparent bias in the recent studies reviewed, it is nonetheless appropriate to note that several of those studies were funded by the electric utility industry, including Northeast Utilities and Hydro Quebec.

The issue of the impact of transmission lines on property values frequently arises when new projects are proposed and when right-of-way acquisition is initiated. The immediate catalyst to this research is the proposed Northern Pass transmission line, which will extend some 180 miles from the Canadian border to southern New Hampshire. The transmission line would create a new connection between Hydro-Quebec's primarily hydroelectric resources and the New England power grid, supplying electricity to customers in the New England region. Approximately 40 miles of the proposed route will consist of new right-of-way between the New

Hampshire/Canadian border and Groveton, New Hampshire. An additional 8-mile section of the route through Concord, Chichester and Pembroke may also consist of new right-of-way development. The balance of the project will follow existing rights-of-way.

Synopsis

The majority of the literature reviewed[1]--covering 50 or more studies conducted over several decades in a variety of settings by several dozen researchers using a variety of techniques-- finds that High Voltage Transmission Lines (HVTLs) have a modest or no measurable impact on property values. Many of the studies find no impact and those that do find an impact generally find that the impact is under 10% and that it diminishes quickly as distance from the transmission corridor increases—diminishing greatly beyond 50 feet from the easement and generally disappearing at distances beyond 200-500 feet. Several of the studies cited do find a more significant impact, but these stand in contrast to the majority of the findings. At least one study found an *increase* in value as a result of improved views and the perceived preservation of open space from adjacent land. Overall, however, modest or no price impact is revealed-- these "outlier" studies notwithstanding.

The reviewed studies differ greatly in the level of detailed data they incorporate and the rigor of the analysis. As noted in the following accounts of the reviewed research, a few of the studies consider whether an easement crosses (encumbers) the impacted property, versus whether the property is adjacent to the easement. None of the studies allow for the compensation paid for the easement at the time it was acquired. If they did so, the net impact reported would be offset in whole or in part by that compensation.

The findings of the reviewed studies are inconsistent with many of the opinions expressed by potentially affected landowners when a project is proposed, including the proposed Northern Pass. What underlies this inconsistency? Some peer reviewers of individual studies, as noted in the following summaries, believe that the measurement techniques (which include paired analysis of sales of similar properties (1) impacted and (2) not impacted by HVTLs and more rigorous regression statistical analysis) are too crude to pick up value changes attributable to the

[1] "Reviewed" includes articles summarized on the following pages and prior research cited in those summaries.

presence of an HVTL. While it is true that no analytical technique is perfect, the consistency of the findings, based on diverse techniques at different points in time in different geographic settings by diverse researchers tends to refute this view. If there was a consistently large impact, those impacts would likely be revealed by the techniques relied on in the studies examined in the course of this literature review.

The concern of potentially impacted landowners is understandable. Few would be indifferent to the introduction of an adjacent HVTL. But the question posed in the research is not whether people are indifferent to HVTLs, but rather—*does the impact rise to the level of having a consistent, major, measurable impact on property values?* The majority of the research examined in this literature review indicates it does not.

The value of real estate is driven by a host of factors and personal preferences. The presence of an HVTL line is but one of a multiplicity of factors taken into account when buying or selling real estate. Simply put, the research suggests that the presence of an HVTL is not a primary consideration for all (or possibly most) buyers. Most of the studies find that the measurable impact of an HVTL on value is generally less than 10 percent or not evident. Some buyers may be deterred and look elsewhere; others may not.

As several of the researchers note (and as common sense dictates) these research findings should not be applied to every property in every setting impacted by an HVTL. In some settings and for some properties, an HVTL will have a significant impact on value. In those instances where the easement crosses a property, property owners have a well-established right to full compensation for both the land under the easement and loss in value to the remainder of their property—they are made whole. Only a site-specific analysis, however, can authoritatively establish the impact on a particular property or group of properties.

Overview of the Research

Articles reviewed in the course of preparing this analysis, including those examined by AER and older research cited in the examined literature, stretch back some 50 years. As noted by Priestley

(2007)[2], the fundamental purpose of this body of research is to answer the question: "Does the presence of high voltage overhead transmission lines on or near a property affect the value of that property?" If effects are present, additional dimensions explored in some of the research include:

> What is the magnitude of the effect?
>
> What characteristics of the line or right-of-way are associated with that effect?
>
> What types of property are most vulnerable to impacts?
>
> Do impacts change over time?
>
> Does proximity to a transmission line affect appreciation?
>
> To what degree are transmission line property value effects influenced by concerns about electric and magnetic fields?

Priestly goes on to note that there are three basic methodologies deployed in these studies:[3]

> *Appraiser Studies*. These studies include paired sales analysis in which sale prices for properties located close to the transmission line are contrasted with the sale prices of matched properties located in areas presumed to be out of the transmission line zone of influence.
>
> *Attitudinal Surveys*. These studies explore the opinions of property owners and/or real estate professionals as to their perception of the effect of transmission lines on property sales values.
>
> *Statistical Analyses*. Statistical analyses began to appear in the 1970s. These studies rely on a statistical comparison of the sale price of properties close to or abutting a transmission line as compared to properties away from the transmission line. They typically utilize regression analysis, which endeavors to correlate price/value with a multiplicity of factors (unit size, lot size, number of bedrooms, year built, proximity to the transmission line, etc.).

None of these techniques is perfect. The appraisal studies suffer from the difficulty of finding true paired sales or adjusting sales for the passage of time, unit condition, etc. The attitudinal surveys can be heavily influenced by prevailing media coverage, sample selection and anecdotal comments. Regression analysis requires large amounts of data and careful coding and interpretation of that data to generate reliable results. There is not, however, a material difference in the fundamental conclusion of a modest impact using these different methodologies.

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[2] Thomas Priestly, PhD. *Transmission Lines and Property Values: Review of the Research and Summary of Key Findings.* Prepared for New York Regional Interconnection, Inc. May 2007.

[3] Priestly (2007) Page 3.

An additional caveat is important to note. All these studies are generally designed to reflect the central tendency of the research findings. That is, words such as "typically" and "on average" should be applied to essentially all of the research findings. As noted by Chalmers (2009)[4]:

> "It is fair to presume that the direction of the effect (on property values) would in most circumstances be negative, but the existence of a measurable effect and the magnitude of such an effect can only be determined by empirical analysis of actual market transactions."[5]

That is to say, the research reviewed indicates the findings in specific circumstances and reflects the central tendency measured by the researcher. This is valuable information and does provide substantial insight as to the effect of transmission lines on property values. As noted by Chalmers, however, there are limitations as to the applicability of the research to specific circumstances outside the studied area. In layman's terms, "your mileage may vary."

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[4] James Chalmers PhD and Frank Voorvaart PhD "High-Voltage Transmission Lines: Proximity, Visibility, and Encumbrance Effects" *Appraisal Journal*. Summer 2009.
[5] Chalmers (2009) Page 240.

Thomas Jackson, "Electric Transmission Lines: Is there An Impact on Residential Land Values?" *Right of Way*, November/December 2010.

The author notes that most of the transmission line impact studies have focused on the impact of transmission lines on residential property values and that there have been relatively few studies examining the impact to rural land used for agricultural or recreational purposes.[6]

The researcher examines prior research and notes that:

> "Two regression-based studies were also reviewed that considered the effects of transmission lines on rural acreage. One of these considered agricultural land from 136 to 350 acres and the other focused on recreational properties of 10 to 160 acres. Both these studies found that power line structures in easements do not have a significant impact on the price and value of rural acreage tracts."[7]

The author goes on to examine whether or not an impact can be identified in the studied setting—rural Wisconsin, by applying regression analysis to the sale of 88 properties impacted by the transmission line and 297 properties not so affected. The conclusion of the analysis is stated as follows:

> The analyses presented here investigated the extent to which rural land values in Wisconsin have been adversely impacted by the presence of high-voltage electric transmission lines. The general finding was that there were small (1.11%-2.44%) discounts that could be attributable to the presence of the lines and the encumbrance of the properties by the easements. Neither of these small differences were (sic) statistically significant."[8]

The study does examine properties that are crossed by an easement and distinguishes whether an easement is on the edge of a property, whether it clips a portion of the property, whether it bisects a property and whether it crosses the property diagonally. The author notes:

"The results indicated that online sales in the middle pattern had an average adjusted price difference of -3.8%. The diagonal pattern was associated with a difference of -2.1%. The edge/clipping pattern sales had no loss."[9]

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[6] Sponsorship of the research underlying this article is not disclosed.
[7] Jackson (2010) Page 33.
[8] Jackson (2010) Page 35.
[9] Jackosn (2010) Page 34.

Jackson does discuss the value of the actual easement area, but the discussion is vague and difficult to interpret. Suffice to say that some of the above observed value declines would probably have been compensated at the time the utility acquired the easement.

This research was the subject of a rebuttal prepared by John Schmick appearing in the

> March/April 2011 issue of *Right of Way*.[10] In essence, Schmick argues that Jackson did not fully reflect all the factors influencing the value of rural land, such as the quality of the rural land for agricultural or timber purposes. He notes, "The general categories listed in this article (use, size, features and location) do not adequately address the fact the rural land prices are influenced by a number of additional factors….If any single factor influencing value in the marketplace is omitted from the study model, then that model may well be flawed and its conclusion meaningless."[11]

His rebuttal, however, offers even less analysis of factors influencing value, citing only the summary table of unadjusted sales in the Jackson analysis.

Schmick concludes: "The unfortunate part of this article is that other appraisers and right of way professionals may try to use this in their own work without understanding the questions raised here."[12]

[10] John Schmick, *Right of Way*, March/April 2011, Page 30.
[11] Schmick, (2011), Page 30.
[12] Schmick (2011), Page 31.

Chalmers and Voorvaart (2009) "High Voltage Transmission Lines: Proximity, Visibility and Encumbrance Effects". *The Appraisal Journal,* Summer 2009

This article appears in the summer 2009 issue of the *Appraisal Journal.* This research was conducted under contract to Northeast Utilities. The analysis includes both a review of the literature and the results of a multiple regression analysis of a 345 Kv transmission line in nine neighborhoods located in four study areas in Massachusetts and Connecticut.

Chalmers notes that the existing literature is extensive, but of uneven quality "…ranging from anecdotal reports to large, rigorously conducted statistical studies."[13] Chalmers notes that there are essentially 16 studies that form the core of the professional literature and are widely quoted and cross-referenced to one another. Chalmers summarizes the findings of these studies as follows:

> "Over time, there is a consistent pattern with about half 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 percent and usually in the range 3-6 percent.
>
> Where effects are found, they decay rapidly as distance to the lines increase and usually disappear at about 200 feet to 500 feet (61 meters to 91 meters).
>
> Two studies investigating the behavior of the effects 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-effect studies were preliminarily released in 1992."[14]

Chalmers goes on to note that "These general conclusions have characterized the appraisal and economic literature throughout the last 25 years, and there do not appear to be any new and different trends in the research."[15] Chalmers poses an interesting question:

> "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

[13] Chalmers et al (2009) Page 228.
[14] Chalmers (2009) Page 229.
[15] Chalmers (2009) Page 229.

> can it be that if people are so intensely adverse to HVTLs (high voltage transmission lines), we do not see more of a market effect? This inconsistency is seen clearly when residents along existing HVTLs are interviewed."[16]

Chalmers looks to the research to address this seeming dilemma by summarizing the results of five attitudinal studies. His conclusions are:

> "A high proportion of the residents were aware of the lines at the time of purchase.
>
> 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."[17]

Having considered the statistical and appraisal research and the attitudinal surveys, Chalmers concludes the research review element of his work as follows:

> "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."[18]

The second element of his research examines the impact of 345 impacted properties in nine neighborhoods located in four study areas in Massachusetts and Connecticut. A total of 1,654 properties were considered and characterized as to their visibility/proximity to the transmission line. The settings included both suburban and rural neighborhoods. These 1,654 sales occurred in 1999-2007. Of the 1,654 sales, 1,286 were viewed as qualified for additional analysis (excluding sales that were not arm's length, excluding duplicate sales, etc.).

The bottom line conclusion of the analysis is:

> "In the four study areas examined here, there is no evidence of systematic effects of either proximity or visibility of 345- 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

[16] Chalmers (2009) Page 229.
[17] Chalmers (2009) Page 229-230.
[18] Chalmers (2009) Page 230.

> it is measured varies. The hypothesis that proximity values are more vulnerable to transmission line effects in a down market also is considered, although no evidence 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 value properties are more vulnerable to transmission line effects is considered; again, the data provide 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."[19]

He does consider whether all or a portion of the easement crosses the studied properties. Regarding these encumbered properties his conclusion is:

> 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 the encumbrance variable in Continuous Distance Model 2 implies an effect of approximately $3,000 for a property with 12,000 square feet encumbered and a sale price of $300,000."[20]

The authors do not address the issue of whether a property is crossed by an easement, versus lying adjacent to it.

This study was the subject of two follow-up comments, also appearing in the *Appraisal Journal*. The first appeared on page 390 of the *Appraisal Journal* Fall 2009. In it, John F. Havenmeyer supports the Chalmers findings, citing somewhat anecdotal experiences in the Syracuse, New York area.

The second comment was authored by Kerry Jorgensen of Sandy, Utah and appeared in the Winter 2010 issue of the *Appraisal Journal*. This retort questions the study's reliance on multiple regression analysis, noting for example that the model may have been influenced by the variables being correlated with each other. The effect of this is to over-emphasize the effect of some variables and under-report the impact of others. Jorgensen notes "The amount of impact in any particular case can only be estimated reliably by a trained and experienced appraiser, and multiple linear regression is but one of the tools the appraiser might look to in making that

[19] Chalmers (2009) Pages 239-240.
[20] Chalmers (2009) Pages 237-238

determination…For a particular property the impact of power lines on its appearance, on the quality of its views and on its overall appeal are a nuanced decision that can only be make on a case-by-case basis."[21] Jorgensen goes on to note: "A thorough reading of the literature on the impacts of high-voltage transmission lines leads to a conclusion that the effect of adjoining an HVTL easement can range widely, which is only common sense. Reported impacts range from a small positive impact on value to a negative impact as high as 14%. The central tendency is somewhere in the range of 5% or 6%."[22]

The authors responded to the Jorgensen comments by explaining their methodology in more detail and highlighting the limitations of their findings: "…the existence of a measurable effect and the magnitude of such an effect can only be determined by empirical analysis of actual market transactions."[23]

[21] Kerry Jorgensen, *Appraisal Journal*, Winter *2010*, *Page 110*.
[22] Kerry Jorgensen, *Appraisal Journal*, Winter *2010*,*Pages 109-111*.
[23] Chalmers, *Appraisal Journal*, Winter 2010, Pages 111-112.

Thomas Priestley, PhD
"Transmission Lines and Property Values:
Review of the Research and Summary of Key Findings" CH2M Hill, 2007.

This report was prepared for the New York Regional Interconnection, Inc. in May of 2007. The report presents a comprehensive review of literature addressing the issue of the impact of transmission lines on property values. The report refers to an initial literature review completed by Kroll and Priestley in 1992, which summarized and evaluated findings of over 30 studies. That first review was then updated by Priestley in 2005 and then updated again in 2007 to cover the 2005-2007 period. The major findings of the Priestley literature review, which is arguably the most comprehensive uncovered in our literature search are as follows.

Impact on Single-Family Residences

The relevant findings of the literature review with respect to single-family residences are:

> "Most of the research studies based on paired sales analysis have found that transmission lines have no effect on the value of nearby single-family residences. In addition, a number of the analyses using multiple regression analysis…"found that transmission lines do not have a significant effect on the sale prices of nearby properties, including single-family homes." [24]

> "A few of the paired-sales studies as well as many of the studies that relied on multiple regression analysis found that transmission lines have a statistically significant effect on the sales values of nearby single-family residences. Although these price reduction effects are statically significant, in most cases they are not large, generally ranging from 2 to 10 percent."[25]

> "A study undertaken by Des Rosiers (2003) in a suburb of Montreal found that in general in the areas studied, homes adjacent to the transmission line right-of-way and facing a transmission tower experienced a drop in property value of 10 percent. They also found that in specific cases, where the setback from the transmission line is very limited, the impact for homes adjacent to the line and facing a tower can be higher, ranging from 10 to 15 percent in areas with lower price homes, and from 15-to 20 percent in areas with more expensive homes."[26]

> "A number of studies provide evidence that in some cases overhead transmission lines and their rights-of-way may have positive effects on the value of some properties. …The most frequently mentioned benefit of having a property located next to a transmission

[24] Priestley (2007) Page 5.
[25] Priestley (2007) Page 5.
[26] Priestley (2007) Page 5.

> line right-of-way is the advantage of having one less neighbor. …The Des Rosiers study found that for properties located next to transmission line rights-of-way, but not right next to a transmission tower, there is a positive price impact that ranges from 7 to 22 percent. Des Rosiers also found that for properties that were not immediately adjacent to the right-of-way, but for which the transmission corridor affords views that have an open character, the presence of the corridor creates property value increases in a range of 3 to 4 percent." [27]

> "An apt summary of the findings of the credible research on transmission line effects on property values is provided by Des Rosiers who observed that: "In short, most studies conclude that proximity to an HVTL per se does not necessarily lead to a drop in the value of surrounding properties and that other physical as well as neighborhood variables prevail in the price determination process."[28]

Impacts on Vacant Residential Land

The Priestley analysis cites five studies examining the impact of transmission lines on vacant residential land. Three of the studies found no effect on the value of residential land, one study did indicate some negative effect on the value of lots that are in a subdivision but unimproved with houses. One study, by the University of Quebec in Montreal in 1982, did find a significant impact on the value of second home lots when both proximity to and a view of the transmission line was apparent.

Agricultural Land

The literature reviewed by Priestley shows mixed results with respect to the impact of transmission lines on the value of agricultural land. Several of the studies found that transmission lines do not have a statistically significant effect on the value of properties crossed by the line. Other studies have found some effect, ranging from 2-20 percent. The impact on the value of agricultural land was generally seen to rise if that agricultural land also had a residential development potential.

Effects of Distance

The research cited by Priestley indicates that any perceived impacts of the transmission lines on property values declined sharply over relatively small distances. The studies cited by Priestley find that the impacts disappear almost entirely between 200 and 500 feet from the power line.

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[27] Priestley (2007) Page 6.
[28] Des Rosiers (2002) Page 277 cited in Priestley (2007) Page 6.

The Effects of Time

Priestley notes "there is some evidence to suggest that the property value effects of developing a new transmission line or upgrading an old one may decrease over time." [29]

Impact on Appreciation

Priestley notes only one study that made an explicit assessment of the impact of transmission lines on property value appreciation. That study found "…that residences abutting the transmission line right-of-way appreciated at the same rate as the set of comparison homes located further away."[30]

Impact of Electric and Magnetic Fields

Although the science regarding the impact of electromagnetic fields is less than convincing, the studies cited by Priestley do not find that those concerns translate into declining property values.

The studies reviewed vary greatly in how the analysis treats distance to the easement/HVTL and whether or not the easement actually crosses the HVTL impacted properties.

[29] Priestley (2007) Page 7.
[30] Priestley (2007) Page 8.

Jennifer Pitts and Thomas O. Jackson
"Power Lines and Property Values Revisited". *The Appraisal Journal*, Fall 2007.

This article reviews the findings of previous studies, in noting that most of the prior studies of this issue, "Many studies indicate that the HVTLs have no significant effect on residential property values." [31]

The authors go on to note that:

> "When negative impacts are evident, studies report an average discount of between 1 percent and 10 percent of property values. This diminution in value is attributable to the visual unattractiveness of the lines, potential health hazards, disturbing sounds and safety concerns. 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.
>
> "Research has also 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 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 tower.
>
> "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. It has also been found that higher-end custom homes are generally more sensitive to the negative impacts of HVTL than lower-end homes."[32]

After reaching the above conclusions based on prior studies the authors interviewed realtors and appraisers in three California subdivisions including Discovery Bay near Brentwood, Summer Lake near Oakley, and Sierra View in Roseville. These communities are located in central California east of San Francisco.

The authors are somewhat casual in their research methods and, as such, the findings should be viewed as anecdotal. The findings are:

[31] Pitts (2007), Page 323.
[32] Pitts (2007), Pages 323-324.

> "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 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. …
>
> The remaining realtors and appraisers had observed negative impacts on homes directly adjacent to a power line right-of-way. They said that on average the indicated price discounts range between 2 percent and 7 percent for adjacent homes. For homes not directly adjacent but with a view of the power lines, average price impacts were estimated to between 0 and 5 percent, depending on the view and proximity to the lines. On average, homes adjacent to or within 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 properties in close proximity to the lines, but without a direct view. …
>
> The impact of power lines on residential property values may also be influenced by a buyer's personal preference. Some realtors and appraisers indicated that there may 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."[33]

The study does not distinguish between whether a property is crossed by an easement versus adjacent to an easement.

This research was critiqued in a follow-up issue of *The Appraisal Journal.*[34]The authors of this critique begin by noting that the research for this article was supported, in part at least, by the power industry and the condemner and formed the basis for testimony in a court case and that "…the jury did not accept the government's approach."[35]

The critique goes on to cite lot sales in an 11 lot subdivision in Sacramento County, wherein lots encumbered by a HVTL right of way sold at a discount of 18.6% to those not so encumbered and that the lots encumbered were more difficult to sell.

[33] Pitts (2009) Page 324.
[34] See David Harding et al, "Comments on 'Property Lines and Property Values Revisited" *Appraisal Journal.* Winter 2008, Pages 81-82.
[35] Harding (2008) Page 81.

Dean Chapman
"Transmission Lines and Industrial Property Value"
***Right-of-Way* (November-December 2005)**

This study examines the impact of HVTLs on industrial properties utilizing an interview technique with over 100 survey interviews with buyers, sellers, tenants, property managers and brokers in northern California, Salt Lake City and Las Vegas. The study methodology is more anecdotal than controlled and scientific.

The researcher concludes:

> "For the most part, the attitude from participants in my survey is basically summed up by a broker in Roseville who sold a medical office building within 20 feet of a large lattice tower for 230 Kv lines. He said, 'I wish they weren't there, but the property would have sold for the same price with or without them.'"[36]

He further notes: "The only rule of thumb to be gleaned from reading this article is there is no rule of thumb. Every property is unique and must be carefully analyzed individually based on its own characteristics."[37]

Chapman does address the effect of the location of an easement on a property and the effect of the extent of the property that is covered by the easement. He notes: "I was surprised to find absolutely no impact on value for typically shaped, level parcels encumbered with transmission line easements up to about 30% of the parcel's size."[38] For parcels where the easement covers a great portion of the site, he does note an impact on value, "I found several sales of parcels that had a 50% encumbrance from transmission lines with only a 10%-20% drop in value."[39] He attributes this less than expected impact to the fact that ordinances control how large a building can be placed on a site to a greater degree than the easement area:

> "In each of these examples, the buyer was forced to place a building on one specific portion of the parcel, but the price for the land was only slightly affected because the potential building size had not been diminished. Obviously, the most important

[36] Chapman (2005) Page 27.
[37] Chapman (2005) Page 20.
[38] Chapman (2005) Page 21.
[39] Chapman (2005) Page 21.

> consideration for these buyers was building size. The visual aspect of the transmission lines was inconsequential to them."40

The most significant impact he found was when an easement bisected a parcel, requiring the building area to be constructed in two buildings rather than one. In that case, a paired sales analysis indicated a 38% drop in value.

For the most part this article addresses properties crossed by an easement, wherein the HVTL is actually on the property. It is worthy to note that at some point the current or a prior owner was compensated for the land underlying the HVTL and damages to the remaining land. As such, a portion, if not all, of the perceived difference in value was offset by that compensation.

[40] Chapman (2005) Page 22.

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

This research re-examines the findings in a prior analysis.[41] In this analysis the researchers utilized the same data in the earlier study and added additional home sales that were collected but not required for the original study.[42]

The original study utilized a paired sale methodology to identify any difference in sale price between properties abutting rights-of-way transmission lines in Portland, Oregon; Vancouver, Washington; and Seattle, Washington and those located in the same cities but not abutting transmission lines rights-of-way. The original study concluded "…no significant difference in sale price between the subjects and the comps."[43] However, the original study did not utilize adequate controls for differences between the two paired sales. The authors address this shortcoming in the current article.

The current study uses a statistical technique, Analysis of Covariance (ANCOVA). A total of 712 transactions are incorporated into the data, including 300 abutting a transmission line and 312 that did not abut a line. The overall conclusion of the analysis is: "The data does not support a finding of a price effect from abutting an HVTL right-of-way."[44] Further, they find "The data also does not support a difference in price appreciation over time for properties abutting and not abutting an HVTL right-of-way."[45]

The authors caution against generalizing from the study results:

> "This conclusion cannot and should not be generalized outside of the data, however. The caution regarding generalization stems from the data not being representative of other counties and or locations."[46]

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[41] J. R. Coger, Steven Bottemiller and James Cahill, "Transmission Line Impact on Residential Values," *Right-of-Way* (September/October 1996): 13-17.
[42] The authors do not cite a sponsor for their research, but Priestly (op cit.) cites the support as being from the Bonneville Power Administration.
[43] Wolverton (2003) Page 244.
[44] Wolverton (2003) Page 252.
[45] Wolverton (2003) Page 252.
[46] Wolverton (2003) Page 252.

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

This research utilizes a regression analysis examining the sale of 507 single-family homes sold over the 1991-1996 period in the city of Brossard in the Greater Montreal Area, Canada. The author notes "The author thanks the Appraisal Division of the City of Brossard as well as the Unite Expertise Immobiliere of the TransEnergie Group, Hydro-Quebec Corp., for their support throughout the study." [47] As is true for several of the regression analyses examined in this literature review, Des Rosiers controls for a number of variables influencing property values including quality of constructions, lot size, landscaping, and most importantly, distance from the easement. He analyzes the effect of distance to the easement and to the actual transmission line as well as to the pylons supporting those lines, along with the potential view of both, but does not control for whether the line actually crosses the analyzed property.

The conclusions of the analysis are as follows:

> "A residential property that is both adjacent to an HVTL easement and facing a pylon experiences a significant drop in value due to the visual encumbrance. This drop averages 9.6 percent and can be as high as 21 percent.
>
> In contrast, properties located 1 or 2 lots away from a pylon usually benefit from a market premium, which mirrors the improved visual clearance and increased intimacy thus generated. Results obtained with the global sample show price increases between 10.5 and 12.6%."[48]

The study incorporates an extensive bibliography of the impact literature.

[47] Des Rosiers, (2002) Page 301.
[48] Des Rosiers (2002) Page 291.

Thomas Jaconetty. "Do You Want Your Children Playing Under Those Things?: The Continuing Controversy About High Voltage Electromagnetic Fields, Human Health and Real Property Values". ***Assessment Journal*****: May/June 2001.**

This article, designed to inform the thinking of government assessors, examines a variety of issues surrounding HVTLs and their impacts, including legal case law, health impacts and impacts on property values. For the most part, the article reviews literature and case law.

As to the impact on property values, the study reviews a sample of the literature and notes, "Considering all of the market evidence, a value loss of less than 10 percent may be a reasonable expectation for residential properties. The negative impact is possibly greater for other types of properties."[49]

Jaconetty does not address the issue of whether an easement crosses a property or other distance factors in his literature search.

[49] Jaconetty, (2001) . Page 24.

Glenn Rigdon
"138Kv Transmission Lines and the Value of Recreational Land"
***Right-of-Way* (December 1991)**

Although this article is dated, it is worthy of note because it examines the impact of a HVTL in a rural recreational setting—in this case, rural Wisconsin. The focus of the analysis is on the impact of the HVTL on undeveloped recreational land. The analysis utilized multiple regression analyses examining sales that occurred between 1986 and 1991, a period reported to have relatively flat prices overall within this market setting. The analyst examines the sale of 46 parcels ranging in size from 40 acres to 88 acres. There were two study areas incorporated into the analysis. Both were located in a recreational area with lakes and forest resources in rural Wisconsin. The conclusion of the analysis as set forth by the author is:

> "Thus, no relationship was established between sales price and the approximate distance of properties to transmission lines in Marquette County. Even when grouped, neither properties traversed by power lines, those in proximity of power transmission lines, nor those located over 3 miles away showed a statistically significant relationship with sales price."[50]

Although no specific mention is made of the impact of an encumbrance, it appears in the discussion included in this article that all or most of the properties considered impacted by an HVTL were crossed by the easement (encumbered).

[50] Rigdon (1991). Page 18.

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

Thomas O. Jackson* and Jennifer Pitts**

Abstract

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

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

EMFs and Health Effects

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

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

Survey Research

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

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

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

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

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

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

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

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

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

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

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

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

Statistical Sales Price Analyses

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

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

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

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

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

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

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

Hamilton and Schwann (1995) review previous literature concerning the effects of high voltage transmission lines on property values and also present new research on this topic. Previous studies reviewed by them found that overhead transmission lines can, in some instances, reduce the values of nearby properties, but these effects are generally less than 5% of property value. The impacts are observed in the immediate area of the transmission line and diminish quickly with distance, usually disappearing at 200 meters. Neither height of the lines nor voltage is found to have a significant impact. When a new line is constructed, the impacts may be larger initially but tend to dissipate quickly. In a few studies, a positive impact is found, which is generally associated with a right-of-way that's accessible for recreational use, is attractively landscaped or provides added privacy. In all of the literature reviewed, other neighborhood factors dominate the explanation of variations in property values. The authors' own study analyzes 12,907 arms-length sales of single-family detached homes in four neighborhoods in the Vancouver area between 1985 and 1991. The neighborhoods are in close proximity to existing transmission lines. The authors find that properties adjacent to a line lose 6.3% of value due to proximity and visual impact. Properties more distant from a line lose on average only 1% of their value.

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

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

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

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

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

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

Other Studies and Techniques

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Kinnard (1967), in his seminal study of these issues, conducted surveys of market participants (see survey research section) and analyzed over 1,200 sales and resales of residential properties in the same 17 subdivisions located in nine suburban towns in Metropolitan Hartford, Connecticut. All of these subdivisions, developed between 1954 and 1964, were either intersected by or abutted a tower line right-of-way. Kinnard found that sales prices did not vary significantly based on proximity to a tower line right-of-way. However, the lots closest to the right-of-way were generally larger, which means that more land area can be obtained closer to a power line for the same price as a smaller, more distant lot. The rate of absorption and financing terms of properties close to a power line were not significantly different from those of more distant properties. Over time, negative market impacts decreased substantially. Overall, Kinnard concluded that the value of residential property is not significantly affected by proximity to a tower line. Although negative attitudes toward these lines do exist, market evidence shows that properties near tower lines are readily salable on competitive market terms.

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

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

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

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

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

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

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

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

Conclusion

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

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